The Whistler

Gang-gang Cockatoo
Breeding Black-necked Storks
Raptors at Woodville
Far Eastern Curlew
Pycroft's Petrel in Australia
Little Tern at Stockton Beach
Gould's Petrel on Broughton Island
Noisy Miner
Introduced avian species
Analysis of long-term studies

An annual publication of the

Hunter Bird Observers Club
Affiliated with BirdLife Australia

Number 17
2023

The *Whistler* is the scientific journal of the Hunter Bird Observers Club Inc.

ISSN 2208-9845 (electronic copy); ISSN 1835-7385 (hard copy)

All papers are peer-reviewed prior to publication.

The aims of the Hunter Bird Observers Club (HBOC), which is affiliated with BirdLife Australia, are:

- ***To encourage and further the study and conservation of Australian birds and their habitat***
- ***To encourage bird observing as a leisure-time activity***

Publication of **The *Whistler*** is managed by a team:
Alan Stuart (Joint Editor), Neil Fraser (Joint Editor)
Liz Crawford (Formatting and proofreading), Rob Kyte (Cover design and printing)

Printed by NCP Printing, Newcastle

Authors wishing to submit manuscripts for consideration for publication should consult **Instructions for Authors** on page 104 and then submit their manuscripts to the **Editors** at whistler@hboc.org.au

Front cover: Gang-gang Cockatoo *Callocephalon fimbriatum* - Photo: Alwyn Simple
Back cover: Little Tern *Sternula albifrons* - Photo: Steve Merrett
Spine: Sharp-tailed Sandpipers *Calidris acuminata* - Photo: Rob Palazzi

The *Whistler* is proudly supported by

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Editorial

This is the 17th annual edition of *The Whistler*, and as usual it has been a pleasure for us to bring it all together. We hope that it will also be a pleasure for you to read. By coincidence, there are 17 articles in this edition. They span a wide range of topics; some of them report on long-term studies and some on chance observations, while the rest lie somewhere in between.

Tom Kendall reports results from a long-term study at a property near East Seaham, in which many Hunter Bird Observers Club members have had involvement over the years. It is arguably the longest continuous study of woodland birds ever conducted in the Hunter Region. The property is managed with an emphasis on sustainability, and the study reveals that there have been some significant changes to bird populations over time.

Another long-term study location is at Salamander Bay on Port Stephens, where an area of wetlands and woodland is almost surrounded by housing and industrial development. Lois Wooding and Graeme Stevens have supplemented their 15 years of data with reports from ecological consultants, and they demonstrate the importance for wildlife of this small suburban oasis. We hope their report will assist Port Stephens Council planners working on the next stage of the Salamander Waters Estate development.

A paper by Neil Fraser about a breeding event by Little Terns on the Worimi Conservation Lands demonstrates why this is an endangered species in New South Wales. Predation and disturbance devastated the colony, with only six of 45 chicks fledging and with Ghost Crabs proving to be a significant predator of the young chicks.

In another paper, Neil reviews the status of introduced avian species in the Hunter Region, tracing the arrival and spread of each species and their population trends. It is a timely contribution, especially given the frequent community angst about the spread of Common Mynas in our towns and suburbs.

The fifth full paper in this edition summarises a five-year study of Gould's Petrel breeding activities on Broughton Island. It is a valuable contribution to our knowledge about this threatened species, since it is the first detailed study of how a new Gould's Petrel breeding colony develops. The high breeding success rate from artificial nest boxes is encouraging.

There are twelve shorter articles (including one book review) in this edition and together they comprise more than 40% of the total pages of articles. We are delighted with this outcome. And what's more, there are six first-time authors or co-authors. There can be no doubt that *The Whistler* plays an important role in stimulating local birdwatchers towards becoming contributing ornithologists.

Four of the short notes describe unusual dietary items for some of our common species – Laughing Kookaburra, Grey Butcherbird, Noisy Miner, and Australian White Ibis. These notes were all based initially upon chance observations; they show that there is still much to learn and document about Australian birds. Four other notes report examples of interesting bird behaviour: the first local report of pre-roost assembly by Gang-gang Cockatoos; the first-ever-reported single nest brood overlap by Galahs; the first documented instance for New South Wales of site fidelity by the Far Eastern Curlew; and the first modern record for Australia for Pycroft's Petrel – and what's more it was exploring for breeding sites.

The final four of the shorter articles deal with various other topics. Neil Fraser reviews the Action Plan for Australian Birds 2020, finding some flaws; Mike Newman considers insights about raptors from his observations of them at his then-home in Woodville; Ashley Carlson describes the bird population of Bootawa Dam in the under-documented northern part of our region; and Ann Lindsey and Rob Kyte report on

two recent breeding records of the endangered Black-necked Stork at Hexham Swamp within the Hunter Estuary.

We are the editors but production of *The Whistler* involves a large team. Firstly, we thank all the authors – it takes perseverance to sit at a desk, analyse data and write about it, and it takes stoicism to deal with picky reviewers and editors. The reviewers undertake serious work, which underpins *The Whistler's* credibility. That vital work often goes unacknowledged publicly (although our preference is for open reviews). We thank Liz Crawford for her diligent cross-checking while she formats each manuscript to *The Whistler's* style guide, and we also thank Rob Kyte who manages the production and printing of the hard copies. The ongoing support of the HBOC Management Committee is much appreciated, and we also thank the Newcastle Coal Infrastructure Group for their continuing financial support for publication of this journal.

Alan Stuart and Neil Fraser
Joint Editors

Frugivory in the Laughing Kookaburra associated with artificial food provisioning

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Received 10 March 2023, accepted 28 March 2023, published on-line 27 April 2023.

INTRODUCTION

This short note presents observations of the Laughing Kookaburra *Dacelo novaeguineae* exploiting cultivated fruit in response to artificial food provisioning. Both observations were made at an urban parkland in Tanilba Bay, New South Wales, Australia (32.721ºS, 151.993ºE) on 13 February 2022.

Artificial food provisioning or supplementary feeding is a widespread activity in which members of the public provide food to wildlife in return for closer interactions with wildlife (Newsome & Rodger 2008; Davies *et al.* 2009). The practice occurs globally and is one of the most common forms of human-wildlife interactions in developed countries (Jones & Reynolds 2008). However, a number of negative consequences associated with artificial food provisioning have been raised, including the habituation of animals to human presence and the associated increased risks of anthropogenic injuries for animals that are drawn in (Christiansen *et al.* 2016), impacts on animal nutrition and health (Civitello *et al.* 2018), and alterations to natural patterns of behaviour and ecology where provisioning occurs over an extended period of time (Orams 2002).

Kookaburras are large to medium-sized kingfishers that are exclusively carnivorous (Legge 2004). The Laughing Kookaburra has a particularly broad diet, comprising invertebrates, including insects, spiders and molluscs, and vertebrates such as lizards, snakes, small mammals and birds, and occasionally frogs and fish (Green *et al.* 1988; Rose 1997; Higgins 1999). Their hunting style typically consists of a sit-and-wait technique from an elevated position in which the kookaburra swoops down on prey that comes within view (Forshaw & Cooper 1983). The Laughing Kookaburra is also opportunistic and readily habituates to food provisioning (Legge 2004; Chapman 2015).

OBSERVATIONS

In the first observation of frugivory, the kookaburra was seen perched in a large tree, holding a banana peel (**Figure 1**). The kookaburra repeatedly slapped it against a tree branch for approximately two minutes until the majority of the peel had broken off and dropped to the ground, after which the kookaburra swallowed the part of the peel that remained in its bill (**Figure 2**). After approximately 15 minutes, a kookaburra, potentially the same individual, descended to the ground, recovered the remains of the peel and flew away with it.

Figure 1. A Laughing Kookaburra grasping a banana peel by the tip of its bill, between slapping actions against a tree branch. (Photo by Matthew Mo).

Directly after the above observation, a second kookaburra was observed perched in a tree with a wedge of apple in its bill (**Figure 3**). The wedge appeared to have been freshly cut based on the light-coloured appearance of the apple flesh, not showing signs of enzymatic browning. The kookaburra grappled with the wedge in its bill for approximately two minutes before flying out of view.

Figure 2. Following slapping against a tree branch, a banana peel was reduced to a smaller portion for swallowing by a Laughing Kookaburra. (Photo by Matthew Mo).

Figure 3. A Laughing Kookaburra handling a wedge of apple in its bill (Photos by Matthew Mo).

DISCUSSION

Observations of frugivory in the Laughing Kookaburra are significant given the extensively studied carnivorous diet of the species (Higgins 1999). Although the observations were limited to a small period of time and a single location, the behaviour was observed in multiple kookaburras, at least two individuals and potentially three individuals. This provides evidence that this behaviour, while clearly opportunistic, was not isolated.

Although the banana peel was potentially a discarded item and no person/s were directly observed provisioning food, the freshly cut appearance of the apple wedge was firm evidence that artificial food provisioning was involved. Cultivated fruit is a common food item involved in artificial provisioning, being commercially available and relatively inexpensive (Orros & Fellowes 2015; Støstad *et al.* 2017). The Laughing Kookaburra is also a common species attending food provisioning stations, with one study identifying them within the top ten birds in Australia that exploit artificial food (Chapman 2015). Based on the contrast between cultivated fruit and the normal diet of the Laughing Kookaburra (Higgins 1999), the person/s provisioning the food were likely providing the food for other species, which the kookaburras exploited.

There is a growing body of scientific literature reporting wildlife exploiting provisioned food contrary to their usual diet (Chace & Walsh 2006; Baicach *et al.* 2015; Feng & Liang 2020; Mo 2021). One prominent example in birds has involved Rainbow Lorikeets *Trichoglossus moluccanus*, which naturally feed on fruit, pollen and nectar (Higgins 1999), exploiting mince meat left out for carnivorous birds (Gillanders *et al.* 2017). The observations in this short note represent a reversal of this scenario, in which a carnivorous species opportunistically switches to plant-based foods for the benefit of conserving hunting effort.

Notably, the behaviour the first kookaburra displayed with the banana peel is the same technique kookaburras use to dismember large prey into portions that can be swallowed whole (Parry 1970). How the kookaburra would have dismembered the apple wedge was not observed. It may have adopted the same technique or relied on conspecifics to cooperatively dismember.

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Book Review

The Action Plan for Australian Birds 2020

Edited by Stephen T. Garnett and G. Barry Baker

CSIRO Publishing, Melbourne, 2021, 816 pp., numerous tables and summaries,
Hardback, A4 format, $150, ISBN 9781486311903

Can the weight of a book be an indication of its importance? Coming in at 3.2 kg, *The Action Plan for Australian Birds 2020* gives the appearance of being a significant new contribution to Australian ornithology. The volume presents the results of a vast amount of analysis and documentation of information on Australia's threatened species and is probably the most comprehensive review of the threats to the country's avifauna ever produced. Information included is considered essential for the conservation of Australia's avifauna. However, despite its weight and its 816 pages, the objective of the action plan is not clear and neither is the intended audience.

The *2020 Action Plan* is the most recent in a series that have been produced by BirdLife Australia and its predecessors every decade since 1990 (Garnett 1992; Garnett & Crowley 2000; Garnett *et al*. 2011). The plan presents reviews of the conservation status of 316 species and subspecies from Australia and its territories. Of these, 216 taxa are threatened. Each taxon account contains the 2020 conservation status, the justification for assignment of status including the IUCN Red List criteria used, and a comparison with the status assigned in the previous plans. Status certainty is provided with an explanation for any changes. Current status is compared to the IUCN Red List, the EPBC Act and threatened species listings by Australian states and territories. A range map for each taxon is provided together with a summary of abundance, ecology and monitoring activity. A threat assessment for each species or subspecies is presented together with conservation objectives and recovery plans or conservation advice. Research and management actions required for conservation are presented. Much of the information is presented in tables. A bibliography accompanies each review. Each of the reviews was prepared by multiple authors with over 300 experts contributing. The BirdLife Australia Threatened Species Committee vetted the text of each review.

The Introduction to the *2020 Action Plan* describes the methodology used and the three types of accounts; most-detailed accounts being for threatened taxa, and less-detailed accounts for those that are currently considered of Least Concern, and those now considered extinct. The protocols for each section are described including the five IUCN Red List Criteria. A 12-page table is provided in the front of the document listing all Australian avian taxa that meet IUCN Red List Criteria for Critically Endangered, Endangered, Vulnerable and Near Threatened when applied to the region of Australia, Australia's oceanic island territories and Australia's Exclusive Economic Zone. The accounts are of 316 ultrataxa, 31 of which are considered extinct. Of the extant taxa, 184 (15%) are threatened, 21 Critically Endangered, 76 Endangered, 87 Vulnerable and 34 Near Threatened. Additionally, there are accounts for 65 taxa of Least Concern. The table also includes all Australian bird taxa considered threatened, Near Threatened or extinct in the 2010 plan or currently listed as threatened under the EPBC Act 1999 or listed as threatened or Near Threatened on the global IUCN Red List, but which are now considered by the authors to be Least Concern or Vagrant. There are no accounts provided for these taxa. The reason for their inclusion is unclear and their presence is confusing.

The good news in the plan is that the status of 15 taxa have been downlisted as a result of sustained conservation management. The most prominent is the Southern Cassowary which has had its threatened status removed. This is due to the establishment of the Wet Tropics Management Area which ensures management of its habitat. Additionally, 12 taxa that remain at the same status, have had their threat level reduced over the last decade.

With the publication of four plans encompassing 40 years of measured 'action', it should be possible to assess that performance. This has been attempted by Recher (2022) who produced the following table with several qualifications (**Table 1**).

Table 1. Number of taxa and status for Australian birds, including exotic species and vagrants, as listed in the four Action Plans (after Recher 2022).

Year	No. Taxa[A]	Threatened[B]	Extinct	Critically Endangered	Endangered	Vulnerable	Near Threatened	Insufficiently known	Least Concern
1992	1074	127 (11.8%)	23	XX[C]	26	40	32	29	XX[C]
2000	1375	155 (11.3%)	25	32	41	82	81	XX[C]	1114
2010	1266	148 (11.7%)	27	20	60	68	63	XX[C]	1028
2020	1276	184 (14.4%)	31	21	76	87	34	XX[C]	1061

Numbers should be used cautiously, as changes in the definition of what a taxon is and nomenclature, affect the numbers given in the different publications.
[A] Includes extinct taxa. Note that the definition of a taxon has changed between reports.
[B] Includes Critically Endangered, Endangered, Vulnerable and insufficiently known: excludes extinct taxa.
[C] Category was not used this year.

This table shows that the numbers of Extinct, Critically Endangered, Endangered and Vulnerable taxa have increased since the 2010 plan, while the numbers of Near Threatened taxa have declined. In part, the increase is attributed to the recent fires on Kangaroo Island that have resulted in new listings for most of the local sub-species. Conversely, actions to eliminate predators on off-shore islands have decreased threat levels for many taxa, particularly sea birds on Macquarie Island.

The 2020 plan also reveals that the nature of threats has changed over the past decade and the influence of climate change is starting to overwhelm all others. This is most obvious in Queensland's wet tropical rainforests where the range of 20 taxa has decreased as they retreat up the mountains. Previously identified threats such as land clearing, invasive species and changes in fire regime remain. Threatened species from the Hunter Region included in the plan are shown in **Table 2**. Our two most prominent threatened species, the Critically Endangered Swift Parrot and Regent Honeyeater head the list. The majority of Endangered, Vulnerable and Near Threatened species are pelagic birds and migratory waders. The Australasian Bittern and the Australian Painted-snipe are included as Endangered. Five of our woodland birds are included in the plan as either Endangered or Vulnerable: Rufous Scrub-bird, Glossy Black-Cockatoo, Gang-gang Cockatoo, Southern Whiteface and Diamond Firetail.

Table 2. Threatened species from the Hunter Region included in the *2020 Action Plan.*

Critically Endangered	Endangered	Vulnerable	Near Threatened
Swift Parrot	Antipodean Albatross	White-tailed Tropicbird	Sooty Albatross
Regent Honeyeater	Indian Yellow-nosed Albatross	White-throated Needletail	White-capped Albatross
	Grey-headed Albatross	Wandering Albatross	Flesh-footed Shearwater
	Australasian Bittern	Campbell Albatross	Streaked Shearwater
	Lesser Sand Plover	Sooty Shearwater	Greater Sand Plover
	Australian Painted Snipe	Hutton's Shearwater	Great Knot
	Black-tailed Godwit	Gould's Petrel	Red-necked Stint
	Bar-tailed Godwit	Grey Plover	White-fronted Tern
	Eastern Curlew	Hooded Plover	South-eastern Boobook
	Ruddy Turnstone	Latham's Snipe	
	Curlew Sandpiper	Terek Sandpiper	
	Rufous Scrub-bird	Common Greenshank	
		Asian Dowitcher	
		Red Knot	
		Sharp-tailed Sandpiper	
		Little Tern	
		Glossy Black-Cockatoo	
		Gang-gang Cockatoo	
		Southern Whiteface	
		Diamond Firetail	

Local woodland species that have had their threat level increased from 2010 to 2020, include Swift Parrot (Endangered to Critically Endangered), Southern Rufous Scrub-bird (Near Threatened to Endangered), South-eastern Boobook (Least Concern to Near Threatened), South-eastern Glossy Black-Cockatoo (Near Threatened to Vulnerable) and Gang-Gang Cockatoo (Near Threatened to Vulnerable).

The increase for the South-eastern Boobook has been in response to the widespread use of new-generation anticoagulant rodenticides during the recent mouse plague. The increase for the South-eastern Glossy Black-Cockatoo is in response to the loss of food sources due to the 2019-20 bush fires.

However, this list does not provide a true picture of the extent of threats to species in our region. Many additional species that are under threat in the Hunter Region are included in the schedule of the NSW Biodiversity Conservation Act 2016 which lists 13 Critically Endangered, 22 Endangered and 92 Vulnerable avian species in the state.

Many aspects of the 2020 plan will be difficult to understand for anyone who is not conversant with the detailed taxonomy and ecology of many species and subspecies. The threats to a number of these 'splits' can be highly variable. For example, Little Tern *Sternula albifrons* is split into three populations: Indo-Pacific Little Tern *Sternula albifrons sinensis* which breeds on most of the Australian coastline and is Vulnerable; a non-breeding population of the same subspecies that is Least Concern; and the Tasman Little Tern *Sternula albifrons placens* which breeds on the east Australian coast and is also Vulnerable.

The numerous subspecies listed in the plan have all been assigned their English names. This includes Eastern Siberian Whimbrel, Alaskan Bar-tailed Godwit, Eastern Black-tailed Godwit, Palaearctic Ruddy Turnstone, North-eastern Siberian Red Knot and New Siberian Islands Red Knot. Many of these names will be unfamiliar to most birdwatchers, and although they are listed in the BirdLife Australia Working List of Australian Birds, they are not generally listed in the most common field guides.

The intended audience for the book is not obvious and the editors make no such claims for the document. It is not a book that most bird watchers would refer to. Each Australian State and Territory has its own list of threatened species and action plans such as the NSW Save our Species programme (NSW Department of Planning and Environment 2023). The Commonwealth, through the EPBC Act provides protection and management of matters of national environmental significance which include nationally threatened avian species and migratory species. It achieves this through the implementation of legislative processes. The inclusion of two conservation statuses for species, both based on the same IUCN criteria, the global IUCN Red list status and that for Australia and Territories, will undoubtedly create some confusion. Conservation managers assessing priorities, when referring to this volume for guidance, will be confronted by as many as four different conservation statuses for some species. Sadly, most of the species' plans are 2-4 dot points of generic actions such as conserve habitat, reduce predation, reduce fires or provide education. In reality, conservation plans need to be much more detailed and they should identify the funding and all other resources required for effective implementation. Ultimately, the volume is more of a conservation status report than a plan. It does however provide a benchmark against which the changing status of Australian avifauna populations can be measured.

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Small crabs: a new prey record for Grey Butcherbird

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Received 28 March 2023, accepted 19 June 2023, published on-line 30 June 2023.

On 15 October 2022, I observed an adult Grey Butcherbird *Cracticus torquatus* capture a small crab in the Mambo Wetlands Reserve (32º 43' 47"S, 152º 05' 40"E) at Salamander Bay. The mangroves are part of an Estuarine Saltmarsh Complex in the tidal zone at the northern end of the reserve and are located between coastal forest to the south and the shores of Salamander Bay to the north.

The butcherbird was first heard giving a short, soft intermittent call and was then subsequently observed perched in a Grey Mangrove *Avicennia marina* at a height of about 0.4 m above the ground. Several small crabs were moving around the muddy substrate below. The bird successfully captured a crab by sally-pouncing, then returned briefly to the perch. It then flew off with its prey towards a nearby stand of Black She-oak *Allocasuarina littoralis*. The tide was rising at the time and there was 1-2 cm of water over some of the area.

When the muddy substrate across the Estuarine Saltmarsh Complex is exposed, numerous small crabs are present, foraging around the base of the mangroves and amongst the adjacent Samphire *Sarcocornia quinqueflora*. The crabs are dark reddish-brown, 20-30 mm across the carapace with pink-orange claws and large dark-brown eyes on stalks. They tend to retreat rapidly into burrows when disturbed.

This record may represent a previously unreported foraging behaviour for Grey Butcherbird. There are no references in HANZAB (Higgins *et al*. 2006) describing the species foraging for crabs or foraging amongst mangroves, although they have been recorded as being present in mangroves in South Australia (Matheson 1976).

Although the observed foraging behaviour may have been opportunistic, it is possible that this was a regular occurrence at this location. I had heard the bird calling intermittently amongst the mangroves for a period of time before I located it, suggesting it was accustomed to foraging in this habitat. I have observed small crabs in this area at low tide on numerous occasions.

A pair of Grey Butcherbird has previously been observed nesting in the nearby Black She-oak that surround the saltmarsh. It is possible that the adult bird I observed was providing the crabs to chicks or fledglings in the she-oak.

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Changes in avian species diversity following revegetation and an emphasis on sustainability at an East Seaham cattle-breeding property (2004-2018)

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Received 9 September 2022, accepted 4 July 2023, published online 7 August 2023

Regular surveys of the avian population were conducted for 15 years across five sites on a cattle breeding property near East Seaham. The habitats were a mixture of remnant woodland, farm dams, ephemeral wetlands, open grassland and riparian forest. Habitat restoration had been undertaken in some areas. The property was being managed in accordance with sustainability principles.

A total of 81 surveys were conducted between 2004 and 2018 and 175 species were recorded. Eight threatened species were recorded; White-throated Needletail *Hirundapus caudacutus*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, Little Lorikeet *Glossopsitta pusilla*, White-fronted Chat *Epthianura albifrons*, Scarlet Robin *Petroica boodang*, Grey-crowned Babbler *Pomatostomus temporalis*, Varied Sittella *Daphoenositta chrysoptera*, and Dusky Woodswallow *Artamus cyanopterus*. Breeding or breeding behaviour was observed for 37 species.

The average annual species count for 2004-2018 was relatively constant at 54.3 with a standard deviation of ±2.6. The total average annual count was relatively constant averaging 256 from 2010-2015 and then increasing after 2016 to a maximum of 524.5 in 2018, following widespread rainfall.

The increase in numbers of Australasian Figbird *Sphecotheres vieilloti* over the survey period was statistically highly significant, while the increase in numbers of Rose Robin *Petroica rosea* was significant. The decline in numbers of White-winged Chough *Corcorax melanorhamphos* was statistically highly significant while the declines of Azure Kingfisher *Ceyx azureus* and Tawny Frogmouth *Podargus strigoides* were significant.

Species diversity on the property was considerably higher than on a number of similar properties that had been subject to long-term surveying in the Hunter Region.

INTRODUCTION

Greswick Angus is a cattle breeding property of 121 hectares located adjacent to the Williams River at East Seaham. It is situated between the Wallaroo National Park, Columbey National Park and Columbey State Conservation Area. In 2004 family members John and Janelle Spearpoint through a property management planning process adopted a whole-of-farm approach to change business practices to emphasise sustainability. A balance was developed between the farming business, sustainability, erosion control and the impact on the Williams River catchment. Part of this plan was the fencing off and revegetation of the riverbank boundaries of the property. In spring 2001 and 2002 some 6,000 trees grown from seeds collected across the property were planted to revegetate the riverbank areas and provide shade lots for stock. Water-edge plants were planted along the river edge to stabilise the banks and native emergent macrophytes were planted in the shallow sections of the river to provide a wave action buffer (Spearpoint 2006).

In 2004 a request for assistance with bird surveys was made to Hunter Bird Observers Club and bi-monthly bird surveys were commenced across the property in September 2004.

"Surveying the birds and their lives on Greswick Angus was instigated by the need to monitor visible indicators of environmental health over the course of the Williams River Best Management Practice Project. In July 2004 Greswick Angus was selected as the Demonstration Site for this unique 4-year trial that focused on helping to protect the quality of the Lower Hunter's drinking water supply.

"The project aimed to demonstrate and trial various methods for restoring riparian vegetation including bank erosion control, fencing, weed control,

revegetation and regeneration as well as stock and pasture management within the riparian zone." (Clarke 2008).

METHODS

The first survey was conducted in September 2004 and covered the entire property. Surveys of individual sites commenced in November 2004. In 2015, the only survey conducted was a whole of property survey. All other years had between 5 and 7 surveys of all sites.

Observations were recorded in an Excel spreadsheet with separate worksheets for each site. The spreadsheet has been used to compile the data in this paper. Data from surveys up to and including December 2018 were analysed for this article.

Results are presented as Reporting Rates (RR). RR is the number of records for a species divided by the number of surveys, expressed as a percentage. The average counts per year and average number of species observed for the years 2010 to 2018 were calculated and are presented graphically.

To test the statistical significance of population changes over the survey period, the Chi Square test (with an assumption of unequal variance) was conducted on records of species from periods 2004-2010 and 2011-2018. Probability (P) values of less than 0.05 were classified as statistically significant and P values of less than 0.01 as statistically highly significant (Fowler & Cohen 1996).

The survey details and observations for the five sites and the remainder of the property were also submitted to BirdLife Australia. (https://birdata.birdlife.org.au/)

Site descriptions and survey protocols

At the commencement of surveys, the property was divided into five 2-ha sites, each representing a differing vegetation community. The five sites are shown in **Figure 1**.

Between two and nine observers conducted surveys on the second Tuesday of each alternate month commencing at 7.00 am in warmer months and 7.30 am during colder months with the final survey being completed by around 1.00 pm. Sites were surveyed in the same order on each occasion.

Initially the sites were surveyed for 20 minutes. Due to the growth of the revegetation plus changes over time in HBOC personnel, the 20-minute time frame was expanded to whatever time it took to complete a survey. Birds seen or heard for the five specific sites plus the remainder of the property were separately recorded and the data entered into the spreadsheet. Breeding or breeding behaviour was recorded and included observations of adult birds inspecting hollows, collecting nesting material, nest building, carrying food or together with dependent young.

Figure 1. The Greswick Angus property at East Seaham showing five survey sites.

On some occasions during the 15-year period, surveys of the property as a whole or some of the sites were not conducted due to flooding, impassable tracks or other unexpected factors. The routes normally taken and survey methods are detailed separately below for each site.

Front Gate Forest

The first site surveyed was an area of approximately 200 x 100 m, from the homestead east to the property boundary (**Figure 1**). The dominant vegetation was remnant mature Spotted Gum *Corymbia maculata* and Grey Ironbark *Eucalyptus paniculata* with the density and diversity of the understorey of primarily native shrubs and herbs, varying according to frequency of grazing (**Figure 2**). Observers walked the perimeter of the site recording those birds within the site, while birds observed or heard outside the site were recorded as part of the overall property list.

Figure 2. Front Gate Forest (photo: Janelle Spearpoint)

Quarry Lane

Quarry Lane was the second site surveyed and comprised a strip of riparian vegetation along the Williams River approximately 600 x 20 m (**Figure 1**, **Figure 3**). The site was dominantly remnant rainforest which had been supplementarily planted with woodland and rainforest species. The vegetation mainly consisted of Swamp Oak *Casuarina glauca* along the river with rainforest trees and shrubs behind. This was the most floristically diverse section of the property containing flowering gums *Eucalyptus* spp., *Angophora floribunda* and fruiting rainforest species such as Lilly Pilly *Syzygium smithii,* Cheese Tree *Glochidion fernandi* and Wild Quince *Guioa semiglauca*. Observers walked the length of the site recording birds within the site, while birds observed in the paddocks or on the river were recorded as part of the overall property list.

Figure 3. Quarry Lane (photo: Tom Kendall)

Bamboo Bend

The next site surveyed was also a strip of riparian vegetation along the Williams River approximately 400 x 20 m (**Figure 1**, **Figure 4**). This section had been significantly revegetated and plant growth increased over the survey period. The area had less complex vegetation than Quarry Lane. The site was named after a stand of mature Bamboo (*Bambusa* spp.) midway along the transect. Observers walked the length of the site recording birds within the site, while birds observed in the paddocks or on the river were recorded as part of the overall property list.

Figure 4. Bamboo Bend (photo: Tom Kendall)

Lagoon

This site, located northeast of Bamboo Bend, was an area of ephemeral freshwater wetland, with both open water and areas dominated by a sedge *Juncus* sp. and grasses (**Figure 1**, **Figure 5**). Outside of flood times, the site was approximately 300 x 40 m and was connected to the river by a drainage

channel and a flood gate. The water level increased during flooding of the Williams River or periods of substantial rains. During dry periods, the lagoon was dry and regularly grazed (**Figure 6**). A transect was walked around the perimeter of the site with some noise being made during Spring and Summer to flush cryptic birds such as Latham's Snipe.

Figure 5. Lagoon almost at capacity (photo: Tom Kendall)

Figure 6. Lagoon dry. (photo: Tom Kendall)

The Swamp

The last area surveyed was a shallow freshwater wetland approximately 300 x 60 m connected to the river by a drainage channel and a flood gate (**Figure 1**). This area was dominated by sedge *Juncus* sp. with limited open water except when at capacity (**Figure 7**). The site was periodically grazed (**Figure 8**). A transect was made to the east and west from a midway access point with observers walking through the grass and sedge to flush birds. Access was limited during times of high-water level or flood.

Figure 7. The Swamp in flood. (photo: Tom Kendall)

Figure 8. The Swamp dry (photo: Tom Kendall)

The Rest of Greswick Angus

The balance of the property primarily consisted of grazing pasture interspersed with tree lots planted as part of the revegetation project. The bulk of this area was cropped and grazed on a rotational basis. There were at least five dams of varying size and ephemerality across the property with several temporary wet areas that were rainfall or flood dependent (**Figure 1**). All birds observed outside of the five nominated sites were recorded. Some sections of the property were not completely surveyed such as the riparian strip from the northern end of Bamboo Bend northwards for approximately 800 m along the river and sections of the grazing lands.

RESULTS

By December 2018 a total of 175 species had been recorded during 81 surveys. Between 55 and 116 species were seen each year (**Table 1**). The average species per year was 97.6. Average species per survey ranged from 48.8 to 59.5 with the overall

average being 54.4. The overall yearly RR for Greswick Angus for all species are presented in **Table 2**. The yearly RR for all species from each of the six survey sites are presented in the **Appendix** (https://www.hboc.org.au/wp-content/uploads/Greswick-Angus-Appendix-The-Whistler-Vol-17.pdf)**.** Eight threatened species were recorded and are listed in **Table 3**. Breeding behaviour was observed for 37 species that are listed in **Table 4**. Five species whose numbers have undergone significant or highly significant change over the survey period are listed in **Table 5**. The average counts per year and average number of species observed for the years 2010 to 2018 are shown in **Figure 9**.

DISCUSSION

Greswick Angus Overall

A total of 175 species was recorded across the property during the 81 surveys conducted. This highlights the diversity of habitat available despite being in relatively small parcels. The property provides a link between adjacent National Parks and Conservation Areas and allows species to forage and migrate widely. These larger nearby woodland areas may also assist in populating the site as habitat develops, or repopulating the site during recovery from drought.

Twenty-six species have RRs > 80% (**Table 2**). Twenty-one of these species would be expected on a farming property with grazing land and farm dams in the Hunter Region. The remaining five species in that category are associated with the riparian strip of remnant and revegetated vegetation, e.g. Brown Thornbill *Acanthiza pusilla* and Grey Fantail *Rhipidura albiscapa*.

There are twenty-eight species with RRs between 40% and 79% (**Table 2**). Two of these, the Oriental Dollarbird *Eurystomus orientalis* and Sacred Kingfisher *Todiramphus sanctus*, are migratory but seem to be site-faithful with a high RR each year. Breeding of the Sacred Kingfisher has been recorded with the Oriental Dollarbird a likely breeder as suitable hollows were available. The remainder were a diverse mix of woodland, grassland and wetland species reflecting the mix of habitats available on the property.

The remaining birds comprise 121 species with RR <39% (**Table 2**). They represent a broad range of species which is indicative of the mix of habitats. This group includes two migratory waders, Latham's Snipe *Gallinago hardwickii* (RR 29.6%) and Bar-tailed Godwit *Limosa lapponica* (RR 1.2%). The latter was a single bird in February 2017 observed foraging on the muddy edges of a farm dam. Other groups of species include 19 summer visitors, 2 winter visitors (robins), and 10 raptor species (**Table 2**).

The Williams River attracted waterfowl such as Eurasian Coot *Fulica atra* and Dusky Moorhen *Gallinula tenebrosa* that were not normally seen within the boundaries of the property. Four species of tern and one gull were recorded on the property and along the Williams River; Greater Crested Tern *Thalasseus bergii*, Australian Gull-billed Tern *Gelochelidon macrotarsa,* Common Tern *Sterna hirundo,* Caspian Tern *Hydroprogne caspia* and Silver Gull *Larus novaehollandiae*. The associated riparian vegetation attracted species which utilised the river to forage such as Azure Kingfisher *Ceyx azureus* and Australasian Darter *Anhinga novaehollandiae*.

The riparian forest contained a mix of woodland and rainforest tree species with an understorey during normal times. Species such as Grey Fantail, Superb Fairy-wren *Malurus cyaneus*, White-browed Scrubwren *Sericornis frontalis*, Brown Thornbill plus other thornbill and honeyeater species foraged and bred in this strip. Wet sclerophyll bird species such as Lewin's Honeyeater *Meliphaga lewinii*, Satin Bowerbird *Ptilonorhynchus violaceus*, Wompoo Fruit-Dove *Megaloprepia magnifica* and Brown Cuckoo-Dove *Macropygia phasianella* inhabited the riparian strip in conjunction with dry sclerophyll species such as Striated Pardalote *Pardalotus striatus*, Rufous Whistler *Pachycephala rufiventris*, Brown-headed Honeyeater *Melithreptus brevirostris* and Varied Sittella *Daphoenositta chrysoptera*.

A group of two Moreton Bay Figs *Ficus macrophylla* and one Port Jackson Fig *Ficus rubiginosa* were present between The Lagoon and Bamboo Bend. When fruiting, they attracted Channel-billed Cuckoo *Scythrops novaehollandiae*, Eastern Koel *Eudynamys orientalis*, Topknot Pigeon *Lopholaimus antarcticus* and Australasian Figbird *Sphecotheres vieilloti*.

From 2004-2018, species recorded ranged from 36-81 while total number of birds recorded varied from 160-1507 (2010-2018 only). This is a minimum count as not all areas of the property were surveyed and birds of passage moving through the property may not have been recorded.

Table 1. Survey records summary, Greswick Angus overall

	All Surveys	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Number of Surveys	81	2	6	6	7	7	7	6	5	5	6	6	1	5	6	6
Number of Species	175	74	93	97	110	106	116	96	101	103	97	109	55	92	104	107
Species per Survey	54.4	54.5	53.2	52.5	57.7	53.6	53.1	52.0	52.6	56.4	48.8	56.8	55.0	54.8	55.3	59.5
Species RR≥80%	26	35	32	33	32	28	26	31	27	36	31	34	55	38	34	38
Species RR≥40%	54	74	57	48	66	60	59	52	68	70	46	58	55	65	57	63

Table 2. Species reporting rates, all surveys, Greswick Angus overall (*Summer Visitor, **Winter Visitor)

Common Name	RR% All Surveys	2004 RR%	2005 RR%	2006 RR%	2007 RR%	2008 RR%	2009 RR%	2010 RR%	2011 RR%	2012 RR%	2013 RR%	2014 RR%	2015 RR%	2016 RR%	2017 RR%	2018 RR%
Masked Lapwing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Noisy Miner	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Pacific Black Duck	98.8	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Eastern Rosella	98.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	100.0	100.0	100.0	100.0	100.0
Brown Thornbill	98.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	80.0	100.0	100.0	100.0	100.0	100.0	100.0
Australian Magpie	98.8	100.0	100.0	83.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Willie Wagtail	98.8	100.0	100.0	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Laughing Kookaburra	97.5	100.0	100.0	100.0	85.7	100.0	85.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Yellow Thornbill	97.5	100.0	83.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	100.0	100.0	100.0	100.0	100.0
Yellow-faced Honeyeater	97.5	100.0	100.0	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3	100.0
Pied Butcherbird	97.5	100.0	100.0	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0	83.3	100.0	100.0	100.0	100.0
Grey Fantail	97.5	100.0	100.0	100.0	100.0	85.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	83.3
Superb Fairy-wren	96.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Australian Raven	96.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	60.0	100.0	83.3	100.0	100.0	100.0	100.0	100.0
Whistling Kite	95.1	100.0	100.0	100.0	100.0	85.7	100.0	83.3	100.0	100.0	83.3	100.0	100.0	100.0	83.3	100.0
Black-faced Cuckoo-shrike	92.6	100.0	100.0	100.0	100.0	100.0	85.7	100.0	80.0	100.0	83.3	83.3	100.0	80.0	83.3	100.0
Magpie-lark	92.6	100.0	100.0	100.0	100.0	71.4	85.7	100.0	80.0	80.0	83.3	100.0	100.0	100.0	100.0	100.0
Welcome Swallow	91.4	100.0	100.0	83.3	100.0	85.7	85.7	100.0	80.0	100.0	83.3	100.0	100.0	100.0	83.3	83.3
White-faced Heron	90.1	100.0	66.7	83.3	100.0	100.0	85.7	66.7	100.0	100.0	100.0	83.3	100.0	80.0	100.0	100.0
Grey Butcherbird	88.9	50.0	100.0	100.0	85.7	100.0	71.4	100.0	100.0	100.0	50.0	100.0	100.0	100.0	66.7	100.0
Purple Swamphen	87.7	100.0	83.3	100.0	100.0	71.4	100.0	100.0	80.0	100.0	66.7	100.0	100.0	80.0	66.7	83.3

Common Name	RR% All Surveys	2004 RR%	2005 RR%	2006 RR%	2007 RR%	2008 RR%	2009 RR%	2010 RR%	2011 RR%	2012 RR%	2013 RR%	2014 RR%	2015 RR%	2016 RR%	2017 RR%	2018 RR%
Cattle Egret	86.4	100.0	83.3	100.0	100.0	85.7	57.1	50.0	80.0	100.0	100.0	83.3	100.0	100.0	83.3	100.0
White-browed Scrubwren	86.4	100.0	83.3	66.7	100.0	71.4	100.0	100.0	100.0	80.0	100.0	83.3	100.0	80.0	66.7	83.3
Australian Wood Duck	84.0	100.0	100.0	83.3	100.0	85.7	85.7	83.3	60.0	40.0	83.3	100.0	100.0	60.0	100.0	83.3
Galah	82.7	100.0	100.0	100.0	85.7	85.7	71.4	83.3	60.0	100.0	50.0	100.0	100.0	100.0	83.3	50.0
Silvereye	81.5	100.0	66.7	66.7	85.7	85.7	100.0	83.3	60.0	80.0	83.3	50.0	100.0	100.0	83.3	100.0
Grey-crowned Babbler	76.5	100.0	100.0	100.0	42.9	42.9	42.9	66.7	60.0	100.0	66.7	83.3	100.0	100.0	100.0	100.0
Yellow-rumped Thornbill	75.3	100.0	83.3	66.7	100.0	100.0	100.0	66.7	40.0	80.0	83.3	50.0	100.0	20.0	83.3	66.7
Crested Pigeon	74.1	100.0	33.3	66.7	57.1	85.7	28.6	100.0	100.0	80.0	33.3	100.0	100.0	100.0	100.0	83.3
Lewin's Honeyeater	74.1	50.0	33.3	50.0	42.9	85.7	71.4	83.3	60.0	80.0	100.0	100.0	100.0	100.0	83.3	83.3
Golden-headed Cisticola	71.6	100.0	100.0	66.7	71.4	57.1	57.1	83.3	100.0	100.0	66.7	83.3	100.0	60.0	33.3	50.0
Striated Pardalote	65.4	50.0	83.3	100.0	71.4	71.4	57.1	66.7	60.0	80.0	66.7	83.3	0.0	80.0	16.7	33.3
Little Black Cormorant	64.2	50.0	50.0	83.3	85.7	28.6	71.4	33.3	80.0	60.0	50.0	50.0	100.0	80.0	83.3	83.3
Straw-necked Ibis	64.2	50.0	83.3	83.3	100.0	57.1	71.4	33.3	20.0	20.0	33.3	66.7	100.0	80.0	83.3	83.3
White-bellied Sea-Eagle	64.2	50.0	66.7	66.7	100.0	42.9	57.1	66.7	40.0	80.0	66.7	66.7	0.0	20.0	100.0	66.7
Red-browed Finch	64.2	100.0	66.7	50.0	42.9	85.7	100.0	100.0	80.0	80.0	16.7	50.0	0.0	60.0	50.0	50.0
Chestnut Teal	59.3	50.0	50.0	16.7	57.1	57.1	85.7	83.3	100.0	80.0	83.3	50.0	0.0	40.0	16.7	66.7
Rainbow Lorikeet	59.3	50.0	83.3	33.3	42.9	57.1	57.1	33.3	40.0	60.0	33.3	83.3	100.0	100.0	66.7	83.3
Common Myna	58.0	50.0	50.0	83.3	85.7	71.4	57.1	66.7	60.0	60.0	50.0	50.0	100.0	60.0	50.0	0.0
Australian Pelican	55.6	100.0	83.3	66.7	85.7	85.7	42.9	50.0	20.0	60.0	16.7	16.7	100.0	80.0	16.7	66.7
Little Pied Cormorant	53.1	0.0	33.3	16.7	71.4	28.6	71.4	66.7	20.0	100.0	16.7	66.7	100.0	40.0	83.3	83.3
Golden Whistler	51.9	0.0	50.0	50.0	28.6	42.9	42.9	50.0	60.0	60.0	66.7	100.0	0.0	60.0	50.0	50.0
Noisy Friarbird	50.6	50.0	66.7	33.3	42.9	71.4	28.6	33.3	40.0	40.0	33.3	50.0	0.0	100.0	66.7	66.7
Red Wattlebird	49.4	0.0	50.0	33.3	42.9	71.4	14.3	83.3	40.0	60.0	33.3	16.7	100.0	60.0	66.7	83.3
Australasian Darter	48.1	50.0	66.7	83.3	71.4	14.3	28.6	50.0	80.0	40.0	33.3	16.7	0.0	20.0	66.7	66.7
Blue-faced Honeyeater	48.1	0.0	0.0	0.0	42.9	57.1	14.3	16.7	40.0	60.0	50.0	83.3	100.0	100.0	100.0	83.3
Little Corella	46.9	50.0	33.3	33.3	71.4	28.6	28.6	33.3	60.0	60.0	50.0	50.0	100.0	80.0	16.7	66.7
White-necked Heron	44.4	0.0	50.0	16.7	42.9	57.1	28.6	0.0	20.0	40.0	100.0	66.7	100.0	60.0	50.0	50.0
Eastern Yellow Robin	44.4	0.0	16.7	0.0	28.6	28.6	14.3	16.7	40.0	100.0	83.3	66.7	100.0	60.0	66.7	83.3
Oriental Dollarbird *	43.2	50.0	50.0	33.3	42.9	14.3	57.1	50.0	60.0	20.0	50.0	33.3	100.0	40.0	50.0	50.0
Wedged-tailed Eagle	42.0	0.0	83.3	100.0	42.9	42.9	42.9	50.0	40.0	40.0	16.7	33.3	0.0	40.0	16.7	16.7
Dusky Moorhen	42.0	50.0	66.7	100.0	71.4	28.6	42.9	0.0	60.0	20.0	0.0	50.0	0.0	0.0	66.7	33.3

Common Name	RR% All Surveys	2004 RR%	2005 RR%	2006 RR%	2007 RR%	2008 RR%	2009 RR%	2010 RR%	2011 RR%	2012 RR%	2013 RR%	2014 RR%	2015 RR%	2016 RR%	2017 RR%	2018 RR%
Sacred Kingfisher *	42.0	50.0	16.7	33.3	28.6	42.9	42.9	33.3	60.0	40.0	50.0	50.0	100.0	40.0	50.0	50.0
Australasian Pipit	42.0	50.0	50.0	50.0	71.4	57.1	57.1	66.7	20.0	20.0	33.3	33.3	0.0	20.0	16.7	33.3
Black Swan	39.5	0.0	50.0	0.0	57.1	42.9	42.9	33.3	60.0	60.0	50.0	33.3	100.0	40.0	16.7	33.3
Grey Teal	38.3	0.0	0.0	0.0	28.6	71.4	57.1	0.0	40.0	60.0	33.3	0.0	0.0	60.0	83.3	83.3
Brown Falcon	37.0	0.0	0.0	100.0	42.9	71.4	14.3	33.3	20.0	40.0	33.3	33.3	0.0	40.0	33.3	33.3
Great Cormorant	35.8	50.0	66.7	33.3	28.6	57.1	57.1	0.0	20.0	60.0	16.7	50.0	0.0	0.0	16.7	50.0
Spotted Pardalote	35.8	0.0	50.0	33.3	42.9	28.6	0.0	33.3	20.0	40.0	33.3	33.3	0.0	80.0	16.7	83.3
Great Egret	34.6	0.0	0.0	0.0	42.9	42.9	42.9	33.3	60.0	40.0	33.3	33.3	0.0	40.0	66.7	33.3
Eurasian Coot	34.6	0.0	16.7	33.3	0.0	14.3	0.0	0.0	40.0	20.0	83.3	83.3	0.0	20.0	83.3	83.3
Australian King Parrot	34.6	50.0	66.7	16.7	28.6	28.6	14.3	33.3	40.0	20.0	0.0	50.0	0.0	60.0	50.0	50.0
Olive-backed Oriole	34.6	50.0	50.0	33.3	42.9	28.6	42.9	16.7	20.0	20.0	33.3	16.7	0.0	40.0	66.7	33.3
Grey Shrike-thrush	33.3	0.0	0.0	0.0	28.6	42.9	14.3	66.7	40.0	60.0	33.3	66.7	0.0	80.0	0.0	33.3
Australasian Grebe	32.1	0.0	16.7	16.7	42.9	42.9	57.1	0.0	20.0	40.0	83.3	16.7	0.0	0.0	33.3	50.0
Scaly-breasted Lorikeet	30.9	0.0	16.7	16.7	42.9	28.6	28.6	50.0	20.0	0.0	0.0	50.0	0.0	40.0	50.0	66.7
Scarlet Honeyeater	30.9	100.0	16.7	0.0	71.4	28.6	28.6	50.0	40.0	40.0	16.7	33.3	0.0	0.0	33.3	16.7
Latham's Snipe *	29.6	50.0	50.0	33.3	42.9	42.9	28.6	16.7	40.0	20.0	33.3	33.3	0.0	20.0	0.0	16.7
White-throated Gerygone *	29.6	50.0	0.0	0.0	14.3	28.6	14.3	50.0	40.0	40.0	33.3	50.0	0.0	40.0	33.3	50.0
Eastern Koel *	28.4	50.0	16.7	33.3	42.9	28.6	14.3	50.0	40.0	20.0	16.7	33.3	0.0	0.0	33.3	33.3
Common Starling	28.4	100.0	66.7	66.7	42.9	14.3	14.3	50.0	0.0	20.0	33.3	16.7	0.0	0.0	16.7	0.0
Torresian Crow	27.2	0.0	50.0	66.7	28.6	0.0	0.0	0.0	0.0	0.0	0.0	50.0	100.0	60.0	66.7	33.3
Channel-billed Cuckoo *	25.9	0.0	33.3	16.7	28.6	28.6	14.3	33.3	40.0	20.0	16.7	33.3	0.0	20.0	33.3	33.3
Striped Honeyeater	25.9	0.0	0.0	0.0	0.0	0.0	42.9	83.3	60.0	40.0	16.7	0.0	0.0	20.0	33.3	66.7
Rufous Whistler *	25.9	50.0	33.3	16.7	14.3	28.6	42.9	33.3	40.0	20.0	0.0	33.3	0.0	20.0	16.7	33.3
Satin Bowerbird	24.7	50.0	33.3	0.0	14.3	42.9	57.1	33.3	20.0	0.0	33.3	16.7	0.0	20.0	16.7	16.7
Mistletoebird	24.7	0.0	50.0	33.3	28.6	28.6	42.9	33.3	20.0	0.0	0.0	33.3	0.0	0.0	33.3	16.7
Striated Thornbill	23.5	0.0	0.0	0.0	28.6	42.9	28.6	0.0	0.0	20.0	33.3	16.7	0.0	60.0	33.3	50.0
Bar-shouldered Dove	22.2	50.0	0.0	50.0	14.3	28.6	0.0	33.3	40.0	20.0	16.7	50.0	100.0	0.0	0.0	16.7
Black-shouldered Kite	22.2	100.0	16.7	33.3	14.3	0.0	14.3	16.7	0.0	40.0	83.3	33.3	0.0	0.0	0.0	16.7
Rainbow Bee-eater *	21.0	100.0	33.3	33.3	28.6	42.9	28.6	16.7	20.0	0.0	16.7	0.0	0.0	0.0	16.7	0.0
White-breasted Woodswallow*	21.0	0.0	0.0	16.7	28.6	14.3	28.6	50.0	20.0	60.0	16.7	33.3	0.0	20.0	0.0	0.0

Common Name	RR% All Surveys	2004 RR%	2005 RR%	2006 RR%	2007 RR%	2008 RR%	2009 RR%	2010 RR%	2011 RR%	2012 RR%	2013 RR%	2014 RR%	2015 RR%	2016 RR%	2017 RR%	2018 RR%
Sulphur-crested Cockatoo	19.8	50.0	33.3	50.0	28.6	0.0	14.3	0.0	0.0	0.0	16.7	50.0	0.0	20.0	33.3	0.0
Royal Spoonbill	18.5	0.0	33.3	0.0	28.6	14.3	14.3	16.7	0.0	40.0	16.7	16.7	0.0	0.0	33.3	33.3
Tree Martin	18.5	0.0	16.7	33.3	57.1	28.6	0.0	16.7	0.0	0.0	0.0	0.0	0.0	40.0	16.7	33.3
Australasian Figbird	17.3	0.0	0.0	0.0	0.0	0.0	0.0	16.7	20.0	20.0	0.0	16.7	100.0	60.0	50.0	50.0
White-winged Chough	17.3	0.0	16.7	33.3	42.9	57.1	28.6	16.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brown Quail	16.0	0.0	0.0	0.0	14.3	28.6	28.6	0.0	40.0	40.0	16.7	33.3	0.0	20.0	0.0	0.0
Great Pied Cormorant	16.0	0.0	50.0	16.7	28.6	0.0	28.6	0.0	0.0	20.0	33.3	16.7	0.0	0.0	16.7	0.0
Eastern Spinebill	16.0	0.0	0.0	16.7	0.0	14.3	14.3	16.7	20.0	40.0	16.7	16.7	100.0	40.0	0.0	16.7
Brown-headed Honeyeater	16.0	0.0	0.0	16.7	0.0	0.0	57.1	0.0	20.0	40.0	16.7	50.0	0.0	20.0	0.0	0.0
Swamp Harrier	14.8	0.0	33.3	16.7	28.6	0.0	28.6	0.0	20.0	20.0	0.0	0.0	0.0	0.0	16.7	33.3
Plumed Egret	13.6	0.0	33.3	16.7	0.0	14.3	42.9	0.0	0.0	20.0	0.0	16.7	0.0	20.0	16.7	0.0
Australian White Ibis	13.6	50.0	0.0	0.0	0.0	14.3	42.9	16.7	0.0	40.0	0.0	0.0	0.0	0.0	50.0	0.0
Nankeen Kestrel	13.6	50.0	16.7	33.3	0.0	0.0	0.0	0.0	40.0	0.0	16.7	16.7	0.0	0.0	0.0	50.0
Musk Lorikeet	13.6	0.0	0.0	16.7	42.9	14.3	0.0	33.3	0.0	0.0	16.7	16.7	0.0	20.0	0.0	16.7
Brown Goshawk	12.3	50.0	16.7	16.7	14.3	14.3	0.0	16.7	20.0	0.0	0.0	16.7	0.0	20.0	0.0	16.7
Red-rumped Parrot	12.3	50.0	16.7	33.3	14.3	14.3	0.0	0.0	0.0	20.0	0.0	16.7	0.0	20.0	0.0	16.7
Eastern Whipbird	12.3	0.0	33.3	0.0	14.3	14.3	0.0	0.0	0.0	40.0	0.0	33.3	100.0	0.0	0.0	16.7
Australian Hobby	11.1	50.0	16.7	16.7	14.3	14.3	14.3	0.0	0.0	20.0	0.0	0.0	0.0	20.0	16.7	0.0
Azure Kingfisher	11.1	0.0	33.3	0.0	28.6	28.6	14.3	16.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pied Currawong	11.1	0.0	33.3	0.0	14.3	28.6	28.6	16.7	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Rose Robin **	11.1	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	60.0	50.0	33.3
Nankeen Night-Heron	9.9	50.0	16.7	16.7	14.3	0.0	0.0	0.0	20.0	0.0	16.7	33.3	0.0	0.0	0.0	0.0
Pied Stilt	9.9	0.0	0.0	0.0	14.3	0.0	14.3	0.0	0.0	0.0	16.7	16.7	0.0	0.0	16.7	50.0
Caspian Tern	9.9	0.0	0.0	0.0	14.3	14.3	0.0	16.7	0.0	0.0	16.7	16.7	0.0	0.0	0.0	50.0
Fan-tailed Cuckoo	9.9	0.0	0.0	0.0	0.0	0.0	14.3	16.7	20.0	0.0	16.7	16.7	0.0	0.0	33.3	16.7
Varied Sittella	9.9	0.0	0.0	0.0	0.0	0.0	14.3	16.7	0.0	0.0	16.7	33.3	0.0	20.0	16.7	16.7
Australasian Shoveler	8.6	0.0	16.7	0.0	42.9	0.0	14.3	0.0	0.0	20.0	0.0	0.0	0.0	0.0	16.7	0.0
Tawny Frogmouth	8.6	50.0	16.7	0.0	28.6	42.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White-throated Needletail *	8.6	0.0	0.0	16.7	0.0	14.3	14.3	0.0	20.0	0.0	0.0	16.7	100.0	0.0	16.7	0.0
Pheasant Coucal	8.6	0.0	0.0	0.0	0.0	0.0	14.3	16.7	20.0	0.0	0.0	16.7	100.0	20.0	16.7	0.0
Jacky Winter	8.6	0.0	0.0	0.0	0.0	14.3	28.6	0.0	0.0	0.0	33.3	16.7	0.0	20.0	0.0	0.0

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Greater Crested Tern	7.4	0.0	33.3	16.7	0.0	0.0	0.0	16.7	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White-winged Triller *	7.4	0.0	0.0	16.7	0.0	0.0	28.6	0.0	20.0	0.0	16.7	16.7	0.0	0.0	0.0	0.0
Fairy Martin *	7.4	0.0	0.0	0.0	0.0	14.3	28.6	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3
Yellow-billed Spoonbill	6.2	50.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	16.7	16.7	0.0	0.0	0.0	16.7
Little Lorikeet	6.2	0.0	0.0	0.0	28.6	0.0	0.0	0.0	20.0	0.0	0.0	0.0	100.0	0.0	0.0	16.7
Shining Bronze-Cuckoo *	6.2	50.0	0.0	0.0	0.0	28.6	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Pallid Cuckoo *	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	16.7	0.0	0.0	16.7	33.3
White-naped Honeyeater	6.2	0.0	0.0	0.0	0.0	14.3	14.3	16.7	0.0	0.0	0.0	0.0	0.0	0.0	16.7	16.7
Common Cicadabird *	6.2	50.0	0.0	0.0	0.0	0.0	14.3	16.7	0.0	0.0	0.0	0.0	0.0	20.0	16.7	0.0
Tawny Grassbird	6.2	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	40.0	33.3	0.0	0.0	0.0	0.0	0.0
Hardhead	4.9	0.0	0.0	0.0	0.0	0.0	14.3	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Rock Dove	4.9	0.0	0.0	33.3	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Brown Cuckoo-Dove	4.9	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	20.0	0.0	16.7	0.0	20.0	0.0	0.0
Wonga Pigeon	4.9	0.0	0.0	33.3	0.0	14.3	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Egret	4.9	0.0	16.7	0.0	0.0	14.3	0.0	0.0	0.0	0.0	16.7	0.0	100.0	0.0	0.0	0.0
Peregrine Falcon	4.9	0.0	16.7	16.7	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Yellow-tailed Black-Cockatoo	4.9	0.0	0.0	0.0	0.0	14.3	14.3	0.0	0.0	20.0	0.0	0.0	0.0	20.0	0.0	0.0
Long-billed Corella	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	16.7	0.0	0.0	0.0	16.7	16.7
Variegated Fairy-wren	4.9	0.0	0.0	0.0	0.0	0.0	14.3	0.0	40.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Brown Gerygone	4.9	50.0	0.0	0.0	14.3	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Collared Sparrowhawk	3.7	0.0	0.0	16.7	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Grey Goshawk	3.7	0.0	0.0	16.7	28.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Black-fronted Dotterel	3.7	0.0	16.7	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Crimson Rosella	3.7	0.0	0.0	0.0	0.0	0.0	14.3	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
White-bellied Cuckoo-shrike	3.7	0.0	0.0	0.0	0.0	14.3	14.3	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0
Restless Flycatcher	3.7	0.0	0.0	16.7	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0
Brown Songlark *	3.7	0.0	0.0	33.3	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spotted Dove	2.5	0.0	0.0	0.0	0.0	0.0	0.0	16.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Topknot Pigeon	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	16.7
Black-necked Stork	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	16.7	0.0
Silver Gull	2.5	0.0	0.0	0.0	14.3	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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Horsfield's Bronze-Cuckoo*	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	16.7
Brush Cuckoo	2.5	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0
White-plumed Honeyeater	2.5	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Rufous Songlark *	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	33.3
European Goldfinch	2.5	0.0	0.0	0.0	14.3	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
King Quail	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White-headed Pigeon	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Wompoo Fruit-Dove	1.2	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fork-tailed Swift *	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Pacific Baza	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0
Red-kneed Dotterel	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7
Bar-tailed Godwit *	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Australian Gull-billed Tern	1.2	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Common Tern *	1.2	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern Boobook	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Eastern Barn Owl	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White-throated Treecreeper	1.2	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Southern Emu-wren	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Buff-rumped Thornbill	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Little Wattlebird	1.2	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
White-fronted Chat	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0
Brown Honeyeater	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0
Dusky Woodswallow	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	0.0
Rufous Fantail *	1.2	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spangled Drongo	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0
Forest Raven	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Scarlet Robin **	1.2	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Australian Reed-Warbler	1.2	0.0	0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Little Grassbird	1.2	0.0	0.0	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Double-barred Finch	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0
Plum-headed Finch	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0

In October 2018 over 1500 birds were recorded during the survey. The 81 species observed comprised mainly wetland birds including 286 Grey Teal *Anas gracilis*, 109 Pacific Black Duck *Anas superciliosa*, 71 Cattle Egret *Bubulcus ibis*, 501 Straw-necked Ibis *Threskiornis spinicollis* and 191 Yellow-faced Honeyeater *Lichenostomus chrysops* moving through the riparian zone. Whilst this number is around three times that normally observed it indicates that at certain times and in certain conditions the property can support much larger populations.

Front Gate Forest

Between 2004 and 2018 there were 77 surveys carried out on this site with a total of 51 species recorded (**Appendix Table 1**). This area recorded 7-27 species per year with consistent counts in the high teens to low twenties. Four to six surveys were conducted each year except in 2004, with only one survey conducted in November, and 2015 with surveys in February and April only.

Two species had RR >80%; Noisy Miner *Manorina melanocephala* (RR 97.4%) and Eastern Rosella *Platycercus eximius* (RR 81.8%). Both species appear to find this remnant of open forest highly suitable. Three species had RR 77.9%-40%; Australian Magpie *Gymnorhina tibicen*, Pied Butcherbird *Cracticus nigrogularis* and Grey-crowned Babbler *Pomatostomus temporalis* (**Appendix Table 2**). All five species in the above two categories have been recorded breeding in this site. The remaining 22 species had RR ranging from 32.5% to 5.2% and comprised a mix of open forest species plus some waterfowl utilising the adjacent farm dam.

Tawny Frogmouth *Podargus strigoides*, Blue-faced Honeyeater *Entomyzon cyanotis*, Grey Butcherbird *Cracticus torquatus*, Crested Pigeon *Ocyphaps lophotes* and Common Myna *Acridotheres tristis* have also been recorded breeding in this woodland. A family of White-winged Choughs *Corcorax melanorhamphos* was present between August 2006 and August 2009. This species has not been recorded there since.

Quarry Lane and Bamboo Bend

These two sites were strips of riparian vegetation each approximately 20 metres wide which had been supplementarily planted with woodland and rainforest species. The sites were fenced to exclude grazing. However, at times cattle were allowed to graze the grass border alongside Quarry Lane.

Quarry Lane

Much of Quarry Lane was remnant rainforest species forming a mid-storey with large eucalypt and angophora species providing a canopy. Being the most heavily vegetated site and having a higher complexity of plant species with a good understorey, it recorded the highest diversity of bird species ranging from 23 to 56 (excluding 2004) seen in a calendar year. This is generally about twice the number of species seen in the similar site Bamboo Bend which had 16 to 33 species (excluding 2004). Some of the RR difference may have been influenced by surveys being conducted later in the morning at the latter site.

Between 2004 and 2018, 77 surveys were conducted with 4-6 surveys per year except in 2015 with surveys in February and April only. A total of 102 species was recorded overall with 23 - 56 species per year except in 2004 when only ten species were present on the sole survey (**Appendix Table 3**).

Five species had RR >80% and eight species had RR between 79.9% and 40% (**Appendix Table 4**). Of the thirteen species with RR >40%, ten species were generally found within the riparian vegetation. The other three species, Australian Magpie, Eastern Rosella and Laughing Kookaburra *Dacelo novaeguineae* mainly used the grassy strip and paddocks bordering the riparian vegetated strip. . The remaining 89 species had RR ranging from 36.4% to 1.3%. Of these, 12 species were only seen on one or two occasions.

Summer visitors to Quarry Lane comprised 11 species with the Sacred Kingfisher recorded breeding and Oriental Dollarbird a possible breeder. Two winter species were recorded: Rose Robin *Petroica rosea,* first seen in June 2016; and Scarlet Robin recorded only in August 2007.

At least eleven species have been recorded breeding (**Table 4**). Those were Australasian Darter, Sacred Kingfisher, Superb Fairy-wren, Brown Thornbill, Striated Pardalote, Yellow-faced Honeyeater, Scarlet Honeyeater *Myzomela sanguinolenta*, Brown-headed Honeyeater, Black-faced Cuckoo-Shrike *Coracina novaehollandiae* and Australian Magpie.

Nine additional species may possibly be breeding as suitable habitat was available. These include Oriental Dollarbird, White-browed Scrubwren, Yellow Thornbill *Acanthiza nana*, Eastern Spinebill *Acanthorhynchus tenuirostris*, Lewin's Honeyeater, Golden Whistler *Pachycephala pectoralis*, Grey

Fantail, Eastern Yellow Robin *Eopsaltria australis* and Silvereye *Zosterops lateralis*.

Bamboo Bend

Bamboo Bend, stretching from the southern boundary of the property northward along the Williams River, did not have the structural diversity or complexity of vegetation in Quarry Lane. Large eucalypts and angophoras were present, however, the mid-storey had not yet developed density and complexity with much of it having only been planted in 2001 - 2004. Being on a bend of the river it was also more open to winds from southerly, westerly and northerly aspects which may have impeded growth of revegetation. Possibly adding to this exposure is the complete absence of trees or shrubs on the opposite river bank, negating any buffering effect for westerly winds. . The vegetation structure also had an effect on the diversity of avian species as both cover and foraging resources were limited.

Between 2004 and 2018, 77 surveys were conducted with 4-6 surveys per year except in 2015, with surveys in February and April only. Overall, 71 species were recorded ranging from 16 - 33 per year, except in 2004 with seven species present on the sole survey (**Appendix Table 5**).

Only one species, Superb Fairy-wren, had RR >80%, with seven species having RR 79.9% - 40%, six of which are species that are more commonly found in more open vegetation (**Appendix Table 6**). The remaining 63 species had RR ranging from 29.9% to 1.3%.

The only observation indicating possible breeding was of two adult Brown-headed Honeyeaters feeding four fledged young in June 2014. Suitable breeding habitat was available for resident species such as Superb Fairy-wren, White-browed Scrubwren, Yellow Thornbill, Brown Thornbill, Lewin's Honeyeater, Yellow-faced Honeyeater, Grey Fantail, and Red-browed Finch *Neochmia temporalis*.

Lagoon

Between 2004 and 2018, 78 surveys were conducted with 4 - 6 surveys per year except in 2014 when there were 7 surveys, and in 2015 with only 2 surveys in February and April. A total of 45 species was recorded with species counts varying from 3 to 20 per year, and only one species recorded in the sole survey of 2004 (**Appendix Table 7**). This freshwater wetland periodically dries up and at such times the number of species recorded drops to about half of that recorded when the wetland is at capacity.

No species had RR >80% with only one species having RR between 79.9% and 40%, the Golden-headed Cisticola *Cisticola exilis,* which was recorded in all years (**Appendix Table 8**).

The remaining 44 species had RR ranging from 29.5% to 1.3%. Three of those species, Pacific Black Duck, White-faced Heron *Egretta novaehollandiae* and Masked Lapwing *Vanellus miles* had RR between 29.5% and 26.9%. These species are commonly recorded in wetlands of this nature.

Latham's Snipe has been recorded here on nine of the 15 years surveyed with counts of 1-5 birds. It appears the juncus provides good cover while the occasionally exposed muddy areas provide diurnal foraging opportunities.

Three species have been recorded breeding on this site: Black Swan *Cygnus atratus*; Chestnut Teal *Anas castanea*; and Golden-headed Cisticola.

The Swamp

Between 2004 and 2018, 77 surveys were conducted with 4-6 surveys per year except in 2015 with only 2 surveys in February and April, and 7 surveys in 2014. A total of 41 species was recorded with counts varying from 3 to 18 per year, and only three species recorded in the sole survey of 2004 (**Appendix Table 9**).

The Swamp was a permanent freshwater wetland about the same length as the Lagoon but wider and shallower, with one small area of open water. Bordering the wetland was an area of woodland with a copse of medium-sized trees resulting in an increased number of passerine species.

No species had RR >80% with only two species having RR between 79.9% and 40%; White-faced Heron and Australian Magpie (**Appendix Table 10**). The remaining 38 species had RR ranging from 29.9% to 1.3%.

Latham's Snipe was recorded here on 8 of the 15 years surveyed with counts of 1-13 birds. Again, juncus appears to have provided suitable habitat.

In February 2011 a covey of seven King Quail *Synoicus chinensis* were observed adjacent to the Swamp. A pair of unidentified small quail seen in February 2010 was also believed to have been King

Quail. No species has been recorded breeding at this site although it is possible that species such as Magpie-lark *Grallina cyanoleuca*, Noisy Miner and Australian Magpie may breed in the forested area on the southern border of the site.

Threatened Species

White-throated Needletail *Hirundapus caudacutus* (RR 8.6%), listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), was seen on seven occasions (**Appendix Table 11**).

Seven species listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act) were recorded (**Appendix Table 12**). Grey-crowned Babbler and White-bellied Sea-Eagle *Haliaeetus leucogaster* were common. The other five species were only occasionally present. Varied Sitella was recorded on eight occasions with 1-12 birds seen. Only two of these were winter records (August). Little Lorikeet *Glossopsitta pusilla* was recorded on five occasions. White-fronted Chat *Epthianura albifrons*, Scarlet Robin *Petroica boodang* and Dusky Woodswallow *Artamus cyanopterus* were each observed on one occasion only.

Table 3. Threatened species recorded at Greswick Angus 2004-2018.

Common Name	Rec-ords	RR%	Relevant Act
White-throated Needletail	7	8.6	EPBC Act
White-bellied Sea-Eagle	52	64.2	BC Act
Little Lorikeet	5	6.2	BC Act
White-fronted Chat	1	1.2	BC Act
Scarlet Robin	1	1.2	BC Act
Grey-crowned Babbler	62	76.5	BC Act
Varied Sittella	8	9.9	BC Act
Dusky Woodswallow	1	1.2	BC Act

Breeding Species

A total of 37 species have been recorded breeding or exhibiting breeding behaviour (**Table 4).** This included nest with eggs, birds inspecting hollows, collecting nesting material, nest building, adult birds carrying food or seen with dependent young.

Table 4. Breeding species recorded at Greswick Angus 2004-2018.

Black Swan	Noisy Miner
Australian Wood Duck	Striated Pardalote
Crested Pigeon	White-browed Scrubwren
Tawny Frogmouth	Striated Thornbill
Purple Swamphen	Brown Thornbill
White-faced Heron	Grey-crowned Babbler
Little Pied Cormorant	Olive-backed Oriole
Australasian Darter	Black-faced Cuckoo-shrike
Masked Lapwing	White-winged Triller
Whistling Kite	Australian Magpie
Rainbow Bee-eater	Pied Butcherbird
Sacred Kingfisher	Grey Butcherbird
Galah	White-winged Chough
Eastern Rosella	Willie Wagtail
Superb Fairy-wren	Grey Fantail
Blue-faced Honeyeater	Australian Raven
Brown-headed Honeyeater	Golden-headed Cisticola
Scarlet Honeyeater	Common Myna
Yellow-faced Honeyeater	

The Grey-crowned Babbler was regularly recorded breeding in Front Gate Forest. A family of White-winged Choughs *Corcorax melanorhamphos* was present between August 2006 and August 2009. A nest was being built in August 2006 which was found abandoned after egg hatching on October 2006. A second nest was found blown from a tree on the same date.

Long-term trends

The average number of species observed per year for 2004-2018 and the average number of birds counted per year for 2010-2018 are presented in **Figure 9**. The average annual species was 54.3 and this has remained relatively constant with a standard deviation of ±2.6. Counts of numbers of birds present commenced in April 2010. The average number counted remained relatively constant from 2010-2015, averaging 265. From 2016 the average number counted increased considerably to a maximum of 514.5 in 2018.

The average number of species is a measure of species richness and it appears to have remained relatively constant over the 15 years of survey. The data from Greswick Angus suggests that the property and the surrounding woodland, wetland

and river provide habitat that sustains a diverse range of resident and migratory species.

The pronounced increase in the average number of birds counted from 2016 - 2018 (**Figure 9**) was partly due to the influx of a large number of Anatidae, Ardeidae and Threskiornithidae following widespread rainfall from an East Coast Low in June 2016. In October 2018 the total count was 1507 birds.

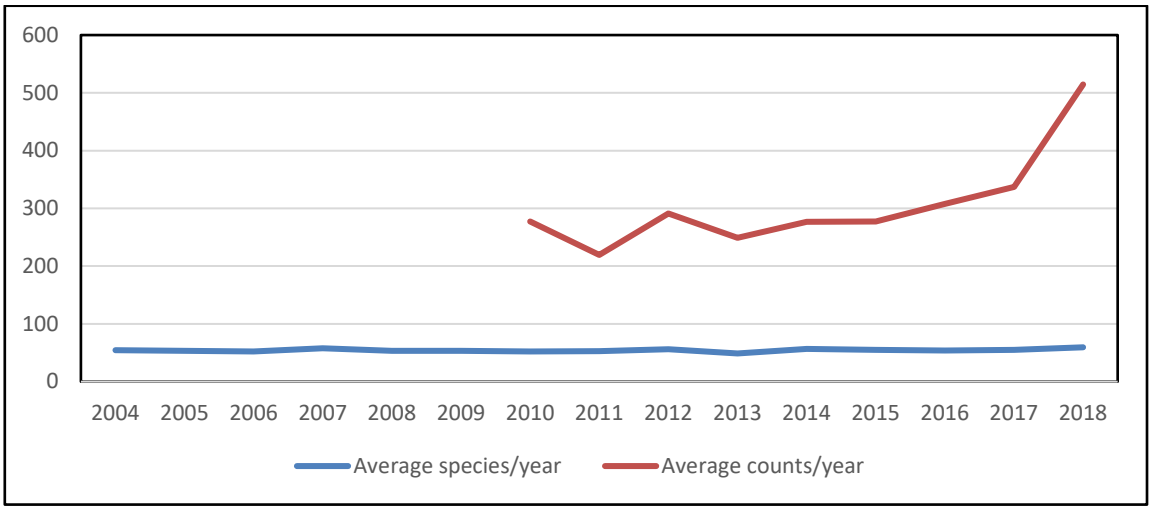

Figure 9. Comparison of the average number of birds counted per year and average number of species recorded per year from 2010 to 2018. Prior to April 2010 species numbers were not recorded.

Table 5. Chi square values and probability of significance of population change for five species from Greswick Angus, for periods 2004-2010 and 2011-2018.

Species	No. of records		$\chi 2$ Value	P	Statistical significance
	2004-2010	2011-2018			
Australasian Figbird	1	13	8.85	< 0.01	Highly significant increase
White-winged Chough	13	1	8.65	< 0.01	Highly significant decline
Azure Kingfisher	8	1	4.01	< 0.05	Significant decline
Rose Robin	1	8	4.00	< 0.05	Significant increase
Tawny Frogmouth	7	0	5.15	< 0.05	Significant decline

The results from Chi Square tests, shown in **Table 5,** indicated there was a statistically highly significant increase in the records of Australasian Figbird and a significant increase in the records of Rose Robin. A statistically highly-significant decline in records of White-winged Chough and a significant decline in records of Azure Kingfisher and Tawny Frogmouth were identified.

The increase in Rose Robin records probably reflects the growth and maturation of the revegetation around areas of its preferred riparian forest habitat at Quarry Lane and Bamboo Bend. Other factors possibly influencing the increase are influx due to drought, or increased time taken during surveys, particularly of the riparian zones. The increase in Australasian Figbird records is probably due to the extent of fruiting of the fig trees located between the Lagoon and the Swamp.

The species exhibiting highly significant and significant declines are not listed as threatened in NSW under the BC Act and are listed as Least Concern by BirdLife International and the IUCN. This indicates that their declines are probably due to local factors. While the decline in Tawny Frogmouth records may be related to the diurnal nature of the surveys, factors influencing a decline in White-winged Chough and Azure Kingfisher records are unclear.

The surveyed status of birds at Greswick Angus is in marked contrast to other regions of Australia where many species, particularly woodland birds, are in steady decline. Over one-third of Australia's

land bird species are woodland dependent and at least one in five of these is threatened and in decline. (Olsen *et al.* 2005).

Diversity

The total species recorded at Greswick Angus, which is a measure of species diversity, was compared to that of similar areas within the Hunter Region that have been surveyed for extended periods. The results are presented in Appendix **Table 6** which shows that the diversity at Greswick Angus is higher than most other areas surveyed in the region, although the range and quality of habitats across these survey sites are not the same. The range of habitats, rehabilitation efforts and management practices at Greswick Angus all undoubtedly contribute to the large number of species present.

Table 6. Comparison of species diversity from long-term studies of selected rural and conservation areas in the Hunter Region.

Location	Land use	Period	Species count	Reference
Butterwick	Cattle grazing	1996-2007	126	Newman (2007)
Green Wattle Creek	Cattle grazing	1996-2009	135	Newman (2009)
Bolwarra	Urban area	1994-2011	112	Tarrant (2011)
Martins Creek	Rural roadside	1999-2013	124	Newman (2014)
Laguna	Former grazing	1979-2012	124	Raine (2014)
Saltwater	National Park	2009-2015	124	Stuart (2015)
Curracabundi	National Park	2010-2013	126	Drake-Brockman (2015)
Dunns Creek	Rural roadside	2008-2014	113	Newman (2017)
Minmi	Reserve	2002-2009	153	Powers & Date-Huxtable (2017)
Tahlee	Private woodland	2014-2018	128*	Fleming (2019)
Booti Booti	National Park	1985-1988, 2012-2015	206	Turner (2020)
Blue Gum Hills	Reserve	2012-2016	91	Little (2021)
Yaraandoo	Cattle grazing	2011-2014	104	Newman (2022)
Greswick Angus	Cattle grazing	2004-2018	175	Kendall (this article)

* Excludes records of waterbirds and shorebirds surveyed from the Tahlee shoreline.

CONCLUSIONS

Greswick Angus is a working cattle breeding property with the priority of providing a sustainable and environmentally responsible business whilst considering the impact of farming activities on the immediate environment as well as the impact of farm runoff on the water supply for the Newcastle area.

The diversity of habitat across the property, namely remnant woodland, farm dams, ephemeral wetlands, open grassland and riparian forest, has contributed to attracting and maintaining significant populations of birds with 175 species recorded over the survey period. Breeding or breeding behaviour has been recorded in at least 37 of the species identified.

In his booklet "Striking the Balance: A Family's Quest for a Sustainable Future in Agriculture" John Spearpoint wrote *"When we planned our revegetation activities, our focus was on erosion control. We didn't really consider any indirect benefits to native plants and animals and the ecosystem services that they provide. Now that we are aware of their benefits, our plan is to maintain and improve bird habitat."* (Spearpoint 2006).

From the results of the monitoring, it is evident that the number of bird species utilising the property has increased. Hill (2015) states "*One of the most useful things that birds can indicate is overall habitat quality. When birds are dependent on the habitat functioning in specific ways, the population trends of birds can tell us about how well the ecosystem*

functions." And *"Since bird numbers can reflect the quality of the habitat, they can also be used to measure the effectiveness of habitat restoration."*

This study has shown that with an environmentally conscious approach, targeted revegetation and sympathetic management, a working farm can provide habitat that sustains as well as increases avian populations from a wide mix of species. In turn, birds provided a positive return benefit, acting as pollinators, seed dispersers and agents of biological control.

ACKNOWLEDGEMENTS

I would like to thank John and Janelle Spearpoint and their sons Hayden and James for allowing and encouraging HBOC involvement, their participation and continuing assistance, and especially for the maintenance of the spreadsheet documenting sightings which has been used to compile this paper. An extra thank you to Janelle Spearpoint for reviewing the draft paper and providing advice in relation to the property and farming activities.

Thanks also to the HBOC team past and present: Christine Cameron, Tom Clarke, Anthony Gooden, Tom Kendall, Neville McNaughton, Lyn Rayward, Leone Storm (Dec'd) and John Storm (Dec'd).

A special thanks to the editors and referee for their invaluable assistance in preparation of the paper, support and statistical analysis.

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Salamander Waters Estate: biodiversity of a highly modified environment

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Received: 24 November 2022, revised version 12 June 2023, accepted 28 July 2023, published online 13 August 2023.

Salamander Waters Estate is a highly modified area designated as a long-term development project by the Port Stephens Council in New South Wales. Over the past two decades most of the planned changes have already been completed. A sports complex, a car park and two ponds with a connecting channel were constructed in 2004-5, and the first of two residential housing estates was completed in 2015-16. Regular, on-going bird surveys of the site suggest that development, to date, has not adversely affected bird life, in fact, the ponds and channel introduced a permanent water source of benefit to all native fauna.

Records drawn from a variety of sources show that the site supports a healthy variety of native species, most were locally resident, some were migratory, and some were of special interest either due to their classification under the NSW *Biodiversity Conservation Act 2016* or because they were generally uncommon in the Hunter Region. Sixteen amphibians (one classified as vulnerable in NSW); twenty seven mammals, including eight marsupials (seven vulnerable); two reptiles, and 155 bird species (seven vulnerable) have been recorded at Salamander Waters Estate. Eighty-two species of plants and trees have been recorded.

Bird species which have been recorded at the site include seven species which currently are classified as vulnerable in NSW: Wompoo Fruit-Dove *Ptilinopus magnificus*; White-throated Needletail *Hirundapus caudacutus*; Fork-tailed Swift *Apus pacificus*; Powerful Owl *Ninox strenua*; Osprey *Pandion haliaetus*; Little Eagle *Hieraaetus morphnoides*; White-bellied Sea-Eagle *Haliaeetus leucogaster*; Glossy Black-Cockatoo *Calyptorhynchus lathami*; Varied Sittella *Daphoenositta chrysoptera* and Satin Flycatcher *Myiagra cyanoleuca*.

Also, several non-avian species listed as vulnerable in NSW have been recorded: Wallum Froglet *Crinia tinnula*; Squirrel Glider *Petaurus norfolcensis*; Little Bent-winged Bat *Miniopterus australis*; Eastern Coastal Free-tailed Bat *Micronomus norfolkensis*; Greater Broad-nosed Bat *Scoteanax rueppellii;* Southern Myotis *Myotis macropus*; Grey-headed Flying Fox *Pteropus poliocephalus* and Koala *Phascolarctos cinereus*.

Although the Stage 1 housing development does not appear to have had a major impact on native flora and fauna, the planned Stage 2 development, which will be twice the size of Stage 1, has the potential to place the existing flora and fauna under considerable pressure. Further development of the site will need to incorporate carefully considered measures to ensure the on-going protection of the site's rich biodiversity, a district asset well recognized by local and visiting birdwatchers.

INTRODUCTION AND OBJECTIVES

The study site, zoned "Residential" in 2000 under the Port Stephens Environmental Plan (https://www.portstephens.gov.au.) is a 20 ha, partially modified parcel of land located off Tarrant Road in Salamander Bay, NSW (at 32º43'53"S; 152º04'44" E). Originally the site consisted of native woodland and an abandoned sand mine. A development project is underway at the site, which is now known as Salamander Waters Estate (Conacher Travers Pty Ltd 1998-1999; Andrews Neil 2007). Site assessments and environmental studies were carried out prior to and during the project's development, which is approximately 70% complete. Development to date has created four definable habitat zones (see "Site Descriptions" below). Habitat demarcation is largely due to the positioning of the ponds and channel, designed to provide drainage and irrigation to the sports complex which is built on fill from the adjacent Waste Disposal Facility. The presence of a permanent water source appears to have attracted wildlife, particularly birds. Over the past two

decades the site has been monitored monthly by the authors and visited regularly by members of the local Tomaree Bird Club and the Hunter Bird Observers Club (HBOC). The final site development stage, a proposed 12-ha 66-lot residential sector, remains at the preliminary concept level https://www.portstephens.gov.au (McDaid 2020).

The objectives of this paper are to describe the location of the study site and its habitats and wildlife, with particular emphasis on avian species. Our intention is to update knowledge of the area's natural complexity, prior to the next stage of residential development, to emphasise the high degree of environmental sensitivity needed in order to protect and preserve the site's rich biodiversity, and to highlight the site's potential to enhance the general public's experience of nature.

METHODS

Between 2008 and 2022, monthly bird surveys were carried out by the authors. The 2-3 hr walking surveys were conducted in accordance with Birdata protocol (https://www.birdata.birdlife.org.au/) and covered, to the fullest extent possible, all habitats within an approximate 500 m radius. Additional data from field trip reports submitted to Port Stephens Council by the Tomaree Bird Watchers (Tomaree Bird Watchers 1999-2000) and from HBOC records (available at https://birdata.birdlife.org.au/), and eBird and Birdata records (https://ebird.org/Australia/; accessed 23/04/2022; https://www.birdata.birdlife.org.au/; accessed 23/04/2022) were collected. The multi-sourced records were cross-checked to eliminate duplication. Sightings recorded during ecological assessments of the area were also tabulated (Conacher Travers 1998-1999; Andrews Neil 2007). All avian species were ranked according to their HBOC classification (Williams 2020), then loosely grouped by their preferred habitat.

The site's development history was provided by the Port Stephens Council (Conacher Travers 1998-1999; Andrews Neil 2007; McDaid 2020). That history assisted in our establishment of pre-development baseline flora and fauna estimates and in the identification of threatened species as defined under the NSW *Biodiversity Conservation Act 2016* (BC Act).

Size and distance measurements pertaining to the study site were obtained using Google Earth (https://www.google.au/earth accessed 13/04/2022). Distances between the study site and nearby wetlands were measured from the centre of the study site to the centre of the main wet areas of the wetlands.

Site descriptions

The approximately 20-ha study site is located west of Soldiers Point Road, and is bounded by Tarrant Road, the Salamander Waste Disposal and Recycling facilities to the north, and the Cromarty Bay estuarine saltmarsh to the west. The completed first stage of Council's planned residential development is situated along part of the eastern boundary, and an as-yet undeveloped area of forest lies to the south-east between the Old Soldiers Point Road (now disused) and Port Stephens Drive.

The varied elements of the study site, excluding the housing development, were loosely classified into four habitat types (**Figure 1**). The four identified habitats are comprised of: mature sclerophyll forest (Habitat 1), open playing fields (the sports complex, Habitat 2); estuarine swamp (Habitat 3); and two leachate ponds connected by a channel (Habitat 4). Two additional wetland areas are located nearby – Wanda Wetlands and Mambo Wetlands – as is the relatively sheltered Cromarty Bay (**Figure 2**).

HABITAT 1 – Forest (Sub-areas 12, 13 and 14).

Sub-area 12 has been described as remnant forest (Andrews Neil 2005, Annex B). The canopy consists mostly of Smooth-barked Apple *Angophora costata* and Blackbutt *Eucalyptus pilularis*. The understorey is mainly Old Man Banksia *Banksia serrata* and Smooth Geebung *Persoonia levis.* The varied ground cover is dominated by Bracken *Pteridium esculentum* and grasses (Andrews Neil 2007). Sub-area 12 contains the site of the planned 66 lot Stage 2 residential development.

Sub-area 13 consists of a low-lying, paperbark forest adjacent to an area of estuarine swamp. The canopy overstorey in this region is predominantly Swamp Mahogany *Eucalyptus robusta* and Broad-leafed Paperbark *Melaleuca quinquenervia* with an understorey of ferns and a ground cover of Cord Rush *Restio tetraphyllus* (Andrews Neil 2007).

Sub-area 14 is formed by a built embankment which serves as a nature corridor that separates the Stage 1 residential area from the northern pond, while also protecting a small area of environmentally threatened *Lepironia* (Grey Sedge) swamp. The embankment is covered in a variety of shrubs and grasses. The *Lepironia* swamp contains Broad-leafed Paperbark and Swamp Mahogany standing in an area permanently inundated with up to 0.5m of water (Andrews Neil 2007).

HABITAT 2 – The sports complex (Sub-areas 4 and 5).

The sports complex, including a large clubhouse and parking area, is bordered by estuarine swamp to the west, two connected ponds to the east, and forest to the south. Tarrant Rd, which provides access to the Waste Disposal Centre and Recycling Depot, forms the northern boundary, beyond which lies a busy industrial area.

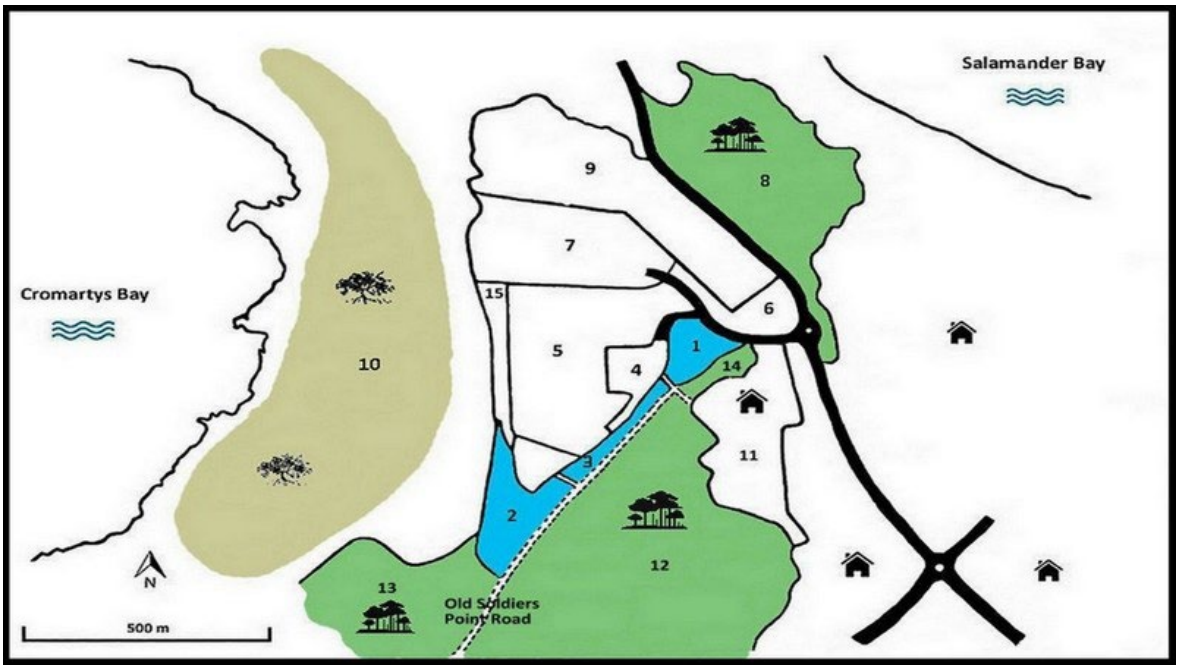

Figure 1. The Salamander Waters Estate Study Site and its sub-areas. (Codes: 1. Pond 1. 2. Pond 2. 3. Connecting channel. 4.Clubhouse and carpark. 5. Playing fields. 6. Recycling facility. 7. Waste disposal facility. 8. Wanda Wetlands. 9. Industrial area. 10. Estuarine Swamp. 11. Stage 1 Residential development (completed). 12. Proposed Stage 2 residential development. 13. Low-lying sclerophyll forest. 14. Nature strip. 15. Service corridor.)

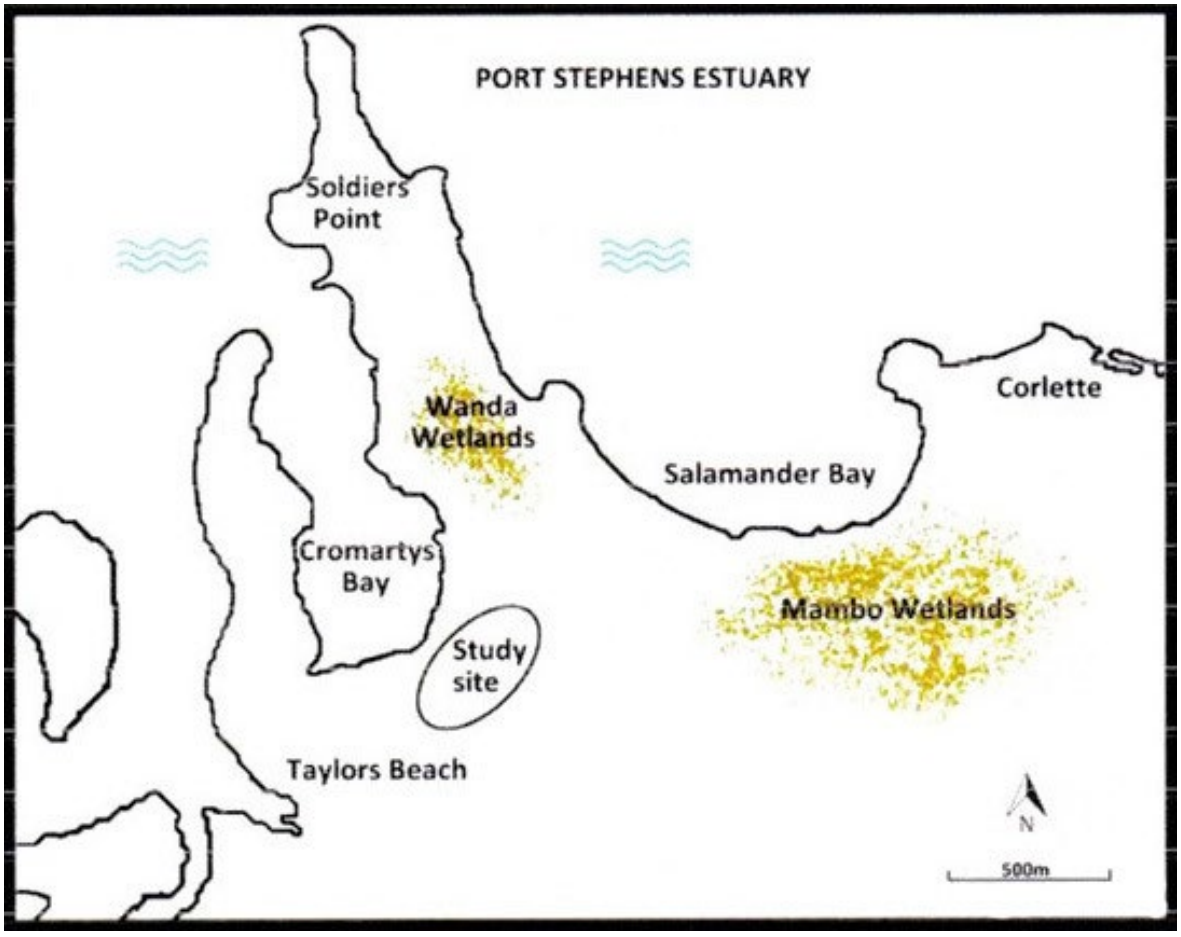

Figure 2. The study site in relation to neighbouring wetlands (Adapted from Google Maps).

HABITAT 3 – Estuarine Swamp (Sub-area 10).

The Estuarine Swamp lies between the sporting complex and Cromartys Bay. A levee protects the playing fields from tidal inundation, and provides vehicular access for mowing, maintenance and reclamation. The majority of the swamp area is covered with mangrove forest. Scattered patches of grassy groundcover occur in the littoral zone.

HABITAT 4 – The ponds and connecting channel (Sub-areas 1, 2 and 3).

The two connected ponds, constructed in 2004-5, intersect the playing fields, the forested areas and the Stage 1 housing development. The ponds are contained by dykes and are designed as aerated catchment basins for leach-water from the playing fields. A pumping system partially filters the pond water which can then be reused to irrigate the playing fields (McDaid 2020).

The smaller, shallower, northern pond (Pond 1) is somewhat rectangular in shape, 150m long and 120m across at the widest point. There is a heavy growth of Broad-leafed Paperbark on small mud islands and in the standing water. Fallen trees have been left to lie in the water. Water levels in the shallowest sections of Pond 1 can become depleted during summer and may completely dry up during severe drought conditions.

The southern pond (Pond 2) is deeper, larger, more open and slightly more rectangular (190m long and 120m across at the widest point). There are no islands in this pond. Flooded Swamp Mahogany and Broad-leafed Paperbark trees stand or lie in the water, and the pond's edges are lined with a thick margin of rushes (possibly *Phragmites australis*).

RESULTS

The collated data yielded a combined species site count of 155 birds; 16 amphibians; 27 mammals, including 8 marsupials; 2 reptiles and 82 plant species, recorded over a period of approximately 24 years **(Tables 1, 5** and **6)**. A list of all the bird species is presented in the **Appendix**. The majority (144 of 155) of the avian species were Category 1 birds (i.e., common or relatively common species within the Hunter Region (Williams 2020)). The recording frequency suggested that 60 of those Category 1 species were site residents, and regular observation of young birds suggests that most resident birds breed within the study site. There were confirmed breeding records for 33 species.

The majority of the 155 avian species recorded were woodland birds (69%). The remainder were classified as either waterbirds (22%) or raptors (9%) (**Table 1**). Habitat 3 (the estuarine swamp) was not formally surveyed as this area was not accessible by foot. From the vantage point of the levee, egrets, ibis and spoonbills could be seen foraging in Habitat 3 at low tide. The three other main habitats were surveyed regularly, with the forest areas (Sub-areas 12, 13 and 14) having the highest species diversity (**Table 2**). Annually 75-101 bird species were recorded during the years spanning 2008-2021 (**Table 3**). There was limited survey effort in 2022.

Ten avian species, which are listed *inter alia* in **Table 4**, are classified as Category 2, i.e., they are species of special interest for the Hunter Region (Williams 2020). Five of those species were confirmed by sightings by the authors: White-throated Needletail *Hirundapus caudacutus*; Osprey *Pandion haliaetus* (which nested successfully in eleven seasons); Glossy Black-Cockatoo *Calyptorhynchus lathami*; White-bellied Sea-Eagle *Haliaeetus leucogaster* and Varied Sittella *Daphoenositta chrysoptera.* The five other Category 2 species: Wompoo Fruit-Dove *Ptilinopus magnificus*; Fork-tailed Swift *Apus pacificus*; Little Eagle *Hieraaetus morphnoides*; Powerful Owl *Ninox strenua*; and Satin Flycatcher *Myiagra cyanoleuca*; were reported elsewhere (Conacher Travers 1998-1999; Tomaree Bird Watchers 1999-2000; Andrews Neil 2007). A further five species are listed in **Table 4** as important local records – Plumed Whistling-Duck *Dendrocygna eytoni,* Peaceful Dove *Geopelia placida,* Latham's Snipe *Gallinago hardwickii*, Spiny-cheeked Honeyeater *Acanthagenys rufogularis* and White-browed Woodswallow *Artamus superciliosus.* Latham's Snipe, a summer migrant of international interest, was often recorded at the site in years when low water levels exposed muddy areas.

The non-avian animal species recorded at the study site are summarised in **Table 5**. Eight of those species are classified as vulnerable under either the NSW *Environmental Planning and Assessment Act 1979*, the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999* or the NSW *Biodiversity Conservation Act 2016*; they are listed in **Table 4**. The vulnerable non-avian species included one amphibian: Wallum Froglet *Crinia tinnula*; six mammals: Squirrel Glider *Petaurus norfolcensis*; Little Bent-winged Bat *Miniopterus australis*; Eastern Coastal Free-tailed Bat *Micronomus norfolkensis*; Greater Broad-nosed Bat *Scoteanax rueppellii;* Southern Myotis *Myotis macropus*; Grey-headed Flying Fox *Pteropus poliocephalus;* and one marsupial: Koala *Phascolarctos cinereus* (Conacher Travers 1998-1999; Andrews Neil 2007). Solitary Koala and Koala with young were observed by the authors.

Table 1. Bird species recorded at the study site between 1998-2022, grouped by guild and by HBOC category classification.

Guild	No of species recorded	No. of resident species	HBOC category classification								
			1	1C	1L	1M	2R	2T	2U	V/ 2T	V
Woodland birds	107	43	72	0	4	25	1	2	1	1	1
Waterbirds	34	15	26	1	2	4	0	0	0		0
Raptors	14	2	7	2	1	0	0	2	1	1	0
Total species	155	60	105	3	7	29	1	4	2	3	1
Percentage of total species:		38.7	68	1.9	4.5	19	0.7	2.6	1.3	1.9	0.7

HBOC category classification (from Williams 2020).
Cat.1: Common or relatively common within the Hunter Region.
1C=cryptic; 1L=locationally restricted; 1M=moves regularly
Cat.2: Of special interest for the Region.
2R=rarely recorded regionally; 2T=has threatened status; 2U=uncommon in Hunter Region; V=vulnerable

Table 2. Bird species recorded in the three main habitats, grouped by guild and by the HBOC category classification.

Guild	No of species recorded	No. of resident species	HBOC category classification								
			1	1C	1L	1M	2R	2T	2U	V/ 2T	V
Habitat 1: Forest											
Woodland birds	96	40	65	0	3	22	1	2	1	1	1
Waterbirds	1	1	1	0	0	0	0	0	0	0	0
Raptors	11	1	6	2	1	0	0	0	1	1	0
Total species	108	42	72	2	4	22	1	2	2	2	1
Habitat 2: Open area (sports complex)											
Woodland birds	19	2	17	0	0	1	0	1	0	0	0
Waterbirds	6	1	6	0	0	0	0	0	0	0	0
Raptors	2	1	2	0	0	0	0	0	0	0	0
Total species	27	4	25	0	0	1	0	1	0	0	0
Habitat 4: Ponds and connecting channel											
Woodland birds	5	3	1	0	1	3	0	0	0	0	0
Waterbirds	32	14	25	1	2	3					
Raptors	3	1	2	0	0	0	0	1	0	0	0
Total species	40	18	28	1	3	6	0	1	0	0	0

For HBOC classifications, see the footnote to **Table 1**.

Table 3. Annual species totals from surveys 2008-2022.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Woodland birds	71	68	64	61	52	55	61	55	70	59	53	58	56	59	42
Waterbirds	24	25	20	23	19	23	23	25	24	25	22	21	19	20	15
Raptors	6	4	3	0	4	4	2	3	4	4	5	2	2	2	1
Annual totals	101	97	87	84	75	82	86	83	98	88	80	81	77	81	58

Note: Limited survey effort in 2022.

Table 4. Species of special interest which were recorded at the study site.

Birds	**Status**
Plumed Whistling-Duck	Uncommon visitor to study site
Wompoo Fruit-Dove	Vulnerable in NSW
Peaceful Dove	Uncommon visitor to study site
White-throated Needletail	Summer migrant, Vulnerable in NSW
Fork-tailed Swift	Uncommon summer migrant
Latham's Snipe	Summer migrant of international interest
Powerful Owl	Vulnerable in NSW
Osprey	Vulnerable in NSW
Little Eagle	Vulnerable in NSW
White-bellied Sea Eagle	Vulnerable in NSW
Spiny-cheeked Honeyeater	Uncommon visitor to study site
Varied Sittella	Vulnerable in NSW
White-browed Woodswallow	Uncommon visitor to study site
Satin Flycatcher	Rare summer migrant to the Hunter Region
Amphibians	**Amphibians**
Wallum Froglet	Vulnerable in NSW
Mammals	**Mammals**
Little Bent-winged Bat	Vulnerable in NSW
Eastern Free-tailed Bat	Vulnerable in NSW
Greater Broad-nosed Bat	Vulnerable in NSW
Grey-headed Flying Fox	Vulnerable in NSW
Large-footed Myotis	Vulnerable in NSW
Koala	Endangered in NSW
Squirrel Glider	Vulnerable in NSW

Table 5. Non-avian fauna list for Salamander Wetlands estate (sources: Conacher Travers 1998; Tomaree Bird Watchers 1999-2000; Andrews Neil 2007; this study).

	Total species seen	**No. of Vulnerable species**	**Conacher Travers (1998)**	**Tomaree Bird Watchers (1999-2000)**	**Andrews Neil (2007)**	**This work**
Amphibians	16	1	12		10	
Mammals	27	7	20	3	11	2
Reptiles	2				1	2

Table 6. Total numbers of plant species recorded at Salamander Wetlands Estate and the numbers of weed species (source: Andrews Neil 2007).

Plant Group	**No. Species**	**Weed Sp.**
Flowering Plants	26	4
Ferns	5	1
Lilies	3	
Vines	5	1
Grass & Sedge	12	3
Herb & Spurge	4	
Legumes	13	1
Small Shrubs & Trees	14	
Total Species	**82**	**10**

Professional assessments of the site's plant species and vegetation communities (**Table 6**) found no threatened flora but recommended the retention of a 2-ha *Lepironia* swamp (Conacher Travers 1998-1999; Andrews Neil 2007).

DISCUSSION

The report of the first site assessment, commissioned by Port Stephens Council and conducted prior to construction of the ponds and the sports complex, appeared fragmented and it was not fully accessible to the authors (Conacher Travers 1998-1999).

The second site assessment was carried out prior to the commencement of the Stage 1 residential development, and after the completion of further ERM flora and fauna surveys (Environmental Resources Management Australia Pty Ltd 2005). The combined data from the two site assessments provided an historical base for the subsequent data which was collected by the authors.

Port Stephens Council, acting on advice from the environmental assessments, carried out revegetation specific to the uptake of moisture (phytocapping) in some site areas (McDaid 2020). The small, environmentally sensitive area of *Lepironia* swamp has been protected, by a combination of dykes and fencing, and the growth of native vegetation within the narrow nature corridor that separates the residential area from the ponds appears robust (Andrews Neil 2007). Survey plans for the 66-lot Stage 2 residential development appear to acknowledge the need for an extension of the existing wildlife corridor (Andrews Neil 2007).

Although the study site has undergone considerable disturbance over the past two decades, regular site monitoring indicates that wildlife populations within the various habitats remain healthy.

HABITAT 1 – Forest (Sub-areas 12, 13 and 14).

Conacher Travers (*in* Andrews Neil 2007) concluded that development of these three sub-areas would not have a significant effect on threatened species, therefore, their report did not provide any recommendations designed to ameliorate the impact of development. This opinion was apparently based upon the assumption that habitats within the site also occurred within local conservation reserves (Andrews Neil 2007). It should be noted that the adjacent habitats at Mambo Wetlands and Wanda Wetlands are likely to already contain their full complement of species, and territorial pressure caused by the infiltration of species under stress in adjacent sites could have adverse effects on the populations in both areas.

These three forested sub-areas are notable in that they provide habitat for woodland birds, which comprised 67.7% of the study site's total avian population. Several woodland species classified as Category 2 (species of special interest for the Hunter Region) were associated with this habitat: White-throated Needletail; Glossy Black-Cockatoo; White-bellied Sea-Eagle; Varied Sittella; Wompoo Fruit-Dove; Fork-tailed Swift; Little Eagle; Powerful Owl; and Satin Flycatcher.

The Andrews Neil report did not find any threatened flora in this habitat, but it did identify a threat to the *Lepironia* swamp (now protected) and a number of threatened faunal species in the area, which included Squirrel Glider, Koala, tree-roosting microchiropteran bats, Grey-headed Flying Fox, Wallum Froglet and Powerful Owl (Andrews Neil 2007).

Andrews Neil (2007) made special reference to the proposed Stage 2 development site, recommending that further residential development should be confined to the eastern and northern section of the proposed site to better enable the retention of hollow-bearing trees and wildlife foraging resources. They also recommended the construction of an adequate ecological buffer for preferred Koala habitat (in Sub-area 12). A further recommendation involved the extension and maintenance of the established Koala corridor developed for the Stage 1 residential site (in Sub-area 14**)**.

HABITAT 2 – The sports complex (Sub-areas 4 and 5).

The well-maintained playing fields are a regular venue for weekend team sport and annual school events. Although the birds retreated during these large events they returned quickly afterwards and did not appear to be fazed by lesser activities like training and unstructured play which took place during the week. It was not uncommon to find a mix of Australian Wood Duck *Chenonetta jubata* (50+ birds), Purple Swamphen *Porphyrio porphyrio*, Australian Magpie *Gymnorhina tibicen*, Magpie-lark *Grallina cyanoleuca* and Laughing Kookaburra *Dacelo novaeguineae* busily foraging in the grass for insects and worms, particularly after mowing and watering. A fence line and a slim verge of shrubbery (width 2m) separate the playing fields from the daily noise and business of large trucks and

earth-moving equipment operating at the Waste Disposal Depot, the Recycling Centre and passing traffic along the Tarrant Road access. Since 2013 a pair of Osprey have successfully nested in a mobile phone tower adjacent to this boundary fence. Dogs are prohibited but were frequently encountered, both on and off leash. Car park traffic, apart from during maintenance activity, is minimal on weekdays. During early mornings and late afternoons, insectivores, particularly Welcome Swallow *Hirundo neoxena*, could often be seen hawking for insects above the playing fields and the car park.

HABITAT 4 – The ponds and connecting channel (Sub-areas 1, 2 and 3).

The manner in which the ponds and the connecting channel intersect the study site provides relatively easy access to safe, reliable and sheltered water sources for fauna from all habitats. The ponds, which are approximately 1 km from both Cromartys Bay and Salamander Bay, are also frequented by estuarine birds, especially cormorants, and there may also have been some interchange of birds between the nearby Wanda and Mambo Wetlands.

Between 2010 and 2015, Australian White Ibis *Threskiornis moluccus* began to colonize Pond 1. A successful rookery was established in 2015 (Wooding 2016). Smaller numbers of active nests were observed in subsequent breeding seasons, suggesting that Pond 1 may serve as an alternative ibis nesting location when overcrowding occurs at the Wanda and Mambo Wetlands, especially in times of inland drought when coastal populations increase.

A combination of standing and fallen trees provided roosts, cover and nesting areas for many avian species including Australasian Darter *Anhinga novaehollandiae*; Little Black Cormorant *Phalacrocorax sulcirostris*; Little Pied Cormorant *Microcarbo melanoleucos*; and occasionally Black Swan *Cygnus atratus*. The noisy excavation and construction of the Stage 1 residential project (approximately 100-200 m from Pond 1) coincided with the 2015 ibis breeding event, but did not appear to disturb the ibis or any of the other waterbirds routinely found in Pond 1, mainly dabbling ducks, Gallinules (Purple Swamphen and Dusky Moorhen *Gallinula tenebrosa*) and Royal Spoonbill *Platalea regia* (LW pers. obs.). When the shallow water in Pond 1 retreated during summer the exposed muddy edges usually attracted Latham's Snipe (1-5 birds). Small numbers of Nankeen Night-Heron *Nycticorax caledonicus* could often be spotted roosting in the Broad-leafed Paperbark on the pond's small islands.

Pond 2 is deeper, quieter, and more remote than Pond 1. Human activity is mostly restricted to dog-walking along what remains of the now abandoned Old Soldiers Point Road, which lies along the pond's eastern boundary**.** The pond's relative isolation provided secluded nesting habitat for many avian species including pairs of Australasian Darter *Anhinga novaehollandiae*, and a pair of Black Swan which nested there annually. Cormorants, and occasionally a White-bellied Sea-Eagle, perched in the tops of the leafless, drowned trees, and in summer White-breasted Woodswallow *Artamus leucoryn* lined up to roost along the bare branches. Diving ducks (e.g. Hardhead *Aythya australis* and Musk Duck *Biziura lobata*) and Australasian Grebe *Tachybaptus novaehollandiae* took advantage of the pond's depth and some Australian Reed-Warbler *Acrocephalus australis* could be heard calling from the pond's thick margin of rushes.

The connecting channel, 280m long and approximately 2.5m wide, carries excess water from the southern pond to the northern pond which, in turn, expels any overflow into the district drainage system. The channel's banks are densely edged with native shrubs and mature trees, predominantly Swamp Mahogany and Blackbutt. Wrens and finches frequented this area, and both species of kingfisher (Azure Kingfisher *Ceyx azureus* and Sacred Kingfisher *Todiramphus sanctus*) used the overhanging branches as hunting perches. Pairs of Sacred Kingfisher nested in the tree hollows and arboreal termite mounds.

CONCLUSIONS

Although the natural quality of the study site was previously disturbed by sand mining, and more recently by the construction of playing fields and residential housing, some development features i.e., the construction of ponds and a wildlife corridor, coupled with the retention of a significant expanse of native forest, appear to have offset any negative effects that development might have had on the site's wildlife population. While the present study was primarily bird-focused, non-avian species were often observed by the authors. The impressive variety of bird species, several of which are threatened species and/or are of special interest for the Hunter Region is an indication of current habitat healthiness. The site has become a popular destination for local birdwatchers. Visiting

birdwatchers are attracted to the site, and subsequently the region, by the information available about the site on-line and in tourist brochures.

To maintain this important district asset when undertaking the next development stage, it is essential that Council pays particular attention to the maximum retention of winter-flowering shrubs and trees, hollow-bearing trees, and Koala habitat. The existing nature corridor should also be extended, widened, and encouraged to become more vigorous, while still providing access for maintenance, safety vehicles and public foot traffic. It is hoped that, with the right care, the area's rich biodiversity can be maintained for the benefit of all concerned.

ACKNOWLEDGEMENTS

We thank Barry McDaid (a Project Management Coordinator for Port Stephens Council) for his helpful reply to our enquiries. We also thank the editors and the referee Andrzej Karpiel for their meticulous attention to detail and their suggestions and advice.

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Appendix: Salamander Waters Estate birdlist (from 1998-2022 surveys)

Brown Quail *Synoicus ypsilophorus*
Plumed Whistling-Duck *Dendrocygna eytoni*
Musk Duck *Biziura lobata*
Black Swan *Cygnus atratus*
Australian Wood Duck *Chenonetta jubata*
Grey Teal *Anas Gracilis*
Chestnut Teal *Anas castanea*
Pacific Black Duck *Anas superciliosa*
Mallard x Pacific Black Duck (hybrid) *A. platyrhynchos/superciliosa*
Hardhead *Aythya australis*
Australasian Grebe *Tachybaptus novaehollandiae*
Rock Dove *Columba livia*
White-headed Pigeon *Columba leucomela*
Spotted Dove *Streptopelia chinensis*
Crested Pigeon *Ocyphaps lophotes*
Peaceful Dove *Geopelia placida*
Bar-shouldered Dove *Geopelia humeralis*
Wompoo Fruit-Dove *Megaloprepia magnifica*
Tawny Frogmouth *Podargus strigoides*
Pheasant Coucal *Centropus phasianinus*
Eastern Koel *Eudynamys orientalis*
White-throated Needletail *Hirundapus caudacutus*
Fork-tailed Swift *Apus pacificus*
Channel-billed Cuckoo *Scythrops novaehollandiae*
Horsfield's Bronze-Cuckoo *Chalcites basalis*
Shining Bronze-Cuckoo *Chalcites lucidus*
Fan-tailed Cuckoo *Cacomantis flabelliformis*
Brush Cuckoo *Cacomantis variolosus*
Pallid Cuckoo *Cacomantis pallidus*
Buff-banded Rail *Gallirallus philippensis*
Dusky Moorhen *Gallinula tenebrosa*
Eurasian Coot *Fulica atra*
Purple Swamphen *Porphyrio porphyrio*
Royal Spoonbill *Platalea regia*
Australian White Ibis *Threskiornis moluccus*
Straw-necked Ibis *Threskiornis spinicollis*
Nankeen Night-Heron *Nycticorax caledonicus*
Striated Heron *Butorides striata*
Cattle Egret *Bubulcus ibis*
Great Egret *Ardea alba*
Plumed Egret *Ardea plumifera*
White-faced Heron *Egretta novaehollandiae*
Little Egret *Egretta garzetta*
Australian Pelican *Pelecanus conspicillatus*
Little Pied Cormorant *Microcarbo melanoleucos*
Great Cormorant *Phalacrocorax carbo*
Little Black Cormorant *Phalacrocorax sulcirostris*
Pied Cormorant *Phalacrocorax varius*
Australasian Darter *Anhinga novaehollandiae*
Black-fronted Dotterel *Elseyornis melanops*
Masked Lapwing *Vanellus miles*
Latham's Snipe *Gallinago hardwickii*
Silver Gull *Larus novaehollandiae*
Powerful Owl *Ninox strenua*
Southern Boobook *Ninox boobook*
Osprey *Pandion haliaetus*
Black-shouldered Kite *Elanus axillaris*
Little Eagle *Hieraaetus morphnoides*
Swamp Harrier *Circus approximans*
Grey Goshawk *Accipiter novaehollandiae*
Brown Goshawk *Accipiter fasciatus*
White-bellied Sea Eagle *Haliaeetus leucogaster*
Whistling Kite *Haliastur sphenurus*
Rainbow Bee-eater *Merops ornatus*
Dollarbird *Eurystomus orientalis*
Azure Kingfisher *Ceyx azureus*
Sacred Kingfisher *Todiramphus sanctus*
Laughing Kookaburra *Dacelo novaeguineae*
Nankeen Kestrel *Falco cenchroides*
Australian Hobby *Falco longipennis*
Peregrine Falcon *Falco peregrinus*
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*
Glossy Black-Cockatoo *Calyptorhynchus lathami*
Galah *Eolophus roseicapilla*
Long-billed Corella *Cacatua tenuirostris*
Little Corella *Cacatua sanguinea*
Sulphur-crested Cockatoo *Cacatua galerita*
Red-rumped Parrot *Psephotus haematonotus*
Eastern Rosella *Platycercus eximius*
Musk Lorikeet *Glossopsitta concinna*
Rainbow Lorikeet *Trichoglossus moluccanus*
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*
White-throated Treecreeper *Cormobates leucophaea*
Variegated Fairy-wren *Malurus lamberti*
Superb Fairy-wren *Malurus cyaneus*
Southern Emu-wren *Stipiturus malachurus*
White-cheeked Honeyeater *Phylidonyris niger*
New Holland Honeyeater *Phylidonyris novaehollandiae*
Brown Honeyeater *Lichmera indistincta*
Blue-faced Honeyeater *Entomyzon cyanotis*
White-naped Honeyeater *Melithreptus lunatus*
Brown-headed Honeyeater *Melithreptus brevirostris*
White-eared Honeyeater *Nesoptilotis leucotis*
Striped Honeyeater *Plectorhyncha lanceolata*
Noisy Friarbird *Philemon corniculatus*
Scarlet Honeyeater *Myzomela sanguinolenta*
Eastern Spinebill *Acanthorhynchus tenuirostris*
Lewin's Honeyeater *Meliphaga lewinii*
Spiny-cheeked Honeyeater *Acanthagenys rufogularis*
Little Wattlebird *Anthochaera chrysoptera*
Red Wattlebird *Anthochaera carunculata*
White-plumed Honeyeater *Ptilotula penicillata*
Fuscous Honeyeater *Ptilotula fusca*
Yellow-faced Honeyeater *Caligavis chrysops*
Yellow-tufted Honeyeater *Lichenostomus melanops*
Noisy Miner *Manorina melanocephala*
Spotted Pardalote *Pardalotus punctatus*
Striated Pardalote *Pardalotus striatus*
Brown Gerygone *Gerygone mouki*
White-throated Gerygone *Gerygone olivacea*
White-browed Scrubwren *Sericornis frontalis*
Yellow Thornbill *Acanthiza nana*
Striated Thornbill *Acanthiza lineata*
Brown Thornbill *Acanthiza pusilla*

Appendix (cont'd)

Buff-rumped Thornbill *Acanthiza reguloides*
Varied Sittella *Daphoenositta chrysoptera*
Australasian Figbird *Sphecotheres vieilloti*
Olive-backed Oriole *Oriolus sagittatus*
Rufous Whistler *Pachycephala rufiventris*
Golden Whistler *Pachycephala pectoralis*
Grey Shrike-thrush *Colluricincla harmonica*
Eastern Whipbird *Psophodes olivaceus*
Black-faced Cuckoo-shrike *Coracina novaehollandiae*
Common Cicadabird *Edolisoma tenuirostre*
Australian Magpie *Gymnorhina tibicen*
Pied Currawong *Strepera graculina*
Grey Butcherbird *Cracticus torquatus*
Pied Butcherbird *Cracticus nigrogularis*
White-browed Woodswallow *Artamus superciliosus*
White-breasted Woodswallow *Artamus leucoryn*
Willie Wagtail *Rhipidura leucophrys*
Rufous Fantail *Rhipidura rufifrons*
Grey Fantail *Rhipidura albiscapa*
Spangled Drongo *Dicrurus bracteatus*
Leaden Flycatcher *Myiagra rubecula*
Satin Flycatcher *Myiagra cyanoleuca*
Restless Flycatcher *Myiagra inquieta*
Magpie Lark *Grallina cyanoleuca*
Black-faced Monarch *Monarcha melanopsis*
Torresian Crow *Corvus orru*
Australian Raven *Corvus coronoides*
Eastern Yellow Robin *Eopsaltria australis*
Australian Reed-Warbler *Acrocephalus australis*
Tawny Grassbird *Megalurus timoriensis*
Little Grassbird *Megalurus gramineus*
Fairy Martin *Petrochelidon ariel*
Tree Martin *Petrochelidon nigricans*
Welcome Swallow *Hirundo neoxena*
Silvereye *Zosterops lateralis*
Common Starling *Sturnus vulgaris*
Common Myna *Acridotheres tristis*
Mistletoebird *Dicaeum hirundinaceum*
Red-browed Finch *Neochmia temporalis*
Australasian Pipit *Anthus australis*

Little Tern breeding on Worimi Conservation Lands, Stockton Beach, summer 2022/23

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Received 5 June 2023, accepted 31 July 2023, published online date 31 August 2023.

A colony of Little Tern *Sternula albifrons* which nested on Worimi Conservation Lands, Stockton Beach was monitored from early December 2022 to the end of January 2023. A maximum of 39 breeding pairs were present in early January. A total of 107 eggs were laid and at least 45 chicks hatched. However, only six chicks successfully fledged, a breeding success rate of 5.6%. Although several potential mammalian and avian predators were identified, the most active predator was the Ghost Crab *Ocypode cordimana* which established burrows and became increasingly active across the site from late-December. Human disturbance at the end of the monitoring period probably contributed to early abandonment of the site. Investigation of Ghost Crab control techniques is recommended to support future breeding events.

INTRODUCTION

The Little Tern *Sternula albifrons* that breeds along the NSW coast in summer is listed as a migratory species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. In NSW it is listed as an endangered species on Schedule 1 of the *Biodiversity Conservation Act 2016.* The breeding population in south-eastern Australia has declined and its beach-breeding sites are particularly prone to human disturbance, predation and natural catastrophes (NSW Office of Environment and Heritage 2021).

Little Tern established a breeding colony on Worimi Conservation Lands (WCL), Stockton Beach in late November 2022 (**Figure 1**). The colony was regularly monitored from early December 2022 until the end of January 2023. This article describes the breeding event on WCL in the summer of 2022/23, summarizes the monitoring results, estimates breeding success, identifies predators and other threats, and provides recommendations for management of future events.

The protection of Little Tern is listed as a desired outcome in the WCL Plan of Management (NSW Office of Environment and Heritage 2015). The plan notes that beachfront vehicular activity disturbs foraging and nesting activity of migratory birds and increases the risk of exposure and predation on eggs and chicks from Silver Gull *Larus novaehollandiae*, Australian Raven *Corvus coronoides* and Red Fox *Vulpes vulpes.*

Recent previous breeding attempts on Stockton Beach/WCL

In December 2010 up to 31 birds were recorded but no breeding activity was observed. However, Little Tern have bred on Stockton Beach, mainly within WCL, on a number of occasions since 2012 (https://birdata.birdlife.org.au/home).

2012-2018

In the summers of 2012/13, 2013/14, 2014/15, 2016/17 and 2017/18, breeding colonies were established on the sandhills immediately north of the Ganyamalbaa camping area at the southern end of WCL (**Figure 1**). In the summer of 2015/16, the birds nested south of the WCL boundary. Nests with eggs, chicks and runners were reported on all six occasions. Birds were present from late-November to early-February. The maximum count was 95 adult birds in November 2014. The outcomes of any of these breeding attempts are unknown; no fledglings were recorded and the survey were irregular. In December 2018, up to 37 birds were in the area but no breeding activity was observed, nor in the two subsequent breeding seasons.

Summer 2021-2022

In the summer of 2021/22 two nesting colonies around 500 m apart were established on the beach at WCL, around 4 km north of the Lavis Lane beach access point. It is possible that some of the birds present in this colony were from an earlier abandoned breeding attempt on the western end of Corrie Island, Port Stephens.

Birds were first noted in the area in early November 2021. The site was regularly surveyed from 22 December. The two colonies had a maximum of 30 breeding pairs present on 30 December 2021 and between five and ten fledglings were recorded. The maximum number of adult birds present was 131 on 14 January 2022. Fox tracks were recorded at the site on several occasions and a fox probably predated many eggs and chicks (P. Blair pers. com.) Both sites were deserted at the end of January 2022.

Figure 1. Location of Little Tern nest sites in the Worimi Conservation Lands. Image from Google Earth.

METHODS

Location and description of the breeding site

The breeding colony was located on Stockton Beach, 4 km north of the Lavis Lane beach access point (32º 49.734'S, 151º 54.254'E). The site was situated in a wide, shallow, north-south trending swale that was open to the beachfront. The site covered approximately 2 ha and was bound by a freshwater lagoon to the northwest and sandhills to the east and west. A line of marine debris extended north-south through the centre of the site. Debris consisted mainly of Giant Reed *Arundo donax* fragments and lesser amounts of anthropogenic waste (**Figure 2, Figure 3**). Several larger tree branches and logs were also present. Vegetation was sparse and comprised isolated clumps of Sea Rocket *Cakile maritima* along the central debris line. Spinifex Grass *Spinifex sericeus* and Juncus Rush *Juncus acutus* surrounded the lagoon to the northwest.

The majority of nests were located in the central part of the site along or close to the marine debris line. Nests were located from 80 to 200 m from the shore line and between 1.5 and 40 m apart. Temporary fencing and signage were erected around most of the site to protect it from interference by beach users.

Details of the monitoring program

The site was monitored weekly around low tide by staff from the NSW National Parks and Wildlife Service (NPWS) and the Department of Planning and Environment, Biodiversity Conservation Department (DPE BCD), assisted by the author and other volunteers. Each survey involved at least two people. Monitoring was conducted in accordance with best practice guidelines (Department of Environment and Climate Change 2008). New nests were located and flagged, and all known nests were checked. Nests were flagged with a marker bearing the nest number, number of eggs and date of discovery. Once hatching commenced, beach debris and clumps of vegetation around the nest site were searched for chicks that had been moved from the nests. Nest locations and the numbers of eggs and chicks were recorded on monitoring sheets. Geolocated plots of nest sites were prepared. Evidence of predation or other losses and site disturbance details were recorded. The flock of Little Tern on the adjacent beachfront was surveyed for fledglings. The numbers of breeding, non-breeding and fledged Little Tern plus all other avian species in the

vicinity of the nest site and on the adjacent beachfront were recorded.

The non-breeding birds are part of a population that breeds in Asia during the austral winter and then migrate to Australia (Higgins & Davies 1996). They are present in small numbers amongst breeding birds roosting on the beachfront and are recognisable as they are adult birds that are not in breeding plumage. Fledglings are young birds, 4-5 weeks old with incompletely developed plumage and limited flight ability. They roost amongst the breeding birds on the beachfront where they are fed by adults.

Figure 2. Breeding site looking east.

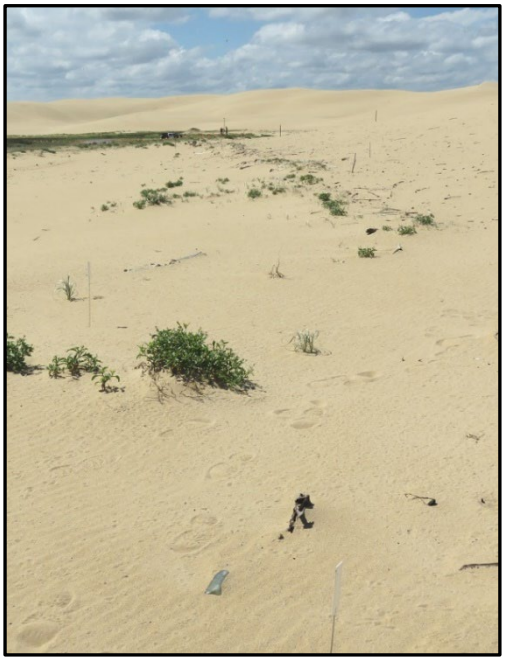

Figure 3. Breeding site looking west towards lagoon. Both images show central marine debris line, nest markers and small patches of Sea Rocket. (Images by N. Fraser)

RESULTS

Results of the weekly site monitoring are summarised in **Table 1** and breeding statistics are summarised in **Table 2**. Records of tracks or other indications of potential predators and evidence of human disturbance on or near the site are summarised in **Table 3**.

Table 1. Weekly site monitoring results at the WCL Little Tern colony, December 2022 to January 2023.

	6 Dec	13 Dec	20 Dec	27 Dec	3 Jan	10 Jan	17 Jan	24 Jan	31 Jan
Breeding birds	15-20	30	40-45	42	88	80	80	60	32
Non-breeding birds			7	2		6	8	10	8
Active nests	6	12	15	19	39	39	30	8	
Eggs	17	32	37	26	53	49	43	12	
Chicks			2	9	21	7	9	7	
Fledglings						1	3	6	4
Dead chicks						3		1	

Table 2. Summarised breeding statistics for Little Tern at the 2022/23 colony.

Breeding pairs	39
Total active nests	53
Total eggs	107
Total fledglings	6
Fledglings/nest site	0.11
Birds fledged/egg	5.6%

Table 3. Tracks of potential predators and records of human interference, December 2022 to January 2023.

Predator / Site Interference	6 Dec	13 Dec	20 Dec	27 Dec	3 Jan	10 Jan	17 Jan	24 Jan	31 Jan
Fox tracks	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dog tracks		✓							✓
Human tracks		✓							
Whistling Kite	✓								
Australian Pied Oystercatcher		✓	✓						
Silver Gull	✓	✓	✓	✓	✓	✓	✓	✓	✓
Australian Raven									✓
Ghost Crab burrows & tracks	✓	✓	✓	✓	✓	✓	✓	✓	
Off-road vehicle tracks								✓	✓

DISCUSSION

The first chicks were discovered on 20 December, indicating that incubation commenced around 30 November, assuming an average incubation period of 21 days (Higgins & Davies 1996). Birds are estimated to have started to arrive on site around mid-November and egg-laying would have commenced soon after. The initial clutches were each of 2-3 eggs. The maximum number of breeding pairs was 39, present on 3 and 10 January 2023. Newly hatched chicks remained in the nest scrape for one to two days before being moved to patches of Sea Rocket or under logs. New nests after 3 January contained only 1-2 eggs; they were from repeat nesting attempts by pairs that had lost eggs or chicks. There was no indication of egg predation up to 3 January, but after that date eggs and many chicks appeared to have been taken. Newly-fledged birds joined the main flock on the beachfront. Four abandoned eggs were found on 24 January. On the morning of 31 January, following several hours of steady overnight rain, no eggs, chicks or breeding birds were located on the nesting site and there were no tracks of Little Tern, Ghost Crab or any other species. It is probable the birds abandoned the site before the end of January following disturbance by recreational vehicles on 24 and 27 January (**Table 3**).

The low percentage of fledglings produced per nest site, 5.6% is indicative of a high level of breeding failure. The fledgling production rate is however comparable to that of many other Little Tern colonies in eastern Australia, which have experienced breeding success of only 6.5 - 17.9% in recent years, due to predation and disturbance (Australian Government Department of Agriculture, Water and Environment 2022).

Predation

Higgins & Davies (1996) listed the following species as reported to predate Little Tern nest sites: Red Fox, feral and domestic dogs *Canis familiaris*, feral and domestic cats *Felis catus,* Black Rat *Rattus rattus*, gulls *Laridae* spp., Black-breasted Buzzard *Hamirostra melanosternon*, Whimbrel *Numenius phaeopus*, Australian Kestrel *Falco cenchroides*, ravens *Corvus* spp., snakes *Serpentes*, lizards *Lacertilia* and Peregrine Falcon *Falco peregrinus*. In a study of Little Tern breeding colonies on sand islands in Wallis Lake near Forster, NSW, Rose (2001) identified predation, or possible predation, by Cat, Silver Gull, Whimbrel, Australian Pied Oystercatcher *Haematopus longirostris*, Caspian Tern *Sterna caspia*, corvids, Galah *Cacatua roseicapilla*, various raptor species, Black Rat, Ghost Crab *Ocypode cordimana* and ants *Iridomyrmex gracilis*.

The low percentage of birds fledged indicates that the colony was subjected to significant predation. However, no active predation was observed during monitoring. Red Fox tracks were regularly observed around the adjacent lagoon, and domestic dog tracks that appeared to accompany off-road vehicle intruders were observed on two occasions. However, these tracks did not venture onto the site. There was no evidence of the presence of other potential predators including Cats, Black Rats, Dingo *Canis lupus dingo*, or Lace Monitor *Varanus varius*.

Potential avian predators recorded at the 2022/23 WCL colony were Australian Pied Oystercatcher, Whistling Kite *Haliastur sphenurus*, Silver Gull and Australian Raven. Tracks of two Australian Pied Oystercatchers crossed the Little Tern breeding site when only eggs were present and apparently there was no predation. A Whistling Kite was recorded at the start of the monitoring and three Australian

Raven at the end; in both instances there were very few eggs or chicks offering any opportunity for predation. A flock of Silver Gull was regularly present around the lagoon and on the beachfront with a maximum number of 86 birds on 20 December. Their numbers decreased subsequently. Although Silver Gull were not observed on the site or displaying an interest in the nesting activities, active defense of nests/chicks by Little Tern against over-flying Silver Gull was observed.

While there were several potential predators present in the area during the monitoring period, the only species from the above list that was continually active on the nesting site was the Ghost Crab *Ocypode* spp.

Ghost Crab

There are six species of Ghost Crab *Ocypode* spp. found in Australia (Lucrezi & Schlacher 2014). The most common species on NSW beaches is *O. cordimana* (**Figure 4**). It is relatively small, up to 3.5 cm, and is almost translucent, with flecks of pink and yellow. It is well camouflaged against the sand and is very fast-moving. The species is largely nocturnal and spends all day in a burrow, emerging at twilight to hunt along the waterline. The burrow, which is built high up on the beach, is sometimes over 100 m from the sea and can be over one metre deep (Lucrezi & Schlacher 2014).

Figure 4. A Ghost Crab *Ocypode cordimana*. (Image The Australian Museum.)

Ghost Crab are often the apex invertebrate predator and scavenger on sandy shores. They consume a broad range of organic matter ranging from small interstitial diatoms and plant matter to the eggs and young of sea turtles and shore-breeding birds. Worldwide, the crabs have been recorded predating eggs and chicks of terns, plovers, oystercatchers, tropicbirds, storm petrels and shearwaters (Lucrezi & Schlacher 2014). A study of Piping Plover *Charadrius melodus* nesting success at Cape Hatteras, North Carolina, USA, showed daily survival rates for nests were lowest in areas where Ghost Crabs were present (Kwon *et al*. 2018).

Initially at the 2022/23 WCL colony there were a few tracks across the site where crabs had travelled to or from their burrows to the beachfront. However, after the third week of monitoring, active crab burrows were noted to be present around the nest sites, particularly in the central breeding area, and the number of burrows increased over time. Crab tracks were most prominent around patches of Sea Rocket and around logs where chicks were hidden. A crab burrow was inevitably located nearby. Drag marks were observed on two occasions leading to burrows. On the final survey on 31 January when no eggs or chicks were present, there were no crab tracks or burrows on site.

The presence of Ghost Crabs on the site may also be related to off-road vehicle activity on the adjacent beachfront. The beachfront was closed to vehicles until early January which approximates with the observed increase in Ghost Crab activity. Several studies in Australia and elsewhere in the world have shown that vehicle activity on sandy beach environments has an impact on Ghost Crab population densities and distribution (Moss & McPhee 2006; Noriega *et al*. 2012; Lucrezi *et al*. 2014). Larger Ghost Crabs sometimes relocate their burrows away from the beachfront in response to vehicular activity (Lucrezi *et al*. 2014). Without access to beachfront foraging, those crabs will shift their foraging to the eggs and chicks of beach-nesting birds (C. Tourenq pers. comm.).

Rose (2001) experimented with deterrents to control Ghost Crab and found that the pesticide Chlorpyrifos (Australian Pesticides and Veterinary Medicines Authority 2019) proved effective. He baited small fish with the chemical and placed them in crab burrows. The majority of burrows disappeared within two days and the baiting stopped further crab predation of the Little Tern colony. In 2019 the registration of Chlorpyrifos for domestic and agriculture use was cancelled by the Australian Pesticides and Veterinary Medicines Authority due to the risk to human health and the environment.

Other losses

Four dead chicks were discovered over the survey period. Two advanced chicks were found dead beneath a log and a recently hatched chick was found dead in an exposed location. These chicks could have been killed by a predator such as a Silver Gull and not eaten, or they may have died of

starvation. A broken egg containing an unborn chick was also located, possibly indicating the actions of an unknown predator. Additionally, four abandoned eggs were found during the monitoring period.

Human disturbance

Apart from regular weekly monitoring, there was no human disturbance of the site until the last two weeks of monitoring. Human footprints were observed near the fence on 13 December, but did not enter the site. Beach closures throughout December and early January undoubtedly reduced disturbance by beach users. Tracks from off-road vehicles were observed across the site in late-January. A regular route used by a quadbike tour operator approached close to the northern end of the site.

A remotely monitored camera was installed at the northern end of the site on 24 January. It did not identify any predators but recorded two off-road vehicles on the evening of 24 January (**Figure 5**), a trail bike on the morning of 27 January and three quad bikes on the evening of 27 January (**Figure 6**). These vehicles traversed the immediate western end of the site but did not encroach onto the active nest areas. The margins of the lagoon at the northwest end of the site were also extensively churned up by off-road vehicles during this period. This lagoon was not within the area covered by the camera. It is probable that this vehicular activity with its associated noise and driving lights contributed to the birds abandoning the site before the end of January.

Figure 5. Off-road vehicle near the breeding colony at 2016 h on 24/01/2023.

It seems probable that human disturbance and off-road vehicle activity around the previous breeding site north of the Ganyamalbaa Camping Area resulted in birds permanently abandoning that area as well. The site is within the WCL Recreational Vehicle Area and an examination in January 2023 revealed it was covered in vehicle tracks. This location, however, was atypical of Little Tern breeding sites that are generally located closer to the ocean – they are either on the beach or within frontal dunes (Higgins & Davies 1996).

Figure 6. Quad bikes near the breeding colony at 1907 h on 27/01/2023. (Images from NPWS remote site monitoring camera.)

Dispersal

Birds began to disperse from the site after 17 January and by 31 January the numbers on site had halved. Although the locations to which the birds initially disperse are unknown, there were a number of sightings of Little Tern from nearby areas where the birds had not bred. Eight birds in breeding plumage were at the mouth of the Myall River, Port Stephens (21 km northeast) on 24 January (Trish Blair pers. comm.) and a mixed flock of 20+ birds in breeding and non-breeding plumage with two fledglings was at the southern end of Stockton Beach (14.5 km southwest) on 31 January (Paul Fuller pers. comm.).

From late December 2022, increasing numbers of birds in non-breeding plumage were observed by the author foraging and roosting in Salamander Bay, Port Stephens. The maximum number was 50 birds on 25 January 2023. This count included a number of recently fledged birds. All birds had departed by 3 February (**Table 5**). A previous observation by the author of 83 birds in the same locality in February 2018 suggests this may be a regular assembly point for the species from around the region prior to commencing its northern migration. Little Tern did not nest in Port Stephens in summer 2022/23.

Table 5. Little Tern numbers at Salamander Bay, December 2022 to February 2023. Observations by the author.

5 Dec	21 Dec	6 Jan	19 Jan	25 Jan	3 Feb
0	20	33	38	50	0

Other local breeding colonies

There were three other monitored breeding colonies of Little Tern in or near the Hunter Region over the 2022/23 summer period; two colonies in the Manning River estuary at Harrington and at Farquhar Inlet, and a colony at the Karagi Point sandspit in The Entrance channel. The latter site is the second most successful nesting site in NSW.

In the Manning estuary, Ghost Crabs were present around the nesting sites but were not a major predator. In December 2020 a Ghost Crab was observed dragging a 2-3-day old chick from its nest towards a burrow (A. Morris pers. comm.). The crabs predated relatively small numbers of eggs and chicks compared to Australian Gull-billed Tern *Gelochelidon macrotarsa* and foxes (Darnell 2020).

At the Karagi Point sandspit in the 2022/23 summer nesting season, 31 chicks fledged from an estimated 150 chicks hatched (Central Coast Community News 2023). Silver Gull moved onto the sandspit following the loss of their nearby sand island roosts due to heavy rains and high tides, and predated many chicks. The nesting site is reshaped annually by winter storms and Ghost Crabs are unlikely to become established on this site (A. Morris pers. comm.).

CONCLUSIONS

The Little Tern breeding event on WCL in the summer of 2022/23 largely failed. Breeding success of 5.6% (6 fledglings from 53 nests and 107 eggs) was low, but sadly that success rate is comparable to other sites in eastern Australia that have suffered significant predation and human disturbance. Although a flock of Silver Gull was present during the monitoring period and the presence of other potential predators was observed in the area, the most active predator on the site appears to have been Ghost Crab, which mainly took young chicks.
Human disturbance late in the breeding period is unlikely to have affected breeding success but probably led to the early abandonment of the site.

If the Ghost Crab is confirmed to be a major predator of Little Tern nesting colonies, it is recommended that NPWS investigate the use of baiting or non-lethal methods to control their presence on breeding sites. Other recommended measures are the complete fencing and signposting of the site and restriction of recreational and commercial ORV activity in the immediate vicinity.

ACKNOWLEDGEMENTS

The Worimi people are thanked for their welcome and allowing monitoring of Little Tern on their land. The following people are thanked for assistance with site monitoring and management: Christophe Tourenq, Katherine Howard, Lou Stanton, Beryl Cowan, Louise Williams and Trish Blair. Katherine Howard and Christophe Tourenq are thanked for reviewing this article and suggesting amendments. Alan Morris is thanked for refereeing the article and providing additional information.

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Regular late afternoon assembly by a group of Gang-gang Cockatoo at Martinsville in April 2023

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Received 21 July 2023, accepted 7 August 2023, published online 31 August 2023.

This note describes the regular late afternoon assembly by a group of up to 25 Gang-gang Cockatoo *Callocephalon fimbriatum* during a period of fourteen days in April 2023, with associated notes on their movement and feeding behaviour.

OBSERVATIONS

On 18 April 2023, Mr Les Sharpe of Martinsville, on the eastern edge of the Watagans, informed me of a large gathering of Gang-gang Cockatoo having occurred that afternoon in tall eucalypts on the southern boundary of his property. He was initially seeking confirmation of their identity. He accurately described Gang-gang Cockatoo males and females, with accompanying photographs. His estimate was that 15-20 birds had been present.

The following day, Les Sharpe reported that at least 20 birds had again gathered at the site in the afternoon with some begging youngsters being fed.

On 20 April, I visited the property and watched with Les Sharpe at 4.10 pm as pairs and small parties of three and four Gang-gang Cockatoo began to arrive from various directions and their numbers gradually built up. It was initially difficult to get an exact count as birds were progressively arriving and those already present were moving around actively in the high canopy (with much calling).

At 4.45 pm there was a perceptible change in activity. Groups of five or more birds progressively gathered and moved off quietly, all heading in the same direction. This allowed an accurate count of 25 individuals to be made. All of the groups of cockatoos flew in a westerly direction towards the Watagans.

On 22 April, birds were again present and they followed a similar afternoon pattern every day throughout April, until 1 May when only a small group of four or five birds was present. On 23 April and some later dates, birds were recorded feeding on mature seed capsules of Northern Grey Ironbark *Eucalyptus siderophloia* which was the dominant forest species in the assembly area. Birds also went down to drink at a small dam within the forested area.

LOCAL STATUS OF THE GANG-GANG COCKATOO

According to HANZAB (Higgins 1999), the Hunter Region is at the northern end of the species' range, with the normal limit being bounded by Munghorn Gap, Scone, Singleton and the Myall Lakes National Park. The Hunter Region Annual Bird Reports show that the Watagans and Laguna areas are the local stronghold for the species (Stuart 1994-2018; Williams 2019-2020).

In the breeding season, usually October to January but also recorded in late August and early September (Higgins 1999), Gang-gang Cockatoo are usually recorded as pairs and small family groups, but elsewhere within their range they are known to form larger flocks at other times of the year (Higgins 1999). Higgins noted non-breeding flocks of up to 60 birds, with one record of a winter flock of 150 birds in the ACT (Higgins 1999). The Hunter Region Annual Bird Reports (Stuart 1994-2018; Williams 2019-2020) have also recorded occasional large groups, with examples detailed in **Table 1**.

Table 1. Previous high counts of Gang-gang Cockatoo in the Hunter Region.

Date	Location	No. of birds
26 April 1997	Watagans	50
11 August 1998	Kurri Kurri	30
13-15 Oct 2000	Laguna	15
9-12 April 2004	Laguna	20
20 Nov 2004	Quorrobolong	16
20 April 2005	Watagan S.F.	18
14 Sept 2013	Watagans	20 approx.
21 May 2017	Laguna	20
2018	Pelton	18

DISCUSSION

HANZAB (Higgins 1999) indicates that movements by Gang-gang Cockatoo are not fully understood – for example there are seasonal altitudinal movements in some areas, generally in the southern parts of the range, but not in others, and abnormal movements have been recorded which are presumed to be in response to food availability, fires and droughts. Where flocks gather in larger numbers outside the breeding season it may be in response to prevailing conditions and food availability.

Consistent with the Martinsville observations are reports from near Geelong of groups of 15-20 Gang-gang Cockatoo sometimes observed moving to roosts at dusk during their autumn-winter influxes to the area (Dedman 1980). Also, at a separate location near Geelong in autumn, a group of nine birds was observed drinking at a pond in the late afternoon then flying to a group of tall eucalypts where they were assumed to roost (Higgins 1999). Near Bacchus Marsh a small family group of three birds also drank from a small pond before going to roost (Hewish 1986).

As with other areas of their range where there have been large assemblies of Gang-gang Cockatoo, most of the records for the Hunter Region have been one-off sightings or for unspecified periods of time, although two records from Laguna each spanned three to four days. The Martinsville records are the first local examples of an extended period of regular assembly prior to roosting and as such they are a further insight into Gang-gang Cockatoo behaviour.

HANZAB (Higgins 1999) states that Gang-gang Cockatoo form a monogamous pair bond but there seems to be a clear advantage in pairs and family groups assembling into a larger gathering before moving to roost, perhaps as a predator response.

ACKNOWLEDGEMENTS

I thank Les Sharpe for his detailed observations from Martinsville and Alan Stuart for assistance with extracts from the Hunter Region Annual Bird Reports.

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The Whistler **17 (2023)**: 46-49

Noisy Miner and other species taking processed sugar packets

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Received 15 August 2023, accepted 20 August 2023, published online 4 September 2023.

The Noisy Miner *Manorina melanocephala* is a mid-sized gregarious honeyeater with a widespread distribution in the eastern and south-eastern parts of Australia (Higgins *et al*. 2001). Although a woodland species it has adapted well to human presence and has become common in cities and suburbs within its range (Longmore 1991). The Noisy Miner primarily eats nectar, fruit and insects, and occasionally small reptiles and amphibians (Barker & Vestjens 1990). It also is known to opportunistically eat anthropogenic food items including bread, meat and cheese (Higgins *et al*. 2001; Delgado & Correa 2015).

In 2013-2014, a Noisy Miner foraging behaviour was observed in Wollongong, in which some birds were taking packets of sugar from a table in a local café, flying a short distance, landing, opening the sugar packet with their bill, and then eating the contents (Delgado & Correa 2015). The behaviour was observed on five occasions between October 2013 and May 2014, all at the same café and presumably involving the same cohort of birds each time. The authors noted that the birds were able to discriminate between the sugar packets (which were white) and the similarly-sized packets of artificial sweetener stevia (light green) and instant coffee (black) in containers on the same table. The authors stated it was the first time that this foraging behaviour by Noisy Miner had been reported.

On 6 August 2023 I observed similar Noisy Miner behaviour at a café at Pearl Beach, New South Wales. Packets of sugar were in a glass jar on an empty outdoor table at the café. A Noisy Miner landed on the table, pulled out a sugar packet and flew off with it for a distance of 4 to 5 m. The bird landed on the nearby road, opened the packet using its bill, and ate the contents (see **Figure 1**). A minute or so later, it or another miner landed on the same table and began to pull out another sugar packet. At that point, I intervened, and closed the lid of the jar.

Figure 1. A Noisy Miner at Pearl Beach extracting the contents from a sugar packet that it had opened.

On 11 August at the same Pearl Beach café, at least two individual birds were engaged in the activity. I retrieved a sugar packet from which they had been feeding (see **Figure 2**). It had a hole approximately 10 mm x 10 mm, about the same size as the hole made by the Wollongong birds (Delgado & Correa 2015).

Figure 2. A recovered sugar packet that had been opened by a Noisy Miner at Pearl Beach. The bird made a small hole in the packet, from which it removed sugar crystals.

The jars on the café table contained packets of raw sugar, processed sugar and artificial sweetener

(aspartame-based). I only saw birds taking packets of processed sugar.

In response to my subsequent inquiries to local birdwatchers for similar examples, I learnt that this behaviour by Noisy Miner has become widespread, but seemingly patchily so. Instances were reported to me from Wamberal (near Terrigal NSW) in August 2023 (B. Sampford pers. comm.); Newcastle East in about late 2022 (P. Vaughan pers. comm.); and twice from a café in the Adelaide Botanic Gardens – in about 2018 (M. Clarke pers. comm.) and in November 2022 (J. Logan-Warner pers. comm.). Also, a group of Noisy Miner at a café in Bicentennial Park Sydney have been taking sugar packets for several years (J. Harrington pers. comm.).

DISCUSSION

Sugars and processed sugar

"Sugar" is the generic name for a group of sweet-tasting carbohydrates, many of which occur naturally in plant products (https://en.wikipedia.org/wiki/sugar; accessed 15 August 2023). Two groups of plants, Sugarcane (*Saccharum officinarum*, S. *sinense*, *S. barberi* and hybrids of these) and Sugar Beet *Beta vulgaris*, produce relatively-large amounts of a carbohydrate called sucrose. The juices from those plants are processed commercially to produce "sugar", a widely used food additive/sweetener in our modern world. Processed sugar (also known as refined sugar) is pure sucrose.

Processed sugar as a dietary item for birds

Many bird species cannot digest sugary substances because those birds lack the enzyme sucrase that allows sugars to be metabolised. A bird which does not produce sucrase can become ill if it eats sugar-rich food. However, nectarivores such as honeyeaters, lorikeets and hummingbirds do produce sucrase and thus they can have a sugar-rich diet. Of course, honeyeaters are not exclusively nectar-feeders but nectar is an important component of the diet of many honeyeater species.

Nectar contains up to ~80% sugar (https://www.britannica.com/science/nectar accessed 10 August 2023), with the three main sugars being sucrose, fructose and glucose (Chalcoff 2006). Their ratios in nectar vary, depending upon factors such as the plant species and the local environment (Chalcoff 2006). Sucrose is a disaccharide, formed chemically from one molecule each of fructose and glucose. When ingested by a nectarivore, sucrose is metabolised firstly into fructose and glucose which then become further metabolised, releasing energy (https://www.britannica.com/science/nectar accessed 10 August 2023).

Thus, nectarivore species are physiologically well-equipped to ingest sucrose and use it as an energy source. Hence it would not harm a nectarivore to eat some processed sugar. Importantly however, nectar also contains traces of proteins, salts, acids, and essential oils (https://www.britannica.com/science/nectar; accessed 10 August 2023). Those trace components are not available in processed sugar. Birds eating nectar would also occasionally ingest insects that had been feeding at the nectar source, thus receiving additional protein supplements for their diet.

It would be unhealthy for a bird to live exclusively on processed sugar as it would not obtain the necessary trace supplements of proteins, essential oils and so on. However, it would not cause any short-term harm for a nectarivore to eat processed sugar, and the bird would receive an energy boost when it ate the sugar.

About the innovation

The phenomenon of birds eating processed sugar is not new. Many bird species will eat processed sugar when it is available to them. For example, sugar solutions are often used to attract hummingbirds to feeding stations (Dunn 2021). Spangled Drongo *Dicrurus bracteatus*, Silver-crowned Friarbird *Philemon argenticeps* and Blue-faced Honeyeater *Entomyzon cyanotis* have been observed eating spilt sugar at a wharf in Lucinda, Queensland in 2015 (G. Voss pers. comm.). Noisy Miner (and other species) have been observed flicking the lids off sugar bowls in cafés (using their bill) and then licking the contents of the bowl (S. Griffin pers. comm.; L. Bunt pers. comm.). However, the innovation of taking packets of sugar and opening them is recent. There are no reports of this behaviour by any bird species until about 20 years ago (the Lesser Antillean Bullfinch *Loxigilla noctis*, see below), and the first record of Noisy Miner doing it was in

2013. But it was only in that same general timeframe that sugar began to become widely available as individual-serve packets at cafés, driven primarily by hygiene concerns (https://en.wikipedia.org/wiki/sugar_packet, accessed 15 August 2023). It seems it hasn't taken long for some species to learn how to exploit this new type of sugar availability.

Reports of similar behaviour by other bird species

In the West Indies the behaviour has been observed in some Lesser Antillean Bullfinch, a forest-dwelling bird in the island of Saint Lucia which has become relatively tame around humans (Reader *et al*. 2002). They were the only species on Saint Lucia observed to have this behaviour. Ten years later, the behaviour had not spread beyond birds inside a *c*200 m radius of the location of the original observations (Ducatez *et al*. 2013).

It has been documented as behaviour by House Sparrow *Passer domesticus* in Auckland New Zealand: in 2017 there was a report of birds regularly taking packets of sugar from a local café, opening them and eating the contents (New Zealand Herald 19 December 2017; https://www.nzherald.co.nz accessed 8 August 2023).

At least four other Australian species have been observed doing this sort of behaviour – Blue-faced Honeyeater in Noosa (P. Vaughan pers. comm.), White-quilled Honeyeater *E. albipennis* in Darwin (L. Finch pers. comm.) and both Rainbow Lorikeet *Trichoglossus moluccanus* and Sulphur-crested Cockatoo *Cacatua galerita* in Sydney (J. Smart pers. comm., G. Stevens pers. comm.).

I also carried out an internet search which revealed several examples of video footage showing bird species from outside of Australia exhibiting the same general behaviour. The species were not identified in those video clips.

Mechanism for learning the behaviour

The endemic Barbadian Bullfinch *L. barbadensis* has recently been split from the Lesser Antillean Bullfinch (Audet *et al*. 2018). It frequently uses opportunistic, innovative feeding behaviours that take advantage of anthropogenic food sources. In contrast, its closest avian relative in Barbados, the Black-faced Grassquit *Tiaris bicolor*, is considered a conservative species; i.e. its behaviours in the wild have little-changed over time. The two species are closely related to Darwin's finches and belong to the family Thraupidae, a neotropical clade that typically shows high rates of evolutionary diversification, colonization, and feeding innovations in the wild (Audet *et al*. 2018).

Researchers investigated wild-caught individuals from both species. The problem-solving skills differed considerably; for example most of the bullfinches quickly figured out how to lift the lid off a jar of food while all the grassquits were stumped by the challenge (Audet *et al*. 2018). These performances were in line with the differences in the birds' innovativeness in the wild (Audet *et al*. 2018). The researchers then compared the expression of all genes in six parts of the brain of the two bird species. A family of genes stood out: glutamate neurotransmitter receptors, especially in the part of the bird brain that corresponds to humans' prefrontal cortex. Glutamate receptors are known to be involved in a variety of cognitive traits in humans and other mammals (Audet *et al*. 2018).

Thus, the ability to learn a new behaviour is related to specific brain chemistry. Some birds can learn quickly, and some can almost never learn.

Mechanism for the spread of the behaviour in Noisy Miner

There appear to be two possible mechanisms for how Noisy Miner in many different locations have developed the capability to take sugar packets, open them and eat the contents:

1. A Noisy Miner somewhere, learnt how to do it and that capability spread firstly to other birds in that bird's cohort (by them copying) and thence progressively to other groups of Noisy Miner. A variant of this mechanism would be that a Noisy Miner first observed a different species, e.g. Rainbow Lorikeet, opening sugar packets and it copied the behaviour.
2. The behaviour was separately developed by Noisy Miner in multiple locations, approximately contemporaneously.

The Noisy Miner's social organisation has been well-studied (Dow 1979; Higgins *et al*. 2001). Birds

live in colonies, which can be large – sometimes involving several hundred birds. Within those colonies, males spend most of their time outside of the breeding season in coteries of 10-25 males. Those coteries are fairly stable, but smaller groups within a coterie (mostly involving 5-8 males) regularly form temporary coalitions – these are transitory flocks of foraging, bathing, roosting and mobbing individuals (Dow 1979; Higgins *et al*. 2001). Sometimes, members of other coteries join a temporary coalition. Thus, there are frequent close interactions between many individual males. Although females have smaller activity spaces than males and the activity spaces of individual females usually do not overlap, each female interacts with many males (Dow 1979; Higgins *et al*. 2001).

It seems likely that birds within a coterie of Noisy Miner would quickly learn from watching an innovative individual from that coterie that had developed the capability to take sugar packets, open them and eat the contents. Because there is frequent cross-coterie interaction, in the form of temporary coalitions, it seems probable that the sugar-taking behaviour would eventually permeate throughout the entire Noisy Miner colony.

However, Noisy Miner are intolerant of intruders from any other colony of them, and quickly drive an intruder away (Higgins *et al*. 2001). Therefore it is unlikely that birds in another colony would have the opportunity to learn the behaviour by watching it in the original colony. Moreover, there appear to be sizable geographic distances between colonies of Noisy Miner exhibiting the sugar-taking behaviour. Thus, there seems to be no evidence for the new behaviour as having radiated from a single point.

The evidence suggests that the behaviour was approximately contemporaneously developed in multiple locations. That would not be a surprising result by a species which is known to be highly innovative (e.g. see Sulikowski & Burke 2011).

CONCLUSIONS

The capability to take and open sugar packets is not intrinsic natural behaviour but several bird species in Australia and elsewhere have learnt to do so. A distinguishing feature is that they are innovative species that appear to be comfortable living in close proximity to humans.

ACKNOWLEDGEMENTS

Thanks to Marg Clarke, Jess Logan-Warner, Louise Finch, Peter Vaughan, Beverley Sampford, George Voss, Jim Smart, Judy Harrington, Sally Griffin, Laraine Bunt and Graeme Stevens for sharing their observations.

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The first confirmed modern record for Pycroft's Petrel in Australia

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Received 30 June 2023, accepted 14 September 2023, published online 20 September 2023.

A record of a Pycroft's Petrel *Pterodroma pycrofti* in an artificial nest box on Broughton Island highlights the value of programs to remove feral animals from islands which host colonies of breeding seabirds. Pycroft's Petrel breeds on a relatively small number of New Zealand islands. Its presence on Broughton Island during the species' usual breeding season suggests it may have been prospecting for nesting sites.

INTRODUCTION

Broughton Island (32º 37'S, 152º 19'E) is located on the New South Wales coast, 16 km northeast of the entrance to Port Stephens. It is an important seabird breeding location, hosting many tens of thousands of Wedge-tailed Shearwater *Ardenna pacifica* pairs each year plus lesser numbers of Short-tailed Shearwater *Ardenna tenuirostris* and Little Penguin *Eudyptula minor* (Carlile *et al*. 2012; Carlile *et al*. 2022). A programme to eradicate feral rabbits and rats on the island was conducted in 2009 (Priddel *et al*. 2011).

In 2009 a pair of Gould's Petrel *Pterodroma leucoptera* bred on the island (Carlile *et al*. 2012). Although several hundred pairs breed on two nearby islands, Cabbage Tree Island and Boondelbah Island (Carlile & Priddel 2004; Priddel & Carlile 2004), it was the first known record from Broughton Island for this species, which is classified as Endangered under the Commonwealth Environment Protection and Biodiversity Conservation Act. To encourage more Gould's Petrel to breed on Broughton Island, six artificial nest boxes and a call-playback system were installed near the island's highest point, Pinkatop, in mid-2017. Those nest boxes now are regularly visited by Gould's Petrel and there have been several successful breeding events (Stuart *et al*. in prep.).

OBSERVATIONS

During the Hunter Bird Observers Club's regular visits to monitor the bird population of Broughton Island (see Stuart *et al*. 2017 for an overview of the monitoring program), we inspect the nest boxes for any Gould's Petrel breeding activity. In the afternoon of 25 October 2019, we found an adult Gould's Petrel in one box. Another box had two birds – an adult Gould's Petrel and a second, smaller seabird. This second individual was noticeably paler than the Gould's Petrel, and also had a white underbody and mostly white underwing with narrow black border and carpal bar.

At that time, we were uncertain about the identity of the second bird. We took a series of photos of its head, wing and underwing, and also photos of the two birds side by side for comparison (**Figures 1** and **2**). Overnight, we sent photos to two seabird experts, who then circulated them to others. The plumage characteristics indicated one of the paler 'Cookilaria' species of *Pterodroma* petrel; the feedback was that the unknown bird possibly was a Pycroft's Petrel *P. pycrofti*. At the time of our record, the Pycroft's Petrel did not appear on the modern checklist of Australian birds.

The next morning, 26 October, we returned to the nest box with measuring equipment. The two Gould's Petrel adults had departed; however, the unknown bird was still present in the same nest box as on the previous day. We collected biometric measurements and took more photos.

We considered there to be five contender *Pterodroma* species: Gould's Petrel, Pycroft's Petrel, Cook's Petrel *P. cookii*, De Filippi's Petrel *P. defilippiana* and Stejneger's Petrel *P. longirostris*. Cook's Petrel is often recorded in Australian waters; there are sixteen confirmed records for the species in the Birds Australia Records Committee (BARC) archives. This number of records means that Cook's Petrel it is no longer on the BARC review list. There are no previous confirmed records of Pycroft's Petrel or De Filippi's Petrel in Australian waters. There are three confirmed records in BARC's archives of Stejneger's Petrel.


(a)


(b)

Figure 1. The Pycroft's Petrel (a) and a Gould's Petrel (b) after their temporary removal from an artificial nest box on Broughton Island on 25 October 2019 (photos: Alan Stuart).


(a)


(b)

Figure 2. The Pycroft's Petrel after its temporary removal from an artificial nest box on Broughton Island on 26 October 2019: (a) upper wing (b) underwing (photos: Alan Stuart).

In **Table 1** we compare the relevant biometric information for the Broughton Island bird with the five contender species. Gould's Petrel, Cook's Petrel and De Filippi's Petrel could be eliminated by the wing measurement. Additionally, the ratio of wing length to bill length based upon the published biometric data for Cook's Petrel and Pycroft's Petrel (Marchant & Higgins 1990) eliminated the former and was fully consistent with the latter (**Figure 3**).

Whilst the wing, bill and tarsus measurements of the Broughton Island bird were within the range for Stejneger's Petrel, this species could be eliminated based on plumage characteristics.

Table 1. *Pterodroma* petrels: measurement ranges of contender species[1]

	Wing (mm)	Bill (mm)	Tarsus (mm)	Weight (g)
Broughton Island bird	216	24.4	28.5	140
Pycroft's Petrel	207-229	22.5-25.8	26.9-30.8	127.5-201.0
Gould's Petrel	222-224	24.6-25.5	29.2-30.3	170-220
Cook's Petrel	223-245	24.4-29.9	27.9-32.0	112-250
De Filippi's Petrel	229-241	28.5-29	29-31	–
Stejneger's Petrel	198-230	22.8-26	26.3-30.1	–

[1]Sources: Marchant & Higgins (1990); Murphy (1936).

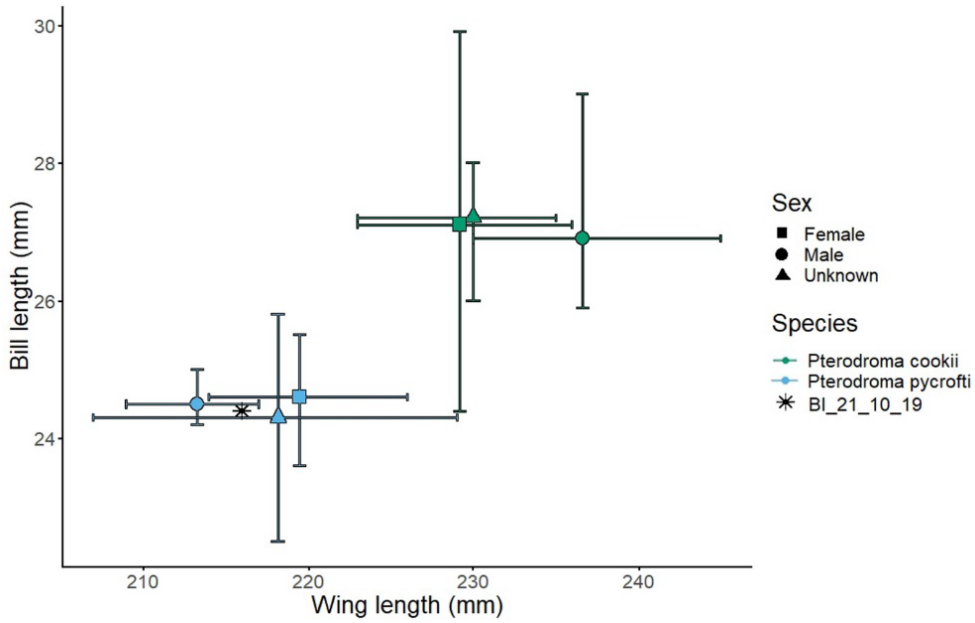

Figure 3. Plots of the ratios of wing length and bill length for Cook's Petrel and Pycroft's Petrel (based on published data in Marchant & Higgins 1990) and for the Broughton Island bird (diagram produced by S. Gorta).

We submitted a report to BARC for review by a panel of experts. Our submission was unanimously accepted, based upon the combination of biometric measurements and plumage detail, as the first confirmed modern record for Pycroft's Petrel in Australia (BARC 2020).

DISCUSSION

Pycroft's Petrel formerly bred on Norfolk Island but became extinct there in *c*.1800 following Polynesian settlement (Holdaway & Anderson 2001). There also are sub-fossil records from Lord Howe Island (McAllan *et al*. 2004). Thus, there have been no confirmed records for Pycroft's Petrel in Australia for more than 200 years.

The species is listed as globally Vulnerable by IUCN due to its restricted breeding range. It is now only known to breed on twelve islands off the north-eastern coast of New Zealand (predominantly in the Mercury, Hen and Chicken, and Poor Knights island groups), with the majority of the population breeding on just one of those, Red Mercury Island (BirdLife International 2023). The total breeding population is estimated at 5,000-10,000 pairs, within a total population of 30,000-40,000 individuals.

The population of Pycroft's Petrel has expanded in recent years – for example Red Mercury Island had 1,000-2,000 pairs in 1989-1991 and 2,000-3,000 pairs in 1998, while surveys in 2010 indicated that the population had expanded to 5,000-10,000 pairs (BirdLife International 2023). Probably the main factor behind the population increase has been the removal of feral animals, especially Polynesian Rat *Rattus exulans*. There have also been some chick relocations from Red Mercury Island to other islands (BirdLife International 2023).

Pycroft's Petrel has not been recorded foraging in Australian waters in modern times. Two at-sea reports of the species have been submitted to BARC – for single birds seen off Swansea in October 2002 and off Bremer Bay (near Albany WA) in February 2018. Neither report was accepted by BARC, as other similar species could not be categorically excluded.

Studies utilising geolocators have shown that, when not breeding, Pycroft's Petrel disperse to the central and eastern tropical Pacific (BirdLife International 2023). However, in May 2005 a banded adult was found offshore of Papua New Guinea (PNG), which may indicate that some birds spend the non-breeding season in the PNG region, although the timing of the recovery does not rule out the possibility of a passing migrant (BirdLife International 2023). However, the PNG and Broughton Island records, considered together, suggest that westerly movements by Pycroft's Petrel may be more common than previously thought.

The 2019 record from Broughton Island is particularly significant since it was of a bird in a nesting cavity. The record was made during the breeding season for Pycroft's Petrel which extends from October to April. Whilst Pycroft's Petrel usually digs its own burrow in well-drained soil rather than using a pre-existing cavity (BirdLife International 2023), the presence of the bird in the nest box over at least two days during the breeding season for the species at its NZ breeding sites suggests it was prospecting for a nest site. This suggests that Pycroft's Petrel could potentially expand its breeding range, and that sightings of the species in Australian waters may increase in future.

The Broughton Island record highlights the importance of removal of feral predators from seabird-breeding islands. These actions have allowed the Pycroft's Petrel world population to increase and allowed Gould's Petrel to start breeding on Broughton Island. Gould's Petrel had not been recorded on Broughton Island prior to rodent removal. The 2019 record also demonstrates the value of establishing supplementary nesting habitat for seabirds – both to aid in the recovery of extant seabird populations and to facilitate nest-site prospecting by other species of seabird.

The 2019 record also shows the value of regular monitoring at seabird colonies so as to identify the arrival/establishment of new species, especially at sites where active island restoration has taken place. And, given that visits by humans to what typically are remote sites will be infrequent, thus missing out on records of short-staying seabirds, there seems to be a potential role for supplementary electronic monitoring (such as using trail cameras and remote acoustic recorders).

ACKNOWLEDGEMENTS

We thank Mick Roderick and Nicholas Carlile for their advice about the bird's probable identification and for circulating the photos to other seabird experts, such as Matt Rayner. We also thank Simon Gorta who compared the biometric data in HANZAB for Gould's Petrel and Pycroft's Petrel, in particular the ratios of their wing length to bill length, and generated Figure 3. The reviewer, Emily Mowat, made many helpful suggestions which improved the original report.

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Introduced avian species in the Hunter Region: ecological threats or benign interlopers?

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Received 2 July 2023, accepted 22 September 2023, published online 27 September 2023.

A study of the arrival, distribution and abundance of introduced avian species in the Hunter Region identified 15 species which established populations within the region. Currently, seven of those species are locally common. The others are either uncommon or rare, and in one case, locally extinct. Twelve species established wild populations, with varying degrees of success. The three most abundant species currently are Common Myna *Acridotheres tristis*, Spotted Dove *Streptopelia chinensis* and Common Starling *Sturnus vulgaris*. Most of these species were released in the mid-19th century, mainly around Sydney, and arrived in the Hunter Region from the late 1870s to early 1980s. The population trend for one species, Common Myna has increased over the last 22 years, while the long-term population trend of the other species is either uncertain, declining or unknown.

The introduced species are mainly restricted to urban, peri-urban and agricultural areas that have disturbed habitat. There are no indications they have successfully adapted to undisturbed native habitat.

Numerous accounts have reported introduced species as having a detrimental effect on native species through aggressive competing for nest sites and food sources. However, the few scientific studies that have been conducted found detrimental effects were limited to urban areas or areas with disturbed habitat. The extent of the impact varied with the type of vegetation cover and the size of the species. These studies also suggest that efforts currently directed towards controlling Common Myna by culling in heavily urbanised environments are misdirected. The studies suggest that resources would be better directed towards improving natural habitat quality in these areas, if the purpose of control is to enhance urban bird diversity.

INTRODUCTION

Most birdwatchers pay little attention to the presence of introduced avian species in our region and very few would make the effort to follow-up on a reported sighting. However, introduced species have been reported to have had a major impact on Australia's environment, threatening our unique biodiversity and reducing overall species abundance and diversity. Additionally, introduced species are reported to have major economic and societal consequences (Baker *et al*. 2014).

Potential interactions in ecological processes between introduced and native avian species are extensive and include: competition for nesting sites; competition for food; interference competition; predation; brood parasitism; hybridisation; and disease (Baker *et al*. 2014).

In the past, bird species were introduced to provide food for domestic use, and as wild stock for recreational hunting purposes or for aesthetic reasons. For example, birds such as the House Sparrow *Passer domesticus* were introduced into agricultural areas from the mid-1800s with the expectation that they would control insect pests. In addition to these deliberate introductions, accidental introductions have occurred through avicultural escapees and from birds hitching rides on boats and planes (Baker *et al*. 2014).

Many avian species were introduced into Australia by "Acclimatization Societies" in the mid-19th century. Those societies aimed to introduce, acclimatise and domesticate useful or ornamental birds, fish, insects, vegetables and other exotic species (Tout-Smith 2003). They espoused the Lamarckian theory that the environment could bring about evolutionary change in species as they adapted to their new surroundings. The activities of these societies, however, were also driven by the belief that Australian fauna and flora were in some way deficient or impoverished and also by an element of nostalgia amongst early settlers for the "Old Country" with a desire to see and hear familiar species. Fortunately, most of the introductions by these societies were unsuccessful, but among their more notorious successes were the introduction of

European Rabbit *Oryctolagus cuniculus* and Blackberry *Rubus fruticosus* to Australia and Common Brush-tailed Possum *Trichosurus vulpecula* to New Zealand.

The objective of this article is to review the history, status and distribution of introduced avian species in the Hunter Region and assess the extent of their threats to Australian native birds. For the purposes of this study, an introduced species is defined as one that was deliberately or accidentally introduced into an ecosystem where it previously did not occur naturally.

METHODS

Records of introduced species within the Hunter Region were extracted from Birdata (https://birdata.birdlife.org.au/home). The Reporting Rates (RR) for four periods from 1982 to 2022 were calculated using the combined data from all survey types. RR is defined as the number of records for a species divided by the number of surveys, expressed as a percentage. Early records were taken from *Emu,* unpublished Hunter Bird Observer Club (HBOC) records and other publications. Recent publications were reviewed for ecological studies. Regional distribution maps were sourced for six species based on their records in the Birdata and eBird databases. Long-term population trends were taken from the Hunter Region Annual Bird Report (Williams 2020).

RESULTS

Although there are numerous reports of the release or the arrival of introduced species around capital cities, there are few reports documenting their dispersion into other areas, such as the Hunter Region. However, there are records in Birdata for 15 introduced species in the Hunter Region covering the past 41 years. As will be detailed later, three of those species have never established wild populations in the Hunter Region. The Reporting Rates for the other twelve species for four periods spanning 1982-2022 are presented in **Table 1** along with their long-term population trends. There were no records for some species over some of the periods.

Table 1. Introduced species that have established wild populations at different times in the Hunter Region, with their Reporting Rates from Birdata for four periods from 1992 to 2022, and their long-term Hunter Region trends as described in the 2019 Hunter Region Annual Bird Report (ABR) (Williams 2020).

Common Name	RR%				ABR Long-term Trend 1993-2019
	1982-1990	1991-2000	2001-2010	2011-2022	
Mallard	1.9	2.1	0.6	0.5	Uncertain
Rock Dove	6.6	7.0	3.0	4.7	Uncertain
Spotted Dove	13.3	23.3	11.9	12.2	Uncertain
Long-billed Corella	-	1.0	2.0	1.2	Decline
Eurasian Skylark	-	-	< 0.1	-	Insufficient data
Red-whiskered Bulbul	-	0.6	0.2	0.1	Decline
Common Starling	22.0	29.7	12.3	6.6	Decline
Common Myna	10.2	20.9	12.6	13.2	Stable
Common Blackbird	0.4	0.3	0.2	0.3	Uncertain
Nutmeg Mannikin	-	-	-	-	No records
House Sparrow	11.7	14.6	3.7	1.9	Decline
European Goldfinch	1.0	1.4	0.8	0.1	Decline

Mallard

The Mallard *Anas platyrhynchos* was first released in the Royal Botanic Gardens Victoria in Melbourne during 1871-1872 (Long 1981). No accounts of its intentional release in NSW were found.

There was no mention of the Mallard in several early to mid-20th Century articles on introduced species in Australia (Chisholm 1926a; Chisholm 1950; Blake 1951). A comment by Tarr (1950) stated that the species is 'feral on some Sydney lakes.' Morris (1975) described the species as rare in NSW, and that records of them were of birds which possibly had escaped from domestic enclosures. Morris reported the presence of a pair at Avoca Lagoon during 1973/1974 and a male at Kooragang Island in August 1972. Hamonet (1986) documented three Hunter Region records between 1976 and 1986; at Jewells Swamp, Awabakal Nature Reserve and Stockton Borehole Swamp.

In the Hunter Region, the species is classified as an uncommon resident, with records mainly from near-coastal wetlands in the southeast (Williams 2020). The long-term trend is uncertain, in part due to many of the records being thought to be of hybrids with Pacific Black Duck *A. superciliosa* (Williams 2020).

Rock Dove

No accounts of Rock Dove *Columba livia* being intentionally introduced into NSW were found. Some arrived as domesticated birds with the early settlers and then escaped, thus becoming Australia's first established introduced species (Long 1981). This pattern of escape from domestic enclosures has continued up until the present (Long 1981). There was no mention of the Rock Dove in several early to mid-20th Century articles about introduced species in Australia (Chisholm 1926a; Chisholm 1950; Blake 1951), apart from a comment by Tarr (1950) that the species is 'feral in all the larger cities.' Morris (1975) described the species as common in urban areas and man-made habitats throughout the Gosford, Wyong and Newcastle area. Hamonet (1986) described the species as invariably seen around urban and city areas of the Hunter Region.

The Rock Dove is classified as a common resident throughout the Hunter Region, found mainly around urban areas. It has an uncertain long-term trend (Williams 2020). The species' regional distribution is shown in **Figure 1**.

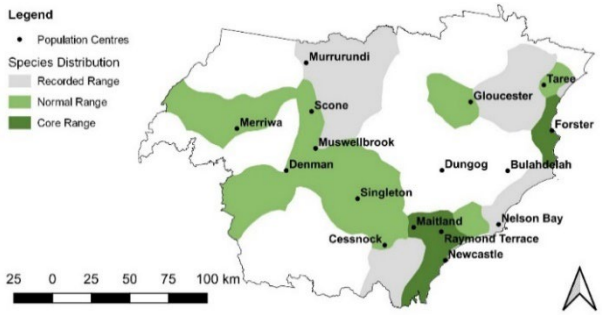

Figure 1. Distribution of Rock Dove in the Hunter Region 2022.

Spotted Dove

The Spotted Dove *Streptopelia chinensis* was introduced to Victoria during the 1860s and 1870s (Long 1981). It is not known when it was introduced into NSW but Chisholm (1926a) recorded the species as being present in the Sydney and Blue Mountains area and with its population and range increasing rapidly. Morris (1975) described the species as common in urban and modified rural landscapes in the Gosford, Wyong and Newcastle areas. Hamonet (1986) recorded the species as present mainly in the eastern sector of the region, in urban and agricultural areas and areas of altered forest. Its population remains centred mainly around urban regions in eastern areas of the Hunter Region (Williams 2020).

The Spotted Dove is classified as a common resident of the Hunter Region. Its long-term trend is uncertain (Williams 2020). The regional distribution is shown in **Figure 2**.

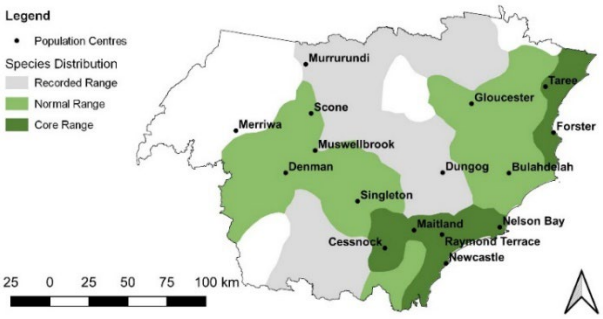

Figure 2. Distribution of Spotted Dove in the Hunter Region 2022

Long-billed Corella

The Long-billed Corella *Cacatua tenuirostris* is an endemic species normally found in the south-east of South Australia and from western Victoria to southern New South Wales. However, it has established populations in other parts of eastern Australia, probably by escapees from domestic enclosures (Marchant *et al*. 1999). It was first reported in the Hunter Region at Buttaba in 1982 (HBOC records). These records suggest the species possibly was released from Blackbutt Reserve. It was recorded as a newly-established local resident in 1993 (Stuart 1994). Today, the species' population is mainly centred around Newcastle, Maitland, Raymond Terrace and Lake Macquarie.

It is classified as resident in the Hunter Region and its long-term trend indicates a possible decline in the local population (Williams 2020).

Eurasian Skylark

The Eurasian Skylark *Alauda arvensis* was first introduced in Victoria in the 1850s (Long 1981). In NSW, birds were introduced near Sydney in 1866, then subsequently from 1870 to 1872 and again in the 1880s (Ryan 1906; Tarr 1950; Long 1981). Some birds were released at West Maitland in 1879 (Cooper *et al.* 2020). By the 1950s it was common in coastal districts and the central western areas of the state (Long 1981). Morris (1975) reported the species as being present at The Entrance in 1957 and with one bird recorded at Kooragang Island in 1970. Hamonet (1986) reported a single record from near the Myall Lakes. There are records of some birds at Deep Pond, Kooragang Island in 1994, 1996, 2003 and 2005-2007 (Stuart 2008).

There have been no confirmed sightings in the Hunter Region since 2007. The species is now classified as an accidental visitor (Williams 2020).

Red-whiskered Bulbul

The Red-whiskered Bulbul *Pycnonotus jocosus* was introduced into NSW by the NSW Acclimatization Society in 1880 (Tarr 1950). By 1919-1920 it was well-established around Sydney (Long 1981). However, Barrett (1945) stated that the species was not introduced intentionally and that birds were descendants of early escapees from domestic enclosures. By the 1950s and 1960s it had been reported up to 100 km from Sydney (Long 1981). The species was first recorded in the NSW Central Coast in 1973 (at Kincumber and Tumbi Umbi), with numbers thought possibly to be increasing (Morris 1975). It became established in the lower Hunter Region within another ten years (Blakers *et al*. 1984). Hamonet (1986) reported birds as having been present in Maitland in 1982 and Martinsville in 1983. Birdata records indicate that the local population is currently concentrated around Belmont and Caves Beach on the eastern side of Lake Macquarie.

The species is classified as an uncommon resident in the Hunter Region. Its long-term trend indicates a possible decline in the local population (Williams 2020).

Common Starling

The Common Starling *Sturnus vulgaris* was imported into Victoria by private individuals from 1856 to 1858 and small numbers were released by the Victorian Acclimatization Society between 1863 and 1871 (Ryan 1906). The species had become established in Victoria by 1862 (Long 1981). In NSW, birds were released in 1880 and they spread rapidly (Long 1981). They were present throughout settled parts of the state by 1926 (Chisholm 1926a). In the Hunter Region birds were recorded at Belltrees in 1909 and a large number were present in the Muswellbrook-Quirindi area in 1921 (Stuart 2009). Morris (1975) described the species as a common resident in the Gosford, Wyong and Newcastle areas, occurring most commonly in agricultural lands, suburban parks and gardens and around the margins of wetlands. Hamonet (1986) described the species as widespread throughout the region. Birdata records indicate the species is now distributed through all areas of the Hunter Region. Most records are from urban centres and surrounding cleared agricultural areas. The regional distribution is shown in **Figure 3**.

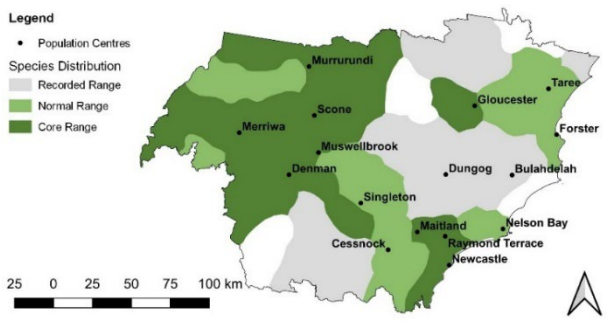

Figure 3. Distribution of Common Starling in the Hunter Region 2022

The Common Starling is classified as a common resident of the Hunter Region although the long-term trend suggests a possible decline in the local population (Williams 2020).

Common Myna

The Common Myna *Acridotheres tristis* was introduced from India (Long 1981). There were several introductions around Melbourne in the period between 1863 and 1872 and it had become well-established in Melbourne by 1883 (Ryan 1906). It is not known how the species arrived in NSW but they were common in Sydney by 1896 (Chisholm 1926a). The first record for the Hunter Region was from the Newcastle Steel Works in the 1950s and by 1970 the species had colonised the Cardiff and Edgeworth areas (Horne 1978). Horne also predicted that the range of the birds would probably increase considerably in New South Wales as suitable habitat occurs in coastal resorts, in the Hunter Valley and on the tablelands.

Morris (1975) described the species as being regularly reported around St Albans-Wisemans Ferry and in the Newcastle area. Morris *et al*. (1981) recorded the species as widespread on the Central Coast by 1960 and extending to Wallis Lake, Raymond Terrace and Allyn River. Hamonet (1986) reported it was mainly confined to the eastern part of the region, but apparently spreading westward into the Hunter Valley. The species is now widespread throughout the Hunter Region with populations concentrated in the Lower Hunter and around rural towns, and throughout agricultural districts. A study by Old *et al*. (2014) showed Common Myna in Greater Sydney to be restricted to urban and peri-urban areas. The species is now considered to have become commensal with human settlement (Wilson 1973; Higgins *et al*. 2006).

The Common Myna is classified as resident in the region and its long-term trend is reported to be stable (Williams 2020). However, across NSW its population is increasing (Cooper *et al*. 2020). The species' distribution in the Hunter Region in 2000 is shown in **Figure 4** and the current distribution in **Figure 5**. These two maps reveal that there was a considerable increase in the extent of distribution and population in the western and coastal parts of the region over the intervening period.

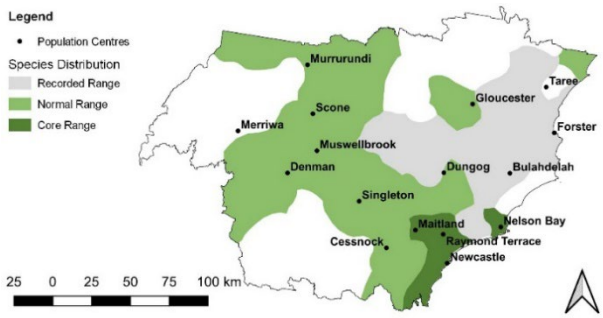

Figure 4. Distribution of the Common Myna in the Hunter Region 2000

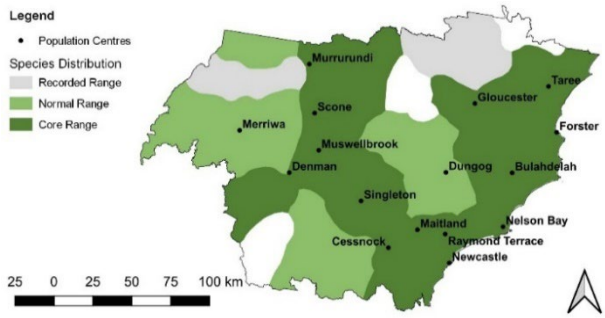

Figure 5. Distribution of Common Myna in the Hunter Region 2022

Common Blackbird

The Common Blackbird *Turdus merula* was first released around Melbourne between 1864 and 1872 (Ryan 1906). A release at Sydney in 1872 reportedly failed (Long 1981). The present population in NSW is thought to have originated from a release from a domestic enclosure in 1940 (Long 1981). Chisholm (1926a) reported that the only sightings of the species in NSW were from Albury and the Sydney Botanic Gardens. A few birds were reported in inner Sydney suburbs and parts of the Blue Mountains from 1952 onwards (Hindwood & McGill 1958). Some birds appeared in the Canberra district in 1949 and by 1959 they were widespread through the Sunraysia district along the Murray River (Long 1981). Morris (1975) made no mention of the species in the Gosford, Wyong and Newcastle area, but subsequently he reported the species as having established on the Central Coast by the 1940s and as being present at Dungog in 1959-60 (Morris *et al.* 1981).

The Common Blackbird has a localised distribution around many inland towns in the Hunter Region, in particular around Maitland and Cessnock, and the central regional areas of Merriwa, Scone and Muswellbrook. It is classified as resident around inland towns but with an uncertain long-term trend (Williams 2020). The regional distribution is shown in **Figure 6**.

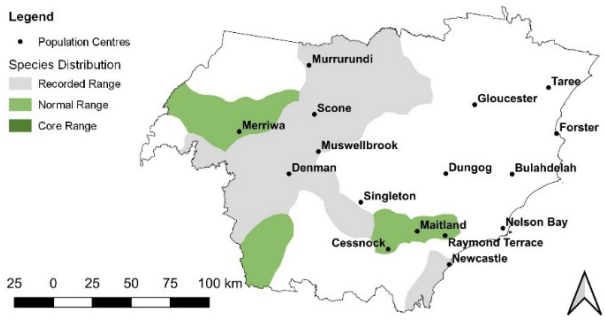

Figure 6. Distribution of Common Blackbird in the Hunter Region 2022

Nutmeg Mannikin

There are conflicting reports as to when the Nutmeg Mannikin *Lonchura punctulata* was first recorded in NSW. The species was seen at Chester Hill in the late 1920s and there were sightings in the Sydney area in the 1930s and 1940s (Cooper *et al*. 2020). However, other sources claim the initial population was established in the Sydney area by aviary escapees in about 1950 (Long 1981; Morris *et al*. 1981). Before 1960, all records were from suburban Sydney, but by 1962 it had been found on the NSW north coast at Taree, Glenreagh and Grafton (Gosper 1976). In the Hunter Region, the earliest records were from Speers Point and Shortland in 1965 (HBOC records). Recher (1975) recorded the species as present in the Myall Lakes area. Subsequently, it was regularly recorded at Cockle Creek, Speers Point, Teralba, Garden Suburb, Shortland, Cooranbong and Myall Lakes (Hamonet 1986).

The Nutmeg Mannikin is classified as possibly extinct in the Hunter Region (Williams (2020). There have been no reports from the region since 1991 apart from an eBird record of a single bird at Cooranbong in May 2022 (https://ebird.org/checklist/S108793587). The Cooranbong bird was considered to be an aviary escapee (M. Roderick pers. comm.).

House Sparrow

The House Sparrow *Passer domesticus* was first released in Melbourne in 1863. There were subsequent releases in Melbourne and elsewhere in Victoria by the Victorian Acclimatization Society from 1864 to 1872 (Long 1981). The birds were sourced from China, England and Java (Long 1981). By 1906 the species had spread widely into southern NSW (Long 1981) and was described as ubiquitous in the state in 1925 (Chisholm 1926a). Hamonet (1986) reported the bird as widely distributed throughout the urban and country areas of the Hunter Region.

Today, the House Sparrow is present throughout the Hunter Region with higher numbers reported around populated areas. It is classified as resident although its long-term trend suggests a recent decline (Williams 2020). The regional distribution is shown in **Figure 7**.

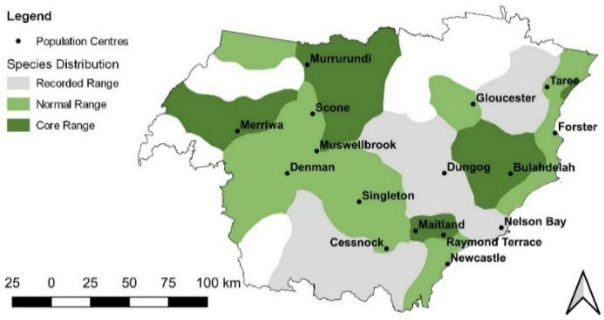

Figure 7. Distribution of House Sparrow in the Hunter Region 2022

European Goldfinch

The European Goldfinch *Carduelis carduelis* was introduced around Melbourne in 1863 and 1864 by the Victorian Acclimatization Society (Long 1981). There are no records of early introductions in NSW but some birds were released in 1880 (Long 1981) and the species was recorded as being present before 1886 (Chisholm 1926a). Their range expansion in NSW was very rapid; by 1926 birds were present near Comboyne to the north of the Hunter Region (Chisholm 1926b). In the Central Coast and the Hunter Region, small flocks were regularly recorded at The Entrance, Kooragang Island, St Albans and the Upper Hunter (Morris 1975). Hamonet (1986) reported sightings at Kooragang, Morpeth, Cockle Creek, Hexham Swamp, Myall Lakes, Broke, Widden Valley and Barrington Tops. The local population has been in decline over the past 20 years (**Table 1**) and today there are only occasional sightings from the Maitland area and Ash Island.

The species is classified as an uncommon resident in the 2019 HBOC Annual Bird Report (Williams 2020). The HBOC Records Appraisal Committee is currently considering reclassifying the species as a vagrant in the Hunter Region (A. Stuart pers. comm.).

Other Species

Three other non-endemic species have been recorded in Birdata in the Hunter Region; Helmeted Guineafowl *Numida meleagris*, Indian Peafowl *Pavo cristatus* and Red Junglefowl *Gallus gallus*. These birds are considered to have escaped from domestic enclosures rather than being part of self-sustaining wild populations (Stuart 2018). They are also classified as exotic escapees in eBird (https://ebird.org/australia/explore). They are recorded infrequently in peri-urban areas, mainly near the coast.

DISCUSSION

The majority of the above species were originally introduced in Australia for aesthetic reasons. Common Starling, Common Blackbird and House Sparrow were introduced with the intent of assisting agricultural interests by controlling insects. The Common Myna was introduced into urban areas for aesthetic reasons and for insect control in agricultural regions (Horne 1978). The following discussion reviews some relevant aspects of the ecology of introduced species and briefly discusses their impact on native species. Research on the impact of two of the most-abundant species, Common Myna and Common Starling, is summarised. Species with little or no research or reported data are not discussed.

Colonisation of the Hunter Region

The introduction of avian species into Australia has been documented in some detail for Melbourne and Sydney (Long 1981), but information about the range-expansion into other areas is fragmentary. For the Hunter Region, records provide first observation dates which only indicate broad arrival timeframes.

A review of articles published in the *Emu* between 1901 and 1925 revealed an absence of records for introduced species apart from the Common Starling (Stuart 2009). However, a review by Chisholm (1926a) documented eleven introduced species in NSW at that time. Chisholm did not include Mallard or Rock Dove. Early 20th century ornithologists referred to these as 'feral species', perhaps recognising that they had not been intentionally released.

Nine species have documented arrival timeframes in the Hunter Region: Eurasian Skylark in 1879 (Cooper *et al*. 2020); European Goldfinch in 1926 (Chisholm 1926b); Common Myna in the 1950s (Horne 1978); Mallard 1972 (Morris 1975); Common Blackbird 1959-60 (Morris *et al.* 1981); Long-billed Corella 1982 (HBOC records); and Red-whiskered Bulbul 1982 (Hamonet 1986). The Common Starling arrived sometime prior to 1909 (Stuart 2009). The House Sparrow was described as ubiquitous in NSW by 1925 (Chisholm 1926a). It can be inferred that the Rock Dove, Spotted Dove and House Sparrow arrived in the region in the first half of the 20th century.

Distribution

The most widely-distributed introduced species in the Hunter Region is the Common Myna, followed by the Common Starling and House Sparrow. All three are distributed to varying extents from coastal areas to the western limit of the region. The population of most introduced species is greatest around urban areas, peri-urban districts, and in cleared agricultural districts. The only introduced species with a limited local distribution are Long-billed Corella and Red-whiskered Bulbul.

Habitat destruction disadvantages most native birds but can provide suitable habitat for introduced avian species (Baker *et al*. 2014). The development of peri-urban districts around Sydney has been shown to support introduced species population growth (Leishman 1994). The distribution pattern for many introduced species in the Hunter Region reflects the pattern of habitat loss and modification.

Population trends

The only introduced species with an increasing population trend in the region is the Common Myna. All other species have declining or uncertain trends, or are locally extinct (Williams 2020). A study of population trends of introduced species in Brisbane, Sydney, Melbourne and Perth by Campbell *et al*. (2022), using Birdata records, demonstrated mostly similar trends to those for the Hunter Region. The Mallard, Spotted Dove, Common Starling, Common Blackbird, House Sparrow and European Goldfinch populations were declining. Conversely, the population trend for Rock Dove was increasing in Brisbane, Melbourne and Sydney, but declining in Perth.

Competition with other species

Competition between introduced and native avian species is extensive and includes competition for nesting sites, competition for food, and interference competition (Baker *et al*. 2014). Interference competition is a direct form of competition, in which individuals of one species actively dominate a resource, preventing or decreasing the access of another species to that resource. While there are numerous documented reports of competition, few studies have attempted to determine the magnitude of the impact.

Grarock *et al*. (2012), found that following the establishment of the Common Myna in four urban regions around Canberra between 1989 and 1993, the long-term abundance (birds per km^2) of three cavity-nesting species declined. These were Sulphur-crested Cockatoo *Cacatua galerita*, Crimson Rosella *Platycercus elegans*, and Laughing Kookaburra *Dacelo novaeguineae*. The long-term abundance of eight small species (Striated Pardalote *Pardalotus striatus*, Rufous Whistler *Pachycephala rufiventris*, Willie Wagtail *Rhipidura leucophrys*, Grey Fantail *Rhipidura albiscapa*, Magpie-lark *Grallina cyanoleuca*, House Sparrow, Silvereye *Zosterops lateralis*, and Common Blackbird) also declined. However, the long-term abundance of three larger species, Australian King-Parrot *Alisterus scapularis*, Eastern Rosella *Platycercus eximius* and Common Starling, increased following the establishment of Common Myna. The degree of decline in abundance was shown to vary with vegetation type. The largest decline occurred in dry forest and urban grassland, while areas with tree cover had the least decline. Two of the species with declining abundance, House Sparrow and Common Blackbird, were established introduced species.

Lermite & Griffin (2018) conducted a study to determine whether the provision of artificial nest boxes supported breeding by cavity-nesting native birds in urban areas, or whether competition from introduced cavity-nesting species such as Common Myna offset the benefits. While native species and Common Myna both nested in the boxes, over time native parrots exhibited greater breeding success than Common Myna.

These studies indicate that competition between introduced species and native avian species is complex and that factors such as the type of habitat, type of species and change in species richness and diversity have to be considered. Both of the above studies (Grarock *et al*. 2012; Lermite & Griffin 2018), were conducted in urban areas where Common Myna was more abundant.

Predation

A review of studies investigating predation of native bird species by introduced ones (Baker *et al*. 2014) identified examples of predation by Common Myna and Red-whiskered Bulbul. However, none of the studies demonstrated that predation was a major threat to native birds. Conversely, it is probable that the decline in the population of the Eurasian Skylark is the result of predation by introduced mammals. As a ground-nesting species, it is easy prey for feral Cat *Felis catus* and the Red Fox *Vulpes sp*. The vulnerability of Eurasian Skylark was recognised by Chisholm nearly 100 years ago. He commented that its chance of long-term survival was poor (Chisholm 1926a).

Hybridisation

The only introduced species that is thought to pose a threat through hybridisation with local species is the Mallard. Its presence has caused the decline or extinction of some populations of Pacific Black Duck *A. superciliosa* in New Zealand, Lord Howe Island and Macquarie Island (Guay & Tracey 2009). Mallard and Pacific Black Duck are closely related and can interbreed easily, frequently producing fertile hybrid offspring (Taysom 2016). Furthermore, Mallard are readily-domesticated birds that then become non-migratory. The domestication process has resulted in highly variable genomic changes that enhance their ability to interbreed and produce fertile, stable offspring (Lavretsky *et al*. 2023).

A Mallard is bigger and more aggressive than a Pacific Black Duck and other members of the genus *Anas*. Where there is a stable food supply and water source, they out-compete their endemic relatives. This has occurred in New Zealand where Pacific Black Duck (Grey Duck)/Mallard hybrids have become well adapted to the local habitat and are better suited to the increasingly agricultural and urban landscapes of the region.

A study of hybridisation between Mallard and Pacific Black Duck in Victoria found that the overall frequency of hybridisation was just 1.5% (Taysom 2016). The study also revealed that the frequency of hybridisation tended to be higher in urban areas than in rural areas. Williams (2020) states the majority of Mallard records in the Hunter Region are probably of hybrid birds. However, the

work of Taysom (2016) indicates this may be an overstatement.

Introduced species as pests

The Hunter-Central Rivers Natural Resource Management Region has 24 avian species listed as pests, the second highest number for any region in Australia. This list includes 14 of the 15 introduced species described in this article plus a number of other species that have not been recorded in the immediate Hunter Region. Long-billed Corella is not listed. Species are listed because they have significant agricultural and environmental impacts as well as causing damage to social amenity and infrastructure (West 2011). Two of these species are listed among the 100 world's worst invasive alien species by the Invasive Species Specialist Group of the Species Survival Commission of the World Conservation Union (Lowe *et al*. 2000). The Common Myna is third on the list and the Common Starling is ninetieth.

In Australia, Common Myna, Common Starling, House Sparrow and Common Blackbird cause damage in horticulture, viticulture and grain crops by eating fruit and newly-sown and newly-germinated grain. Rock Dove deface buildings with their droppings and spread bird lice which has human health consequences (West 2011). Red-whiskered Bulbul and Common Blackbird spread seeds of noxious and exotic weeds in their droppings (West 2011; Mo 2015).

Common Starling may also carry parasites and diseases which are of concern in food production and livestock industries. They are implicated in carrying, and in some cases transmitting, Salmonella, Cryptococci, Newcastle Disease and transmissible gastroenteritis, although the risk of transmission to humans has not been quantified (West 2011).

Common Myna

Of the 15 introduced species, Common Myna appears to present the greatest threat to the native avian population. It is also the species which has been subject to the most research. It is considered to be a threat to native species biodiversity due to its territorial behaviour and nest cavity competition (Centre for Invasive Species Impacts 2013). Trapping programmes to control the species are widespread in NSW where they are supported by Local Land Services (Local Land Services 2018).

Common Myna has the widest distribution of the introduced species across the Hunter Region. It is also the most abundant (**Table 1**). Over the past 22 years its population and distribution has expanded considerably (**Figures 3** and **4**). However, its distribution is restricted to urban and semi-rural areas within its range (Old *et al*. 2014). It is very well adapted to modified habitats (Higgins *et al*. 2006). It forages on the ground and mostly eats invertebrates or fallen fruit, although occasionally it also eats the eggs or nestlings of other avian species. It nests in tree hollows or cavities in urban structures. The species is aggressive, and agonistic behaviour has been recorded towards Silver Gull *Larus novaehollandiae*, Black-billed Gull *Larus bulleri*, Rock Dove, Spotted Dove, Eastern Rosella, Superb Parrot *Polytelis swainsonii*, Red Wattlebird *Anthochaera carunculata*, Australian Magpie *Gymnorhina tibicen*, House Sparrow, Common Blackbird and Common Starling. The birds often usurp the nest-hollows of other species, destroy nests and eggs, and kill nestlings (Higgins *et al*. 2006).

However, its perceived impacts are often based on anecdotal or generalised information, and there is a limited amount of scientific research that has studied the actual impacts. As the abundance of native species frequently changes because of habitat clearing, fragmentation and urbanisation, it is hard to separate the effects of Common Myna from the prevailing environmental factors (Centre for Invasive Species Impacts 2013).

The previously mentioned study of the impact of Common Myna on the abundance of native species in an urban environment (Grarock *et al*. 2012), indicated that Common Myna primarily take advantage of habitat change when colonising a new area. High numbers, in combination with habitat change, had a negative impact on some cavity-nesting species and smaller birds, but not on larger species. However, tree density strongly influenced the abundance of Common Myna which were far more abundant in urban areas with fewer trees than in nature reserves. There were no negative associations identified between Common Myna abundance and total species abundance and richness, or large native bird abundance and richness (Grarock *et al*. 2012).

A study of the foraging aggression of the Common Myna in an urban environment indicated they did not display significantly more aggression than other species, and displayed significantly less aggression than the Australian Magpie. Furthermore, the presence of Common Myna at a

feeding resource had no greater effect on the abundance of heterospecific individuals than the presence of any other species (Haythorpe *et al*. 2012).

These studies suggest that efforts to cull Common Myna numbers in heavily urbanised environments with the objective of enhancing the diversity and survival of some native species are misdirected. Resources would be better directed towards re-establishment of habitat suitable for native species in these areas. This is more likely to achieve a positive permanent outcome (Lowe *et al*. 2011).

While Common Myna are widespread throughout eastern Australia, their true effect on the environment and agriculture is largely unknown. A study on the impact of the species in Greater Sydney showed the species prefers urban habitats or areas with human habitation, and does not appear to penetrate into large areas of native bushland when preferred habitat is available (Old *et al*. 2014). The authors further stated: "The social behaviour and population dynamics of males and females in rural and urban areas require further study, particularly because management of birds in rural fringes of cities may be redundant if the birds captured are subordinates to the actual breeding population in urban areas".

Common Starling

The Common Starling is the third most abundant introduced species in the region. The species is stated as having a detrimental effect on native ecosystems, particularly through the tendency to out-compete native bird species for food and nest sites (Lowe *et al*. 2000; Centre for Invasive Species Impacts 2013). It was initially introduced to agricultural areas due to its reputation for eating insect pests and larvae. However, it rapidly became a pest in fruit orchards, around feedlots for intensive livestock production, and in areas of newly germinated grain (Higgins *et al*. 2006).

Common Starling mainly inhabits built-up areas and farmland, usually where trees or artificial structures are available for roosting and nesting, and where there are open grassy areas for foraging. It forages mainly on the ground for invertebrates, as well as fruit and nectar from plants. Outside of the breeding season, Common Starling can form flocks of hundreds and sometimes thousands of birds. Many of the problems created by Common Starling stem from their presence in large flocks. When a large flock settles onto a field or orchard, they can do considerable damage in a short time. Their abundance can also lead to reduced avian diversity.

The birds are aggressive, and agonistic behaviour towards native species is common, particularly around nest hollows. They will usurp occupied hollows, if possible, occasionally killing the occupants (Higgins *et al*. 2006). Agonistic behaviour has been recorded towards Australian Ringneck *Barnardius zonarius*, Crimson Rosella *Platycercus elegans*, Bluebonnet *Northiella haematogaster*, Swift Parrot *Lathamus discolor*, Mulga Parrot *Psephotellus varius*, Orange-bellied Parrot *Neophema chrysogaster*, Blue-winged Parrot *Neophema chrysostoma*, Sacred Kingfisher *Todiramphus sanctus*, Striated Pardalote, Black-faced Cuckoo-shrike *Coracina novaehollandiae,* House Sparrow and Common Myna (Higgins *et al*. 2006).

Although there are numerous records of competition with native species, there do not appear to be any studies that demonstrate detrimental effects on the abundance or species richness of native species. It should also be noted that the areas habituated by Common Starling tend to be highly altered habitats with reduced species diversity.

CONCLUSIONS

Twelve introduced avian species have been identified as having established wild populations in the Hunter Region. They became established in the region from the late 1870s up to the early 1980s and today are dominantly resident in urban, peri-urban and agricultural areas. Seven species are common; the others are uncommon or rare, and in one case, locally extinct. Increasing urbanisation plus habitat loss and modification has aided expansion and population growth of some introduced species by reducing competition from native species. Although distribution maps show many species are widespread through the region, none of the species have successfully colonised undisturbed, well-structured native forests or woodlands.

The population of one species, Common Myna, has increased over the past 22 years, while the long-term population trend of the other species is either uncertain, declining or unknown. Competition with native species appears limited to those areas that have been impacted by human habitation or agricultural activity. However, the impact and extent of competition is complex and has not been extensively researched. As a result, the negative

impacts of introduced species on the native avian population may have been overstated. More research is required in order to demonstrate the influence of introduced species on the abundance and species richness of impacted populations. There is a limited amount of research on Common Myna and Common Blackbird; the impact of the Spotted Dove, which is the second most abundant introduced species in the region, has not been studied. Lavretsky *et al.* (2023) highlighted the importance of understanding the impact of introduced species: "Although considered paradoxical to biological conservation, understanding the capacity for wildness among feral and feral admixed populations in human landscapes is critical as such interactions increase in the Anthropocene."

Our towns, cities and peri-urban areas are now recognised as an essential habitat to support the survival of the many native species that have adapted, with varying degrees of success, to this modified habitat. While the effective management of introduced species that also prefer these habitats may assist in ensuring the survival of some native species, the re-establishment of habitat more suitable for native species in urban and peri-urban areas is more likely to achieve a positive permanent outcome.

ACKNOWLEDGEMENTS

Dan Williams is thanked for providing species distribution maps for the Hunter Region and Alan Stuart is thanked for providing historical reports, including that by Ed Hamonet. Mick Roderick is thanked for refereeing the article and providing comments and suggestions which considerably improved the original manuscript.

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The Whistler **17 (2023)**: 66-68

Single-nest brood overlapping in the Galah in the Hunter Region, New South Wales

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Received 14 September 2023, accepted 23 September 2023, published online 29 September 2023.

INTRODUCTION

The Galah *Eolophus roseicapillus* is a common parrot found in open habitats over much of Australia (Australian Museum 2021). It is a seasonal breeder that lays clutches from late July or early August to early November (Higgins 1999). It mostly uses hollows in Eucalyptus spp. and uses the same hollow in successive years (Rowley 1990). The average clutch size is 4.3 eggs (range 2-8) and the median incubation period is 23.4 days (Rowley 1990). The mean nestling period is 49.4 days (range 45.6-59.1) (Rowley 1990) to 52 days (range 45-62) (Smith & Saunders 1986).

Brood overlapping occurs when birds begin a second clutch while their first brood still depends on them (Blomqvist *et al*. 2001; Burley 1980; Hill 1986; Surmackie & Podkowa 2022; Wiggins *et al*. 1984). It is rare when it involves a single nest and the second clutch is laid before the first brood fledges. This single-nest brood overlapping usually occurs in nest boxes (Surmackie & Podkowa 2022). Galahs may begin a replacement clutch 12-18 days after the failure of eggs or small young. McGilp (1923) stated that Galahs have at least two broods in good years but Rowley (1990) disagreed.

This note describes two successive clutches that were invested-in simultaneously in the same nest box at Thornton (32º24'S 150º38'E), New South Wales.

METHODS

On 31 July 2022, a nest box containing eucalyptus leaves treated with lice and mite spray was installed 5.5 m above the ground on a steel pole in our backyard. It was located beside a Eucalyptus sp. (approximately 21 m tall) and above an understorey of native shrubs: Callistemon spp., Banksia spp. and Grevillea spp. A custom-made camera was mounted in the ceiling of the nest box allowing the eggs and young to be viewed opportunistically.

RESULTS

The observations of the breeding event are summarised in **Table 1**.

Table 1. Opportunistic observations of Galah breeding in a nest box in a suburban backyard in the Hunter Valley in 2022

Date (2022)	Observation
31 July	Nest box was installed; adult birds mated on the nest box roof
10 August	No eggs were in the nest box
29 August	First clutch: at least two eggs had been laid (partially covered by leaves)
16 September	First brood: three small young had hatched
24 September	Only one young remained, Chick 1/2022
13 November a.m.	Parents were in the nest box with Chick 1/2022. Female was very still with head down. Male was arranging leaves.
13 November p.m.	Second clutch: Two eggs had been laid. Chick 1/2022 was still in the nest box (**Figure 1**).
16 November	Second clutch: Three eggs had been laid. Chick 1/2022 was still in the nest box (**Figure 2**).
18 November p.m.	Chick 1/2022 was asleep in the nest box (**Figure 3**).
19 November a.m.	Chick 1/2022 was no longer in the nest box and had presumably fledged.
29 November	Second clutch: Four eggs had been laid.
11 December	Second brood: One small young from the new clutch had hatched.
January 2023	No surviving young were observed in the nest box.

On 13 November, the beginning of a second clutch (two eggs) was discovered in the nest box with the sole surviving young from the first clutch, Chick 1/2022, who was at least 58 days old (**Figure 1**).

On 16 November, the second clutch contained three eggs (**Figure 2**). On 18 November, Chick 1/2022 was still in the nest box (**Figure 3**) but on 19 November, Chick 1/2022, who was at least 64 days old, was gone. At least one young from the second clutch hatched but the nesting was unsuccessful.

Figure 1. The sole surviving young from the first clutch, Chick 1/2022, is inspecting two eggs from the second clutch on 13 November 2022.

Figure 2. Chick 1/2022 is sitting beside three eggs from the second clutch on 16 November 2022.

Figure 3. Chick 1/2022 is sleeping beside three eggs (partially covered with leaves in the nest bowl) from the second clutch on 18 November 2022. A parent is blocking the entrance to the nest box.

DISCUSSION

This appears to be the first report that provides evidence of Galahs laying a second clutch while caring for a large unfledged young. Previous reports provide evidence of Galahs re-nesting only after failure of a clutch or brood (Rowley 1990; Smith & Saunders 1986).

In the present study, a second clutch may have been laid because the adults sensed that the sole surviving young from the first clutch was unlikely to fledge. The young was near the maximum nestling age (at least 58 days old) (Rowley 1990; Smith & Saunders 1986) when the first two eggs of the second clutch were discovered. It had not been observed climbing the internal ladder or looking out of the nest box, which were expected milestones for its age (Pryor pers. obs.). However, it presumably fledged (not observed) when it was at least 64 days old, which was older than the maximum reported nestling age (Rowley 1990; Smith & Saunders 1986).

The second clutch may have been started before Chick 1/2022 fledged because the length of the breeding season was a constraint. Seasonal breeders have a certain amount of time available for breeding and some may be able to rear a second brood only if they overlap successive clutches (Hill 1986). Some birds that lay eggs early in the breeding season are more likely to overlap successive clutches (Hill 1986; Wiggins *et al*. 1984). However, these findings contrast with the observation on 10 August that the Galahs had not started laying eggs.

These Galah parents may have carried out this rare behaviour because they were experienced breeders that were capable of producing a second clutch quickly and raising more young (Blomqvist *et al*. 2001). A pair have bred in a nest box in our backyard for five consecutive breeding seasons, including 2022. The Galah is a long-lived and monogamous species (Higgins 1999) and pairs have time to become efficient in breeding (Burley 1980). In addition, because the male and female incubate the eggs and provision the young, they can potentially take on different roles to provide different kinds of care for young of different developmental phases (Burley 1980).

A cue may have stimulated the Galahs to re-nest at an inappropriate time (Wiggins *et al*. 1984). One cue may have been the loss of most of the first brood. Some bird species lay second clutches more quickly when they lose most of their first brood soon after hatching (Blomqvist *et al*. 2001; Parish *et al*. 1997). Another cue may have been the

abundance of food. The year 2022 was warmer and wetter than average, with a third successive La Niña becoming established by early September (Bureau of Meteorology 2023). It provided conditions that promoted widespread growth and seeding of grasses and other plants that Galahs feed on. Similar to these observations of Galahs, Wiggins *et al.* (1984) found that Common Tern *Sterna hirundo* that laid a second clutch before the first brood fledged had lost one or two chicks and were raising only one chick when food abundance allowed the successful raising of two to three chicks.

The brood overlapping described in this note did not improve the reproductive success of the Galah pair because the second brood failed. Young in the second brood may have died for the same (unknown) reasons that two young in the first brood died. Alternatively, the adults may have concentrated their parental care on the fledged, still-dependent Chick 1/2022 and may have not provided optimal care to young in the second brood. These observations are similar to those reported in other studies (Surmackie & Podkowa 2022; Wiggins *et al.* 1984).

CONCLUSIONS

The Galah may (rarely) re-nest before its dependent young fledge, especially if the first brood has a low survival rate but is not known to successfully fledge chicks from two broods in a single breeding season.

ACKNOWLEDGEMENTS

I am grateful to Nick Milton for building and installing the nest box and camera and for taking the photographs.

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Raptors at Woodville – insights into the difficulties of assessing raptor populations

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Received 28 September 2023, accepted 3 October 2023, published online 31 October 2023.

Whole-of-month lists of birds recorded from my home at Woodville in the Hunter Valley provided a valuable inventory of the raptor population of that location between 2000 and 2013. The results were consistent with those conducted contemporaneously at the nearby Morpeth Wastewater Treatment Works using a more rigorous survey protocol. Differences in the results reflect the attraction of some raptor species to wetlands (Morpeth) and the close proximity of the Woodville site to woodland. Collecting monthly inventories of raptor records in this manner at an array of locations has the potential to provide improved insights into their regional status.

INTRODUCTION

The birding community has a peculiar fascination with raptors. As apex predators the status of raptors informs ecologists about the state of the environment. For birders, a raptor sighting inevitably creates excitement, the reasons for which are multi-faceted, invoking the adjectives majestic, spectacular and rare.

As a guild, raptors are well represented in the Hunter Region, but tracking their status is challenging. Generally, they have large territories, are scarce and infrequently recorded in short duration surveys such as BirdLife Australia's preferred Birdata 2ha 20-minute surveys. Appreciating this difficulty, raptor experts realised the need for a survey protocol uniquely targeting Birds of Prey (BOP) and the BOP Watch project was initiated in the 1980s (Baker-Gabb & Steele 1999).

BOP Watch involved recording the occurrence of birds of prey while driving cars; essentially it involved monitoring an extended transect over an extended period of time. Cooper *et al.* (2014) also appreciated the advantage of sampling large areas over extended periods of time, perpetuating the use of the protocols of the First Australian Atlas (Blakers *et al.* 1984) in NSW. This involved recording birds in 10-minute latitude/longitude grids. Newman & Lindsey (2016) tracked the trajectories of raptor species at the Morpeth Wastewater Treatment Works (WWTW) monthly between 2001 and 2015 using Birdata 500m surveys.

In Tasmania, I have successfully established statistically significant trends for the Grey Goshawk and other raptor species using the 25-year data sets of Ralph Cooper and Richard Ashby (Newman *in prep*.). Both sampled 5km areas in a consistent manner at approximately monthly intervals. Cooper's approach was to spend approximately 50 hours a month visiting a number of locations within approximately 5km of his home in peri-urban Launceston. In contrast, Ashby's surveys were made over a period of around 4 hours on one day, using a fixed route through bushland in NW Tasmania.

Reflecting on the success of these analyses for Tasmania, I realised that I had a number of potentially suitable Hunter data sets each involving more than a decade of monthly monitoring. However, although most of those data sets sampled areas of 50ha or greater of woodland, they involved same-day surveys that only had restricted views of the sky (the primary domain of most raptors). Hence, I chose to evaluate a data set based upon whole-of-month observations from my home, where I had unrestricted views of the sky.

METHODS

The observations were made from my property at Woodville in the Hunter Region of NSW (32.667ºS, 151.614ºE). The property was approximately 2ha in size, located in lightly timbered country on the edge of the Butterwick flood plain. Nearby woodland at Green Wattle Creek provided connectivity to well-forested ridges in the Duns Creek area.

Birds were recorded opportunistically throughout the month and submitted as Birdata 500m surveys, although observations almost exclusively occurred from within the 2ha area of the property. The survey duration was nominally recorded as four hours, but a bird-orientated family is always peripherally aware of the presence of unusual species. Over a 14-year period 142 surveys were completed (average 10.1 surveys/annum; range 5-12 surveys/annum). The number of surveys in different months varied from 7 to 14 with an average of 11.8 surveys/month. Results were expressed as Reporting Rates (RR) to correct for differences in the numbers of surveys in different years in temporal and seasonal analyses, respectively. Reporting rate is the number of records for a species divided by the number of surveys, expressed as a percentage.

I had been living at Woodville for seven years when these surveys commenced and was familiar with the raptors of the area, an important factor with respect to the reliability of the survey data, given the challenges associated with raptor identification.

RESULTS

Sixteen species of diurnal and one nocturnal raptor species were recorded at Woodville over a 14-year period commencing January 2000 (**Table 1**). The nocturnal Southern Boobook was the most regularly recorded species (RR 36.6%). Whistling Kite was the most frequently recorded diurnal raptor (RR 20.4%) and nine of the diurnal species had RRs of <5%, with four being recorded on a single occasion.

Table 1. Occurrence and reporting rates of raptor species at Woodville between 2000 and 2013 based on 142 monthly Birdata 500m surveys.

Species common name	Scientific name	Number of records	Reporting Rate (%)
Black-shouldered Kite	*Elanus axillaris*	11	7.7
Square-tailed Kite	*Lophoictinia isura*	1	0.7
Pacific Baza	*Aviceda subcristata*	1	0.7
Wedge-tailed Eagle	*Aquila audax*	20	14.1
Swamp Harrier	*Circus approximans*	8	5.6
Spotted Harrier	*Circus assimilis*	1	0.7
Grey Goshawk	*Accipiter novaehollandiae*	4	2.8
Brown Goshawk	*Accipiter fasciatus*	7	4.9
Collared Sparrowhawk	*Accipiter cirrocephalus*	2	1.4
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	11	7.7
Whistling Kite	*Haliastur sphenurus*	29	20.4
Southern Boobook	*Ninox boobook*	52	36.6
Nankeen Kestrel	*Falco cenchroides*	20	14.1
Australian Hobby	*Falco longipennis*	24	16.9
Brown Falcon	*Falco berigora*	5	3.5
Black Falcon	*Falco subniger*	1	0.7
Peregrine Falcon	*Falco peregrinus*	3	2.1

Temporal trends

With exception of the Southern Boobook and Whistling Kite (**Figure 1**) there were insufficient records to establish meaningful temporal trends. The annual RRs of Southern Boobook and Whistling Kite both decreased, at rates of 25%/decade and 53%/decade respectively. The average annual RR of the other 14 raptor species decreased by 40%/decade (**Figure 2**).

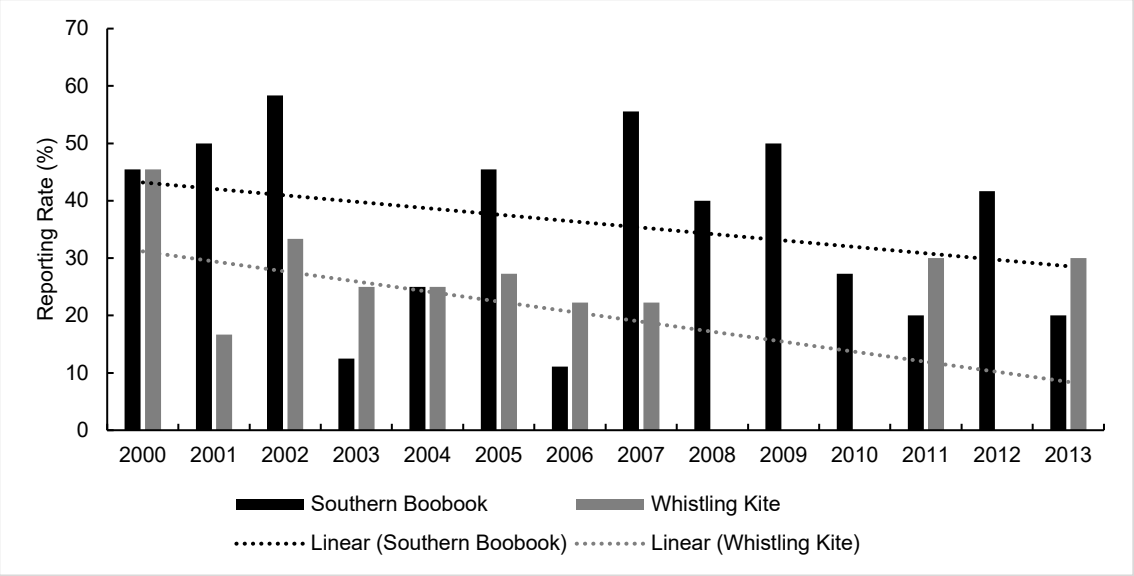

Figure 1. Variation in the Annual Reporting Rates of the Southern Boobook and Whistling Kite for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

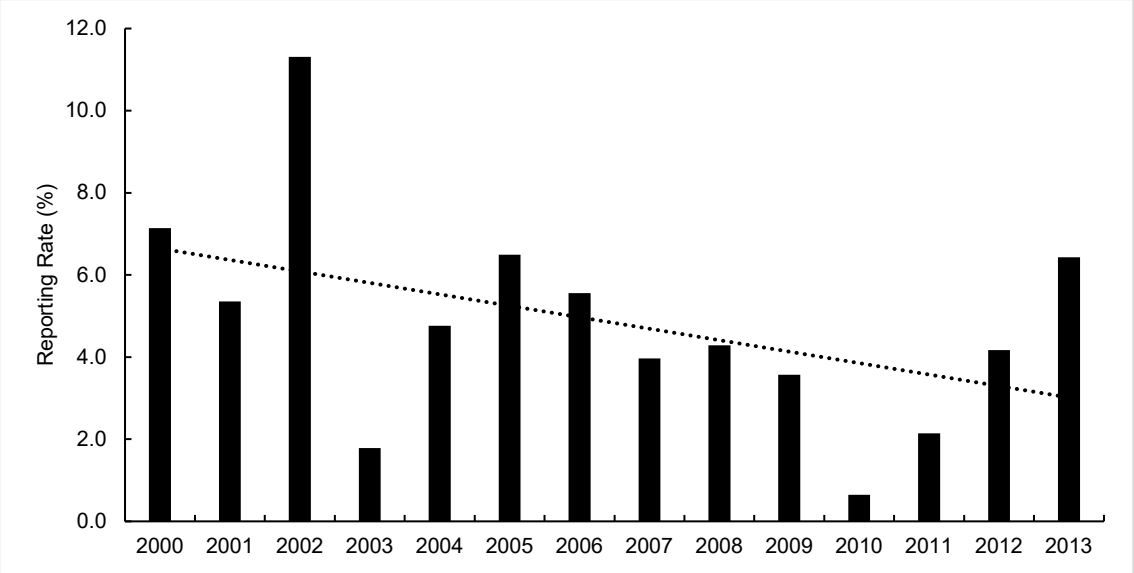

Figure 2. Variation in the mean Annual Reporting Rate of 14 raptor species for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

Seasonal variations

There were sufficient records to establish meaningful seasonal trends in occurrence for six species. The Southern Boobook was recorded throughout the year, but primarily between September and April (**Figure 3**).

The patterns of occurrence of the Whistling Kite and Wedge-tailed Eagle were remarkably similar, with most records of both species occurring between January and June (**Figure 4**). In contrast, the Black-shouldered Kite and Nankeen Kestrel were mostly recorded between June and November (**Figure 5**). There was no clear seasonal pattern in the occurrence of the Australian Hobby (**Figure 6**).

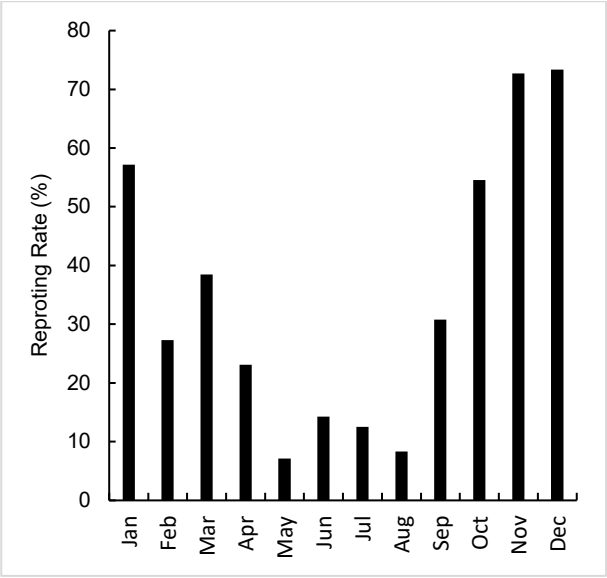

Figure 3. Seasonal variation in the Reporting Rate of the Southern Boobook for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

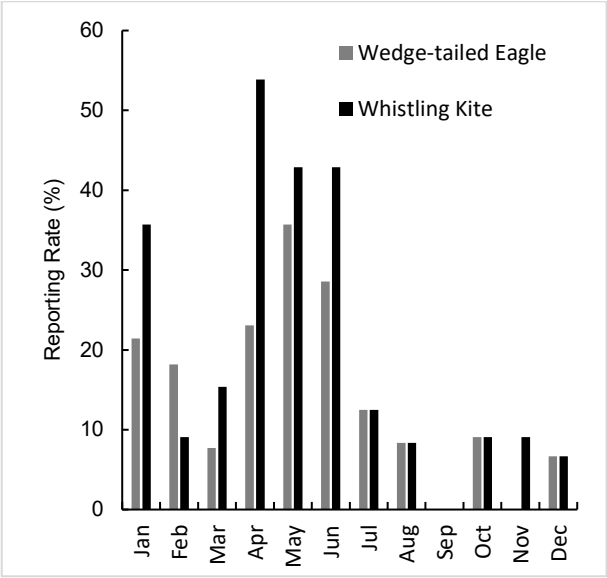

Figure 4. Seasonal variation in the Reporting Rate of the Wedge-tailed Eagle and Whistling Kite for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

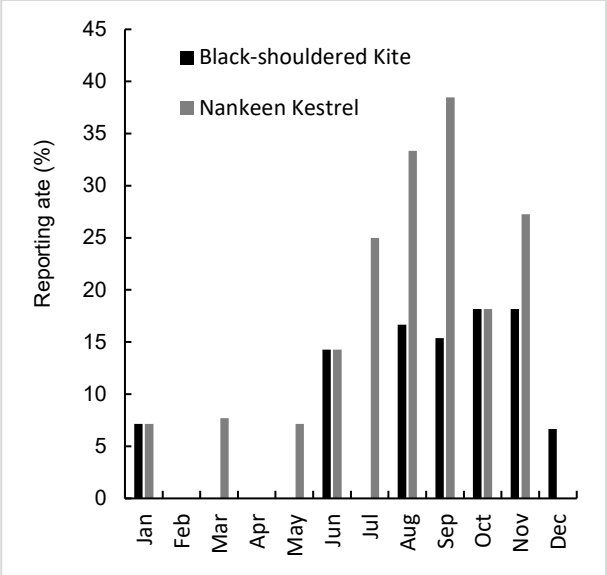

Figure 5. Seasonal variation in the Reporting Rate of the Black-shouldered Kite and Nankeen Kestrel for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

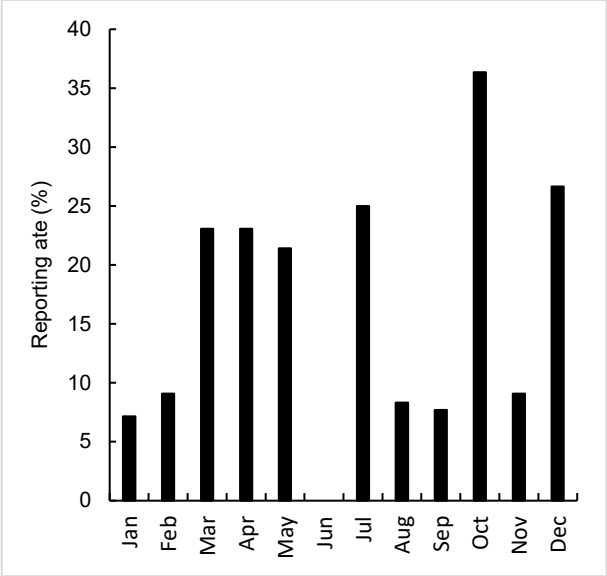

Figure 6. Seasonal variation in the Reporting Rate of the Australian Hobby for monthly Birdata 500m surveys at Woodville between 2000 and 2013.

DISCUSSION

Comparison with other studies

The 16 diurnal species seen between 2000 and 2014 represent a high proportion of the 20 raptor species regularly recorded in the Hunter Region. A 17th species, Black Kite *Milvus migrans* was observed within 1 km of my property.

The relative magnitudes of the RRs in **Table 1** are generally consistent with the status of raptor species in the Hunter Region. For instance, Birdata surveys conducted monthly at the Morpeth WWTW, located approximately 10km from Woodville (Newman & Lindsey 2016), provide an excellent basis for comparison (**Figure 7**). Sixteen diurnal raptor species were recorded in both studies, of which 15 were common to both locations. It is not surprising that a number of species were recorded more frequently at Morpeth WWTW because wetlands provide important foraging opportunities for raptors and some, like the White-bellied Sea-Eagle, were breeding at the site.

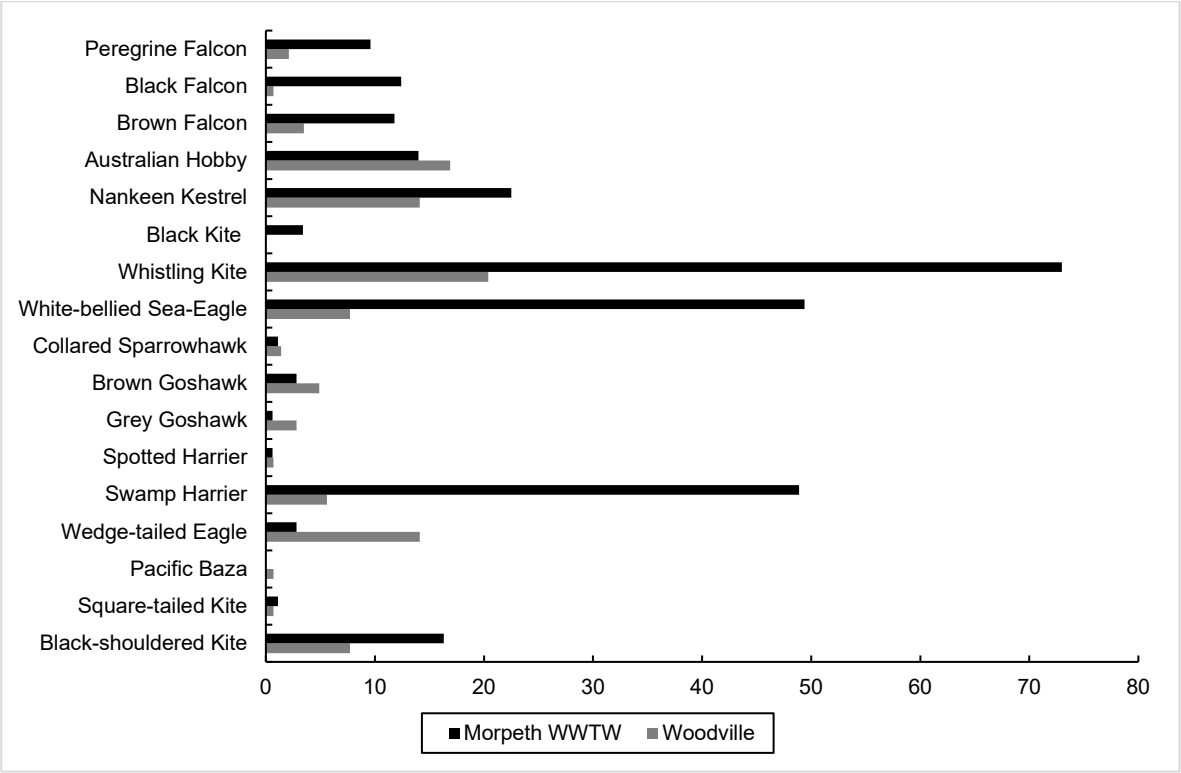

Figure 7. Comparison of the occurrence of diurnal raptors at Morpeth WWTW (176 surveys between 2001 and 2015) and at Woodville (142 surveys between 2000 and 2013).

Temporal trends

The decreases in RR observed in this study are consistent with those identified at the regional scale by Cooper *et al.* (2014) for the period 1986 to 2006. The Morpeth study identified similar decreasing trends that were statistically stronger because there were more raptor records than at Woodville. However, a more recent analysis provides tentative evidence of more stable populations (Williams 2019).

Seasonal occurrence

The period of peak occurrence of the Southern Boobook corresponds to its breeding season (Cooper *et al.* 2016). Most records of this species relate to calling birds. The extent to which the dearth of records between May and August relates to decreased vocalisation, as opposed to movement from the area, is unclear (Cooper *et al.* 2014).

Raptors primarily breed in late winter and spring. Hence, the predominance of Whistling Kite and Wedge-tailed Eagle records in late summer and autumn may indicate the post-breeding dispersal of birds into the area and the absence of nearby nest sites. Conversely, the increased occurrence of Nankeen Kestrel and Black-shouldered Kite in spring may indicate that they were breeding nearby at that time and that they subsequently dispersed.

Because of the absence of any clear pattern of seasonal variation, the Australian Hobby appeared to be an uncommon resident.

The role of whole month surveys

The results presented in this paper suggest that this type of survey has a niche as part of the portfolio of survey protocols. It lacks the rigour of repeat surveys conducted in a consistent manner, such as those made at Morpeth WWTW. In addition, these survey lists don't record how frequently common species are recorded and hence may over-state the occurrence of less common species. However, regularly recorded species usually involve the same birds. An alternative approach is to record opportunistic sightings of raptors as individual records using the BLA incidental sighting survey protocol, but most observers are more likely to record less-common species using this approach, again resulting in over-reporting of scarce species.

The Woodville surveys provide insights into the differences in raptor occurrence across the landscape (e.g. the Woodville surveys record more Accipiter species than Morpeth because of its proximity to woodland). Conducting whole-of-

month inventories of occurrence at an array of survey sites has the potential to increase knowledge of regional raptor populations.

CONCLUSIONS

Whole-of-month surveys on a property at Woodville provided valuable insights into the raptor populations of the area despite the lack of rigor associated with the method of data acquisition. The results were generally consistent with those from a more rigorous study at the Morpeth WWTW and studies elsewhere in the Hunter Region (Williams 2019).

ACKNOWLEDGEMENTS

I thank Alan Stuart for encouraging me to write this paper and document another of my Hunter data sets, reminding me of 20 wonderful years spent living on the edge of a flood plain.

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A five-year study of the use by Gould's Petrel of artificial nest boxes on Broughton Island, New South Wales

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Received 30 June 2023, accepted 8 October 2023, published online 30 October 2023.

In mid-2017, six artificial nest boxes were installed on Broughton Island, New South Wales along with a call-playback system and loudspeaker. The purpose of the installation was to encourage the nationally threatened Gould's Petrel *Pterodroma leucoptera leucoptera* to breed on the island. The small number of nest boxes, and their close proximity to one another, prompted a study of their utilisation on Broughton Island by Gould's Petrel. After their installation, the nest boxes were inspected several times each breeding season. The five-year study enabled insights into the early stages of Gould's Petrel colony establishment. Such insights had not been possible for other newly establishing Gould's Petrel populations, which have been on islands that were less frequently monitored, and which had more-dispersed nesting site locations.

The five-year study confirmed many of the findings about breeding behaviour from previous studies. Egg-laying occurred between late November and mid-December, with chicks hatching by mid-January and fledging in mid-March to mid-April. There was clear evidence of partner fidelity, and breeding pairs used the same nest box every time.

Breeding success rates were higher than found in other studies. From a total of ten eggs laid over the five breeding seasons, eight chicks hatched and all of those chicks successfully fledged. Four of the nest boxes were productive i.e., they yielded at least one fledged chick during the five-year study. For all six nest boxes there was at least one season with some breeding activity recorded.

The importance of the artificial nest boxes on Broughton Island for Gould's Petrel is highlighted by the fact that no breeding in natural nesting sites has been recorded on the island since the first record in 2009.

At one nest box, where a Gould's Petrel pair bred successfully in the 2021/22 season, they were displaced in the following season by a pair of Wedge-tailed Shearwater *Ardenna pacifica*. This highlights the difficulties faced by Gould's Petrel attempting to breed in competition with a substantial local population of a much larger seabird.

INTRODUCTION

Gould's Petrel *Pterodroma leucoptera* is a small species of gadfly petrel (a genus of about 35 species, all having speedy weaving flight). There are two subspecies – *P. leucoptera leucoptera* ("Gould's Petrel") which breeds on Australian islands (Priddel *et al*. 1995; Carlile & Priddel 2004), and *P. leucoptera caledonica* ("New Caledonian Gould's Petrel") which breeds in mountainous areas of New Caledonia (Bretagnolle *et al*. 2021). Both subspecies are considered to have decreasing populations and are classified internationally as vulnerable (IUCN Red List 2018).

Until recently, the Gould's Petrel was known to breed on only two islands near Port Stephens – many hundreds of breeding pairs on Cabbage Tree Island and a translocated smaller population on nearby Boondelbah Island (Carlile & Priddel 2004; Priddel & Carlile 2004; Commonwealth of Australia 2023). However, small breeding populations have since established on Broughton Island (Carlile *et al*. 2012) and Little Broughton Island (Carlile *et al*. 2020; S. Callaghan pers. obs.), both about 10km away from the other two islands (see **Figure 1**), and on Montague Island near Narooma NSW (Carlile *et al*. 2020; E. Mowat pers. comm.). Importantly, feral rabbits and rats were removed from all of those three islands about 10-12 years ago (e.g. see Priddel *et al*. 2011; Gregory *et al*. 2014).

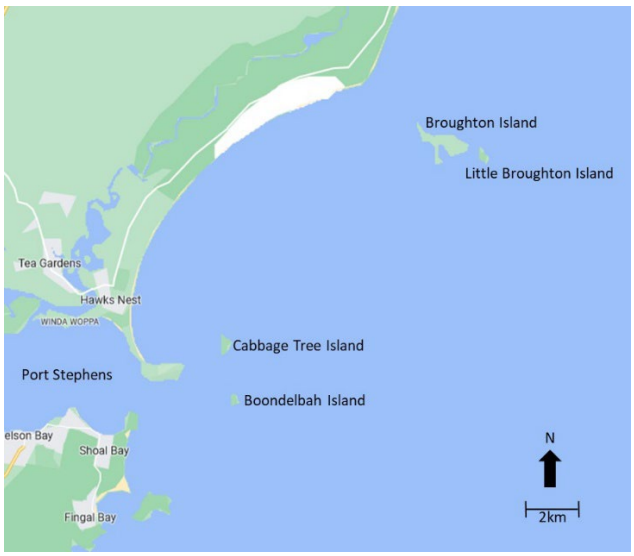

Figure 1. Location of Broughton Island and some other important islands off Port Stephens (original map sourced from Google Maps)

Study site

Broughton Island (32º 37'S, 152º 19'E) is the main island of the Broughton Group, located north-east of Port Stephens in New South Wales. Broughton Island is an important seabird breeding location, each year hosting many tens of thousands of Wedge-tailed Shearwater *Ardenna pacifica* pairs plus lesser numbers of Short-tailed Shearwater *Ardenna tenuirostris* and Little Penguin *Eudyptula minor* (Carlile *et al*. 2012; Carlile *et al*. 2022).

In December 2009, Gould's Petrel was recorded on Broughton Island for the first time; a bird incubating an egg was found in a rock crevice within a scree slope at the base of Broughton Island's highest point, "Pinkatop" (Carlile *et al*. 2012). That area was searched again in 2020 but no Gould's Petrel nests could be located, nor have any of their nests been found in natural cavities elsewhere on the island despite intensive searching (NPWS records).

In 2017, to encourage Gould's Petrel to breed on Broughton Island, six artificial nest boxes and a call-playback system plus loudspeaker were installed on the upper slope of Pinkatop by the Hunter Coast branch of NSW National Parks and Wildlife Service (**Figure 2**). The nest box design had long been used with success for the Gould's Petrel colonies on Cabbage Tree Island and Boondelbah Island (Priddel & Carlile 1995). Call playback is an established means for encouraging seabirds to use a restored or newly constructed site (e.g. Zhou *et al*. 2017).

The nest boxes on Broughton Island lie within an area of approximately three metres radius, a few metres from a cliff edge. Each nest box has a tunnel ~250 mm long, leading to a small cavity underneath the false floor of the nest box. The tunnels, made of agricultural pipe, are 100 mm in diameter at their entrance. Most nest boxes have a 100 mm to 85 mm PVC reducer near the start of the tunnel, aimed at preventing access by the larger Wedge-tailed Shearwater. During each breeding season, Gould's Petrel calls were broadcast every night through a loudspeaker in order to attract birds to investigate the site.

Figure 2. Two of the Gould's Petrel nest boxes and the loudspeaker (photo: A. Stuart).

During the five years since installation, the nest boxes were inspected in the breeding season by Hunter Bird Observer Club (HBOC) members during their regular visits to Broughton Island to monitor its bird population (Stuart *et al*. 2017; Stuart 2020), and irregularly at other times. The frequent visitation to the nest boxes enabled a study which has yielded insights into Gould's Petrel breeding behaviour at a newly establishing breeding site. Here, we present results from the first five years of the study.

METHODS

Adult Gould's Petrels begin to visit nesting sites in October although egg-laying does not occur until late November or early December, and chicks fledge in April

(Marchant & Higgins 1990). Therefore, the nest box inspections on Broughton Island spanned October to April each breeding season.

All nest box inspections were done in daylight hours. The time of day for inspections was tide-dependent (because of site access issues at high tide). After arrival at the nest box site, the boxes were inspected one at a time and the presence of an adult bird(s), egg or chick recorded. An individually numbered metal band was applied to every previously unbanded adult Gould's Petrel found in a nest box (under a permit obtained from the Australian Bird and Bat Banding Scheme). The band numbers of any previously banded birds present were recorded on each visit. A band was also applied to chicks when they had reached a sufficiently advanced stage of development.

A nest box was classified as *Active* (A) in a breeding season if at least one adult bird was present in it at any time, and as *Breeding Active* (B) if there was an egg or a chick present. A nest box was classified as *Productive* (P) if a chick hatched in it that season and the chick developed to a size large enough for it to be banded. If later the nest box was found to be empty, that banded chick was treated as having fledged.

The presence of a chick in a nest box was interpreted as an egg having previously been present, whereas the presence of an egg did not imply that a chick would be produced.

The nest boxes were arbitrarily numbered 1-6 during installation and we have used that numbering scheme for the present report.

RESULTS

Overview

During the 2018-2023 breeding seasons, the nest boxes were inspected a total of 30 times, ranging from 4-8 visits per season – details are in **Table 1**. The first record of an adult Gould's Petrel in a Broughton Island nest box was on 24 October 2018, and the first successful breeding record was in the 2019/20 season, from a different nest box. An egg was first discovered in that nest box (box #5) on 18 December 2019 and a chick subsequently fledged (**Figure 3**).

Tables 2 and **3** summarise the overall results for each nest box, spanning five breeding seasons. By the end of the 2022/23 breeding season, chicks had fledged at least once from four of the six nest boxes, with a total of eight chicks fledging over the four years since the first confirmed breeding activity in 2019/20.

Sixteen different adult Gould's Petrels (including one dead bird) were recorded in the Broughton Island nest boxes between October 2018 and February 2023. In addition, a Pycroft's Petrel *P. pycrofti* was found in nest box 2 in October 2019, together with an adult Gould's Petrel (Stuart & Clarke 2023).

Table 1. Number of nest box inspections during the 2018-2023 breeding seasons.

Year	No. of inspections
2018/19	4
2019/20	8
2020/21	7
2021/22	6
2022/23	5

Figure 3. The first Gould's Petrel chick from the Broughton Island nest boxes (photo: R. Kyte).

Table 2. Summary of the results for each Gould's Petrel nest box for 2018-2023.

Nest box No.	No. of individual adult birds	No. of eggs	No. of chicks hatched	No. of chicks fledged
1	4	1	0	0
2	2*	2	2	2
3	1	1#	1	1
4	6	1	0	0
5	3	4#	4	4
6	-	1#	1	1

*Does not include the Pycroft's Petrel found in October 2019
#Presence of an egg inferred from the later presence of a chick

Table 3. Summary of the results for each nest box in each breeding season from 2018/19 to 2022/23. (Codes: A: the nest box was active that season; B: the nest box had a breeding record (egg or chick); P: the nest box was productive that season i.e. a chick was considered to have fledged)

Nest box number	Activity	2018/19	2019/20	2020/21	2021/22	2022/23	Totals
1	A			✓	✓	✓	3
	B			✓			1
	P						0
2	A		✓	✓	✓	✓	4
	B			✓	✓		2
	P			✓	✓		2
3	A					✓	1
	B					✓	1
	P					✓	1
4	A	✓	✓	✓	✓	✓	5
	B			✓			1
	P						0
5	A	✓	✓	✓	✓	✓	5
	B		✓	✓	✓	✓	4
	P		✓	✓	✓	✓	4
6	A				✓		1
	B				✓		1
	P				✓		1
Individual adults		4	4	3	8	7	16
Total eggs		0	2	3	3	2	10
Total fledged chicks		0	1	2	3	2	8

Results for each nest box

Nest box 1

This nest box was active in three seasons, with an egg laid in one season, but it yielded no chicks.

An adult Gould's Petrel was recorded three times in the 2020/21 season; during the December and January visits it was in the nest box with a second bird – probably the same bird both times but banding equipment was not to hand during either visit. In the late December 2020 visit, there was an egg with the two birds, but it was cold. In the next inspection, four weeks later, the egg had disappeared but the two birds were again present.

A different pair was recorded in this nest box in three inspections spanning December–January in the 2021/22 season. There was no evidence of them breeding and there were no further records of either bird.

The original bird from 2020 was again present in the 2022/23 season but no breeding activity occurred. No other adult bird was recorded present.

Nest box 2

This nest box was active in four seasons and produced two chicks from two eggs; both chicks successfully fledged.

In the 2019/20 season (in October 2019), an adult Gould's Petrel was found sharing the nest box with a Pycroft's Petrel. The Pycroft's Petrel was present for at least two days (Stuart & Clarke 2023), but it was never recorded again. The same individual Gould's Petrel was in the nest box again (alone) in the December 2019 visit.

There was no evidence of the presence of a second Gould's Petrel that season. However, a pair of Gould's Petrels, one of which was the individual previously seen with the Pycroft's Petrel, used this nest box across the three subsequent seasons – 2020/21, 2021/22 and 2022/23. The pair successfully raised chicks in both the 2020/21 and 2021/22 breeding seasons. They were also seen together in the nest box in February 2023, but no egg was laid that season.

Nest box 3

This nest box was active in one season and produced a chick which successfully fledged.

There was only one record of an adult Gould's Petrel from this nest box (a single bird in October 2022) and the nest box was empty when inspected on 15 November 2022. However, in the next inspection, on 3 February 2023, a young chick was present. It was still there in the next visit, on 17 March 2023. In the subsequent visit on 16 April 2023, it had almost complete adult plumage (just a few small downy areas remained).

Nest box 4

This nest box was active in all five seasons, with an egg laid in one season, but it yielded no chicks.

Six different adult Gould's Petrels were recorded in this nest box. Five of those records were one-offs, including a dead bird in the tunnel in December 2019 – one of its wings had become caught as it was departing. We removed the dead bird.

One bird was present during every breeding season since it was initially banded in December 2019. In late January 2021, this bird was seen incubating an egg; however, in the next inspection six weeks later, the egg was cold and there was no longer an incubating bird present.

Nest box 5

This nest box was active in all five seasons and produced three chicks, all of which successfully fledged.

Two birds were regularly recorded visiting this nest box. Both birds were banded in December 2018 (on different dates), and they were first found together in the nest box in January 2019. In the 2019/2020 season, this pair laid the first egg recorded in the Broughton Island nest boxes, and a chick fledged successfully.

In the 2021/2022 season, a third adult bird was present in November 2021. The bird was alone, and there were no further records of it. The following month there was an egg, which, during inspections about two weeks apart, was observed being incubated in turn by the original pair of birds. A chick was successfully raised to fledging by the pair that season, as well as in the 2022/23 season.

Nest box 6

This nest box was active in one season and produced a chick which successfully fledged. The chick, which was first detected in mid-January 2022 and banded in late February, was at the end of an excavated burrow which extended ~30cm beyond the floor of the nest box.

The nest box was inspected three times during November-December 2021 but the burrow was not investigated. Consequently, the incubating Gould's Petrel at the end of the burrow was not detected. A chick was heard vocalising from within the burrow on 20 January 2022 and it was confirmed to be a Gould's Petrel chick during a visit three weeks later.

During an overnight surveillance in late February 2022 an adult Gould's Petrel was seen to approach the tunnel entrance (S. Callaghan pers. obs., with N. Carlile).

Signs of an excavation from the nest box floor were first noticed in November 2020. At the time, the significance was not appreciated. However, in the 2022/23 breeding season, the excavated burrow was occupied by a Wedge-tailed Shearwater chick.

DISCUSSION

The utilisation and successful breeding by Gould's Petrel in the Broughton Island nest boxes demonstrated the success of the sound attraction system in conjunction with provision of artificial nesting habitat. From 30 nest box inspections over five breeding seasons, several facets of Gould's Petrel breeding behaviour on Broughton Island became apparent. These are discussed below. Some of the interpretations are tentative, some support the findings from previous studies, and some appear to be new findings.

Partner fidelity

Gould's Petrel is known to be monogamous (Marchant & Higgins 1990; Department of Environment and Conservation NSW 2006). At two of the Broughton Island nest boxes there were clear demonstrations of partner fidelity. The same pair was recorded in nest box 5 in all five seasons, and they raised three chicks over that period. There was a one-off record of another bird at that nest box: perhaps it was an exploratory visit by that bird. The date of that visit was early in the 2020/21 breeding season; the original pair bred successfully later in that same season. In nest box 2, the same pair was recorded in three seasons (spanning 2020-2023) and they raised two chicks during that time. There were no records of any other adult Gould's Petrel at nest box 2 in the five-year study.

Two other nest boxes yielded chicks which fledged, which therefore meant that breeding pairs were using them. However, the infrequency of nest box inspections limited our opportunities to obtain additional information about partner fidelity.

Nest box fidelity

No Gould's Petrel was ever found in a nest box other than the one in which it was first recorded. That seems an unsurprising finding in the cases where there was an established pair breeding or attempting to breed at a particular nest box, such as nest boxes 2 and 5. It was a more surprising result for the other nest boxes although of course some birds might have prospected in other boxes during times when we were not present on the island.

Mostly those other nest boxes only had one-off records for any individual bird, but the situations at nest boxes 1 and 4 were more complex.

At nest box 1, a Gould's Petrel was present in 2020/21 and was partnered with another bird (presumably the unbanded bird present with it during two nest box inspections in December/January) because an egg eventually appeared. The following season two different birds used that nest box. They were found together in three nest box inspections that season, thus presumably were a pair although there was no evidence of breeding. One of the birds which had been present in 2020/21 reappeared two seasons later. For the intervening season what is unknown is whether: it attempted to use nest box 1 and was driven off by the pair which had taken over; it investigated other nest boxes (because of the competing pair in nest box 1); or it did not return to Broughton Island that season.

At nest box 4, one particular Gould's Petrel was recorded in every breeding season except the first one (2018/19). It was part of a breeding pair, since it was recorded with an egg in the 2020/21 season. It is not known if the bird's partner was one of the four other Gould's Petrel found alive in that nest box at some time during our 5-year study.

We could not find any previous report about Gould's Petrel using the exact same nesting cavity although they undoubtedly return to the same general breeding site each season (O'Dwyer 2004; Priddel & Carlile 2007; Kim 2014). Breeding site fidelity is well-documented in many seabird species (e.g. Mariné & Cadiou 2019; Pagenaud *et al*. 2022).

Incubation and fledging

There was clear evidence that both birds of a pair share the egg-incubation duties. That agrees with the findings of other studies (Marchant & Higgins 1990; O'Dwyer 2004).

Because the nest box inspections were relatively infrequent, details about the timetable for Gould's Petrel incubation and fledging on Broughton Island are somewhat uncertain. The earliest egg found was on 27 November (in nest box 5 in 2020). Nine days later, on 6 December, a second egg had appeared, in nest box 2. In other seasons, the early summer inspections fell within the period 16-18 December; there never were any eggs laid subsequent to those visits. Thus, the egg-laying period was late November to mid-December, which agrees with the timing at other breeding locations (Fullagar 1976).

In the late December inspections that occurred each year during 2019-2021, birds were still incubating eggs – there were no chicks at that stage. Also, on 2 January 2020, the sole egg that had been laid that season was still being incubated. In 2022, all three eggs had hatched by 20 January, while in 2021, two eggs had hatched by 30 January and one egg was still being incubated. However, several weeks later that egg was found cold in the nest box and thus it may not have been viable in the 30 January visit. Thus, all the hatchings seemed to be completed by about mid-January. That suggests an incubation period of about six weeks, broadly in line with previous findings (Marchant & Higgins 1990).

The dates for when chicks fledged are uncertain. In all the mid-March nest box inspections over the five seasons, every known chick was still present. On 20 April 2020, the sole chick that season had gone – it had been present when last checked on 9 March. In 2023, the two chicks from that season were still present on 17 March. By 16 April, one of those chicks had fledged. The other chick was still present, but it was in almost fully developed adult plumage and probably would have departed the nest box 1-2 days later. Thus, the fledging period on Broughton Island seems to have been between mid-March and mid-April, which again is broadly in line with other studies (Fullagar 1976; Marchant & Higgins 1990).

Breeding success and the fate of chicks

Ten eggs in total were laid in the Broughton Island nest boxes during the study period, with eight chicks hatching. In nest box 1 in December 2020, two birds were together in the nest box plus there was a cold

egg. This suggests that the pair was inexperienced and had mistimed their incubation shifts, leading to the egg having been left unincubated for too long. The reason for the hatching failure in nest box 4 is unclear. However, the female's partner may have been inexperienced, since the circumstantial evidence (i.e., there only being one-off records of any other bird) suggests that they had not been paired for long.

All eight chicks which hatched eventually fledged. The 100% fledging success rate for chicks and the overall 80% breeding success rate are much higher than has been found in studies on Cabbage Tree Island, where the main Gould's Petrel breeding colony is located (for example, Priddel *et al*. 1995; Priddel & Carlile 2007). The higher success rates on Broughton Island possibly reflect the absence of predators such as Pied Currawong *Strepera graculina* and the greater protection of eggs and chicks from unfavourable weather conditions provided by the artificial nest boxes. Importantly though, this result is from only a small sample size.

None of the chicks fledged from the nest boxes have yet been recorded returning to Broughton Island. Gould's Petrel are thought to begin breeding at around twelve years of age, and to start returning to their natal grounds from around five years old to begin to establish pair-bonds (Priddel & Carlile 2007). However, data on age of first breeding are limited (Department of Environment and Conservation NSW 2006). Continued monitoring will determine whether the former chicks start visiting the island, and any data on age of first return and first breeding will add to knowledge of the species' biology.

Nest prospecting by non-breeders

We found 16 different adult Gould's Petrel in nest boxes over the five-year study, ten of which were one-off records. The ten birds with one-off records possibly were exploring for nesting opportunities but had not yet found a partner. The actual duration of these one-off visits is uncertain, because the nest box inspections usually were well-spaced in time.

Sometimes in those seasons we found a prospecting bird in one of the nest boxes that was already being used by an established pair. A Gould's Petrel exploring for nesting opportunities might have been chased off from a particular nest box the pair of "owners". We found no evidence that those prospecting birds explored any of the other nest boxes. However, our inspections were infrequent.

We inspected the nest boxes 30 times across five breeding seasons, which equates to about three per cent of the available dates (five seasons each of 212-213 days for October-April inclusive). It is therefore very likely that additional individuals would have visited the nest boxes for short periods, with their presence going unrecorded.

Natal origins of adult birds

None of the adult birds found in Broughton Island nest boxes were already banded when they were first encountered. Thus, their natal origins are uncertain. It seems probable that they were born on Cabbage Tree Island, which in many years hosts up to 1,000 breeding pairs (Commonwealth of Australia 2023). The next largest breeding colony is on Boondelbah Island, which is estimated to host 70 or so individuals (Commonwealth of Australia 2023) - about 35 pairs.

Each breeding season, bands are placed onto some Cabbage Tree Island Gould's Petrel chicks, but only to a small proportion of the overall cohort (T. Clarke pers. obs.). Thus, there is only a low probability of encountering a banded Cabbage Tree Island bird on Broughton Island.

Nest boxes approaching capacity

Within the first three seasons, some nest boxes had established pairs or possible pairs using them, but in every breeding season there were unoccupied nest boxes available for use by other birds. For example, there were no records of a Gould's Petrel in nest box 1 in the 2018/19 or 2019/20 seasons. Similarly, there were no records from nest box 6 until 2021/22, and none from nest box 3 until the 2022/23 breeding season.

Perhaps during the first three breeding seasons, only a few Gould's Petrel had identified that there were potential breeding sites on Broughton Island. In each of those three seasons, we only found totals of four different individuals in nest boxes. However, in the following two seasons, the numbers of visiting birds increased. We recorded 7-8 individuals in nest boxes each season and those totals did not include any birds from the breeding pairs in nest boxes 3 and 6. In both cases, we never encountered an adult bird during our inspections, only chicks which later fledged.

The results suggest that the nest boxes were nearing capacity by the end of the fifth breeding season. Four nest boxes had hosted successfully-breeding

pairs, while nest boxes 1 and 4 had each contained an egg that did not hatch.

Competition with Wedge-tailed Shearwater

The Gould's Petrel chick in nest box 6 in 2021/22 was at the end of a burrow excavated ~30cm beyond the cavity underneath the floor of the nest box. An important consideration is how that burrow was formed.

Although the New Caledonian subspecies *caledonica* is known to dig burrows, the Australian subspecies *leucoptera* usually does not (Marchant & Higgins 1990). Therefore, it seems unlikely that an Australian Gould's Petrel would have excavated a burrow ~30cm in length.

The Wedge-tailed Shearwater is a burrow-digging species (Marchant & Higgins 1990). Over the study period, there were an increasing number of Wedge-tailed Shearwater burrows in the area around the nest boxes, in line with the overall increase in their population on the island (Carlile *et al*. 2022). Trail cameras were deployed occasionally in the area around the nest boxes – these captured many overnight comings and goings by shearwaters. It seems likely that, during their explorations to find sites for burrows, shearwaters would inspect the tunnels of the nest boxes. The tunnel at nest box 6 lacked a 100 mm/85 mm diameter reducer and a Wedge-tailed Shearwater would have been able to pass all the way through into the nest box.

A plausible scenario is that a shearwater excavated the new burrow at the beginning of the 2020/21 breeding season but for some reason did not breed there that season or the following one. That allowed the opportunity for a pair of Gould's Petrels to use the box in 2021/22, and they successfully raised a chick. However, they could not compete with the larger Wedge-tailed Shearwater pair which used the burrow in 2022/23 and thus they were not able to breed.

The intention is to install a 100mm/85mm diameter reducer into the entrance burrow before the start of the 2023/24 breeding season to prevent access by shearwaters.

CONCLUSIONS

The small number of nest boxes on Broughton Island has enabled a close study of their utilisation by Gould's Petrel. Given that the nest boxes can easily be accessed and monitored, and likely contain most if not all of the breeding activity on the island, this has given us a valuable insight into the early stages of Gould's Petrel colony establishment. This has not been possible in other newly establishing populations such as on Boondelbah and Montague islands, which are less frequently monitored and have more-dispersed nesting site locations.

The importance of the artificial nest boxes on Broughton Island for Gould's Petrel is highlighted by the fact that no breeding in natural nesting sites has been recorded on the island since the first record in 2009.

The five-year study confirmed many of the findings about breeding biology from previous studies. Breeding success rates were much higher than found in other studies, including 100% of the chicks which hatched, eventually fledged.

All six nest boxes were active in at least one breeding season i.e., they were visited by adult birds even if those birds did not breed. Four of the nest boxes were productive i.e., they yielded at least one fledged chick during the five-year study. For all six nest boxes there was at least one season with some breeding activity recorded.

Based upon the frequency of nest box visitation and use for breeding, and the high breeding success rate for pairs utilising the boxes, the installation of additional artificial nest boxes on Broughton Island should be considered. Additionally, because of the high breeding success rate in the artificial nest boxes, their use should be considered for Little Broughton Island, where currently none have been deployed.

ACKNOWLEDGEMENTS

Funding for the nest box installation on Broughton Island came from the general public – the supporters of the many teams competing in the BirdLife Australia 2016 NSW Twitchathon. Nest box design and installation was overseen by Nicholas Carlile. Some of the records used for this report came from additional inspections of the nest boxes by Emily Mowat and Simon Gorta. Greg Little, Rob Kyte, Emily Mowat and Mattea Taylor banded some of the birds. Emily Mowat reviewed the draft manuscript and made many helpful suggestions and comments. The Hunter Coast branch of NSW National Parks and Wildlife Service (NPWS) covered the costs associated with our visits to Broughton Island. There was close collaboration between NPWS and HBOC throughout the project.

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Site fidelity of Far Eastern Curlew in Port Stephens estuary

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Received 4 October 2023, accepted 12 October 2023, published online 30 October 2023.

INTRODUCTION

This note details the presence of a banded and flagged Far Eastern Curlew *Numenius madagascariensis* during three consecutive non-breeding seasons within the Swan Bay region of Port Stephens estuary. Such sightings show that this individual is demonstrating estuary-level site fidelity upon returning to Australia after its southward migration from the northern hemisphere.

Port Stephens estuary is an elongate east-west waterway located at the mouth of the Karuah River, approximately 30km NNE of Newcastle in New South Wales, Australia (see **Figure 1**). The study site is located at the western end of the estuary (see **Figure 2**).

METHODS

A female Far Eastern Curlew *Numenius madagascariensis* was caught during evening shorebird mist netting activities at Gir-Um-Bit National Park, Swan Bay (32.706509ºS, 151.971343ºE), on 16 January 2022. Based on plumage, it was aged as a first-year bird. This capture was part of a larger research program investigating the movement and foraging behaviour of shorebirds in the Hunter Region. The bird was fitted with a metal band on the left leg and two engraved and coloured leg flags bearing the code 'AAA' on the right leg – an orange leg flag on the tibia and a green one on the tarsus (**Figure 3**) and then released unharmed. This study was carried out under Australian Bird and Bat Banding Scheme (ABBBS) Project 851601, Banding Authority 3289, and NSW Scientific Licences SL102458 and SL101909.

Figure 1: Port Stephens estuary showing Swan Bay study area (Google Maps 2023)

Subsequent detections of the flagged bird in Port Stephens were through incidental re-sightings made using spotting telescopes. Only positive readings of the 'AAA' leg flag engraving were used for this report.

Figure 2: Study area showing location of initial capture (red), foraging (blue), and roosting re-sightings (yellow) (Six Maps 2023).

Figure 3: Metal band and engraved colour flags fitted to the legs of the Far Eastern Curlew (L. Williams 2022).

RESULTS

Since banding, Far Eastern Curlew individual 'AAA' has been detected within the Swan Bay area on four separate occasions during both high tide and low tide over three consecutive non-breeding seasons: 2021-22, 2022-23 and 2023-24 (see **Table 1** and **Figure 2**). No sightings were recorded during the austral winter months even though the site was visited at least once every month. During high tide 'AAA' was observed roosting as part of a larger flock of Far Eastern Curlew, while during low tide she was observed foraging alone.

DISCUSSION

Records of the presence of Far Eastern Curlew individual 'AAA' in the same area of Port Stephens for three consecutive non-breeding seasons demonstrates inter-year site fidelity. This individual is probably returning to the Swan Bay region because this site affords the bird high quality and predictable roosting and foraging areas.

Inter-year site faithfulness has been frequently documented in migratory shorebird species both at their breeding sites (for example, Antonov 2010; Ruthrauff *et al*. 2021; Sandercock & Gratto-Trevor 2022) and their migration stop-over sites (for example, Buchanan *et al*. 2012; Taylor & Bishop 2008). Few published studies, however, have reported site fidelity between years in migratory shorebirds within Australia. Coleman & Milton (2012) observed Bar-tailed Godwit *Limosa lapponica* and Grey-tailed Tattler *Tringa brevipes* returning annually to Moreton Bay, Queensland, based on flagging studies, while Ross *et al.* (2023) recorded inter-annual site fidelity rates of between 84.1% and 98.2% for recaptured banded and flagged adult Curlew Sandpiper *Calidris ferruginea* and Red-necked Stint *Calidris ruficollis* at Melbourne Water Western Treatment Plant (Werribee) and Yallock Creek in Victoria over a 40-year period.

Likewise, there are few published reports on migratory shorebird site fidelity in the Hunter Region. Crawford & Herbert (2013) discussed observations of flagged Bar-tailed Godwit returning to the Hunter Estuary for successive austral summers, and other individuals using the estuary as an inter-annual stop-over during their southward passage to New Zealand or Victoria. Similarly, small numbers of flagged Red Knot *Calidris canutus* have been observed to stop-over at Stockton Sandspit and Kooragang Dykes during

consecutive southward migrations (Crawford & Herbert 2017). The use of geolocators on Ruddy Turnstone *Arenaria interpres* confirmed migration stop-over site fidelity in successive years at Newcastle Beach (Gosbell *et al*. 2018). Double-banded Plover *Charadrius bicinctus* are reported to have high site fidelity on wintering grounds in the Hunter Region, including in the Hunter Estuary (historically), Port Stephens, Manning Estuary and at Worimi Conservation Lands (Lindsey & Fraser 2022).

Regarding the Far Eastern Curlew, a report by the Threatened Species Recovery Hub outlines that this species shows high inter-annual site fidelity based on GPS and satellite tracking of 22 individuals captured across sites in the Northern Territory, Western Australia, Queensland and Victoria (NESP Threatened Species Recovery Hub 2021). We found no prior published evidence that Far Eastern Curlew return repeatedly to the same overwintering estuary within New South Wales. To our knowledge, this is therefore the first published evidence of this trait in Far Eastern Curlew of New South Wales estuaries.

The use of the same non-breeding site each year highlights the importance of the Swan Bay area as a critical roost and foraging site for Far Eastern Curlew. This finding reinforces the need for ongoing protection and management of this site, especially given the Far Eastern Curlew's federal listing as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment 2023).

Table 1. Sightings of Far Eastern Curlew 'AAA' within Port Stephens estuary.

Date	Location	Coordinates	Notes	Observer
16 Jan 2022	Gir-Um-Bit National Park	32.706509ºS, 151.971343ºE	Caught in mist net. Banded and flagged	HBOC and University of Newcastle bird banding team
05 Feb 2022	Gir-Um-Bit National Park	32.706509ºS, 151.971343ºE	Roosting in saltmarsh	T. Clarke
08 Oct 2022	Gir-Um-Bit National Park	32.705622ºS, 151.969706ºE	Roosting in saltmarsh	N. Fraser
05 Jan 2023	Swan Bay	32.696333ºS, 151.978957ºE	Foraging	L. Williams
18 Sept 2023	Gir-Um-Bit National Park	32.709224ºS, 151.970743ºE	Roosting in saltmarsh	G. Little

ACKNOWLEDGEMENTS

We acknowledge the banders who assisted in the initial capture and the HBOC members involved in monthly surveys for re-sighting data. Funding for shorebird mist netting and flagging equipment was provided by a Hunter Local Land Services Grant and two NSW Department of Planning and Environment Saving Our Species Program Grants. This financial assistance is greatly appreciated. We thank the NSW National Parks and Wildlife Service for granting permission to capture and survey shorebirds on their estate. We also acknowledge the traditional owners of the land, the Worimi People, on which this study took place.

AUTHOR CONTRIBUTIONS

LAW and JL wrote the manuscript; JL and GL led the catching efforts; ASG contributed to the draft; all other authors contributed to the catching and survey efforts and are listed in alphabetical order.

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Two years of bird surveys at Bootawa Dam, Bootawa, New South Wales

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Received 8 October 2023, accepted 15 October 2023, published online 30 October 2023.

Eleven bird surveys were undertaken at Bootawa Dam, Bootawa, New South Wales (NSW), spanning two years between September 2020 and July 2022. A total of 103 species were recorded during the surveys, with an additional seven species during other visits. A total of five species were recorded breeding during the surveys.

Of the 110 species recorded, only one, White-bellied Sea-Eagle *Haliaeetus leucogaster* is listed as vulnerable in NSW. However, Glossy Black-Cockatoo *Calyptorhynchus lathami*, which is also listed as vulnerable within NSW, has also been observed on the site.

With 153 ha of the 220-ha site covered with a mix of mature and maturing native vegetation, the site provides habitat for resident avian and small to medium sized mammal species, and refuge for migrating species throughout the broader landscape within the surrounding, predominantly, cleared grazing landscape.

INTRODUCTION

Habitat loss for agriculture is a major threat to biodiversity, not only in Australia (Dorrough *et al*. 2007; Brady *et al*. 2009) but globally (Attwood *et al*. 2008; Henle *et al*. 2008; Hendrickx *et al*. 2007). Although these papers primarily discuss the impacts on arthropods, they form the lower levels of the food chain and thus directly impact many avifaunal species. Therefore, preserving and enhancing native vegetation within a cleared or semi-cleared landscape is encouraged.

Located approximately 8 km west of Taree, on the lower mid-north coast of New South Wales (NSW), is Bootawa Dam (31.92ºS, 152.38ºE), the major water supply for the larger urban centres of Wingham, Taree, Tuncurry and Forster and many smaller surrounding villages (**Figure 1**). Construction of the dam wall commenced in the early 1960s with completion of the wall and associated infrastructure in 1967. The water treatment plant was rebuilt and commissioned in 2010 to accommodate more modern standards of water filtration and treatment and increased capacity to service a growing population. Water for the dam is pumped from the nearby Manning River and is not reliant on catchment runoff.

When acquired for water storage purposes in 1965, the original parcel of land comprised 121 ha. Boundaries of this parcel included most of the valley ridgeline, upstream of the dam wall, except for a small section to the east. Bordering the northern boundary, an additional parcel of land, 94 ha in size, was acquired in 1973. In 2013, 5 ha of land was purchased from the neighbours to incorporate the short eastern ridgeline section. The total site now covers 220 ha, of which the dam footprint is approximately 23 ha.

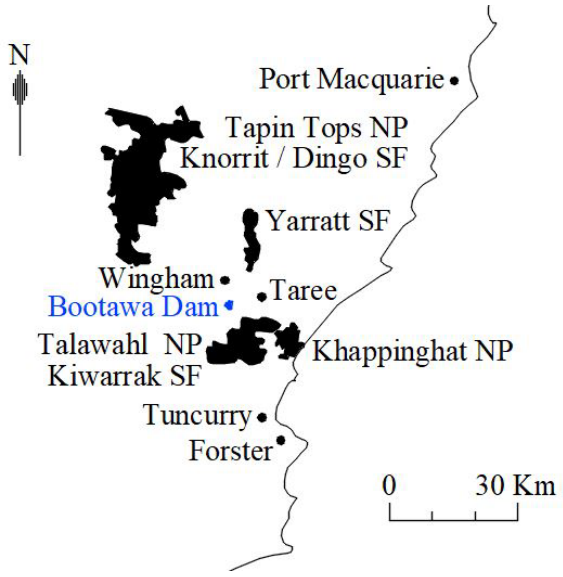

Figure 1. Locality sketch

The nearest Bureau of Meteorology (BOM) recording station (No. 060030) is located in Taree, approximately 10 km east-north-east of Bootawa

Dam. Average rainfall for the area is 1182 mm (1881 to 2022) from an average of 90 rain days per year. The mean January maximum temperature is 29.0˚, while the mean July minimum temperature is 5.9˚ (1907 to 2005) (Bureau of Meteorology). However, the survey period covered some of the driest and wettest periods in the region. Many surrounding areas were still recovering from the dry of 2019 and the devastating fires in the later parts of 2019 and into early 2020. This was followed by significant rainfall in late 2020 and early 2021 with a resultant flood in March 2021. Significant rainfall was received again at the end of 2021 and into early 2022. While no direct impact could be measured on avian records or recording rates from these extreme climatic conditions, they did impact access to the site to undertake the surveys, on numerous occasions (also see Methods).

Site Description

Similar to much of the current surrounding landscape, the original site was predominantly cleared grazing pasture with remnant trees, many of which are over 80 years old (C. Stone pers. comm.). While much of the ground immediately surrounding the dam was routinely slashed, the northern parcel was allowed to regenerate with naturally occurring floral species. Additionally, where slashing was more difficult in small wet gullies and areas with steeper grades, other pockets of native vegetation also flourished.

Vegetation on the northern parcel and in other pockets is a mix of wet and dry sclerophyll forest, open forest with grassy understorey and dry rainforest. The canopy includes Pink Bloodwood *Corymbia intermedia*, White Mahogany *Eucalyptus acmenoides*, Thick-leaved Mahogany *E. carnea*, Tallowwood *E. microcorys*, Grey Ironbark *E. paniculata*, Small-fruited Grey Gum *E. propinqua*, Brush Box *Lophostemon confertus* and Turpentine *Syncarpia glomulifera*. The sparse mid-stratum is layered, consisting of a mix of Forest Oak *Allocasuarina torulosa* and acacia species while the ground layer is mid-dense comprising graminoids, forbs and twiners (Trees Near Me NSW 2023).

In 2008, many of the areas previously slashed were planted out with a select range of forestry tree species for the purpose of obtaining carbon credits (**Figure 2**). The forestry mix consisted of *Corymbia variegata*, Blue-leaved Stringybark *Eucalyptus agglomerata*, Blackbutt *E. pilularis*, Grey Gum *E. punctata*. Management of these plantation areas included periodic slashing between the rows of and individual trees. In more recent years, only basic slashing between the rows has continued, which has allowed native floral species to infill between the individual trees and start to form an understorey. Recently, several small sections of trees have been removed to allow plantings of more Koala *Phascolarctos cinereus*-friendly species to occur.

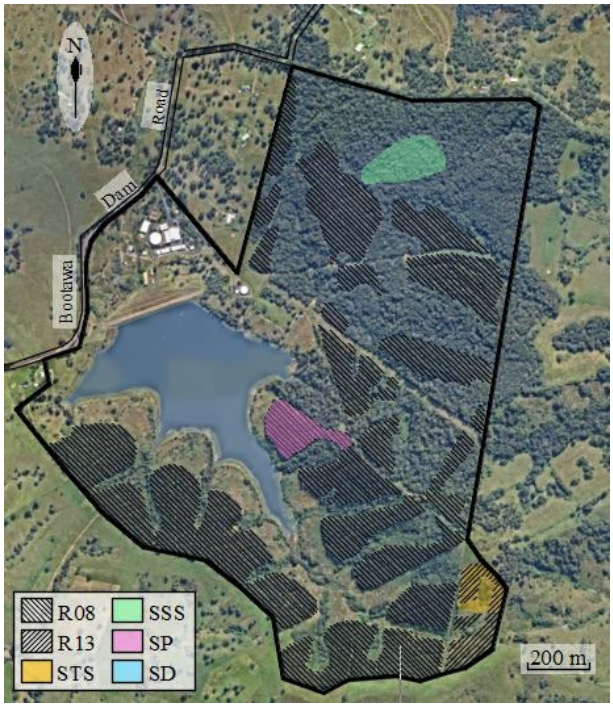

Figure 2. Map of Bootawa Dam showing revegetation and survey areas. R08 = areas revegetated in 2008; R13 = area revegetated in 2013; STS = Trig Station survey area; SSS = Sclerophyll Slope survey area; SP = Plantation survey area; and SD = Dam survey area. Refer to Site Description and Methods for more details.

Following the purchase of the eastern parcel in 2013, most of the area was revegetated with a mix of endemic species for habitat (**Figure 2**). Species comprised Native Quince *Alectryon subcinereus*, Rose Myrtle *Archirhodomyrtus beckleri*, Pink Bloodwood, Jackwood *Cryptocarya glaucescens*, Blueberry Ash *Elaeocarpus obovatus*, Flooded Gum *Eucalyptus grandis*, Tallowwood, Small-fruited Grey Gum, Forest Red Gum *E. tereticornis*, Sandpaper Fig *Ficus coronata*, Cheese Tree *Glochidion ferdinandii*, Brush Box, White Cedar *Melia azedarach*, Plum Pine *Podocarpus elatus*, Turpentine and Red Cedar *Toona ciliata*.

The combined area of mature and maturing vegetation totals approximately 153 ha. Covering 78% of the site, excluding the dam footprint, habitat within the Bootawa Dam site is sufficient in size to accommodate resident avian and small to medium sized mammal species and provides a refuge for transient or migrating species. Within the broader landscape, Bootawa Dam is centred between

Talawahl and Khappinghat National Parks and Kiwarrak State Forest to the south and south-east, Yarratt State Forest to the north-east and Tapin Tops National Park and Knorrit and Dingo State Forests to the north-west (**Figure 1**).

METHODS

Initially, surveys were to be undertaken every second month commencing in September 2020 and targeting a date in the middle of each survey month. Unfortunately, extreme climatic conditions (see introduction above) impacted the timing of surveys being completed, with one survey cancelled (March 2022) and another one (March 2021) set back by three weeks due to tracks being too wet to traverse.

The dam site was entered within one hour of sunrise. Four survey areas, Trig Station, Sclerophyll Slope, Plantation and the Dam (see descriptions below; **Figure 2**), were surveyed in the same order each visit. Birds were also recorded generally within the site between survey areas. Birds utilising a specific survey area were recorded within the survey area. Birds observed flying over the survey area were excluded from the specific survey area but included in the general survey area. Counts for species recorded are an estimate of individuals seen within each area or the general area. Observations of birds on the dam were made from several different locations with total numbers of birds averaged between all the locations.

Records from individual survey areas were entered into the BirdLife Australia atlas (Birdata; https://birdata.birdlife.org.au/) as either a 500-m area search (Sclerophyll Slope, Dam) or a 2-ha, 20-min search (Trig Station, Planation).

Trig Station (31.9267ºS, 152.3850ºE) is located at the eastern end of the site, within the parcel that was purchased and revegetated in 2013, and contains the most recent revegetation works on the site. At the commencement of surveys, trees were approximately three metres high with an understorey of Blady Grass *Imperata cylindrica*, Bracken Fern *Pteridium esculentum* and Kikuyu *Pennisetum clandestinum*. A small, steep gully contained several large, > 15 m high, remnant trees. This survey area was considered a '20-minute 2-ha' site.

Sclerophyll Slope (31.9140ºS, 152.3820ºE) is located within the northern parcel acquired in 1973. Vegetation within this area was the most mature of the survey areas, with developed canopy, mid-stratum and ground layers. This survey area was considered a 'within 500-m' site.

Plantation (31.9219ºS, 152.3784ºE) is one of the many areas revegetated fifteen years ago with forestry species. There has been active slashing between the rows over the years and pruning of lower branches of the forestry trees during the early years. This particular patch is located between a small, vegetated gully and an older native forest remnant. This survey area was considered a '20-minute 2-ha' site.

Dam (31.9200ºS, 152.3749ºE) consisted of the large, open water body of the dam proper and includes the emergent macrophyte vegetation around the edge. Water levels varied during the course of the total survey period but were not recorded. This survey area was considered a 'within 500-m' site.

Breeding records were based on the following criteria: active visible nest, feeding of a dependent juvenile or observing a recently fledged juvenile.

Total species and individuals in the Trig Station and Plantation survey areas were statistically tested using the Yates-corrected Chi-square test (Fowler & Cohen 1994). For one degree of freedom, Chi-square results between 3.84 and 6.62 are considered to be 'Significant', while over 6.63 the result is 'Highly Significant'.

A fauna survey was undertaken at Bootawa Dam between 11 and 15 October 2020, by Midcoast Council. This survey included the placement of two sound recording devices (Wildlife Acoustics Song Meter SM4). Recordings were made between 1930h and 2230h in the evening and then again from 0300h to 0600h in the morning. These recordings were analysed for avian calls and included as additional species.

RESULTS

From all surveys, 103 species of birds were recorded, with an additional seven species recorded during other visits (refer **Appendix**: available at https://www.hboc.org.au/wp-content/uploads/Bootawa-surveys-Appendix-The-Whistler-Vol-17.pdf). Of this total, only one species, White-bellied Sea-Eagle *Haliaeetus leucogaster*, is listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act), with no species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. However, an additional species, the Glossy Black-Cockatoo *Calyptorhynchus lathami*, which is listed as vulnerable under the BC Act, has been observed regularly onsite by staff (C. Stone pers. comm.). The average number of species recorded during the 11 visits was 46 (32-58; **Table 1**) with the average number of individuals recorded being 216 (133-369; **Table 1**).

Table 1. Summary of birds recorded during surveys at Bootawa Dam, Bootawa.

Year	Month	Species	Individuals
2020	12 September	48	142
	22 November	58	217
2021	24 January	52	270
	11 April	46	303
	29 May	37	133
	11 July	32	168
	19 September	54	201
	14 November	53	171
2022	16 January	49	166
	25 May	35	232
	31 July	46	369
Total Average		46	216

Table 2. Summary of birds recorded in individual areas during surveys at Bootawa Dam, Bootawa. Refer to Methods for descriptions of individual survey areas. Sp - species recorded; Ind - individuals recorded.

Year	Month	Trig Station		Sclerophyll Slope		Plantation		Dam		General	
		Sp	Ind	Sp	Ind	Sp	Ind	Sp	Ind	Sp	Ind
2020	12 September	7	11	17	39	9	20	7	38	26	44
	22 November	8	22	20	37	2	2	10	95	36	69
2021	24 January	9	23	12	20	7	12	7	107	39	106
	11 April	7	9	9	12	5	6	11	204	29	75
	29 May	1	2	11	18	2	2	6	56	24	55
	11 July	4	10	11	18	6	8	6	97	19	35
	19 September	14	24	14	30	6	8	8	47	36	92
	14 November	8	12	18	30	5	7	8	44	37	78
2022	16 January	12	19	15	22	8	13	5	23	34	88
	25 May	5	14	5	5	5	9	9	162	19	42
	31 July	4	11	10	18	10	20	11	254	28	66
Total Average		7	14	12	21	6	10	8	102	30	68

Table 3. Species recorded in 70% or more of surveys at Bootawa Dam, Bootawa.

Species	RR %	Species	RR %
Hardhead	100	Noisy Miner	73
Pacific Black Duck	82	Yellow Thornbill	91
Great Crested Grebe	100	Golden Whistler	100
Wonga Pigeon	73	Grey Shrike-thrush	100
Purple Swamphen	91	Eastern Whipbird	91
Eurasian Coot	73	Black-faced Cuckoo-shrike	82
Little Pied Cormorant	91	Australian Magpie	100
Little Black Cormorant	91	Pied Butcherbird	73
Laughing Kookaburra	91	Grey Fantail	100
Eastern Rosella	82	Torresian Crow	100
Rainbow Lorikeet	100	Eastern Yellow Robin	91
White-throated Treecreeper	100	Welcome Swallow	73
Lewin's Honeyeater	100	Silvereye	82
Yellow-faced Honeyeater	100	Red-browed Finch	73

Table 4. Species recorded across all terrestrial survey sites during surveys at Bootawa Dam, Bootawa. Refer to Methods for descriptions of individual survey areas.

Species	Trig Station		Sclerophyll Slope		Plantation	
	Average	Min-Max	Average	Min-Max	Average	Min-Max
Laughing Kookaburra	2	1-2	2	1-2	1	1-1
White-throated Treecreeper	2	2-2	1	1-2	1	1-1
Scarlet Honeyeater	2	1-2	4	3-5	2	1-3
Eastern Spinebill	1	1-1	2	1-2	1	1-1
Lewin's Honeyeater	1	1-1	2	1-3	1	1-3
Yellow-faced Honeyeater	2	1-3	2	1-3	2	1-4
Spotted Pardalote	2	2-2	2	1-2	2	1-2
Yellow Thornbill	5	5-5	3	2-4	3	2-4
Brown Thornbill	2	1-3	2	1-2	2	2-2
Golden Whistler	2	1-2	2	1-5	1	1-3
Grey Fantail	1	1-2	2	1-3	2	1-2
Eastern Yellow Robin	1	1-1	1	1-2	1	1-1
Silvereye	3	1-5	2	2-4	2	2-3
Red-browed Finch	2	2-2	2	2-3	2	2-2

Numbers of species and individual numbers recorded within each survey area, and generally, are shown in **Table 2**.

Of the 28 species recorded on 70% or more surveys and considered to be resident, ten were recorded in all surveys (**Table 3**). Twenty species were recorded in a single survey only. Five species were recorded breeding during the surveys; Great Crested Grebe *Podiceps cristatus*, Fan-tailed Cuckoo *Cacomantis flabelliformis*, Masked Lapwing *Vanellus miles*, Large-billed Scrubwren *Sericornis magnirostra* and Golden Whistler *Pachycephala pectoralis*.

Fourteen species were recorded in all terrestrial survey areas (**Table 4**), however only ten of those species are considered resident (**Table 3**).

The Trig Station and Plantation survey areas are similar in size, each being approximately 2 ha. The Chi-square test produced a non-significant result ($x^2_1 = 0.91$) for total species recorded between the two areas ($n = 31$ and $n = 23$ respectively). However, a comparison of total individuals between the two respective areas (Trig Station $n = 152$; Plantation $n = 107$) was highly significant with $x^2_1 = 7.47$, $P < 0.01$. This result reflects the different avian density supported by the vegetation structure of the two sites. Planted and managed for forestry purposes in 2008, the Plantation area contains basically no under or mid-storey, with lateral tree branches removed, and a monoculture canopy at a consistent height of select eucalyptus species. Although only planted 5 years later in 2013, the lower portion of the canopy of the mixed species in the Trig Station area blended with the existing ground-layer. The upper canopy layer is uneven in height and the lateral branches of the tree species were allowed to develop, creating a broad vegetation matrix to support more foraging individuals.

DISCUSSION

The following paragraphs provide some commentary on the observations of the various orders / family groups of birds recorded during the individual surveys and generally. For a full list of species recorded during the surveys, generally and additionally, refer to the **Appendix**.

Brush-turkey and Quails (Galliformes): The only species recorded within this order was the Brown Quail *Synoicus ypsilophorus*. It was recorded by call only during the faunal survey. Being a cryptic species, its presence on the site is probably more common than indicated.

Ducks (Anseriformes): Moderately represented by five species with Hardhead *Aythya australis* recorded in all visits ($n = 11$) and Pacific Black Duck *Anas superciliosa* considered resident ($n = 9$) at the dam. Hardhead numbers averaged 18, but varied considerably (1-68).

Grebes (Podicepiformes): All three grebe species were recorded on the dam with Great Crested Grebe recorded in all surveys ($n = 11$) and breeding. Interestingly, Great Crested Grebe is considered resident within the Hunter area on large water bodies (Williams 2020), however Birdata considers the area outside the species' normal range. There

was an average of 18 individuals recorded across all the dam surveys ranging from 4 to 31. In January 2021, 16 juvenile birds of varying ages were accompanied by 15 adult birds. Numbers of Australasian Grebe *Tachybaptus novaehollandiae* also varied considerably (1-60) with a resultant average of 31 (n = 7).

Pigeons and Doves (Columbiformes): Moderately represented by six species, with Wonga Pigeon *Leucosarcia melanoleuca* the only species classed as resident (n = 8). The majority of these records were made when traversing along access tracks throughout the site.

Frogmouths and Swifts (Caprimulgiformes): Both Tawny Frogmouth *Podargus strigoides* and Owlet-nightjar *Aegotheles cristatus* were recorded by call, once and twice respectively, during site visits, however both species were regularly heard calling on the audio recordings during the fauna survey. With both species being nocturnal and cryptic, these species are more than likely breeding residents on the site.

Cuckoos (Cuculiformes): A well represented order with six species recorded moderately to infrequently during all site visits. Fan-tailed Cuckoo, the most commonly recorded cuckoo species (n = 7), was recorded breeding with a recently fledged individual being fed by a Large-billed Scrubwren.

Rails (Gruiformes): Both Purple Swamphen *Porphyrio porphyrio* and Eurasian Coot *Fulica atra* are considered resident on the site, recorded in ten and eight surveys respectively. Coots were only recorded on the main dam with an average of 43 (2-120) individuals during all visits. However, swamphens only utilised a small downstream sediment pond, with macrophytic growth dominated by cumbungi *Typha orientalis*, and grassed areas adjacent to the main treatment plant structure.

Herons, Egrets, Ibis and Cormorants (Pelecaniformes): Only five species were recorded within this diverse group of water dependent birds. Both Little Pied Cormorant *Microcarbo melanoleucos* and Little Black Cormorant *Phalacrocorax sulcirostris* were recorded in all but one of the dam surveys (n = 10). Although predominantly observed perched on the main dam pontoon structure, both species also utilised the dam for fishing. Wading species, such as Great Egret *Ardea alba* and White-faced Heron *Egretta novaehollandiae*, were only observed on a few (n = 2) to moderate (n = 4) occasions, respectively, foraging around the dam edge.

Waders, Plovers and Button-quails (Charadriiformes): Commensurate with the location and habitat for this diverse order of predominantly coastal type species, it was only represented by four species. Masked Lapwing was recorded moderately frequently (n = 7), but not sufficiently to be considered resident, and the observation of adults with two small runners confirmed breeding of the species. Painted Button-quail *Turnix varius* was recorded during one survey, however being cryptic and there being plenty of suitable habitat, it is more than likely a resident species.

Owls (Strigiformes): Within this order, only the Southern Boobook *Ninox boobook* was heard during the fauna survey recordings and could be considered resident on the site. However, the presence of suitable roosting and nesting habitat onsite and within the surrounding landscape that is predominantly cleared grazing, would also be suitable for use by Barn Owl *Tyto alba*.

Kites, Eagles and Goshawks (Accipitriformes): Of the four species recorded during the surveys, both White-bellied Sea-Eagle, which was observed on five occasions, and Wedge-tailed Eagle *Aquila audax*, recorded twice, utilise the dam for hunting. Wedge-tailed Eagle has been observed hunting Eurasian Coot off the water's surface (C. Stone pers. comm.).

Bee-eater, Dollarbird and Kingfishers (Coraciiformes): Only Laughing Kookaburra *Dacelo novaeguineae* is classed as resident (n = 10), of the four species observed within this order. An Azure Kingfisher *Ceyx azureus* was observed during our site induction tour, but was not sighted subsequently.

Falcons (Falconidae): Only a single Nankeen Kestrel *Falco cenchroides* was recorded on one occasion from this order, circling over the slashed grass downstream of the dam wall. Abundant grazing land surrounding the dam site would provide more suitable habitat for this species to hunt over.

Cockatoos, Parrots and Lorikeets (Psittaciformes): Only Eastern Rosella *Platycercus eximius* and Rainbow Lorikeet *Trichoglossus moluccanus* were recorded sufficiently to be considered resident (n = 9 and n = 11 respectively). Predominantly, both species were observed within the scattered trees, which include numerous large

bottlebrush *Callistemon sp*. shrubs, in the vicinity of the main building structure. Interestingly, Sulphur-crested Cockatoo *Cacatua galerita* was recorded during the evening fauna survey recordings only, suggesting individuals utilise the site for roosting, and possibly nesting, but had departed, to forage, prior to our arrival onsite to undertake surveys.

Passeriformes

Pittas (Pittidae): Noisy Pitta *Pitta versicolor*, the only pitta within the family to be found locally within the Hunter Region (Williams 2020), was heard calling numerous times throughout the recordings from the fauna survey. The many forested gullies on the site provide a substantial amount of suitable habitat for this ground-foraging species, which is more-than-likely, an annual winter migrant to the site.

Bowerbirds (Ptilonorhynchidae): Satin Bowerbird *Ptilonorhynchus violaceus*, the only species within this family to be found locally, was recorded in two surveys only. Both observations were in the scattered vegetation within the vicinity of the main building structure.

Treecreepers Climacteridae): White-throated Treecreeper *Cormobates leucophaea* was the only species observed within this family and was recorded in all visits (n = 11). Recorded most regularly in the 'Sclerophyll Slope' (n = 9) survey area, it was also recorded moderately frequently (n = 5) throughout the site generally and across all three terrestrial survey areas.

Fairy-wrens (Maluridae): Two of the four wren species observed, being Superb *Malurus cyaneus* and Red-backed Fairy-wrens *M. melanocephalus*, were recorded moderately frequently (n = 7 and n = 6 respectively) in small family groups averaging four and three respectively.

Honeyeaters (Meliphagidae): A well represented family with 10 species recorded during surveys. Both Lewin's Honeyeater *Meliphaga lewinii* and Yellow-faced Honeyeaters *Caligavis chrysops* were recorded in all survey visits (n = 11) and across all three terrestrial survey areas, with Noisy Miner *Manorina melanocephala* recorded sufficiently to meet residence status (n = 8). Lewin's Honeyeater was recorded in all 'Sclerophyll Slope' surveys while Yellow-faced Honeyeater was recorded in all 'Plantation' surveys.

Pardalotes (Pardalotidae): Both Spotted Pardalote *Pardalotus punctatus* and Striated Pardalote *P. striatus* were observed at moderate (n = 7) or low (n = 2) frequency respectively during the surveys. Spotted Pardalote was recorded across all three terrestrial survey areas and generally.

Gerygones, Scrubwrens and Thornbills (Acanthizidae): A reasonably well represented family with eight species recorded, including one, the Large-billed Scrubwren, breeding. Ironically, the only time the Large-billed was recorded was when it was observed feeding a recently fledged Fan-tailed Cuckoo. Yellow Thornbill *Acanthiza nana* was the only species classed as resident (n = 10) and although predominantly recorded in the 'Sclerophyll Slope' (n = 8) survey area, it was also recorded at low levels at both the 'Trig Station' (n = 1) and 'Plantation' (n = 3) survey areas and also moderately generally (n = 6). Similar to the Yellow Thornbill, but at lower rates, Brown Thornbill *A. pusilla* was recorded across the three terrestrial survey areas and generally.

Figbird and Orioles (Oriolidae): Both Australasian Figbird *Sphecotheres vieilloti* and Olive-backed Oriole *Oriolus sagittatus* were recorded generally in low numbers (n = 1 and n = 2 respectively).

Shrike-tit (Falcunculidae): Eastern Shrike-tit *Falcunculus frontatus* was recorded twice generally either singularly or as a pair.

Whistlers and Shrike-thrushes (Pachycephalidae): Both Golden Whistler and Grey Shrike-thrush *Colluricincla harmonica* were recorded in all survey visits (n = 11). Golden Whistler was recorded across all three terrestrial survey areas and generally, and was also observed breeding.

Whipbird (Psophodidae): The only locally endemic species within the family, Eastern Whipbird *Psophodes olivaceus* is classed as a resident (n = 10).

Cuckoo-shrikes and Trillers (Campephagidae): Of the two species observed within this family, Black-faced Cuckoo-shrike *Coracina novae-hollandiae* is classed as resident (n = 9) while Common Cicadabird *Edolisoma tenuirostris* was only recorded twice generally. On a separate occasion, a flock of more than 70 Black-faced Cuckoo-shrike was observed (C. Stone pers. comm.). It is presumed that this was an aggregation of migrating individuals (Higgins *et. al.* 2006).

Currawongs, Butcherbirds and Woodswallows (Artamidae): Two of the four species of this family, Australian Magpie *Gymnorhina tibicen* and Pied

Butcherbird *Cracticus nigrogularis*, were observed and are considered resident (n = 11 and n = 8 respectively) within the general site.

Fantails (Rhipiduridae): Of the three species observed, Grey Fantail *Rhipidura albiscapa* was recorded in all survey visits (n = 11) and across all three terrestrial survey areas and generally.

Flycatchers and Monarchs (Monarchidae): Magpie-lark *Grallina cyanoleuca* was only recorded moderately (n = 7), generally within the site. Considered a summer migrant to the region (Williams 2020), Leaden Flycatcher *Myiagra rubecula* was recorded on five occasions during spring and summer months and is more-than-likely a regular summer migrant to the site.

Crows and Ravens (Corvidae): Classed as a resident species, Torresian Crow *Corvus orru* was recorded in all site visits (n = 11).

Robins (Petroicidae): Within the robin family, only Eastern Yellow Robin *Eopsaltria australis* was recorded. Classed as resident (n = 10), it was recorded across all three terrestrial areas and generally.

Reed-Warblers (Acrocephalidae): The only species observed within this family, Australian Reed-Warbler *Acrocephalus australis* was recorded during a single survey only.

Songlarks and Grassbirds (Locustellidae): Mostly recorded within the Blady Grass understorey in the 'Trig Station' survey area (n = 5), the Tawny Grassbird *Cincloramphus timoriensis* was recorded at medium frequency (n = 6). As revegetation matures and shades out the Blady Grass, suitable habitat for this species will decline over time.

Martins and Swallows (Hirundinidae): Represented by two species only, Welcome Swallow *Hirundo neoxena* was recorded as a resident (n = 8) predominantly about the main building structure and maintained grass up to the dam wall. Tree Martins *Petrochelidon nigricans* were recorded moderately frequently (n = 6) about the main building structure and towards Bootawa Dam Road.

White-eyes (Zosteropidae): The Silvereye *Zosterops lateralis* was recorded at resident status (n = 9). Close inspection of the individual birds present during surveys was not undertaken to determine which sub-species occupied the site at various times of the year. It is more-than-likely that a transition of sub-species through the site occurred rather than a consistent resident year-round population being present.

Starlings and Myna (Sturnidae): Within this family, only a single Common Myna *Acridotheres tristis* was recorded during one survey only. Dominated by remnant and regenerating vegetation over much of the site, the habitat is less suitable for this species, which was observed in greater numbers within surrounding grazing areas.

Mistletoebird (Dicaeidae): The only locally occurring species of this two-species family, Mistletoebird *Dicaeum hirundinaceum* was recorded at low rates (n = 2) generally.

Finches (Estrildidae): Only a single finch species, Red-browed Finch *Neochmia temporalis*, was recorded and is considered a resident (n = 8). It was observed widely across most survey areas and generally, with an average of 5 (2-9) individuals.

Revegetation plantings have been shown to be productive for avian assemblages (Lindenmayer *et al.* 2012). While the statistical test resulted in no substantive difference between the Trig Station and Plantation survey areas for species, the highly statistical result confirmed field observations of low numbers of individuals utilising the area, predominantly traversing the Plantation between more mature habitats located either side of the area. With the altered plantation management currently practised onsite of slashing between rows only, and not between individual trees, development of a shrub layer between trees should enhance the plantation areas across the Bootawa Dam site.

CONCLUSIONS

The mix of vegetation types present across the Bootawa Dam site provides habitat for a good cross section of avian species. Continued proactive management of the forestry areas and maturing revegetation will provide an ideal island environment within the predominantly cleared grazing landscape over time. These surveys are considered baseline surveys, and further surveys would be encouraged periodically to monitor changes over time, particularly within the maturing revegetation areas.

ACKNOWLEDGEMENTS

Firstly, I would like to thank David Turner for accompanying me on each of the surveys. His visual and

auditory identifications increased the recording rates for the surveys whilst providing companionship during each outing. The Water Services division of MidCoast Council is thanked for approving access to the site to undertake the surveys. A big shout out goes to Craig Stone, one of the dam's staff, who not only gave us our site induction and provided a history of the site, but also received text messages in the early hours of Saturday or Sunday mornings when we checked into the site for our surveys. Acknowledgement is also made of *The Whistler* editors for suggested improvements.

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Appendix. List of bird species recorded during surveys at Bootawa Dam, Bootawa, NSW. This is available on-line at https://www.hboc.org.au/wp-content/uploads/Bootawa-surveys-Appendix-The-Whistler-Vol-17.pdf.

Fourth and fifth confirmed breeding records of Black-necked Stork in the Hunter Estuary near Newcastle, NSW

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Received 22 October 2023, accepted 26 October 2023, published online 30 October 2023.

A pair of Black-necked Stork *Ephippiorhynchus asiaticus* has now bred successfully in Hexham Swamp, New South Wales, in three successive years, 2020, 2021 and 2022. Six juveniles, two in each year, have fledged from three different nests all of which were located in the same general area of Hexham Swamp. Four of the juvenile birds were banded before they fledged but there have been no reported sightings of them subsequently. There were five sightings in early 2023 of unbanded juveniles, presumably those from the 2022 breeding event.

In view of the persistent breeding activity and the dearth of suitable nest trees, we recommend that investigations be made into the possibility of erecting artificial nest platforms in Hexham Swamp.

INTRODUCTION

The Black-necked Stork *Ephippiorhynchus asiaticus* is a large waterbird resident across the Indian sub-continent and south-east Asia. The sub-species *australis* occurs in Australia and Papua New Guinea. The breeding biology of this species is not well understood. It is classified as Endangered under the *NSW Biodiversity Conservation Act 2016;* hence it is important that information about its breeding behaviour is documented. It is known to breed as solitary pairs in often difficult-to-access places, making detailed breeding studies a challenge.

The first confirmed breeding record for Black-necked Stork in the Hunter Region was in 2017. The region is regarded as the southern limit of its the breeding range.

This note documents the fourth and fifth Black-necked Stork breeding events in the Hunter Estuary. The three previous breeding events in the estuary involved two events at Tomago on private land and one at Hexham Swamp. A pair bred successfully at Tomago in 2017 and 2018 using the same nest both times, and with one young bird fledging each year (Lindsey 2019b). In 2020 there were two chicks in a nest in Hexham Swamp, with both of those birds considered to have successfully fledged (Lindsey 2020).

The two new breeding events occurred in Hexham Swamp in 2021 and 2022. The swamp (see **Figure 1** for some key locations) covers almost 2000 ha and supports a range of wetland types including mangroves and saltmarsh (Local Land Services 2022). The dominant vegetation is Common Reed *Phragmites australis*. Other vegetation includes Cumbungi *Typha latifolia* and various *Casuarina* and *Melaleuca* species (Winning & Saintilan 2009).

Black-necked Stork usually choose a flat-topped tree on which to build their nest (Clancy & Ford 2011). The nest is substantial and can be one to two metres wide and one metre high. The same nest may be used year after year and each time it is reinforced with new branches (Clancy & Ford 2013). Few suitable trees are available in Hexham Swamp to support such a large nest platform.

METHODS

Some of the observations for this report were made using binoculars, telescopes or cameras at various locations around Hexham Swamp. The majority of such observations were from an observation point at Kau Ma Park, Fletcher (**Figure 1**).

Use of drones

Land access to the nest sites was difficult as it entailed walking in water for over one kilometre through tall, dense Cumbungi and Common Reed vegetation. From Kau Ma Park, it was difficult for observers to see into the

nest. Hence, drones were used to assist the monitoring program.

The main drone used, an Autel EVO II, was flown by trained pilots. The drone was never flown directly over the nest site. Each time that a drone was flown, an observer or observers at Kau Ma Park used telescopes to monitor for any signs of distress on the part of the storks, in which case the drone was to be withdrawn.

Additional details about the use of drones to observe breeding Black-necked Stork will be documented in a future article.

Banding the chicks

Black-necked Stork chicks were banded under a licence held by Dr Greg Clancy (banding authority 536). Once the chicks were considered old enough to be banded, two people walked to the nest tree, with an observer or observers at Kau Ma Park monitoring the behaviour of the storks. The observer/s and banding team were in radio communication at all times. Chicks were lowered one at a time to the ground in a cloth bag, banded, measured and photographed, and then returned to the nest.

OBSERVATIONS

The nest used by the Black-necked Stork pair in 2020 disintegrated prior to the 2021 season (AL pers. obs.). The branches on which the nest was resting (in a Narrow-leaved Paperbark *Melaleuca linariifolia*) were well spread out and there was little support underneath the nest platform. In the 2021 and 2022 breeding events, nests were constructed in other trees.

Figure 1. Some key landmarks in Hexham Swamp (map modified from an image sourced from Google Maps).

Breeding event in 2021

The 2021 nest (32º51'25" S, 151º39'39" E) again was straddled between trunks of a *Melaleuca linariifolia.* The nest was first discovered on 17 November, when one of us (AL) observed two well-developed young on the nest. As they were large and looked almost ready to fledge, we decided to band them as soon as possible. This took place on 19 November (**Figure 2**).

During a week of strong winds, heavy rain and storms from 21 to 27 November, the nest collapsed. Photographs taken using the drone on 1 and 2 December confirmed that the nest was on the ground but lying above water level. There was one young bird standing on the fallen nest (**Figure 3**); it was identified as the younger of the two birds banded on 19 November. There was no sign of the other young bird. On 8 December, R. Kyte and G. Little walked out to the nest site and successfully stabilised the trunks of the tree with ropes, then lifted the nest platform back onto the top of the tree and put the young bird into the nest. The bird was later observed to be standing in the nest with outstretched wings, and bill-clapping. It is assumed to have fledged between 9 and 11 December as it was not seen again after 11 December. On 15 December photographs taken by the drone confirmed that the young bird was not on or

underneath the nest or anywhere within the immediate surrounds.

Figure 2. Two juvenile storks immediately after they had been banded (Photo: G. Little 19/11/2021.)

Figure 3. A juvenile stork on the nest which had fallen to the ground. (Photo: B. McDonald 07/12/2021.)

Breeding event in 2022

From April 2022 one of us (RK) sometimes observed two adult storks flying back and forth to a Swamp She-oak *Casuarina glauca* (32º51'08"S, 151º40'04"E) north-west of the 2021 nest site (**Figure 1**). On 24 April the storks were observed to be copulating whilst on the tree. On 2 June the drone was launched and the adult male was photographed sitting on the nest. The female joined him and they both stood together for some time. On 23 July the adults were standing on the nest together when observers arrived at the Kau Ma Park observation point. Then on 30 August the storks were again observed together on the nest, firstly with the male sitting and the female standing. They changed positions and the female sat down whilst the male flew off, collected some sticks and returned to the nest. The drone was launched and when it arrived at the nest site, the female was sitting and the male standing. Shortly afterwards the female stood up, revealing five eggs. Again they changed positions and the male sat down on the eggs. When the drone was next flown to the nest on 19 September the female was sitting. The male flew in with a stick which he placed on the nest. Shortly afterwards the female stood up and two chicks and two eggs could be seen (**Figure 4**). The next observation was made on 23 October by J. Little using a telescope at Kau Ma Park. She observed the female standing on the nest with two young at her feet.

Figure 4. Adult pair with two chicks and two eggs. (Photo: L. Williams 19/09/2022.)

On 29 November the drone was again deployed. The female stork was standing on the nest and two large young birds were visible. On 4 December an attempt was made to band the young birds, but before this could be done, they flew away.

Although this nest remained viable throughout the 2022 breeding event, it became unstable during the following year's breeding event (in prep.).

DISCUSSION

Since it is known that Black-necked Storks will return to the same nesting site (Clancy & Ford 2013), we think that the 2020, 2021 and 2022 breeding events in Hexham Swamp involved the same pair of Black-necked Stork each time. The fact

that the pair chose three different trees in three years may be indicative of the unsuitability of nesting trees in Hexham Swamp. Each tree proved to be unstable in the long term.

The deployment of drones allowed detailed observations within the nest which would not have been possible to achieve using a telescope or binoculars.

Figure 5. Pair of adult Black-necked Stork with juvenile near the Pipeline Track, Hexham Swamp. (Photo: P. Fuller 25/01/2023.)

CONCLUSIONS & RECOMMENDATION

From 2020 to the end of 2022, six Black-necked Stork chicks fledged, from three different nests. Four of those birds had been banded; however none of the banded birds was ever seen subsequently. There were several sightings of unbanded juvenile birds. In January 2023 there were three sightings made from along the Pipeline Track, Hexham Swamp of an unbanded juvenile in the company of an adult pair (E. Vella pers. comm., S. Owen pers. comm., P. Fuller pers. comm.; **Figure 5**). At the same location in March 2023, a juvenile was present while at the same time the adults could be seen in the distance standing on the 2022 nest tree (T. Kendall pers. comm.). A juvenile bird was sighted, also in March 2023, near Bulbul Crescent, Fletcher (C. Dearing pers. comm.). Presumably those latter sightings involved one or both of the juveniles which fledged from the 2022 nest before they could be banded.

After leaving the nest, Black-necked Stork juveniles often remain with their parents or in the same area for several months (Clancy & Ford 2013). The 2017 Tomago juvenile presumably remained in the estuary from August 2017 when it left the nest to May 2018 when it was taken into care (Lindsey 2019a). However, after it was released in Hexham Swamp in July 2018, it left the area and was next sighted in Port Stephens (Lindsey 2019a). Given the large number of birdwatchers in the Hunter Region, it is surprising that so few sightings have been made and that there have been no sightings of any of the banded young.

In view of the dearth of suitable nest trees in Hexham Swamp and the persistence of the adult storks to nest in that area, we recommend that investigations be made into the possibility of erecting artificial nest platforms. Such platforms have been successful in Europe and Asia for White Stork *Ciconia ciconia* and Oriental Stork *Ciconia boyciana* respectively. So far as we are aware, artificial platforms have not been trialled for Black-necked Stork in Australia.

ACKNOWLEDGEMENTS

We would like to thank the many people who were involved in keeping watch on these breeding events from Kau Ma Park. The observers were: J. Lewis, J. Little, E. McDonald, L. Parashou, R. and M. Stewart and M. Taylor. G. Little assisted RK with the banding activities. Also, E. Vella, S. Owen, P. Fuller, T. Kendall and C. Dearing provided information about their opportunistic sightings.

The drone pilots included M. Formby, RK, C. Larkin, B. McDonald, R. Palazzi, L. Williams and R. Zimmerman. They are registered Remotely Piloted Aircraft (RPA) pilots and fly in accordance with Civil Aviation Safety Regulations (CASR) Part 101 Micro and Excluded Remotely Piloted Aircraft Operations.

We are also grateful to National Parks and Wildlife Service, Hunter Local Land Services and Awabakal Aboriginal Land Council for permission to access their land. We are also grateful to National Parks and Wildlife Service and Hunter Local Land Services for permission to fly drones over their land. We thank Hunter Bird Observers Club Inc. for the loan of their drone.

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Unusual prey item for Australian White Ibis: Longfin Eel

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Received 23 October 2023, accepted 27 October 2023, published online 30 October 2023.

INTRODUCTION

The main diet of the Australian White Ibis *Threskiornis moluccus* is aquatic wildlife (Marchant & Higgins 1990). Three studies of stomach contents have been reported for the species (McKeown 1934; Carrick 1959; Lowe 1984). McKeown (1934) examined the stomach contents of three Australian White Ibis in south-western New South Wales, finding mainly insects, spiders, freshwater mussels and freshwater crayfish. Carrick (1959) assessed the stomach contents of 202 birds from sites distributed between northern Victoria and southern Queensland. He found that the main dietary components by weight were frogs, fish, freshwater crayfish, beetles, crickets and grasshoppers. Lowe (1984) studied the stomach contents of 17 Australian White Ibis. In seven birds which had been foraging in intertidal habitats beside Westernport Bay in south-eastern Victoria, the main items in the stomach were isopod crustaceans such as shrimps and crabs. In ten birds which had foraged terrestrially, the stomach contents mainly comprised earthworms, insects and gastropod molluscs.

The range of prey items listed above are relatively small-sized. For example, most insects weigh only a few grams, while shrimps can weigh 5-15 g depending upon the species. Freshwater crayfish are larger – for example, a fully-grown Yabby *Cherax destructor* weighs 75-80 g but young ones are about 20 g (AZ Animals 2023). There is one report of an Australian White Ibis taking a "fish eel" (Fordyce 1973). However, that report had little detail.

OBSERVATIONS

On 14 October 2023 at around 10:30 am when we were on Ash Island (the western section of Kooragang Island in the Hunter Estuary) we were watching an Australian White Ibis foraging in a shallow freshwater pond (32.8594ºS, 151.7220ºE) and saw it capture an eel. Later inspection of our photos revealed the prey to be a Longfin Eel *Anguilla reinhardtii* of estimated length 30-40 cm. We estimated the size of the eel by comparing it with the ibis's bill (**Figure 1**). The bill of an Australian White Ibis is 149-158 mm long for females and 183-197 mm for males (Australian Bird Study Association 2019).

Figure 1. An Australian White Ibis on Ash Island carrying its Longfin Eel prey (Photo: Alan Stuart).

For about a minute, the ibis repeatedly picked up the eel, shook it and then dropped it back into the shallow water. During this time, the bird also moved the eel 5-10 m from the point of capture. Some of that movement was because a nearby Great Egret *Ardea alba* had approached, seemingly with the intention of snatching the prey. Eventually the egret desisted.

The ibis then started to nibble all along the eel's body. It did that several times, going in either direction (an example is shown in **Figure 2**). It then attempted to ingest the eel, by transferring it along the down-facing bill into the oral cavity and swallowing it whole (**Figure 3**). However, it soon regurgitated the eel and did some more nibbling along the length of the eel's body. After that, it walked out of our line of vision, still carrying the eel.

The process, from the ibis first starting to nibble the eel's body, took about two and a half minutes.

Figure 2. The Australian White Ibis nibbling at its prey (Photo: Ross Zimmerman).

Figure 3. The Australian White Ibis making the first attempt to ingest the eel (Photo: Alan Stuart).

DISCUSSION

There had been little rain in the Newcastle area in the preceding several months and the pond was drying out. Possibly, the eel was more exposed than normal to predation because of the pond having become smaller and shallower.

An adult Longfin Eel is about 150 cm long and weighs around 2 kg (Gomon & Bray 2021). We estimated the Ash Island eel to be 30-40 cm long; hence its weight was probably 400-500 g. Clancy (2011) investigated the weights for Longfin Eel eaten by Black-necked Stork *Ephippiorhynchus asiaticus* in northern New South Wales and found similar results (weight range 480-600 g). Clearly, a Longfin Eel of any age would be considerably heavier than the normal prey items for Australian White Ibis.

We suggest that the purpose of the nibbling action by the ibis was to crush bones of the eel's skeleton, making the prey easier for the ibis to ingest. Clancy (2011) has described similar behaviour by Black-necked Stork when it is eating eels.

ACKNOWLEDGEMENTS

We thank Tom Kendall for his help in identifying the species of eel.

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