Improving Habitat and Connectivity in the Farming Landscape for Birds in Moore River Catchment

A report by InSight Ecology

for Moore Catchment Council

December 2012

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Recommended citation: InSight Ecology, 2012. Improving habitat and connectivity in the farming landscape for birds in Moore River catchment. Report by InSight Ecology for Moore Catchment Council.

Photographs: (front cover): The photograph at the top displays a landscape which has been substantially fragmented into narrow strips of native vegetation largely disconnected from other remnants. This was taken from a ridgeline woodland and shrubland remnant on Jenny Kelly's farm (managed by Neil Botha) at Gillingarra, looking north toward Bindoon-Moora Road (4 May 2011). The photograph below shows a landscape with improved habitat connectivity through the retention of remnant native vegetation along drainage lines and hillslopes (4 May 2011). This was taken from the same ridgetop remnant used in the photograph above. All photographs presented in this report without credits were taken by InSight Ecology.

Acknowledgements

This work was commissioned by Moore Catchment Council (MCC) to identify, protect and promote the re-connection of remnant native vegetation and their avifaunal communities on ridges, slopes, along riparian zones and on sandplains. It was funded by the WA State NRM Program 2010-2012.

I am grateful to MCC and particularly Ingrid Krockenberger of MCC, for the opportunity to work in this landscape. Ingrid managed the project providing local knowledge, spatial data, NRM expertise and landholder liaison. Ingrid also supplied GIS data, helped with farm access and landholder liaison, and provided valued insights to the project.

I am equally grateful to a number of farmers participating in the project for permission to access and work on their properties. These included Sarah and Geoff Mason ("Carrah Farms", Calingiri), Bob Harridge ("Cooinda Park", New Norcia), John Stephanelli (owner) and Bob and Ann Hendry (managers) of "Flora Downs", West Gillingarra, Nick and Suzanne Woods ("Damara Downs", Calingiri), Rick and Jackie Pearson ("Sammon Hills", Waddington), and Nick Scotney ("Wensleydale", Piawaning). Their views, reflections and shared knowledge about the land and how they are managing it for their future were invaluable. I am particularly grateful for the warm hospitality and vibrant company provided by Geoff and Sarah at Carrah Farms. This report also benefited from discussions held with local farmers at two talks on the project given by InSight Ecology as part of the community engagement component of the project on 3 and 4 July 2012 at Gillingarra and Calingiri.

I am also grateful to Northern Agricultural Catchments Council (NACC) for access to 2009 avifaunal survey data collected by InSight Ecology for the West Koojan-Gillingarra CDI Project. Similarly, I am appreciative of access provided by MCC to earlier (2008) work by InSight Ecology on the revegetation of drainage lines and protection of remnant native vegetation for avifauna and other taxa in east Moore River catchment. Cheryl Gole and Claire Bartron of BirdLife Australia (formerly Birds Australia) provided information on Important Bird Areas in and near the study area and the Carnaby's Black-Cockatoo Recovery Project, respectively. Joe Tonga of Natsync Environmental provided some individual sightings and photographs of birds obtained while monitoring fauna on Carrah Farms in April 2012.

Executive summary

The Calingiri-New Norcia-Gillingarra-Piawaning district (the 'study area') is a mixed cropping-grazing landscape located about 130 km northeast of Perth within the southern Moore River catchment. This area has retained approximately 30% of its native vegetation cover since its European settlement over 130 years ago. This is significantly more than other parts of the Western Australian cropping zone where only 2-5% of native vegetation remains. This confers significant conservation value to the study area's remnants and their protection and rehabilitation. Added to this is the district's location within the Southwest Australia Ecoregion - an area of outstanding yet critically threatened biological diversity and Australia's only global biodiversity hotspot.

Remnant native vegetation of the study area is mostly wandoo woodland, mallee, and dryandra shrubland on the lateritic ironstone and granite ridges and upper slopes, shrubland/heath on some valley slopes and, occasionally, valley floors, york gum, wandoo and salmon gum woodland along drainage lines, and some ephemeral wetlands along valley floors. Some of these upland plant communities are in notably good ecological condition following fencing and exclusion of livestock. Others are recovering from past grazing and weed invasion. The heaviest human footprint, however, has typically been on the sandy and loamy valley floors and lower slopes where removal of woodland, shrubland and heathland has substantially fragmented and degraded habitat for wildlife. As a consequence, remaining patches of native vegetation have become disconnected from their upland counterparts, surrounded by a matrix of cropping and grazing land, roads and villages. This has prevented or at best significantly impeded the normal movement and dispersal of key groups of native fauna across the landscape.

This report presents the results of a 2011-2012 study of bird communities and habitats in remnant native vegetation and native and exotic woody perennial crops across the study area. This was undertaken to provide baseline information on mainly terrestrial bird species and their habitat in remnant and planted vegetation at selected sites in the study area. These data provide new knowledge of the avifauna of this landscape and their conservation requirements. This information will be used to help inform strategies and actions to improve habitat quality and connectivity across the district. The role of revegetation including woody perennial crops in contributing to this work is of importance in a landscape that is exploring the commercial value of these plantations. The project also builds on avifaunal data obtained through recent projects completed in the southern Moore River catchment, e.g. the 2011 Recovery and Protection of the Moore River Catchment's Threatened Natural Assets Project and earlier work (2008-09). Collectively, the results of these projects will help inform and guide management of the farming landscape for biodiversity conservation and sustainable production outcomes.

The surveys were conducted in spring (October) 2011 and autumn (April 2012) at 15 sites (6 farming properties) across the catchment. These sites were located in remnant wandoo and marri woodland and shrubland on lateritic ironstone and granite ridges, breakaways and upper slopes, wandoo and york gum woodland on lower slopes and along drainage lines, isolated salmon gum woodland patches, banksia and coastal blackbutt woodland and melaleuca shrubland on valley floors, and ephemeral wetlands. Key bird attributes sampled at each of these sites were relative abundance, species richness, community structure (based on composition of foraging guilds), and habitat use.

The bird assemblages of the study area are a microcosm of a formerly more diverse and extensive avifauna. They are characterised by a diverse mix of ground, shrub, canopy and aerial insectivores, nectarivores/insectivores, a nectarivore, ground granivores, a canopy granivore, carnivores, omnivores, and some aquatic guilds. A total of 1,167 individual birds from 68 species were recorded during the surveys in the study area. Most (61 or 89.7%) of these were terrestrial species with aquatic species (7 or 10.3%) comprising the remainder. Fewer terrestrial birds (7.4%) were recorded in spring (561) than in autumn (606). This was probably caused by an autumnal influx of ground granivores from neighbouring areas such as Australian Ringneck and Elegant Parrot seeking food, nomadic species tracking seasonally available fruit and other food, e.g. Silvereye, post-natal dispersal of new season young birds, e.g. Red-capped Robin, Splendid Fairy-wren and White-fronted Chat, and the higher detectability of resident species following completion of breeding, e.g. Red-capped Robin and Splendid Fairy-wren.

More terrestrial birds were recorded in remnants than in revegetation in the study – 378 individuals from 48 species in spring compared with 183 birds from 37 species in plantings in the same season. There was a 14.3% decrease in the number of land bird species recorded in autumn (36) compared with spring (48). This difference was not as marked as in the previous study (2011) in which 39 land bird species were recorded in autumn and 61 in spring. This most likely reflected the inclusion of a greater number of revegetation sites (8) in the 2012 sample relative to the 2011 study (3 revegetation sites). Summer breeding migrants such as Shining Bronze-Cuckoo, Sacred Kingfisher and White-winged Triller and nomadic honeyeaters including Western Wattlebird and Spiny-cheeked Honeyeater contributed to the larger spring complement.

The most abundant species in remnants were ubiquitous, resilient and adaptive birds of farming landscapes. They included Australian Ringneck, Galah, Brown Honeyeater, Weebill and Silvereye. The latter three species readily foraged and sometimes nested in dense foliage of plantings including tagasaste, eucalypts and brushwood. The least abundant birds in remnants across both seasons were Peregrine Falcon, Red-capped Parrot, Spotted Pardalote, Scarlet Robin, Golden Whistler, Western Spinebill and Yellow-plumed Honeyeater.

A total of 14 foraging guilds were recorded during the study – 10 of these were terrestrial and the remaining 4 aquatic. Seven foraging guilds were most commonly encountered in the surveys - ground insectivores, shrub insectivores, canopy insectivores, aerial insectivores, carnivores, ground granivores, and nectarivores/insectivores. Representative ground insectivores were Splendid Fairy-wren, White-winged Fairy-wren, Red-capped Robin and Australian Magpie. Shrub insectivores included Western Thornbill, Rufous Whistler, Grey Shrike-thrush, and Grey Fantail. Canopy insectivores were Weebill, Western Gerygone and Striated Pardalote. Aerial insectivores were commonly Welcome Swallow, Tree Martin and Black-faced Cuckoo-shrike. Carnivores included Grey Butcherbird, Pied Butcherbird, Sacred Kingfisher and Wedge-tailed Eagle. Ground granivores included the ubiquitous Australian Ringneck and Galah, Little Button-quail and, in autumn only, Elegant Parrot. Brown Honeyeater, Red Wattlebird and Yellow-throated Miner were common nectarivores/insectivores recorded in both seasons. Several of these species readily exploited food, shelter and occasionally nest sites available in older revegetation, e.g. Splendid Fairy-wren, Red-capped Robin, Rufous Whistler, Weebill, Western Gerygone, Brown Honeyeater and for the first time in studies by InSight Ecology in the district, Western Thornbill and Grey Shrike-thrush. These latter two species are normally core woodland insectivores but in the study also foraged through 11 year-old eucalypt, melaleuca and acacia plantings on Carrah Farms.

Thirty-eight (38) bird species or 55.9% of the sampled bird community were observed breeding during the study. Most (31) were terrestrial species while the remainder (7) were aquatic species in an ephemeral wetland on Flora Downs and spring-flowing streams at Carrah Farms and Sammon Hills. Most (71%) breeding records came from remnants and included obligate and facultative hollow-nesters – e.g. Carnaby's Black-Cockatoo, Galah, Australian Ringneck and Sacred Kingfisher, large and small upper canopy-nesters – e.g. Wedge-tailed Eagle, Australian Magpie, Magpie-lark and Weebill, shrub-nesters – e.g. Inland Thornbill (recorded nesting in 6-8 year-old broombush revegetation), Red-capped Robin and Silvereye, and ground or near-ground nesters – e.g. Splendid Fairy-wren and Little Button-quail. Several aquatic species were breeding in the wetland on Flora Downs. Revegetation provided nest sites for 18 or 47.4% of all breeding bird species detected in the study – a substantial component which highlighted the value of planted habitats for birds in the study area.

Occurring within the Calingiri Important Bird Area, the study area provided habitat for 45 bird species of global, national, WA state or local conservation significance. Seventeen (17) of these species are significant at national and state levels. One of these – the nationally endangered Carnaby's Black-Cockatoo - was recorded during the study. The remaining 28 species are locally significant because of the extent of loss and fragmentation of their habitat across the catchment, possible consequent declines in population size and contractions in range, or other threats. Several of these species were recorded during the study – e.g. Peregrine Falcon, Scarlet Robin, Elegant Parrot, Crimson Chat, Western Thornbill, Inland Thornbill, Golden Whistler and Grey Shrike-thrush.

Practical actions to protect, enhance and re-connect existing bird assemblages and their habitat are presented. These emphasise the importance of maintaining and, where possible, increasing the size and connectivity of key remnants while improving their condition for woodland and shrubland/heathland birds through adoption of a landscape design. The mitigation of threats, particularly ongoing vegetation clearance, salinity, waterlogging, pest plant and animal incursion, and impacts associated with climate change is discussed. The importance of obtaining and using empirical knowledge of the biology and ecology of birds in fragmented landscapes to inform conservation and sustainable natural resource management planning and projects is emphasised. Some basic but key concepts and considerations to help the reader understand the influence of landscape scale on habitat restoration and the relevance of the science of connectivity conservation are also presented.

Finally, a suite of recommendations are put forward to protect, re-connect and improve habitat for birds in the study area. These focus on protecting and increasing connectivity between the real bush gems in the district. These include wandoo, marri and salmon gum woodland on Carrah Farms, Damara Downs, Cooinda Park, Sammon Hills and Wensleydale. Linking these upland blocks to their lowland and riparian york gum, salmon gum and banksia-coastal blackbutt woodland counterparts would improve connectivity for woodland birds and other fauna. These may include the near-threatened Chuditch and conservation-dependent Quenda – both species sighted recently on Carrah Farms. These are some of the key building blocks for re-connecting habitat and fauna populations and communities across the district. Also, the opportunity to improve connectivity of remnant woodland in the Calingiri district with the adjacent and extensive Bindoon Military Training Area woodland and southern Darling Range reserves warrants further investigation.

Contents

1. Introduction

1.1 Project background

The native vegetation of southwestern Australia has been extensively fragmented by over 130 years of clearance for agriculture, roads and urban development (Saunders and de Rebeira 1991; Cramer and Hobbs 2005). Native fauna dependent on habitat provided by this vegetation have consequently declined and, in many districts, disappeared (Burbidge and McKenzie 1989; Abbott 1997). Coupled with pressure from predation by introduced mammalian carnivores - European fox, cat and rodents, competition from rabbits, weeds, feral bees and introduced and naturalised native birds, altered fire regimes, and a changing climate, ecosystems of this region are at risk of further degradation and potential collapse (Hobbs 1993; Keighery et al 2004; Department of Environment and Conservation [DEC] 2006). Small mammal, reptile, and dispersal-limited and habitat condition-sensitive terrestrial bird species are particularly vulnerable (Brooker and Brooker 1997, 2001; Huggett et al 2004; Keighery et al 2004; InSight Ecology 2007).

Paradoxically, these impacts have occurred in Australia's only global biodiversity hotspot – the forests and woodlands of southwestern Australia. Dry eucalypt woodlands belong to one of the 10 Australian ecosystems most vulnerable to tipping points – the Mediterranean ecosystems of southwestern Australia (Laurance et al 2011). Tipping points occur where modest environmental changes can cause disproportionately large changes in the properties or characteristics of ecosystems (also see ecological thresholds, reviewed in Huggett 2005).

The need for strategic, science-informed action to attempt to arrest these declines has led to a range of biodiversity conservation and natural resource management programs and projects across the state's southwest in recent years. These have targeted predator and pest management (e.g. DEC's Western Shield Project, NACC's Weeds of National Significance Project), threatened species and community conservation (e.g. BirdLife Australia's Carnaby's Black-Cockatoo Project, WWF's Woodland Watch Project), conservation planning (e.g. WWF's Southwest Australia Ecoregion Initiative, the Wilderness Society Australia's Great Western Woodlands Project), ecological rehabilitation and restoration (e.g. DEC's natural diversity recovery catchment program, Greening Australia and Bush Heritage Australia's Gondwana Link Project), salinity mitigation (e.g. the Catchment Demonstration Initiative), and conservation farming (e.g. Moore Catchment Council's riparian fencing and protection of priority woodland remnant projects, perennial pastures and other production systems projects). A common goal of these initiatives has been to educate land managers and ultimately improve how land is managed for better on-ground biodiversity conservation and production outcomes.

At the catchment and farm scales, Moore Catchment Council (MCC) has recently (2006-current) initiated four projects to protect priority native woodland, shrubland and heathland remnants, revegetate degraded riparian and valley-floor systems, utilise saltbush pastures to mitigate wind erosion, and improve habitat and connectivity on farms for threatened and declining birds. These have been funded by the State NRM Program, the Federal Government's Caring For Our Country (CFOC) Program, and private investment. In addition, MCC has recently completed a number of other CFOC-funded erosion control, pest and weed management, and community engagement projects across Moore River catchment.

This report investigates the relative abundance, species richness and structure of bird communities and their use of habitat in the study area. Results are discussed in the context of the role and importance of remnant and planted vegetation as bird habitat and to facilitate bird movement along linkages and potential corridors in the district and surrounding areas. This work builds on the results of previous bird-related studies undertaken by InSight Ecology to inform the management of remnant and planted habitats for birds and other fauna in this catchment (see InSight Ecology 2008, 2009, 2010, 2011).

1.2 Objectives

This report presents the results of baseline surveys of terrestrial and some aquatic birds and their habitat conducted over two seasons in remnant native vegetation and planted native and exotic woody perennial crops at sites in the Calingiri-New Norcia-Gillingarra-Piawaning district of southern Moore River catchment (the 'study area'). Specifically, the report aims to:

- Describe the relative abundance, species richness, structure (using composition of foraging guilds) and conservation significance of bird communities present;
- Characterise bird use of habitat in remnant and revegetated sites, including woody perennial crops;
- Identify key biological conservation and natural resource management issues in the study area;
- Review the connectivity of vegetation cover and the role of revegetation for bird conservation in the study area;
- Provide recommendations to help protect bird habitat and improve ecological connectivity across the southern Moore River catchment.

2. Methods

2.1 Site selection and mapping

Familiarity with the study area (Figure 1) and land ownership patterns was established during bird surveys undertaken by InSight Ecology for previous projects in the catchment. These included the Revegetation of Natural Drainage Lines and Protection of Remnant Vegetation in the East Moore Catchment Project (2006-08), West Koojan-Gillingarra Catchment Demonstration Initiative (CDI) (2006-09), and Recovery and Protection of the Moore River Catchment's Threatened Natural Assets Project (2010-11).

A total of 15 sites were selected for bird surveying across 6 farms in the study area for this project (Figure 1 and Table 1). These surveyed a mix of remnant native vegetation (7 sites) and revegetation (8 sites). Revegetation surveyed comprised 4 mixed eucalypt and shrubland and 4 woody perennial crop sites (one site each of sandalwood, brushwood, saltbush and tagasaste).

Vegetation communities surveyed in remnants included eucalypt woodland – principally wandoo, york gum and salmon gum, mixed woodland/shrubland/heath, and ephemeral freshwater/brackish wetland. Table 1 shows stratification of the survey effort by site number, site and property name, remnant or revegetation status, season surveyed, vegetation type, topographic unit, and soil type/geology. No nature reserves, national parks or road reserves were surveyed during the study.

Aerial photographs were supplied by MCC for each site to assist in selection of surveying routes, identification of vegetation communities, and analysis of landscape context and broad patterns. Analysis of habitat and landscape connectivity used Google™earth satellite-aided imagery ground-truthed by site inspections conducted by InSight Ecology.

All sites selected had either already been fenced under the project or previous projects. The wetland site was dry in autumn but inundated during winter and spring. Several of the sites had been separately assessed for the condition, composition and health of their remnant native vegetation, land use history, and fauna habitat types present during previous studies undertaken by InSight Ecology and Moore Catchment Council.

Figure 1: Location of the study area. The black line indicates the location of Moore River catchment. Blue dots represent properties containing sites studied in this project. Red stars represent the location of properties surveyed for birds under the previous project (see InSight Ecology 2011). Green-infilled areas are the Important Bird Areas that occur within southern Moore River catchment. Image: Moore Catchment Council.

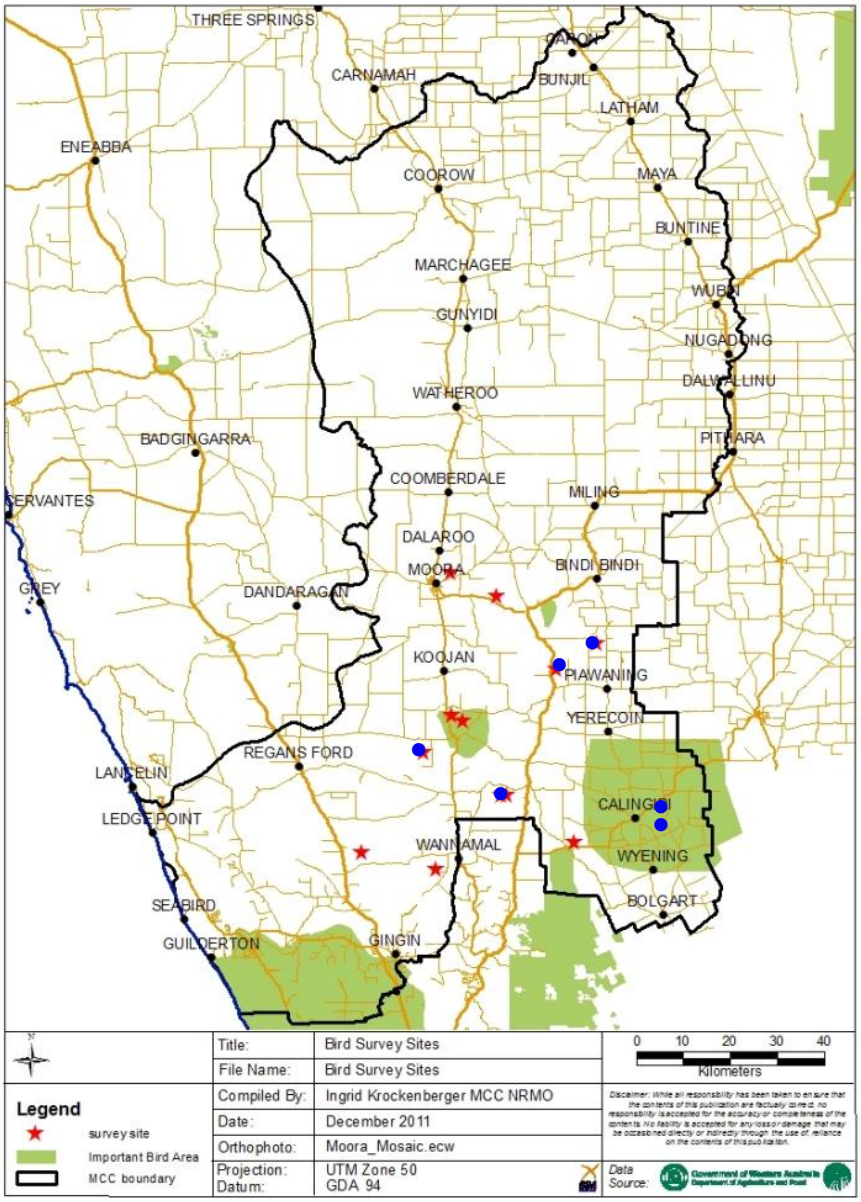


Table 1: Sites surveyed for birds in the study area. Stratification of survey effort follows the approach used in the Recovery and Protection of the Moore River Catchment's Threatened Natural Assets Project (InSight Ecology 2011) and CDI Project (InSight Ecology 2010). Each site has been previously surveyed for birds by InSight Ecology. Sites shown with an asterisk have been surveyed by InSight Ecology since 2008-present. Sites surveyed by InSight Ecology since 2011 are shown by an inverted "v".

Site no.	Site and property name	Remnant or revegetation	Seasons surveyed	Vegetation type/s and land use history	Topographic unit	Soil type/ geology
1*	Mason (Carrah Farms, Calingiri)	remnant	spring-autumn 2011-12	wandoo-marri woodland, banksia-acacia-dryandra shrubland, heathland; historically lightly logged	ridgetop/ breakaway, upland slopes	lateritic ironstone capping with granite outcrops
2*	Mason (Carrah Farms, Calingiri)	revegetation Site 1 (main creek)	spring-autumn 2011-12	mixed species plantings (11 years old)	lower valley slopes, drainage line	sand
3*	Mason (Carrah Farms, Calingiri)	revegetation Site 2 (Lang-wood Creek)	spring-autumn 2011-12	*Melaleuca thyoides*, *M. radula*, saltbush, hakea (5-6 years old)	riparian	sand
4*	Mason (Carrah Farms, Calingiri)	revegetation Site 3 (Gooden Gully)	spring-autumn 2011-12	allocasuarina-acacia-melaleuca-salmon gum plantings (9-10 years old)	lower slopes, drainage line	sand
5*	Hendry for Stephanelli (Flora Downs, Gillingarra West)	remnant	spring-autumn 2011-12	mixed banksia-coastal blackbutt-nuytsia woodland, sandplain heath, ephemeral wetland; past lightly grazed now fenced	valley floor	deep sand
6^	Hendry for Stephanelli (Flora Downs, Gillingarra West)	revegetation	spring-autumn 2011-12	tagasaste plantation (part of 26 ha plantation, 5 years old, cut 2009 & grazed summer 2011)	valley floor	deep sand
7^	Harridge (Cooinda Park, New Norcia)	remnant	spring-autumn 2011-12	wandoo woodland, with dryandra, xanthorrhoea, heathy; excluded from past grazing, fully fenced	ridgetop/ breakaway, upland slopes	lateritic ironstone capping with granite
8^	Woods (Damara Downs, Calingiri)	remnant	spring-autumn 2011-12	wandoo woodland; heavily grazed in past, fenced in 2005	low hill	lateritic ironstone capping
9^	Woods, (Damara Downs, Calingiri)	revegetation	spring-autumn 2011-12	brushwood (*Melaleuca uncinata*) - 4 ha, 6 years old, fully fenced	lower slopes/ riparian	sand
10^	Pearson (Sammon Hills, Waddington)	remnant	spring-autumn 2011-12	york gum-wandoo woodland; past grazed, needs new fencing	low ridgeline	lateritic granite
11^	Pearson (Sammon Hills, Waddington)	remnant	spring-autumn 2011-12	york gum woodland; past grazed and logged, now fully fenced	riparian	sand, sandy loam
12^	Pearson (Sammon Hills, Waddington)	revegetation	spring-autumn 2011-12	sandalwood plantation, ca. 5-6 years old, fenced	lower slopes/ near-riparian	sandy loam
13^	Scotney (Wensleydale, Piawaning)	remnant	spring-autumn 2011-12	salmon gum woodland; heavily grazed in past, now fenced	lower valley slopes	sand
14^	Scotney (Wensleydale, Piawaning)	revegetation	spring-autumn 2011-12	saltbush along drainage line (9 month-old in April 2012), fenced	saline riparian system	sand
15^	Scotney (Wensleydale, Piawaning)	revegetation	spring-autumn 2011-12	mixed eucalypts and shrubs (10 years old) adjoining saltbush plantings; sheep-grazed in autumn, fenced	saline riparian system	sand

2.2 Bird surveys and land use

All of the sites were surveyed once in each of two different seasons – spring (5-11 October 2011) and autumn (24-27 April 2012) by the same experienced ornithologist (Andrew Huggett [A.H.]). These sites occurred on properties dispersed across the southern and south-eastern parts of the catchment (Fig. 1). Most properties were grazed by sheep and/or cattle and farmed for wheat, oats, barley and/or canola. All remnants and revegetation had been fenced to exclude livestock. Scotney's saltbush and mixed species plantings were occasionally grazed by sheep in autumn while Flora Downs' tagasaste plantation was heavily grazed by cattle in the summer of 2011-12.

Surveys were generally conducted during periods of peak bird activity in the morning (ca 0730-1100) and afternoon (ca 1600-1830). Surveys did not occur during windy or wet weather. Each site was surveyed for 30-150 minutes by A.H. undertaking an area search (Loyn 1987; Huggett et al. 2004; InSight Ecology 2008, 2010, 2011) 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). Occasionally, point counts every 100 m along line transects were used with recording swaths of 50 m each side of the line in strips of revegetation where area searches could not be accurately deployed due to the narrowness of the strip. Wherever possible, sampling of paddock edge vegetation was avoided. Two different age-classes of revegetation were surveyed – 5-6 and 10-11 year old – on one property (Carrah Farms). Where possible, revegetation and remnant sites on Carrah Farms were surveyed during the same session, ie. during the morning or the afternoon survey periods of the same day.

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, nesting, pursuing potential mates, courtship feeding mates, 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). 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). In addition, historical records of bird occurrence in the catchment were accessed from DEC's NatureMap species reports (4 May 2011) and RAOU (now BirdLife Australia).

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, help assess connectivity, and assist in the selection of survey sites. A total of 773 photographs were taken of the survey sites and the surrounding landscape, plant communities, and bird and mammal fauna. An additional 59 photographs were taken of

the 4 July 2012 bird field day. These were taken using a Canon PowerShot SX210 IS® 14x zoom digital camera and archived in an image library using Microsoft Office Picture Manager 2007® software. Some of these images are presented in this report. All images, data and related material were stored on a standard 500GB ATA HDD backed up to a 500GB external HDD.

A total of 30.6 hours (2.04 hours per site across 15 sites) was spent surveying birds in the study area in October 2011 and April 2012. Of this effort, remnants were sampled for a total of 17.8 hours (2.5 hours per site, 7 sites) while 12.7 hours were spent in revegetation (1.6 hours per site, 8 sites). This greater (16.6%) amount of time spent surveying in remnants relative to revegetation reflected the habitat complexity, quality and size of remnants. The amount of time spent surveying remnants in spring and autumn was similar. The study focused on terrestrial birds while also recording the presence of aquatic birds at an ephemeral wetland on the Flora Downs remnant native vegetation site.

Throughout this report the common names of birds have been used. This facilitates ease of reading and interpretation by non-ornithologists. The scientific names of these species are provided in the appendices. The location of each bird survey site is provided in Appendices 1-3. Appendix 3 provides detailed images of the distribution of remnant native vegetation at four of the six properties that participated in this study.

Plates 1-24 show representative remnant and planted sites surveyed for birds in the study area. These reflect each of the main topographic, soil/geologic, vegetation, bird habitat and revegetation types sampled in the study.

Remnant native woodland and shrubland communities

Plate 1: Dryandra shrubland mixed with wandoo woodland on Mason's ridgetop remnant (October 2011).

Plate 2: Wandoo woodland on breakaway, Mason's remnant, with tree hollow habitat for a range of bird, bat and reptile species (October 2011).

Plate 3: Wandoo woodland with Xanthorrhoea ground cover, Harridge's ridgetop remnant (October 2011)

Plate 4: Xanthorrhoea (grass tree) provided habitat for small mammals, reptiles and birds on Harridge's ridgetop remnant (April 2012).

Plate 5: Salmon and york gum woodland recently fenced on Scotney's property provides hollows for cavity-nesters such as Galah and Striated Pardalote (October 2011).

Plate 6: Active Wedge-tailed Eagle's nest in an older salmon gum at Scotney's site. Sometimes birds like the Zebra Finch nest in the underside of these structures (October 2011).

Plate 7: A york gum riparian remnant on Pearson's property which provided food and nest sites for Red Wattlebird, Western Gerygone and Weebill, among others (April 2012).

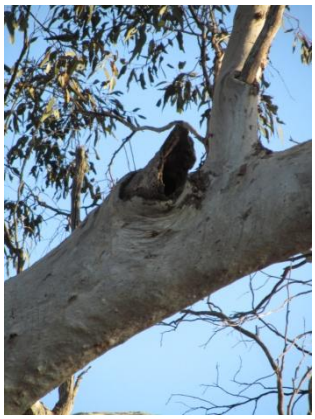
Plate 8: Weebills are tiny, insect-eating birds that glean the foliage and branches of york gum and wandoo, maintaining tree health (Pearson's riparian remnant, October 2011).

Plate 9: Hendry's remnant shrubland on sandplain in autumn. It has been recently fenced to exclude stock and contrasts with Plate 10 taken after winter rains (April 2012).

Plate 10: Near the same site shown in Plate 9, an ephemeral wetland occurs in spring. Winter rains transformed this site into a lush oasis for nesting aquatic bird such as ducks, cormorants, herons,and ibis. Raptors also foraged and nested here (October 2011).

Plate 11: Wandoo remnant on Woods' site, showing an absence of natural regeneration on the past-grazed, now-fenced lateritic ridge (October 2011).

Plate 12: Spouts in old wandoo at the site surveyed in Plate 11 were used by nesting Galah and inspected by Carnaby's Black-Cockatoo (October 2011).



Planted native eucalypts, brushwood/shrubs, saltbush and sandalwood and exotic tagasaste

Plate 13: Part of a 4 ha brushwood plantation on Woods' farm. Red-capped Robin and Rufous Songlark foraged in this planting (April 2012).

Plate 14: Saltbush planted in July 2011 on Wensleydale provided foraging habitat for White-fronted Chat and Red-capped Plover.

Plate 15: 10 year-old eucalypt and *Melaleuca thyoides* plantings provided cover, nest sites and foraging substrates for insectivorous birds adjacent to saltbush plantings on Wensleydale (October 2011).

Plate 16: Sandalwood planted with acacia and allocasuarina on Pearson's property adjacent to the Great Northern Highway (April 2012).

Plate 17: Pearson's sandalwood plantation in fruit, October 2011.

Plate 18: 11 year-old plantings of melaleuca, acacia and eucalyptus provided foraging, nest and shelter sites for small insectivorous birds at Mason's farm (revegetation site 1, April 2012).

Plate 19: Recent echidna foraging activity occurred in Mason's 11 year-old eucalypt, melaleuca and acacia plantings (revegetation site 1, October 2011).

Plate 20: Dense rows of melaleucas (planted 2006-08) on the eastern side of Langwood Creek (Mason revegetation site 2) provided nest and foraging sites for Inland Thornbill and Splendid Fairy-wren (Oct 2011).

Plate 21: Saltbuster (*Melaleuca thyoides*) planted in dense rows across the western side of Langwood Creek (Mason revegetation site 2) was foraged through by Splendid and White-winged Fairy-wrens (October 2011 and April 2012).

Plate 22: 9-10 year-old Salmon Gum planted along Gooden Gully (Mason revegetation site 3) supported a breeding pair of Red-capped Robin (male shown, October 2011).

Plate 23: Part of a 26 ha tagasaste plantation planted 2007 and cut 2009, showing dense blue lupin and ryegrass cover between rows, Flora Downs, October 2011.

Plate 24: The same tagasaste plantation shown in Plate 23 but grazed down by cattle in December-January 2011 (photo taken April 2012). Red-capped Robin foraged within and between rows in April 2012.

2.3 Data analysis

Four 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 in both seasons (ie. spring 2011 and autumn 2012). These were bird relative abundance, species richness, composition of foraging guilds (as a key indicative component of bird community structure), and habitat use (e.g. foraging, nesting, roosting, feeding, mate pursuits, calling). A total of 15 replicates (sites) were used – 7 in remnant native vegetation and 8 in revegetation.

Assignment of species recorded in the surveys to foraging guilds was based on existing professional knowledge and published data, especially from HANZAB (see references). Bird use of habitat was analysed qualitatively from notes compiled 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 Microsoft Excel 2007® and

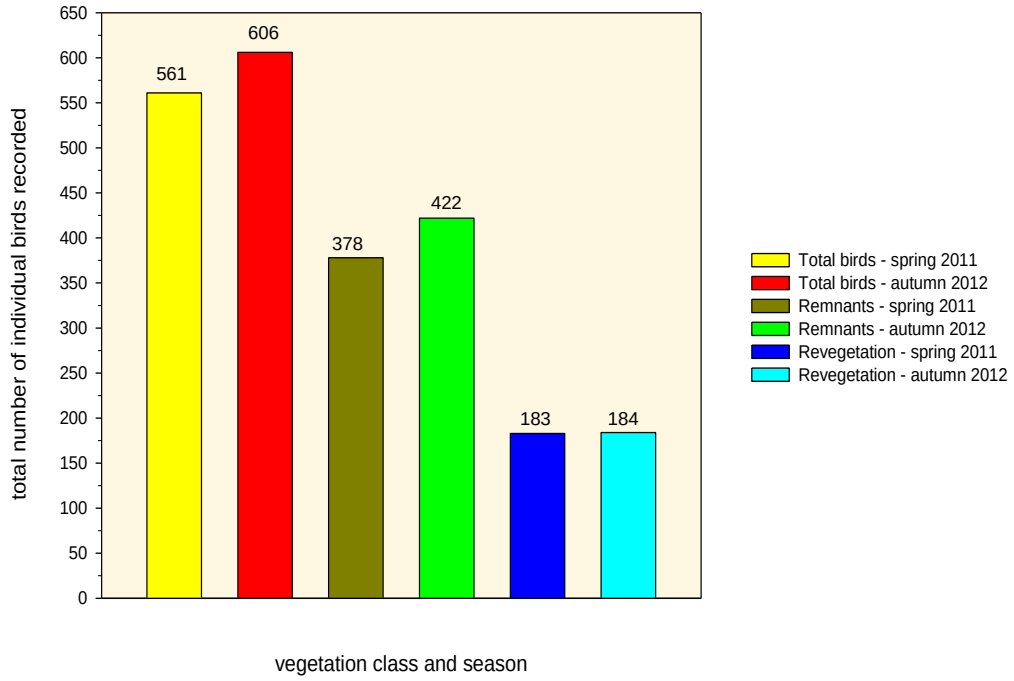
SigmaPlot Version 11.2® (Systat Software, Inc. 2009), with the results presented in graphical and tabular form. Survey effort was calculated according to treatment type and across the survey period.

3. Results

3.1 Relative abundance

A total of 1,167 individual birds were recorded during the study (see Appendices 1 and 2). Terrestrial birds accounted for almost all (1,155 or 99%) of this total with the remainder (12) being aquatic birds. Fewer land birds were recorded in spring (561) than in autumn (606). This represented a slight (7.4%) reduction in the total number of birds recorded between these two seasons (Figure 2). In spring, 378 land birds (mean 2.45, standard deviation [sd] 4.31) occurred in remnants while 183 (mean 1.19, sd 1.98) were recorded in revegetation. In autumn, 422 land birds (mean 2.83, sd 4.84) occurred in remnants compared with 184 (mean 1.26, sd 2.89) in revegetation. Thus, the total number of birds recorded in revegetation in spring and autumn remained relatively constant.

Figure 2: Total number of birds recorded in remnants and revegetation, October 2011 - April 2012



The most abundant bird species recorded in remnant native vegetation and revegetation during the study were Australian Ringneck (150 individuals in total – 63 in spring and 87 in autumn), Galah (119 – 62, 57), Brown Honeyeater (93 – 52, 41), Weebill (89 – 48, 41), Tree Martin (67 – 19, 48), Silvereye (54 – 6, 48), and Western Gerygone (47 – 27, 20). The same individuals of a number more sedentary bird species may have been recorded during both the spring and autumn surveys. The numbers of some of these species remained low but relatively constant between these seasons. These included White-winged Fairy-wren, Western Thornbill, Striated Pardalote, Singing Honeyeater, Inland Thornbill and Rufous Whistler. These are generally birds of core woodland and shrubland habitats in good condition.

The least abundant species recorded in remnant native vegetation and revegetation during the study were Spotted Pardalote (one individual in spring), Western Spinebill (1 in autumn), Australian Hobby (1 in spring), Peregrine Falcon (1 in autumn), Golden Whistler (1 in spring), Little Button-quail (2 in spring), Yellow-plumed Honeyeater (1 in spring, 2 in autumn), Scarlet Robin (4 in autumn), Grey Shrike-thrush (2, 4), and Inland Thornbill (4, 2).

Most species were less abundant in revegetated sites than they were in remnants. However, some species were present in reasonable numbers in older revegetation, e.g. Australian Ringneck (31), White-fronted Chat (29), Elegant Parrot (24), Weebill (21) and Silvereye (17).

In spring 2011, six (6) aquatic bird species were recorded in a seasonal wetland on Flora Downs. These included Pied Cormorant, Little Black Cormorant, Straw-necked Ibis, Purple Swamphen, Eurasian Coot and White-faced Heron. The Red-capped Plover was detected in young saltbush plantings on Wensleydale.

Section 3.2 displays images of some of bird species recorded during the study.

3.2 Bird species richness

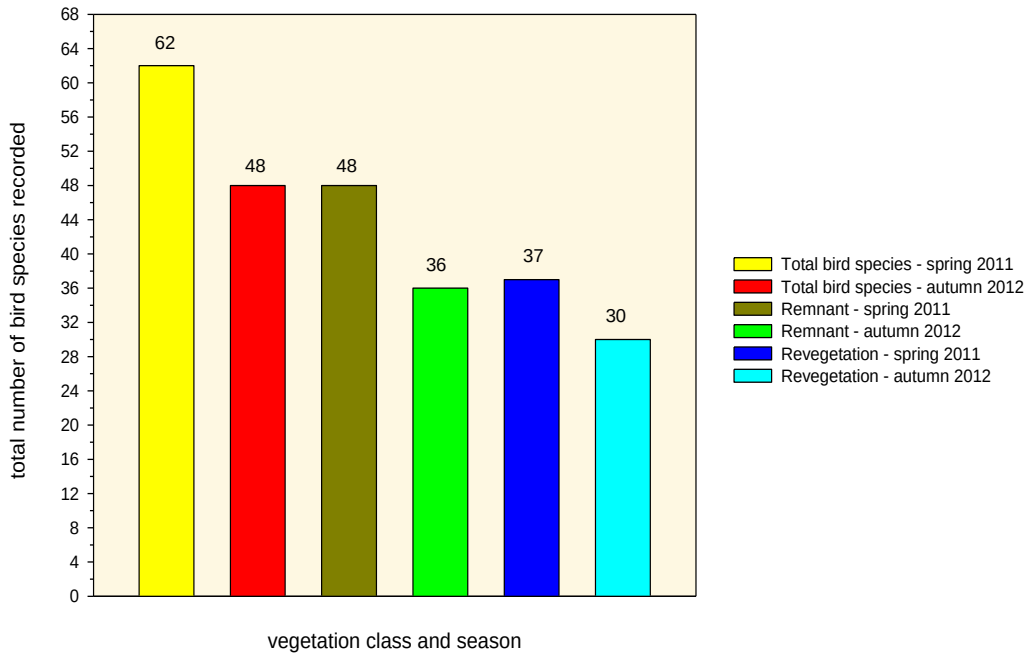
A total of 68 bird species was recorded during the study (Appendices 1 and 2). This included 61 terrestrial species and 7 aquatic species. Most (62) of these species were detected in spring while 48 were recorded in autumn (Figure 3). Remnants produced a total of 48 bird species (42 terrestrial and 6 aquatic) in spring and 36 species (all terrestrial) in autumn (Figure 3). This represented a 14.3% decrease in the number of terrestrial bird species recorded in autumn relative to spring.

Bird species richness was higher in remnants (48 species in spring – mean 3.2, sd 2.73, 36 in autumn – mean 2.4, sd 2.44) than in revegetation (37 in spring – mean 2.4, sd 2.61, 30 in autumn – mean 2, sd 2.13). However, this difference was not as substantial as recorded in the previous study (see InSight Ecology 2011) which included several of the same sites investigated in the current work. This most likely reflected the inclusion of a greater number of revegetation sites (8) relative to remnant sites (7) than was obtained in the 2011 sample (16 remnant and only 3 revegetation sites).

Changes in bird species richness between spring 2011 and autumn 2012 were more evident in surveyed remnants and some older revegetation sites. An influx of migratory and nomadic species occurred in remnants in spring. Nomadic species such as Yellow-plumed, Tawny-crowned, and Spiny-cheeked Honeyeaters, Western Wattlebird and Red Wattlebird were recorded in flowering dryandra, banksia and wandoo woodland and myrtaceous/proteaceous shrubland. Insectivorous summer breeding migrants such as White-winged Triller, Rufous Songlark, and Spotted Pardalote were recorded along woodland/paddock edges and in some older revegetation. Crimson Chat occurred in planted saltbush along a saline drainage at Wensleydale while the summer breeding migrant Sacred Kingfisher foraged along Langwood Creek at Carrah Farms and other sites. Carnaby's Black-Cockatoo occurred in significant numbers in Carrah Farms' wandoo woodland remnant and in Woods' wandoo remnant in spring. The ephemeral wetland on Flora Downs attracted small breeding populations of cormorants, ibis, coot and swamphen. Species such as Red-capped Parrot, Peregrine Falcon, Western Spinebill, Grey Fantail and Scarlet Robin occurred in autumn in high quality wandoo woodland remnants on Carrah Farms and Cooinda Park.

The composition of terrestrial bird communities sampled in particularly younger age classes of revegetation was generally more stable between autumn and spring. A cohort of relatively hardy or adaptive species such as Galah, Australian Ringneck, Weebill, Western Gerygone, Red Wattlebird, Brown Honeyeater, Rufous Whistler, Willie Wagtail and Silvereye exploited the food and cover resources of especially older mixed-species plantings across both seasons.

Figure 3: Total number of bird species recorded in remnants and revegetation, October 2011 - April 2012



No exotic bird species were detected during the surveys in the study area. However, one native species naturalised from eastern Australia – Laughing Kookaburra – was recorded in two remnants (Carrah Farms and Sammon Hills) in spring and autumn.

A suite of native species associated with larger, higher quality and better connected woodland and shrubland habitats were recorded, often in low numbers, in some remnants in the study area. These were Carnaby's Black-Cockatoo, Splendid Fairy-wren, Variegated Fairy-wren, White-winged Fairy-wren, Western Thornbill, Inland Thornbill, Spiny-cheeked Honeyeater, Western Wattlebird, Tawny-crowned Honeyeater, Golden Whistler, Grey Shrike-thrush, Scarlet Robin and Red-capped Robin.

Plates 25-54 depict terrestrial bird species recorded during surveys undertaken for this project in the study area.

Plate 25: A Peregrine Falcon was detected in Mason's wandoo woodland remnant in April 2012 (photo: Joe Tonga).

Plate 26: A pair of Wedge-tailed Eagle foraged for rabbits along Pearson's york gum creek in April 2012 and nested at Wensleydale remnant. (en.wikipedia.org).

Plate 27: Red-capped Plover (breeding male shown – en.wikipedia.org) foraged among young saltbush plantings along a saline drainage line on Wensleydale, October 2011.

Plate 28: Pairs and individuals of endangered Carnaby's Black-Cockatoo were recorded inspecting potential nest hollows in wandoo remnants at Mason's and Woods', Oct. 2011. (male feeding female, Carrah Farms, Sept. 2012)

Plate 29: A flock of Carnaby's Black-Cockatoo drinking and bathing in a sheep trough near Langwood Cottage, Carrah Farms, September 2012 (photograph taken by InSight Ecology and courtesy Sarah & Geoff Mason).

Plate 30: Sacred Kingfisher foraged for frogs and aquatic invertebrates along Langwood Creek (Carrah Farms), at Sammon Hills and in other remnants, October 2011.

Plate 31: Horsfield's Bronze-Cuckoo was detected attempting to parasitise an Inland Thornbill nest at Mason's revegetation site 2, October 2011 (ABID via en.wikipedia.org).

Plate 32: Shining Bronze-Cuckoo also parasitises thornbill, fairy-wren and other small insectivorous bird nests. A group of 6 birds foraged in Mason's revegetation site 1, October 2011 (flickr.com).

Plate 33: Red-capped Parrot was recorded perching on an old wandoo stag in Mason's wandoo remnant, April 2012 (adult male shown – boca.org.au)

Plate 34: A flock of 24 Elegant Parrot foraged beside Mason's revegetation site 2 in April 2012 (adult male shown - ibc.lynxeds.com)

Plate 35: A Southern Boobook was flushed from its day roost in Mason's wandoo remnant, April 2012 (Joe Tonga obs.; image of a young bird - Greg Clancy).

Plate 36: Splendid Fairy-wren was recorded in higher quality remnants at Carrah Farms, Cooinda Park and Flora Downs in both seasons (adult male - ibc.lynxeds.com).

Plate 37: White-winged Fairy-wren bred and foraged in Mason's revegetation site 2 utilising dense 4-6 year-old plantings of *Melaleuca thyoides* and also in Scotney's saltbush in both seasons (en.wikipedia.org).

Plate 38: Weebills are tiny birds that glean leaves and branchlets for insects. They were recorded in remnants and revegetation at most sites in both seasons (David Cook, (COG).

Plate 39: Western Gerygone is a small insectivore detected in remnants and older revegetation in both seasons across the study area (Peter Head).

Plate 40: Small groups of Western Thornbill foraged and bred in larger wandoo remnants on Carrah Farms and Cooinda Park and foraged in Mason's 11 year-old plantings (Brian Jenkins).

Plate 41: Inland Thornbill nested in dense 6 year-old melaleuca revegetation on Carrah Farms in October 2011 (ibc.lynxeds.com).

Plate 42: Western Spinebill foraged in a flowering *Banksia menziesii* and *B. prionotes* woodland remnant on Flora Downs in April 2012 (Tony Crittenden).

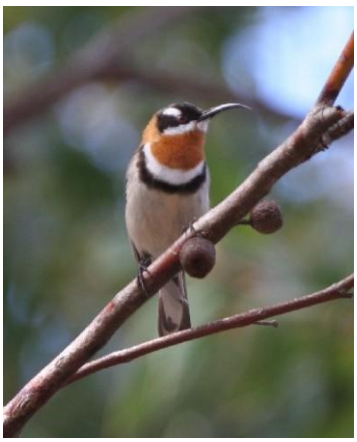


Plate 43: Yellow-plumed Honeyeater foraged in flowering york gum isolates within Mason's Langwood Creek revegetation in April 2012 (ibc.lynxeds.com).

Plate 44: Western Wattlebird foraged in flowering coastal blackbutt/banksia woodland on Flora Downs remnant in October 2011 (bird.net.au).

Plate 45: Tawny-crowned Honeyeater foraged in flowering dryandra patches (October 2011) and low shrubland (April 2012) in Mason's wandoo ridgetop remnant (Nevil Lazarus).

Plate 46: Crimson Chats are summer breeding migrants and were recorded in young saltbush plantings on Wensleydale, October 2011 (left: male, right: female - Melissa Cundy DEC).

Plate 47: White-fronted Chats are sedentary sedentary or locally nomadic ground-foraging insectivores detected in saltbush plantings on Wensleydale and Mason's Langwood Creek mixed species plantings (left: male – taken by by InSight Ecology and courtesy Alison Doley; right: female – bird.net.au).

Plate 48: The summer breeding migrant White-winged Triller forages for insects on the ground and in shrubs, often using dead branches as lookouts. It was recorded in Mason's revegetation and Flora Downs remnant in October 2011 (male shown).

Plate 49: A hardy, resilient insectivore, the Rufous Whistler occurred at most sites including 10-11 year-old revegetation on Carrah Farms and Wensleydale (above: adult male at nest – B&B Wells DEC; below: adult female – Greg Clancy).

Plate 50: The Grey Shrike-thrush is one of the finest songbirds of our bush, with many regional dialects. It was recorded in low numbers in only 3 larger remnants – on Carrah Farms, Flora Downs and Cooinda Park. An immature bird was detected in Mason's 11 year-old revegetation in April 2012 (above: adult male - birdlife.org.au; below left: adult male - Harvey Perkins COG; below right: immature bird - Geoffrey Dabb COG).

Plate 51: Grey Fantail often follows other small birds searching for insects in remnants and 6+ year-old eucalypt and acacia revegetation (en.wikipedia.org).

Plate 52: Red-capped Robin foraged and nested in Mason's wandoo remnant in October 2011. Immatures and adults foraged in native and exotic plantings in April 2012 (left: adult male; right: adult female – ibc.lynxeds.com).

Plate 53: Scarlet Robin is sensitive to habitat degradation and overgrazing. It was detected only in larger wandoo remnants on Carrah Farms and Cooinda Park in April 2012 (adult male – birdforum.net).

Plate 54: Rufous Songlark is a summer breeding migrant that foraged and may have nested in some native and exotic plantings (shown calling in Flora Downs' tagasaste, October 2011).

3.3 Bird community structure and habitat

3.3.1 Composition of foraging guilds

The composition of foraging guilds is an important indicator of bird community structure (Ford 1989; Wiens 1989; Mills 2007) and, in turn, ecosystem health (Vesk and Mac Nally 2006; InSight Ecology 2008, 2011). A total of 14 foraging guilds were recorded during surveys in the study area. Ten (10) of these were terrestrial (Figure 4) and four (4) aquatic (Appendices 1 and 2). Nine (9) terrestrial guilds occurred in spring and 10 in autumn. The 4 aquatic guilds were recorded in spring only. All of the terrestrial guilds occurred in remnant sites while 9 terrestrial guilds were also recorded in revegetation sites – the missing guild being nectarivores. An ephemeral wetland within the Flora Downs remnant, Langwood Creek (Carrah Farms) and an ephemeral stream on Sammon Hills supported the aquatic guilds. Two of these guilds were also represented in revegetation sites – aquatic and terrestrial insectivore and aquatic insectivore/molluscivore.

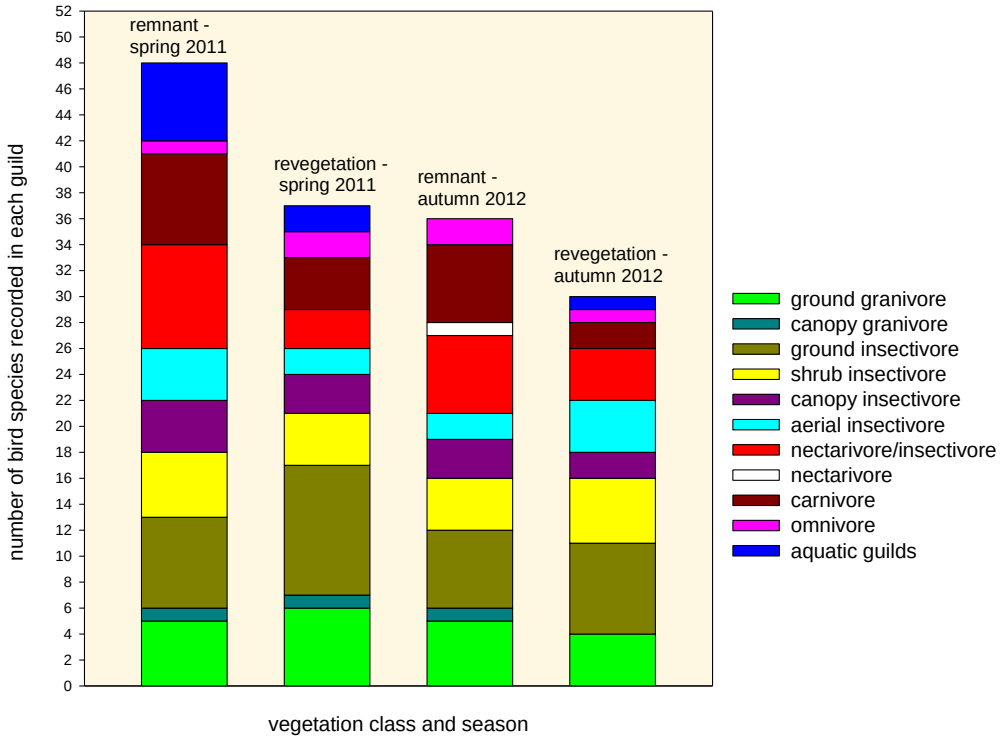
The terrestrial bird community of the study area featured a total of 10 foraging guilds. Seven (7) were commonly sampled during the study – ground insectivores, carnivores, ground granivores, nectarivores/insectivores, shrub insectivores, canopy insectivores, and aerial insectivores (Figure 4). Ground insectivores comprised 23% (14 species) of all terrestrial bird species recorded in both remnants and revegetation during the surveys undertaken for this study. They accounted for 16.7% (spring, 7 species) and 16.7% (autumn, 6 species) of all terrestrial bird species recorded in remnants during the study. In revegetation, they represented 28.6% (spring, 10 species) and 24.1% (autumn, 7 species) of all land birds recorded during the surveys. The main ground insectivores recorded in remnants were Splendid Fairy-wren, Yellow-rumped Thornbill, Australian Magpie, Magpie-lark, and Red-capped Robin. Ground insectivores recorded in older (10+ year-old) revegetation were Splendid Fairy-wren, Willie Wagtail, White-fronted Chat, Red-capped Robin and Australasian Pipit. Some summer breeding migrants – Crimson Chat, Brown Songlark and Rufous Songlark – also utilised older revegetation. The conservation-significant Scarlet Robin was detected in autumn 2012 in two of the highest quality and larger remnants surveyed in the study – Mason's Carrah Farms and Harridge's Cooinda Park.

Carnivores accounted for 18% (11 species) of all terrestrial bird species recorded in both remnants and revegetation in this study. The number of carnivores was relatively evenly distributed across both seasons in remnants with 7 species (16.7% of all terrestrial bird species surveyed in remnants) recorded in spring and 6 species (16.7% of all terrestrial bird species recorded in remnants) in autumn. In revegetation, 4 species (11.4% of all land birds recorded in revegetation) detected in spring were carnivorous while 2 carnivores (6.9% of all land birds recorded in revegetation) were recorded in autumn. Carnivores included Grey Butcherbird, Pied Butcherbird, Laughing Kookaburra, the summer migrant Sacred Kingfisher, Southern Boobook, and 6 raptor species including Wedge-tailed Eagle, Brown Falcon, the conservation-significant Peregrine Falcon, Australian Hobby, Black-shouldered Kite and Nankeen Kestrel.

Ground granivores were the third most represented guild in the study, comprising 14.7% (9 species) of all terrestrial bird species recorded in both remnants and revegetation in this study. The number of ground granivorous species recorded in remnants in spring and autumn was identical (5 species each or 11.9% of all terrestrial birds recorded in remnants in spring and 13.9% in autumn) but was slightly higher in revegetation in spring (6 species or 17.1% of all land birds recorded in revegetation) relative to autumn (4 species or 13.8%). Member species in

remnants were Stubble Quail, Common Bronzewing, Little Button-quail, Galah, Long-billed Corella, Little Corella, and Australian Ringneck. Revegetation supported Common Bronzewing, Crested Pigeon, Little Button-quail, Galah, Little Corella, Australian Ringneck and the part-nomadic Elegant Parrot. Two canopy granivores, the nationally endangered Carnaby's Black-Cockatoo, and the forest-associated Red-capped Parrot were also recorded in the study – the former species at Mason's Carrah Farms and Woods' Damara Downs properties and the latter in the Carrah Farms wandoo and marri remnant. Red-capped Parrot is at the northern edge of its distributional limit in the study area (Higgins 1999; Pizzey and Knight 2007)

Figure 4: Composition of bird foraging guilds in remnants and revegetation, October 2011 - April 2012



Nectarivores/insectivores represented 13.1% (8 species) of all terrestrial bird species surveyed in the study. They were recorded substantially more in remnants (8 species or 19% of all terrestrial birds recorded in remnants in spring; 6 or 16.7% in autumn) than in revegetation (3 or 8.6% of all land birds recorded in revegetation in spring and 4 or 13.8% in autumn). Some species were detected in remnants but not revegetation. These included the blossom or nectar nomads Western Wattlebird, Spiny-cheeked Honeyeater and Tawny-crowned Honeyeater. Others such as Singing Honeyeater, Brown Honeyeater, Red Wattlebird and Yellow-plumed Honeyeater foraged in isolated old york gums embedded within Carrah Farms' Langwood Creek plantings, 9-10 year-old eucalypt, acacia and melaleuca plantings along Carrah Farms' Gooden Gully, and 5-6 year-old planted sandalwood on Sammon Hills. Three of the nomadic honeyeaters - Tawny-crowned, Yellow-plumed and Western Spinebill - were present in autumn when york gum was flowering and insects still plentiful. Nectarivores were represented by only one species – Western Spinebill – and only in autumn in flowering banksia woodland on Flora Downs. The resident Yellow-throated Miner was present in low numbers in both seasons in surveyed wandoo and york gum remnants on Sammon Hills.

Shrub insectivores accounted for 11.5% (7 species) of all terrestrial bird species recorded in the study. They included 11.9% (5 species) of all terrestrial bird species recorded in remnants and 17.1% (6 species) in revegetation. They were recorded substantially more in remnants (8

species or 19% of all terrestrial birds recorded in spring, 6 or 16.7% in autumn) than in revegetation (3 or 8.6% in spring and 4 or 13.8% in autumn). Western Thornbill, Rufous Whistler, Golden Whistler, Grey Shrike-thrush and Grey Fantail were recorded in remnants while Mason's 6+ year-old revegetation supported Inland Thornbill and the summer breeding migrant Horsfield's Bronze-Cuckoo. Two core woodland endemic species - Western Thornbill and Grey Shrike-thrush - were detected, for the first time, foraging along Mason's 11 year-old eucalypt, melaleuca and acacia plantings in autumn 2012.

Canopy insectivores comprised 8.2% (5 species) of all terrestrial bird species recorded in the study. Slightly more of these species occurred in remnants (4 or 9.5% of all terrestrial birds recorded in remnants in spring; 3 or 8.3% in autumn) than in revegetation (3 or 8.6% of all land birds recorded in revegetation in spring and 2 or 6.9% in autumn). Member species were Weebill, Western Gerygone, the summer breeding migrant Spotted Pardalote (race *substriatus*), the sedentary Striated Pardalote, and the summer breeding migratory nest parasite Shining Bronze-Cuckoo. Weebill and Western Gerygone foraged and possibly nested in 5-6 and 9-11 year-old revegetation on Carrah Farms, sandalwood on Sammon Hills, and wandoo remnant on Carrah Farms and Cooinda Park. Striated Pardalote foraged throughout most wandoo, york gum and marri remnant sites in both seasons. One male Spotted Pardalote was detected in riparian york gum on Sammon Hills in October 2011. A group of 6 mostly male Shining Bronze-Cuckoo foraged in 8 year-old salt river gum, flat-topped yate, acacia and melaleuca plantings on Carrah Farms in October 2011.

Aerial insectivores accounted for 8.2% (5 species) of all terrestrial bird species recorded in the study. In spring, more of these species occurred in remnants (4 species or 9.5% of all land birds recorded in remnants in spring) than in revegetation (2 species or 5.7% of all land birds recorded in revegetation in spring). However, in autumn this trend was reversed – 2 species (5.5%) occurred in remnants and 4 (13.8%) in revegetation. Each of the five species recorded foraged the airspace of both remnants and revegetation. These were Black-faced Cuckoo-shrike, Welcome Swallow, Tree Martin, the summer breeding migrant White-winged Triller, and Black-faced Woodswallow.

Two omnivores were recorded during the study – Australian Raven and the partly-nomadic Silvereye. In October 2011, Silvereye responded to 'squeaking' calls in Flora Downs' tagasaste plantation suggesting the bird was nesting in nearby tagasaste foliage. Silvereye also foraged in 8 year-old salt river gum and flat-topped yate plantings on Carrah Farms and in banksia and wandoo remnants on Flora Downs, Cooinda Park and Carrah Farms in April 2012.

Seven (7) aquatic guilds were detected, collectively accounting for 10.3% (7 species) of all avifauna recorded in the study. Most of these species occurred in spring in an ephemeral wetland and streams on Flora Downs, Sammon Hills and Carrah Farms. These guilds and their member species were aquatic herbivore/insectivore (Purple Swamphen and Eurasian Coot), aquatic insectivore (Straw-necked Ibis), aquatic molluscivore/insectivore (Red-capped Plover), aquatic and terrestrial insectivore (White-faced Heron), and piscivore (Little Black Cormorant and Pied Cormorant).

Four of the 10 terrestrial bird foraging guilds recorded marked changes in their composition between the spring and autumn surveys. These were canopy insectivores (40% decrease in autumn relative to spring), shrub insectivores (28.6 % decrease in autumn relative to spring), nectarivores/insectivores (25% decrease in autumn relative to spring), and nectarivores (100% increase in autumn relative to spring). The remaining 6 terrestrial guilds showed no significant

variation in their composition or number of member species between spring and autumn. Section 4.2.3 discusses some possible reasons for these results.

3.3.2 Bird habitats and their utilisation

A range of terrestrial and some aquatic habitats were utilised by birds at surveyed sites in the study area. In general, remnants provided a wider suite of foraging, roosting, nesting and refuge habitats for birds than did younger more structurally simpler revegetation. These included ground substrates (rocky outcrops, fallen decaying logs, leaf, bark and branch debris), ground-covering vegetation (vines, prostrate and low shrubs, herbs and grasses), understorey plants (epacridaceous, myrtaceous and proteaceous shrubs, grass-trees Xanthorrhoea spp. and tall grasses), and canopy trees such as Coastal Blackbutt *Eucalyptus todtiana*, Wandoo *E. wandoo*, York Gum *E. loxophleba*, Salmon Gum *E. salmonophloia*, Marri *Corymbia calophylla*, River Red Gum *E. camaldulensis*, Acorn Banksia *Banksia prionotes*, Slender-leaved Banksia *B. leptophylla*, WA Christmas Tree *Nuytsia grandiflora*, Rock She-oak *Allocasuarina heugeliana*, Swamp She-oak *Casuarina obesa*, and various acacia and melaleuca species. Some remnants and revegetation sites supported an ephemeral freshwater/brackish wetland, seasonally-flowing creeks, and farm dams.

These broad habitat types offered a suite of different classes of microhabitat and key resources for birds in the surveyed remnants. Hollows in the branches and trunks of wandoo, marri, york gum, and salmon gum offered nest and shelter sites for Carnaby's Black-Cockatoo, Australian Ringneck, Long-billed Corella, Little Corella, Galah, Wedge-tailed Eagle, Sacred Kingfisher, Laughing Kookaburra, and Tree Martin. The dead outer branches of coastal blackbutt, york gum, and wandoo provided perches for aerial insectivores (Tree Martin, Black-faced Cuckoo-shrike and White-winged Triller) and carnivores (e.g. Wedge-tailed Eagle and Grey Butcherbird) to launch their pursuits of prey. Exfoliating bark on tree trunks and wedged in tree branch apices were searched for spiders and other invertebrates by Grey Shrike-thrush, Rufous Whistler, Red Wattlebird and Weebill. The surfaces of leaves and branchlets in wandoo, marri, york gum, salmon gum, coastal blackbutt and banksia canopies were searched for lerps and other insects by Western Gerygone, Weebill, Striated Pardalote, Singing Honeyeater and Rufous Whistler. Sugary exudates from eucalypt branches and trunks were harvested by Singing Honeyeater, Red Wattlebird and Western Wattlebird. Dense foliage also provided nest sites for Australian Raven, Magpie-lark, Australian Magpie, and Nankeen Kestrel.

The floristically diverse shrubland remnants provided insects and copious amounts of nectar from spring/autumn-flowering banksia, dryandra, hakea, melaleuca, adenanthos, calothamnus, xanthorrhoea, petrophile, verticordia, *Eremaea pauciflora* and other proteaceous, myrtaceous and epacridaceous plants at sites on Carrah Farms, Cooinda Park, Sammon Hills and Flora Downs sites. Sedentary, seasonally nomadic, and part-migratory honeyeaters foraged intensively in these habitats – Brown Honeyeater, Red Wattlebird, Western Wattlebird, and Spiny-cheeked Honeyeater were key examples. Ground insectivores (Variegated Fairy-wren, Splendid Fairy-wren and occasionally White-winged Fairy-wren) took ants, flies, small wasps and moths attracted to these nectar-rich habitats. Red Wattlebird, Western Wattlebird and Spiny-cheeked Honeyeater maintained feeding territories around mature *Banksia menziesii* and *B. prionotes* stands in the Flora Downs remnant. Shrub insectivores (Western Thornbill, Inland Thornbill, Grey Fantail and Rufous Whistler) foraged in dense clumps of broombush, dryandra, rock she-oak, and acacia on rocky ridges at the Carrah Farms and Cooinda Park remnant sites.

A suite of ground cover microhabitats provided food, shelter, and breeding resources for birds in the remnants. These included low shrubs, vines, grasses, rocky outcrops, fallen rotting logs and branches, and leaf and bark debris. Ground-foraging insectivores (Red-capped Robin, Variegated Fairy-wren, Splendid Fairy-wren, Yellow-rumped Thornbill) and ground granivores (Common Bronzewing, Crested Pigeon, Little Button-quail, Australian Ringneck) foraged, and in some instances bred, in these microhabitats.

Microhabitats for a range of aquatic birds were provided by water bodies within surveyed remnants including stagnant and flowing open water, mud and sand flats along creeks and dam margins, reedbeds and shrubby fringes of creeks and dams, shallow pooled water in paddocks drains, and dead trees in freshwater/brackish wetlands. Pied Cormorant, White-faced Heron, Straw-necked Ibis, Purple Swamphen and Eurasian Coot foraged and probably nested in an ephemeral wetland on Flora Downs. Its dense melaleuca and leptospermum shrubland fringe also provided a diversity of nesting opportunities for several terrestrial bird species. Standing dead trees in this wetland provided perches for White-faced Heron and Pied Cormorant.

Revegetation sites surveyed in the study area included mixed eucalypt, melaleuca, acacia and hakea plantings on Carrah Farms and Wensleydale, plantations of tagasaste (Flora Downs), brushwood (Damara Downs) and sandalwood (Sammon Hills), and young saltbush plantings on Wensleydale. The older (9-11 year-old) plantings began to provide a degree of structural complexity and resource utility (roosts, nest sites, food) that attracted small insectivores usually found in high quality core woodland remnant habitats – Western Thornbill, Red-capped Robin, Rufous Whistler, Shining Bronze-Cuckoo and Grey Shrike-thrush. Revegetation site 1 on Carrah Farms is a case in point and included recent evidence of Echidna foraging and remote camera footage of the threatened Chuditch. These plantings varied between 3-9 rows (20-70 m wide) and 600-800 m long and contained 11 year-old salt river gum, flat-topped yate, river red gum, marri. allocasuarina, acacia and melaleuca. This created canopy, shrub understorey, and ground cover layers including fallen leaf and bark debris. These plantings occurred on the floors and slopes of shallow sandy valleys and targeted saline riparian zones and gullies.

Younger (5-6 year-old) plantings of *Melaleuca thyoides*, *M. uncinata*, *M. hamulosa*, *Hakea recurva*, and *Acacia saligna* along Langwood Creek (Carrah Farms) provided a structurally simpler set of habitats for birds dependent on dense lower to mid-canopy cover, e.g. Splendid Fairy-wren, Inland Thornbill and Western Gerygone. Commercial woody perennials planted on Flora Downs (5 year-old tagasaste), Damara Downs (6 year-old brushwood) and Sammon Hills (5-6 year-old sandalwood) supplied varying levels of basic habitat specifically food, shelter and nesting sites for some insectivorous, omnivorous and carnivorous birds. Of these, the dense and fast growth habit of tagasaste enabled Silvereye and possibly Red-capped Robin to nest within the rows.

Habitat and microhabitat types that occurred at the remnant and revegetated sites and examples of bird species that utilised these habitats included (and see Plates 55-66):

- Airspace above remnants and revegetation - Welcome Swallow, Tree Martin, Black-faced Cuckoo-shrike and White-winged Triller;
- Fencelines along revegetation-paddock edges - Willie Wagtail, Red-capped Robin, Yellow-rumped Thornbill, White-fronted Chat, Brown Songlark, Rufous Songlark and Australasian Pipit;
- Overhead powerlines, poles and windmills - Nankeen Kestrel, Galah, Australian Ringneck, Black-faced Woodswallow, Australian Magpie, Pied Butcherbird, Australian Raven and Welcome Swallow;

- Dead branches and standing dead trees (stags) – Southern Boobook, Wedge-tailed Eagle, Brown Falcon, Nankeen Kestrel, Galah, Pied Butcherbird, Australian Magpie, Magpie-lark and Sacred Kingfisher;
- Open ground under planted vegetation providing some leaf and bark litter, seeds and invertebrates - Common Bronzewing, Galah, Splendid Fairy-wren, White-winged Fairy-wren, Yellow-rumped Thornbill, Red-capped Robin, Australian Magpie, Willie Wagtail, Australian Raven, Magpie-lark and Australasian Pipit;
- Saline drainages and samphire flats – White-fronted Chat, Crimson Chat, Red-capped Plover, Australasian Pipit and Welcome Swallow;
- Shrub and canopy foliage and bark/stem substrates including tree hollows providing leaf and bark insects, vertebrate prey, nectar, fruit and nest/roost sites – remnants and older plantings: Western Gerygone, Weebill, Striated Pardalote, Red-capped Robin, Scarlet Robin, Peregrine Falcon, Grey Fantail, Rufous Whistler, Singing Honeyeater, Brown Honeyeater, Red Wattlebird, Silvereye and Tree Martin, and younger plantings: Weebill, Western Gerygone, Brown Honeyeater, Grey Fantail and Silvereye;
- Creeks, farm dams, vegetated dam margins, ephemeral wetlands and pooled water in paddocks and remnants (rock pools) - aquatic species: Straw-necked Ibis, White-faced Heron, Pied Cormorant and Purple Swamphen and terrestrial species: Little Button-quail, Sacred Kingfisher, Laughing Kookaburra, Splendid Fairy-wren, Variegated Fairy-wren and Common Bronzewing.

Plates 55-56: Fencelines along the edges of paddocks and revegetation and remnants were often used as foraging aids and lookouts by small ground insectivores (left: male Red-capped Robin; right: female White-fronted Chat. Photographs by InSight Ecology and courtesy M. & J. O'Callaghan/DEC (Red-capped Robin) and Alison Doley (White-fronted Chat).

Plates 57-58: The outer dead branches of both living and dead trees provided ideal lookout and rest perches for the threatened Carnaby's Black-Cockatoo (left: Ingrid Krockenberger) and conservation-significant Peregrine Falcon (right: Joe Tonga).

Plates 59-60: Open ground mixed with fallen acacia branches and a canopy of 11 year-old eucalypt, acacia and melaleuca plantings supported populations of the ground-foraging Red-capped Robin (young male shown left) and shrub insectivore Grey Fantail (shown right) on Carrah Farms in April 2012.

Plates 61-62: Multiple layers of remnant native vegetation in a wandoo ridgetop remnant at Carrah Farms provided a diverse suite of foraging, nesting and refuge habitats for core woodland birds (left: hollow-bearing wandoo; right: flowering dryandra among wandoo - September 2012). Several of these birds are sensitive to the effects of habitat loss, fragmentation and reduced habitat condition and have declined across the WA farming zone.

Plates 63-64: 11 year-old eucalypt, melaleuca and acacia revegetation on Carrah Farms (left, April 2012) provided habitats that attracted some birds normally found in high quality woodland and shrubland remnants. A seasonally flowing stream was foraged along by Sacred Kingfisher in October 2011 – note younger melaleuca plantings in the background (Langwood Creek, Carrah Farms).

Plates 65-66: Woody perennial crops offered a set of simpler but important supplementary habitats for opportunistic/adaptive bird species such as Red-capped Robin, Silvereye and Yellow-rumped Thornbill and those of edges and more open habitats. e.g. Brown Songlark, White-fronted Chat and Australasian Pipit. These crops included 5 year-old tagasaste on Flora Downs (left, showing blue lupin and ryegrass-sown between rows, October 2011), 6 year-old brushwood at Damara Downs (right, April 2012), 9 month-old (at time of survey - April 2012) saltbush on Wensleydale, and 5-6 year-old sandalwood at Sammon Hills.

3.4 Breeding activity

A total of 76 individual records of breeding activity were obtained for 38 bird species surveyed in the study area (31 terrestrial and 7 aquatic species – Appendices 1 and 2). This represented 55.9% of the total bird community sampled during the surveys and 50.8% of all terrestrial bird species surveyed and occurred mainly in spring. Most (69 or 90.8%) of these records were for terrestrial species while 7 (9.2%) related to aquatic species. Remnants accounted for 54 or 71% of these records with the remaining (22 records or 28.9%) breeding observations being made in revegetation. Thus, remnants provided breeding resources for 30 species or 78.9% of all birds that were recorded breeding in the study area. In contrast, revegetation supported 18 or 47.4% of all breeding bird species detected in the study – a substantial component which highlighted the value of planted habitats for birds in the study area.

Observations of breeding activity in the study area comprised both direct and indirect records. Direct records included observations of birds constructing nests, incubating eggs, carrying food en route to nests, searching for nests to parasitise (ie. bronze-cuckoos), feeding nestlings or fledglings, and decoy behaviour. The latter activity involves adults faking broken wings to draw the surveyor away from recently fledged young which are usually secreted in nearby dense vegetation – a strategy commonly used by Red-capped Robin, for example. Indirect records involved observations of breeding territory defence (including calling), mate pursuits, copulation, pair protection and maintenance including allo-preening and pursuit and expulsion of rival males, courtship provisioning involving males feeding females to enhance the female's breeding condition and thus reproductive success potential, and courtship display.

Direct evidence of breeding bird activity accounted for 33 records across 20 species – 27 records (16 species) in remnants and 6 (6 species) records in revegetation or 43.4% of all breeding bird records obtained during the study. In remnants, these included obligate hollow-nesters (Galah, Little Corella, Australian Ringneck and Tree Martin), canopy and shrub nesters (Western Thornbill, Grey Fantail, Silvereye, Red Wattlebird and Common Bronzewing), stick platform nesters (Wedge-tailed Eagle and Australian Raven), a small open-cup nesting

insectivore (Red-capped Robin), and 5 aquatic species. In revegetation, an open-cup nesting insectivore (Willie Wagtail), a canopy nester (Weebill), two shrub nesters (Inland Thornbill and Silvereye), and two ground or near-ground nesters (White-winged Fairy-wren and Little Button-quail) were recorded. Little Button-quail nested in a thick ground cover of blue lupin and ryegrass sown between rows of tagasaste at the Flora Downs revegetation site. The Inland Thornbill record was in Carrah Farms' 6-8 year-old *Melaleuca uncinata* rows (Mason revegetation site 2) in October 2011. This is the first documented record for this species in revegetation in the study area.

Evidence of indirect bird breeding activity comprised a total of 43 records for 24 species. This represented 56.6% of all breeding bird records obtained in the study. Indirect breeding observations were obtained in both remnants (27 records of 17 species) and revegetation (16 records of 15 species). In remnants, species included ground or near-ground nesters (Splendid, Variegated and White-winged Fairywren, Common Bronzewing and Rufous Songlark), canopy insectivores (Weebill and Western Gerygone), shrub insectivores (Western Thornbill, Grey Fantail and Rufous Whistler), a small tree hollow nesting insectivore (Striated Pardalote), a hollow and tree termite nesting carnivore (Sacred Kingfisher), honeyeaters (Brown Honeyeater, Spiny-cheeked Honeyeater and Western Wattlebird), an aerial insectivore (Black-faced Cuckoo-shrike), and a stick platform nester (Australian Magpie). In revegetation, species included parasitic migratory insectivores (Shining Bronze-Cuckoo and Horsfield's Bronze-Cuckoo), ground or near-ground nesting insectivores (White-winged Fairy-wren, Rufous Songlark and Australasian Pipit), canopy insectivores (Weebill and Western Gerygone), two honeyeaters (Brown Honeyeater and Red Wattlebird), small shrub nesters (Grey Fantail, Rufous Whistler and Silvereye), and stick platform nesters (Grey Butcherbird, Australian Magpie and Australian Raven).

3.5 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 an international biodiversity hotspot. It is the only globally recognised terrestrial biodiversity 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).

The study area also occurs within one Important Bird Area (IBA) in Western Australia – Calingiri (see Figure 1). IBAs are sites that are recognised as internationally important for bird conservation (Dutson et al 2009). Each of these IBAs has been nominated on the basis of supporting known populations of south-west endemic bird species. These include breeding areas in the wheatbelt for the nationally endangered Carnaby's Black-Cockatoo (Dutson et al 2009).

Forty-five (45) bird species of global, national, WA state or local conservation significance have been recorded, could be reasonably expected to occur in suitable habitat, or have gone extinct in the WA wheatbelt and/or the study area (Table 2). Their current conservation status is also indicated. Seventeen (17) of these species are of conservation significance at national and WA state levels. The remaining 28 species are locally significant because they may be experiencing

substantial declines in population size and contractions in distributional range as their core habitats become smaller, more fragmented and thus increasingly disconnected and isolated, and of poorer condition or adversely affected by other factors such as culling, overgrazing, predation by feral animals, and a changing climate.

Table 2: The conservation status of significant terrestrial and terrestrial-aquatic bird taxa of the Western Australian wheatbelt. Global status follows IUCN (2001, 2006) and refers to the status of the species not subspecies. CITES means protected under the Convention on International Trade in Endangered Species. National status observes Garnett and Crowley (2000). Status in WA is based on HANZAB (1990-2006) and in accordance with WA Wildlife Conservation Act 1950 (Schedule 4: Other Specially Protected Fauna). 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 surveys undertaken in the study area by InSight Ecology (2008-2012). LC=Least Concern, NT=Near Threatened, EN=Endangered, V=Vulnerable, EX=Extinct (likely), U=Unlikely to occur due to lack of suitable habitat or is beyond the species' normal distributional range; UK = unknown status (data deficient), ADL= at or near distributional limit of species or race. Superscripts after common names indicate that the species was recorded during surveys conducted by InSight Ecology for this or previous projects in southern Moore River catchment[1], or by local farmers or bird observers in recent years[2]. Note that Wedge-tailed Eagle numbers have historically declined across the wheatbelt in response to culling by landholders. In the absence of new targeted surveys in the study area their current status remains uncertain despite anecdotal claims that numbers are increasing.

Common name	**Scientific name**	**Global status**	**National status**	**Status in WA**	**Status in WA wheatbelt**	**Likely status in study area**
Birds of global, national and/or WA state conservation significance						
Malleefowl	*Leipoa ocellata*	V	V	V	V	EX/UK
Peregrine Falcon	*Falco peregrinus*	CITES-listed	LC	Schedule 4 species	UK	UK
Brush Bronzewing[1]	*Phaps elegans*	LC	LC	NT?	UK	UK
Australian Little Bittern	*Ixobrychus dubius*	LC	NT	NT	NT	EX
Australian Bustard	*Ardeotis australis*	NT	NT	NT	V	EX/UK
Bush Stone-curlew	*Burhinus grallarius*	NT	NT	NT	V	EX
Hooded Plover (western)	*Thinornis rubricollis* race *tregellasi*	NT	NT	NT	NT	UK/EX?
Red-tailed Black-Cockatoo (south-western)	*Calyptorhynchus banksii* race *naso*	NT	NT	NT	NT	EX?
Carnaby's Black-Cockatoo[1,2]	*Calyptorhynchus latirostris*	EN	EN	EN	EN	EN
Western Corella (southern)	*Cacatua pastinator* race *pastinator*	EN	EN	EN	EN	EN, ADL
Western Rosella (wheatbelt)	*Platycercus icterotis* race *xanthogenys*	NT	NT	NT	NT	EX
Barking Owl (southern – WA sub-population)	*Ninox connivens connivens*	LC	NT	NT	UK	UK, ADL
Masked Owl (southern Australia)	*Tyto novaehollandiae* race *novaehollandiae*	LC	NT	NT	UK	UK, ADL
Rufous Fieldwren (western	*Calamanthus campestris* race	NT	NT	NT	V	UK

Common name	Scientific name	Global status	National status	Status in WA	Status in WA wheatbelt	Likely status in study area
wheatbelt)	*montanellus*					
Western Yellow Robin[2]	*Eopsaltria griseogularis*	LC	LC	NT	UK	U/UK
Crested Shrike-tit (western)	*Falcunculus frontalis* race *leucogaster*	NT	NT	NT	NT	EX
Southern Scrub-robin[2]	*Drymodes brunneopygia*	LC	LC	LC	UK	UK, ADL
Birds of local conservation significance (Moora-Gillingarra-Calingiri-New Norcia district)*						
Wedge-tailed Eagle[1]	*Aquila audax*	LC	LC	LC	UK	UK
Purple Swamphen[1]	*Porphyrio porphyrio*	LC	LC	LC	LC	LC, ADL
Red-capped Plover[1]	*Charadrius ruficapillus*	LC	LC	LC	LC	LC
Elegant Parrot[1]	*Neophema elegans*	LC	LC	LC	LC	UK, ADL
Little Button-quail[1]	*Turnix velox*	LC	LC	LC	LC	LC
Regent Parrot (western)[2]	*Polytelis anthopeplus* race *anthopeplus*	LC	LC	LC	LC	UK
Red-capped Parrot[1,2]	*Purpureicephalus spurius*	LC	LC	LC	UK	NT, ADL
Splendid Fairy-wren[1,2]	*Malurus splendens*	LC	LC	LC	LC	LC
Variegated Fairy-wren[1]	*Malurus lamberti* race *assimilis*	LC	LC	LC	LC	LC, ADL
Southern Emu-wren[1]	*Stipiturus malachurus*	LC	LC	V	EN	NT?, ADL
White-browed Scrubwren[1]	*Sericornis frontalis* race *maculatus*	LC	LC	LC	LC	UK
Western Gerygone[1,2]	*Gerygone fusca*	LC	LC	LC	LC	LC
Western Thornbill[1,2]	*Acanthiza inornata*	LC	LC	LC	LC	LC, ADL
Inland Thornbill[1,2]	*Acanthiza apicalis*	LC	LC	LC	LC	LC
Spotted Pardalote[1,2]	*Pardalotus punctatus*	LC	LC	LC	LC	ADL
Western Spinebill[1,2]	*Acanthorhynchus superciliosus*	LC	LC	LC	LC	LC, ADL
White-eared Honeyeater[1]	*Lichenostomus leucotis*	LC	LC	LC	UK	UK, ADL
Brown-headed Honeyeater[1,2]	*Melithreptus brevirostris* race *leucogenys*	LC	LC	LC	LC	LC
New Holland Honeyeater[1,2]	*Phylidonyris novaehollandiae*	LC	LC	LC	LC	LC, ADL
Western Wattlebird[1]	*Anthochaera lunulata*	LC	LC	LC	LC	ADL
Crimson Chat[1]	*Epthianura tricolor*	LC	LC	LC	LC	UK
White-fronted Chat[1]	*Epthianura albifrons*	LC	LC	LC	LC	LC
White-browed Babbler[2]	*Pomatostomus superciliosus*	LC	LC	LC	NT	UK
Varied Sittella[1]	*Daphoenositta chrysoptera* race *pileata*	LC	LC	LC	LC	UK
Golden Whistler[1]	*Pachycephala pectoralis*	LC	LC	LC	LC	LC
Jacky Winter[1]	*Microeca fascinans*	LC	LC	LC	UK	UK
Grey Shrike-thrush[1,2]	*Colluricincla harmonica*	LC	LC	LC	LC	LC
Scarlet Robin[1]	*Petroica boodang*	LC	LC	LC	UK	UK, ADL

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

The bird species of highest conservation value observed during the study was Carnaby's Black-Cockatoo, detected in two Wandoo ridgetop remnants and flying over older revegetation in October 2011. This species is listed under Schedule 2 (Fauna that is rare or likely to become extinct) of the WA 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 ongoing WWF-BirdLife Australia-community conservation initiative in the study area and across other parts of its range, including in part of its non-breeding range on the Swan Coastal Plain (see Dutson et al 2009).

Two other species of high global and national conservation significance could be expected to occur or may have historically occurred in the study area but were not recorded during the study. They are the Western Corella and Malleefowl. There are anecdotal reports of Malleefowl presence on some farms in and near the study area over the past decade. A third species – Peregrine Falcon – was recorded in a wandoo remnant on Carrah farms in April 2012. It is listed under Schedule 4 of WA Wildlife Conservation Act 1950 and protected under the Convention on International Trade of Endangered Species.

The conservation status of 7 other species that might still occur in the study area but were not recorded during the study was indeterminable due to a lack of data. These included Australian Bustard, two owls (Barking and Masked), and three declining ground insectivores (Rufous Fieldwren, Western Yellow Robin and Southern Scrub-robin). One individual Southern Scrub-robin was recorded by Donna Rayner of Mingenew-Irwin Group in 2007 along the Moore River at Mogumber Farm. This site was re-surveyed by InSight Ecology as part of the CDI Project in April and October 2009 but no scrub-robins were detected (see InSight Ecology 2010). Western Yellow Robin has been recorded in drier country in the northern Moore River catchment around Coorow and Dalwallinu (see Huggett et al 2004; InSight Ecology 2007) so its presence in the moister southern Moore River catchment would be less likely.

Nineteen (19) or 65.5% of the 29 species of local conservation significance listed in Table 2 were recorded during the study. These included 5 ground insectivores (Splendid Fairy-wren, Variegated Fairy-wren, Crimson Chat, White-fronted Chat and Scarlet Robin), 4 shrub insectivores (Western Thornbill, Inland Thornbill, Golden Whistler, Grey Shrike-thrush), one canopy insectivore (Spotted Pardalote), 2 remnant-only honeyeaters (Western Spinebill and Western Wattlebird), one canopy insectivore (Western Gerygone), 2 ground granivores (Little Button-quail and Elegant Parrot), a canopy granivore (Red-capped Parrot), one carnivore (Wedge-tailed Eagle), an aquatic herbivore (Purple Swamphen), and an aquatic insectivore/molluscivore (Red-capped Plover). Remnant shrubland, woodland, wetland, and riparian zones provided key habitats for these species in the study area. The local conservation status of 9 other species – Regent Parrot, White-eared Honeyeater, Brown-headed Honeyeater, New Holland Honeyeater, Varied Sittella, Jacky Winter, White-browed Babbler, White-browed Scrubwren and Southern Emu-wren – was indeterminable due to a lack of data.

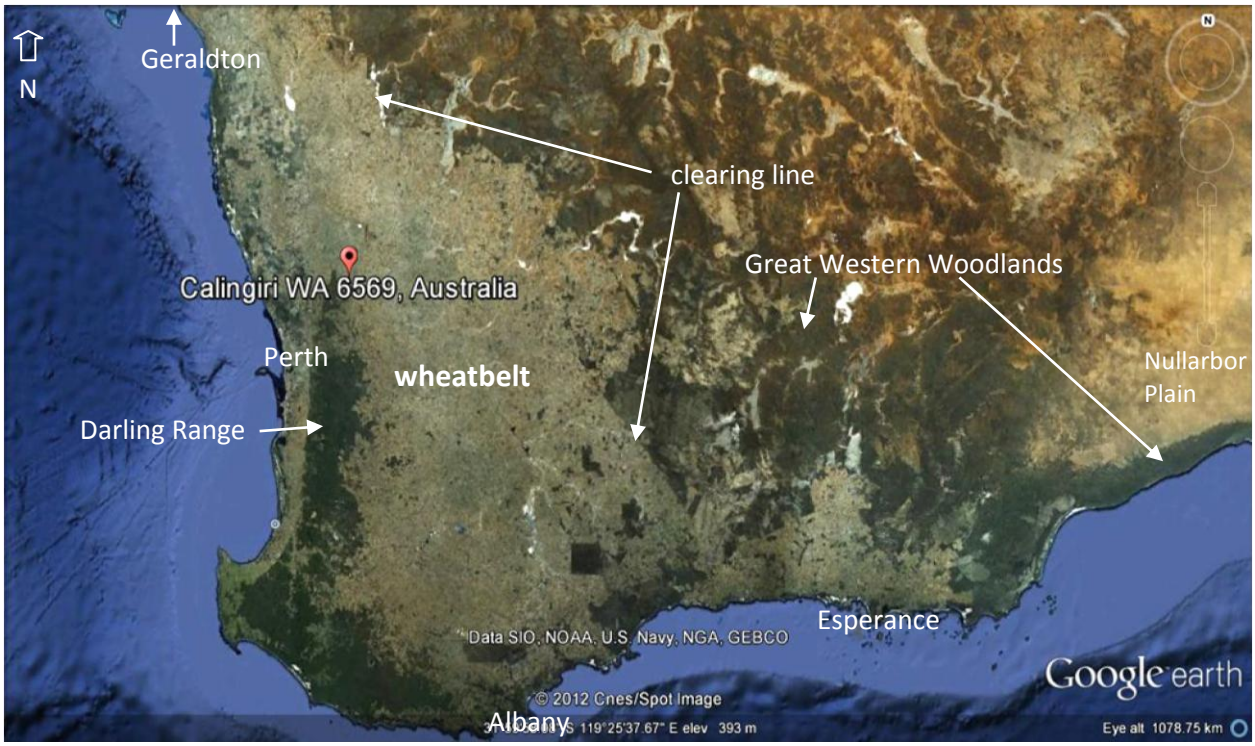
4. Discussion

4.1 Landscape context and effects

The human ecological footprint on the native vegetation of the Western Australian wheatbelt has been particularly heavy and wide-reaching (Figure 5). In many districts less than 10% of the

original native vegetation cover remains. The central wheatbelt has only 2 to 5% of its original native vegetation (Frost et al. 1999) typically present as highly isolated nature reserves and narrow roadside remnants. This ranks the ecosystems of these landscapes and their remnant fauna among some of the most fragmented and threatened in the world (Saunders and Ingram 1995; DEC 2008; InSight Ecology 2008, 2009, 2011; Laurance et al 2011).

Figure 5: Spatial distribution of remnant native vegetation across the southwest of Western Australia. The extent of historical land clearing to establish the wheatbelt is clearly evident, spanning the area from north and north-east of Geraldton (actual town is just north of image extent) in the north, east to the clearing line, and south to the Pacific Ocean coast from Albany to east of Esperance. Darling Range is the strip of remnant native vegetation shown just east of Perth and which links with the woodlands, shrublands, heathlands and wetlands of the south coast. The Great Western Woodlands extend east of the clearing line towards the edge of the Nullarbor Plain and in a strip along the southeast WA coastline. Image: Google™earth (2012 Cnes/Spot image); distance from east to west represented by image: 1,078.75 km.



Significantly, the Moora-Calingiri-Gillingarra-New Norcia landscape supports about 30% of its original native vegetation cover. Most of this vegetation occurs along lateritic ironstone or granitic hills and ridges such as at Carrah Farms and Cooinda Park, and along Moore River and its tributaries.

The degree of habitat connectivity varies across this landscape in response to patterns of past land clearance and the associated occurrence of arable, accessible land along the sandy lower valley slopes and floors. Some larger upland patches of remnant woodland and shrubland are linked to adjacent drainage lines via midslope and lowland woodland and shrubland strips or small uncleared remnants such as on Carrah Farms at Calingiri and around Gillingarra (Plates 67-68 and Appendix 3). Elsewhere in the district, however, remnant native vegetation of the lower valley slopes and especially the valley floor is often poorly connected to adjacent upland woodland patches, usually only by narrow strips of york gum and wandoo stands along drainage lines (Plate 69). In other places, these patches are effectively islands surrounded by

pastures and crops and often grazed by livestock (Plate 70). Despite this, several significant blocks of mixed sandplain heathland, shrubland, banksia and coastal blackbutt woodland, and wetland still occur. Together with the ridgetop woodlands and shrublands, these are the true ecological gems of the local farming landscape. The protection and enhancement of their ecological condition is paramount (see Section 5). Several of these sites have been recently fenced to exclude livestock (see InSight Ecology 2011 and Appendix 3).

The potential for the long-term ecological recovery is therefore higher in southern Moore River catchment than in the more cleared northern and central WA wheatbelt districts where only 2-12% of remnant native vegetation remains (Huggett et al 2004). The condition and spatial arrangement of remnant native vegetation in the study area also contributes to this more positive restoration outlook in the southern Moore River landscape. A third key factor in this prognosis is the role of planted vegetation in providing supplementary habitat and to help link and widen remnant patches across topographic units (ie. ridges to valley floors and drainage lines) and establish new habitat 'building blocks' for re-connecting bush at the local and regional scales (see Section 4.3.2).

Plate 67: Local habitat connectivity is relatively high on Carrah Farms, for example, where a 68 ha ridgetop wandoo remnant (surveyed in this study) connects with other remnants to the north and south via a network of riparian plantings (May 2011, courtesy G. & S. Mason).

Plate 68: 'Stepping stones' of dryandra and mallee heath on Brian Kelly's ridgeline, york gum and wandoo woodland midslope remnants, and riparian woodland present key building blocks for improving habitat connectivity around Gillingarra (April 2009).

Plate 69: Narrow strips of unfenced york gum woodland provide a lower level of habitat connectivity with upper slope and ridgeline remnants in this West Gillingarra landscape (April 2009 - taken by InSight Ecology, courtesy Jim Kelly and NACC).

Plate 70: 'Islands' of remnant heathland are disconnected from other remnant heathland in this landscape at Bundarra Nature Reserve, Gillingarra West (April 2009 - taken by InSight Ecology, courtesy DEC).

The study area also 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 occurrence and composition of bird assemblages and their movement into and out of the area.

Importantly, the study area provides key life cycle resources including refugia such as granite outcrops, sandplain heath and shrublands, and wandoo/york gum/salmon gum 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. The location of the study area adjacent to a centre of narrow endemism between Gingin and New Norcia (Williams and Mitchell 2001) enhances the value of this role. This is an area containing concentrations of locally endemic plant and animal species, that is, 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, InSight Ecology 2009, 2011).

4.2 Bird assemblages of the study area

4.2.1 Landscape and habitat attributes

Bird assemblages of the Moora-Gillingarra-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, these bird communities have evolved in response to the type, amount, condition, connectivity, spatial arrangement, floristic composition, and structural complexity of habitats available in remnant and planted vegetation at different spatial and temporal scales. Other factors such as the pattern and timing of historical land clearance and influence of fire history and climate change are also implicated.

At the site scale, small variation in the quality, extent, spatial arrangement, floristic composition and structural characteristics of habitats help determine the abundance, diversity and richness of bird assemblages present. Coupled with anthropogenic factors such as degree of physical disturbance - from livestock grazing, removal of understorey and ground cover, fire, logging, firewood collection, pest plant and animal incursion, dieback (*Phytophthora*), and vegetation clearance for road widening and boundary adjustments, these influences shape the type of bird (and other fauna) communities present in the catchment today.

Interspecific differences in the way bird species are able to use their habitat and respond to change in the quality and seasonal availability of these resources also help determine the composition of the bird fauna of the study area. There are even behavioural and tolerance differences between individual birds of the same species that can affect their ability to persist and reproduce in modified habitats and landscapes. These reflect age and genetic factors, e.g. young birds require experience gained over time to know their habitat – where to find food, shelter, mates and how to recognise, avoid or repel potential predators, competitors and nest parasites.

Within the context of the Southwest Australia Ecoregion, bird assemblages of the study area are likely to be less taxonomically and functionally rich than those of more extensive and contiguous woodland and shrubland communities along the Darling Range and to the southeast (e.g. Great Western Woodlands) and south (e.g. Fitzgerald Biosphere Reserve/Gondwana Link). This reflects the degree of loss, fragmentation and modification of remnant native vegetation that has occurred in the Moora-Gillingarra-Calingiri-New Norcia district since European settlement. Some evidence for this exists in the low-moderate number of core (interior) woodland and shrubland bird species that were recorded in the study area's remnants – 29 species from 10 foraging guilds. Three of these guilds were represented by only one or two member species which may, at first glance, indicate a taxonomically depauperate bird fauna. The risk that this might be due to inadequate sampling was substantially minimised by surveying sites thoroughly over two different seasons.

4.2.2 Trajectories of potential change in bird communities

Changes over time and space in the variables that shape bird communities in the study area may be implicated in potential fluxes in the conservation status of bird species and communities in the study area. Trajectories of potential change include persistence, decline, increase/expansion, and potential recovery.

A suite of birds of the interior of woodland and shrubland remnants appear to be currently persisting in the study area, albeit in low-moderate numbers and despite local and landscape-scale threats to their survival. Some of these birds belong to the postulated 'next-wave' of likely extinctions of woodland and shrubland species in the WA wheat-sheepbelt (Recher 1999; InSight Ecology 2008, 2009). They are also termed 'decliners' or 'conservation-reliant species' (InSight Ecology 2007; Scott et al 2010). These are species whose local populations may become extinct if intervention does not occur as the condition, size, connectivity, and intactness of their habitat continues to be eroded by grazing livestock, local land clearing events, cats and foxes, rabbits (as agents of ground cover removal and soil erosion) and weeds. In the study area these include the ground insectivore Scarlet Robin and shrub-foraging insectivores Inland Thornbill, Western Thornbill, Grey Shrike-thrush, and Golden Whistler.

Other bird species appear to have increased in abundance and/or expanded their distributional range across the region. These include common, more resilient birds include mostly ground granivores – Long-billed Corella, Australian Ringneck, Galah, Crested Pigeon and possibly Common Bronzewing, the nectarivore/insectivore Brown Honeyeater, and the canopy insectivore Weebill.

The most abundant species recorded in both remnants and revegetation in the study area – Weebill, Australian Ringneck, Brown Honeyeater, Galah, Splendid Fairy-wren, Australian Raven and Silvereye - are adaptable, opportunistic, and quite resilient species. Some of their member guilds – canopy insectivore, ground granivore, nectarivore/insectivore, and ground insectivore – generally contained other species of greater sensitivity to the local consequences of habitat loss and fragmentation, principally reduced patch size, increased patch isolation, lowered habitat condition, and increased amount of edge. These included Little Button-quail, Red-capped Parrot, Tawny-crowned Honeyeater, Spiny-cheeked Honeyeater, Western Wattlebird, Golden Whistler, Red-capped Robin and Scarlet Robin – most of which were recorded only in woodland and/or shrubland remnants.

A candidate for population recovery in the study area and surrounding wandoo woodland districts is the nationally endangered Carnaby's Black-Cockatoo. This species may be slowly recovering its breeding numbers, largely in response to targeted revegetation and protection/restoration of breeding and non-breeding (on Swan Coastal Plain) and foraging habitat by BirdLife Australia and WWF, together with a network of local community groups.

Some species appear to have gone locally extinct following the large-scale clearance of native woodland and shrubland for farming over 130 years ago and the introduction of mammalian predators 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 71), granivores dependent on suitable tree hollows for nesting (Western Rosella – Plate 72 and Red-tailed Black-Cockatoo (subspecies *naso* – Plate 73), and the Crested Shrike-tit - a canopy insectivore dependent on insects in decorticating bark of large eucalypt woodland remnants (Plate 74).

Plate 71: Bush Stone-curlew – a Vulnerable species in the WA wheatbelt (Garnett and Crowley 2000) (en.wikipedia.org).

Plate 72: Male Western Rosella. The wheat-belt subspecies *xanthogenys* is listed nationally as Near Threatened (Garnett and Crowley 2000) (flickr.com).

Plate 73: Red-tailed Black-Cockatoo, southwest WA subspecies *naso* (female), listed nationally as Near Threatened (Garnett and Crowley 2000).

Plate 74: Crested Shrike-tit (western subspecies *leucogaster*) listed nationally as Near Threatened (Garnett and Crowley 2000) (A. Pattison/Global Twitcher).

4.2.3 Seasonal changes

Fluctuations in the abundance, species richness, and composition of terrestrial bird populations and communities recorded during the study reflected seasonal changes in food availability, species-specific movement patterns including migration, dispersal and nomadism, and timing of surveys during breeding and non-breeding periods. These patterns were particularly evident in remnants but also in older revegetation.

The presence of slightly more birds in remnants and revegetation in autumn compared with spring could be attributed to a number of factors. These include an influx of ground granivores Australian Ringneck (38% more individuals recorded in autumn) and Elegant Parrot (0 individuals in spring, 24 in autumn) from neighbouring areas searching for food, nomadic species tracking seasonally available fruit and other food supplies, e.g. Silvereye (6 birds in spring, 48 in autumn), increased availability of aerial insects for Tree Martin (19 in spring, 48 in autumn), post-natal dispersal of new season young, e.g. Red-capped Robin (3 in spring, 14 in autumn), Splendid Fairy-wren (9 in spring, 26 in autumn) and White-fronted Chat (11 in spring, 18 in autumn), and the higher detectability of sedentary species after the breeding season had finished, e.g. Splendid Fairy-wren and Red-capped Robin.

The numbers of some typical woodland and shrubland species such as Rufous Whistler, Grey Fantail, Weebill, Western Gerygone, Western Thornbill, Striated Pardalote, Singing Honeyeater, Red Wattlebird, and Australian Raven remain unchanged or only slightly varied across both seasons. Decreased supply and presumably lower quality of eucalypt, melaleuca and other nectar flows in autumn relative to spring seems likely to have accounted for a smaller autumn honeyeater component, e.g. Brown Honeyeater numbers fell by 21% and Spiny-cheeked Honeyeater and Western Wattlebird were not recorded.

Fluctuations in the numbers of other bird species reflected the availability of temporary water bodies in spring for several breeding aquatic species and the spring arrival of breeding migratory species from other areas in WA's north, south and east. This latter group included White-winged Triller, Crimson Chat, Spotted Pardalote, Sacred Kingfisher, Shining Bronze-Cuckoo, Horsfield's Bronze-Cuckoo, Rufous Songlark, and Brown Songlark.

Several factors are likely to have been implicated in the observed moderately higher bird species richness of remnants and revegetation in spring relative to autumn. The spring availability of nectar and insects in flowering wandoo, dryandra, calothamnus and other shrubs attracted Western Wattlebird and Spiny-cheeked Honeyeater. Swarming spring insects provided food for two aerial insectivores – Black-faced Woodswallow and White-winged Triller. The 8 summer breeding migrants mentioned above were also present in spring but not autumn. Carnaby's Black-Cockatoo occurred in small/medium-sized breeding populations in spring but not autumn when this species moves to the Swan Coastal Plain for winter. Temporary water bodies attracted 5 aquatic species that were absent by autumn.

Some other factors may help explain the pattern of seasonal changes to bird assemblages observed in the study. These include local (ie. remnant, habitat patch and revegetation block/strip) variation in the condition, food resources, and nesting and refuge value of plant communities, habitat patch and landscape metrics (especially perimeter-area ratio, patch size, shape and connectivity), disturbance history (weeds, feral animals, fire, clearing, recreation), climate change effects, and the need for survey replication over several seasons and years.

4.3 Bird use of habitat

4.3.1 Remnant native vegetation

Remnant woodland, shrubland and wetland habitats continued to provide the main living space for native bird communities in the study area (see also InSight Ecology 2008, 2011). They supported more individuals and species of birds than did planted vegetation. This reflected their larger size and greater structural complexity and floristic diversity which generally provided a wider range of foraging, nesting, roosting and refuge resources than available in revegetation.

Birds recorded only in remnants were ground granivores – Stubble Quail and Long-billed Corella, a canopy granivore – Red-capped Parrot, ground insectivores – Variegated Fairy-wren, Scarlet Robin and Magpie-lark, a shrub insectivore - Golden Whistler, canopy insectivores – Striated Pardalote and Spotted Pardalote, three honeyeaters – Spiny-cheeked Honeyeater, Western Wattlebird and Yellow-throated Miner, four raptors – Wedge-tailed Eagle, Brown Falcon, Peregrine Falcon and Australian Hobby, and 5 aquatic species. Some of these species – Scarlet Robin, Golden Whistler, Spotted Pardalote, Western Wattlebird and Spiny-cheeked Honeyeater are usually associated with core woodland and shrubland habitats. Others such as Western Spinebill, Tawny-crowned Honeyeater, Yellow-plumed Honeyeater and Western Wattlebird exploited the abundance and diversity of nectar and insects associated with spring-flowering ground cover, shrub and tree species available in the multi-layered, fenced-off remnants. Summer visitors from northern and inland areas - White-winged Triller and Sacred Kingfisher - utilised standing dead trees and the outer dead branches of living york gum and wandoo in and adjacent to remnants to perch and launch foraging forays.

Differences in bird species richness that occurred between sampled remnants can be attributed in part to site-specific variation in the size, condition, connectedness, and habitat structural complexity of remnants (see also Section 4.4). Fine-scale variation that occurred within habitats in individual remnants influenced the range and type of microhabitat available for use by birds. This may also have helped shape the composition and structure of resident and migratory bird communities recorded in the study. 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 such as Western Thornbill, Grey Shrike-thrush, Splendid Fairy-wren and some nectarivores/insectivores - Tawny-crowned Honeyeater, Western Spinebill, Yellow-plumed Honeyeater - for sites containing a range of microhabitats.

Observed variations in the condition, structural complexity and floristic diversity of habitats in remnants also reflected the impact of historical land use practices including past land clearing patterns. Examples include cattle grazing in the Flora Downs woodland and wetland remnant (recently fenced) and sheep grazing in the Sammon Hills riparian and wandoo remnants (also now fenced). In contrast, the wandoo/marri remnant surveyed on Carrah Farms has been fenced off for longer than most of the other remnants surveyed in the study. Thus, much of the original or at least older regrowth native vegetation at this site seems to have been retained. In effect, upland remnants surveyed on Carrah Farms and Cooinda Park and the sandplain remnant sampled on Flora Downs are isolates of a once more extensive and better connected woodland/shrubland continuum (Section 4.4). This characterised the Moora-Gillingarra-

Calingiri-New Norcia district prior to the arrival of European settlers. These remnants also provide some of the building blocks needed to re-connect key remnants and landscape units across the study area and as such deserve priority protection, rehabilitation and enhancement (Section 5).

4.3.2 Planted vegetation

Plantings of native and exotic vegetation have been undertaken in parts of the study area since the early 1980s. These were established primarily to mitigate water-logging, control soil erosion, provide windbreaks for crops and livestock, and improve the aesthetic qualities of the landscape. Later (post-1995) plantings have focused on providing wildlife habitat including potential movement corridors, mitigating salt impact, and integrating soil and water management activities to improve sustainability outcomes. These wider, more layered and usually native vegetation strips have introduced a degree of bird habitat complexity into revegetated drainage lines and waterways and linkage into the local landscape. The three revegetation sites along drainage lines on Carrah Farms that were surveyed for birds in this and previous studies (InSight Ecology 2008, 2011) are prime examples of these conservation-focused plantings in the district.

Birds able to forage and, in some cases, breed in the more established (6-11 year-old) plantings have been attracted by developing shrub and canopy cover and an abundance of insect prey. Ground insectivores such as Splendid Fairy-wren and White-winged Fairy-wren called for mates and/or defended breeding territory in older melaleuca-eucalypt-acacia-she-oak revegetation along drainage lines on Carrah Farms. Shrub insectivores such as Grey Fantail, Inland Thornbill and Rufous Whistler nested or were detected calling for mates in 6 and 11 year-old strips on Carrah Farms (revegetation sites 1 and 2). Canopy insectivores including Weebill and Western Gerygone and nectarivores/insectivores - Brown Honeyeater and Red Wattlebird – also foraged and called for potential mates in this revegetation.

For the first time since bird populations have been systematically studied on Carrah Farms (2008), Western Thornbill and Grey Shrike-thrush were recorded foraging in the older site (site 1) on this property. These are species more commonly associated with high quality woodland such as the wandoo/marri ridgeline remnant located nearby (less than 1 km) from these plantings (see Appendix 3).

Younger (9 months-3 years) plantings generally lack the structural complexity and canopy development to offer more than supplementary foraging habitat to a small group of more resilient, adaptable or open country species such as Silvereye, White-fronted Chat and Australasian Pipit. No nests were detected in these younger plantings.

The role and contribution of commercial woody perennial plantings as habitat for birds and other fauna in the study area should not be overlooked. A mix of native - brushwood, eucalypt, saltbush and Australian Sandalwood *Santalum spicatum* - and exotic (tagasaste) species provided important supplementary foraging, roosting and, in some cases, nesting habitat for several bird species. Red-capped Robin foraged in five year-old tagasaste at Flora Downs while Little Button-quail and probably Silvereye nested at that site. Older mixed eucalypt and shrub plantings at Carrah Farms provided foraging, roosting and occasionally nest resources for Splendid Fairy-wren, Silvereye, Shining Bronze-Cuckoo, Western Thornbill, Grey Fantail and Grey Shrike-thrush – all species of woodland and shrubland remnants. Inland Thornbill nested in Carrah Farms' 8 year-old *Melaleuca uncinata* plantings off Langwood Creek.

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 (see Section 4.4). This would be a key beneficial outcome for the conservation of threatened and declining Western Australian biodiversity at the landscape scale.

4.4 Re-connecting bush for birds

Strategic efforts to facilitate the movement of animals (and plants) between different locations within highly fragmented landscapes by increasing connectivity and patch size remain one of the major challenges in conservation biology and landscape restoration. These connectivity conservation (see Worboys and Pulsford 2011) projects are often well intentioned and usually well planned but can fall a long way short of achieving their ultimate objective – to arrest the slide of populations, species and communities toward extinction by improving their movement, dispersal and gene exchange between patches (see Hilty et al 2006 and a corridor effectiveness review by Gilbert-Norton et al 2010).

The failure or poor performance of these projects is often characterised by an absence or inadequate knowledge of the biology and ecology of individual species in highly fragmented landscapes *prior* to the planned intervention. Information is needed about the occurrence, size and composition of and habitat use by species in source or origin (ie. large remnants on one side of a planned corridor) and destination (ie. remnants on the other side of a planned corridor) habitat, reproductive success and recruitment, population demographics (e.g. age and sex ratios), and movement and dispersal patterns including gap-crossing behaviour. Some bird species, for example, are differentially sensitive to crossing gaps between remnants and plantings while others may move along planted 'corridors' but will not necessarily breed in them (see Lynch and Saunders 1991; Saunders and de Rebeira 1991; Haas et al 1995; InSight Ecology 2009). The type and degree of threats present at and near the planned linkage site including mammalian predators (fox and cat), weed species present and extent, livestock grazing, fire management and road maintenance also require consideration.

Other data needed to make informed on-ground decisions about the location, design, construction and maintenance of proposed wildlife corridors and stepping stones relate to the type, size, quality, proximity, connectedness and spatial arrangement of the matrix surrounding the targeted restoration sites. This is the local, district and regional landscape within which the remnants occur (see examples provided in Figures 6-8). It contains habitat that may assist the movement of species across the landscape such as revegetation and remnants along road reserves. Activities such as the clearance of native vegetation to establish mines, highways or other development that happen elsewhere in these landscapes can influence the success or failure of connectivity conservation projects at the property and local scales.

The reality is, however, that much of this information is often time consuming and expensive to obtain. Advances in computer-based modelling techniques offer some assistance. The challenge is to ensure these models are validated using empirical data on avifauna, for example, in

habitats within and surrounding the landscape targeted for restoration. Another approach, the use of indicator and focal species as proxies for other biota that have or are thought to have similar habitat, movement and dispersal requirements, can also help reduce costs associated with obtaining species-specific data to inform these re-connection efforts. These come with some significant caveats and cautions but also a number of potential benefits (reviewed in Huggett 2007). The hope is that by using partial-'umbrella' approaches such as focal species other species will, in time, also be restored to self-sustaining levels thus averting their local extinction.

One challenge to any restoration project that aims to stem the 'tide' of species extinctions in fragmented landscapes is the extinction debt effect. This is the ongoing loss of species from fragmented landscapes long after the original loss and fragmentation of habitat has occurred (Ford et al 2009; Kuussaari et al 2009; Wearn et al 2012). In landscapes such as the Western Australian wheatbelt where much of the clearing took place over 100 years ago, bird species may still be going extinct from small isolated remnants. The implications of this for connectivity conservation efforts require careful consideration especially in the project planning and implementation phases. Knowledge of extinction debt dynamics in a landscape can, however, be used to improve the chances of restoration success and thus help stem the extinction 'tide' by being able to identify areas for conservation where extinction debt is the greatest (see, for example, Wearn et al 2012). Equally important is the need to consider the impact of habitat changes occurring that are not related to fragmentation and which can reduce reproductive success and recruitment in woodland bird populations (see, for example, Fahrig 1997; Ford et al 2001; Ford et al 2009).

There is also a need to be aware of other habitat and landscape restoration options that are available. Strategic revegetation to increase the size of existing remnants and activities that improve habitat condition can be more achievable than attempting to plant extensive areas of new habitat linkages (reviewed in Falcy and Estades 2007). Establishing stepping stones of habitat to facilitate bird and other fauna movement between key remnants is also a well-known option (see, for example, Fischer et al 2006). Buffers around existing key remnants, widening existing remnants in road reserves by re-locating fences into paddocks (requires farmer cooperation), and strategic management of commercial woody perennials as supplementary habitat are other important options. Ideally, a strategic landscape restoration program evaluates and deploys a mix of these interventions to improve connectivity and habitat condition, increase remnant size, and provide supplementary habitat.

Understanding the ecological processes that drive faunal responses to restoration actions and the scale at which they operate are pre-requisites for the effective long-term recovery of species and communities in fragmented landscapes (Wiens et al 2002; Huggett 2005; Lindenmayer et al 2010). In the current study, relevant scales include sub-regional, district and local. The following images provide representative examples of these scales (Figures 6-8). Figures 7 and 8 also indicate suggested locations of strategic interventions to re-connect, enhance and protect habitat for woodland and shrubland birds in the study area and the surrounding landscape (also see Sections 4.5 and 5). The sizes of swaths selected are measured in a straight-line from east to west.

Figure 6: Spatial distribution of remnant native vegetation at the sub-regional scale (400 km swath), from the Indian Ocean coast in the west to parts of the clearing line in the east. The main blocks of remnant native vegetation are shown along the coast, adjoining the southern tip of the study area (Bindoon Military Training Area or BMTA), and east of the clearing line. BMTA is 17,168 ha of wandoo woodland grading into mixed wandoo-jarrah-marri-york gum and banksia woodland and is significantly located, in conservation terms, at the northern end of the Northern Jarrah Forest (DSEWPaC 2012). It connects tracts of quality native woodland along the Darling Range including Julimar State Forest and Perth hills' remnants to the south with nature reserves and privately owned remnants in the study area to the immediate north. This conveys high priority to the protection of this large block and its linkage with these remnants including those on Carrah Farms and Damara Downs. BMTA is listed on the Register of the National Estate. Image: Google™earth (2012).

Figure 7: Spatial distribution of remnant native vegetation at the district scale (56 km swath), from Calingiri in the east to West Gillingarra in the west. Properties surveyed during the study and shown in the image include Carrah Farms, Damara Downs, Cooinda Park and Flora Downs. Suggested sites for increasing habitat connectivity using a mix of corridor and stepping stone plantings and increasing the size and enhancing the condition of existing remnants are shown as a red line, along key riparian zones. Note that these sites are schematic only, requiring site-scale refinement. Image: Google™earth (2012).

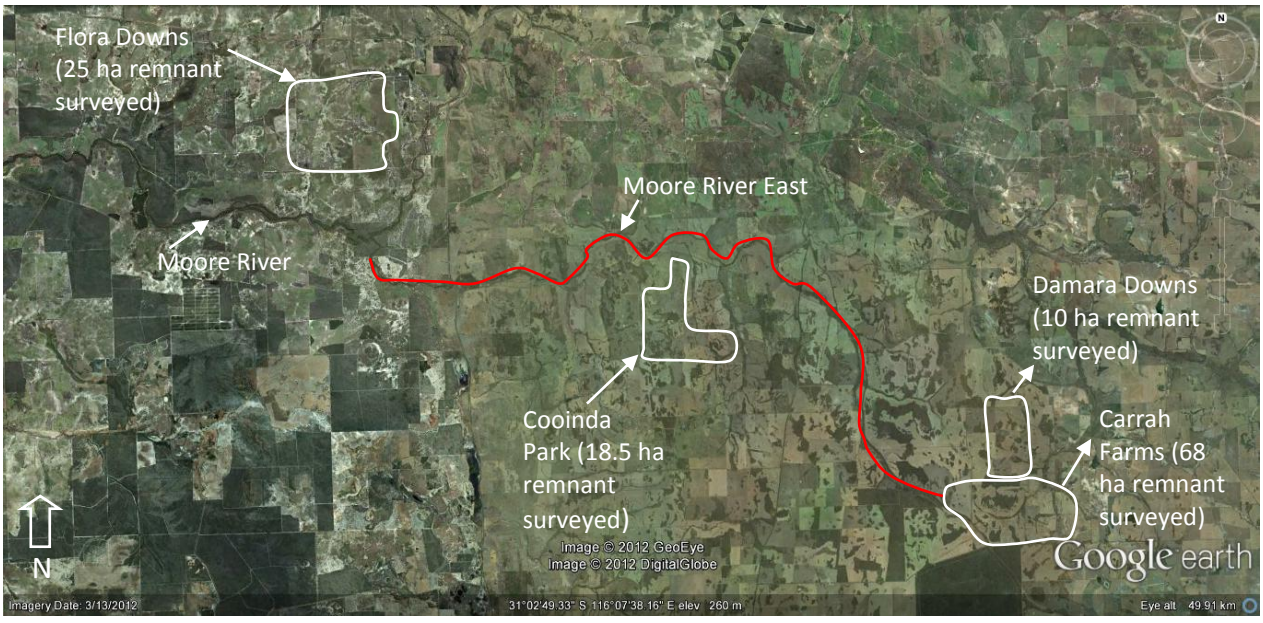
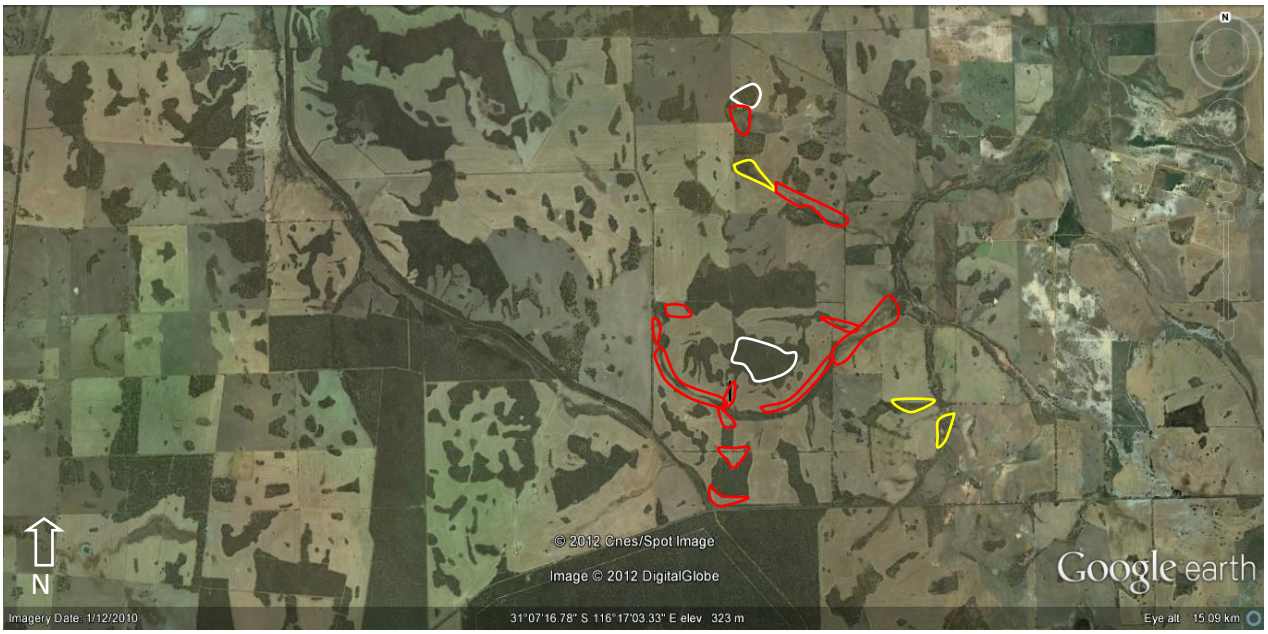


Figure 8: Spatial distribution of remnant native vegetation at the local scale (17 km swath), centring on Carrah Farms and Damara Downs near Calingiri. Enclosed white lines show the location of remnants surveyed in this part of the study area – the smaller remnant on Damara Downs to the north and the larger remnant on Carrah Farms to the south. Yellow lines denote revegetation surveyed in the study on these properties. Suggested sites for increasing habitat connectivity using a mix of corridor and stepping stone plantings and increasing the size and enhancing the condition of existing remnants (where applicable) are shown in red, often along key riparian zones. Note that these sites are schematic only and will require site-scale refinement. Image: Google™earth (2012).



4.5 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. These should focus on ensuring that the 'next wave' of ground-, shrub-, and canopy-foraging insectivores that are most vulnerable to local extirpation are adequately protected and their habitat carefully managed. These are the species and guilds most sensitive to reduced core remnant and habitat size 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). 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. Emphasis is also 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 drainage lines and as buffers around wetlands 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 and maintenance of fences is essential to ensure habitat condition is improved 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). 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.

5. Recommendations

An opportunity still exists to adopt a strategic whole-of-landscape approach to conserving and managing biodiversity in the study area and its 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). It has been recommended in avifaunal work undertaken for the CDI Project (InSight Ecology 2010), Revegetation of Natural Drainage Lines and Protection of Remnant Vegetation in the East Moore Catchment Project (InSight Ecology 2008), and Recovery and Protection of the Moore River Catchment's Threatened Natural Assets Project (InSight Ecology 2011). Strategies and actions contained in the DEC Buntine-Marchagee recovery 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 over three years, 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. This 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.

There remains substantial potential in the study area 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. Some elements of the landscape design approach are already being implemented in Moore River catchment in other projects.

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.

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 this study and previous ones in the catchment, 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, increasing the size of key remnants, 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 advocated 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 farming system.

The recommended specific actions are (some of these have commenced in the district):

- Develop a landscape design for the southern Moore River 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. Funding from the Caring for our Country (CFOC) program, Australian Biodiversity Fund, National Wildlife Corridors Plan, or other sources should be pursued to allow this work to commence. This will require the collaboration of local landholders, LCDCs, 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 southern Moore River 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 (systematicallyfor 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 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), continuing to fence 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 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 possibly declining bird species (e.g. Western Thornbill, Inland Thornbill, Varied Sittella) 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.

Priority attention should be given to connecting existing higher quality remnants on Carrah Farms, Cooinda Park, Flora Downs and Sammon Hills properties to revegetated riparian zones and ridgelines. 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 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 sustained sheep and grazing.

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 auditing) 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 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;
- Devise 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 utilise and respond to revegetation (especially the novel habitat value of crops like tagasaste and saltbush), habitat protection, and land use practices in the study area. These include active adaptive management studies and applied research.

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Appendices

Appendix 1: All individual birds recorded by InSight Ecology during the spring (5-11 October) 2011 survey in the study area

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
1	Common Bronzewing	*Phaps chalcoptera*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	resting	no	
2	Common Bronzewing	*Phaps chalcoptera*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	resting	nd	
3	Common Bronzewing	*Phaps chalcoptera*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	nesting	yes	flushed off nest 4m up in horizontal salmon branch
4	Crested Pigeon	*Ocyphaps lophotes*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	2	foraging	no	10 yr old eucalypts N side main channel
5	Little Black Cormorant	*Phalacrocorax sulcirostris*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, likely nesting	yes	in freshwater seasonal wetland
6	Pied Cormorant	*Phalacrocorax varius*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, likely nesting	yes	in freshwater seasonal wetland
7	White-faced Heron	*Egretta novaehollandiae*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, mate pursuit	yes	in freshwater seasonal wetland
8	White-faced Heron	*Egretta novaehollandiae*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	1	flyover	no	
9	Straw-necked Ibis	*Threskiornis spinicollis*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	nd	in freshwater seasonal wetland
10	Wedge-tailed Eagle	*Aquila audax*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	flyover	no	above freshwater seasonal wetland, mobbed by 2 ravens

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
11	Wedge-tailed Eagle	*Aquila audax*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	flying nr nest	yes	adult female obs flying to nr active nest @ S 30 44 47.2 E 116 21 59.3 (10-15 yo nest in old salmon gum)
12	Nankeen Kestrel	*Falco cenchroides*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	perching	no	in *E.occidentalis* dead branch
13	Nankeen Kestrel	*Falco cenchroides*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	1	foraging	no	
14	Brown Falcon	*Falco berigora*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging	nd	over banksia woodland/heath
15	Australian Hobby	*Falco longipennis*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	perching	no	
16	Purple Swamphen	*Porphyrio porphyrio*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, likely nesting	yes	in freshwater seasonal wetland
17	Eurasian Coot	*Fulica atra*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, likely nesting	yes	in freshwater seasonal wetland
18	Red-capped Plover	*Charadrius ruficapillus*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	3	foraging	no	2 females, 1 male along saltbush main channel
19	Little Button-quail	*Turnix velox*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	2	foraging, likely nesting	yes	flushed fr shallow scrape (likely nest, no eggs) in 50-60 cm high oats and lupins in interrows
21	Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	flyover	not determined (nd)	
22	Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	4	flyover	no	from Mason remnant (nearest further upslope)
23	Carnaby's Black-Cockatoo	*Calyptorhynchus latirostris*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	2	0	calling, nesting (?)	nd	perched in wandoo

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
24	Galah	*Eolophus roseicapillus*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	3	perching, flying	no	Goodden Gully eucs, sheoaks & melaleuca
25	Galah	*Eolophus roseicapillus*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	2	foraging	no	N edge of channel along 10 yr old planted eucs
26	Galah	*Eolophus roseicapillus*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	flyover	no	
27	Galah	*Eolophus roseicapillus*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	4	0	calling, nesting	yes	in wandoo
28	Galah	*Eolophus roseicapillus*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	33	0	nesting, calling	yes	min 3 pairs nesting in wandoo
29	Galah	*Eolophus roseicapillus*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	8	0	nesting, calling, defending	yes	nesting in old larger york gum along ck
30	Galah	*Eolophus roseicapillus*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	10	0	calling, foraging, nesting	yes	in older Salmon Gum
31	Long-billed Corella	*Cacatua tenuirostris*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	12	0	calling, foraging, nesting	yes	in older Salmon Gum
32	Little Corella	*Cacatua sanguinea*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	flyover	nd	
33	Little Corella	*Cacatua sanguinea*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	6	0	nesting, calling, flying	yes	in wandoo
34	Little Corella	*Cacatua sanguinea*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	perching, calling	nd	not as many suitable nest holes in york gum as wandoo
35	Australian Ringneck	*Barnardius zonarius*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	7	0	calling, mate pursuit	yes	
36	Australian Ringneck	*Barnardius zonarius*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	7	foraging, flying	no	
37	Australian Ringneck	*Barnardius zonarius*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	7	0	nesting, calling, defending	yes	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
38	Australian Ringneck	*Barnardius zonarius*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	21	0	feeding, calling, nesting	yes	nesting in old wandoo, feeding on everlasting daisy-like heads
39	Australian Ringneck	*Barnardius zonarius*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	4	foraging, calling	nd	
40	Australian Ringneck	*Barnardius zonarius*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	3	flyover	no	
41	Australian Ringneck	*Barnardius zonarius*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	6	0	calling, nesting	yes	in wandoo
42	Australian Ringneck	*Barnardius zonarius*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	4	0	nesting	yes	in wandoo
43	Australian Ringneck	*Barnardius zonarius*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	4	0	foraging, calling	likely	
44	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	calling, perching	nd	in isolated marri nr plantings with w/w trillers & rufous songlark (along Langwood Ck)
45	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	1	calling	nd	calling from dead branch of Nutysia isolate within patch
46	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	O71011	1300-1310	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	5	perching, nest detecting	yes	attempting to parasitise Inland Thornbill nest in 8 yo *Melaleuca uncinata* rows nr paddock & old marri
47	Shining Bronze-Cuckoo	*Chalcites lucidus*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	6	foraging, mate calling	yes	mostly males in 8 yrold salt river gum, acacia, melaleuca uncinata & flat-topped yate (*E. occidentalis*) plantings
48	Laughing Kookaburra	*Dacelo novaeguineae*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	flyover to main creek	likely	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
49	Sacred Kingfisher	*Todiramphus sanctus*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	calling, mate pursuit	yes	pair in wandoo breakaway
50	Sacred Kingfisher	*Todiramphus sanctus*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	foraging, calling	nd	along flowing Langwood Creek
51	Sacred Kingfisher	*Todiramphus sanctus*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	calling	nd	
52	Sacred Kingfisher	*Todiramphus sanctus*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	foraging, calling	likely	wandoo ridgetop
53	Splendid Fairy-wren	*Malurus splendens*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	nd	one adult male nr granite boulders southern slope heath patch (usual spot)
54	Splendid Fairy-wren	*Malurus splendens*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	2	foraging	nd	in 1.7m *Melaleuca uncinata* nr paddock edge along Goodden Gully
55	Splendid Fairy-wren	*Malurus splendens*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	6	0	foraging, territory calling, flying	yes	
56	White-winged Fairy-wren	*Malurus leucopterus*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	4	territory calling, foraging	yes	eclipse-plumage male and 3 females in *M. thyoides* and saltbush plantings along Langwood Ck
57	White-winged Fairy-wren	*Malurus leucopterus*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	6	foraging	yes	group in isolates of pink-flowering grevillea, Hakea and Dryandra 20 m S samphire drainage line containing planted saltbush
58	Variegated Fairy-wren	*Malurus lamberti*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	4	0	foraging, territory calling	yes	moving between weed edge of adjacent wheat crop & 20m back to remnant
59	Variegated Fairy-wren	*Malurus lamberti*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	5	0	foraging, territory calling	yes	2 adult males, one female and 3 immat birds in heath

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
60	Weebill	*Smicrornis brevirostris*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	4	0	calling, mate pursuit & territory defence	yes	
61	Weebill	*Smicrornis brevirostris*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	3	foraging, calling, mate pursuits	yes	in *E. occidentalis* & *E. sargentii* + sheoaks & acacia
62	Weebill	*Smicrornis brevirostris*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	5	foraging	no	in 3 m swamp mallet & taller eucs N side gully
63	Weebill	*Smicrornis brevirostris*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	2	0	foraging, calling	nd	
64	Weebill	*Smicrornis brevirostris*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	12	0	foraging, calling	likely	
65	Weebill	*Smicrornis brevirostris*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	11	0	foraging, territory calling, mate pursuits	yes	
66	Weebill	*Smicrornis brevirostris*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	3	foraging, calling	nd	
67	Weebill	*Smicrornis brevirostris*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	5	foraging	nd	male in 10 yrold eucs and allocasuarina plantings N side main channel; and S side main channel plantings
68	Weebill	*Smicrornis brevirostris*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	3	0	calling, foraging	yes	in wandoo
69	Western Gerygone	*Gerygone fusca*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	8	0	calling, territory calling	yes	
70	Western Gerygone	*Gerygone fusca*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	4	foraging, mate calling	yes	in *E. occidentalis* & *E. sargentii* + sheoaks & acacia

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
71	Western Gerygone	*Gerygone fusca*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	3	foraging, calling	no	in taller eucs/dead sheoaks N side of gully
72	Western Gerygone	*Gerygone fusca*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	5	0	foraging, calling	yes	2 grps; 1 of 2 birds foraging ground and lower canopy in wandoo, with WT, 2nd grp giving extended call in Darwinia plot
73	Western Gerygone	*Gerygone fusca*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging	nd	in blackbutt woodland bordering wetland
74	Western Gerygone	*Gerygone fusca*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	5	0	territory calling, mate pursuits, foraging	yes	musical extended (territory?) call noted; ground and understorey foraging with Western Thornbill group under wandoo & on ant-like insects on wandoo sap stains
75	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	2	0	foraging	nd	
76	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	2	foraging	nd	
77	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	4	foraging, calling	nd	in 10 yr old euc & allocasuarina N side plantings
78	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	3	foraging, calling	nd	along fenceline and into tag rows
79	Western Thornbill	*Acanthiza inornata*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	5	0	foraging, courtship feeding	yes	male obs courtship feeding female in flowering *Melaleuca radula* (insects) stand (SE facing below wandoo breakaway); 3 others in group foraging over fallen debris

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
80	Western Thornbill	*Acanthiza inornata*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	5	0	foraging, calling, with 1 young	yes	adults + 1 fledgling foraging on ground, over logs, in wandoo foliage to 3m and on ant-like insects on wandoo sap stains, with Western Gerygone grp @ S 31 03 02.3 E 116 08 48.0
81	Inland Thornbill	*Acanthiza apicalis*	O71011	1300-1310	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	4	defending nest from Horsfields Bronze-Cuckoo	yes	nesting in 8 yo *Melaleuca uncinata* rows nr paddock & old marri (5 Horsfield Bronze-Cuckoo perched)
82	Spotted Pardalote	*Pardalotus punctatus*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	foraging, calling	nd	
83	Striated Pardalote	*Pardalotus striatus*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	6	0	foraging, mate calling & pursuits	yes	2 males & 1 female in 1 grp
84	Striated Pardalote	*Pardalotus striatus*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	4	0	calling, foraging	yes	1 pair in Darwinia enclosed area on Wandoo ridgetop and other nr WSW edge of remnant
85	Striated Pardalote	*Pardalotus striatus*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	1	0	calling	nd	
86	Striated Pardalote	*Pardalotus striatus*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	calling	nd	
87	Striated Pardalote	*Pardalotus striatus*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	calling	nd	
88	Singing Honeyeater	*Lichenostomus virescens*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	1	foraging	no	in 4m dense flowering *Melaleuca uncinata*
89	Singing Honeyeater	*Lichenostomus virescens*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	nd	over banksia woodland/heath

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90	Singing Honeyeater	*Lichenostomus virescens*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	3	foraging, flying, calling	nd	in 10 yr old euc & allocasuarina N side plantings
91	Yellow-plumed Honeyeater	*Lichenostomus ornatus*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	nd	
92	Yellow-throated Miner	*Manorina flavigula*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	5	0	calling, flying	nd	
93	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	5	0	foraging, calling, competing with Little Wattlebird	yes	in banksia/blackbutt woodland; competing aggressively with Little Wattlebird for banksia access
94	Western Wattlebird	*Anthochaera lunulata*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	4	0	foraging, territory defence calling	yes	in banksia/blackbutt woodland; defending territory and banksia access against Spiny-cheeked HE
95	Red Wattlebird	*Anthochaera carunculata*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	calling, perching	yes	in isolated york gum and flew into *Melaleuca thyoides* plantings
96	Red Wattlebird	*Anthochaera carunculata*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	1	foraging	no	
97	Red Wattlebird	*Anthochaera carunculata*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	9	0	foraging, calling, feeding yng	yes	with 3 recent fledglings being fed insects by adults in flowering york gum along ck

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
98	Crimson Chat	*Epthianura tricolor*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	11	foraging, flying, calling	nd	one adult male, one adult female in saltbush drainage channel; 2nd group of 9 birds (3 adult males, rest females & sub-adults) flew to edge eucalypt plantings with windrowed debris piles and in Acacia isolates fringing samphire side tributary of main channel
99	White-fronted Chat	*Epthianura albifrons*	101011	0830-1100	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	11	foraging, flying, calling	no	total 3 separate groups: 2 flyover; 2nd group of 6 incl 2 adult males, 2 adult females & 2 sub-adults foraging in saltbush ridge-swale sequences of main channel on small leaf and ground insects; 3rd group of 3 in samphire side tributary nr Crimson Chat group
100	Tawny-crowned Honeyeater	*Glyciphila melanops*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	foraging	nd	in flowering tall Dryandra ridgetop patch
101	Brown Honeyeater	*Lichmera indistincta*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	15	0	foraging, territory calling	yes	in flowering wandoo patches
102	Brown Honeyeater	*Lichmera indistincta*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	7	foraging, mate calling	yes	in insect-laden *E. sargentii* & *E. occidentalis* plantings
103	Brown Honeyeater	*Lichmera indistincta*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	4	foraging	no	in taller eucs/dead sheoaks N side of gully
104	Brown Honeyeater	*Lichmera indistincta*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	19	0	foraging, territory calling, flying	yes	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
105	Brown Honeyeater	*Lichmera indistincta*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	7	0	foraging, territory calling, mate pursuits	yes	in flowering wandoo (patchy)
106	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	no	
107	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O61011	0820-0940	Harridge/Nixon riparian remnant	S 31 03 19.0 E 116 09 25.8	3	0	calling, perching	yes	in wandoo along creek
108	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	perching	nd	in freshwater seasonal wetland
109	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	2	foraging	nd	
110	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	calling	nd	
111	White-winged Triller	*Lalage sueurii*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	5	perching	nd	3 males & 2 females in isolated marri nr plantings with rufous songlark & horsfield's bronze-cuckoo
112	White-winged Triller	*Lalage sueurii*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	nd	in freshwater seasonal wetland
113	Golden Whistler	*Pachycephala pectoralis*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	nd	immat male in wandoo ridgetop
114	Rufous Whistler	*Pachycephala rufiventris*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	3	foraging, mate calling	yes	2 adult males and 1 female in isolated york gum remnant and planted allocasuarina
115	Rufous Whistler	*Pachycephala rufiventris*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	2	foraging	no	in taller eucs N side of gully
116	Rufous Whistler	*Pachycephala rufiventris*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	nd	male in 10 yrold eucs and allocasuarina plantings N side main channel

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
117	Rufous Whistler	*Pachycephala rufiventris*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, territory calling	yes	2 males territory calling
118	Rufous Whistler	*Pachycephala rufiventris*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	calling	no	adult male
119	Rufous Whistler	*Pachycephala rufiventris*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	3	0	foraging, mate calling, contests	yes	2 adult males competing for 1 adult female
120	Grey Shrike-thrush	*Colluricincla harmonica*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	nd	in flowering white thryptomene patch of marri/wandoo ridgetop
121	Grey Shrike-thrush	*Colluricincla harmonica*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	no	in heathy banksia woodland
122	Black-faced Woodswallow	*Artamus cinereus*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	nd	
123	Grey Butcherbird	*Cracticus torquatus*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	1	0	calling	nd	
124	Grey Butcherbird	*Cracticus torquatus*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	1	foraging, calling	yes	male calling from dead branches & Nutysia isolates
125	Grey Butcherbird	*Cracticus torquatus*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	1	0	foraging	no	obs taking mantid
126	Pied Butcherbird	*Cracticus nigrogularis*	O81011	0925-1010	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	foraging	nd	
127	Pied Butcherbird	*Cracticus nigrogularis*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	no	in 10 yr old eucs along N edge of saltbush channel
128	Australian Magpie	*Cracticus tibicen*	O91011	0835-0910	Pearson Wandoo remnant	S 30 49 10.9 E 116 34 35.0	1	0	foraging	no	

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129	Australian Magpie	*Cracticus tibicen*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	foraging	yes	with 1 juvenile
130	Australian Magpie	*Cracticus tibicen*	O91011	1015-1045	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	1	foraging	nd	
131	Australian Magpie	*Cracticus tibicen*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	no	
132	Australian Magpie	*Cracticus tibicen*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	1	foraging, calling	yes	
133	Grey Fantail	*Rhipidura albiscapa*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	foraging, calling, mate pursuit	yes	pair in old wandoo nr new house site
134	Grey Fantail	*Rhipidura albiscapa*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	2	foraging, calling, flying	yes	
135	Grey Fantail	*Rhipidura albiscapa*	O51011	1710-1820	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	1	foraging	no	taller drought stricken eucs and sheoaks N side of gully
136	Grey Fantail	*Rhipidura albiscapa*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	1	0	nesting	yes	in wandoo shrubland halfway up slope
137	Grey Fantail	*Rhipidura albiscapa*	O61011	1000-1120	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	1	0	nesting	yes	in wandoo woodland top of ridge @ S 31˚02'57.0" E 116˚08'50.0"
138	Willie Wagtail	*Rhipidura leucophrys*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	2	foraging	no	in 10 yr old eucs along N edge of saltbush channel
139	Willie Wagtail	*Rhipidura leucophrys*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	nesting, calling	yes	in york gum remnant beside plantings
140	Australian Raven	*Corvus coronoides*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, chasing WT Eagle	yes	in freshwater seasonal wetland

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
141	Australian Raven	*Corvus coronoides*	O91011	1725-1830	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	4	0	calling, foraging	likely	old nest found in Salmon Gum
142	Australian Raven	*Corvus coronoides*	111011	1740-1820	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	2	flyover	yes	
143	Magpie-lark	*Grallina cyanoleuca*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	4	0	foraging	nd	edge of Banksia woodland
144	Red-capped Robin	*Petroica goodenovii*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	3	0	foraging, territory calling	yes	adult male and female feeding/decoying away from 1 wk-old fledgling in wandoo
145	Rufous Songlark	*Cincloramphus mathewsi*	O51011	1600-1700	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	calling, perching	nd	in isolated marri nr plantings with White-winged Trillers & Horsfield's Bronze-Cuckoo
146	Rufous Songlark	*Cincloramphus mathewsi*	O61011	1605-1825	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	perching, calling, flying (male display flights)	yes	one male and one female flying from canopy perches in blackbutt woodland bordering wetland
147	Rufous Songlark	*Cincloramphus mathewsi*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	perching, calling, foraging	no	1 male in N side planted eucs and allocasuarina along fenceline
148	Rufous Songlark	*Cincloramphus mathewsi*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	3	perching, calling, aerial displays	yes	3 calling males, likely female nearby; using coastal blackbutt & Nuytsia isolates & tops of tall tag as calling stations & lookouts
149	Rufous Songlark	*Cincloramphus mathewsi*	111011	1740-1820	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	2	perced, calling	yes	2 males calling for females & territorial displays into adjacent paddock on powerline wires (pics)

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
150	Brown Songlark	*Cincloramphus cruralis*	101011	1105-1120	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	3	perching, calling, foraging	no	3 calling males along edge of saltbush and planted eucalypts
151	Silvereye	*Zosterops lateralis*	O51011	1030-1110	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	4	foraging, calling, flying	yes	in edge plantings of 8 yrold salt river gum & yate
152	Silvereye	*Zosterops lateralis*	111011	1050-1130	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	2	calling, perching, likely nesting	yes	used tops of tag as lookouts and calling stations; responded to squeaking so likely breeding within tag
153	Tree Martin	*Petrochelidon nigricans*	O51011	0755-1005	Mason remnant	S 31 07 29.9 E 116 18 02.1	10	0	foraging, nesting, calling	yes	colony nesting in old wandoo spouts nr new house area
154	Tree Martin	*Petrochelidon nigricans*	111011	1640-1720	Woods remnant	S 31 05 50.1 E 116 18 04.0	9	0	foraging, nesting	no	at wandoo spouts

Appendix 2: All individual birds recorded by InSight Ecology during the autumn (24-27 April) 2012 survey in the study area

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
1	Stubble Quail	*Coturnix pectoralis*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	flushed	no	E edge of remnant by Joe Tonga (confirmed)
2	Common Bronzewing	*Phaps chalcoptera*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	3	0	foraging, resting	no	
3	Common Bronzewing	*Phaps chalcoptera*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	2	0	calling, flying	yes	pre-breeding call
4	Crested Pigeon	*Ocyphaps lophotes*	250412	1010-1045	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	2	resting	no	under low-cut tag shade
5	Crested Pigeon	*Ocyphaps lophotes*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	1	foraging	no	main channel edge with planted eucs
6	Crested Pigeon	*Ocyphaps lophotes*	270412	1030-1045	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	2	foraging	no	S side main channel plantings
7	White-faced Heron	*Egretta novaehollandiae*	260412	0900-0930	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	1	flyover	no	to upstream dam
8	Black-shouldered Kite	*Elanus axillaris*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	1	foraging	no	over main channel samphire & low saltbush
9	Wedge-tailed Eagle	*Aquila audax*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	nesting	yes	obs (+ pics) by Joe Tonga on wandoo ridgeline @ S 31 07 54.7 E 116 18 24.7 inactive nest, likely adult female
10	Wedge-tailed Eagle	*Aquila audax*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	perched, flying	no	adults likely after rabbits in dead york gum W bank ck nr rented house @1720, then flew upstream
11	Brown Falcon	*Falco berigora*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	flyover	no	with rodent towards main farm house

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
12	Peregrine Falcon	*Falco peregrinus*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	perched on dead wandoo outer branch	no	observed & photographed (confirmed) by Joe Tonga on N side of remnant nr new house site
13	Galah	*Eolophus roseicapillus*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	9	0	perching, calling, flying	no	
14	Galah	*Eolophus roseicapillus*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	30	0	foraging, calling, flying, perching	yes	some foraging on spilt grain in adjacent paddock feeder
15	Galah	*Eolophus roseicapillus*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	4	0	perched, calling	no	
16	Galah	*Eolophus roseicapillus*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	12	0	perched, calling, flying	yes	nesting in dead and live wandoo
17	Galah	*Eolophus roseicapillus*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	2	flyover	no	
18	Long-billed Corella	*Cacatua tenuirostris*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	2	0	perching, calling, flying	no	
19	Long-billed Corella	*Cacatua tenuirostris*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	13	0	calling, foraging, flying	no	ca 100-120 flock observed at harvest (Nick Scotney)
20	Australian Ringneck	*Barnardius zonarius*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	8	0	foraging, calling	no	
21	Australian Ringneck	*Barnardius zonarius*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	perched	no	
22	Australian Ringneck	*Barnardius zonarius*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	7	flying, calling	no	through planted rows W bank from old york gums
23	Australian Ringneck	*Barnardius zonarius*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	flyover	no	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
24	Australian Ringneck	*Barnardius zonarius*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	9	0	foraging, calling	no	
25	Australian Ringneck	*Barnardius zonarius*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	9	0	foraging, calling, flying	no	
26	Australian Ringneck	*Barnardius zonarius*	260412	0900-0930	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	3	foraging, flying	no	foraging in grassy inter-rows
27	Australian Ringneck	*Barnardius zonarius*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	5	0	perching, calling, flying	no	
28	Australian Ringneck	*Barnardius zonarius*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	30	0	foraging, calling, flying	no	
29	Australian Ringneck	*Barnardius zonarius*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	7	0	calling, foraging, flying	no	
30	Australian Ringneck	*Barnardius zonarius*	270412	1030-1045	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	2	flyover	no	S side main channel plantings
31	Australian Ringneck	*Barnardius zonarius*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	4	foraging, flying	no	
32	Red-capped Parrot	*Purpureicephalus spurius*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	calling	no	in old ridgetop wandoo
33	Elegant Parrot	*Neophema elegans*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	24	foraging, calling, flying	no	paddock edge and fenceline beside first rows of reveg E of ck nr road fr Langwood Cottage then down to creek plantings
34	Southern Boobook	*Ninox novaeseelandiae*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	flushed from wandoo day roost	no	E edge main remnant (Joe Tonga's obs - confirmed)

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
35	Laughing Kookaburra	*Dacelo novaeguineae*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	foraging, calling	no	W upper slope nr ck
36	Splendid Fairy-wren	*Malurus splendens*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	3	0	foraging, calling, flying	no	2 non-breeding plumage males and 1 female moving between tammar and M. radula shrubland patches
37	Splendid Fairy-wren	*Malurus splendens*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	foraging	no	adult male in Melaleuca & acacia clumps
38	Splendid Fairy-wren	*Malurus splendens*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	6	foraging, calling, moving	no	2 grps moving between 2-4m tall Melaleucas E bank of ck through reedy ck to younger Melaleuca plantings W bank
39	Splendid Fairy-wren	*Malurus splendens*	240412	1735-1750	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	3	foraging, calling	no	in gully melaleuca, pre-roosting
40	Splendid Fairy-wren	*Malurus splendens*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	10	0	foraging, calling, flying	no	heathy Blackbutt & flowering Banksia woodland
41	Splendid Fairy-wren	*Malurus splendens*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	3	0	pre-roosting	no	adult male, 2 females in regrowth wandoo nr SW cnr fence
42	White-winged Fairy-wren	*Malurus leucopterus*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	7	foraging, calling, flying	no	adulkt male, 2 adult females, juveniles - in young saltbush S side of main drainage ditch
43	Weebill	*Smicrornis brevirostris*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	foraging, calling	no	upper slope wandoo
44	Weebill	*Smicrornis brevirostris*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	3	foraging, calling	no	taller eucs near S fenceline
45	Weebill	*Smicrornis brevirostris*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	foraging	no	in planted eucs row at S end

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
46	Weebill	*Smicrornis brevirostris*	240412	1735-1750	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	5	foraging, decoy flights	yes	started @ S 31 07 56.4 E 116 19 36.2; in drier salmon gum & allocasuarina rows; decoys suggested young nearby
47	Weebill	*Smicrornis brevirostris*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	14	0	foraging, calling	no	
48	Weebill	*Smicrornis brevirostris*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	3	0	foraging, calling	no	
49	Weebill	*Smicrornis brevirostris*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	10	0	foraging, calling	no	2 grps of 5 each: 1 upstream and other downstream
50	Weebill	*Smicrornis brevirostris*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	2	calling, foraging	no	in wandoo isolates within plantation
51	Western Gerygone	*Gerygone fusca*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	4	0	foraging, calling	no	
52	Western Gerygone	*Gerygone fusca*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	4	foraging, calling	no	
53	Western Gerygone	*Gerygone fusca*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	5	foraging, calling, flying	no	with Weebill in planted eucs E end of site nr road
54	Western Gerygone	*Gerygone fusca*	240412	1735-1750	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	2	foraging	no	drier salmon gum slope
55	Western Gerygone	*Gerygone fusca*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	no	Blackbutt & Banksia woodland
56	Western Gerygone	*Gerygone fusca*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	foraging, calling	no	wandoo & dryandra ridgetop
57	Western Gerygone	*Gerygone fusca*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	2	0	foraging	no	
58	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	3	0	foraging, calling	no	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
59	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	foraging	no	nr sandalwood plantation along creekline
60	Western Thornbill	*Acanthiza inornata*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	6	0	foraging, calling	no	foraging with Splendid FW group in low-medium Melaleuca radula and Isopogon shrubland SE slope
61	Western Thornbill	*Acanthiza inornata*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	5	foraging, calling,flying	no	in Melaleuca, allocasuarina & taller eucs - likely entered from main remnant
62	Western Thornbill	*Acanthiza inornata*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	5	0	foraging, calling	no	lower slope wandoo regrowth nr S fence below breakaway
63	Inland Thornbill	*Acanthiza apicalis*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	foraging	no	through planted rows Melaleuca, Allocasuarina & eucs, with WG & Weebill
64	Striated Pardalote	*Pardalotus striatus*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	4	0	calling, foraging	no	lower slope (wandoo regrowth)
65	Striated Pardalote	*Pardalotus striatus*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	3	0	foraging, calling	no	
66	Striated Pardalote	*Pardalotus striatus*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	3	0	foraging, calling	no	
67	Striated Pardalote	*Pardalotus striatus*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	1	0	foraging, calling	no	
68	Striated Pardalote	*Pardalotus striatus*	270412	0810-0915	Scotney wandoo remnant	270413	1	0	calling	no	
69	Western Spinebill	*Acanthorhynchus superciliosus*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	calling	no	in flowering Banksia menziesii & prionotes woodland
70	Singing Honeyeater	*Lichenostomus virescens*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	foraging, calling, flying	no	flying from older york gum isolates up ck into Melaleuca & euc plantings

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
71	Singing Honeyeater	*Lichenostomus virescens*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	3	0	foraging, calling	no	in flowering Banksia menziesii W edge of heath
72	Yellow-plumed Honeyeater	*Lichenostomus ornatus*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	no	in marri tops (immature plumage)
73	Yellow-plumed Honeyeater	*Lichenostomus ornatus*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	foraging	no	in older york gum near road starting flowering then into plantings
74	Yellow-throated Miner	*Manorina flavigula*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	5	0	foraging, calling	no	
75	Yellow-throated Miner	*Manorina flavigula*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	foraging, calling	no	
76	Red Wattlebird	*Anthochaera carunculata*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	foraging, calling	no	in old york gum along creek bordered by plantings
77	Red Wattlebird	*Anthochaera carunculata*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, calling	no	in flowering Banksia prionotes
78	Red Wattlebird	*Anthochaera carunculata*	260412	1615-1640	Pearson wandoo remnant	S 30 49 10.9 E 116 34 35.0	1	0	foraging, calling	no	
79	Red Wattlebird	*Anthochaera carunculata*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	7	0	foraging, calling	no	hawking insects on warm day in upstream york gums
80	Red Wattlebird	*Anthochaera carunculata*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	2	calling, foraging	no	in wandoo isolates within plantation
81	White-fronted Chat	*Epthianura albifrons*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	12	foraging, calling, flying	no	paddock edge and fenceline beside first rows of reveg E of ck nr road fr Langwood Cottage then down to creek plantings
82	White-fronted Chat	*Epthianura albifrons*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	6	foraging, calling, flying	no	in saltbush and samphire main channel, in loose groups

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
83	Tawny-crowned Honeyeater	*Glyciphila melanops*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	3	0	foraging, calling, flying	no	flying between dead branches of young post-fire wandoo regrowth (SE slope)
84	Brown Honeyeater	*Lichmera indistincta*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	6	0	foraging, calling	no	nr WT Eagle nest in soon to flower dryandra
85	Brown Honeyeater	*Lichmera indistincta*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	2	foraging, calling, flying	no	in flowering euc nr road then into Melaleuca & euc plantings along ck
86	Brown Honeyeater	*Lichmera indistincta*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	20	0	foraging, calling, flying	no	Blackbutt & flowering Banksia woodland
87	Brown Honeyeater	*Lichmera indistincta*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	6	0	foraging, calling, flying	no	reported very poor nectar flows from Wandoo this year (local apiarist via Bob Harrdige); no wandoo flowering this site; taking Calothamnus nectar nr fence @ S 31 02 56.6 E 116 08 54.5
88	Brown Honeyeater	*Lichmera indistincta*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	6	0	foraging, calling	no	
89	Brown Honeyeater	*Lichmera indistincta*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	perched	no	nr sandalwood plantation along creekline
90	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	no	
91	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	foraging	no	hovered over rows of planted melaleucas & allocasuarina
92	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	2	0	perching	no	
93	Rufous Whistler	*Pachycephala rufiventris*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging, calling	no	adult male
94	Rufous Whistler	*Pachycephala rufiventris*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	2	foraging, calling	no	adult male and female in taller eucs & allocasuarina

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
95	Rufous Whistler	*Pachycephala rufiventris*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	3	0	calling, foraging	no	2 adult males, 1 adult female in Banksia woodland
96	Rufous Whistler	*Pachycephala rufiventris*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	foraging, calling	no	adult male & female on ridgetop
97	Rufous Whistler	*Pachycephala rufiventris*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	2	0	foraging, calling	no	adult male & female
98	Rufous Whistler	*Pachycephala rufiventris*	270412	0810-0915	Scotney wandoo remnant	270413	1	0	calling	no	
99	Grey Shrike-thrush	*Colluricincla harmonica*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	calling	no	
100	Grey Shrike-thrush	*Colluricincla harmonica*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	foraging, calling	no	immature with bronze eyebrow and frontal streaks
101	Grey Shrike-thrush	*Colluricincla harmonica*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	foraging	no	Banksia and Blackbutt woodland
102	Grey Shrike-thrush	*Colluricincla harmonica*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	1	0	calling	no	below S breakaway slope of wandoo
103	Black-faced Woodswallow	*Artamus cinereus*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	1	perched	no	on fence along SW cnr of plantation @ S 30 49 04.6 E 116 15 43.9
104	Grey Butcherbird	*Cracticus torquatus*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	calling	no	
105	Grey Butcherbird	*Cracticus torquatus*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	foraging, calling	no	adult
106	Grey Butcherbird	*Cracticus torquatus*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	2	0	calling, foraging	no	
107	Pied Butcherbird	*Cracticus nigrogularis*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	1	perched, calling	no	in old marri E edge of older plantings (nr bronze-cuckoo site last spring)
108	Australian Magpie	*Cracticus tibicen*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	1	0	perched	no	in blackbutt at edge heath

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
109	Australian Magpie	*Cracticus tibicen*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	pre-roosting	no	in ridgetop wandoo
110	Australian Magpie	*Cracticus tibicen*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	1	0	foraging	no	
111	Australian Magpie	*Cracticus tibicen*	260412	0900-0930	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	1	flyover	no	
112	Australian Magpie	*Cracticus tibicen*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	foraging	no	
113	Australian Magpie	*Cracticus tibicen*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	1	foraging	no	
114	Australian Magpie	*Cracticus tibicen*	270412	1030-1045	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	no	S side main channel plantings
115	Grey Fantail	*Rhipidura albiscapa*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	2	0	foraging, calling	no	
116	Grey Fantail	*Rhipidura albiscapa*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	foraging, calling	no	
117	Grey Fantail	*Rhipidura albiscapa*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	2	0	foraging, calling	no	heathy Blackbutt & flowering Banksia woodland
118	Grey Fantail	*Rhipidura albiscapa*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	1	0	foraging, calling	no	along ck nr house access rd
119	Willie Wagtail	*Rhipidura leucophrys*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	1	perched	no	on fenceline E edge of strip
120	Willie Wagtail	*Rhipidura leucophrys*	270412	0940-1025	Scotney saltbush	S 30 46 46.2 E 116 20 36.5	0	1	flyover	no	from planted eucs N bank of main channel
121	Willie Wagtail	*Rhipidura leucophrys*	270412	1030-1045	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	no	adult male in Melaleuca & euc plantings S of main channel

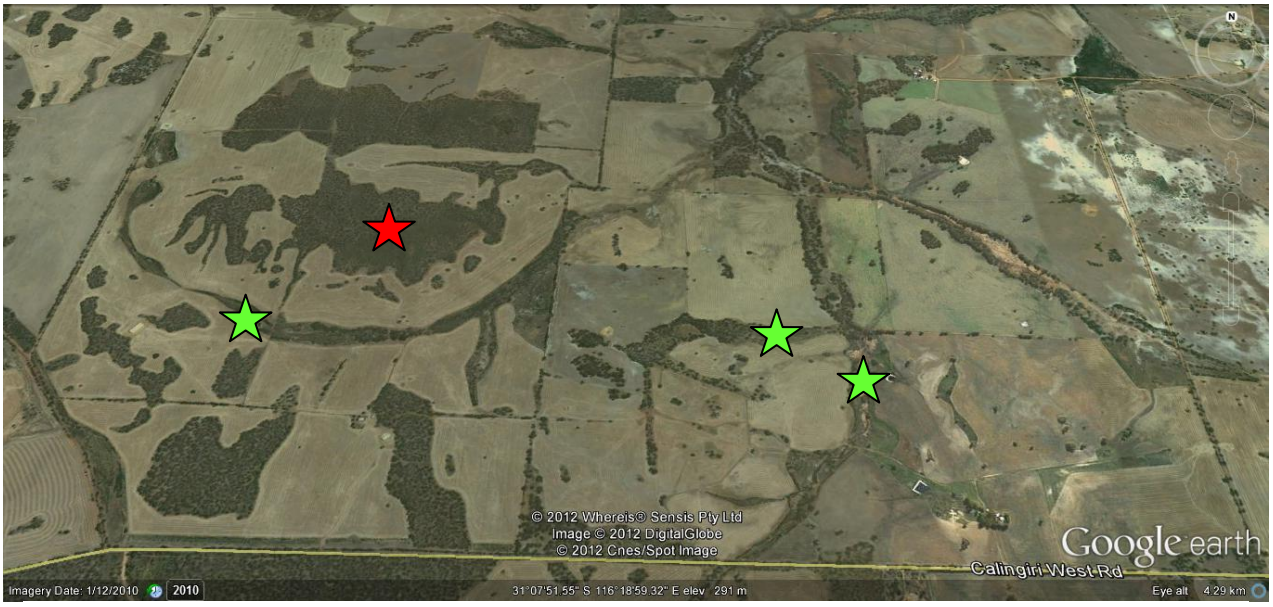
Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
122	Australian Raven	*Corvus coronoides*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	calling	no	
123	Australian Raven	*Corvus coronoides*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	2	0	pre-roosting	no	ridgetop wandoo
124	Australian Raven	*Corvus coronoides*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	1	0	foraging	no	
125	Australian Raven	*Corvus coronoides*	260412	1645-1750	Pearson riparian remnant	S 30 49 13.5 E 116 16 17.2	2	0	foraging, perching	no	
126	Australian Raven	*Corvus coronoides*	270412	0810-0915	Scotney wandoo remnant	270413	2	0	calling, flying	no	
127	Magpie-lark	*Grallina cyanoleuca*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	2	0	foraging	no	
128	Scarlet Robin	*Petroica boodang*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	no	N edge of remnant nr new house site (Joe Tonga's obs.)
129	Scarlet Robin	*Petroica boodang*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	3	0	foraging, calling, pre-roosting	no	adult male gave thin repeated "sear-see-see-sear" call 20m in fr paddock edge in upslope wandoo @ S 31 02 58.4 E 116 08 56.3; 2nd grp of 2 birds (adult male & female) pre-roosting in wandoo regrowth SW cnr fence
130	Red-capped Robin	*Petroica goodenovii*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	1	0	foraging	no	adult male on SE upper slope
131	Red-capped Robin	*Petroica goodenovii*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	3	foraging, calling, decoy	no	adult male & female with juvenile, likely bred as male displayed decoy, in dead acacias along creekline
132	Red-capped Robin	*Petroica goodenovii*	250412	1010-1045	Hendry tagasaste plantation	S 30 58 03.8 E 115 58 18.2	0	4	foraging, flying, calling	no	flew in 15 m from E fenceline to tag rows (1.7 m tall grazed last summer)

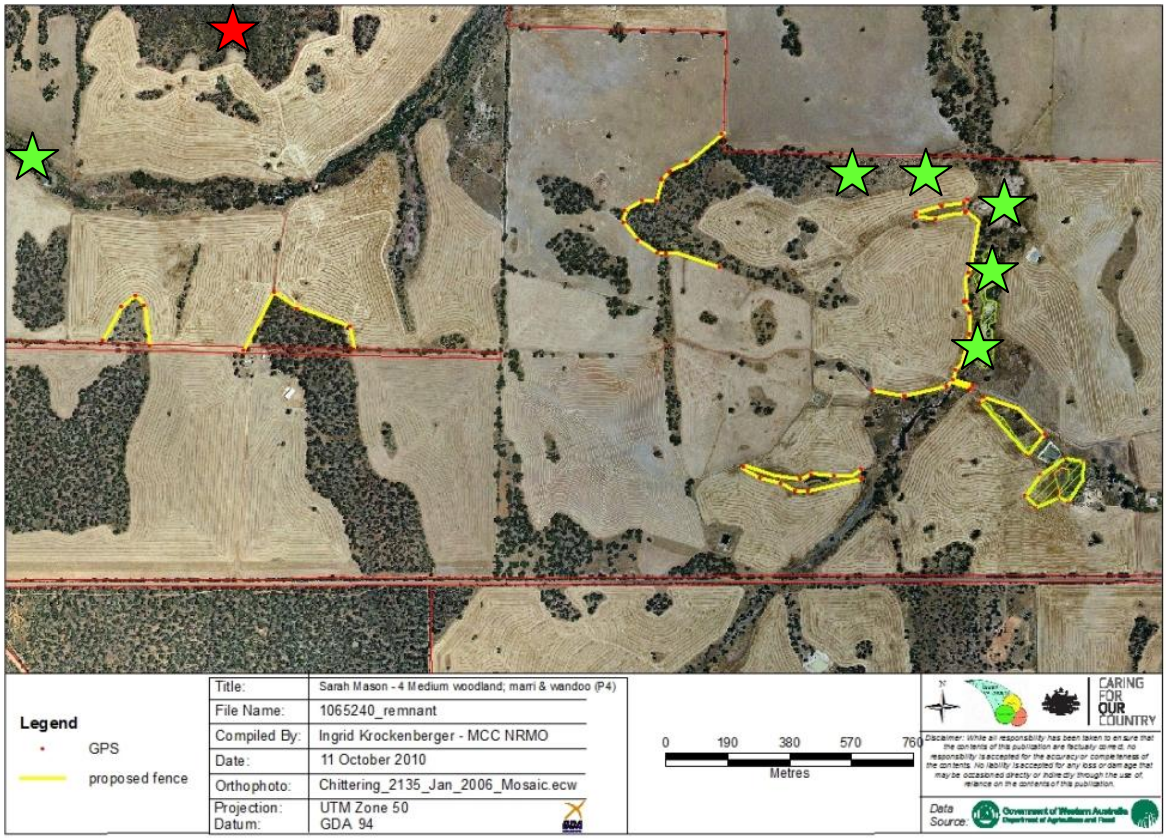
Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
133	Red-capped Robin	*Petroica goodenovii*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	3	0	foraging, calling	no	adult male & female with 1 juvenile, thus bred
134	Red-capped Robin	*Petroica goodenovii*	260412	0900-0930	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	2	foraging, flying	no	adult male & female, flew fr adjacent remnant (not surveyed remnant) into low brushwood nr bore-fed dam then back
135	Red-capped Robin	*Petroica goodenovii*	270412	1030-1045	Scotney eucalypt/mixed species plantings	S 30 46 52.5 E 116 20 29.3	0	1	foraging	no	adult male in Melaleuca & euc plantings S of main channel
136	Silvereye	*Zosterops lateralis*	240412	0745-1000	Mason remnant	S 31 07 29.9 E 116 18 02.1	12	0	flying, calling	no	over wandoo breakaway
137	Silvereye	*Zosterops lateralis*	240412	1020-1130	Mason Reveg 1	S 31 07 91.2 E 116 17 79.6	0	3	foraging, calling,flying	no	taller eucs & allocasuarina
138	Silvereye	*Zosterops lateralis*	240412	1615-1730	Mason Reveg 2	S 31 08 17.5 E 116 19 35.2	0	5	foraging, calling, moving	no	along creek plantings to isolated york gums
139	Silvereye	*Zosterops lateralis*	240412	1735-1750	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	3	foraging	no	drier salmon gum slope
140	Silvereye	*Zosterops lateralis*	250412	0810-0940	Hendry remnant	S 30 58 59.1 E 115 58 24.9	18	0	foraging, flying, calling	no	2 in Banksia, others overhead, others in blackbutt/banksia woodland
141	Silvereye	*Zosterops lateralis*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	7	0	foraging, calling, flying, roosting	no	2 roosting nr SFW & Scarlet Robin SW cnr area
142	Welcome Swallow	*Hirundo neoxena*	240412	1735-1750	Mason Reveg 3	S 31 07 96.3 E 116 19 44.5	0	5	foraging, calling	no	drier salmon gum & allocasuarina slope
143	Tree Martin	*Petrochelidon nigricans*	250412	1605-1750	Harridge ridgetop remnant	S 31 02 57.0 E 116 08 50.0	12	0	foraging, calling	no	
144	Tree Martin	*Petrochelidon nigricans*	260412	0750-0850	Woods remnant	S 31 05 50.1 E 116 18 04.0	7	0	foraging, perching	no	

Record No.	Common Name	Scientific Name	Date	Time	Site name	Site location	Remnant	Revegetation	Behaviour	Breeding	Comments
145	Tree Martin	*Petrochelidon nigricans*	260412	0900-0930	Woods brushwood plantation	S 31 06 11.0 E 116 18 00.4	0	15	foraging, flying	no	
146	Tree Martin	*Petrochelidon nigricans*	270412	0810-0915	Scotney wandoo remnant	S 30 44 38.7 E 116 21 54.6	7	0	calling, foraging, flying	no	
147	Tree Martin	*Petrochelidon nigricans*	270412	1520-1600	Pearson sandalwood plantation	S 30 49 01.8 E 116 15 51.5	0	7	foraging, flying, calling	no	
148	Australasian Pipit	*Anthus novaeseelandiae*	270412	0940-1025	Scotney saltbush plantings	S 30 46 46.2 E 116 20 36.5	0	4	foraging	no	in ridge-furrow sequences naturally samphire with saltbush planted on ridges

Appendix 3: Spatial distribution of remnant native vegetation and location of sites on properties surveyed for birds in the study. Images: Google™earth 2012 (above) and Moore Catchment Council (below). Stars indicate the approximate location of sites (remnants = red, revegetation = light green) surveyed for birds by InSight Ecology for the project. The GPS coordinates for each surveyed site are provided in Appendices 1 and 2. Images were not available for the other two participating properties "Cooinda Park" (Bob Harridge) and "Damara Downs" (Nick & Suzanne Woods).

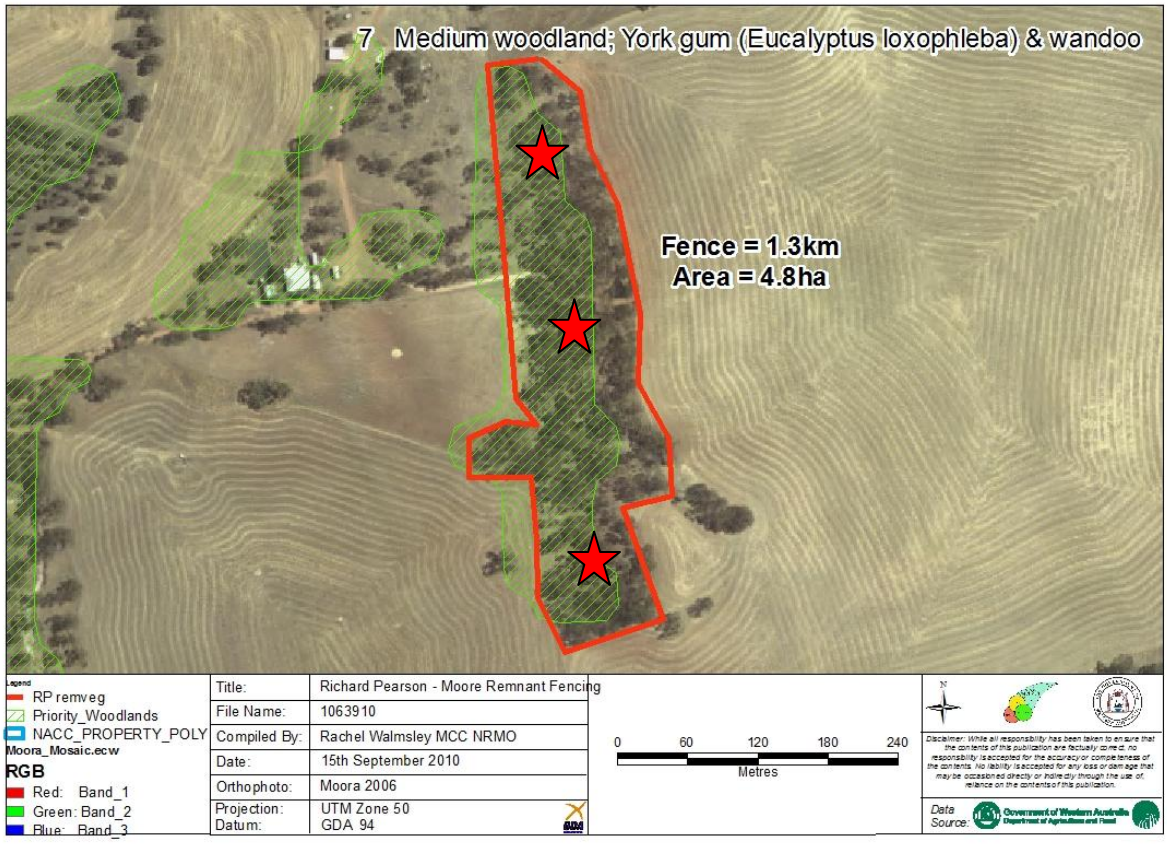
1. "Carrah Farms" (Sarah and Geoff Mason), Calingiri – distance from east to west represented by image: 4.29 km.



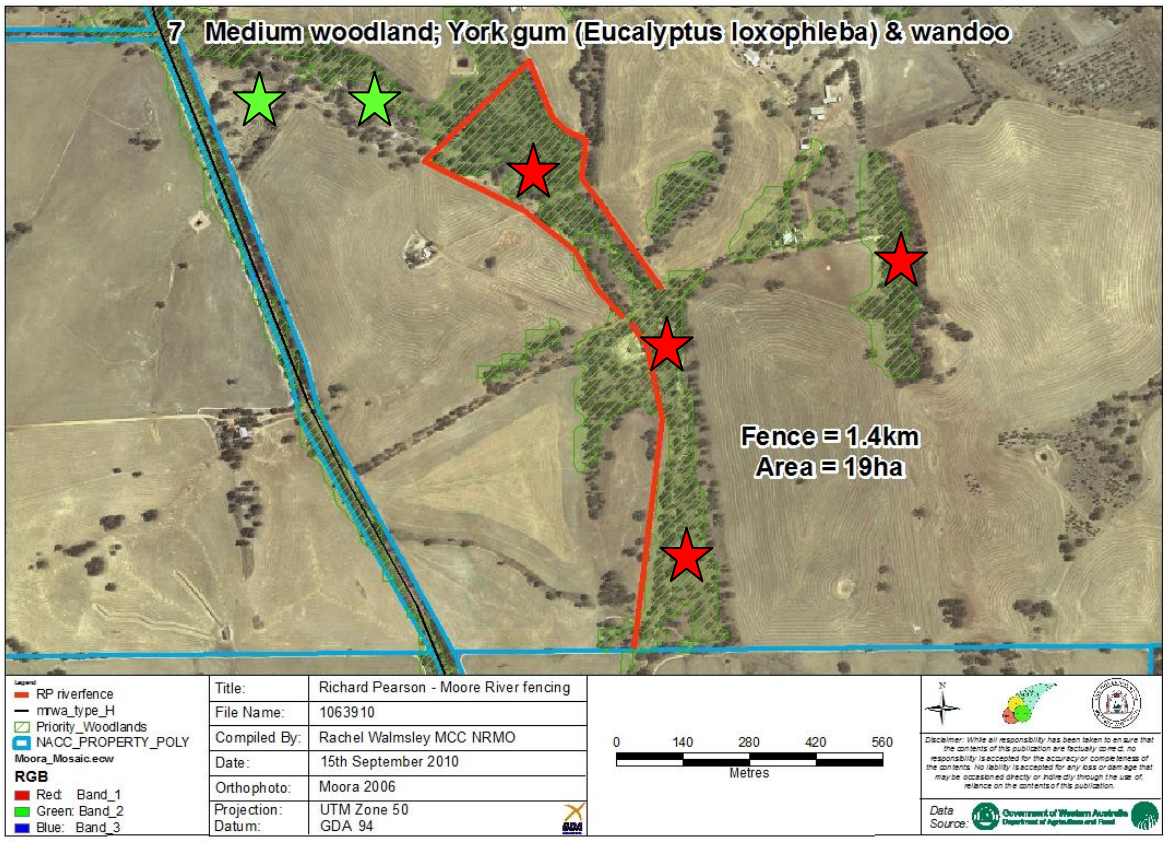


2. “Flora Downs” (owner: John Stephanelli, managers: Bob and Ann Hendry), Gillingarra West – distance from east to west represented by image: 5.3 km.

3. “Sammon Hills” (Rick and Jacqui Pearson), Waddington/Piawaning



"Sammon Hills" riparian york gum remnant and sandalwood plantings



4. "Wensleydale" (Nick Scotney), Piawaning (also includes saltbush, eucalypt and mixed species plantings east of the site shown below)