# A Survey of Birds in Planted and Remnant Native Vegetation around Calingiri and New Norcia, East Moore Catchment, WA

InSight Ecology

December 2008




for the project

*Revegetation of Natural Drainage Lines and Protection of Remnant Vegetation in East Moore Catchment*



# A Survey of Birds in Planted and Remnant Native Vegetation around Calingiri and New Norcia, East Moore Catchment, WA

**Report by**

**InSight Ecology**
**PO Box 6287**
**Coffs Harbour Plaza NSW 2450**
**andrew.huggett@bigpond.com**
**Ph. 02 6653 7973**

**for**

**Moore Catchment Council**
**PO Box 337**
**Moora WA 6510**

**December 2008**

**Recommended citation**: InSight Ecology, 2008. *A Survey of Birds in Planted and Remnant Native Vegetation around Calingiri and New Norcia, East Moore Catchment, WA*. Report by InSight Ecology for Moore Catchment Council.



**Photographs** (front cover): Upper set, clockwise from top left: powderbark wandoo (*Eucalyptus accedens*) woodland/shrubland remnant at Carrah Farms, Calingiri; wheat and remnant wandoo (*E. wandoo*) woodland mosaic, "Carrah Farms" (Calingiri); shrubland revegetation along a creek with grassed alleyway ("Carrah Farms", Calingiri); 13-year old Salt River Gum (*Eucalyptus sargentii*) revegetation at "Chart Farm", New Norcia. Lower set, left to right: a group of Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) foraging on wild radish near the junction of Carani West Road and Calingiri-New Norcia Road; male and female Red-capped Robin (*Petroica goodenovii*) at nest (courtesy B&B Wells and DEC WA); adult male Splendid Fairy-wren (*Malurus splendens*) (courtesy Australian Museum). All photographs without credits in this report were taken by InSight Ecology.

**ACKNOWLEDGEMENTS**

This work was commissioned by Moore Catchment Council (MCC) as part of the "Revegetation of Natural Drainage Lines and Protection of Remnant Vegetation in East Moore Catchment" Project.

I am grateful to the Northern Agricultural Catchments Council, Jodie Watts, MCC and especially the MCC project officer, Lana Kelly, for the opportunity to work in this landscape. Lana was an invaluable source of local knowledge and enthusiasm and supplied maps and project background information.

I also acknowledge the local farmers involved in the East Moore Project and previous projects such as Cockys For Landcare (Shire of Victoria Plains). The Bailey, Glass, Mason/Gooden, Nixon, and Woods families kindly allowed me to access their properties to undertake the survey and supplied valuable local information on their revegetation works and, in some cases, bird sightings. Discussions with others such as Cynthia McMorran, John Longman and Ingrid Krockenberger also informed this report. They demonstrated that the spirit of nature conservation on farms is just as healthy now as it was when I first started working in the wheatbelt.

## EXECUTIVE SUMMARY

The European discovery of Moore River 172 years ago and the founding of a Benedictine mission at New Norcia in 1846 marked the start of non-indigenous impact on the Calingiri-New Norcia district, situated 130 km northeast of Perth in the WA wheatbelt. Today, less than 25% of the original native vegetation of this area remains. Much of this is confined to blocks and strips along stony ridges and alluvial creeklines. This is significantly more than other central and northern wheatbelt districts in WA where only 2% to 12% of remnant vegetation remains. Incongruously, all of the WA wheatbelt occurs within the Southwest Australia Ecoregion, an area of outstanding yet critically threatened biological diversity and Australia's only internationally recognised biodiversity hotspot.

Over the past 15 or so years, strips of planted native trees and shrubs have been established usually in narrow strips along drainage lines in the Calingiri-New Norcia area. These aimed to mitigate salt impact, establish windbreaks, control soil erosion, and provide wildlife habitat. In 2006, a project was commenced by Moore Catchment Council to revegetate these natural drainage lines and protect remnant native vegetation (the East Moore Catchment Project).

This report describes the results of an October 2008 survey of the land bird community and habitats present in planted and remnant native vegetation at selected sites across the Calingiri-New Norcia district ("the study area"). Undertaken as part of the East Moore Catchment Project, it specifically describes the abundance, species richness, foraging guild composition of, and habitat use by, bird communities in this area. The conservation significance of this avifauna and their management within an agricultural landscape are discussed. Recommendations to protect and enhance the amount, condition, and connectivity of bird habitat are presented.

The bird assemblages of the Calingiri-New Norcia district are a microcosm of a once more diverse and extensive wheatbelt avifauna. They are characterised by a diverse mix of ground insectivores, shrub and canopy insectivores, nectarivores/insectivores, ground granivores, and carnivores. A total of 326 individual birds across 36 species were recorded in the study area. Birds were more abundant in native revegetation (58% of all individuals recorded) than woodland and shrubland remnants (42%). The most abundant species were ubiquitous birds of the wheatbelt - Brown Honeyeater, Weebill, Australian Ringneck, and Singing Honeyeater. However, remnants contained more species (30 or 83% of all species recorded) than did planted sites (21 or 58% of all species recorded). This reflected the wider range of foraging, nesting and refuge resources available to birds in remnants than in the relatively young, narrow and structurally simplistic revegetation.

Remnants supported 30 species across 10 guilds while planted sites hosted 21 species from 9 guilds. This is indicative of the larger amount, better condition, and spatial

arrangement of vegetation retained in this landscape relative to neighbouring central and northern wheatbelt districts. Sixteen bird species (or 47% of the sampled bird community) were observed breeding during the survey. While most of this occurred in remnants, older planted vegetation provided suitable nesting sites for 12 species.

As many as 28 bird species of conservation significance have been recorded or could be expected to occur in the study area. These include species that are thought to have now gone extinct in the wheatbelt and those that have been recently recorded by local farmers. Many of these birds are members of the predicted 'next wave' of declining species likely to go locally extinct. They include ground-foraging insectivores (e.g. Western Yellow Robin, Southern Scrub-robin, Shy Heathwren and Crested Bellbird), a ground granivore (Western Rosella), and a canopy insectivore (Crested Shrike-tit – western subspecies). The nationally endangered Carnaby's Black-Cockatoo was recorded in the study area during the survey while Malleefowl has been reported by farmers.

Specific recommendations to protect and restore the habitat of especially declining bird species in the study area focus on the need to adopt a whole-of-landscape approach to biodiversity conservation and management in the East Moore Catchment. This is built around the development and implementation of a landscape design based on the ecological requirements of declining woodland and heath/shrub/mallee birds. This is a strategic habitat and landscape restoration planning tool that is also a working document. It is currently being successfully implemented in Buntine-Marchagee Catchment situated within the upper Moore River drainage system to the north. The design provides recommendations to guide the enlargement of key remnants and core habitat area, their reconnection via planted habitat linkages, and the management of key threats to habitat restoration such as grazing, feral animals and weeds, and community inertia.

A suite of communication and education actions are also recommended. Finally, the need to be aware of the potentially adverse impact of introduced and naturalised bird species on the local native avifauna is discussed and some management guidelines are provided.

# TABLE OF CONTENTS

# 1. Introduction

## 1.1 Project background

One of the key threats to ecologically sustainable farming and the conservation of threatened and declining biodiversity in southern Australian agricultural systems is rising saline groundwater (Cramer and Hobbs 2002, 2005; Huggett et al. 2004). Episodes of land clearing and other poor land management practices across, for example, the Western Australian wheatbelt have mobilised salts in soils. This has led to the sterilisation of substantial tracts of formerly productive land and has placed other areas at risk of 'ecological death' through loss of viable habitat (Clarke et al. 2002; Keighery et al. 2004).

The need for urgent and informed action in these zones provided the impetus for the "Revegetation of Natural Drainage Lines and Protection of Remnant Vegetation in the East Moore Catchment" Project. Begun in 2006 and completed in December 2008, this project aimed to prioritise and implement strategic and integrated conservation works (ie. fauna and flora surveys, mapping, fencing, revegetation and community education) to protect and restore remnant native vegetation and natural drainage areas. It also aimed to improve the productive value of land for agriculture by addressing the salinity threat.

The project builds on local action plans established under the Northern Agricultural Region's (NAR) Natural Resource Management Strategy (Northern Agricultural Catchments Council [NACC] 2004) and Targeted Investment Program (NACC 2007). Previous Landcare initiatives in the catchment through the Yerecoin-Piawaning and Calingiri-New Norcia Land Conservation District Committees (LCDCs), in partnership with state and local government bodies, have established a solid community support base for the project. These have included, for example, the Drive for Landcare (Cockys for Landcare) Project and the Carnaby's Black-Cockatoo Recovery Project.

## 1.2 Objectives

This report presents the results of a baseline survey of mainly terrestrial birds and their habitat undertaken at selected sites in the study area. Specifically, the report aims to:

- Describe the abundance, species richness and foraging guild composition of bird communities present at selected sites in the study area;
- Characterise bird use of habitat (planted and remnant native vegetation);
- Discuss the conservation significance of birds recorded during the survey;
- Identify land management issues and make recommendations to protect and enhance the amount, condition, and connectivity of habitat for key avifauna in the study area.

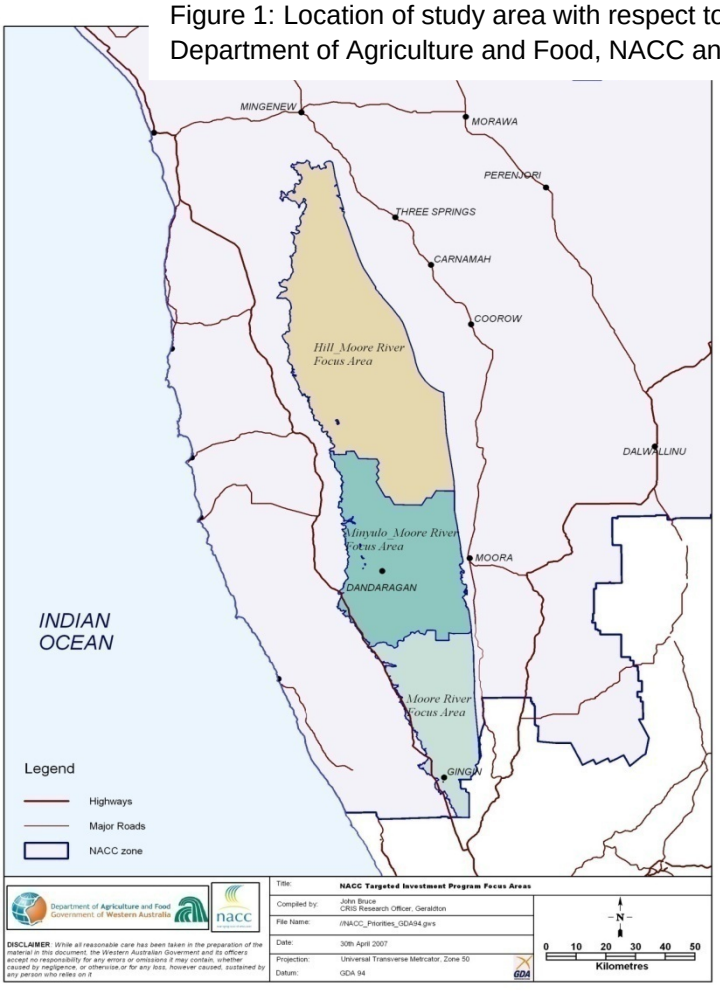
## 2. Methods

### 2.1 Field survey

An inspection of the study area (Figure 1) was undertaken on 27 October 2008 with the project officer Lana Kelly. A sampling design was developed based on the results of this visit and previous bird surveys in the WA cropping zone undertaken by InSight Ecology, including a bird survey of revegetation on “Chart Farm” (New Norcia) on 11 April 2008.

A total of ten (10) sites were selected for bird surveying across five (5) farms in the Calingiri and New Norcia districts of the southern part of the NAR. Six (6) of these were patches of native shrubs and trees planted along natural drainage lines (revegetation) while the remaining four (4) comprised remnant native shrubland and Wandoo woodland on mostly lateritic/granitic ridges and breakaways. Properties surveyed for birds in this report included “Carrah Farms” (Sarah Mason/Caroline Gooden), “Border Reivers” (T & G Nixon), “Fenwick Farm” (Rex & Tracy Glass), “Emdavale” (Steve & Suzanne Woods), and “Chart Farm” (Vern & Judy Bailey) (see Plates 1-16, pages 4-6).

Figure 1: Location of study area with respect to NACC TIP Focus Areas* (courtesy Department of Agriculture and Food, NACC and Moore Catchment Council)




*Targeted Investment Program


Yellow line indicates East Moore Catchment (northwest boundary)

All sites were surveyed over a period of three (3) days (28-30 October) in spring 2008 by one experienced ornithologist (Andrew Huggett [A.H.]). Surveys were conducted during periods of peak bird activity in the morning (ca 0700-1000) and afternoon (ca 1530-1830). Where possible, surveys did not occur during windy or wet weather. Surveys undertaken on 29 October 2008 were, however, conducted in between light shower periods and this may have reduced bird activity and thus the potential for detecting birds at the sites affected. These were both Glass revegetation sites and Woods revegetation and remnant sites.

Each site was surveyed for 40-60 minutes by A.H. undertaking an area search (Loyn 1987; Huggett et al. 2004) of habitat. This involved A.H. steadily walking a loop route in which different forward and return legs, separated where possible by a distance of at least 60 metres (to minimise the potential for recording the same bird twice), were taken through the main habitats present at each site. Where possible, an equivalent area was surveyed in both remnants and revegetation (ca 5 ha per site). Two different age-classes of revegetation were surveyed – 5-8 years and 10-15 years since planting. Where possible, revegetation and remnant sites on the same property were surveyed during the same session, ie. during the morning or the afternoon survey periods of the same day. All surveyed remnants were located within 1.5-2 km of their corresponding revegetation site.

All birds observed or heard at a site were recorded, including individuals flying over the site. Data recorded included the species present, number of individuals observed, date, time and location (site) of record, behaviour (ie. foraging/feeding, breeding, calling, mobbing, resting, flying), use of habitat, and other relevant information such as age, species composition and condition of remnants and revegetation, weather, and bird interactions (eg. predation, predator avoidance, mating/mate pursuits). Using nomenclature consistent with Christidis and Boles (2008), these data were entered in taxonomic order into a MS Excel spreadsheet.

The standard ornithological identification reference used in the field was Pizzey and Knight (2007). Barrett et al. (2003) in conjunction with Saunders and Ingram (1995) were used to confirm reported distribution and dispersal patterns of birds, especially nomadic and seasonally migratory species. These latter two texts were consulted in addition to relevant volumes of the authoritative “Handbook of Australian, New Zealand and Antarctic Birds” (or HANZAB, various editors – see References).

All observations were made using a pair of Zeiss 10x40BT® binoculars fixed to a Pro-Harness® chest-strap. Aerial photographs and maps of each of the properties and the district were used to provide landscape context and assist in the selection of survey sites. A total of 226 photographs were taken of the survey sites and the surrounding landscape and avifauna. These were shot using a Ricoh Caplio R3 7.1x zoom® digital camera. Some of these images are presented in this report.

A total of 9.08 hours was spent on surveying birds at sites in the study area. Of this effort, remnants were sampled for a total of 3.75 hours while 5.33 hours were spent in revegetation. This difference reflected an emphasis on sampling revegetation which is a key focus of the East Moore Project. This variance in proportionate survey effort was not considered to significantly affect the results of the bird survey or their interpretation. This is because bird assemblages in remnants in the study area were more species-rich and structurally diverse than those recorded in planted patches (see Section 3). This compensated, to a degree, for the greater time spent surveying in revegetation. Also, an adequate sample of bird species richness and community structure was obtained from the remnants relative to the revegetation sites.

Throughout this report the common names of birds have been used. This facilitates ease of reading and interpretation by farmers and others. The scientific names of these species are provided in the Appendix.

Plate 1: Bailey revegetation site – 13-year old Salt River Gum, note absence of shrubs and ground cover

Plate 2: Bailey revegetation site showing central drain with eucalypts planted each side and in the background

Plate 3: Glass remnant site – high quality low shrubland complex on a granitic/lateritic rise

Plate 4: Glass revegetation site – 4-5-year old eucalypts in rows along a salinising creekline

Plate 5: Mason remnant site – high quality low shrubland dominated by Dryandra with Powder-bark Wandoo patches on a lateritic ridge

Plate 6: Mason remnant site – Powderbark Wandoo shrubby woodland offering a diverse suite of microhabitats for birds and other fauna

Plate 7: Mason remnant site: Wandoo woodland with good stag (hollow tree) development

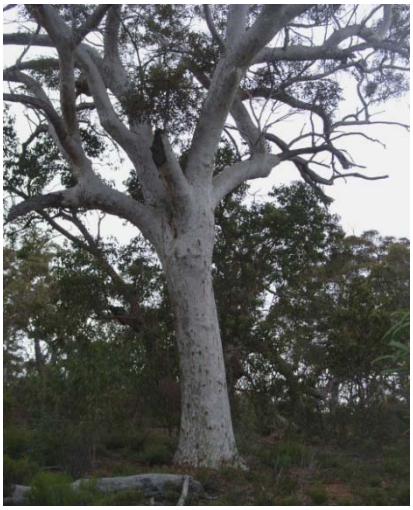


Plate 8: Mason remnant site: mature hollow-bearing individual Wandoo

Plate 9: Mason revegetation site - Acacia and *Casuarina obesa* rows (6-8 yr old?) along waterlogged creekline

Plate 10: Mason revegetation site - structural complexity and floristic diversity in creekline plantings such as this one offer resources and microhabitats for birds, insects and reptiles

Plate 11: Nixon revegetation site: 10+ year-old eucalypts planted along a creekline without shrub and ground cover layers

Plate 12: Nixon remnant site – quality Dryandra shrubland on an unfenced lateritic/granitic ridge

Plate 13: Nixon remnant site – mixed Powderbark Wandoo-Dryandra woodland on lateritic slope

Plate 14: Nixon remnant site – old-growth Powderbark Wandoo with hollows for owlet-nightjars, etc.

Plate 15: Woods remnant site – old York Gum woodland with grassy ground cover and lots of fallen woody debris

Plate 16: Woods revegetation site – 3-row wide eucalypt/Melaleuca/Casuarina planting along a saline drainage line

2.2 Data analysis

Three key attributes of bird communities were selected for analysis from data collected at each site in each treatment type (ie. revegetation or remnant) in the study area. These were bird abundance, species richness, and composition of foraging guilds (as a key indicative component of bird community structure). A total of 10 replicates of treatment type (ie. 6 revegetation and 4 remnant sites) were used in analyses undertaken for this report.

Assignment of species recorded in the surveys to foraging guilds was based on existing knowledge and published data, especially from HANZAB. Bird use of habitat was analysed qualitatively from notes made during site surveying.

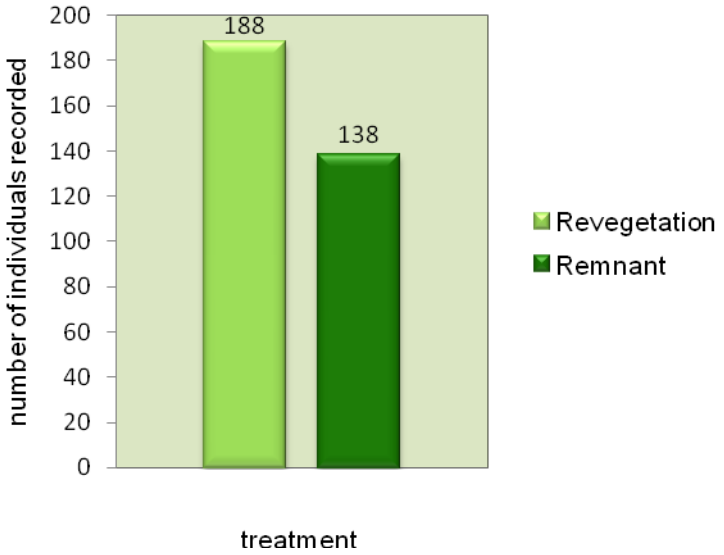
Bird survey data were examined for the total, mean, and standard deviation from the mean statistic for each treatment type and for the overall study area using MS Excel, with the results presented in graphical and tabular form. Survey effort was calculated according to treatment type and across the survey period.

## 3. Results

3.1 Bird abundance

A total of 326 individual birds were recorded during the survey in the study area (Appendix). Of this total, 57.7% (188 birds - mean 2.07, standard deviation [sd] 3.49) occurred in revegetation sites while 42.3% (138 birds – mean 1.42, sd 2.39) were observed in remnant sites (Figure 2).

Figure 2: Total bird abundance by treatment, October 2008



The most abundant bird species recorded in the survey were, in order of highest number, Brown Honeyeater (60 individuals at 8 sites – Plate 17), Weebill (49 at 8 sites – Plate 18), Australian Ringneck (30 at 8 sites – Plate 19), Singing Honeyeater (25 at 5 sites – Plate 20), and Tree Martin (20 at 5 sites – Plate 21). Brown Honeyeater was recorded more in revegetation sites (37 birds or 61.7% of the total number of this species recorded in the survey) than in remnants (23 birds or 38.3%). Weebill was recorded in similar numbers in both revegetation (23 birds or 46.9%) and remnants (26 birds or 53.1%). Australian Ringneck was found more in revegetation (23 birds or 76.7%) than in remnants (7 birds or 23.3%). Singing Honeyeater also utilised revegetation more (23 birds or 92%) than remnants (2 birds or 8%), as did Tree Martin (14 birds or 70% in revegetation, 6 birds or 30% in remnants).

The least abundant bird species recorded in the survey were a group of five species - Elegant Parrot (Plate 22), Red-capped Parrot, Grey Shrike-thrush (Plate 23), New Holland Honeyeater (Plate 24), Silvereye (Plate 25), and Little Button-quail (Plate 26). Only one individual of each of these species was recorded at only one site. Other less abundant species were Grey Fantail (2 birds at one site – Plate 27), White-cheeked Honeyeater and Western Spinebill (3 birds each at one site – Plates 28 and 29), Rufous Whistler (4 birds at 4 sites – Plate 30), Western Gerygone (5 birds at 3 sites – Plate 31), and Western Thornbill (6 birds at one site – Plate 32).

Plate 17: Brown Honeyeater at nest (photo: B&B Wells and DEC)

Plate 18: Weebill – a small bird that gleans leaves for insects in remnant woodland and 4+ year-old revegetation alike (photo: David Cook)

Plate 19: Australian Ringneck (subsp. *semitorquatus* shown but the nominate *zonarius* was recorded in the study area) (photo: wikipedia)

Plate 20: Singing Honeyeater - common insect- and nectar-foraging bird of revegetation and remnants (photo: B&B Wells, DEC)

Plate 21: Tree Martin at eucalypt nest hollow (photo Julian Robinson)

Plate 22: Male Elegant Parrot foraging (photo: Chris Tzaros/Birds Australia)

Plate 23: Grey Shrike-thrush, commonly observed foraging for insects on the ground (photo: Paul Walbridge)

Plate 24: New Holland Honeyeater at nest (photo: Purnell Collection, Australian Museum)

Plate 25: Silvereye, a disperser of seeds contained in fruit, a large part of their diet (photo: wikipedia)

Plate 26: Little Button-quail, flushed in poison bush shrubland, Glass remnant (photo: swiss7)

Plate 27: Grey Fantail, a summer breeding migrant to southern WA (photo: wikipedia)

Plate 28: White-cheeked Honeyeater, a nectar nomad in the WA wheatbelt (photo: B&B Wells)

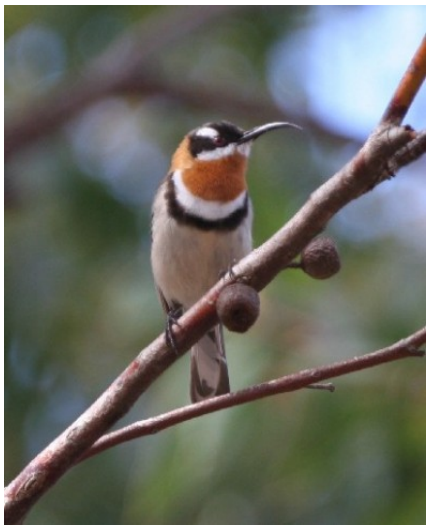


Plate 29: Male Western Spinebill (photo: Tony Crittenden)

Plate 30: male Rufous Whistler at nest (photo: B&B Wells, DEC)

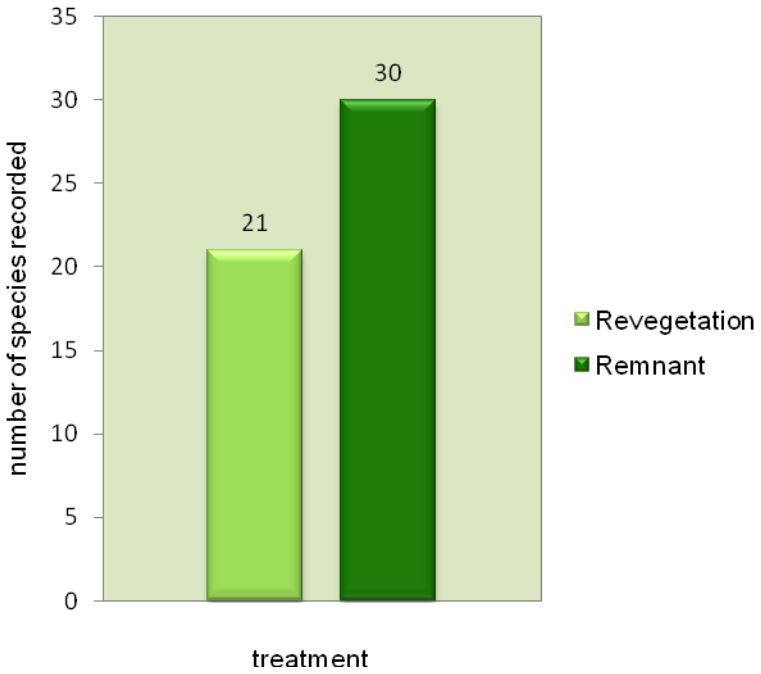
Plate 31: Western Gerygone - a small, partly migratory insectivore that breeds in southwest WA in summer before some of the population moves north and east in winter (photo: Peter Head)

Plate 32: Western Thornbill – a small sedentary insectivore that forages on the ground, in low shrubs and in trees (photo: Brian Jenkins)

## 3.2 Bird species richness

A total of 36 bird species were recorded during the survey in the study area (Appendix). Thirty (30) or 83.3% of these species were detected in remnant sites while 21 (58.3%) occurred in revegetation sites. Figure 3 shows this variation in bird species richness (or the number of bird species) recorded across the two treatments.

Figure 3: Bird species richness by treatment, October 2008



Remnant sites offered a generally wider suite of foraging, perching, shelter and breeding resources for woodland and shrubland birds than did revegetation sites. Species dependent on tree hollows (for nest and shelter), bare tree branches (for staging points for foraging and/or observation), and structurally complex and floristically diverse habitat, or that predate small birds and their eggs and young were recorded in remnants but not in revegetation. These included Elegant Parrot, Rainbow Bee-eater, Western Thornbill, New Holland Honeyeater, White-cheeked Honeyeater, Western Spinebill, Grey Shrike-thrush, one omnivore (Australian Raven), and three carnivores (Grey Butcherbird, Brown Goshawk and Brown Falcon).

Small birds that glean lerps and other insects from the leaves and bark of eucalypts and other plants (Western Gerygone, Weebill and Striated Pardalote) were recorded in both revegetation and remnant sites. Honeyeaters present in revegetation sites were attracted by flowering eucalypts and insects. They included Red Wattlebird, the nectar nomad/summer breeding migrant Brown-headed Honeyeater, and the year-round residents - Brown Honeyeater and Singing Honeyeater.

Birds that forage on the ground, either by actively searching or pouncing, also occurred in revegetation sites of 10 years of age or more. Australasian Pipit and Red-capped Robin were recorded at some of these sites.

Some remnant sites were notably richer in bird species than others such as Mason's and Glass's. These were generally well managed remnants fenced off from sheep and/or cattle, and in Glass's case, fortuitously containing *Gastrolobium* sp and other 'poison bush' plants. Mason's remnant site was particularly rich in sedentary and migratory/nomadic honeyeater species, ground and shrub-foraging insectivores, and hollow-nesting parrots and cockatoos (including Carnaby's Black-Cockatoo). Wood's remnant site of old York Gum and Wandoo woodland provided many potential and actual nesting hollows for parrots, cockatoos and Tree Martin.

In a similar vein, more established and structurally diverse revegetation sites (Mason's and Bailey's) supported a richer bird community than younger and less stratified revegetation sites (Woods and Glass's 'Site 2'). At the latter sites, the absence of site-level habitat heterogeneity for birds and other fauna - mid, lower and ground layers of vegetation and decaying logs, leaf litter, exfoliating bark and rock substrates – was notable.

## 3.3 Bird community structure and habitat

### 3.3.1 Composition of foraging guilds

Foraging guild composition is a key indicative component of bird community structure (Ford 1989; Wiens 1989; Mills 2007). A total of 11 bird foraging guilds were recorded in the study area (Figure 4 and Appendix). These included ten dryland guilds and one

wetland (aquatic omnivore) guild. Nine (9) of the ten dryland guilds occurred in remnant sites while nine (9) dryland guilds were recorded in revegetation sites. The wetland guild was recorded in the Woods remnant site.

The main foraging guilds present in the study area were ground granivores, nectarivores/insectivores, carnivores, ground insectivores, and shrub insectivores (Figure 4). Ground granivores comprised 16.7% (6 species) of all species recorded by guild in the survey. Species of this guild occurred in similar numbers in both revegetation (4 species) and remnant sites (5 species). They included Australian Ringneck, Galah, Crested Pigeon, Carnaby's Black-Cockatoo, Elegant Parrot, and Little Button-quail. The latter species was only detected in Glass's remnant while the Elegant Parrot only occurred in the Mason remnant.

Nectarivores/insectivores also accounted for 16.7% (6 species) of all species recorded by guild. Six member species were detected in remnants, including 3 migratory or nomadic honeyeaters (White-cheeked, New Holland, and Brown-headed) while revegetation sites supported 4 member species. Other species of this guild were the generally sedentary honeyeaters (Brown Honeyeater, Singing Honeyeater and Red Wattlebird), all of which occurred in revegetation sites.

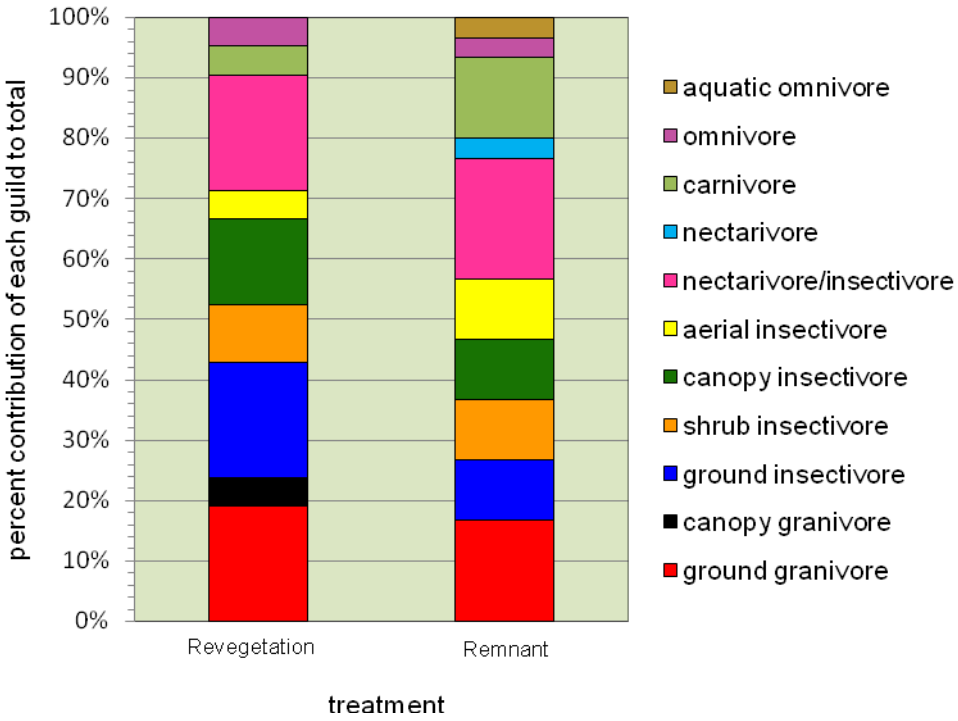
Carnivores represented 13.9% (5 species) of all species recorded by guild. One carnivore (Pied Butcherbird) occurred in revegetation while 4 carnivores (Grey Butcherbird, Australian Magpie, Brown Goshawk, and Brown Falcon) occupied remnants. The two raptor species were observed perched in the upper branches of Wandoo (*Eucalyptus wandoo*) and Powderbark Wandoo (*E. accedens*) actively scanning for prey in the Glass and Nixon remnants.

Ground insectivores and shrub insectivores each contributed 11.1% (4 species each) to the total guild complement of the surveyed sites. Three ground insectivores utilised both revegetation and remnant sites alike (Splendid Fairy-wren, Red-capped Robin, and Australasian Pipit), while Willie Wagtail was recorded in revegetation only. Remnants recorded 3 shrub insectivores (Rufous Whistler, Grey Shrike-thrush and Western Thornbill) while only Rufous Whistler and Grey Fantail occupied revegetation and then only more established (Bailey's 13+ age-class) plantings.

Other guilds recorded included canopy insectivores and aerial insectivores (8.3% or 3 species each). Striated Pardalote, Weebill and the summer partial migrant Western Gerygone occurred in the canopies of 6 year+ revegetation and in remnants. Tree Martin was the only aerial insectivore that occupied both revegetation and remnant sites. Black-faced Cuckoo-shrike and the summer migrant Rainbow Bee-eater only occurred in remnants. Two species of omnivore (Australian Raven and Silvereye) accounted for 5.6% of the overall guild total. One species each (2.8%) of canopy granivore (Red-capped Parrot, in Mason's revegetation), nectarivore (Western Spinebill,

in Mason's remnant) and aquatic omnivore (Pacific Black Duck, in Woods' remnant) were recorded.

Figure 4: Composition of bird foraging guilds by treatment, October 2008




### 3.3.2 Habitat use

A range of habitats were utilised by birds at the surveyed sites. Remnant sites offered a structurally more complex and floristically more diverse suite of habitats than the revegetation sites. These included ground substrates (rocks, fallen logs, leaf and bark debris), ground-covering vegetation (vines, prostrate shrubs, herbs and grasses), understorey plants (proteaceous and myrtaceous shrubs, *Xanthorrhoea* spp., tall grasses), and canopy trees (typically Wandoo, Marri [*Corymbia calophylla*], York Gum [*Eucalyptus loxophleba* ssp *loxophleba*] and Powderbark Wandoo).

A selection of different microhabitat types and key resources for birds were offered by the broad habitat types in remnants. Hollows in Wandoo and Marri tree branches and stems offered potential nest and shelter sites for Red-capped Parrot, Elegant Parrot, Australian Ringneck, Galah, cockatoos and Tree Martin. The dead outer branches of York Gum and Wandoo provided perches for aerial insectivores (Rainbow Bee-eater, Tree Martin and Black-faced Cuckoo-shrike) and carnivores (Grey Butcherbird and Brown Falcon) to launch feeding forays. Exfoliating bark and tree branch apices were searched for invertebrate prey by Rufous Whistler, Grey Shrike-thrush and Red Wattlebird. The moderate to dense canopy foliage of Wandoo, Powderbark Wandoo,

Marri and York Gum (generally between 10-18 m tall) was searched for leaf and branch-dwelling insects by Weebill, Striated Pardalote and Western Gerygone while also providing concealment for an ambush predator, the Brown Goshawk.

Flowering Dryandra, Adenanthos and other proteaceous and some myrtaceous shrubs provided nectar and insects for several sedentary and migratory/nomadic honeyeaters, including Western Spinebill and White-cheeked Honeyeater. Shrub insectivores such as Western Thornbill, Rufous Whistler and Splendid Fairy-wren foraged and possibly nested in Dryandra and other understorey shrubs. The ground-foraging Red-capped Robin was observed nesting in a Dryandra fork 1.5 m above the ground in the Nixon remnant (Section 3.3.3). Grasses, flowering herbs and groundcover plants provided seeds, fruit and insects for Australasian Pipit, Carnaby's Black-Cockatoo (foraged on wild radish in road verge – Sections 3.3.4 and 3.4), Galah, and Australian Ringneck. Little Button-quail foraged in dense low shrubland in Glass' remnant. An aquatic omnivore, Pacific Black Duck, was observed resting in a flowing freshwater stream in Woods' remnant.

The habitats and microhabitats available for birds to utilise in revegetation sites reflected their developmental stage (5-15 year age-class), design (often 1-2 vegetation layers only planted typically in 3-5 row wide strips each side of a drainage line), and purpose (primarily as agents of secondary salinity mitigation, wind protection and/or soil erosion control). Habitat and microhabitat types at these sites and their avifauna were:

Airspace above revegetation (Tree Martin);

Fencelines along revegetation-paddock edges (Willie Wagtail, Red-capped Robin, Australian Raven);

Open ground under planted trees and shrubs, samphire and other groundcover plants such as the exotic Spiny Rush *Juncus acutus* which grows along drainage lines and deep drains running through some revegetation sites (Australasian Pipit, Red-capped Robin, Australian Raven, Crested Pigeon, Galah);

Shrub and canopy foliage (generally between 2-10 m tall – Weebill, Striated Pardalote, Western Gerygone, Splendid Fairy-wren, Grey Fantail, Rufous Whistler);
Flowering Salt River Gum and other eucalypts such as River Red Gum, Flat-topped Yate, Salmon Gum and Marri (Brown-headed Honeyeater, Brown Honeyeater, Singing Honeyeater, Red Wattlebird);

Some stem and branch bark and apices (on the 10+ age-class of planted eucalypts – Rufous Whistler and Red Wattlebird).

In the predominantly young revegetation sites there was a general absence of hollow-bearing trees, dense shrub layers, ground-covering plants outside of drainage lines and

drains, ground substrates (rocks, accumulated leaves, bark and old fruit, and fallen logs and branches), and topographic variation. This latter attribute reflected the siting of all revegetation sites in salt-affected lowland riparian zones.

Plates 33-42 show several different types of bird habitat and microhabitat present in the study area.

Plate 33: Mounded rows of 13 year-old Salt River Gum (Bailey revegetation site) provide canopy foliage for foliage gleaners such as Striated Pardalote and Weebill - note lack of ground cover

Plate 34: A young Red-capped Robin used low branches of 13 year-old Salt River Gum to forage on open ground between planted rows (Bailey revegetation site)

Plate 35: Mixed shrubland with isolated Wandoo trees, a fallen hollow log and patches of open ground – Splendid Fairy-wrens were recorded here (Glass remnant site)

Plate 36: Dense low shrubland with rocky outcrops and stands of 1.7 m mallee provided foraging and shelter microhabitat for Splendid Fairy-wren and Little Button-quail (Glass remnant site)

Plate 37: The dead part of this tree provided perch and nest sites for Tree Martins while Willie Wagtails nested in the living lower section (Glass revegetation site 2)

Plate 38: Standing dead trees (stags) in a saline drainage line provided foraging perches for the migratory Rainbow Bee-eater and Crimson Chat (Glass revegetation sites 2 and 4 are on each side of this location)

Plate 39: Stag development in Wandoo woodland offering potential shelter and nest sites for mammals, reptiles, bats, parrots and owls (Mason remnant site)

Plate 40: Nectar produced from, and insects attracted to, these young eucalypts provided food for honeyeaters and Splendid Fairy-wren (Mason revegetation site)

Plate 41: Adenanthos (shrub) provided nectar for six honeyeater species (Mason remnant)

Plate 42: Grassy York Gum woodland offering cover, seed and nest sites (Woods remnant)

### 3.3.3 Breeding activity

A total of 34 records of breeding activity were obtained for 16 bird species at the survey sites (Appendix). Thus, 47% of the total bird community sampled during the survey was engaged in breeding activity.

Direct evidence of breeding activity accounted for 12 records or 35.3% of the total number of breeding bird records obtained in the survey. These involved 10 species observed either sitting on nests, delivering food to a nest, or procuring material to build a nest. Five (5) of these species were detected in remnants and seven (7) in revegetation. In remnants, these included Splendid Fairy-wren, Weebill, Western Thornbill, Red-capped Robin and Brown Honeyeater. A female Red-capped Robin was observed sitting on a nest 1.5m up in a Dryandra fork in Nixon's remnant. A male was also observed delivering prey to recently hatched nestlings in this nest. In revegetation, Splendid Fairy-wren, Red-capped Robin, Grey Fantail, Willie Wagtail, Rufous Whistler, Australasian Pipit and Tree Martin were detected directly engaging in breeding activity. A pair of Grey Fantail was observed collecting cobwebs for nest-binding to a branch in an 8-10 year old planted eucalypt at Nixon's revegetation site.

Indirect evidence of breeding behaviour included birds calling and/or defending breeding territory or engaged in mate pursuits. A total of 22 records or 64.7% of all observed breeding activity consisted of this type of evidence and involved 10 species. Nine (9) of these species occurred in remnants. They were Rainbow Bee-eater, Striated Pardalote, Weebill, Western Gerygone, Red Wattlebird, Singing Honeyeater, Brown Honeyeater, Rufous Whistler and Australasian Pipit. Six (6) of these species were recorded in revegetation and included Western Ringneck, Striated Pardalote, Weebill, Western Gerygone, Singing Honeyeater and Rufous Whistler.

### 3.3.4 Opportunistic sightings

Two sets of opportunistic sightings were made of birds near the survey sites. In the first, a group of 14 Carnaby's Black-Cockatoo were observed (at 0625 hours) foraging in wild radish along the verge of Calingiri-New Norcia near its junction with Carani West Road (Plates 43 and 44). The second sighting was of a female Crimson Chat perched in a standing dead tree within a saline drainage line between Glass revegetation sites 2 and 4 (Plate 45). This latter species is nomadic, moving south in spring from drier northern and inland regions before returning north/inland in autumn.

A Western Brush (or Black-gloved) Wallaby *Macropus irma* was sighted along the southern fence of the Glass remnant at 0750 hours on 30 October 2008 (Plate 46). This species is the closest relative to the now extinct Toolache Wallaby *Macropus greyi* (Wann and Bell 1997). This conveys a level of significance to *M. irma* in genetic conservation terms. Numerous spider, ant, grasshopper and dragonfly sightings were

made, especially in the more densely planted and structurally complex (in revegetation terms) Mason revegetation site (Plates 47 and 48).

Plate 43: The patch of wild radish beside Calingiri-New Norcia Road near Carani West Road junction

Plate 44: Part of a group of Carnaby's Black-Cockatoo feeding on wild radish at the location shown in Plate 43

Plate 45: Male Crimson Chat (note: only the duller female was sighted next to the Glass revegetation sites - photo: Melissa Cundy DEC)

Plate 46: Western Brush (or Black-gloved) Wallaby at southern fence, Glass remnant site

Plate 47: Unidentified medium-sized spider in Mason revegetation site's shrub and tree rows

Plate 48: Unidentified grasshopper species in grassy new shrubland (Mason revegetation site)

## 3.4 Birds of conservation significance

The study area occurs within Southwest Australia, a region recognised internationally as Endemic Bird Area No. 186 (BirdLife International 2003), a 'Global 200' Ecoregion (WWF 2006), and as an international biodiversity hotspot – the only hotspot in Australia and among only 34 worldwide (Conservation International [CI] 2007). This recognition is based on the region's critical priority for conservation, given that it supports 2,948 endemic plant species, 80% of which are found nowhere else in the world, 3 endemic threatened (ET) birds, 6 ET mammals, and 3 ET amphibians (CI 2007). The region is also recognised as having undergone major habitat loss and fragmentation, losing at least 70% of its original habitat extent (CI 2007).

Twenty-eight (28) bird species of international, national, state or local conservation significance have been recorded, could be reasonably expected to occur in suitable habitat, or have gone extinct in the wheatbelt zone of this region (Table 1). Some birds of conservation significance have been observed on properties in the Calingiri-New Norcia district by farmers (e.g. Rex Glass and Sarah Mason, pers comm) and in the study area during this survey. Their current conservation status at all levels is also indicated.

Table 1: The conservation status of significant terrestrial and terrestrial-aquatic bird taxa of wheatbelt habitats in Western Australia. Global status follows IUCN (2001, 2006) and refers to the status of the species not subspecies. National status observes Garnett and Crowley (2000) while status in WA is based on HANZAB (1990-2006). Status in WA wheatbelt follows Serventy and Whittell (1976), Saunders and Ingram (1995), Barrett et al (2003), and Huggett et al (2004). Status in the study area is based on data from HANZAB (1990-2006) and results of the current survey. LC=Least Concern, NT=Near Threatened, EN=Endangered, V=Vulnerable, EX=Extinct (likely), U=Unknown status (data deficient). The subscripts [1] and [2] after common names indicate that the species was recorded during this survey or by local farmers in recent years, respectively.

| **Common name** | **Scientific name** | **Global status** | **National status** | **Status in WA** | **Status in WA wheatbelt** | **Likely status in study area** |
|---|---|---|---|---|---|---|
| Malleefowl[2] | *Leipoa ocellata* | V | V | V | V | EN |
| Australian Little Bittern | *Ixobrychus dubius* | LC | NT | NT | NT | EX |
| Australian Bustard | *Ardeotis australis* | NT | NT | NT | V | V |
| Bush Stone-curlew | *Burhinus grallarius* | NT | NT | NT | V | EN/EX? |
| Hooded Plover (western) | *Thinornis rubricollis tregellasi* | NT | NT | NT | NT | NT |
| Red-tailed Black-Cockatoo (south-western) | *Calyptorhynchus banksii naso* | NT | NT | NT | NT | EX? |
| Carnaby's Black-Cockatoo[1,2] | *Calyptorhynchus latirostris* | EN | EN | EN | EN | EN |
| Western Corella (southern) | *Cacatua pastinator pastinator* | EN | EN | EN | EN | EN |
| Western Rosella (wheatbelt) | *Platycercus icterotis xanthogenys* | NT | NT | NT | NT | EX |
| Barking Owl | *Ninox connivens* | LC | NT | NT | U | U |

| Common name | Scientific name | Global status | National status | Status in WA | Status in WA wheatbelt | Likely status in study area |
|---|---|---|---|---|---|---|
| (southern – WA sub-population) | *connivens* | | | | | |
| Masked Owl (southern Australia) | *Tyto novaehollandiae novaehollandiae* | LC | NT | NT | U | U |
| Thick-billed Grasswren (western) | *Amytornis textilis textilis* | NT | NT | NT | EX | EX |
| Shy Heathwren (western) | *Hylacola cauta whitlocki* | NT | NT | NT | V | V |
| Rufous Fieldwren (western Wheatbelt) | *Calamanthus campestris montanellus* | NT | NT | NT | V | V |
| Redthroat | *Pyrrholaemus brunneus* | LC | LC | LC | NT | U/NT? |
| Scarlet Robin (south-western) | *Petroica multicolor campbelli* | LC | LC | LC | NT | V/U |
| Western Yellow Robin[2] | *Eopsaltria griseogularis* | LC | LC | NT | V | V |
| Southern Scrub-robin[2] | *Drymodes brunneopygia* | LC | LC | LC | NT | NT |
| Crested Shrike-tit (western) | *Falcunculus frontalis leucogaster* | NT | NT | NT | NT | EX |
| Crested Bellbird (southern)[2] | *Oreica gutturalis gutturalis* | NT | NT | NT | NT | V |
| Birds of local conservation significance (Calingiri-New Norcia district)* | | | | | | |
| Regent Parrot (western) | *Polytelis anthopeplus anthopeplus* | LC | LC | LC | LC | U/NT? |
| White-browed Babbler[2] | *Pomatostomus superciliosus* | LC | LC | LC | LC | U/NT? |
| Red-capped Parrot[1] | *Purpureicephalus spurius* | LC | LC | LC | NT | NT |
| Splendid Fairy-wren[1,2] | *Malurus splendens* | LC | LC | LC | LC | LC |
| Blue-breasted Fairy-wren | *M. pulcherrimus* | LC | LC | LC | LC | U |
| Western Gerygone[1] | *Gerygone fusca* | LC | LC | LC | LC | LC |
| Western Thornbill[1] | *Acanthiza inornata* | LC | LC | LC | U | U |
| Western Spinebill[1] | *Acanthorhynchus superciliosus* | LC | LC | LC | LC | U |

*These species are in addition to birds of global, national, and state significance that have been recorded or may occur in the study area and which are listed above.

The bird species of highest conservation value observed during the survey was Carnaby's Black-Cockatoo, detected in Mason's remnant and revegetation sites and in Woods remnant site. This species is listed under Schedule 2 (Fauna that is rare or likely to become extinct) of the WA Government's Wildlife Conservation Act 1950 and the Wildlife Conservation (Specially Protected Fauna) Notice 2008 (2). It is listed as "Endangered" under international classificatory (IUCN Red List of Threatened Species 2001, 2006) and national legislative (Environment Protection and Biodiversity

Conservation Act 1999) systems. Carnaby's Black-Cockatoo has been the subject of an apparently successful ongoing conservation initiative in the Calingiri-New Norcia area and across other parts of its range.

The co-occurrence of several species of migratory/nomadic honeyeater in the Mason remnant was also of local conservation significance. Similarly, the irruptive Crimson Chat and migratory Bee-eater observed near the Glass revegetation sites and in Woods remnant (Bee-eater only) conferred some local conservation value to these sites and their dead trees and the dead outer branches of living trees.

### 3.5 Constraints to the interpretation of results

A number of factors need to be considered when interpreting the significance of the results for bird community structure, habitat use, and conservation management. These are:

- Minimal survey effort and replication, ie. one survey undertaken over three days in one season and one year only, across 10 sites;
- Missed or lowered detection of some bird species due to sub-optimal weather conditions (ie. cooler and showery conditions associated with frontal movement across the area on the second day of the survey) and breeding activity (ie. individuals sitting on nests as opposed to actively foraging). This also potentially contributed to lower estimates of bird abundance and species richness in each survey site;
- Targeting of revegetation (in addition to remnants) reduced the potential for sampling a more diverse range of bird species that would be expected if surveys were conducted exclusively in remnant native vegetation;
- Landscape-scale effects – the influence of the size and connectedness of remnants, amount and type of edge habitat present, impact of land use activities occurring within the regional landscape, cross-landscape movement patterns of some bird species (and the impact of this on other species and genetic exchange), and climate change impacts on bird communities of the study area.

These factors did not, however, adversely affect the results of the survey or its recommendations. Rather, they are simply considerations that commonly apply to many biodiversity surveys. Recognition of the potential influence of these factors on survey results can also help improve the design and conduct of future investigations.

## 4. Discussion

### 4.1 Landscape context and effects

The human ecological footprint on the woodland and shrubland ecosystems of the Western Australian wheatbelt has been particularly heavy and wide-reaching. In many districts less than 10% of the original native vegetation cover remains. In the central wheatbelt, as little as 2 to 5% of the original native vegetation is left (Frost et al. 1999). This ranks these ecosystems and their remnant faunas among some of the most fragmented and threatened in the world (Saunders and Ingram 1995; Huggett 2008).

Significantly, the Calingiri/New Norcia landscape supports less than 25% of its original native vegetation cover. Most of this vegetation occurs along lateritic or granitic low ridges and rises in the area. While some of these upland patches are connected to midslope and lowland woodlands and shrublands, many are effectively islands surrounded by pastures and crops and sometimes grazed by livestock. Despite this, there is higher potential for landscape recovery in this catchment than in the central and northern wheatbelt regions, largely because of the amount, condition, and spatial arrangement of native vegetation retained in the landscape. The retention of strips of remnant woodland along streams and the revegetation of these zones around Calingiri/New Norcia help provide additional potential 'building blocks' for re-connecting remnant patches in the landscape.

The study area occurs within a regional landscape characterised by decreasing intensification of land use along a gradient from west (urban) to east (wheat farming and grazing). The rapidly urbanising Swan Coastal Plain lies to the west and contrasts strongly, in terms of the amount, extent and configuration of remnant native vegetation, with central wheatbelt districts to the east. These land uses and their proximity, at a landscape scale, to the study area, influence the composition, occurrence and regional movement of bird species into and out of the area.

In effect, the Calingiri/New Norcia area probably provides many of the key life cycle resources (including refugia, e.g. granite outcrops and Wandoo woodlands) for conservation-reliant bird and other fauna species (e.g. Critical Weight Range mammals) that are no longer available or are much less available in the adjoining urban and central wheatbelt landscapes. This can be substantiated by the location of the study area within a centre of narrow endemism, between Gingin and New Norcia (Williams and Mitchell 2001). This is an area containing concentrations of locally endemic plant and animal species, ie. species with ranges of less than 100 km (Williams and Mitchell 2001). Concentrations of locally endemic species are often indicative of higher quality of habitat and diversity of available ecological niches in a particular area, relative to other neighbouring areas (Keighery et al. 2004).

## 4.2 Bird assemblages of the study area

Bird assemblages of the Calingiri/New Norcia district reflect the nature of the landscape within which they occur and the influence of their neighbouring regional landscapes (Section 4.1). Specifically, they have evolved in response to the type, amount, condition, connectivity, spatial arrangement, species composition, and structural complexity of habitats available in remnant and planted vegetation at different spatial and temporal scales.

With change in these parameters over time have come apparent fluxes in the survival, persistence, increase/expansion, and recovery of several bird species and foraging guilds in the study area. Some species appear to have gone locally extinct following the large-scale clearance of native woodland and shrubland for farming over 120 years ago and the introduction of exotic predatory mammals such as the European fox and cat. These include the Bush Stone-curlew - a ground insectivore highly susceptible to fox predation, loss and fragmentation of its open woodland habitat, and trampling of nesting habitat by livestock (Plate 49), granivores dependent on suitable tree hollows for nesting (Western Rosella – Plate 50 and Red-tailed Black-Cockatoo – Plate 51), and the Crested Shrike-tit - a canopy insectivore dependent on insects in decorticating bark of eucalypt woodland (Plate 52). Other species, however, seem to have been able to persist in the remnants while others have increased in abundance and/or expanded their distributional range. This latter group of more resilient birds include mostly open-country ground granivores (Australian Ringneck, Galah and Crested Pigeon) and possibly two versatile nectarivores/insectivores (Brown Honeyeater and Singing Honeyeater). Yet other species appear to be on the recovery trail, mostly due to direct intervention such as targeted revegetation and protection/restoration of breeding and foraging habitat, e.g. for Carnaby's Black-Cockatoo.

Plate 49: Bush Stone-curlews with fledgling (bottom right), a Vulnerable species in the WA wheatbelt (photo: wikipedia)

Plate 50: Male Western Rosella. The wheatbelt subspecies *xanthogenys* is listed nationally as Near Threatened (photo: flickr.com)

Plate 51: Red-tailed Black-Cockatoo, southwest WA subspecies *naso* (female) listed nationally as Near Threatened (Photo: DEC)

Plate 52: Crested Shrike-tit (western subspecies *leucogaster*) listed nationally as Near Threatened (Photo: A.Pattison/GlobalTwitcher)

The most abundant species recorded in the study area (Brown Honeyeater, Weebill, Australian Ringneck and Singing Honeyeater) are opportunistic, adaptable and quite resilient species that foraged and probably nested in both remnant and planted native vegetation. Their member guilds (nectarivore/insectivore, canopy insectivore, and ground granivore) contained other species of greater sensitivity to the local consequences of habitat loss and fragmentation (ie. reduced patch size, increased isolation, lowered habitat condition, and increased amount of edge). These included Carnaby's Black-Cockatoo, Elegant Parrot, White-cheeked Honeyeater, and Western Spinebill.

A cohort of bird species that are declining in number across the WA wheatbelt (see Huggett 2008) were also recorded, in low numbers, in the study area. In time, these are at risk of becoming locally extinct as the condition, size, connectivity, and intactness of their breeding, foraging and refugia habitat continues to be eroded by grazing livestock, local land clearing events (e.g. for road maintenance, property fencing, crop expansion), feral predators, and weeds. Of particular concern are the shrub insectivore Western Thornbill, canopy granivore Red-capped Parrot, and the ground granivore Elegant Parrot. Both parrot species require suitable and available nesting hollows in Wandoo and Marri trees while Western Thornbill requires larger patches of intact remnant woodland with well developed shrub and canopy layers. The population dynamics of Carnaby's Black-Cockatoo will need to be properly monitored and their nesting and foraging habitat continue to be protected over the long-term (see Section 5.2).

Of greater concern, however, was the absence during the survey of other key woodland and shrubland decliners – Scarlet Robin (south-western subspecies), Western Yellow Robin, White-browed Babbler, Southern Scrub-robin, Shy Heathwren (western subspecies), Crested Bellbird, and Malleefowl. The lack of detection of these species points to key causal factors such as declining core habitat condition, impaired connectivity between key larger remnants and landscape units, and incursion by feral

predators and grazing livestock. The modest survey effort invested for this report may also have contributed to these absences (also see Section 3.5 for other potential constraints). Fortunately, recent local farmer records exist for all of these species except the Shy Heathwren and Scarlet Robin, although these records require further investigation (Section 5.2).

Bird assemblages of the study area are likely to be less taxonomically and functionally rich than those of the Darling Range and other more contiguous woodlands to the south. This is probably because of the degree of loss, fragmentation and modification of remnant native vegetation that has occurred in the Calingiri/New Norcia district since clearing for farming and roads. Evidence for this level of bird community simplification could be found in the low species richness of foraging guilds recorded in the study area. These were dominated by only 4-6 species each of ground granivores, nectarivores/insectivores, carnivores, and ground and shrub insectivores. However, more comprehensive sampling of the bird fauna over different seasons and years would be expected to provide an improved estimate of the taxonomic and functional richness and condition of these assemblages.

## 4.3 Bird use of habitat in the study area

### 4.3.1 Utilisation of remnant native vegetation

Most of the birds recorded in the study area occurred in patches of remnant native vegetation, principally Wandoo/Powderbark Wandoo woodland and proteaceous and myrtaceous shrubland on the rocky ridges and York Gum/Jam (*Acacia acuminata*) woodland on the valley slopes and floor. These vegetation communities offer bird habitat of higher quality with a wider range of foraging, nesting and refuge opportunities than available in structurally simpler and younger planted vegetation in the study area.

Birds recorded only in remnants were shrub insectivores (Western Thornbill, Grey Shrike-thrush), nectarivore (Western Spinebill), nectarivores/insectivores (New Holland Honeyeater, White-cheeked Honeyeater), ground granivore (Elegant Parrot), aerial insectivore (Rainbow Bee-eater), and carnivores (Brown Falcon, Brown Goshawk, Grey Butcherbird). Some of these species (Western Thornbill, Elegant Parrot, Brown Goshawk) are forest/woodland interior birds, preferring the interior (core) of remnants away from edge impacts. Others (New Holland Honeyeater, White-cheeked Honeyeater and Western Spinebill) are attracted to the abundance and diversity of nectar and insects associated with flowering ground cover, shrub and tree species available in the multi-layered, fenced-off remnants. Summer visitors from northern and inland zones (Rainbow Bee-eater and Crimson Chat) utilise standing dead trees and the outer dead branches of York Gum, Marri, Wandoo, Powderbark Wandoo, Salmon Gum (*E. salmonophloia*) and other tree species in and adjacent to remnants to forage and move through.

Differences in bird species richness that occurred between sampled remnants (Section 3.2) can be attributed in part to site-specific variation in the size, condition, connectedness, and habitat structural complexity of remnants. Remnants on the Woods and Nixon properties had fewer species of ground and shrub insectivores and nectarivores/insectivores than were recorded in the higher quality and structurally more complex Mason remnant. The Glass remnant was intermediate between these two sets of sampled remnants, containing more remnant low shrubland habitat than the predominantly York Gum woodland at the Woods site.

Fine-scale variation (ie. within habitats in individual remnants) in the range and type of microhabitat available for use by birds may also have influenced the composition and structure of resident and migratory bird communities recorded in the survey. Differences in the amount and distribution of foliage cover, height of cover, floristic composition, and spatial arrangement of ground substrates such as logs, leaf litter, grasses and rocky outcrops are factors implicated in influencing bird community composition and structure (see, e.g., Wiens 1989; Huggett 2000). Some evidence for this was found in the apparent preference of shrub and ground insectivores (e.g. Western Thornbill, Grey Shrike-thrush, Splendid Fairy-wren,) and some nectarivores and insectivores (e.g White-cheeked Honeyeater, New Holland Honeyeater) for sites containing a range of microhabitats. Much more work is needed, however, to investigate the role and importance of microhabitat variation in shaping the bird communities of the study area (Section 5.2).

The impact of land use management regimes such as the cattle grazing in the Nixon remnant and past patterns of clearing in the Woods remnant has contributed to the observed variation in the condition and structural complexity of bird habitat in these remnants. In contrast, the Mason and Glass remnants are fully fenced and much of their original native vegetation seems to have been retained – these are microcosms of the formerly more extensive and more interconnected Calingiri/New Norcia woodlands and shrublands. They are also some of the building blocks for re-connecting key remnants and landscape units across the study area and as such deserve special conservation management focus (Section 5.2).

### 4.3.2 Planted native vegetation and birds

Strategic plantings of native vegetation have been undertaken in parts of the study area since the early 1990s (Vern Bailey pers comm). These were established primarily to mitigate water-logging, control erosion, and provide windbreaks for crops and livestock. Later (post-2000) plantings have focused on providing wildlife habitat/potential corridors, mitigating salt impact, and integrating soil and water management. These wider and more layered efforts have introduced a degree of bird habitat complexity into revegetated drainage lines and waterways. The Glass, Mason and Woods revegetation sites provided examples of these plantings in the study area

Birds able to forage and, in some cases, breed in the older (10-15 year-old) plantings have been attracted by developing shrub and canopy cover and an abundance of insect prey. Shrub insectivores such as Grey Fantail and Rufous Whistler and the ground insectivore Red-capped Robin nested in the Nixon and Bailey revegetation. Canopy insectivores including Weebill, Western Gerygone, and Striated Pardalote and nectarivores/insectivores (Brown-headed, Brown and Singing Honeyeaters and Red Wattlebird) foraged and called for potential mates in Mason, Bailey and Glass revegetation. Younger (4-8 year-old) plantings generally lacked the structural complexity and canopy development to offer more than supplementary foraging habitat to a small group of more resilient, open country birds (Australasian Pipit, Red-capped Robin, Australian Raven and Crested Pigeon). No nests were detected in these younger plantings.

Plantings of native trees and shrubs along drainage lines and lower valley slopes are performing a landscape connectivity role in the study area. They are helping to re-connect lowland habitat with upslope remnant patches in the study area. This is also enhancing the width and structure of remnant lowland woodland stands, especially as foraging and breeding space for small ground- and shrub-dwelling insectivorous birds. Moreover, it is re-introducing connectivity into the landscape as a whole which may, in time, allow other fauna species such as Critical Weight Range mammals (e.g. Woylie [Brush-tailed Bettong], Chuditch [Western Quoll] and Wambenger [Brush-tailed Phascogale]) to return (or be re-introduced) to areas from which they had previously disappeared. This would be a key beneficial outcome for the conservation of threatened and declining wheatbelt biodiversity at the landscape scale.

## 4.4 Targeting conservation action

A cornerstone of sustainable ecosystem management involves identifying and protecting, through strategic intervention, species, communities and habitats of conservation significance. Specific conservation strategies and actions are developed and implemented to achieve these objectives. Opportunities currently exist to improve the protection of birds (and other fauna) and their habitat from threats and threatening processes, as part of a landscape approach to biodiversity conservation across the catchment (Section 5.1). These should focus on ensuring that the ‘next wave’ of ground- and shrub-foraging insectivores predicted to go locally extinct are adequately protected and their habitat appropriately managed. These are the species and guilds most sensitive to reduced core remnant and habitat area and connectivity and declining habitat condition.

Protection of existing populations and guilds of threatened and declining avifauna and their habitat is the priority bird conservation action in the study area. This includes monitoring the size, demography, and genetic health of, and habitat use by, these populations and the implementation of practical measures to mitigate key threats

(Section 5.2). Benchmarks may need to be devised to permit evaluation of the performance of these measures over time.

Increasing the size and improving the condition and connectivity of remnant native vegetation is another action requiring priority attention in the study area (Section 5). Emphasis is needed on revegetation that increases the width and length of existing key remnants and helps connect ridge, valley slope and floor landscape units. Block or 'stepping stone' plantings of local species should also be integrated into the landscape-based revegetation design. Stratification and renewal of existing planted zones along creeks and saline drainages is needed to provide structural complexity and improved breeding habitat value for declining birds and other fauna. Fencing of key identified remnants and all revegetation is essential to ensure habitat condition is improved and maintained and threats from livestock trampling and browsing of native vegetation are removed. Attention to appropriate fire management actions and control of feral animal and plant pests are also needed.

A practical and interactive community education and participation plan should form the basis of a long-term conservation strategy in the study area (Section 5.2). This should inform and guide the conservation commitment to protecting threatened and declining bird species, guilds and communities (and other fauna and flora) in perpetuity. It should also enable strategic revegetation and best-practice habitat restoration to occur, based on the development and implementation of a community-endorsed landscape design (Section 5.1).

## 5. Recommendations

### 5.1 Adopting a whole-of-landscape approach

An opportunity exists to adopt a strategic whole-of-landscape approach to conserving and managing biodiversity in the East Moore catchment, using land birds as a planning tool or template. The precedent for this approach has been established in Buntine-Marchagee Catchment situated within Moore River Catchment to the north of the study area (see Department of Environment and Conservation 2008). Strategies and actions contained in this plan that relate to the conservation of birds and other fauna are based on the production of a community-informed landscape design (Huggett et al. 2004). This used field survey data of vegetation and bird communities, GIS data, and landholder feedback to develop a design for the long-term protection and restoration of the habitat of declining woodland and heath/shrub/mallee bird species.

The Buntine-Marchagee design is currently guiding strategic revegetation and habitat protection and management activities in the catchment for the period 2007-2027. It has recently been listed by the Society for Ecological Restoration International as one of the Top 25 ecological restoration projects in Australasia. The other WA-listed project is the Gondwanalink initiative in the southwest.

There is substantial potential in the Calingiri/New Norcia district and the East Moore catchment generally to develop a landscape design for habitat protection and restoration, adapted from the Buntine-Marchagee work. This would provide a robust scientific and community-endorsed basis for strategically planning and implementing actions to help, over time, restore ecological structure and function to the landscape. It would also help integrate and coordinate ecological restoration actions occurring in one part of the catchment with those proposed for, or underway in, other parts of this landscape and indeed neighbouring regions.

In this way, the potential for achieving key local, regional and cross-regional biodiversity conservation and management goals and targets may be substantially increased. The outcome should ultimately be a more resilient, functional and biodiverse landscape that serves as a model for habitat restoration and landscape recovery in other agricultural systems.

## 5.2 Specific actions

The recommendations below provide a set of practical actions to help protect and manage birds and their habitats in the study area. They are informed by the results of the recent survey, knowledge of bird species and communities in the WA wheatbelt, and understanding of the principles and practices of landscape ecology in agricultural environments. Key landscape ecological and biodiversity conservation drivers include the creation and maintenance of habitat and landscape connectivity, protection and restoration of habitat condition, complexity and floristic diversity, mitigation of threats and threatening processes, and community education and participation.

This suite of recommended actions is by no means exhaustive. Rather, it provides a useful framework to begin tackling the task of protecting declining woodland and heath/shrub/mallee birds and restoring and managing their habitat. In the immediate term, these actions can be implemented within an adaptive management framework. Ideally, however, the actions should emerge from issues identified during research and development of the recommended landscape design. This will help ensure that land management issues and actions to remediate their impact on birds and other biota are addressed within the whole-of-landscape approach outlined in Section 5.1. It will also provide key opportunities for local landholder participation in, and ownership of, the landscape design. This is essential to the long-term success of the design.

Collectively, this approach will ultimately boost the potential for landscape recovery over time. This has important consequences for humans and biodiversity alike in this salt-impacted farming system.

The recommended specific actions are:

*Develop a landscape design for the East Moore Catchment (or the study area initially)*

This should be based on the ecological requirements of declining woodland and heath/shrub/mallee birds in the catchment. A pilot study option is to apply this to the study area only (Calingiri/New Norcia). Funding from the Caring for our Country (CFOC) program or other sources should be pursued to allow this work to commence. This will require the collaboration of local landholders, LCDCs (Calingiri/New Norcia and Gillingarra-West Koojan), NACC, Shire of Victoria Plains (and possibly adjoining councils), and other partners.

A key task is to establish baseline data of bird populations and communities in remnants and revegetation in the study area (or across East Moore Catchment). This will require professional surveys to be undertaken of bird populations and guilds, targeting declining woodland and heath/shrub/mallee species, and obtaining data on occurrence, abundance and breeding status. A greater number of sites in more remnants and revegetation across different landscape units in the study area should be surveyed in this way. Nocturnal birds could also be surveyed (possibly for the first time in the area). The results of these surveys should help inform a separate monitoring study of declining bird population size, demography, local/regional conservation status, breeding success, genetic health, and habitat use, especially of core remnants and revegetation. The role and importance of microhabitat variation in influencing bird community structure and use of revegetation and remnants could also be investigated. A relationship with a WA university could be developed to help undertake this work through student projects.

A detailed vegetation survey of remnants and revegetation in the study area would also be required. Both bird and vegetation datasets should then be incorporated with landscape information into a GIS mapping framework to drive the landscape design process (see Huggett et al. 2004).

Local landholder and LCDC engagement in, and support of, these information gathering activities from the outset are strongly recommended.

*Implement a strategic habitat protection and revegetation program, using the study area as a trial for implementing the proposed landscape design*

This should include the targeting of key remnants to join together, focusing also on connecting remnant upslope and valley floor patches (including revegetated areas), fencing them to exclude livestock (see below), controlling feral animal pests (fox, cat, rabbit) and weeds, and managing the fire risk. Other important parts of the program are the planting of new ‘stepping stones’ of local native vegetation to connect key ecological neighbourhoods (see Huggett et al. 2004) and renovation of existing planted areas to increase habitat structural complexity and reduce the weed burden. These actions aim to increase the size and improve the connectivity and habitat condition of key remnants across the study area.

New habitat linkages should be at least 80 metres (preferably 100 metres) in width. This will minimise the amount of edge habitat created and thus reduce incursion by edge-specialist bird species (e.g. Yellow-throated Miner, Australian Raven). Wider linkages may also encourage area-sensitive declining bird species (e.g. Crested Bellbird, Southern Scrub-robin, Western Yellow Robin) to enter, forage and move through them. New linkages should also be generally linear, elliptical or oblong in shape, avoiding sharp corners or angles. Highly angular linkages may impede the movement of small area-sensitive birds, forcing them to cross open gaps. This may increase their risk of being predated by carnivorous birds such as Pied Butcherbird and raptors like the Brown Falcon and Australian Hobby.

Particular attention should be given to connecting existing higher quality remnants on the Mason and Glass properties, for example, to revegetated riparian zones. Renovation of some of these plantings will be needed to improve their quality as bird habitat. This will involve within-site enhancement plantings and the addition of ground microhabitat such as native grasses, decaying logs (obtained from on-farm pruning/lopping and not from existing remnants or windblown trees in remnants), and rocks (sourced from quarries not from existing remnants), where possible. This has the effect of introducing patchiness into revegetation to ensure that a mosaic of different types of microhabitat is available for bird use.

The permanent removal of grazing livestock from remnants such as Nixon's site should be a high priority. The practice of allowing livestock to graze revegetated areas during times of reduced paddock feed should be stopped. Many years of hard work establishing structurally complex and floristically diverse revegetation for woodland birds and other fauna can be ruined by one sheep grazing episode.

Consultation and negotiation with local landholders and LCDCs is essential and requires skilful and experienced field extension effort (see *Communication* section below).

The performance of the proposed landscape design should be evaluated over time, with attention paid to progress achieved with establishing habitat linkages, 'stepping stones', fencing key remnants, and feral animal and weed control. Benchmarks for biodiversity-based revegetation of ex-agricultural land may need to be developed to allow measurable evaluation (and audit) of the effectiveness of this work.

*Communication, education and knowledge acquisition*

Support existing programs and help initiate new communication and education activities in the study area, especially those that strengthen links between farmers, local/regional NRM bodies, and ecologists. These include:

- Field training days in the latest revegetation and habitat restoration techniques for biodiversity conservation on farms;
- Workshops on landscape design recommendations including corridors, fencing, and the ecological importance of retaining dead trees on farms. Standing dead trees offer valuable perching, foraging and roosting microhabitat for resident and migratory land birds (e.g. as surveyed in the Mason, Woods and Nixon remnants and Glass revegetation – see Plates 37 and 38) and other taxa such as bats;
- Strengthen existing links and establish new communication avenues with local, regional and state media to ensure wider dispersal and sharing of information and knowledge;
- Devising novel ways to engage farmers in strategic vegetation management for birds. Opportunities for 'hands-on' local farmer participation in the proposed landscape design project exist, from assisting with bird surveys to planting new habitat linkages and fencing remnants;
- Work with local councils to improve road verge management practices, particularly along flora roads and routes that connect key remnants for declining woodland birds. Support any proposed studies of the values and management of road verges for threatened and declining biodiversity;
- Consider preparing a communication plan for biodiversity conservation in the study area (or reviewing any existing one to capture the points raised above);
- Encourage studies of biodiversity that will provide new knowledge to improve our understanding of how animals and plants respond to revegetation, habitat protection, and land use practices in the study area. These include active adaptive management studies.

*Introduced and naturalised birds*

Although no exotic species of birds were recorded during the survey, there is a need to be vigilant about their likely occurrence in the study area and be aware of their potentially adverse impact on native birds. Laughing Dove (*Streptopelia senegalensis*) has been recorded near wheat bins further north at Wubin and is likely to be nesting in *Banksia prionotes* woodland remnants near freshwater lakes around Marchagee, south of Coorow. This species was introduced to Perth from India in 1898 and has radiated out into the wheatbelt, following spilt grain along roads and rail routes (Blakers et al. 1984). It nests in the well-foliaged branches of *Banksia prionotes*, Sandplain Cypress *Actinostrobus arenarius*, and other woodland plants, reducing the number of available nest sites for birds such as Grey Shrike-thrush, Grey Butcherbird, Brush Bronzewing, Common Bronzewing, and Brown-headed Honeyeater. Also, their ability to breed at any time after rain can result in this species becoming quickly established in woodland remnants in the wheatbelt and towns.

Similarly, Rock Dove (Feral Pigeon) *Columba livia* may occur in the study area. It may have established wild populations around local towns and homesteads in the district.

The native carnivore, Laughing Kookaburra *Dacelo novaeguinae*, was introduced to southwest WA from eastern Australia in 1897 and became naturalised in wheatbelt and coastal zones soon after (Pizzey and Knight 2007). It may occur in the study area and can compete for nests in tree hollows with local native hollow-nesters like Carnaby's Black-Cockatoo, Red-capped Parrot, Australian Ringneck, nocturnal birds (e.g. Southern Boobook), marsupials and bats.

Further bird surveys recommended above should increase the potential for detection and estimation of the abundance, habitat use, and breeding status of these exotic and naturalised species. Records from local farmers should also be accessed to help determine their presence in the study area and patterns of occurrence, abundance, and, if possible, breeding status and habitat use.

Direct control measures for the exotic species including trapping, euthanasia and destruction of nests may be necessary to reduce numbers, remove individuals, or destroy local populations. Stock watering points (troughs, dams, creeks) and grain storage sites and routes should be monitored for Laughing Dove and Rock Dove activity. Education activities should include the distribution of ecological and biological information about these species to raise community awareness and provide knowledge about control and preventative measures.

## References


Barrett, G., Silcocks, A., Barry, S., Cunningham, R., Poulter, R., 2003. The New Atlas of Australian Birds. Birds Australia (RAOU), Melbourne.

BirdLife International, 2003. BirdLife's online World Bird Database: the site for bird conservation. Version 2.0. Cambridge, UK: BirdLife International. Available from URL: http://www.birdlife.org

Blakers, M., Davies S.J.J.F., Reilly, P.N., 1984. The Atlas of Australian Birds, Royal Australasian Ornithologists Union (RAOU) and Melbourne University Press, Melbourne.

Christidis, L. and Boles, W. E., 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Melbourne.

Conservation International, 2007. Biodiversity Hotspots. Available from URL: http://www.biodiversityhotspots.org/xp/hotspots/australia/Pages/default.aspx

Cramer, V.A. & R.J. Hobbs, 2002. Ecological consequences of altered hydrological regimes in fragmented ecosystems in southern Australia: impacts and possible management responses. *Austral Ecology*, 27:546-564.

Cramer, V. A. and R. J. Hobbs, 2005. Assessing the ecological risk from secondary salinity: questions of scale and threshold responses. *Austral Ecology.*

Clarke M. J., George, R. J., Bell, R.W., Hatton, T.J., 2002. Dryland salinity in south-western Australia: Its origins, remedies, and future research directions. *Australian Journal of Soil Research*, 40: 93-113

Department of Environment and Conservation, 2008. The Buntine-Marchagee Natural Diversity Recovery Catchment Plan 2007-2027. Department of Environment and Conservation, Perth, WA.

Department of Environment, Water, Heritage and the Arts. Environment Protection and Biodiversity Conservation (EPBC) Act 1999, Canberra. Available from URL: http://www.environment.gov.au/epbc/about/index.html

Ford, H. A., 1989. Ecology of Birds: An Australian Perspective. Surrey Beatty & Sons Pty. Ltd, Chipping Norton, Sydney.

Frost, F., Lambeck, R., Dymond, W., Rowley, T., and Gowdie, T., 1999. Living Landscapes. A report commissioned by Natural Heritage Trust, Canberra.

Garnett, S. G. and Crowley, G. M., 2003. The Action Plan for Australian Birds. Environment Australia and Birds Aistralia, Melbourne.

Higgins, P. J., (Ed.), 1999. Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbird. Oxford University Press, Melbourne.

Higgins, P. J. and Davies, S. J. J. F., (Eds.), 1996. Handbook of Australian, New Zealand and Antarctic Birds. Volume 3: Snipe to Pigeons. Oxford University Press, Melbourne.

Higgins, P.J, Peter, J. M., and Steele, W. K., (Eds), 2001. Handbook of Australian, New Zealand and Antarctic Birds. Volume 5: Tyrant-flycatchers to Chats. Oxford University Press, Melbourne.

Higgins, P. J. and Peter, J. M., (Eds.), 2002. Handbook of Australian, New Zealand and Antarctic Birds. Volume 6: Pardalotes to Shrike-thrushes. Oxford University Press, Melbourne.

Higgins, P. J., Peter, J. M., and Cowling, S. J., (Eds.), 2006. Handbook of Australian, New Zealand and Antarctic Birds. Volume 7: Boatbill to Starlings. Oxford University Press, Melbourne.

Huggett, A. J., 2000. An Experimental Study of the Impact of Gaps and Clusters Silviculture on Insectivorous Birds in a Continuous Forest Landscape. PhD thesis, School of Biological Sciences, University of New England, Armidale, NSW, Australia.

Huggett, A., 2008. The birds of Buntine-Marchagee catchment: Their ecology, conservation and management in a farming landscape. Public lecture given at WA Museum Geraldton 26 November 2008.

Huggett, A. J., Parsons, B. C., Atkins, L. A., and Ingram, J. A., 2004. Landscape Design for Bird Conservation in the Buntine-Marchagee Catchment, Western Australia. Technical Report on Component 1 of Testing approaches to landscape design in cropping lands project.to Land & Water Australia, CSIRO Sustainable Ecosystems.

IUCN, 2001. Red List Classification Criteria and Categories, International Union for Conservation of Nature (IUCN) Species Survival Commission, Gland, Switzerland.

IUCN, 2006. Red List of Threatened Species, International Union for Conservation of Nature (IUCN), Gland, Switzerland.

Keighery, G. J., Halse, S.A., Harvey, M.S., McKenzie, N.L., 2004. A biodiversity survey of the Western Australian agricultural zone. *Western Australian Museum Supplement* No. 67

Loyn, R. H., 1987. Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests. 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. 65-75. Surrey Beatty & Sons and CSIRO, Sydney.

Marchant, S. and Higgins, P.J. (Eds.), 1990. Handbook of Australian, New Zealand and Antarctic Birds. Volume 1: Ratites to Ducks. Oxford University Press, Melbourne.

Marchant, S. and Higgins, P.J. (Eds.), 1993. Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings. Oxford University Press, Melbourne.

Mills, A.M., 2007. Foraging segregation in a breeding bird guild declines following nesting. *Canadian Journal of Zoology* 85, 141-150.

Pizzey, G. and Knight, F., 2007. The Field Guide to the Birds of Australia. Eighth edition (P. Menkhorst ed.), HarperCollinsPublishers Pty Ltd, Sydney.

Saunders, D. A. And Ingram, J., 1995. Birds of Southwestern Australia: An Atlas of Changes in Distribution and Abundance of the Wheatbelt Fauna. Surrey Beatty & Sons, Sydney.

Serventy, D. L, and Whittell, H. M., 1976. Birds of Western Australia (Fifth revised version), UWA Press, Perth.

Wann, J. M. and Bell, D. T., 1997. Dietary preferences of the black-gloved wallaby *Macropus irma* and the western grey kangaroo *M. fuliginosus* in Whiteman Park, Perth, Western Australia. *Journal of the Royal Society of Western Australia*, 80, 55-62.

Wiens, J. A. 1989. The Ecology of Bird Communities, Volume 1: Foundations and Patterns. Cambridge University, Cambridge, UK.

Williams, K. and Mitchell, D., 2001. Jarrah Forest 1 - Subregional description and biodiversity values *in* A Biodiversity Audit of Western Australia's 53 Biogeographical Subregions in 2002. Department of Conservation and Land Management, Perth.

WWF, 2006. The Southwest Australia Ecoregion – Jewel of the Australian Continent. Southwest Australia Ecoregion Initiative, WWF Australia, Wembley, Perth. Available from URL: http://wwf.org.au/publications/southwest-australia-ecoregion-jewel-booklet/

Appendix: All individual birds recorded during the October 2008 survey in the study area by InSight Ecology (records of breeding activity are shown in bold in the Behaviour column)

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| Pacific Black Duck | *Anas superciliosa* | 1625-1710 | Woods | 0 | 2 | flushed from shallow freshwater stream |
| Little Button-quail | *Turnix velox* | 0700-0800 | Glass | 0 | 1 | flushed from low dense poison bush cover SW corner |
| Brown Goshawk | *Accipiter fasciatus* | 0650-0750 | Nixon | 0 | 1 | perched in top Powderbark Wandoo |
| Brown Falcon | *Falco berigora* | 0700-0800 | Glass | 0 | 1 | old adult (lt brown back) perched wandoo E edge |
| Crested Pigeon | *Ocyphaps lophotes* | 0845-0945 | Nixon | 2 | 0 | foraging |
| Crested Pigeon | *Ocyphaps lophotes* | 1725-1805 | Woods | 1 | 0 | foraging |
| Carnaby's Black-Cockatoo | *Calyptorhynchus latirostris* | 1550-1650 | Mason | 0 | 3 | flyover |
| Carnaby's Black-Cockatoo | *Calyptorhynchus latirostris* | 1720-1820 | Mason | 7 | 0 | perched in dead eucalypt among creek revegetation |
| Carnaby's Black-Cockatoo | *Calyptorhynchus latirostris* | 1625-1710 | Woods | 0 | 2 | perched, calling |
| Galah | *Cacatua roseicapilla* | 0845-0945 | Nixon | 3 | 0 | perched, calling |
| Galah | *Cacatua roseicapilla* | 0940-1015 | Glass | 4 | 0 | foraging on ground |
| Galah | *Cacatua roseicapilla* | 0700-0800 | Glass | 0 | 7 | foraging & calling wandoo edge |
| Red-capped Parrot | *Purpureicephalus spurius* | 1720-1820 | Mason | 1 | 0 | in old marri N side of creekline |
| Australian Ringneck | *Barnardius zonarius* | 0845-0945 | Nixon | 6 | 0 | perched, calling |
| Australian Ringneck | *Barnardius zonarius* | 1550-1650 | Mason | 0 | 2 | perched, calling |
| Australian Ringneck | *Barnardius zonarius* | 1720-1820 | Mason | 6 | 0 | in old marri N side of creekline |
| Australian Ringneck | *Barnardius zonarius* | 0810-0915 | Glass | 2 | 0 | perched, calling |
| Australian Ringneck | *Barnardius zonarius* | 0940-1015 | Glass | 5 | 0 | perched, calling |
| Australian Ringneck | *Barnardius zonarius* | 1625-1710 | Woods | 0 | 5 | perched, calling |
| Australian Ringneck | *Barnardius zonarius* | 1725-1805 | Woods | 2 | 0 | mate-calling |
| Australian Ringneck | *Barnardius zonarius* | 0915-1015 | Bailey | 2 | 0 | perched |
| Elegant Parrot | *Neophema elegans* | 1550-1650 | Mason | 0 | 1 | perched on dead tall wandoo |

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| Rainbow Bee-eater | *Merops ornatus* | 1625-1710 | Woods | 0 | 4 | mate-calling & foraging dead saplings & outer branches Yorks |
| Rainbow Bee-eater | *Merops ornatus* | 0700-0800 | Glass | 0 | 2 | foraging out from wandoo edge |
| Splendid Fairy-wren | *Malurus splendens* | 1550-1650 | Mason | 0 | 4 | foraging in more open Dryandra/Wandoo patch (1 adult male, 2 females, 1 juv male = **bred**) |
| Splendid Fairy-wren | *Malurus splendens* | 0650-0750 | Nixon | 0 | 5 | foraging in Dryandra slope near RCR nest |
| Splendid Fairy-wren | *Malurus splendens* | 1720-1820 | Mason | 2 | 0 | male & female, latter with dragonfly held for nest delivery (**breeding**) |
| Splendid Fairy-wren | *Malurus splendens* | 0700-0800 | Glass | 0 | 2 | foraging in poison bush/wild oats SW edge of remnant (two females) |
| Striated Pardalote | *Pardalotus striatus* | 0650-0750 | Nixon | 0 | 1 | mate-calling |
| Striated Pardalote | *Pardalotus striatus* | 0845-0945 | Nixon | 2 | 0 | mate-calling |
| Striated Pardalote | *Pardalotus striatus* | 1550-1650 | Mason | 0 | 2 | mate-calling |
| Striated Pardalote | *Pardalotus striatus* | 1720-1820 | Mason | 1 | 0 | mate-calling in euc rows |
| Striated Pardalote | *Pardalotus striatus* | 0810-0915 | Glass | 2 | 0 | mate-calling in 10+ yo revege |
| Striated Pardalote | *Pardalotus striatus* | 0940-1015 | Glass | 1 | 0 | mate-calling in 10+ yo revege |
| Striated Pardalote | *Pardalotus striatus* | 0700-0800 | Glass | 0 | 1 | mate-calling in 10+ yo revege |
| Weebill | *Smicrornis brevirostris* | 0650-0750 | Nixon | 0 | 12 | **bred**, 2 fledglings with adults in powderbark stand |
| Weebill | *Smicrornis brevirostris* | 0845-0945 | Nixon | 4 | 0 | territory defence, calling |
| Weebill | *Smicrornis brevirostris* | 1550-1650 | Mason | 0 | 4 | territory defence, calling |
| Weebill | *Smicrornis brevirostris* | 1720-1820 | Mason | 4 | 0 | foraging in edge eucalypt rows |
| Weebill | *Smicrornis brevirostris* | 0940-1015 | Glass | 4 | 0 | foraging & calling in 10+ yo reveg |

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| Weebill | *Smicrornis brevirostris* | 1625-1710 | Woods | 0 | 7 | foraging in 15m tall mature York & Wandoo |
| Weebill | *Smicrornis brevirostris* | 0700-0800 | Glass | 0 | 3 | territory defence, calling |
| Weebill | *Smicrornis brevirostris* | 0915-1015 | Bailey | 11 | 0 | foraging & calling in 13-15 yo reveg (salt river gum etc) |
| Western Gerygone | *Gerygone fusca* | 0650-0750 | Nixon | 0 | 2 | territory calling and foraging in powderbark wandoo |
| Western Gerygone | *Gerygone fusca* | 0845-0945 | Nixon | 2 | 0 | foraging and territory calling in 5-8m tall planted eucalypts |
| Western Gerygone | *Gerygone fusca* | 1550-1650 | Mason | 0 | 1 | calling |
| Western Thornbill | *Acanthiza inornata* | 1550-1650 | Mason | 0 | 6 | observed courtship feeding insect to mate (=**breeding**) |
| Red Wattlebird | *Anthochaera carunculata* | 0845-0945 | Nixon | 2 | 0 | foraging in flowering 10 yo eucalypts |
| Red Wattlebird | *Anthochaera carunculata* | 1550-1650 | Mason | 0 | 1 | foraging & territory calling |
| Red Wattlebird | *Anthochaera carunculata* | 0700-0800 | Glass | 0 | 1 | calling wandoo edge |
| Red Wattlebird | *Anthochaera carunculata* | 1625-1710 | Woods | 1 | 0 | foraging in foliage of mature York and Wandoo woodland |
| Red Wattlebird | *Anthochaera carunculata* | 0915-1015 | Bailey | 5 | 0 | foraging on nectar in flowering 13-15 yo salt river gum |
| Singing Honeyeater | *Lichenostomus virescens* | 0810-0915 | Glass | 12 | 0 | foraging, mate pursuits in 10+ yo euc reveg |
| Singing Honeyeater | *Lichenostomus virescens* | 0940-1015 | Glass | 7 | 0 | foraging, mate pursuits in 10+ yo euc reveg |
| Singing Honeyeater | *Lichenostomus virescens* | 1725-1805 | Woods | 2 | 0 | calling |
| Singing Honeyeater | *Lichenostomus virescens* | 0700-0800 | Glass | 0 | 2 | territory calling & foraging |
| Singing Honeyeater | *Lichenostomus virescens* | 0915-1015 | Bailey | 2 | 0 | territory calling & foraging |
| Western Spinebill | *Acanthorhynchus superciliosus* | 1550-1650 | Mason | 0 | 3 | 2 males, 1 female in flowering eucs |
| Brown Honeyeater | *Lichmera indistincta* | 0650-0750 | Nixon | 0 | 8 | territory calling & foraging |

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| Brown Honeyeater | *Lichmera indistincta* | 1550-1650 | Mason | 0 | 13 | with fledged young = **bred** |
| Brown Honeyeater | *Lichmera indistincta* | 1720-1820 | Mason | 16 | 0 | foraging/calling mainly in edge rows of 5-7m tall eucalypts |
| Brown Honeyeater | *Lichmera indistincta* | 0810-0915 | Glass | 4 | 0 | foraging/calling in 10+ yo revege |
| Brown Honeyeater | *Lichmera indistincta* | 0940-1015 | Glass | 2 | 0 | foraging/calling in 10+ yo revege |
| Brown Honeyeater | *Lichmera indistincta* | 1725-1805 | Woods | 2 | 0 | foraging in flowering eucalypt edge |
| Brown Honeyeater | *Lichmera indistincta* | 0700-0800 | Glass | 0 | 2 | foraging in individual Wandoos S edge |
| Brown Honeyeater | *Lichmera indistincta* | 0915-1015 | Bailey | 13 | 0 | foraging, calling in 13-15 yo flowering euc reveg |
| Brown-headed Honeyeater | *Melithreptus brevirostris* | 1550-1650 | Mason | 0 | 2 | leaf-gleaning |
| Brown-headed Honeyeater | *Melithreptus brevirostris* | 0915-1015 | Bailey | 7 | 0 | foraging in flowering 8m tall Salt River Gum reveg |
| New Holland Honeyeater | *Phylidonyris novaehollandiae* | 1550-1650 | Mason | 0 | 1 | immat bird foraging with WCHE & Brown HE |
| White-cheeked Honeyeater | *Phylidonyris niger* | 1550-1650 | Mason | 0 | 3 | foraging in flowering Adenanthos (see pic) & juvs with streaked front |
| Red-capped Robin | *Petroica goodenovii* | 0650-0750 | Nixon | 0 | 4 | 2 adults with few day old young in nest in 1.5m fork Dryandra sp. (**bred**) |
| Red-capped Robin | *Petroica goodenovii* | 0915-1015 | Bailey | 2 | 0 | 1 juvenile and 1 adult female in outer row of planted salt river gums nr paddock edge, thus **bred** in reveg |
| Rufous Whistler | *Pachycephala rufiventris* | 0845-0945 | Nixon | 1 | 0 | mate-calling |
| Rufous Whistler | *Pachycephala rufiventris* | 1550-1650 | Mason | 0 | 1 | mate-calling |
| Rufous Whistler | *Pachycephala rufiventris* | 0700-0800 | Glass | 0 | 1 | mate-calling |
| Rufous Whistler | *Pachycephala rufiventris* | 0915-1015 | Bailey | 1 | 0 | foraging low in individual prickly paperbark, observed |

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| | | | | | | holding dragonfly for nest delivery |
| Grey Shrike-thrush | *Colluricincla harmonica* | 0650-0750 | Nixon | 0 | 1 | calling on slope of ridge |
| Grey Fantail | *Rhipidura fuliginosa* | 0845-0945 | Nixon | 2 | 0 | collecting cobwebs for nest, defending territory & foraging aphids within old Acacia blossums; likely **nesting** in 5m tall she-oaks |
| Willie Wagtail | *Rhipidura leucophrys* | 0810-0915 | Glass | 4 | 0 | likely **nesting** in live lower branches of stag eucalypt |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | 1625-1710 | Woods | 0 | 1 | perched and foraging from dead outer branches |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | 0700-0800 | Glass | 0 | 1 | perched in Wandoo |
| Grey Butcherbird | *Cracticus torquatus* | 0650-0750 | Nixon | 0 | 1 | calling on slope of ridge |
| Pied Butcherbird | *Cracticus nigrogularis* | 0845-0945 | Nixon | 2 | 0 | calling in 15 yo planted eucalypts |
| Australian Magpie | *Gymnorhina tibicen* | 0700-0800 | Glass | 0 | 2 | foraging |
| Australian Raven | *Corvus coronoides* | 0845-0945 | Nixon | 3 | 0 | foraging |
| Australian Raven | *Corvus coronoides* | 0810-0915 | Glass | 2 | 0 | foraging |
| Australian Raven | *Corvus coronoides* | 0940-1015 | Glass | 2 | 0 | calling |
| Australian Raven | *Corvus coronoides* | 1725-1805 | Woods | 1 | 0 | calling |
| Australian Raven | *Corvus coronoides* | 0915-1015 | Bailey | 1 | 0 | flyover |
| Australasian Pipit | *Anthus novaeseelandiae* | 0810-0915 | Glass | 4 | 0 | observed holding live insects for nest delivery in 60 cm tall pasture weeds alongside drain (=**breeding**) |
| Australasian Pipit | *Anthus novaeseelandiae* | 0700-0800 | Glass | 0 | 2 | aerial displays (territorial) & foraging in poison bush/wild oats SW edge (=**breeding**) |
| Tree Martin | *Hirundo nigricans* | 1550-1650 | Mason | 0 | 4 | foraging overhead |
| Tree Martin | *Hirundo nigricans* | 0810-0915 | Glass | 6 | 0 | likely **nesting** in stag |

| Common Name | Scientific Name | Time | Site | Revegetation | Remnant | Behaviour (incl. breeding evidence) |
|---|---|---|---|---|---|---|
| Tree Martin | *Hirundo nigricans* | 0940-1015 | Glass | 4 | 0 | foraging overhead |
| Tree Martin | *Hirundo nigricans* | 1625-1710 | Woods | 0 | 2 | foraging overhead |
| Tree Martin | *Hirundo nigricans* | 0915-1015 | Bailey | 4 | 0 | foraging overhead |
| Silvereye | *Zosterops lateralis* | 0650-0750 | Nixon | 0 | 1 | bark-probing for insects |
| | | | | | | |
| | Mean | | | 1.93814433 | 1.42268 | |
| | SD | | | 3.016670464 | 2.39285 | |
| | Total individuals | | | 188 | 138 | |
| | Total species | | | 21 | 30 | |
| | | | | | | |
| | **Breeding** | | | | | |
| | *Direct* evidence (nesting, delivering food and/or nest materials to nest): total 12 records (10 species - 5 in remnants & 7 in revegetation; 7 records in revegetation, 5 in remnants) | | | | | |
| | *Indirect* evidence (territory calling/defence, mate pursuits): total 22 records (10 species - 6 in revegetation & 9 in remnants; 9 records in revegetation & 13 in remnants | | | | | |