The Whistler

Stockton sand dune system
Tracking Far Eastern Curlew
Galahs double brooding
Brahminy Kites and urbanisation
Breeding Pied Oystercatchers
Little Shearwater on Broughton Island
Long-term avian studies

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- To encourage and further the study and conservation of Australian birds and their habitat
- To educate members and the public, encouraging an interest in Australian birds and their habitat.

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Front cover: Rainbow Lorikeet *Trichoglossus moluccanus* - Photo: Rebecca Citroni
Back cover: Silvereye *Zosterops lateralis* - Photo: Rob Palazzi
Spine: Sharp-tailed Sandpipers *Calidris acuminata* - Photo: Rob Palazzi

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Editorial

This issue of *The Whistler* epitomizes why the Hunter Bird Observers Club produces a regionally-focussed journal. Of the fourteen papers and short notes, nine of them are about some aspect of the birds of a local area. The other five articles use a local focus to illustrate more widely applicable learnings about some particular species.

Five full papers are about birds of a local area. Graeme Stevens and Lois Wooding analyse about 20 years of data from their surveys at Salamander Waters Estate, finding that many significant changes have occurred over time. It is an important follow-on paper to their 2023 article which first introduced us to the site and its birdlife. Ashley Carlson compares two urban sites from near his home in Forster, finding some significant differences in their bird populations and relating that to habitat differences for the two sites. Alan Stuart has provided two papers, the first giving an overview of recent surveys of the Hunter Estuary (which is now a 26-year project by HBOC members), the second detailing the common birds and seasonal visitors to Broughton Island based upon 13 years of survey effort by HBOC members. In the fifth paper, Mike Newman demonstrates how the planting of a native garden, at Woodville, led to a massive increase in diversity and numbers of local birds.

All five papers show what we can learn from long-term monitoring projects. Of the studies, the one on Broughton Island is the shortest, at thirteen years! Monitoring, recording, analysing – it's a simple but effective recipe.

The five papers each make use of statistical analyses in order to show which of any observed changes were unlikely to be random. We, the editors, realise that statistics are a foreign land for many readers and some would-be authors. Please note that we are always available with advice and assistance to authors about how they might analyse their data. It's how to move from arm-waving to cold hard facts.

An article by John Goswell rounds out the full papers about birds of a local area. John's article about the Stockton sand dune system provides a refreshingly different approach to a study of the birds of a local area. John starts with the habitats – describing the six main ones of the beach and dune system – and then he explains in turn why each habitat attracts the birds which it does. This systematic approach is far more widely relevant than just the Stockton dunes.

Three shorter articles round out the offerings about local areas. The first one is about Ross Wallbridge Reserve, at Raymond Terrace, and demonstrates that site's importance for some waterbirds. Another article details the massive numbers of lorikeets, Rainbow Lorikeets predominantly, that roost at night at Raymond Terrace. The numbers are remarkable, for a species which was uncommon in our region until 25-30 years ago. The third short article describes how Pied Oystercatchers now breed often, and successfully, in some of the eastern parts of Port Stephens.

This issue of *The Whistler* has five articles which are species-specific; although they describe local studies or observations, the findings have wider implications. A short note about Silvereyes taking Gahnia seeds is intriguing – why would they do that? A paper by Kim Pryor on Galah breeding behaviour adds new information about that species, including the first-ever documented instance of probable double-brooding. Lois Wooding's review of Brahminy Kites highlights their spread (or return) to the Hunter Region and discusses factors affecting their long-term prospects. Martin Schulz and Susanne Callaghan report the first records for Broughton Island for Little Shearwater – and probably the birds were nest-prospecting. That's good news for this threatened species. And the final paper, from a team at the University of Newcastle, unveils a new way for tracking the movement of shorebirds – in this case a Far Eastern Curlew but potentially it is applicable for many other species.

It's timely here to mention taxonomy. About halfway through 2025, a new unified bird taxonomy was released – the AviList. Since then, we have used the AviList taxonomy when editing articles. However, several articles had already been accepted, and published online, using the previous, but now superseded, BirdLife Australia Working List taxonomy. Therefore, this issue uses two taxonomies – we certainly hope that won't ever happen again! Mostly though, the changes aren't substantial (and, they can be worked out).

Finally, there are many people and organisations to thank. Firstly, the authors – it's not an easy task to analyse data and write about it, and then have to deal with picky reviewers and editors. The reviewers undertake serious work, which often goes unacknowledged publicly (although our preference is for open reviews). We thank Liz Crawford for her diligent cross-checking of facts while she formats each manuscript, and also Rob Kyte who manages the production and printing of the hard copies. We appreciate the ongoing support of the HBOC Management Committee, and we also thank the Newcastle Coal Infrastructure Group for their continuing financial support.

Alan Stuart and Neil Fraser
Joint Editors

Silvereyes eating Gahnia seeds

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On 24 January 2024, author Mat Spillard observed and photographed a flock of five to six Eastern Silvereye (*Zosterops lateralis cornwalli*) foraging on the seeds of *Gahnia clarkei* at the Salamander Waters Estate, Salamander Bay (**Figure 1**). Mat had also observed and photographed this behaviour two years previously at the Blue Lagoon, Salamander Bay (**Figure 2**). On both occasions the birds consumed multiple seeds.

Figure 1. Silvereye (subspecies *cornwalli*, the Eastern Silvereye) foraging on *Gahnia clarkei,* Salamander Waters Estate, Salamander Bay, January 2024 (photo by Mat Spillard).

Figure 2. Silvereye (subspecies *cornwalli*, the Eastern Silvereye) foraging on *Gahnia clarkei*, Blue Lagoon, Salamander Bay, 2022 (photo by Mat Spillard).

Gahnia clarkei, commonly known as Tall Saw-sedge, is a species of evergreen sedge that grows around semi-permanent wetlands and damp shady areas. It is widespread throughout eastern Australian coastal areas from south of 25º latitude. It is 1.5-2 m tall and the same width range. In summer, the plants produce large flower spikes, 50-125 cm long, with shiny red seeds. The seeds darken when ripe and are very hard (PlantNET NSW 2024).

The seeds of *Gahnia* species are not easily digested except by birds with strong bills, such as the Red-browed Finch *Neochmia temporalis*, which can crack the seeds open and eat their contents (for an example, see Geelong Field Naturalists Club 2023). Various parrot and rosella species have also been reported to eat *Gahnia* seeds (J. Goswell pers. comm.). However, there also are several reports of seeds passing undigested, or apparently so, through a bird species after it has eaten them (J. Goswell pers. comm.).

Silvereyes have a thin pointed bill which is adapted for taking fruit and small insects. The bill is not designed for cracking seeds. Silvereyes feed on a wide variety of fruits and insects, plus nectar, other invertebrates, food scraps, flowers and seeds. They forage mainly by gleaning, predominantly amongst the shrub-layer (BirdLife Australia 2023a). Silvereyes often forage in small groups, and in mixed-species flocks. On occasions they can be highly destructive in orchards and vineyards and as such are sometimes considered a pest. Much of the seed ingested by Silvereyes is secondary (from foraged fruits they have eaten) and the birds are known to be important agents for seed dispersal in some forests (BirdLife Australia 2023a).

As *Gahnia clarkei* seeds are very hard, it is questionable as to whether the Silvereyes would be deriving any nutritional value from consuming them. French (1996) studied the gut passage rate of seeds in Silvereye and showed that the passage rate was short, 6-28 minutes, and that much of the passed seed was still viable. This is characteristic of frugivorous birds. For example, a study of the viability of the seeds of soft fruit following ingestion and passage by the frugivorous species

White-spectacled Bulbul *Pycnonotus xanthopygos*, Common Blackbird *Turdus merula* and European Robin *Erithacus rubecula* showed high levels of germination (Barnea *et al*. 1991). This indicates that the ingestion of seeds by non-granivorous species has relatively little impact on the coating of the seeds.

A similar observation was made recently of a male Eastern Shrike-tit *Falcunculus frontatus* foraging on the stem of a *Gahnia clarkei* seed head near Smiths Lake in March 2024 (R. McDonell pers. comm.). Although not actually seen to consume any seeds, the bird appeared to be foraging for them (**Figure 3**). The Eastern Shrike-tit is generally considered to be an insectivore. It forages on invertebrates, mainly insects and occasionally fruit, seeds or their arils (BirdLife Australia 2023b). Again, it is questionable as to whether the bird would derive any nutritional value from these seeds.

Figure 3. An Eastern Shrike-tit apparently collecting *Gahnia clarkei* seeds at Smiths Lake in March 2024 (photo by Rob McDonell).

When birds eat indigestible seeds, such as those of the various *Gahnia* species, the obvious question is why they would do that. We suggest that the hard, indigestible seeds might function as a vegetable equivalent of a gastrolith (i.e. a bio-gastrolith). Gastroliths are hard objects within the digestive tract of animals, that aid them to digest their food (Wings 2007; Gill 1990). Birds 'grind' food in their gizzard, aided by hard gritty materials, before returning it to the digestive part of their stomach.

We also note that there is a potential benefit for the plant: germination would be facilitated by contact with the birds' stomach acid, which would weaken the tough seed coat (Wikipedia 2024).

Regardless of the explanation for this activity, these observations do not appear to be often documented.

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Peregrine Falcons taking seabirds – a comment on Stuart *et al*. 2024

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Stuart *et al.* (2024) described, and reviewed literature cases of, Australian Peregrine Falcons *Falco peregrinus macropus* taking shearwaters *Ardenna*/*Puffinus* spp. and other procellariiform seabirds. Relying on HANZAB (Marchant & Higgins 1993) and references cited therein, they suggested that the behaviour is rarely reported, especially compared with coastal-dwelling overseas Peregrine Falcon subspecies. Although the digital HANZAB is freely available online via the BirdLife Australia website (publications page), it has not been updated, so the raptor volume (1993) is 30 years out of date. An explicit HANZAB update on the Australian falcons (Debus 2022: 120–125), to the same format and layout, cited post-HANZAB sources listing various procellariiform seabirds, including shearwaters, in Australian Peregrine Falcon diets; these are hunted up to nine km out to sea, or from oil rigs at sea. Additionally, there are many Silver Gulls *Chroicocephalus novaehollandiae* recorded in some of the cited recent dietary studies. Slater & Elmer (2024: 212) also recorded White-faced Storm Petrels *Pelagodroma marina* and Little Shearwaters *Puffinus assimilis* as Peregrine Falcon prey. So, the habit is likely as common in coastal-dwelling Australian Peregrine Falcons as elsewhere in the world.

Regarding nocturnal hunting, Mooney (2013) found that Peregrine Falcons will perform their typically noisy and active nest defence at night with a partial moon, and suggested that falcons (Falconiformes) have better night vision than other diurnal raptors (Accipitriformes), owing to falcons' higher rod to cone ratio. This capacity would explain the Peregrine Falcon's ability to hunt crepuscularly or at night, especially by artificial light in or near urban situations.

As a footnote on Peregrine Falcon subspecies, alleged south-west Australian subspecies *submelanogenys* is now thought to be invalid (Debus 2022: 111; Slater & Elmer 2024: 206), although the definitive DNA work is yet to be done.

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Using motus automated telemetry to quantify habitat use and movement in a Far Eastern Curlew within the Hunter Estuary, NSW, Australia

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We report a case study which illustrates how motus automated telemetry can reveal biologically interesting and management-relevant regional patterns of movement and habitat use of threatened shorebird species. The study reports the behaviour of a first-year Far Eastern Curlew *Numenius madagascariensis* equipped with a motus automated telemetry tag over a one-month period within the Hunter Estuary on the east coast of Australia. The bird showed a seasonal change in habitat use, which may be indicative of young birds using less frequented and potentially less favourable foraging grounds. The study contributes knowledge necessary for protecting the nonbreeding habitat of IUCN red-listed migratory shorebirds in Australia, thereby supporting evidence-based estuary-level land management.

INTRODUCTION

The last decade has seen phenomenal progress in mapping the interhemispheric flight paths of long-distance migratory shorebirds, driven by significant expansion of global satellite coverage and miniaturisation of satellite tracking technology (Chan *et al*. 2019; Gould *et al*. 2024). This global research effort has revealed awe-inspiring levels of spatial detail about the bi-annual, long-distance journeys of a range of shorebird species and has played a key role in mobilising political attention to the dramatic population declines of this taxonomic group, as well as in motivating international cooperation to discover and address the causes of decline at the flyway level (East Asian-Australasian Flyway Partnership 2024; Rogers *et al*. 2023).

About 2 million individuals from 37 species use the East Asian-Australasian Flyway (EAAF) to make bi-annual flights between their northern hemisphere breeding grounds in the Arctic tundra and their nonbreeding grounds in Australia's rich landscape of coastal estuaries (Department of Climate Change, Energy, the Environment and Water 2023). Arriving late September and departing the following April, Australia's migratory shorebird community spends more than half of its annual cycle in nonbreeding habitat, more than in staging and breeding areas combined. There is an increasing awareness that lack of knowledge about the ecology and behaviour of sexually mature birds in their nonbreeding habitat, and sexually immature birds that remain in Australia year-round, is hampering effective land management decisions at the intra-estuary level, as well as conservation strategies and priorities by government agencies (BirdLife Australia 2020).

Motus is the largest global automated telemetry network, centrally managed by Birds Canada (https://motus.org). Motus operates via fixed antenna stations which listen continuously for the signals of small, lightweight VHF nanotags (Taylor *et al*. 2017; Griffin *et al*. 2018). Each nanotag emits an individually identifiable digital pulse. Detection patterns across a local array, as individuals disappear from one station's antenna(s) and re-appear on another station's antenna(s), identify where the individuals are day and night, 7 days/week. Signal strength variability yields additional behavioural information (e.g., feeding versus roosting). Motus technology has the major advantage of providing an affordable means of tracking technically unlimited numbers of individuals simultaneously on a local to global scale, providing adequate sample sizes to begin studying, for example, relationships between individual health profiles and variation in movement patterns. A further advantage is that tags can be as small as 0.13 g. This technological advancement makes it possible to track a range of low body weight shorebirds that cannot be tracked currently with other systems. The global motus network now spans 34 countries across five continents, with >2000 stations and 402 tagged species (https://motus.org/about/, last accessed 3 December 2024). This significant growth since its inception in 2012 is testament to the power of this technology and the confidence that it will remain a technology of choice, complemented by other more expensive tracking methods where appropriate.

The Hunter Estuary, which includes the Ramsar-listed Hunter Wetlands National Park contains internationally significant shorebird habitat (Roderick & Stuart 2016; BirdLife Australia 2020; Stuart & Lindsey 2021). The Hunter has a long history of heavy industry and is the largest coal exporting port in the southern hemisphere. Of Australia's 37 migratory shorebird species, more than half are declining, and the Hunter has been noted as one of the areas with sharper declines (Clemens *et al*. 2016). The reasons why some estuaries are losing shorebirds faster than others remains a matter of speculation. Given that many migratory shorebirds are known to show strong levels of site fidelity, returning year after year to the same estuary (Buchanan *et al*. 2012; Coleman & Milton 2012; Little *et al*. 2023; Ross *et al*. 2023; Sandercock & Gratto-Trevor 2023), one possible explanation is that environmental factors local to the area and detrimental to shorebird health (e.g., contamination of the food chain) may increase mortality during northbound migratory journeys, meaning that site-loyal birds fail to return the following year.

The Hunter Estuary has a rich history of community-led surveys conducted by a regional birding club, the Hunter Bird Observers Club (Stuart & Lindsey 2021). Monthly whole-estuary surveys have been conducted for over 20 years and the significant declines they have revealed have provided the impetus for complementary monitoring methods to fill the knowledge gaps that high-tide, diurnal counts cannot address, including where the birds forage and roost across the tidal and circadian cycles (BirdLife Australia 2020). The Hunter Estuary currently hosts a network of eight motus automated telemetry stations, complemented by another three in the nearby Port Stephens Estuary. The array is being used to obtain key movement and habitat use information within and between estuaries, covering a range of migratory and resident shorebird species and recording continuously every day. This is a case study on a young female Far Eastern Curlew *Numenius madagascariensis* equipped with a motus automated telemetry tag over a one-month period within the Hunter Estuary.

METHODS

Location

The Hunter Estuary is located at the mouth of the Hunter River, approximately 150 km north of Sydney in New South Wales, Australia (**Figure 1**). The motus array in the Hunter Estuary has expanded gradually since 2020. At the time of the present study the estuary hosted four stations, each consisting of a 6.5 m steel mast with an antenna attached to the top (**Figure 2**). Each station is equipped with a SensorGnome radio receiver, which processes and registers the antenna detections along with date and time.

Three of the stations are equipped with an omnidirectional antenna approximately 9 m above the ground, yielding temporally high-resolution presence/absence data, while one is equipped with a 6-element directional Yagi antenna approximately 6.5 m above the ground to detect fly-bys across the estuary. Omnidirectional antenna sites were strategically placed near recently restored and intensively managed intertidal habitat, where usage by shorebirds at low tide and during the night was unknown. The directional antenna is positioned to detect movements along the north-south axis between the tidal mudflat in Fullerton Cove and the well-known high-tide roost at Stockton Sandspit. With tags set to emit a pulse every ~10-15 s, the motus stations provide temporally high-resolution detections, which can be mapped easily to the tidal and daylight cycles.

Subject

A young Far Eastern Curlew was caught during nocturnal shorebird mist netting activities at Stockton Sandspit (32.883566S, 151.790257E), on 18 March 2023. The bird was fitted with a metal band on the left leg and colour flags engraved with 'AAE' on the right leg, with orange over green on the tibia. The bird was also fitted with a 2.7 g motus nanotag transmitter, glued to a small spot of trimmed feathers between the scapulae. Once in place, the tag was covered by feathers, except for the thin 9-cm long antenna that extended along the back. The bird was sexed, weighed, measured (length of wing, bill, tail), and was aged as a first-year bird based on plumage before being released unharmed.

The tagged bird was then detected whenever it was near one of the four automated telemetry stations. Data was downloaded from each of the stations for analysis. Detections ceased either when the tag fell off, or the bird did not return to the proximity of any station (which of these happened for this bird is not known). Tidal data were sourced from the Bureau of Meteorology. Spline interpolation was used to produce a continuous tidal curve and examine shorebird movements in relation to changes in water level.

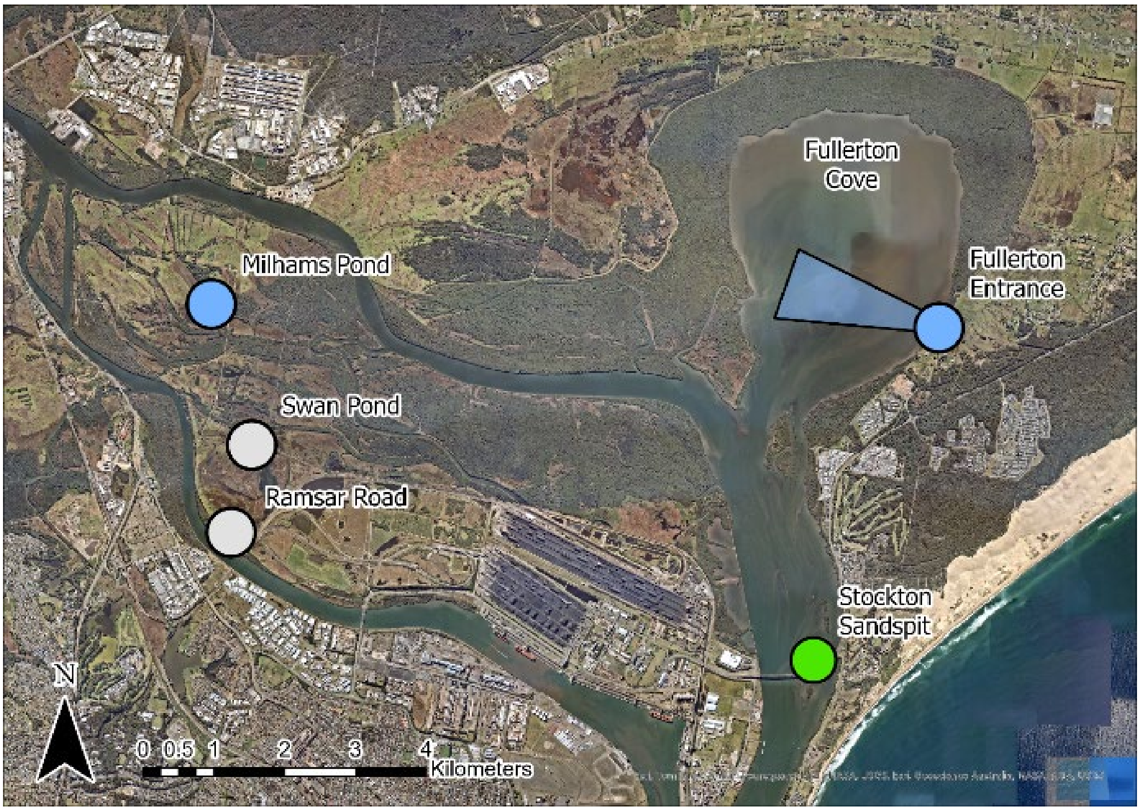

Figure 1. The Hunter Estuary showing the initial catch site, Stockton Sandspit (green circle), the location of four motus automated telemetry stations (blue/white circles), and the Fullerton Cove mudflat. Blue circles are stations where the Far Eastern Curlew with flag 'AAE' was detected, and white circles are stations where it was not detected. The different shape at Fullerton Entrance represents the directional orientation of the 6-element Yagi antenna and illustrates how it detects birds flying between the mudflat and the high tide roost. N.B., the shape is not indicative of the detection range of the antenna (see text for more details). Note: Milhams Pond is located on Ash Island.

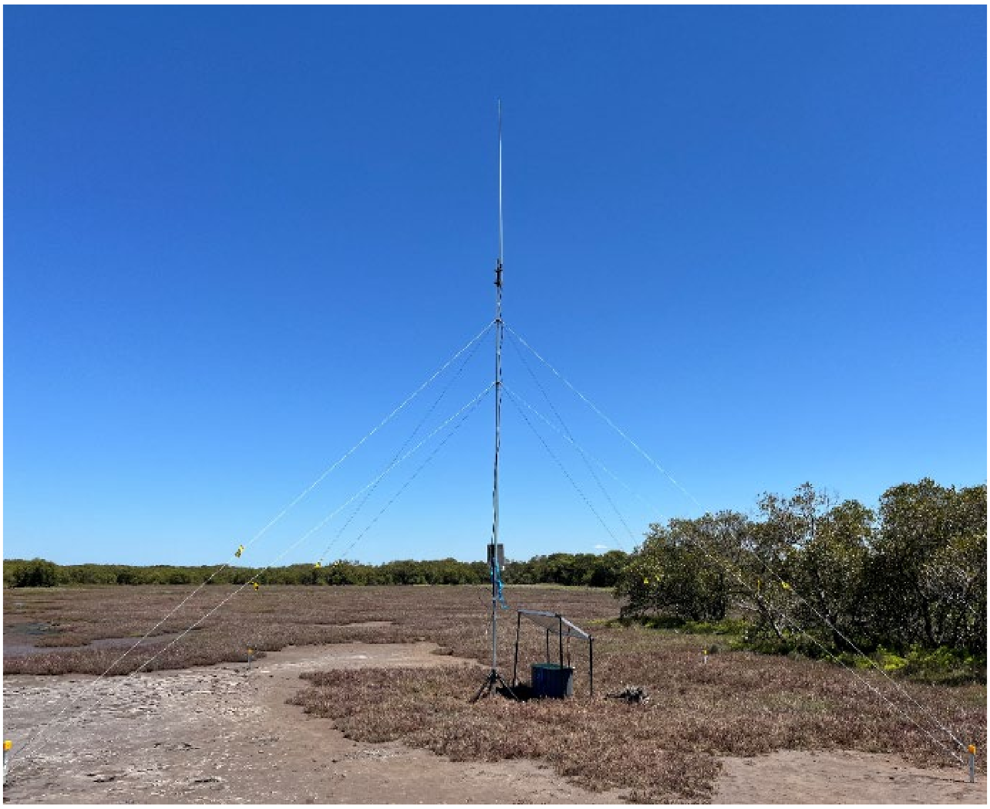

Figure 2. A typical Motus automated telemetry station with an omnidirectional antenna.

Motus automated telemetry

The features of motus are explained in detail elsewhere (Griffin *et al*. 2018). Briefly, nanotag transmitters emit a coded digital pulse that is specific to each tag, allowing for individual identification. The pulse interval is set by the user and can range from about 2 pulses/min to about 10 pulses/min. The pulse interval influences battery life and should be used strategically. In the present study, the curlew was equipped with a transmitter that pulsed every few seconds in order to ensure that rapid fly-bys past the directional antenna at Fullerton Entrance were not missed. As the battery life for this size nanotag is far longer than the expected glue attachment time, battery life was not a consideration. Knowing the pulse interval allows the researcher to calculate the total detection time for each motus station by multiplying the number of detections by the time interval between pulses. Detection range of a given station depends upon multiple antenna- (type, height), bird (height above ground), tag (size, residual battery life) and environmental (vegetation) factors, making it difficult to estimate. The estimated detection range of the stations used here can be found by visiting motus.org (https://motus.org/data/receiversMap) and selecting the option "show estimated antenna ranges". As a bird moves around its environment (e.g., searching for food), turning towards and away from the antenna, the signal reaching the antenna varies in strength. For this reason, periods of high variability in signal strength can be indicative of periods of activity, while periods of low variability can be indicative of periods of resting (Griffin *et al*. 2018).

RESULTS

The curlew was detected by the telemetry array on a total of 29 days, with the first detection on 25 March 2023 (7 days after transmitter attachment), and the last detection on 23 April 2023. **Figure 3** depicts the repeated pattern of tag detections across two telemetry stations, namely Milhams Pond and Fullerton Entrance (note: Fullerton Entrance refers to the telemetry station, and Fullerton Cove to the mudflat). The pattern reveals that the curlew visited Milhams Pond daily during late March, with regular fly-bys detected on the Fullerton Entrance station when leaving Milhams Pond. Mid-April, this pattern of repeated visitation to Milhams Pond ceased after a last visit to Milhams Pond on 16 April 2023 and from there onwards only fly-bys on the Fullerton Entrance station were detected. The curlew spent continuous bouts of up to 17 h at Milhams Pond, but only very brief duration bouts (maximum 7 min) at Fullerton Entrance, indicative of flying past the antenna (**Figure 4**).

Examining the detections patterns in more detail and superimposing tidal and circadian cycles revealed that the bird spent the low tides of late March at Milhams Pond and remained there for high tides during the daytime where the tidal amplitude was relatively low (**Figure 5**). An analysis of signal variance suggests that, during these periods of low high-tide amplitude, the curlew was either inactive

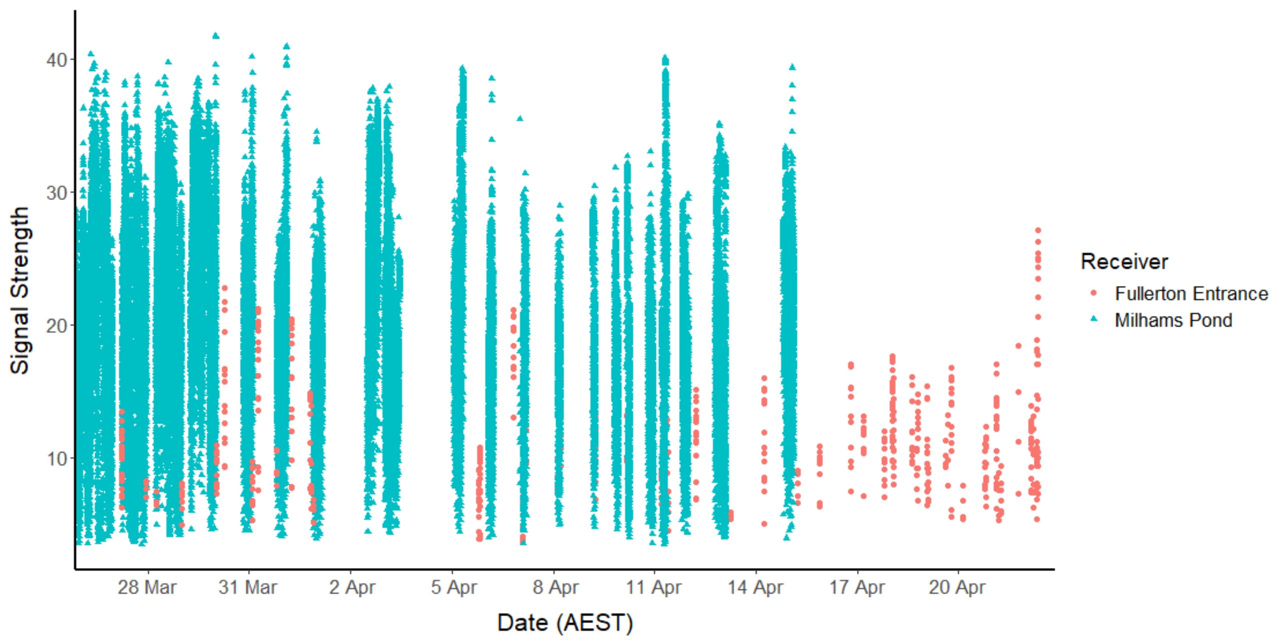

Figure 3. All detections of the tagged Far Eastern Curlew individual, from first (25 March 2023) to last (23 April 2023) detection. Dates on the horizontal axis correspond to the start of the day (i.e. 12 am).

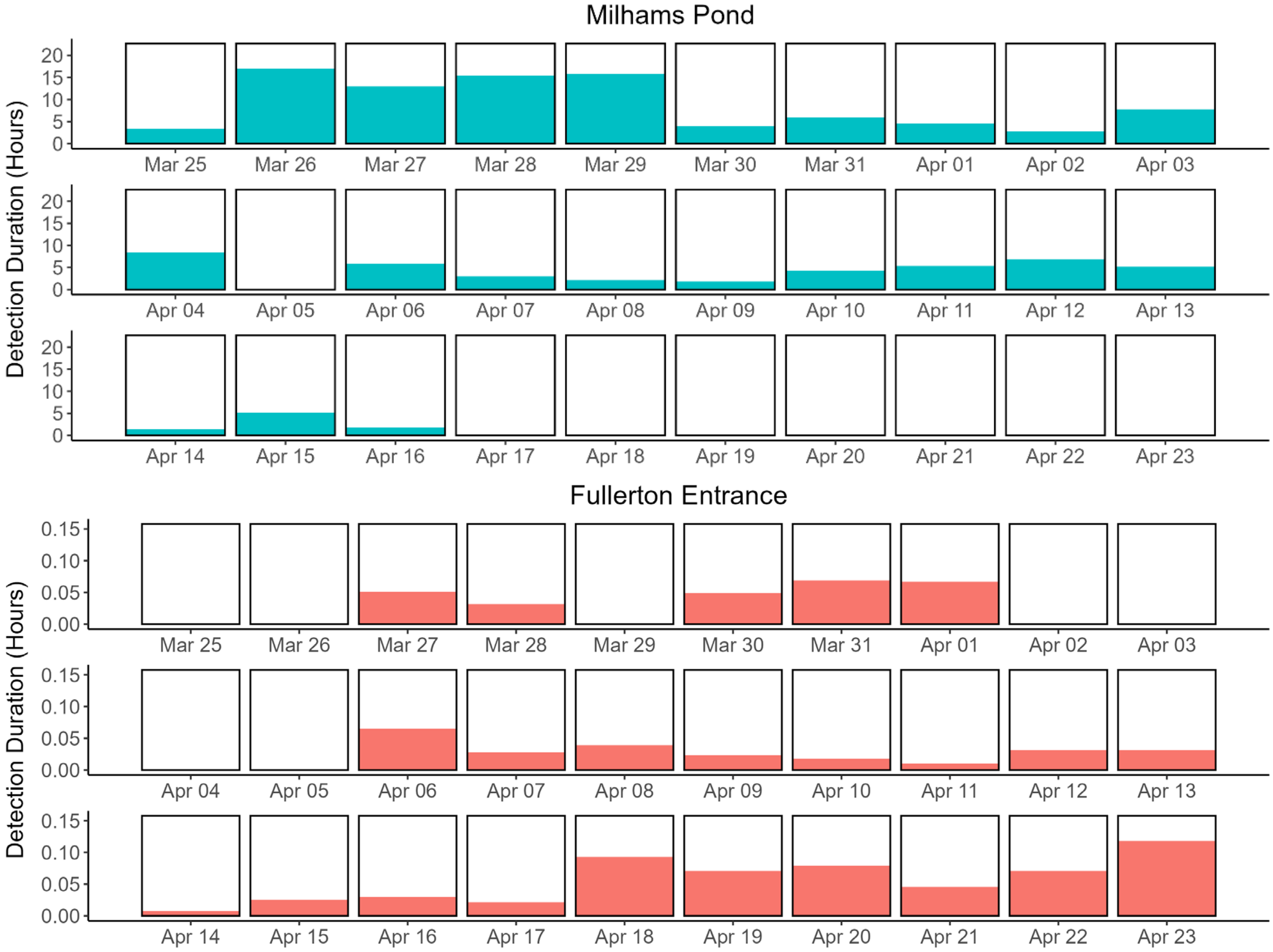

Figure 4. The amount of time each day (in hours) that the tagged curlew was detected at Milhams Pond (top panel) and Fullerton Entrance (bottom panel). Note the different scales on the y-axis across the two panels to improve readability.

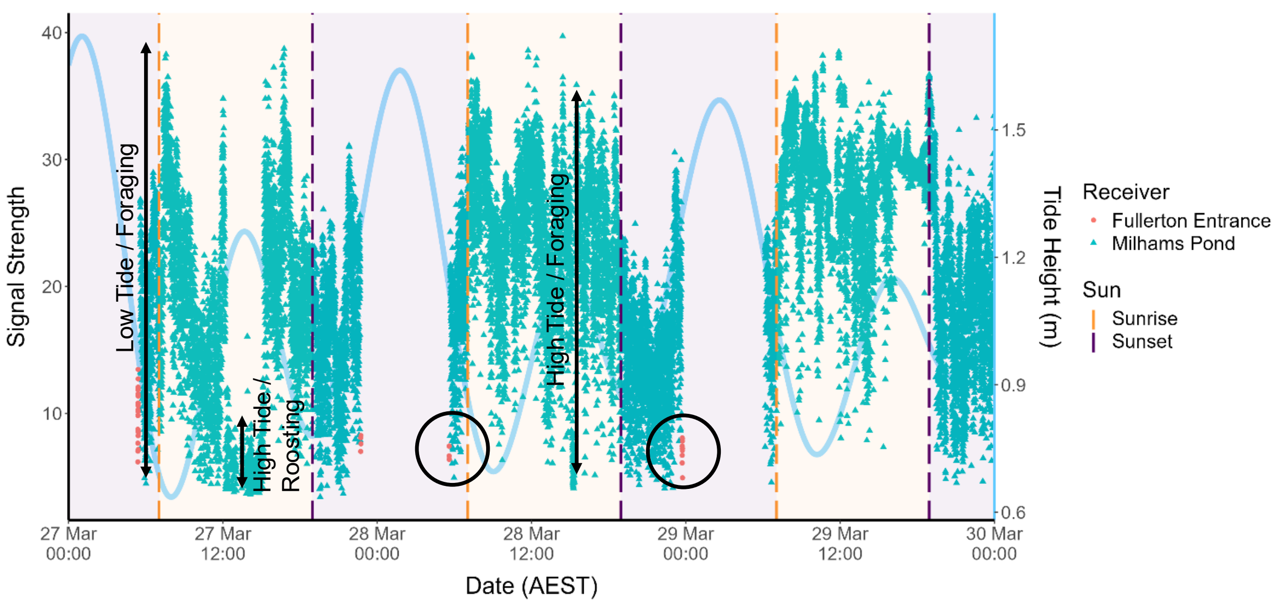

Figure 5. Detections of the curlew for 27-29 March 2023 on two stations within the Hunter Estuary (see **Figure 1**). The undulating blue line indicates the changing tide within the estuary (using Stockton Sandspit as the reference location). The shaded orange and purple backgrounds correspond to daytime and night-time respectively, with dotted vertical lines indicating dawn (orange) and dusk (dark purple), respectively. Vertical arrows show how variation in signal strength is indicative to behaviour (see text for more details). The black circles show examples of a fly-by as referred to in the text.

(low signal strength variation indicative of likely roosting; e.g. 27 March 2023) or was active (high signal strength variation indicative of likely foraging; e.g. 28 March 2023) (**Figure 5**). Arrival and departure at Milhams Pond were flanked by fly-by detections on the Fullerton Entrance antenna. This pattern of detections reveals for the first time that Far Eastern Curlew use Milhams Pond during both the day and the night to feed, that remaining there at high tide is associated with low high-tide amplitudes, and leaving is associated with high high-tide amplitudes. None of these facts were previously known from whole-estuary, high-tide, diurnal population counts.

On 13 April 2023, the bird began missing the low tide foraging period at Milhams Pond despite flying by the Fullerton Entrance station (**Figure 6**), pre-empting full cessation of visits to Milhams Pond on 16 April 2023 (**Figure 7**). During the final period of detections from 17 - 23 April 2023, the curlew repeatedly flew past the Fullerton Entrance antenna on the dropping and rising tide until it was last detected at 7.23 am on 23 April 2023. The most likely interpretation of these fly-by detections on the changing tide is that the curlew was moving between foraging at the large natural mudflat in Fullerton Cove to the north at low tide, and resting within the higher elevation area at Stockton Sandspit to the south, which is well known to be the most important high-tide roost in the Hunter Estuary (Spencer 2010; Stuart & Lindsey 2021).

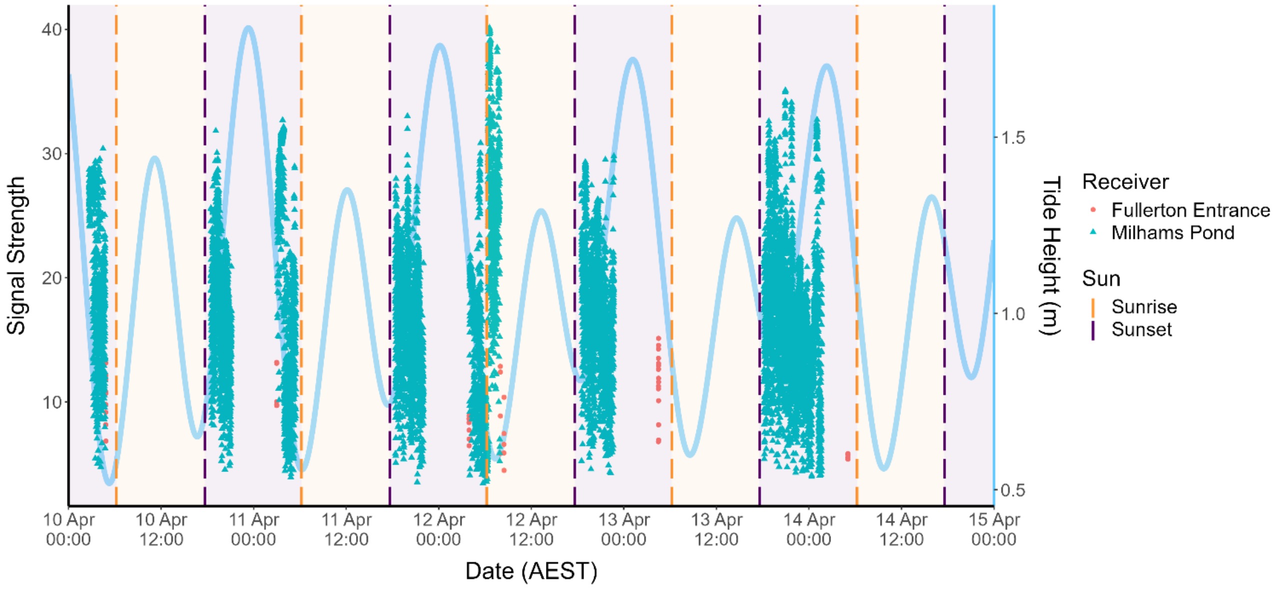

Figure 6. Detections of the Far Eastern Curlew “AAE” for 10-14 April 2023. See **Figure 5** for additional details.

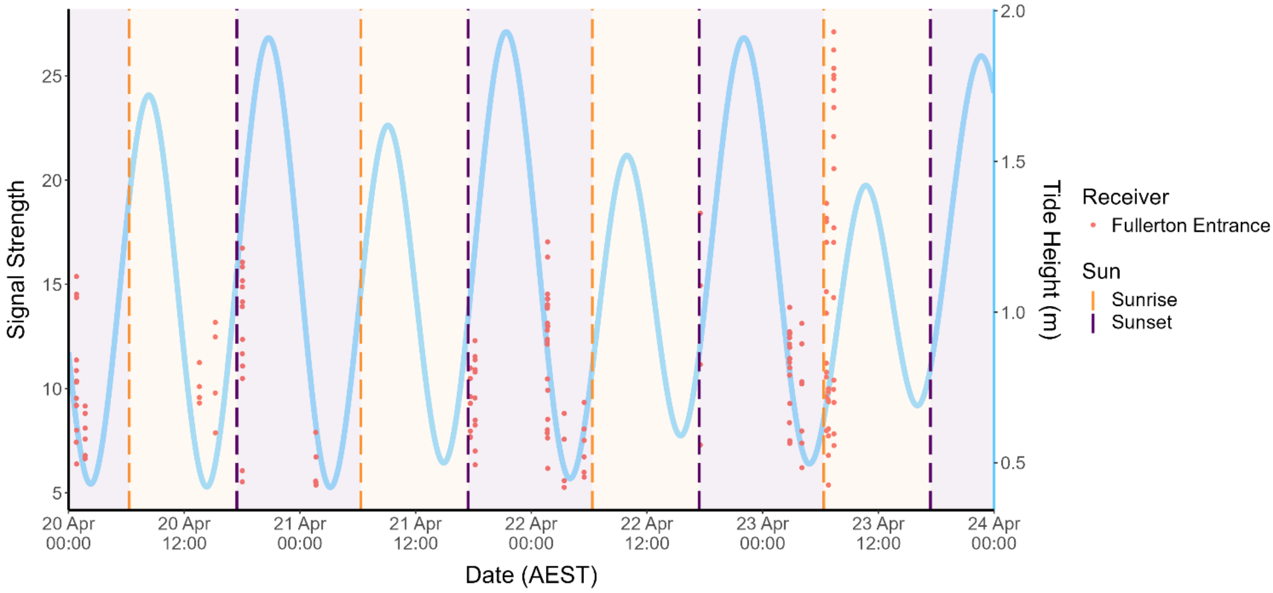

Figure 7. Detections of the Far Eastern Curlew “AAE” for 20-23 April 2023. Pulses of detection on the directional antenna of the Fullerton Entrance station are indicative of fly-bys (see text for details).

There have been several sightings of the banded individual in the Hunter Estuary (see **Table 1**), including one during the motus detection period on which the transmitter antenna was visible on the bird, and several since radio detections ceased on 23 April 2023, on which the transmitter antenna was no longer visible. The first re-sighting after radio detections ceased occurred at the Stockton Sandspit high-tide roost on 29 August 2023**.** The timing of these bird and transmitter sightings confirm first, that the transmitter was detected reliably when it was attached to the bird, and second, that by 29 August 2023, the absence of radio detections was attributable to transmitter loss and not battery failure. It remains unknown whether the absence of detections between 24 April and 29 August 2023 was due to transmitter detachment on 23 April 2023 or due to the bird briefly leaving the estuary (with its transmitter attached).

Table 1. Sightings of Far Eastern Curlew 'AAE' within the Hunter Estuary.

Date	Time	Location	Coordinates	Observer
30 Mar 2023[1]	13:26	Stockton Sandspit	32.883566S, 151.790257E	T. Elks
29 Aug 2023	16:00	Stockton Sandspit	32.883566S, 151.790257E	G. Little and D. Garnett
22 Oct 2023	12:07	Stockton Sandspit	32.883566S, 151.790257E	G. Little and J. Little
04 Nov 2023	16:00-17:00	Stockton Sandspit	32.883566S, 151.790257E	G. Little and J. Little
11 Nov 2023	morning	Stockton Sandspit	32.883566S, 151.790257E	T. Clarke
22 Nov 2023		Stockton Sandspit	32.883566S, 151.790257E	G. Little and J. Little
23 Dec 2023	7:45 – 9:15	Stockton Sandspit	32.883566S, 151.790257E	G. Little and L. Williams
02 Jan 2024	12:17	Stockton Sandspit	32.883566S, 151.790257E	T. Elks
9 March 2024	8:27	Phoenix Flats	32.845843S 151.714384E	A. Stuart, R. Zimmerman, J. Garnham

[1]Transmitter was present

DISCUSSION

The pattern of detections on a fixed array of motus stations across the Hunter Estuary revealed that a first-year Far Eastern Curlew shifted from foraging in an area of intertidal habitat interior to Ash Island to foraging in the tidal mudflat in Fullerton Cove around the time when curlews leave the Hunter Estuary to begin their migratory northbound journey (in April). The habitat shift occurred approximately a week prior to the bird's last detection which would have coincided either with the tag falling off, or the bird leaving the estuary.

Milhams Pond is an area of intertidal habitat on Ash Island with a history of shorebird habitat management. Tide water enters the Milhams Pond system along creek lines flanked by mangroves that link the area to the south arm of the Hunter River. To address an increasing encroachment of mangroves into existing saltmarsh in the early 2000s associated with increasing tidal influence (Herbert 2007), the area was cleared of mangroves in 2009 and Mangrove Propagule Exclusion Devices placed along creek lines where tidal waters enter (Clarke 2009). The area now undergoes annual manual mangrove seedling removal (Clarke 2009; 2010; 2011). There is currently an area of mud below the saltmarsh where tidal inundation is more frequent. Ongoing low-tide surveys at Milhams Pond indicate that the mud is typically used by a small number of Far Eastern Curlew (typically < 10) to forage, in contrast to the large numbers of curlew (typically up to 85) regularly found foraging in Fullerton Cove (Williams *et al*., in preparation). Sediment penetrability is a reliable predictor of foraging substrate selection in Far Eastern Curlew and biomass intake rate increases as substrate resistance decreases (Congdon & Catterall 1994; Finn *et al*. 2007). The restored mud flat at Milhams Pond is not only a much smaller area, its top layer of soft mud is also replaced at around a depth of 15 cm with a very compact clay layer, which is much harder to penetrate than the large expanse of very soft, >1 m deep mud in Fullerton Cove (ASG pers. obs.). While in need of further research, this substrate difference may contribute to explaining why Milhams Pond is used less than Fullerton Cove (Williams *et al*., in preparation), while also suggesting that some individuals, like the tagged bird studied here, forage in less optimal habitat. The exact date on which Far Eastern Curlew leave the Hunter Estuary is not known but typically occurs around early to mid-April. This implies that the curlew's shift to the more commonly used natural mudflat at the end of April may have occurred around or after the time when most curlew were leaving the estuary.

While past work has recorded low instances of intraspecific aggression in this species, the usage of potentially sub-optimal foraging substrate, and a shift to a potentially more optimal foraging substrate around the time when population density would have been decreasing raises the question of whether more subtle social interactions may be influencing access to feeding sites by some individuals (Finn 2010). The individual studied here was a young bird, which may explain why it foraged away from the larger group. Our study calls for more work to compare foraging habitat quality across mudflats with different tidal dynamics and their usage by individuals of different sex and age classes to assist evidence-based land management decisions and shorebird conservation, particularly to prepare for sea level rise.

This case study illustrates how effectively a strategically-designed array of automated telemetry stations, combining omni and directional antennas, can quantify habitat use by shorebirds at a regional level. Automated telemetry yields high temporal resolution, low spatial resolution presence/absence information continuously every day. While the system differs from Global Positioning Satellite technologies that calculate flight paths with varying degrees of accuracy, we argue that conservation of shorebird habitat at the regional level does not typically depend upon detailed path information. Knowing which areas are used, by which species, how often, and for what, is adequate to ensure that critical low-tide feeding, and nocturnal roosting grounds are identified and that investment in protection is guided by relative usage. In the present study, the transmitter yielded 29 days of information. Lotek nanotags set to pulse every few seconds, like the one used here, have battery durations of many months. Hence, that the bird was not tracked for longer was no doubt a result of our attachment method (glue versus harness) and not a limitation of the technology. Careful consideration should be given to attachment methods to make sure the benefit to cost ratio is maximised. In our case, we sought to minimise animal welfare impact while still obtaining enough information to unveil light- and tide-dependent patterns of habitat use. Shorebirds are known to use foraging and roosting grounds repeatedly so shorter periods of tracking can be sufficient to yield the necessary information. Not only did motus yield new knowledge of habitat use, it was also a technically highly reliable system. While the bird was only tracked within the confines of the estuary, the system functioned with high reliability and yielded data every day. While spatial coverage of our motus array is limited, this is not a limitation of the technology per se, but rather of how we are currently using it. Not only can stations be added or moved around to increase coverage, the collaborative nature of motus automated telemetry means the more researchers using it, the greater the economy of scale (Griffin *et al.* 2018). Lastly, the comparatively low-cost of motus automated telemetry make this technology well suited to addressing questions related to individual variation like those raised by the present study, and it is, in fact, currently the only technology that can be used on very small shorebirds.

CONCLUSION

Using motus automated telemetry, this study was able to demonstrate for the first time in this region of Australia repeated foraging in an area of restored intertidal mudflat located on the interior of an island, and also a shift to a potentially higher quality large soft-sediment mudflat open to more tidal influence from the ocean. These patterns call for more research to identify the ecological and social drivers of foraging habitat selection by shorebirds.

PERMITS AND FUNDING

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AUTHOR CONTRIBUTIONS

ASG, CG, LAW and MT contributed to deploying the motus stations and assembling detection data. ASG, CG, LAW and MT wrote the manuscript. CG conducted the analysis of motus detections with the guidance of ASG. All authors contributed to the inception of the project and the significant catching effort required to attach tags to shorebirds.

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The movements in the Hunter Estuary of this first-year Far-eastern Curlew, tagged AAE, were tracked using a network of motus tracking stations (photo: Ted Elks).

Population trends for the birds of Salamander Waters Estate and comparisons with the nearby Mambo Wetlands Reserve populations

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During a fifteen-year study (2008-2022) of the avian population of Salamander Waters Estate, Salamander Bay, Port Stephens NSW, the authors recorded a total of 130 species, almost all of which were birds common to the Hunter Region. Woodland species formed the major population component (90 species) followed by waterbirds (30 species) and raptors (10 species). Surveys were conducted over two time periods (Wooding 2008-2016; Stevens 2017-2022). Comparison of the two data sets indicated a population increase among larger, mobile, somewhat aggressive species, and a decline in populations of small woodland species. One hundred of the 130 species recorded at the site were also recorded at the nearby Mambo Wetlands Reserve during surveys conducted over a similar time period.

INTRODUCTION AND OBJECTIVES

Salamander Waters Estate (**Figure 1**) is located off Tarrant Road, Salamander Bay (at 32º43'5"S, 152º04'44"E) and comprises approximately 20 ha of partially-modified coastal woodland which was zoned as Residential in 2000 under the Port Stephens Environmental Plan (https://www.portstephens.nsw.gov.au). Currently, approximately 50% of the site has been developed for residential housing, public playing fields, sports complex facilities, and associated parking. A second 66-lot residential development, which is still at the primary concept level, will require the removal of 12 ha of the site's native woodland (https://www.portstephens.nsw.gov.au).

An earlier paper described the site's development history, and provided a detailed compilation of multi-sourced flora and fauna records associated with the site between 1998 and 2022 (Stevens & Wooding 2023). This paper is confined to an examination of avian records collected by the authors during monthly bird counts undertaken between 2008 and 2022. Standardised population tests were used to evaluate the current population status of the species found on site, and to indicate possible future population trends, with particular emphasis on resident species. Three additional species of interest, due to their presence just prior to the commencement of the study, are also discussed.

A comparison of the Salamander site's avian records with data collected during a comparable study undertaken at the nearby Mambo Wetlands Reserve was also attempted (Fraser 2018). The locations of the two sites are indicated in **Figure 2**.

METHODS

Between 2008 and 2022, early morning 2-3 hr walking surveys were carried out at approximately monthly intervals. The route was designed to allow optimal coverage of the site's varied habitats, in accordance with Birdata protocol for surveys within a 500 m radius (https://www.birdata.birdlife.org.au/). The study was conducted in two periods. Observations for the first period (2008-2016) were recorded by L. Wooding, and the second period records (2017-2022) were compiled by G. Stevens. Birds were identified both visually and by call, and breeding or probable breeding, was assumed when juveniles of a species were regularly seen, and when adult birds were seen on a nest or observed carrying nesting material or feeding chicks and fledglings.

The data were recorded on MS Excel spreadsheets and subjected to population testing using the Reporting Rate Percentage (RR%) and Chi-square methodologies (Fowler & Cohen 2016). RR is the number of records for a species divided by the number of surveys, expressed as a percentage.

The Chi-square Test, using the Yates correction, was used to compare data from the two study periods, 2008-2016 and 2017-2022, and thus identify species showing notable population changes. Chi-square values above 3.84 indicate less than 5% probability that the result is random ($p < 0.05$) and Chi-square values above 6.63 indicate less than 1% probability that the result is random ($p < 0.01$).

The test results were summarized then tabulated by guild. References to distance were derived from measurements obtained using Google Earth (https://www.googlecom.au/earth).

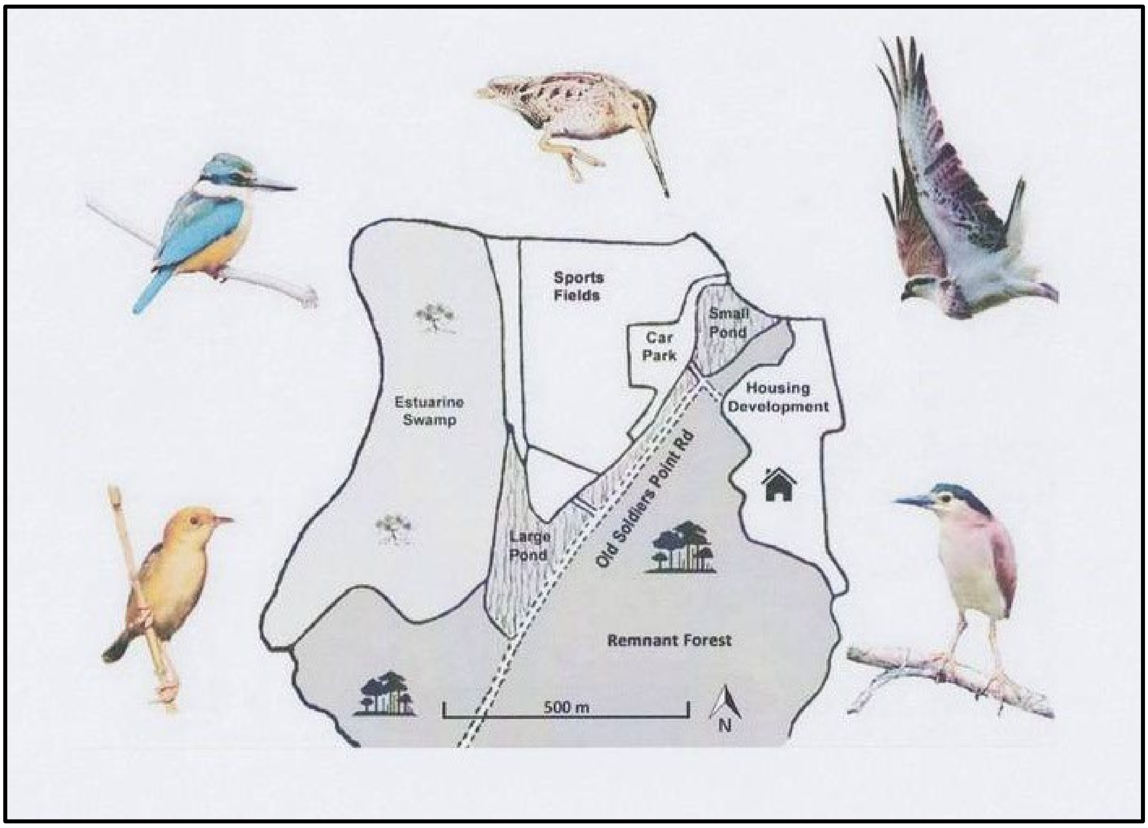

Figure 1. Salamander Waters Estate study site.

Figure 2. Salamander and Mambo study site locations (Adapted from Google Earth).

RESULTS

One hundred and thirty avian species were recorded during the 171 surveys conducted throughout the study (2008-2022). A list of all species and the associated reporting rates are presented in the **Appendix**.

The taxonomic species list was redistributed into four RR groups: >60%; <60% but >30%; <30%; and species only recorded in one data set. The results for each group are summarised in **Table 1**, in order to illustrate the relationship between guild and reporting rate. Woodland birds (90 species, 69%) predominated in all four categories, followed by waterbirds (30 species, 23%) and raptors (10 species, 8%). Seventy-four species recorded comparable RRs across both study periods (<20% variation) which would seem to indicate population stability; 27 species had increased RRs, and 29 species reported a RR decline.

The Chi-square Test identified thirteen species exhibiting highly significant population change ($\chi^2 > 6.63$) and a further five species exhibiting significant population change ($\chi^2 > 3.84$). The eighteen species, and the calculated Chi-square (χ^2) values, are presented in **Table 2**.

Four species recorded during the course of the study were found to be listed as Vulnerable in NSW (*Biodiversity Conservation Act 2016*); Osprey *Pandion haliaetus,* White-bellied Sea-Eagle *Haliaeetus leucogaster,* Glossy Black-Cockatoo *Calyptorhynchus lathami*, and Varied Sittella *Daphoenositta chrysoptera*. A further two species are listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*; Latham's Snipe *Gallinago hardwickii* and White-throated Needletail *Hirundapus caudacutus*.

A comparison between the Salamander Waters and the Mambo Wetlands studies (Fraser 2018) found that 100 of the 130 species recorded at Salamander, including five of the above six vulnerable species, were also recorded at Mambo (77 woodland birds; 16 waterbirds; 7 raptors). Those species that also were recorded at Mambo are indicated as such in the **Appendix**.

DISCUSSION

With the possible exception of the six vulnerable species, the species recorded over the course of the study were common both locally and across the Hunter Region (Williams 2020). The variety of species found was perhaps remarkable given the study site's relatively small area (~20 ha) and that it is bordered by an industrial zone, a housing development, and a well-used sporting facility, with all the associated noise and disturbance generated by human activity (Stevens & Wooding 2023).

The two ponds and connecting channel, which provide an easily accessible, permanent water supply to a variety of habitats within the study area, are perhaps the site's most important feature, particularly during drought events (Stevens & Wooding 2023).

Fraser (2018) used the same Chi-square test for his Mambo Wetlands study. Only two species showing substantial changes in RR were common to both studies: Little Corella *Cacatua sanguinea*; Lewins Honeyeater *Meliphaga lewinii*. The sites differ in size (Salamander ~20 ha; Mambo ~175 ha) and the timing of the studies did not match exactly (Salamander 15 years, 2008-2022; Mambo 20 years, 1999-2018) but there was an 11-year overlap (2008-2018). Given habitat similarities and the minimal site separation distance (~0.7 km), avian interchange between sites was considered a possibility, hence data comparison might contribute to a better overall understanding of the local avian community.

Indications of local population change suggested by the results of the two data sets should be interpreted with caution. Variations in reporting rates may be due to differences in survey methodology, and changing climatic conditions affecting water levels and blossom development. Survey discontinuity in the second half of the survey period due to COVID-19 travel restrictions and other unforeseen circumstances, may also have had a bearing on the results. While ornithological population studies tend to be imprecise, long-term statistical evidence can indicate broad trends among avian groups. The following expanded assessment of some representative species from the Salamander study's test results may suggest generalized on-site trends.

Table 1. Guild distribution of species by Reporting Rates (RR%) at Salamander Waters Estate

Guild	Total	Stable	Increase	Decline
RR >60% (32 species)				
Woodland birds	20	10	5	5
Waterbirds	11	8	3	
Raptors	1		1	
RR >30% to <60% (23 species)				
Woodland birds	18	10	3	5
Waterbirds	5		2	3
Raptors				
RR <30% (49 species)				
Woodland birds	37	35	2	
Waterbirds	8	8		
Raptors	4	3		1
Only seen on one data set (26 species)				
Woodland birds	15		8	7
Waterbirds	6		1	5
Raptors	5		2	3
Species totals	**130**	**74**	**27**	**29**

Table 2. Chi-square (χ^2) values and population trends for 18 species exhibiting significant (χ^2 >3.84) or highly significant (χ^2 >6.63) change in Reporting Rate (RR%) between the 2008-2016 and 2017-2022 surveys.

Species showing significant change	**2008-2016 Surveys**		**2017-2022 Surveys**		**χ^2 Values >3.84**	**Comments**
	RR%	**Records**	**RR%**	**Records**		
Woodland birds (3)						
Spotted Dove	81.3	87	53.1	34	4.11	Decline
Lewin's Honeyeater	29.0	31	51.6	33	4.87	Increase
Torresian Crow	39.8	42	64.1	41	4.58	Increase
Waterbirds (2)						
Eurasian Coot	42.1	45	70.3	45	5.55	Increase
Great Egret	59.8	64	34.4	22	4.66	Increase

Species showing highly significant change	**2008-2016 Surveys**		**2018-2022 Surveys**		**χ^2 Values >6.63**	**Comments**
	RR%	**Records**	**RR%**	**Records**		
Woodland birds (7)						
Crested Pigeon	42.1	45	84.4	54	11.67	Increase
Little Corella	15.9	17	62.5	40	24.72	Increase
Superb Fairy-wren	96.3	103	37.5	24	17.84	Decline
Brown Honeyeater	21.5	23	60.9	39	16.11	Increase
Spotted Pardalote	47.7	51	20.3	13	7.29	Decline
Pied Butcherbird	9.3	10	62.5	40	36.90	Increase
Australian Raven	68.2	73	23.4	15	14.75	Decline
Waterbirds (5)						
Grey Teal	17.5	19	59.4	38	19.58	Increase
Nankeen Night-Heron	42.1	45	12.5	8	10.35	Decline
White-faced Heron	23.4	25	50.0	32	7.74	Increase
Little Pied Cormorant	54.2	58	90.6	58	7.30	Increase
Australasian Darter	45.8	49	82.8	53	8.59	Increase
Raptors (1)						
Osprey	10.3	11	76.6	49	48.27	Increase

Frequently seen species (RR>60%)

Almost all the woodland birds in this group are considered to be resident species, probably breeding, and the waterbirds are considered to be regular visitors from the Port Stephens Estuary. Evidence of population decline in one woodland species in this group was of particular interest. Superb Fairy-wren *Malurus cyaneus* recorded a decline in RR of 58.8% and a highly significant χ^2 value (17.84). This species, found regularly along the edges of the now abandoned old Soldiers Point Road in the first half of the study, became something of a rarity during the second survey period, which took place after the completion of the first housing development. Off-leash dogs, e-scooters and general human disturbance may have been contributing factors; however, a 24.3% RR decline also occurred at the much quieter Mambo site (Fraser 2018). These results may support the suggestion of a potential long-term decline in this species across the Hunter Region (Williams 2020).

The Australian Raven *Corvus coronoides*, an example of a large woodland species, recorded a 44.8% decline in RR and had a highly significant χ^2 value (14.75). Steadily decreasing numbers for this species may be related to the 24.3% RR increase in Torresian Crows *Corvus orru* which had a significant χ^2 value (4.58). Torresian Crows were frequently observed chasing ravens (LW pers. obs.). The Mambo study, which did not record any Torresian Crows, showed a 12.3% RR for Australian Ravens (Fraser 2018).

Reporting rate increases in this group were generally associated with large, mobile species, such as the Little Corella *Cacatua sanguinea* (46.6% RR increase and highly significant χ^2 of 24.72). The only raptor species of interest was a resident pair of Osprey, that established a nest on a mobile phone tower overlooking the playing fields in 2015 and successfully raised a fledgling every year for the remainder of the study period. Ospreys are listed as vulnerable in NSW.

Mid-range sighting frequency (RR<60% but >30%)

Woodland birds are the predominant guild present in this group and included a mix of residents, seasonal migrants and occasional visitors. There were also five waterbird species. Among the eight species having a RR decline, the results for three woodland species were concerning (**Table 2**). Spotted Pardalotes *Pardalotus punctatus*, thought to be resident, recorded a 27.4% RR decline, and a highly significant χ^2 value (7.29). Nest burrows were found in roadside embankments in the same area inhabited by Superb Fairy-wrens (discussed above). The small pardalote population (estimated at 5-10 birds) may have been subjected to similar stress factors. The nest site may also be vulnerable to disturbance by service vehicles. While this species may be at risk at the Salamander site, the long-term trend across the Hunter Region suggests a small, but stable population more consistent with the 2.7% RR increase recorded in the Mambo data (Fraser 2018; Williams 2020).

The 26.5% RR decline in White-throated Gerygones *Gerygone olivacea* was also contrary to an 11% RR increase recorded at the Mambo site. (Fraser 2018). Long-term Hunter Region data suggests a recent population decline in this regular summer migrant (Williams 2020). It is uncertain whether the result for this species was a response to on-site change or a reflection of the regional trend. Similarly, the reason for the 15.5% RR decline in White-browed Scrubwrens *Sericornis frontalis* is not apparent. A similar unexplained change was noted at the Mambo site since 2018 (N. Fraser pers. comm.). Among the waterbirds, significant change (25.4% RR decline) was noticed in sightings of Great Egrets *Ardea alba*, thought to be irregular, solitary visitors from the Port Stephens estuary, and Nankeen Night-Herons *Nycticorax caledonicus* (29.6% RR decline) a nomadic and irruptive species. A camouflage combination of thick leafy pond-cover and cryptic plumage may have meant that roosting Night-Herons were sometimes undetected.

Species seen infrequently (RR<30%)

Trends for this group, containing the largest number of species (49), including three species listed as vulnerable in NSW and one international migrant, cannot be interpreted with certainty due to the infrequency of records. However, Fan-tailed Cuckoos *Cacomantis flabelliformis* and Azure Kingfishers *Ceyx azureus*, were not recorded during the last four years of the study, and Australasian Pipits *Anthus novaeseelandiae*, were no longer observed foraging on the site's playing fields after 2010. All three species are no longer thought to occur on site.

The small decline in Latham's Snipe (9% RR) is mentioned due to international interest in this species, but it should be noted that usually only small numbers (1-4 birds) of this migrant visited the site in drought years when low pondwater levels exposed a muddy verge with a vegetated periphery.

White-bellied Sea-Eagles *Haliastur leucogaster* (vulnerable in NSW) also registered a small decline (7.1% RR) but this species was usually observed in flight, therefore, on-site population relevance is unlikely. Bi-annual, boat-based surveys indicate a regular and increasing presence of this species in the Port Stephens Estuary (Stuart 2024).

There were one-off sightings of Glossy Black-Cockatoos *Calyptorhynchus lathami* at both the Salamander site and the Mambo site (Fraser 2018). This species, thought to be in decline across the Hunter Region, and listed as vulnerable in NSW, was probably an anomaly for both sites (Williams 2020).

Varied Sittella *Daphoenositta chrysoptera*, another vulnerable NSW species, recorded a slight increase (3.5% RR) in the second half of the Salamander study. In the second half of the Mambo study the species declined, with 2.6% RR (Fraser 2018). We suggest that the continued on-site presence of small woodland-dependent flocks of Sittellas would be adversely affected by habitat disturbance.

Additional species of interest

Three species, found just prior to the commencement of the study, or only seen in one early survey, are mentioned as further examples of small avian species that are no longer recorded at the study site, and may no longer occur in the local area. Up until late 2007, Black-fronted Dotterels *Elseyornis melanops* were regularly observed around the edges of the small pond, and were known to breed (LW pers. obs.). A single bird recorded during one 2012 survey is regarded as an anomaly. Records for Red-rumped Parrots *Psephotus haematonotus* ceased in 2008; before then they were often observed feeding on the playing fields (LW pers. obs.). Similarly, site records for Rainbow Bee-eaters *Merops ornatus* ceased in 2007 (LW pers. obs.). The absence of this species is thought to be directly related to the removal of their sand-dune nesting location, to make way for the site's Stage 1 housing development (Stevens & Wooding 2023). There was a single record for this species in the Mambo study (Fraser 2018).

CONCLUSIONS

The majority of the 130 avian species recorded during the 15 years of this study were found to be locally and/or regionally common, with woodland species predominating (90 species). Over the duration of the study, local population increase was observed in 27 species, mainly larger, more-mobile types, while evidence of decline was noted in 29 species, mostly small woodland birds. Records for five woodland species and one waterbird species ceased during the course of the study, and the populations of at least five more woodland species are thought to be at risk. While some waterbirds were known to breed on site, most are assumed to be occasional visitors from the nearby Port Stephens Estuary where populations are thought to be stable (Stuart 2020).The population of the site's only resident raptor, the Osprey, was considered stable.

While populations of larger, more-mobile species would appear to be relatively secure, the study clearly indicates the tenuous on-site situation for small woodland birds, should the indiscriminate clearing of flowering trees and shrubs and mature, hollow-bearing trees occur in order to facilitate future residential development.

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APPENDIX

Species reporting rates from surveys over two time periods at Salamander Waters Estate, 2008-2022, and an indication if the species was recorded at Mambo Wetlands during surveys 1999-2018. Species are listed in order of the number of records at Salamander Waters over 2008-2016.

Common Names	Scientific Names	2008-2016 107 Surveys		2017-2022 64 Surveys		Mambo Wetlands Record
		Records	RR%	Records	RR%	
Dusky Moorhen	*Gallinula tenebrosa*	105	98.1	64	100.0	✓
Magpie-lark	*Grallina cyanoleuca*	105	98.1	64	100.0	✓
Australian Magpie	*Gymnorhina tibicen*	105	98.1	62	96.9	✓
Laughing Kookaburra	*Dacelo novaeguineae*	103	96.3	48	75.0	✓
Superb Fairy-wren	*Malurus cyaneus*	103	96.3	24	37.5	✓
Australian Wood Duck	*Chenonetta jubata*	101	94.4	63	98.4	✓
Australian White Ibis	*Threskiornis moluccus*	101	94.4	63	98.4	✓
Rainbow Lorikeet	*Trichoglossus moluccanus*	101	94.4	62	96.9	✓
Willie Wagtail	*Rhipidura leucophrys*	99	92.5	63	98.4	✓
Pacific Black Duck	*Anas superciliosa*	99	92.5	62	96.9	✓
Yellow-faced Honeyeater	*Caligavis chrysops*	99	92.5	59	92.2	✓
Little Wattlebird	*Anthochaera chrysoptera*	99	92.5	56	87.5	✓
Purple Swamphen	*Porphyrio porphyrio*	92	86.0	46	71.9	✓
Welcome Swallow	*Hirundo neoxena*	89	83.2	49	76.6	✓
Spotted Dove	*Spilopelia chinensis*	87	81.3	34	53.1	✓
Grey Fantail	*Rhipidura albiscapa*	80	74.8	52	81.3	✓
Royal Spoonbill	*Platalea regia*	80	74.8	43	67.2	✓
Brown Thornbill	*Acanthiza pusilla*	80	74.8	39	60.9	✓
Eastern Rosella	*Platycercus eximius*	78	72.9	46	71.9	✓
Chestnut Teal	*Anas castanea*	77	72.0	48	75.0	✓
Little Black Cormorant	*Phalacrocorax sulcirostris*	77	72.0	45	70.3	
Masked Lapwing	*Vanellus miles*	73	68.2	29	45.3	✓
Australian Raven	*Corvus coronoides*	73	68.2	15	23.4	✓
Eastern Great Egret	*Ardea alba modesta*	64	59.8	22	34.4	✓
Little Pied Cormorant	*Microcarbo melanoleucos*	58	54.2	58	90.6	✓
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	58	54.2	28	43.8	✓
White-breasted Woodswallow	*Artamus leucoryn*	57	53.3	37	57.8	✓
Galah	*Eolophus roseicapilla*	52	48.6	32	50.0	✓
Noisy Miner	*Manorina melanocephala*	51	47.7	20	31.3	✓
Spotted Pardalote	*Pardalotus punctatus*	51	47.7	13	20.3	✓
Red-browed Finch	*Neochmia temporalis*	50	46.7	26	40.6	✓
Australasian Darter	*Anhinga novaehollandiae*	49	45.8	53	82.8	
Sacred Kingfisher	*Todiramphus sanctus*	47	43.9	33	51.6	✓
Crested Pigeon	*Ocyphaps lophotes*	45	42.1	54	84.4	✓
Eurasian Coot	*Fulica atra*	45	42.1	45	70.3	
Nankeen Night-Heron	*Nycticorax caledonicus*	45	42.1	8	12.5	
Silvereye	*Zosterops lateralis*	44	41.1	25	39.1	✓
Olive-backed Oriole	*Oriolus sagittatus*	43	40.2	22	34.4	✓
Common Myna	*Acridotheres tristis*	43	40.2	2	3.1	✓
Torresian Crow	*Corvus orru*	42	39.3	41	64.1	
White-throated Gerygone	*Gerygone olivacea*	40	37.4	7	10.9	✓
Variegated Fairy-wren	*Malurus lamberti*	39	36.4	24	37.5	✓

APPENDIX cont.

Common Names	Scientific Names	2008-2016 107 Surveys		2017-2022 64 Surveys		Mambo Wetlands Record
		Records	RR%	Records	RR%	
Oriental Dollarbird	*Eurystomus orientalis*	36	33.6	21	32.8	✓
White-cheeked Honeyeater	*Phylidonyris niger*	34	31.8	18	28.1	✓
Noisy Friarbird	*Philemon corniculatus*	34	31.8	12	18.8	✓
White-browed Scrubwren	*Sericornis frontalis*	35	32.7	11	17.2	✓
Lewin's Honeyeater	*Meliphaga lewinii*	31	29.0	33	51.6	✓
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	31	29.0	7	10.9	✓
White-throated Treecreeper	*Cormobates leucophaea*	28	26.2	4	6.3	✓
Whistling Kite	*Haliastur sphenurus*	27	25.2	2	3.1	✓
White-faced Heron	*Egretta novaehollandiae*	25	23.4	32	50.0	✓
Great Pied Cormorant	*Phalacrocorax varius*	25	23.4			✓
Golden Whistler	*Pachycephala pectoralis*	24	22.4	21	32.8	✓
Red Wattlebird	*Anthochaera carunculata*	24	22.4	16	25.0	✓
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	24	22.4	2	3.1	✓
Brown Honeyeater	*Lichmera indistincta*	23	21.5	39	60.9	✓
Australasian Grebe	*Tachybaptus novaehollandiae*	23	21.5	18	28.1	
Australian Pelican	*Pelecanus conspicillatus*	23	21.5	12	18.8	
Black Swan	*Cygnus atratus*	23	21.5	9	14.1	
Common Starling	*Sturnus vulgaris*	23	21.5			✓
Great Cormorant	*Phalacrocorax carbo*	22	20.6	12	18.8	
Azure Kingfisher	*Ceyx azureus*	22	20.6	2	3.1	
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	21	19.6	8	12.5	✓
Eastern Spinebill	*Acanthorhynchus tenuirostris*	20	18.7	15	23.4	✓
Hardhead	*Aythya australis*	20	18.7	14	21.9	
Grey Butcherbird	*Cracticus torquatus*	20	18.7	8	12.5	✓
Grey Teal	*Anas gracilis*	19	17.8	38	59.4	✓
Bar-shouldered Dove	*Geopelia humeralis*	18	16.8	12	18.8	✓
Australian Reed-Warbler	*Acrocephalus australis*	18	16.8	8	12.5	✓
Little Corella	*Cacatua sanguinea*	17	15.9	40	62.5	✓
Australasian Pipit	*Anthus novaeseelandiae*	17	15.9			✓
Brown Gerygone	*Gerygone mouki*	16	15.0	2	3.1	✓
Grey Shrike-thrush	*Colluricincla harmonica*	15	14.0	8	12.5	✓
Leaden Flycatcher	*Myiagra rubecula*	13	12.1	8	12.5	✓
Latham's Snipe	*Gallinago hardwickii*	13	12.1	2	3.1	
Straw-necked Ibis	*Threskiornis spinicollis*	12	11.2	15	23.4	
Eastern Yellow Robin	*Eopsaltria australis*	12	11.2	7	10.9	✓
Eastern Koel	*Eudynamys orientalis*	12	11.2	6	9.4	✓
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	12	11.2	1	1.6	✓
Osprey	*Pandion haliaetus*	11	10.3	49	76.6	✓
Rufous Whistler	*Pachycephala rufiventris*	11	10.3	22	34.4	✓
Pied Butcherbird	*Cracticus nigrogularis*	10	9.3	40	62.5	✓
Yellow Thornbill	*Acanthiza nana*	9	8.4	11	17.2	✓
Pheasant Coucal	*Centropus bengalensis*	9	8.4	1	1.6	✓

APPENDIX cont.

Common Names	Scientific Names	2008-2016 107 Surveys		2017-2022 64 Surveys		Mambo Wetlands Record
		Records	RR%	Records	RR%	
Blue-faced Honeyeater	*Entomyzon cyanotis*	8	7.5	18	28.1	✓
Australasian Figbird	*Sphecotheres vieilloti*	8	7.5	17	26.6	✓
Spangled Drongo	*Dicrurus bracteatus*	8	7.5	5	7.8	✓
Channel-billed Cuckoo	*Scythrops novaehollandiae*	8	7.5	3	4.7	✓
Eastern Whipbird	*Psophodes olivaceus*	7	6.5	5	7.8	✓
Tree Martin	*Petrochelidon nigricans*	7	6.5	5	7.8	✓
Scarlet Honeyeater	*Myzomela sanguinolenta*	6	5.6	17	26.6	✓
Sulphur-crested Cockatoo	*Cacatua galerita*	6	5.6	16	25.0	✓
Yellow-tailed Black-Cockatoo	*Zanda funerea*	6	5.6	7	10.9	✓
Musk Lorikeet	*Glossopsitta concinna*	6	5.6	1	1.6	✓
Pied Currawong	*Strepera graculina*	5	4.7	3	4.7	✓
Black-shouldered Kite	*Elanus axillaris*	5	4.7	1	1.6	✓
White-throated Needletail	*Hirundapus caudacutus*	4	3.7	7	10.9	✓
Fuscous Honeyeater	*Ptilotula fusca*	4	3.7			
Varied Sittella	*Daphoenositta chrysoptera*	3	2.8	4	6.3	✓
Brown Goshawk	*Accipiter fasciatus*	3	2.8	1	1.6	✓
Swamp Harrier	*Circus approximans*	3	2.8			✓
Brown-headed Honeyeater	*Melithreptus brevirostris*	2	1.9	5	7.8	✓
Shining Bronze-Cuckoo	*Chalcites lucidus*	2	1.9	1	1.6	✓
Buff-banded Rail	*Hypotaenidia philippensis*	2	1.9	1	1.6	✓
Little Egret	*Egretta garzetta*	2	1.9	1	1.6	✓
Brush Cuckoo	*Cacomantis variolosus*	2	1.9	1	1.6	
Pallid Cuckoo	*Heteroscenes pallidus*	2	1.9			
Plumed Egret	*Egretta plumifera*	2	1.9			
Cattle Egret	*Bubulcus ibis*	2	1.9			
Long-billed Corella	*Cacatua tenuirostris*	1	0.9			✓
Common Cicadabird	*Edolisoma tenuirostre*	1	0.9	1	1.6	
Tawny Grassbird	*Cincloramphus timoriensis*	1	0.9	1	1.6	
White-headed Pigeon	*Columba leucomela*	1	0.9			
Peaceful Dove	*Geopelia placida*	1	0.9			✓
Striated Heron	*Butorides striata*	1	0.9			
Black-fronted Dotterel	*Elseyornis melanops*	1	0.9			
Grey Goshawk	*Accipiter novaehollandiae*	1	0.9			✓
Red-rumped Parrot	*Psephotus haematonotus*	1	0.9			
Southern Emu-wren	*Stipiturus malachurus*	1	0.9			✓
Musk Duck	*Biziura lobata*			4	6.3	
Striated Thornbill	*Acanthiza lineata*			2	3.1	✓
Australian Hobby	*Falco longipennis*			1	1.6	
Peregrine Falcon	*Falco peregrinus*			1	1.6	
Glossy Black-Cockatoo	*Calyptorhynchus lathami*			1	1.6	✓
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*			1	1.6	
Striped Honeyeater	*Plectorhyncha lanceolata*			1	1.6	✓
Yellow-tufted Honeyeater	*Lichenostomus melanops*			1	1.6	
Rufous Fantail	*Rhipidura rufifrons*			1	1.6	✓
Little Grassbird	*Poodytes gramineus*			1	1.6	
Species Total: 130						

Same, same but different: A comparison of bird surveys in two areas of urban Forster, New South Wales

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Bird surveys were undertaken at two areas within urban Forster, New South Wales, totalling 19 years (01/2001 to 04/2006, 11/2008 to 04/2012 and 05/2012 to 05/2021). A total of 166 species were recorded during both surveys, of which 11 species are listed as either vulnerable or endangered. A total of 45 species were recorded breeding within either of the two survey areas.

The two survey areas (named here as Hind and Gleneon), were similar in terms of total area surveyed, total species recorded, monthly species counts and numbers of resident species. However, 58 (35%) species exhibited significant or highly significant statistical differences in abundance between the two survey areas. Differing vegetation types and differing proximity to adjacent tracts of vegetation were the main reasons, although several other factors also apply.

Located immediately east of the Hind survey area, the presence of a large tract (70+ hectares) of mature forest was considered fundamental habitat for some of the species recorded within the survey area. Additionally, permanent water in a drainage channel and constructed wetlands provided habitat and foraging opportunities for some species.

Removal of rank grassland areas within the Gleneon survey area, which is currently occurring for the construction of residential housing, potentially will detrimentally impact seven species.

INTRODUCTION

"Rapid urban expansion is considered to be one of the leading threats to global biodiversity (Aronson *et al*. 2014; Seto *et al*. 2012). Urbanisation is typically associated with natural habitat loss, alteration of ecological processes and increased anthropogenic disturbance - all of which can ultimately have a negative impact on the abundance, richness and diversity of native species (McKinney 2002)," (Plummer *et al*. 2020). From analysis of avian abundance data, systematically collected across the United Kingdom through the 'Breeding Bird Survey' scheme, Plummer *et al*. (2020) found that "The majority of species responded negatively to the composition of the built environment, their densities decreasing significantly as building (70% of species), road (61% of species) and built surface (56% of species) percentage land covers increased …". Plummer *et al*. (2020) concluded their study by emphasising the importance of interconnected natural areas within the urban environment and the benefits to both biodiversity, including birds, and the people living in those areas.

Located on the eastern side of Wallis Lake, on the lower Mid North Coast of New South Wales, Forster (**Figure 1**) was originally settled with its twin coastal village of Tuncurry, on the north-western side, during the 1870s. Following first settlement, land around the coastal edges was steadily subdivided for housing, while portions away from the coastal edges were cleared for agriculture pursuits. Fortunately, many tracts of land, marginal for farming purposes, have remained intact. Additionally, prudent planning controls by the council (currently MidCoast Council) over the years have resulted in a mosaic of vegetated parcels remaining within the residential environment, mainly along ridge tops and natural drainage areas.

Avian surveys were conducted in two locations in south Forster totalling 19 years (01/2001 to 04/2006, 11/2008 to 04/2012, and 05/2012 to 05/2021). Data from the two survey areas were compared and are presented here. The extent to which differing composition of vegetation patches within and adjacent to the survey areas may have contributed to species diversity and abundance within the two survey areas is investigated.

METHODS

Site descriptions

Both survey areas were located in urban areas of southern Forster (**Figure 2**), separated by approximately 1.1 km. For a comparison of the general make-up of each survey area, the area was broken into three parts being road, residential and reserve. Road included the road pavement and footpath areas up to residential property boundaries, residential included all privately owned developed land and reserve included public reserve space, drainage reserves and undeveloped private land.

The first survey area ("Hind SA") was centred about Hind Avenue (32.2027˚S, 152.5225˚E), south of the main shopping centre (**Figure 2**). Originally low and partially swampy land was filled and subdivided during the 1980s. Contained within this survey area were two open drains with concrete bases, surrounded by either maintained grass or by mature vegetation. Wetlands were constructed, by the local council, in each of the two open drains during 2003 and planted out with a mix of macrophyte species. These two wetlands provided additional permanent water within the survey area. Boundaries of the Hind SA were Breese Parade to the north, a main drainage channel east of Goldens Road to the east and south and The Lakes Way to the west.

Overall, the Hind SA covers 43.1 ha with road, residential and reserve areas being 4.1 (9.5%), 26.0 (60.3%) and 13.0 (30.2%) ha respectively. Reserve areas within this survey area were a mix of mown grass along the drainage reserves, macrophyte growth within the drainage channel and mature vegetation. Mature vegetation types consist of a mix of either Coastal Sands Apple-Blackbutt Forest (Sydney Red Gum *Angophora costata*, Blackbutt *Eucalyptus pilularis*) and Northern Paperbark-Swamp Mahogany Saw-sedge Forest (Swamp Mahogany *Eucalyptus robusta* and Broad-leaved Paperbark *Melaleuca quinquenervia*) (Trees Near Me 2024). Additionally, to the east of the site was a large tract (70+ ha) of the two pre-mentioned forest types.

The second survey area ("Gleneon SA") was centred about the intersection of Gleneon Drive and Greenview Place (32.2208˚S, 152.5319˚E) (**Figure 2**). Originally a dairy farm with orchards, the Gleneon SA was subdivided in the late 1980s and early 1990s. Fronting Pipers Bay, within Wallis Lake, a caravan park covers part of the southern section of the survey area and was considered residential land. Land east of Tea Tree Road and north of The Lakes Way was undeveloped rank grassland. Boundaries of the Gleneon SA are up to 350 m east of Tea Tree Road, the edge of Pipers Bay to the south, up to 100 m west of Tahiti Avenue and up to 150 m north of The Lakes Way. Birds on Wallis Lake were not included in the survey area. During early 2018, the local council constructed a small wetland within the survey area footprint and planted various macrophyte species. Growth of these aquatic plants has had mixed results; however, the wetland has provided a permanent water body within the survey area.

Figure 1. Aerial image showing location of two urban bird surveys in south Forster, NSW, with reference to Tuncurry, Wallis Lake and Booti Booti National Park. Hind = Hind Avenue survey area; Gleneon = Gleneon Drive survey area. Image courtesy of NearMaps.

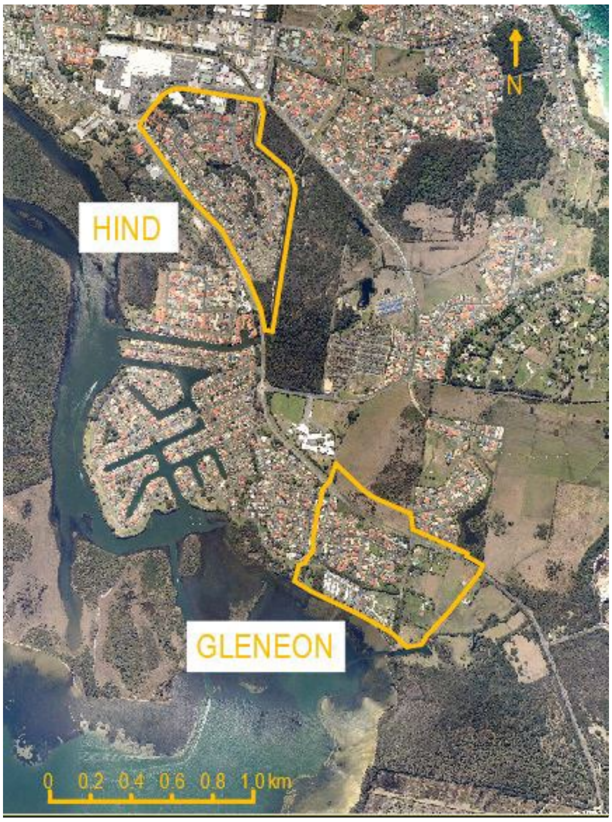

Figure 2. Aerial image showing boundaries of two urban bird surveys in Forster, NSW. Hind = Hind Avenue survey area; Gleneon = Gleneon Drive survey area. Image courtesy of NearMaps.

Overall, the Gleneon SA covers 42.3 ha with road, residential and reserve areas being 7.2 (17.0%), 15.9 (37.6%) and 19.2 (45.4%) ha respectively. Reserve within this survey area was predominately rank, sparsely grazed, grassland on undeveloped private land, areas of mown grass in public reserves and around drainage channels and small tracts of Estuarine Swamp Oak Twig-rush Forest (Trees Near Me 2024) dominated by *Casuarina glauca*. Additionally, to the north and north-east of the site were several small tracts and to the south-east a large tract of the pre-mentioned forest type.

Weather data

Rainfall and temperature data were obtained from the Bureau of Meteorology website (BOM 2024). Their nearest recording station (No. 060013) is located adjacent to Forster breakwall, north of the two survey areas (~3.4 km from Hind and ~5.5 km from Gleneon). The average rainfall for the area was 1220 mm (1896 to 2024) from an average of 89 rain days per year. The mean January and February temperatures varied by only 0.1˚C, being 26.6˚C and 26.5˚C respectively, while the mean July temperature was 18.7˚C (1999 to 2020).

Surveys and data management

Hind Avenue surveys were undertaken between January 2001 and April 2006 and then again between November 2008 and April 2012. Although Gleneon Drive surveys ranged between May 2012 and May 2021, observations between January and July 2016 were misplaced and no observations were undertaken during September 2014. Records of avian species were noted during the combination of daily morning walks and undertaking normal residential activities after work or on weekends, whilst residing in each of the two urban survey areas. Identifications were made either audibly or visually and with the aid of binoculars when required.

Birds were recorded either within or flying over each survey area. Counts for species recorded are the maximum observed at any one time. For larger flocks of birds, five- or 10-unit estimates were periodically made up to a maximum of 100 individuals. Flocks greater than 100, although rare, were recorded as 100. The capping of maximum individuals to 100 will have an impact in the overall average count for that species, however the impact is considered minimal for the purposes of these two survey areas. Although tallied on a weekly basis, records were summarised into monthly lists. These monthly summaries have been entered into the BirdLife Australia atlas (Birdata) as a 'Systematic [within] 500 m [of a central point] area search'. Recording and summarising bird observations into monthly totals will increase the survey effort for each individual month when compared to individual short timeframe surveys conducted monthly. As surveys of these two areas were undertaken in a similar format, survey effort is comparable across both areas.

Due to the differing total number of surveys within each survey area, species observations were converted to a Reporting Rate (RR) for comparison. The RR is the ratio of the number of records to the total number of surveys, expressed as a percentage. Any species with a RR greater than 79%, I considered to be resident within the survey area.

In line with Cooper *et al*. (2014), the following months were combined for seasonal migration comparisons: winter (May, June and July) and summer (November, December and January). For classification as a summer migrant, a species had to be recorded a minimum of four times during summer and at least five times more frequently than in winter (Newman 2007). For a winter migrant, this was reversed.

Breeding records were based on the following criteria: active visible nest; feeding of a dependant juvenile; observing a recently fledged juvenile; repeated visits to a nest (e.g. termitarium by a kingfisher / kookaburra) or to a small patch of vegetation (e.g. clump of grass by a fairy-wren) with food.

The differences in observation frequency for each species from the two survey areas was statistically tested using the Yates-corrected Chi-squared test (Fowler & Cohen 1994). Where the expected frequency of any species was less than 5 in either survey set, species were omitted from further testing, due to insufficient observations. For one degree of freedom, Chi-squared results between 3.84 and 6.62 are considered to be 'Significant', while over 6.63 the result is 'Highly Significant'.

Audible differentiation between Spotted *Pardalotus punctatus* and Striated *P. striatus* Pardalotes is difficult for me. As such, records were predominately by observation only and are therefore under-recorded. During my time in Hind Avenue, pardalotes were only recorded once confirmed by sight. When resident in Gleneon Drive, a 'Pardalote *sp*.' observation line was added to the bird list.

RESULTS

A complete list of species recorded is provided in the **Appendix** (available at https://www.hboc.org.au/the-whistler-volume-19/). The **Appendix** contains a list of birds recorded within each survey area and whether they were observed breeding. It also contains minimum, maximum and average numbers of individuals, overall reporting rates, seasonal reporting rates, migratory classification and any statistical differences in abundance. Overall, 166 species were recorded, with 146 and 142 recorded within the Hind and Gleneon survey areas, respectively.

The average number of species recorded monthly in each survey area was 60 (**Table 1**). This table also shows the remarkably similar results for both minimum and maximum monthly counts.

Eleven species are listed as threatened under either the NSW *Biodiversity Conservation Act 2016* (BC Act) or Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These species, along with their conservation status, are listed in **Table 2**.

Thirty-four species were classified as resident within the Hind SA, of which 16 were recorded in all surveys. Similarly, within the Gleneon SA, 35 species were resident with 18 of them recorded in every survey month. From these two data sets, 29 species were classed as resident at both survey areas. Forty-five species were recorded breeding within one or other of the two survey areas (**Table 3**).

Sixteen species were classified as summer migrants and ten species as winter migrants into either of the two survey areas (**Table 4**). Only seven of the 26 species were migrants into both survey areas.

The Chi-squared test of significance produced nine significant and 49 highly significant differences to the observation of species in the survey areas, which is 35% of the overall species recorded. Twenty-seven differences applied to species in the Hind SA (**Table 5**) and 31 applied to species in the Gleneon SA (**Table 6**). Further commentary on these differences is made within the discussion section of this paper.

Table 1. Summary of monthly averages of birds recorded within two survey areas in urban Forster.

Month	Hind Avenue				Gleneon Drive			
	n	Average	Min	Max	*n*	Average	Min	Max
January	10	64	47	74	8	60	51	67
February	10	59	43	70	8	57	41	67
March	10	56	38	69	8	60	50	64
April	10	56	41	74	8	61	56	70
May	8	58	47	69	8	62	56	68
June	8	57	47	67	8	58	42	66
July	8	60	46	69	8	60	45	65
August	8	62	48	72	9	60	48	67
September	8	62	46	78	8	57	36	73
October	8	66	55	80	9	63	55	74
November	9	61	49	72	9	63	55	76
December	9	60	48	72	9	61	55	72
Total	106	60	38	80	100	60	36	76

Table 2. Species recorded in either of the two urban Forster survey areas and listed as either vulnerable or endangered under the NSW *Biodiversity Conservation Act 2016* (BC Act) or vulnerable or critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). E = endangered, V = vulnerable, CE = critically endangered and V1 = vulnerable.

Species	BC Act		EPBC Act	
	E	V	CE	V1
Wompoo Fruit-Dove		Yes		
White-throated Needletail				Yes
Black Bittern		Yes		
Bar-tailed Godwit				Yes
Latham's Snipe		Yes		
Osprey		Yes		
Square-tailed Kite		Yes		
Spotted Harrier		Yes		
White-bellied Sea-Eagle		Yes		
Swift Parrot	Yes		Yes	
Little Lorikeet		Yes		
Totals	**1**	**8**	**1**	**2**

Table 3. List of species recorded breeding within either of the two urban Forster survey areas. HA = Hind Avenue and GD = Gleneon Drive.

Species	HA	GD	Species	HA	GD
Australian Wood Duck	Yes		Striped Honeyeater	Yes	
Pacific Black Duck	Yes		Little Wattlebird	Yes	Yes
Chestnut Teal	Yes		Red Wattlebird	Yes	Yes
Spotted Dove	Yes	Yes	Yellow-faced Honeyeater	Yes	
Crested Pigeon	Yes	Yes	Noisy Miner		Yes
Tawny Frogmouth	Yes	Yes	Yellow Thornbill	Yes	
Eastern Koel	Yes		Australasian Figbird	Yes	Yes
Channel-billed Cuckoo	Yes		Olive-backed Oriole	Yes	Yes
Lewin's Rail		Yes	Black-faced Cuckoo-shrike	Yes	
Buff-banded Rail		Yes	Pied Currawong	Yes	Yes
Purple Swamphen	Yes		Australian Magpie	Yes	Yes
Dusky Moorhen	Yes		Pied Butcherbird	Yes	
White-faced Heron	Yes	Yes	Grey Butcherbird	Yes	Yes
Masked Lapwing		Yes	Willie Wagtail	Yes	
Southern Boobook	Yes		Leaden Flycatcher	Yes	
Oriental Dollarbird	Yes	Yes	Magpie-lark	Yes	Yes
Sacred Kingfisher	Yes		Torresian Crow	Yes	Yes
Laughing Kookaburra	Yes		Tree Martin	Yes	
Galah	Yes		Welcome Swallow	Yes	Yes
Eastern Rosella	Yes	Yes	Common Starling	Yes	
Rainbow Lorikeet	Yes		Common Myna	Yes	Yes
Scaly-breasted Lorikeet	Yes		House Sparrow	Yes	
Superb Fairy-wren	Yes		**Total**	**41**	**21**

Table 4. Species classified as either summer or winter migrants within either of the two urban Forster survey areas, with a comparison to the 2019 HBOC Annual Bird Report (ABR; Williams 2020). Altitudinal migrant (AM), resident (R), summer migrant (SM) and winter migrant (WM)

Species	Hind Avenue		Gleneon Drive		Status ABR
	Summer	Winter	Summer	Winter	
Grey Teal		WM			R
Topknot Pigeon		WM			R
White-throated Needletail	SM		SM		SM
Eastern Koel	SM		SM		SM
Channel-billed Cuckoo	SM		SM		SM
Straw-necked Ibis		WM		WM	R
Nankeen Night-Heron	SM				R
Cattle Egret				WM	R
Latham's Snipe	SM		SM		SM
Whistling Kite		WM			R
Brahminy Kite	SM				R
Rainbow Bee-eater			SM		SM
Oriental Dollarbird	SM		SM		SM
Azure Kingfisher		WM			R
Sacred Kingfisher	SM				SM
White-cheeked Honeyeater			SM		R
Eastern Spinebill		WM			R
Olive-backed Oriole			SM		R
Golden Whistler				WM	R
Grey Shrike-thrush				WM	R
White-breasted Woodswallow	SM		SM		SM
Rufous Fantail	SM				SM
Leaden Flycatcher	SM				SM
Rose Robin				WM	AM
Australian Reed-Warbler	SM				SM
Silvereye			SM		R
TOTAL	**12**	**6**	**10**	**5**	**26**

Table 5. Results of Chi-squared (χ^2) test of species between two survey areas in southern Forster applying to the Hind Avenue survey area. See Methods for survey area descriptions. HA = Hind Avenue and GD = Gleneon Drive

Species	Number of Records		χ^2	Statistical Significance
	HA	GD		
Grey Teal	11	1	6.24	Significant
Chestnut Teal	81	26	24.22	Highly Significant
Peaceful Dove	38		33.93	Highly Significant
Purple Swamphen	106	59	10.29	Highly Significant
Dusky Moorhen	106		98.07	Highly Significant
Striated Heron	13		10.40	Highly Significant
Great Egret	93	58	5.81	Significant
Southern Boobook	74	15	34.52	Highly Significant
Azure Kingfisher	28		24.51	Highly Significant
Sacred Kingfisher	47	2	37.02	Highly Significant
Peregrine Falcon	17		14.15	Highly Significant
Sulphur-crested Cockatoo	106	70	5.08	Significant
Variegated Fairy-wren	40	13	11.29	Highly Significant
White-cheeked Honeyeater	82	16	39.44	Highly Significant
Spotted Pardalote	55	1	47.16	Highly Significant*
Striated Pardalote	39	3	27.19	Highly Significant*
Grey Shrike-thrush	56	20	14.16	Highly Significant
White-bellied Cuckoo-shrike	25		21.68	Highly Significant
Spangled Drongo	77	24	23.85	Highly Significant
Leaden Flycatcher	33	4	19.61	Highly Significant
Australian Raven	33	8	12.70	Highly Significant
Australian Reed-Warbler	18	2	10.40	Highly Significant
Tree Martin	20	5	7.05	Highly Significant
Silvereye	51	22	9.18	Highly Significant
Common Starling	59	19	17.31	Highly Significant
Red-browed Finch	52	27	5.97	Significant
House Sparrow	67	1	58.45	Highly Significant
Total species	**27**			

* The highly significant statistical result for both pardalote species may not be accurate, due to the author's poor audible differentiation skills.

Table 6. Results of Chi-squared (χ^2) test of species between two survey areas in southern Forster applying to the Gleneon Drive survey area. See Methods for survey area descriptions. HA = Hind Avenue and GD = Gleneon Drive

Species	Number of Records		χ^2	Statistical Significance
	HA	GD		
Brown Quail		11	9.69	Highly Significant
Black Swan	1	10	6.30	Significant
Tawny Frogmouth	36	59	6.46	Significant
Pheasant Coucal	4	50	40.20	Highly Significant
Buff-banded Rail	1	21	17.55	Highly Significant
Straw-necked Ibis	30	53	7.19	Highly Significant
Cattle Egret	8	42	23.76	Highly Significant
White-necked Heron	4	14	5.04	Significant
Silver Gull	2	19	13.15	Highly Significant
Osprey	23	38	4.08	Significant
Black-shouldered Kite	25	51	9.75	Highly Significant
Square-tailed Kite		15	13.91	Highly Significant
Swamp Harrier	2	19	13.15	Highly Significant
White-bellied Sea-Eagle	44	79	11.49	Highly Significant
Whistling Kite	26	51	8.95	Highly Significant
Rainbow Bee-eater		48	48.84	Highly Significant

Table 6 continued

Species	**Number of Records**		χ^2	**Statistical Significance**
	HA	**GD**		
Australian Hobby	20	44	9.67	Highly Significant
Musk Lorikeet	7	22	7.61	Highly Significant
Satin Bowerbird	34	58	7.17	Highly Significant
Blue-faced Honeyeater	7	89	73.21	Highly Significant
Noisy Friarbird	41	66	6.88	Highly Significant
Eastern Spinebill	24	49	9.36	Highly Significant
Noisy Miner	47	100	21.57	Highly Significant
Brown Thornbill	41	66	6.88	Highly Significant
Pardalote *sp*.		13	11.80	Highly Significant*
Eastern Whipbird	5	50	37.84	Highly Significant
White-breasted Woodswallow	30	64	13.60	Highly Significant
Rose Robin	3	12	4.75	Significant
Golden-headed Cisticola	2	31	25.44	Highly Significant
Tawny Grassbird		54	55.20	Highly Significant
Mistletoebird	44	86	15.44	Highly Significant
Total species	**31**			

* The highly significant statistical result for both pardalote species may not be accurate, due to the author's poor audible differentiation skills.

DISCUSSION

As indicated in the site description section above, there are differences in habitat structure, both within and adjacent to each survey area. These differences may, in part, have influenced the avifaunal population of each survey area resulting in statistical differences for 58 species.

Of the 27 statistical differences for species from the Hind SA, four are significant and 23 highly significant. However, two highly significant differences are for the two pardalote species. Located within the Hind Avenue survey area are two constructed wetlands and a drainage channel. These permanent water sources provided foraging opportunities and breeding habitat for eight species recording statistical differences. Water depth within the drainage channel was generally less than 500 mm, except during flooding events. From time to time, macrophyte vegetation in the drainage channel, dominated by cumbungi *Typha latifolia*, was mown by council.

Chestnut Teal *Anas castanea* was recorded just below resident status (RR 76%) within the Hind SA. In contrast, Grey Teal *Anas gracilis*, with a RR of just 10%, was considered a winter migrant. Cooper *et al*. (2014) noted that "… it [Grey Teal] vacates much of the higher-altitude parts of the State [NSW] … during June and July". Grey Teal favoured the drainage channel.

Both Purple Swamphen *Porphyrio porphyrio* and Dusky Moorhen *Gallinula tenebrosa* were recorded as resident and breeding. Macrophyte growth, in the drainage channel to the east, and the maturing vegetation within the constructed wetlands, provided ideal habitat for the two species in the Hind SA. Recently, following maturation of the constructed wetland, Purple Swamphen has become a breeding resident in the Gleneon SA. Two other waterbird species, Striated Heron *Butorides striata* and Great Egret *Ardea alba*, were predominately observed in the drainage channel.

With a RR of 26%, Azure Kingfisher *Ceyx azureus* was classed as a winter migrant within the Hind SA. Although considered a resident species (Higgins 1999; Williams 2020), Higgins states: "Some movements of adult associated with breeding …" and "Seasonality in occurrence apparent in some areas". Conversely, Australian Reed-Warbler *Acrocephalus australis* was recorded as a summer migrant. Again, macrophyte growth within the drainage channel provided suitable habitat.

As mentioned in the site description, a large tract of mature forest, with developed understorey, is located adjacent to the Hind SA. Six species are considered to have recorded statistical differences as a direct result of this large tract of vegetation providing suitable habitat. These species were mainly recorded adjacent to the tract, with some foraging slightly distant, but mostly retreating back into the forest.

Three species, Variegated Fairy-wren *Malurus lamberti,* Silvereye *Zosterops lateralis* and Red-browed Finch *Neochmia temporalis*, were recorded at, or just below, moderate RR and mostly along and adjacent to the drainage channel / forest interface. Transient in nature, Silvereyes were most often recorded along the edge of the understorey, which consisted mainly of Lantana *Lantana camara*. Both Variegated Fairy-wren and Red-browed Finches were often recorded within the grass along the drainage channel, retreating into the understorey when disturbed.

White-cheeked Honeyeaters *Phylidonyris niger* were recorded at just below resident status (RR 77%) in the Hind SA. Conversely, within the Gleneon SA, they appeared predominantly during flowering events by callistemon species in spring (RR 35%) and into summer (RR 19%) resulting in a summer migrant classification. Within Booti Booti National Park, to the south of the Gleneon SA, the species is a breeding resident (Turner 2020). This suggests that the presence of the adjacent forest provided suitable habitat to sustain the species throughout the year.

Grey Shrike-thrush *Colluricincla harmonica* was recorded at moderate rates (RR 53%). Generally, within Booti Booti National Park, they are resident (Turner 2020), however unpublished data by Turner records them at similar rates (RR 48%) on Cape Hawke, part of the National Park, approximately 8 km to the east of the Hind SA. Cooper *et al*. (2020) reported a general decrease in RR for the species within NSW, between 1986 and 2006. They also stated that Grey Shrike-thrushes tend to inhabit remnant vegetation with understorey and not small patches (say <10 ha). Grey Shrike-thrushes are adversely affected by the presence of Noisy Miners *Manorina melanocephala* (Grey *et al*. 1997; Debus 2008). RR for Noisy Miners in the Hind SA was 44%, however in the Gleneon SA, the RR was 100%.

During surveys within Booti Booti National Park (1985-1988 and 2012-2015), Turner (2020) recorded White-bellied Cuckoo-shrike *Coracina papuenis* only once. Within the Hind SA, the species was recorded at a low rate (RR 24%) and not at all within the Gleneon SA. Although preferred habitats are open type sclerophyll forests or woodlands in drier areas, along the coast they include paperbark forests with Broad-leaved Paperbark as a typical tree species (Cooper *et al.* 2020).

The remaining 13 species, recording statistical differences within the Hind SA, are not considered direct beneficiaries of the adjacent forest or the permanent water. These species are more generalists in nature, however the existence of mature vegetation did contribute to the presence of some species.

Southern Boobook *Ninox boobook* was recorded just below resident status (RR 70%) and breeding within the Hind SA. One pair was regularly observed and bred in a large hollow of a Sydney Red Gum in the northern portion of the survey area, while a second pair was known to roost in the southern portion, within a residential backyard.

Both Sacred Kingfisher *Todiramphus sanctus* and Leaden Flycatcher *Myiagra rubecula* were recorded as summer migrants and breeding. A mix of mature trees and partially cleared understorey within the drainage reserves, and termitariums for the kingfisher, provided the ideal habitat for these species, during their stay.

Although possibly nesting on a telecommunications tower on the eastern side of the large tract, Peregrine Falcon *Falco peregrinus* was only recorded at a moderately low rate (RR 16%). The species most likely opportunistically hunted avian species within the Hind SA. Generally silent in behaviour, and observations often fleeting, peregrines were most likely under-recorded in the area.

Sulphur-crested Cockatoo *Cacatua galerita* was resident (RR 100%) within the Hind SA, while achieving a 70% RR within the Gleneon SA. Additionally, average numbers of individuals varied between the two survey areas, being nine and three respectively. Feeding by residents, within the Hind SA, contributed to the increased observations there.

Although recorded within both survey areas, Spangled Drongo *Dicrurus bracteatus* had a RR of 73%, just below resident status within the Hind SA and moderately low (RR 24%) within the Gleneon SA. Drongos benefitted from some periodic feeding by residents, within the Hind SA, and potentially the presence of more mature trees throughout the survey area. Within the Hunter Region, drongos have long been regarded as winter migrants or birds of passage (Hunter Region Annual Bird reports 1-26), however Williams (2020) states them as "Resident in the north of the Region, but typically absent from the south in summer". Cooper *et al.* (2020) suggests a possible southward and lower altitudinal range extension for breeding in response to temperature increases.

Three species of corvid are likely to be recorded within the Forster area. At times, vocalisations of the individual species can be difficult to differentiate, with Torresian Crows *Corvus orru* in particular known to produce a wide range of calls (pers. obs.). Within the Hind SA, loose flocks of up to 20 corvids were observed flying overhead at dusk, particularly during winter. It is suspected that an area of natural bushland, approximately 500 m north and surrounding the water supply reservoir, is a roost site. As the majority of those aggregations were silent, those observations were not included. It is likely that corvid species were under recorded within the Hind SA.

Although Tree Martin *Petrochelidon nigricans* was only recorded at moderately low levels (RR 19%) in the Hind SA, it was also recorded breeding. Birds were observed utilising small hollows in mature Blackbutts.

Overall, Common Starling *Sturnus vulgaris* was recorded moderately (RR 56%) within the Hind SA and also breeding. Within the Gleneon SA, their RR was moderately low (19%). However, over the duration of the Hind survey, starling flock sizes decreased. Based on annual NSW Bird Reports, Common Mynas *Acridotheres tristis* did not arrive in the Forster area until December 2001 (Higgins *et al*. 2006), however, records within the Hind SA commenced in September 2001. After arrival, increases in myna flock sizes correlated with the decrease of starling flock sizes. Records of starlings within the Gleneon SA were predominately of a small population utilising a shallow open drain for drinking. Post surveys, sightings of starlings within Forster have almost ceased (pers. obs.). Williams (2020) suggests a "… potential decline …" within the Hunter Region generally.

House Sparrow *Passer domesticus* was recorded moderately often (RR 63%) within the Hind SA and breeding. Only a single sparrow observation was made within the Gleneon SA, most likely a transient individual. Similar to the decline of Common Starlings, only several small flocks of sparrows remain within Forster.

Of the 31 statistical differences that applied to species in the Gleneon SA, five are significant and 26 highly significant. Thirteen of these species, that have recorded statistical differences, utilized the grazing paddocks and rank grassland habitat within and adjacent to the survey area. However, nearly 15 ha (35.2%) considered reserve (paddocks and grasslands) within this paper, are currently being developed and this will severely impact the abundance of the majority of those species in the future.

Both Brown Quail *Synoicus ypsilophorus* and Buff-banded Rail *Hypotaenidia philippensis* were only recorded at low (RR 11%) to moderately low (RR 21%) rates, respectively. Due to their cryptic nature, they are most likely to have been under-recorded. Conversely, Pheasant Coucal *Centropus phasianinus* was recorded with a RR of 50% overall, and a RR of 88% in summer. All three species favoured the areas of rank grassland and adjacent estuarine Swamp Oak Twig-rush Forest. However, Buff-banded Rail, sometimes with dependant young, was also sighted in residential gardens, with suitable habitat. Rank grassland also provided suitable habitat for both Golden-headed Cisticola *C. exilis* (RR 31%) and Tawny Grassbird *Cincloramphus timoriensis* (RR 54%).

Straw-necked Ibis *Threskiornis spinicollis* was recorded as a winter migrant in both survey areas, however the average in the Gleneon SA (12) was twice that of the Hind SA (6). The presence of some livestock, at times, also provided foraging opportunities for Cattle Egret *Bubulcus ibis*, which was also recorded as a winter migrant in the Gleneon SA. White-necked Heron *Ardea pacifica* was recorded in low rates (RR 14%) within the paddocks.

Four raptors benefitted from hunting over the rank grassland areas; Black-shouldered Kite *Elanus axillaris*, Square-tailed Kite *Lophoictinia isura*, Swamp Harrier *Circus approximans* and Australian Hobby *Falco longipennis*. Turner (2020) noted a highly significant statistical decrease in RR of Black-shouldered Kites within Booti Booti National Park, over the period from 1985 to 2015. From personal observations, only a single pair is present in the Forster area and they breed on an active cattle property north-east of the Gleneon SA.

Classified as a summer migrant within both survey areas, White-breasted Woodswallows *Artamus leucorynchus* forage preferably over the open habitat of the Gleneon SA. Recorded at resident status during spring, summer and autumn, its overall RR averaged 64%.

As mentioned in the site description, Pipers Bay, which is a large embayment of the Wallis Lake system, is located immediately south of the Gleneon SA. Although birds on Wallis Lake were not included in the survey area, five species observed within the survey area are considered to have recorded statistical differences due to the proximity of the bay.

Although Black Swans *Cygnus atratus* are regularly observed foraging and loafing in Pipers Bay (pers. obs.), they were only recorded at a low rate (RR 10%) within the survey area. Also recorded at a moderately low rate (RR 19%) was Silver Gull *Larus novaehollandiae*. This species is most likely under-recorded, with birds traversing between Wallis Lake and local Pacific Ocean beaches, for roosting and foraging opportunities, silently at height or at night. Turner (2020) recorded them as residents within Booti Booti National Park.

Three species of raptors were also recorded more regularly based on the proximity of Pipers Bay to the Gleneon SA. Nesting on the same telecommunications tower that the Peregrine Falcon is suspected of nesting on, east of the large tract of forest, Ospreys *Pandion haliaetus* were regularly observed transporting sticks and fish overhead during the winter, spring and summer periods with an overall RR of 38%. Whistling Kite *Haliastur sphenurus* was recorded at a moderate rate (RR 51%) while White-bellied Sea-Eagle *Haliaeetus leucogaster* was recorded just below resident status (RR 79%). Both Osprey and White-bellied Sea-Eagle are listed as vulnerable under the BC Act (2016).

The remaining twelve species recording statistical differences within the Gleneon SA, are not considered direct beneficiaries of either the rank grassland or proximity to Pipers Bay and are more generalists in nature.

Overall, Tawny Frogmouths *Podargus strigoides* had RRs of 34% and RR 59% within the Hind and Gleneon survey areas, respectively. However, the spring RRs were higher, being 42% and 81%. They also bred regularly within both survey areas. They are generally considered a sedentary species and occupying permanent territories (Kaplan 2007; Rae 2009). However, Cooper *et al*. (2014) noted differences in monthly reporting rates between winter and spring / summer and suggested that birds are more active and vocal during the breeding season, possibly leading to observer bias. Locating roosting birds during autumn and winter proved more difficult than during spring and summer. Additionally, Tawny Frogmouths show high site fidelity when breeding (Higgins 1999) and, as such, once a nest was located, the area was regularly checked during the breeding season.

Classified as a summer migrant, observations of Rainbow Bee-eater *Merops ornatus* were in the Gleneon SA only. Generally, birds were initially heard and then sighted traversing over the survey area, generally either early in the morning or late in the evening. Observations of this species, within the Gleneon SA, may be a result of proximity to available nesting areas, rather than providing preferential foraging habitat.

The vast majority of observations of Musk Lorikeet *Glossopsitta concinna*, within the Gleneon SA (RR 22%), were tied to flowering events. It could be expected that with more mature trees, and greater variety, within the Hind SA, more observations would have been recorded than the resultant 7% RR. Another species producing a surprising statistical result was Satin Bowerbird *Ptilonorhynchus violaceus*. Although found in a variety of habitats, from rainforests to modified urban parks and gardens (Higgins *et al*. 2006; Cooper *et al*. 2016), greater distance between trees within the Gleneon SA provided more opportunities to observe bowerbirds, with a resultant RR of 58%.

Five of the thirteen species of honeyeater recorded within both survey areas produced highly significant statistical differences. One species, White-checked Honeyeater, was previously mentioned within the Hind SA and the remaining four are within the Gleneon survey area. There was a stark difference in recording rates of Blue-faced Honeyeater *Entomyzon cyanotis* between the two survey areas. Recorded at resident status (89%) within the Gleneon SA, mobile juvenile birds observed during summer also suggests that the species bred in close proximity. A RR of just 7% within the Hind SA, was similar to what Turner (2020) recorded within Booti Booti National Park during the first survey period (1985 to 1988) and the second Birds Australia Atlas survey between 1998 and 2002 (Barrett *et al*. 2003).

Overall, observations of Noisy Friarbird *Philemon corniculatus* within the Gleneon SA produced a RR of 66%. Spring, summer and autumn RRs were very similar, being 69%, 69% and 75% respectively, with the winter RR being only 50%. However, the average individual count for spring, summer and autumn was only 3, while for winter, counts averaged 11. Although Turner (2020) suggested that the Booti Booti National Park isthmus does not support migrating Yellow-faced Honeyeaters *Caligavis chrysops*, increased counts of friarbirds, particularly during May, suggests that this conduit is suitable for this larger honeyeater species.

Within the Hind SA, Eastern Spinebill *Acanthorhynchus tenuirostris* was recorded with a low overall rate (RR 23%) and as a winter migrant. However, within the Gleneon SA, it was recorded moderately frequently (RR 49%) overall but at resident status (RR 83%) during winter. It is considered a common resident species within the Hunter Region (Williams 2020). Higgins *et al*. (2001) and Cooper *et al*. (2020) both suggest there are influxes of birds in some locations during winter.

The fifth honeyeater species with a statistically significant difference was Noisy Miner *Manorina melanocephala*, with a RR of 100% within the Gleneon SA and only 44% within the Hind SA. The simpler vegetation structure within the Gleneon SA is consistent with the miner's preferred habitat.

Observed foraging in the Swamp Oak patches on the northern side of the Gleneon survey area, Brown Thornbill *Acanthiza pusilla*, had a moderately high RR of 66%, compared to the RR of 39% within the Hind SA.

Eastern Whipbird *Psophodes olivaceus* was recorded moderately frequently (RR 50%) within the Gleneon SA. Although only recorded in low numbers, there were sufficient records of Rose Robin *Petroica rosea* to be classified as a winter migrant in the Gleneon SA. Post-survey, suitable habitat for both these species has been substantially reduced.

Within the Hind SA, Mistletoebird *Dicaeum hirundinaceum* was recorded moderately frequently (RR 42%) while within the Gleneon SA, it was considered resident (RR 86%). Similar to Musk Lorikeets and Satin Bowerbirds, the greater recording rates for Mistletoebird within the Gleneon SA is surprising, considering that mature vegetation is sparser.

CONCLUSIONS

The two survey areas were similar in terms of total area surveyed, total species recorded, monthly species counts and numbers of resident species. However, differing vegetation types and differing proximity to adjacent tracts of suitable habitat at the two sites resulted in about one-third of all species having significant or highly significant statistical differences in abundance, although two of those results can be attributed to other factors.

A large tract of mature forest located immediately east of the Hind survey area seems to be fundamental habitat for some of the species recorded within the survey area. The presence of numerous mature trees within the survey area, even without understorey in some locations, provides an additional foraging area for resident species and a stepping stone for transient species passing through. Additionally, permanent water in the drainage channel and constructed wetlands provided habitat and foraging opportunities for some species.

The loss of suitable habitat due to clearance of rank grassland areas within the Gleneon survey area, which is currently occurring for construction of residential housing, potentially will detrimentally impact seven species: Brown Quail, Pheasant Coucal, Buff-banded Rail, Black-shouldered Kite, Variegated Fairy-wren, Golden-headed Cisticola and Tawny Grassbird. Several other species are also likely to be impacted. Ongoing surveys, as development occurs within the Gleneon survey area, and a comparison with the data presented here, will provide a summary of impacts of the residential development into the future.

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Appendix. List of species recorded during two urban Forster bird surveys, including reporting rates.
This is available online https://www.hboc.org.au/the-whistler/whistler-19/.

Purple Swamphen: recorded significantly more often at the Hind Avenue site in Forster than at the Gleneon Drive site (photo: Ashley Carlson).

Probable successful double brooding and brood overlapping in the Galah in the Hunter Region, New South Wales

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INTRODUCTION

The Galah *Eolophus roseicapillus* is a small pink and grey cockatoo which is common in grassland and agricultural areas (Higgins 1999). Galahs are monogamous, and pairs usually stay together until one mate dies (Pidgeon 1970). They nest in tree hollows and re-use them in successive years. Galahs usually lay 3-5 eggs from late July or early August to early November (Higgins 1999). Rarely, two females may lay in the same nest (Rowley 1990). The mean interval between eggs is 2.66 days and the median incubation period is 23.4 days (Rowley 1990). The mean nestling period is 49.4 days (Rowley 1990) to 52 days (Smith & Saunders 1986).

Double brooding occurs when females begin a second clutch after successfully raising their first clutch (Trnka & Samaš 2023). Monogamous double brooding occurs when the female re-nests with the same mate (Dowding *et al*. 1999). A female's decision to initiate a second clutch may be influenced by the length of the breeding season, laying date of the first clutch and size of the first clutch (Trnka & Samaš 2023). Double brooding may increase seasonal or lifetime reproductive success (Burley 1980). It is common in many bird species, including Barn Owls *Tyto alba* (Jackson & Cresswell 2017), Little Penguins *Eudyptula minor* (Rowe *et al.* 2020) and Malaysian Plovers *Charadrius peronii* (Yasué & Dearden 2008). It has been reported in Carnaby's Cockatoo (Johnstone *et al*. 2024), but this record is disputed (Saunders & Mawson 2024). Double brooding has also been reported in captive parrots, when conditions are favourable (McGrath 1993).

Brood overlapping occurs when females begin a second clutch before successfully raising their first clutch (Blomqvist *et al*. 2001; Burley 1980; Hill 1986; Surmacki & Podkowa 2022). It is rare when it occurs in the same nest and occurs more often in nest boxes (Surmacki & Podkowa 2022).

Galahs may lay a replacement clutch 12 to 18 days after complete failure of eggs or loss of small young (Rowley 1990). McGilp (1923) and Sindel & Lynn (1989) suggested that Galahs may double brood in good seasons but Rowley (1990) disputes this. Recently, this long-term study found that Galahs may engage in brood overlapping (Pryor 2023).

This note from the present longitudinal study (2002 to 2024 inclusive) describes the successful fledging of one chick from each of two successive overlapping clutches in the same nest box at Thornton (32º24'S 150º38'E), New South Wales. It also provides an update on fledging times of Galah chicks fledged from nest boxes in our suburban backyard.

METHODS

In August 2024, wild Galahs nested in a nest box (Dengate 1997) installed 5.5 m above the ground on a steel pole in our backyard (see Figures 2, 6 in Pryor 2024), near native plants including a *Eucalyptus* sp. (approximately 21 m tall), *Callistemon* spp., *Banksia* spp. and *Grevillea* spp. The nest box had not been cleaned or sprayed for lice and mites since the previous breeding season.

Before a previous breeding season, a wireless webcam had been mounted in the ceiling of the nest box to relay digital video and still images to our mobile phones and computers. Unfortunately, after the first brood of 2024 hatched, it was discovered that the camera was covered with spider web. It was decided to not clean it as this would disturb the nesting birds. Faint images were only possible early on a sunny morning when light entered the nest box.

Photographs of Galah chicks looking out of the nest box were taken with a Canon 5D Mark IV camera with a Sigma 150-600 mm f/5-6.3 DG OS contemporary lens and processed using Canon Digital Photo Professional 4 (www.canon.com).

Sunrise and sunset times were obtained using an online geodetic calculator (Geoscience Australia 2025).

Fledging times relative to sunrise and sunset times were calculated by hand. The nestling periods were estimated using nest box camera observations of eggs and chicks and first sounds of newly hatched young.

For fledging competence, 'flew strongly away' was defined as: dropped < 2 m when it first leapt from the nest box, gained altitude once flying and maintained or increased altitude until out of sight.

RESULTS

Opportunistic observations made during the 2024 breeding season are summarised in **Table 1**.

On 9 August 2024, it was assumed that a clutch had been started because an adult Galah slept in the nest box. The number of eggs was not known. Four chicks hatched (**Figure 1**) but only one chick survived to fledge (**Figure 2**). At 0533 h on 24 October 2024, at approximately 45 days of age, Chick 1/2024 flew strongly away with the female parent only.

Figure 1. Clutch 1: On 22 September 2024, four small young were in the nest box. The numbers are on the heads of the chicks. (Webcam mounted in ceiling of nest box was covered with spider web, resulting in poor quality images inside the nest box.)

One day later, on 25 October 2024, a second clutch containing three eggs was discovered in the same nest box (**Figure 3**). Only one chick from the second clutch survived to fledge (**Figures 4, 5, 6**). At 0503 h on 13 January 2025, at approximately 57-62 days of age, Chick 2/2024 flew strongly away with both parents.

Figure 2. Clutch 1: Chick 1/2024 with the female parent at 0442 h on 24 October 2024.

From 2008 to 2024 inclusive, 29 Galah chicks fledged (**Table 2**). The fledging of 24 of those chicks was observed and the exact times were recorded. Seventeen chicks (71%) fledged in the morning, and 15 of the 17 (88.2%) fledged within 120 min after sunrise. The average fledging time for all 17 morning-fledging chicks was 61 min after sunrise (**Table 2**). The other seven chicks (29%) fledged in the late afternoon and five of these seven (71.4%) fledged within 120 min before sunset. The average fledging time for all seven afternoon-fledging chicks was 88 min before sunset. Overall, 83.3% of chicks fledged either within 120 min of sunrise or 120 min of sunset (**Table 2**). The ratio of morning-fledging chicks to afternoon-fledging chicks is approximately 5:2.

Figure 3. Clutch 2: On 25 October 2024, three eggs were in the nest box. The numbers are above the eggs.

Figure 4. Clutch 2: On 3 November 2024, only one egg could be seen. The number is above the egg.

Figure 5. Clutch 2: On 14 December 2025, one chick, Chick 2/2024, was in the nest box. The number is in front of the beak of the chick.

Figure 6. Clutch 2: Chick 2/2024 with the male parent at 0826 h on 11 January 2025.

DISCUSSION

This appears to be only the second report of Galahs beginning a second clutch before a chick from their first clutch has fledged (Pryor 2023). Furthermore, this appears to be the first report of Galahs successfully raising at least one chick from each of two successive overlapped clutches in the same nest box.

It is assumed that the same Galah pair laid both clutches and successfully raised both chicks. Galahs show nest-site fidelity and after complete nest failure, the majority will lay a replacement clutch in the same hollow (Rowley 1990). Although Rowley (1990) reported two clutches of 10 eggs and one clutch of 11 eggs arising from two females laying in the same nest, I could find no reports of a second female laying eggs in an occupied Galah nest in which young had hatched. In this study, in 2022 when I first observed brood overlapping (Pryor 2023) and in 2024, the surviving chick from the first clutch was within days of fledging when the second clutch was initiated. During this time, a pair of Galahs spent hours in and on the nestbox and nearby eucalypt during the day and night. They did not fly up into the eucalypt or away when family members walked in the backyard, suggesting that they were familiar and comfortable with those people. They advertised their territory by wiping their faces on the nest box and pole, removing patches of bark from the eucalypt and performing the heraldic display (raising crest, spreading wings and tail, and screeching) (Pidgeon 1970), if other Galahs flew in (K. P. pers. obs.). Thus, it is highly unlikely that a different pair would have had the opportunity to lay the second clutch. However, it is acknowledged that because the Galahs were not banded, this study cannot provide absolute evidence that the same Galah pair made both successful breeding attempts.

In 2022 and 2024, the Galahs may have double brooded because there was a substantial reduction of their first brood (Blomqvist *et al*. 2001) and/or the sole surviving young from the first clutch did not appear to be strong enough to climb up to the entrance hole and fledge. Chick 1/2022 was not observed looking out of the nest box and Chick 1/2024 was only observed looking out the day before it fledged. Chick 1/2022 was assumed to have finally fledged (flying competence not observed) when it was older than the maximum reported nestling age of 62 days (Smith & Saunders 1986).

Table 1. Opportunistic observations of Galahs breeding in a nest box in a suburban backyard in the Hunter Valley in the 2024 breeding season

Date	Observation
9 August 2024	First saw adult Galah sleeping overnight in the nest box with breast blocking entrance hole
9 September 2024	First brood: First heard young
22 September 2024	Four young had hatched (**Figure 1**)
4 October 2024	Only one young had survived, Chick 1/2024
17 October 2024	Heard Chick 1/2024 being fed
22 October 2024	Both parents were putting fresh leaves in the nest box Parents were not at the nest box overnight Heard shuffling in the nest box
23 October 2024	First saw Chick 1/2024 looking out of the nest box
24 October 2024	Chick 1/2024 fledged at 0533 h [1], 26 min after sunrise at 0507 h with female parent only (**Figure 2**)
25 October 2024	Second clutch: three eggs had been laid (**Figure 3**)
3 November 2024	Only one egg was visible, but others may have been obscured by parent or covered by leaves (**Figure 4**)
14 December 2024	Second brood: Only one young had survived, Chick 2/2024 (**Figure 5**)
29 December 2024	Heard Chick 2/2024 being fed
6 January 2025	Parent fed Chick 2/2024 through entrance hole from external perch
11 January 2025	Chick 2/2024 was being groomed and fed at entrance hole (**Figure 6**)
12 January 2025	Chick 2/2024 perched in entrance hole with toes visible. Chick and parents commenced pre-fledge calling
13 January 2025	Chick 2/2024 fledged at 0503 h, 4 min after sunrise at 0459 h, with both parents

Table 2. Fledging of Galah chicks relative to sunrise and sunset

Chick hatch number / year	Date chick left nest box	Time chick left nest box (h) [1]	Sunrise [2] (h)	Time after sunrise (min)	Sunset [2] (h)	Time before sunset (min)
Chick 1/2008	10/12/08	0500	0444	16	1857	
Chick 1/2012	2/11/12	0641	0458	103	1824	
Chick 2/2012	4.11.12	1650	0457		1826	96
Chick 3/2012	9.11.12	1410	0453		1830	260
Chick 1/2013	19.10.13	1730	0513		1812	42
Chick 2/2013	20.10.13	0618	0512	66	1813	
Chick 3/2013	21.10.13	1758	0511		1814	16
Chick 1/2014	23.10.14	0600	0509	51	1815	
Chick 2/2014	3.11.14	0535	0458	37	1824	
Chick 3/2014	7.11.14	0615	0454	81	1828	
Chick 1/2015	Not observed					
Chick 2/2015	13.11.15	0530	0450	40	1833	
Chick 1/2016	22.10.16	0545	0509	36	1815	
Chick 2/2016	26.10.16	1735	0505		1818	43
Chick 3/2016	27.10.16	1759	0504		1819	20
Chick 1/2017	16.10.17	0610	0516	54	1810	
Chick 1/2018	20.10.18	0540	0512	28	1813	
Chick 1/2019	24.10.19	0613	0508	65	1816	
Chick 2/2019	24.10.19	Not observed	0508		1816	
Chick 3/2019	25.10.19	0540	0507	33	1817	
Chick 1/2020	24.12.20	Not observed	0449		1905	
Chick 2/2020	25.12.20	0740	0449	171	1906	
Chick 1/2021	20.12.21	1640	0447		1903	143
Chick 1/2022	19.11.22	Not observed	0447		1839	
Chick 1/2023	12.11.23	0509	0451	18	1832	
Chick 2/2023	12.11.23	0756	0451	185	1832	
Chick 3/2023	12.11.23	Not observed	0451		1832	
Chick 1/2024	24.10.24	0533	0507	26		
Chick 2/2024	13.01.25	0503	0459	4		

[1]Australian Eastern Standard Time (AEST) in 24-hour format [2]Sunrise and sunset times from Geoscience Australia

However, Chick 1/2024 was estimated to have fledged before the maximum reported nestling age and was observed flying strongly away. In 2008, 2017, 2018, and 2021, Galahs successfully raised only one young but did not start a second clutch (**Table 2**). Therefore, it remains to be elucidated why the female, which is likely to be, but may not be, the same individual, initiated a second clutch in 2022 and 2024.

Key factors driving double brooding in parrots remain to be clarified. One factor is the timing of moulting (McGrath 1993; Rowley 1988). Rowley (1988) found that breeding Galahs start their annual moult when their nestlings have feathers but have not yet fledged. Moulting is under hormonal control (Payne 1972) and usually entails a loss of interest in nesting, the end of the breeding cycle and regression of the gonads (McGrath 1993; Van Sant 2006). The findings described in this note differ from Rowley's (1988) report that Galahs do not lay more eggs if their nestlings are more than 21 days old. It is possible that in 2022 and 2024, one or both of the adult Galahs had a hormonal imbalance that delayed moulting and allowed them to lay more fertile eggs when their nestling was estimated to be more than 40 days old. Another factor is the natural length of the breeding season (McGrath 1993). This may vary in a species' breeding range because different habitats experience different conditions, for example length of day, temperature and rainfall. Thus, a species may be able to double brood in only part of its breeding range. Other factors are yet to be identified.

Double brooding by captive parrots, especially those that double brood in the wild, has been observed by aviculturists (Bruce Watts, Jeff Jones, John Griffith, and John McGrath pers. comm.) For example, the Wheatbelt hybrid, Port Lincoln parrot *Barnardius zonarius zonarius* x Twenty-eight parrot *Barnardius zonarius semitorquatus*, may lay a second clutch in captivity in a suitable climate (McGrath 1993). Kakariki *Cyanoramphus* spp. may nest all year in captivity (Jennings 1978). My pet Cockatiels *Nymphicus hollandicus* successfully raised one young from a clutch of four eggs (hatched 8 August 2015) followed by one young from a subsequent clutch of six eggs (hatched 1 October 2015) (K. P. pers. obs.). Double brooding may occur more readily in captive parrots because they experience food and water security and a controlled climate.

The most interesting finding was that Galahs may engage in a rare breeding strategy, single-nest brood overlapping. A recent study found that this strategy has been reported in only eight bird species (Surmacki & Podkowa 2022). In the present study, it is possible that the 2022 and 2024 Galahs overlapped successive clutches because they are seasonal breeders that usually lay eggs between late July and early November (Rowley 1990). The length of the breeding season determines the number of clutches that can be produced (Burley 1980) and if two clutches are produced, there must be enough time for the second brood to fledge before the breeding season ends (Hill 1986). Chick 2/2024, which was from an overlapped clutch, had the latest fledging date I have recorded (mid-January). Even the 2020 and 2021 chicks, which were from replacement clutches, fledged in late December (**Table 2**). If committing to double brooding, the Galahs may have also needed to brood overlap to raise their young before summer temperatures made the nest too hot (Larson *et al.* 2015). It is possible that they are only likely to engage in this strategy when breeding in a nest box (Surmacki & Podkowa 2022).

In both 2022 and 2024, the second clutch was well underway before the chick from the first clutch fledged. In 2022, three eggs were observed three days before Chick 1/2022 left the nest box. The fourth egg may have also been laid before the chick left. In 2024, three eggs were observed the day after Chick 1/2024 left the nest box. As the interval between Galah eggs is more than two days, at least two eggs and possibly all three eggs may have been laid before the chick left. Such brood overlapping would have been energetically costly, especially to the female (Surmacki & Podkowa 2022), because parents usually provide extra feeding and grooming to a chick before fledging (K. P. pers. obs.) and continue to feed it for six to seven weeks after fledging (Rowley 1990).

The reason only one young survived in each clutch is unknown. It is possible that most of the young were overcome by lice and/or mites because the box was not treated before the adults moved in. If this was the case, it is unclear why only one chick in a brood would be strong enough to resist the parasites. In the present study, in 2009, the sole surviving chick climbed up to the entrance hole but was too weak to hold its head up. It died the next day, and an inspection of the nest box revealed an infestation of lice and/or mites (K. P. pers. obs.). It is also possible that the Galahs did not adequately provision the other chicks. In the present study, in 2008, real-time video from a camera installed in a previous nest box enabled me to witness that Chick

2/2008 was not fed often and was not seen after the third day (K. P. pers. obs.). Others found that slightly less than 50% of eggs have a fledging outcome and that nestlings die due to inclement weather, disease and wounds (Rowley 1990; Smith & Saunders 1986).

Intriguingly, this appears to be the first report of a chick fledging without waiting for the other parent to arrive and help escort it from the nest. Chick 1/2024 may have acted on instinct because it was ready to leave or may have leaned too far forwards from the nest box entrance and had to fly. In this study, chicks fledging with only one parent have only been observed in 2020, when the male parent disappeared. With the help of supplementary feeding, the female parent exclusively raised two chicks for the four weeks prior to fledging. Chick 1/2020 was assumed to have fledged (flying competence not observed) and the next day Chick 2/2020 was observed flying strongly away with the female parent.

The new observations from the 2024 breeding season (**Table 2**) provide further evidence that Galah chicks usually fledge either within 120 min after sunrise or within 120 min before sunset (Pryor 2018, 2024). They are also consistent with studies that found that Galah chicks usually fledge in the morning (Higgins 1999).

CONCLUSIONS

It appears to be very rare but possible for a Galah pair to double brood in the same nest, overlap the two broods and successfully fledge at least one young from each brood in a single breeding season. Double brooding and brood overlapping could increase a Galah pair's seasonal reproductive success.

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Kim Pryor's long-term study of Galahs breeding in a garden nest box at Thornton has revealed many interesting findings over the years (photo: Jim Smart)

Recent trends for Hunter Estuary waterbird and shorebird populations

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Data from monthly surveys of the Hunter Estuary spanning four years during 2021-2025 were compiled and compared with results from the preceding four-year period. The populations of most migratory shorebirds decreased, continuing their long-term trends of decline. Two species, Bar-tailed Godwit *Limosa lapponica* and Common Greenshank *Tringa nebularia*, had stable or near-stable populations in the estuary. Twelve waterbird or non-migratory shorebird species had increased populations and seem to be benefitting from wetland rehabilitation projects in the estuary. That included two species listed as Vulnerable in New South Wales – Magpie Goose *Anseranas semipalmata* and Latham's Snipe *Gallinago hardwickii*. Five waterbird and shorebird species had reduced numbers, perhaps departing the estuary for breeding sites elsewhere: Grey Teal *Anas gracilis*, Pied Stilt *Himantopus leucocephalus*, Red-necked Avocet *Recurvirostra novaehollandiae*, Red-kneed Dotterel *Erythrogonys cinctus* and Black-fronted Dotterel *Elseyornis melanops*.

INTRODUCTION

During 2021-22, Ann Lindsey and I analysed the data from 22 years of Hunter Estuary monthly surveys carried out by members of the Hunter Bird Observers Club (HBOC) (Stuart & Lindsey 2021; Lindsey & Stuart 2021; Stuart & Lindsey 2022; Lindsey & Stuart 2024). The data set spanned April 1999 to March 2021. Some clear trends were identified – in particular, decreasing populations of most migratory shorebirds, and stable or increasing populations of most of the endemic shorebirds and of many waterbird species. We also showed that many of the waterbirds and some of the endemic shorebirds had seasonal variation in the numbers present.

Four years on from doing those analyses, it seemed timely to assess whether any of the trends were continuing. In this report, I summarise the results for the period April 2021 to March 2025 and compare them with those from the preceding 4-year period April 2017 to March 2021.

METHODS

I extracted HBOC's data from the Birdata portal (https://birdata.birdlife.org.au/) and imported them into an MS Excel spreadsheet. For each of the two periods 2017-2021 and 2021-2025, I calculated the average number of birds present for each species, and I also noted the maximum number that had been present and the number of times that the species was recorded. For migratory shorebirds, which mainly are present in their non-breeding season, I calculated their average counts for the November to March period – those being the main months that the birds were present.

To assess the significance of any observed changes, I used the Chi-square test (which compares the number of observations with the expected number of observations) and the t-test (which compares count data from two data sets). For the latter I used two-tailed t-tests assuming unequal variance, with $p < 0.05$ considered significant and $p < 0.01$ highly significant. For the Chi-square tests, values of χ^2 above 3.84 indicate a statistically significant difference in the number of records.

RESULTS

Forty-seven surveys were done during the 2021-2025 period; there was no survey in August 2021 when COVID-19 related travel restrictions were at a peak. In the preceding 4-year period, all 48 of the scheduled surveys took place.

Migratory shorebirds

Table 1 shows the maximum counts and average November-March counts for the main migratory shorebirds recorded in the Hunter Estuary since 2017. Species with fewer than five records in the eight-year period are not reported. Almost all species had lower numbers for the second time period (both their maximum counts and their November-March average counts). There were two exceptions: Common Greenshank *Tringa nebularia* and Bar-tailed Godwit *Limosa lapponica.* Although the maximum counts for both species were 10-20% lower for 2021-2025 compared with the preceding four-year period, their November-March average numbers for the two periods were similar (down by ~5% for greenshanks, up by ~2% for godwits).

Although the Bar-tailed Godwit numbers for November-March were approximately stable, their May-August counts fluctuated considerably during 2021-2024. In both 2021 and 2024, there were more than 100 birds in the estuary (peak counts 115 in July 2021, 136 in July 2024). The corresponding numbers during 2022 and 2023 were 47 and 76 birds.

The species present in greatest numbers since April 2021 were Sharp-tailed Sandpiper *Calidris acuminata* and Bar-tailed Godwit *Limosa lapponica*. However, Sharp-tailed Sandpiper results were affected by a brief influx in October-November 2023, peaking with a count of 1195 birds. The next highest count for them in the 4-year period was 253 birds in September 2021. In contrast, during 2017-2021 there was a major El Niño event in Australia, leading to dry conditions inland. As a result many thousands of Sharp-tailed Sandpipers were regularly present in the estuary (Stuart 2019).

Data for Double-banded Plovers *Charadrius bicinctus* are not presented in **Table 1** as they are mainly present elsewhere in the Hunter Region in winter months (Fraser & Lindsey 2016). There were five records for them in 2017-2021 (maximum count 60 birds; the 4-year average count was nine birds) and only two records in 2021-2025 (maximum count two birds). Similarly, I have not presented data for Ruddy Turnstones *Arenaria interpres* because they only infrequently roost within the estuary, preferring to roost at coastal rock platforms (Stuart & Lindsey 2021).

Table 1. Maximum counts and average November-March counts for migratory shorebirds in the Hunter Estuary 2017-2021 and 2021-2025. Species with statistically significant trends ($p < 0.05$) for November-March counts are shown in red.

Species	April 2017 – March 2021		April 2021 – March 2025		Pop[n] Trend[1]	*p* (t-test)
	Max count	Nov-Mar Avg.	Max count	Nov-Mar Avg.		
Pacific Golden Plover *Pluvialis fulva*	390	176	195	107	D	0.038
Whimbrel *Numenius phaeopus*	74	33	48	21	D	0.091
Far Eastern Curlew *Numenius madagascariensis*	172	114	135	89	D	0.065
Bar-tailed Godwit *Limosa lapponica*	968	466	745	473	S?	0.454
Black-tailed Godwit *Limosa limosa*	100	40	44	19	D	0.005
Great Knot *Calidris tenuirostris*	4	2	1	1	D	0.175
Red Knot *Calidris canutus*	273	24	69	5	D	0.046
Sharp-tailed Sandpiper *Calidris acuminata*	4583	1075	1195	125	D	0.004
Curlew Sandpiper *Calidris ferruginea*	155	59	78	32	D	0.076
Red-necked Stint *Calidris ruficollis*	60	7	19	9	I?	0.890
Terek Sandpiper *Xenus cinereus*	6	4	6	2	D	0.022
Common Sandpiper *Actitis hypoleucos*	2	1	3	1	D	0.787
Grey-tailed Tattler *Tringa brevipes*	41	22	27	12	D	0.010
Common Greenshank *Tringa nebularia*	135	57	117	54	S	0.822
Marsh Sandpiper *Tringa stagnatilis*	96	31	43	13	D	0.006

[1]Population trends: D – decreasing; I – increasing; S – stable.

Waterbirds and non-migratory shorebirds

A total of 65 waterbird and non-migratory shorebird species were recorded in the Hunter Estuary during 2021-25 (Note: I have treated the Latham's Snipe *Gallinago hardwickii* as a migratory waterbird not as a shorebird, because of its preference for fresh-water habitat rather than saline habitat). Twelve of those species had statistically significant population increases compared with the 2017-2021 results, and three species had statistically significant population decreases. The 15 species are listed in **Table 2**, with the *p* value from the t-test comparisons of the two data sets.

Table 2. Average monthly counts in the Hunter Estuary 2017-2021 and 2021-2025 for waterbirds and non-migratory shorebirds having statistically significant population changes.

Species	**April 2017 – March 2021**		**April 2021 – March 2025**		***p* (t-test)**
	Max count	**Avg. count**	**Max count**	**Avg. count**	
Species with significantly increased populations					
Australasian Darter *Anhinga novaehollandiae*	7	2	11	3	0.005
Chestnut Teal *Anas castanea*	2141	256	2393	475	0.046
Dusky Moorhen *Gallinula tenebrosa*	6	2	65	9	0.009
Great Egret *Ardea alba*	59	10	117	20	0.005
Latham's Snipe *Gallinago hardwickii*	6	1	55	10	0.026
Little Egret *Egretta garzetta*	10	3	29	7	<0.001
Magpie Goose *Anseranas semipalmata*	6	1	27	8	0.018
Musk Duck *Biziura lobata*	2	1	13	4	<0.001
Pacific Black Duck *Anas superciliosa*	172	51	505	86	0.018
Purple Swamphen *Porphyrio porphyrio*	46	15	111	37	<0.001
Royal Spoonbill *Platalea regia*	90	24	168	41	0.001
Wandering Whistling-Duck *Dendrocygna arcuata*	2	<1	8	8	0.013
Species with significantly decreased populations					
Grey Teal *Anas gracilis*	2533	487	1500	215	0.016
Pied Stilt *Himantopus leucocephalus*	1008	416	785	264	0.009
Red-necked Avocet *Recurvirostra novaehollandiae*	5644	1481	2316	364	<0.001

Three species had statistically significant increases in their number of records – Musk Duck *Biziura lobata*, Magpie Goose *Anseranas semipalmata* and Dusky Moorhen *Gallinula tenebrosa* (see **Table 3** for details). For all three species, the Chi-square value was above 6.63, thus the changes can be considered highly significant. Two other species had near-significant changes (χ^2 slightly below 3.84): Latham's Snipe *Gallinago hardwickii* and Eurasian Coot *Fulica atra*.

No species had statistically significant decreases in number of records although for the Common Tern *Sterna hirundo* and Red-kneed Dotterel *Erythrogonys cinctus* the changes could be considered near-significant. Common Tern had one record for 2021-2025 compared to seven records for 2017-2021, χ^2 3.02. Red-kneed Dotterel had 12 records for 2021-2025 compared to 23 records for 2017-2021, χ^2 2.65. The population change (average of 16 birds when present during 2017-2021, average of 6 birds when present during 2021-2025) for Red-kneed Dotterel also was near-significant (*p* 0.077), and similarly for the Black-fronted Dotterel *Elseyornis melanops* (average count 22 when present 2017-2021 and then average count 13 when present 2021-2025, *p* 0.057).

Table 3. Species with statistically significant ($\chi^2 > 3.84$) or near-significant increases in number of Hunter Estuary records for 2021-2025 compared with 2017-2021.

Species	**April 2017 – March 2021**		**April 2021 – March 2025**		**Chi-square (χ^2)**
	Avg. count	**Records**	**Avg. count**	**Records**	
Species with significantly increased records					
Magpie Goose *Anseranas semipalmata*	6	1	8	11	6.94
Musk Duck *Biziura lobata*	1	8	4	26	8.86
Dusky Moorhen *Gallinula tenebrosa*	4	11	9	28	6.91
Species with near-significant increase in records					
Latham's Snipe *Gallinago hardwickii*	2	10	10	21	3.44
Eurasian Coot *Fulica atra*	129	20	75	34	3.41

DISCUSSION

Migratory shorebirds

Stuart & Lindsey (2021) identified that most migratory shorebird species in the Hunter Estuary had decreasing populations. The three exceptions from that study were Sharp-tailed Sandpiper *Calidris acuminata*, Grey-tailed Tattler *Tringa brevipes* and Pacific Golden Plover *Pluvialis fulva*. The populations of all three species had increased, mainly over 2010-2020 (marginally so for the Grey-tailed Tattler). However, all three now have significantly decreased populations in the Hunter Estuary compared to the 2017-2021 period. For the latter two species, the Hunter Estuary trends now reflect those for the East Asian – Australasian Flyway (EAAF). However, it is a different story for Sharp-tailed Sandpipers. Rogers *et al*. (2023) found that Sharp-tailed Sandpiper numbers had increased by ~20% in the EAAF in the past ten years. The population decrease in the estuary is contrary to the Flyway trend and most likely is because of specific climatic conditions. Inland Australia was dry for much of 2017-2021, bringing Sharp-tailed Sandpipers to wetter coastal areas. Conversely, it mostly was wet in the inland during 2021-2025, and hence fewer birds were in coastal areas. Indeed, apart from a brief incursion during October-November 2023, peaking at 1195 birds, the median count of Sharp-tailed Sandpipers in the estuary in the past four years was just 45 birds.

The numbers for most other migratory shorebirds in the Hunter Estuary have continued to decline, reflecting national trends. There are two exceptions – Bar-tailed Godwit and Common Greenshank. For both species, the population trend in the estuary is contrary to that for the overall EAAF. The greenshanks are regularly at Tomago Wetland, and their population stability probably reflects the successful rehabilitation efforts at that site (Lindsey & McNaughton 2012; Lindsey 2021). The reason for the recent stability of the Bar-tailed Godwit population is unclear – it is contrary to the EAAF population trend which has had a 47% decrease in the past ten years, for subspecies *baueri* which occurs locally (Rogers *et al*. 2023).

Waterbirds and non-migratory shorebirds

From 22 years of Hunter Estuary surveys, spanning 1999-2021, the populations of 16 waterbird species were found to be increasing (Lindsey & Stuart 2021; Stuart & Lindsey 2022). For 11 of those species, populations appear to have stabilised in the past four years (or, at least, to have not significantly further increased). However, the numbers for four species have continued to increase significantly: Chestnut Teal *Anas castanea*; Pacific Black Duck *A. superciliosa*; Purple Swamphen *Porphyrio porphyrio*; and Royal Spoonbill *Platalea regia*. A fifth species, Eurasian Coot *Fulica atra*, had lower average numbers but an increased number of records (34 records compared with 20 for the two time periods).

Twelve waterbird species, including the four mentioned above, have experienced population increases over 2021-2025 compared with 2017-2021. The changes for these 12 species perhaps affirm the ongoing benefits from the wetlands rehabilitation projects at Ash Island, Hexham Swamp and Tomago (see Stuart & Lindsey (2021) for details of those projects). Importantly, the list includes two threatened species classified as Vulnerable in NSW: Latham's Snipe *Gallinago hardwickii*; and Magpie Goose *Anseranas* *semipalmata*. Both species had increased numbers of records as well as increased populations.

Three species had significantly decreased populations: Grey Teal *Anas gracilis*; Pied Stilt *Himantopus leucocephalus*; and Red-necked Avocet *Recurvirostra novaehollandiae*. Notably, all three are known to breed inland when conditions are favourable (Cooper *et al*. 2014), which was the case for much of 2021-2025. It is salient that two other inland-breeding species, Red-kneed Dotterel and Black-fronted Dotterel, had near-significant decreases in their number of records in the Hunter Estuary during 2021-2025.

Lindsey & Stuart (2024) found that the numbers of Common Terns in the Hunter Estuary fluctuated – in some years none were present, but several other years had 30 or more individuals. It is unclear whether the paucity of records of them during 2021-2025 is part of the previous pattern of variability or if it reflects a permanent change.

The Hunter Estuary continued to be important for Chestnut Teal, with at least 1% of the total population (i.e. counts of more than 1,000 birds) having been recorded in six of the 47 surveys – March-April 2023, July-September 2023 and February 2025.

CONCLUSIONS

During April 2021 to March 2025, 81 shorebird or waterbird species were recorded in the Hunter Estuary. Comparison with records from the preceding four-year period showed that most of the migratory shorebirds had decreasing populations and that most of the waterbirds and non-migratory shorebirds had stable or increasing populations. Two migratory shorebirds had stable or near-stable populations – Bar-tailed Godwit and Common Greenshank.

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APPENDIX

All species recorded between April 2017 and March 2025.

Species	April 2017 – March 2021 (from 48 surveys)					April 2021 – March 2025 (from 47 surveys)				
	No. of records	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**	**No. of records**	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**
Australasian Bittern *Botaurus poiciloptilus*	0					1		1	1	
Australasian Darter *Anhinga novaehollandiae*	40	2	7	2	3	43	3	11	3	4
Australasian Grebe *Tachybaptus novaehollandiae*	26	11	55	9	12	33	18	92	18	19
Australasian Shoveler *Spatula rhynchotis*	29	18	132	15	27	23	16	53	31	19
Australian Gull-billed Tern *Gelochelidon macrotarsa*	30	16	99	8	26	22	9	21	6	10
Australian Painted-snipe *Rostratula australis*	0					1		1	1	
Australian Pelican *Pelecanus conspicillatus*	48	71	160	79	51	46	88	421	82	99
Australian Pied Oystercatcher *Haematopus longirostris*	42	5	39	5	3	44	5	12	5	4
Australian Shelduck *Tadorna tadornoides*	2	3	4	4	1	2	1	1		1
Australian Spotted Crake *Porzana fluminea*	3	2	3	2		2	3	4	1	4
Australian White Ibis *Threskiornis moluccus*	48	101	1126	155	65	47	139	386	179	112
Australian Wood Duck *Chenonetta jubata*	37	18	101	21	12	37	19	62	17	16
Baillon's Crake *Zapornia pusilla*	2	2	2			2	1	1	1	
Banded Lapwing *Vanellus tricolor*	1	1	1		1	0		0		
Banded Stilt *Cladorhynchus leucocephalus*	1	2	2	2		0		0		
Bar-tailed Godwit *Limosa lapponica*	46	326	968	466	136	46	296	760	473	91
Beach Stone-curlew *Esacus magnirostris*	1	0	0			0		0		
Black Swan *Cygnus atratus*	47	127	429	94	141	46	140	380	118	147
Black-fronted Dotterel *Elseyornis melanops*	40	22	80	6	37	27	13	61	5	20
Black-necked Stork *Ephippiorhynchus asiaticus*	20	2	5	2	1	13	2	4	2	2
Black-tailed Godwit *Limosa limosa*	35	30	100	40	3	29	14	44	19	1
Buff-banded Rail *Hypotaenidia philippensis*	8	1	2	1	1	14	2	9	3	1
Caspian Tern *Hydroprogne caspia*	42	9	43	9	10	38	10	37	7	12
Cattle Egret *Bubulcus ibis*	36	18	97	19	21	39	17	154	15	9
Chestnut Teal *Anas castanea*	48	256	2141	328	226	47	475	2393	436	550
Common Greenshank *Tringa nebularia*	41	44	135	57	18	32	41	117	54	5
Common Gull-billed Tern *Gelochelidon nilotica*	3	1	1	1		1	1	1		1
Common Sandpiper *Actitis hypoleucos*	14	1	2	1		12	1	3	1	1
Common Tern *Sterna hirundo*	7	16	54	16		1	1	1		1
Curlew Sandpiper *Calidris ferruginea*	34	43	155	59	13	23	27	78	32	1
Double-banded Plover *Charadrius bicinctus*	10	9	60	1	16	1	2	2		2

Species	**April 2017 – March 2021 (from 48 surveys)**					**April 2021 – March 2025 (from 47 surveys)**				
	No. of records	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**	**No. of records**	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**
Dusky Moorhen *Gallinula tenebrosa*	11	4	6	4	2	28	9	65	9	5
Eurasian Coot *Fulica atra*	20	129	850	207	58	34	75	464	111	55
Far Eastern Curlew *Numenius madagascariensis*	47	78	172	114	26	47	61	135	89	22
Freckled Duck *Stictonetta naevosa*	2	3	5	3		0		0		
Glossy Ibis *Plegadis falcinellus*	5	8	13	8		1	1	1		
Great Cormorant *Phalacrocorax carbo*	26	2	8	3	2	30	6	46	4	2
Great Crested Grebe *Podiceps cristatus*	0		0			4	2	2	2	2
Great Egret *Ardea alba*	48	10	59	11	6	47	20	117	26	7
Great Knot *Calidris tenuirostris*	10	2	4	2		3	1	1	1	1
Great Pied Cormorant *Phalacrocorax varius*	47	18	66	26	8	44	14	47	21	7
Greater Crested Tern *Thalasseus bergii*	45	9	29	9	6	42	9	32	11	9
Greater Sand Plover *Charadrius leschenaultii*	2	1	1	1		0		0		
Grey Teal *Anas gracilis*	43	487	2533	327	557	44	215	1500	130	195
Grey-tailed Tattler *Tringa brevipes*	40	19	41	22	6	29	11	27	12	3
Hardhead *Aythya australis*	30	48	452	53	19	23	17	123	17	9
Hoary-headed Grebe *Poliocephalus poliocephalus*	11	14	45	8	21	11	12	47	6	14
Latham's Snipe *Gallinago hardwickii*	10	2	6	2		21	10	55	12	
Lesser Sand Plover *Charadrius mongolus*	1	1	1			0		0		
Lewin's Rail *Lewinia pectoralis*	2	2	2	2		1	1	1	1	
Little Black Cormorant *Phalacrocorax sulcirostris*	47	27	151	17	36	47	27	118	25	23
Little Curlew *Numenius minutus*	0		0			1	1	1	1	
Little Egret *Egretta garzetta*	37	3	10	3	2	47	7	29	7	7
Little Pied Cormorant *Microcarbo melanoleucos*	46	7	27	6	7	46	9	22	8	9
Little Tern *Sternula albifrons*	7	4	12	5		6	10	33	5	33
Magpie Goose *Anseranas semipalmata*	1	6	6	6		11	8	27	11	5
Marsh Sandpiper *Tringa stagnatilis*	28	25	96	31	14	22	10	43	13	1
Masked Lapwing *Vanellus miles*	48	124	364	149	106	47	114	397	155	82
Musk Duck *Biziura lobata*	8	1	2	2	1	26	4	13	5	2
Nankeen Night-Heron *Nycticorax caledonicus*	1	6	6		6	1	1	1		1
Mallard *Anas platyrhynchos*	1	1	1	1		0		0		
Pacific Black Duck *Anas superciliosa*	46	51	172	48	49	47	86	505	66	75
Pacific Golden Plover *Pluvialis fulva*	38	108	390	176	9	39	64	195	107	4
Pectoral Sandpiper *Calidris melanotos*	1	1	1	1		1	1	1	1	
Pied Stilt *Himantopus leucocephalus*	48	416	1008	450	406	40	264	785	286	268
Pink-eared Duck *Malacorhynchus membranaceus*	6	79	338	32		11	12	28	21	3

Species	April 2017 – March 2021 (from 48 surveys)					April 2021 – March 2025 (from 47 surveys)				
	No. of records	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**	**No. of records**	**Avg.**	**Max**	**Nov-Mar Avg.**	**May-Aug Avg.**
Plumed Egret *Ardea plumifera*	16	4	22	3	1	20	3	10	4	2
Plumed Whistling-Duck *Dendrocygna eytoni*	0		0			3	1	2	1	
Purple Swamphen *Porphyrio porphyrio*	45	15	46	17	12	45	37	111	24	49
Red Knot *Calidris canutus*	16	76	273	24	2	22	14	69	5	1
Red-capped Plover *Charadrius ruficapillus*	39	21	158	15	33	28	16	103	18	18
Red-kneed Dotterel *Erythrogonys cinctus*	23	16	96	6	26	12	6	16	3	9
Red-necked Avocet *Recurvirostra novaehollandiae*	44	1481	5644	897	2055	33	364	2316	202	412
Red-necked Stint *Calidris ruficollis*	19	10	60	8	16	9	6	19	9	
Royal Spoonbill *Platalea regia*	47	24	90	22	22	46	41	168	46	30
Ruddy Turnstone *Arenaria interpres*	3	1	2	2		0		0		
Sharp-tailed Sandpiper *Calidris acuminata*	38	820	4583	1075	24	25	120	1195	125	23
Silver Gull *Larus novaehollandiae*	48	114	373	146	76	47	145	1291	222	90
Sooty Oystercatcher *Haematopus fuliginosus*	25	6	15	5	4	28	6	19	5	9
Spotless Crake *Zapornia tabuensis*	3	1	2	1	2	3	2	4	1	3
Straw-necked Ibis *Threskiornis spinicollis*	33	47	965	125	16	24	22	140	11	35
Striated Heron *Butorides striata*	27	1	4	1	1	17	2	3	1	2
Terek Sandpiper *Xenus cinereus*	23	3	6	4	1	13	2	6	2	
Wandering Whistling-Duck *Dendrocygna arcuata*	2	2	2	2		3	7	8	6	7
Whimbrel *Numenius phaeopus*	37	24	74	33	9	36	16	48	20	4
Whiskered Tern *Chlidonias hybrida*	7	33	103	20		6	4	11	6	2
White-faced Heron *Egretta novaehollandiae*	48	77	221	48	107	46	83	242	71	100
White-necked Heron *Ardea pacifica*	20	2	8	1	2	11	3	9	5	2
White-winged Black Tern *Chlidonias leucopterus*	0		0			1	5	5		5
Yellow-billed Spoonbill *Platalea flavipes*	1	1	1			0		0		

Large autumn night roosts of Rainbow Lorikeets and other lorikeet species in Raymond Terrace

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Over the past 5 years I have made systematic counts of the exceptional massing of several thousand lorikeets that peaks from late March to early May in Raymond Terrace. They roost in the CBD where massive swirling flocks are impossible to count accurately. I have been conducting counts instead from my roof on the eastern side of town, in Clyde Circuit (**Figure 1**). There I can see the lorikeets returning each afternoon from the east. The elevated position enables views across an 800 metre or so front which accounts for most, but not all, of the returning lorikeets.

It is a challenge and very tiring to count lorikeets in these numbers. They are moving fast, and it is difficult to distinguish Scaly-breasted Lorikeets *Trichoglossus chlorolepidotus* and Musk Lorikeets *Glossopsitta concinna* by any method apart from sound. Binoculars are not useful except for the most distant flocks. My counting technique is to mark down each one hundred Rainbow Lorikeets *Trichoglossus moluccanus*, attempting to count them individually but estimating in tens, twenties or fifties where necessary when larger waves pass over. Marking down each hundred is essential to prevent losing count while also counting other species.

As it is such a challenge, I have not completed these counts often enough to provide evidence beyond showing that there are large numbers of lorikeets in April and May. So, for example, this has not been completed annually, nor has it been weekly to determine when the massing event begins in April and when it ends in May. Also, although I have lived in the town since 2002, I cannot recall which year the massing events began.

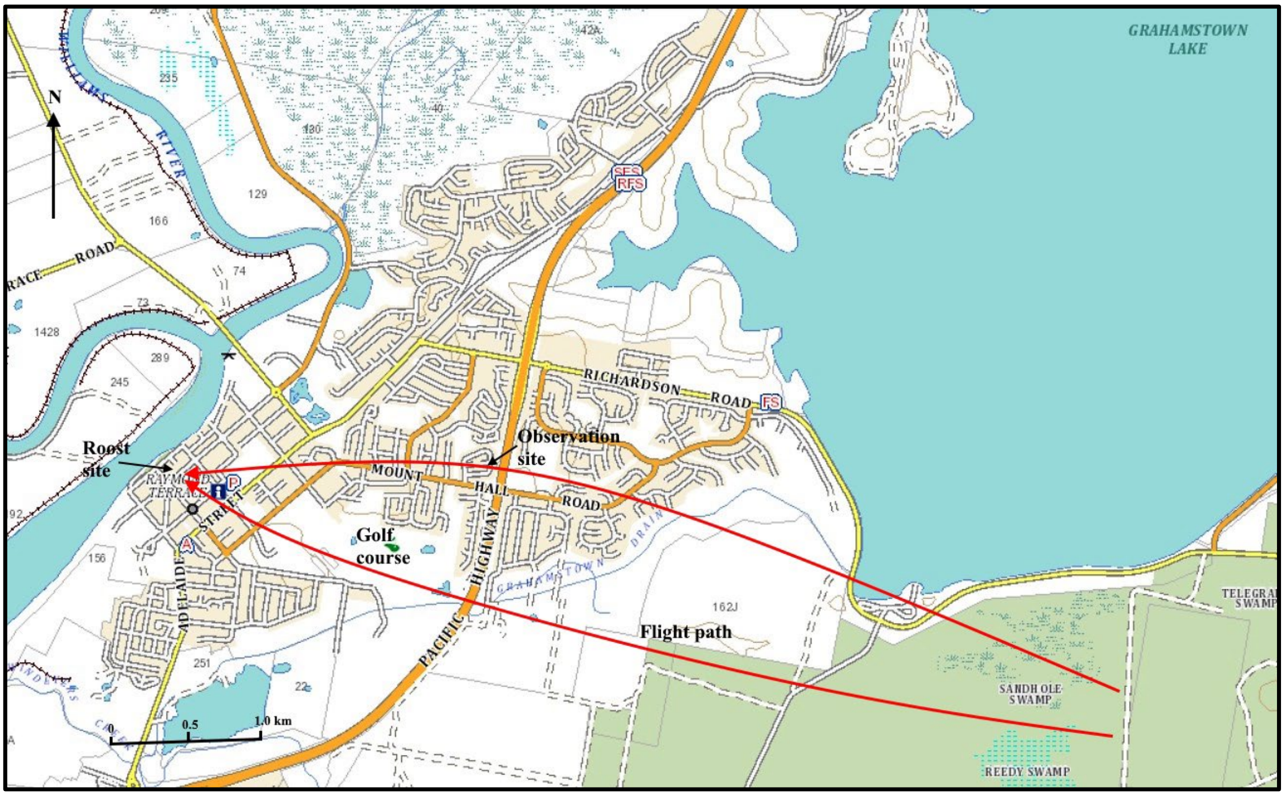

Figure 1. Location map of Raymond Terrace showing observation point, roost site, golf course and flight path from woodland swamps.

As to the massing being mainly autumn only, I can only speculate that it is a post-breeding season aggregation to take advantage of the overlapping flowering of Swamp Mahogany *Eucalyptus robusta* and Broad-leaved Paperbark *Melaleuca quinquinerva* in the extensive swamp woodlands to the east of the town. Also in autumn, there is a large evening movement of thousands of flying foxes in the opposite direction, mostly in a tight stream passing close by my house, indicating a plentiful supply of blossom.

My earliest recollections are around the late 2000s when I noticed the lorikeets massing in a large Liquid Amber *Liquidambar sp.* that was located in Port Stephens Street beside the Veterinary Clinic and entrance to the shopping centre. I recall hearing a deafening roar of lorikeets, then seeing what I estimated to be 1000 lorikeets leaving the tree at once, without any obvious reduction in the sound emanating from the tree. I also observed a Peregrine Falcon *Falco peregrinus* diving off the Telstra tower 100 metres away and hurtling past the tree, before circling around and repeating this several times. I did not see a successful strike but I have found the heads of Rainbow Lorikeets and Common Mynas *Acridotheres tristis* underneath the tower. My recollection also was that previously Scaly-breasted Lorikeets were as plentiful as Rainbow Lorikeets, but none of my actual counts have shown particularly large numbers of them currently.

On 13 May 2025 I went down to the CBD in the afternoon to check on where the lorikeets were now massing since the Liquid Amber was removed. They are massing in an historic row of Canary Island Date Palms *Phoenix canariensis* in Port Stephens Street and a few nearby dense trees. An additional smaller concentration is further north in eucalypts mainly around the netball courts. In years when Musk Lorikeets have also been present, I have observed them concentrating separately further south in tall eucalypts beside the Bowling Club.

Details of the counts from 2014, 2020, 2024 and 2025 are presented in **Table 1**. The arrival time sequences for the 2025 counts are presented in in **Table 2**.

In 2020, the long drought had just ended, and the long catastrophic bushfire season had ended without impacting the local area in any substantial way, perhaps contributing to the exceptional count.

In addition to the Peregrine Falcon that was predating the lorikeets, two Grey Goshawks *Accipiter novaehollandiae* and a Brown Goshawk *Accipiter fasciatus* were recorded but were not seen attempting to predate the lorikeets. Two Osprey *Pandion haliaetus* and two Square-tailed Kites *Lophoictinia isura* were also observed. Other notable observations in May 2025 were counts of up to 85 Figbirds *Sphecotheres vieilloti*, 49 Noisy Friarbirds *Philemon corniculatus*, 55 Yellow-faced Honeyeaters *Lichenostomus chrysops*, 11 Brown-headed Honeyeaters *Melithreptus brevirostris*, 20 White-headed Pigeons *Columba leucomela* and 48 Topknot Pigeons *Lopholaimus antarcticus*. The small honeyeaters and Figbirds were using the tree-lined motorway as a migration path, moving east-northeast in groups of 4 to 20 birds.

Table 1. Details of the counts of lorikeets at Raymond Terrace.

Date	Start time	Duration (h, min)	Rainbow Lorikeets	Scaly-breasted Lorikeets	Musk Lorikeets
26 Feb 2014	19:30	0, 20	375	375	50
25 Mar 2020	15:00	2, 30	4953	41	31
9 May 2024	15:50	1, 30	4560	63	128
7 May 2025	15:27	1, 58	2762	125	9
24 May 2025	15:25	1, 55	1037	30	0

Table 2. Arrival time sequence for Rainbow Lorikeets returning to the roost site in 2025.

Date	7 May 2025	24 May 2025
Start	15:27	15:25
Finish	17:25	17:16
Dusk	17:08	16:57
100 birds	15:40	16:35
200 birds	15:55	16:46
300 birds	16:07	16:51
400 birds	16:15	16:55
500 birds	16:20	16:58
1000+ birds	17:00	17:16

In 2020 I could stand on a flat section of my roof for the count, but with trees growing I have moved up to the sloping section which I would not recommend for anyone without my extensive experience working on roofs. I also intend to move away from the town soon and would suggest the golf course as the next best option for future counts.

Broughton Island: common birds and seasonal visitors

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A long-term bird monitoring project on Broughton Island New South Wales has shown that 26 species are common, being either resident or regularly visiting – eleven species of bush birds, five birds of prey, two shorebirds and eight waterbirds. An additional 27 species had multiple records.

Four species were recorded significantly more often in the autumn and winter surveys than in the spring and summer ones – Brown Goshawk *Tachyspiza fasciata*, Willie Wagtail *Rhipidura leucophrys*, Grey Fantail *Rhipidura albiscapa* and Australasian Gannet *Morus serrator*. There was also an autumn/winter seasonal pattern for the Australian Golden Whistler *Pachycephala pectoralis*, which has not previously been documented to have seasonal movements in the Hunter Region.

INTRODUCTION

Broughton Island (32º 37'S, 152º 19'E, **Figures 1** and **2**) is situated approximately 15 km north-east of the entrance to Port Stephens in New South Wales and forms an important component of the Myall Lakes National Park. Covering an area of 132 hectares, it stands as the largest coastal island in NSW, dominated by open grasslands, sedgelands, and woodland habitats that reach up to 91 metres above sea level at the island's eastern extremity (Carlile *et al*. 2012).

In 2009, the NSW National Parks and Wildlife Service (NPWS) removed feral animals (European Rabbits *Oryctolagus cuniculus* and Black Rats *Rattus rattus*) from the island. Broughton Island was officially declared free of feral animals in 2011 (Priddel *et al*. 2011; Fawcett *et al*. 2016). This intervention was anticipated to trigger significant changes in the island's birdlife – from a combination of the absence of nest predators and a re-vegetation of the island. That was indeed the case for the main breeding seabird on Broughton Island, the Wedge-tailed Shearwater *Ardenna pacifica*, which has experienced a substantial increase in population (Carlile *et al*. 2022).

NPWS had plans in place for monitoring Broughton Island seabirds and enlisted the collaboration of the Hunter Bird Observers Club (HBOC) to monitor additional bird species. Since 2012, I have organised regular surveys by HBOC teams, with an emphasis on monitoring diurnal birds – passerines, shorebirds, waterbirds, and birds of prey (raptors) – while also gathering occasional data on breeding and roosting seabirds. In addition, a banding program for terrestrial birds commenced in 2017, which has added further insights into the island's avian communities (Little & Stuart 2022).

A five-year baseline program launched in 2012 identified the then-resident bird species and documented early trends (Stuart *et al*. 2017). Ongoing surveys and interim reviews have since provided insights into the evolving status of passerines and birds of prey (Stuart 2021; Fraser 2021b). This paper updates those earlier reports and summarises the findings from thirteen years of systematic bird monitoring on Broughton Island.

METHODS

Surveys

Typical visits to Broughton Island for bird monitoring spanned three days, with observers working as teams of 1-2 people traversing most of the island and surveying sites several times during each visit. Occasionally, poor weather conditions caused the visit to be limited to two days, but this shortened time frame still allowed all the island to be surveyed thoroughly. Additional details about the survey methods have been provided in earlier reports (Stuart *et al*. 2017; Stuart 2021).

For consistency of effort, the island was surveyed as five sites each of nominal 500 m radius, using BirdLife Australia's 500 m-radius survey protocol (https://birdata.birdlife.org.au/home) in which the survey duration is not fixed. Typically, the duration of these surveys on Broughton Island was 1-2 hours per site. Three of the sites are land-based; they partition the island into three approximately equal sectors (north-west, north-east, south-west). The other two 500 m radius sites cover the coastline and inshore waters of Providence Beach, on the northern side of the island, and Esmeralda Cove on the south-eastern side (see **Figure 1**). Within the three land-based sites there are six 2 ha sites, surveyed for 20 minutes each time using BirdLife Australia's 2-ha survey protocol (https://birdata.birdlife.org.au/home). The six sites were selected as collectively representing the main habitat types of Broughton Island. For the present study, the data from the 20-minute surveys were included into the presence/absence analysis for each visit to the island.

Occasionally HBOC team members also participated in one-day visits to Broughton Island for varying purposes e.g. to inspect the Gould's Petrel *Pterodroma leucoptera* nest boxes at Pinkatop Head (Stuart *et al*. 2023). Although some of the above sites were surveyed during each of those one-day visits, the survey effort did not cover the whole island. Therefore, the data from the one-day visits were excluded from this analysis.

Analysis of the status of Broughton Island's terrestrial species has been assisted by including key findings from a bird banding project which commenced in mid-2017. A general description of the methods used in the banding project has been presented previously (Little & Stuart 2022).

Data management and data analysis

The records from all surveys were entered into BirdLife Australia's Birdata portal (www.birdata.birdlife.org.au) in real time. In June 2025 I downloaded all the results and converted them into presence/absence format for each 2-day or 3-day visit. I calculated the "trip visit" Reporting Rate for each species, that being the number of records for a species divided by the number of 2-day and 3-day visits, expressed as a percentage.

I used the Pearson's Chi-Square (Goodness-of-Fit) test (Fowler & Cohen 1994) to assess the statistical significance of any differences in the number of records for a species on a seasonal basis. Calculated Chi-Square (χ^2) values above 3.84 indicate a significant difference in the two data sets, to at least 95% confidence level, while χ^2 values above 6.63 indicate that the difference is highly significant, to at least 99% confidence level (Fowler & Cohen 1994). I took into account that the Chi-Square test requires a minimum number of records for the result to be valid.

Figure 1. Broughton Island and some other islands of the Broughton Group (map based on Google Earth sourced 30/6/2025)

Figure 2. Broughton Island and some other islands viewed to the southeast, from an approaching helicopter (Photo: author).

RESULTS

Between September 2012 and June 2025, there were 39 two-day or three-day visits to Broughton Island for bird surveys – 18 of the visits were in either autumn or winter and 21 visits were in spring or summer. In total, 93 species were recorded during the surveys. **Table 1** shows the overall Reporting Rate for the 53 species that had three or more records from the 39 visits, and also their Reporting Rates for the autumn/winter (March to August) and spring/summer (September to February) periods.

DISCUSSION

The bird banding activities have seen many retraps of birds that initially were caught and banded on the island (Little & Stuart 2022; G. Little pers. comm.). Thus, it is clear that many individuals of certain species are regularly present on the island. However, because the visits to Broughton Island have been relatively infrequent (typically, once per season), it cannot with any certainty be concluded that any of those individuals are permanently resident. The discussion below takes that uncertainty into account.

Forty species have only one or two confirmed records on Broughton Island during the systematic surveys. A further eight species were recorded during visits to the island for other activities in the same period (M. Schulz pers. comm.). At this stage, they all should be considered to be vagrants to the island, with one probable exception (Beach Stone-curlew *Esacus magnirostris*, discussed further below). Some of these species might eventually colonise the island, as has already happened for several other species.

Common birds

Twenty-six species – eleven bush birds, five raptors, two shorebirds and eight waterbirds – have had overall Reporting Rates above 60%. In most cases, the autumn/winter and spring/summer Reporting Rates were similar; the exceptions are discussed further below. There were breeding records for 15 of the 26 species.

Three of the 26 species are classified as Vulnerable in NSW – Sooty Oystercatcher *Haematopus fuliginosus*, Osprey *Pandion haliaetus* and White-bellied Sea Eagle *Icthyophaga leucogaster*. There are breeding records from the island for the first two of those species (Fraser 2021a; 2021b). Twenty-five to thirty Sooty Oystercatchers were regularly recorded, making Broughton Island a prime location for this species in the Hunter Region (Wooding 2019). Fraser (2021a) reported five breeding pairs but a sixth pair has since bred at Esmeralda Cove. It is unknown whether all six pairs breed annually.

Silvereyes *Zosterops lateralis* are now one of the commonest birds on Broughton Island, having not been recorded on the island prior to 2011. There are autumn and winter influxes of two migratory subspecies, *westernensis* and *lateralis*, joining the local subspecies *cornwalli* (Little *et al*. 2020).

Golden-headed Cisticolas *Cisticola exilis* and Tawny Grassbirds *Cincloramphus timoriensis* were recorded on almost every visit although they have been less detectable in the autumn and winter visits and sometimes not recorded during those surveys.

Table 1. Overall, autumn-winter and spring-summer trip visit Reporting Rates (RR) and local breeding status for species with three or more records in Broughton Island visits 2012-2025. Species are in descending order of overall RR.

Species	Overall RR (%; from 39 visits)	Autumn-winter RR (%; from 18 visits)	Spring-summer RR (%; from 21 visits)	Breeding records
Silvereye *Zosterops lateralis*	100.0	100.0	100.0	Y
Australian Raven *Corvus coronoides*	97.4	94.4	100.0	Y
Brown Quail *Synoicus ypsilophorus*	97.4	94.4	100.0	Y
Golden-headed Cisticola *Cisticola exilis*	97.4	94.4	100.0	Y
Silver Gull *Chroicocephalus novaehollandiae*	97.4	94.4	100.0	Y
Sooty Oystercatcher *Haematopus fuliginosus*	97.4	100.0	95.2	Y
Swamp Harrier *Circus approximans*	97.4	94.4	100.0	
Tawny Grassbird *Cincloramphus timoriensis*	97.4	94.4	100.0	Y
Welcome Swallow *Hirundo neoxena*	97.4	94.4	100.0	Y
Yellow-faced Honeyeater *Caligavis chrysops*	97.4	94.4	100.0	Y
Bar-shouldered Dove *Geopelia humeralis*	94.9	94.4	95.2	Y
Pacific Reef Heron *Egretta sacra*	94.9	94.4	95.2	
White-bellied Sea Eagle *Icthyophaga leucogaster*	94.9	100.0	90.5	
Australian Pied Cormorant *Phalacrocorax varius*	92.3	88.9	95.2	
Osprey *Pandion haliaetus*	92.3	94.4	90.5	Y
Greater Crested Tern *Thalasseus bergii*	87.2	88.9	85.7	Y
Great Cormorant *Phalacrocorax carbo*	84.6	77.8	90.5	
Red-capped Plover *Anarhynchus ruficapillus*	84.6	94.4	76.2	Y
Australasian Pipit *Anthus australis*	79.5	83.3	76.2	
Whistling Kite *Haliastur sphenurus*	79.5	88.9	71.4	
Little Wattlebird *Anthochaera chrysoptera*	74.4	88.9	61.9	
Buff-banded Rail *Gallirallus philippensis*	71.8	77.8	66.7	Y
Lewin's Rail *Lewinia pectoralis*	69.2	83.3	57.1	
Peregrine Falcon *Falco peregrinus*	66.7	66.7	66.7	Y
White-faced Heron *Egretta novaehollandiae*	64.1	88.9	42.9	
Willie Wagtail *Rhipidura leucophrys*	61.5	94.4	33.3	
Brown Goshawk *Tachyspiza fasciata*	53.8	88.9	23.8	
Australasian Gannet *Morus serrator*	48.7	88.9	14.3	
Black-shouldered Kite *Elanus axillaris*	46.2	44.4	47.6	
Little Pied Cormorant *Microcarbo melanoleucos*	43.6	44.4	42.9	
Pheasant Coucal *Centropus phasianinus*	43.6	22.2	61.9	
Red-browed Finch *Neochmia temporalis*	38.5	44.4	33.3	Y
Wedge-tailed Shearwater *Ardenna pacifica*	38.5	33.3	42.9	Y
Gould's Petrel *Pterodroma leucoptera*	35.9	16.7	52.4	Y
Grey Fantail *Rhipidura albiscapa*	33.3	66.7	4.8	
Little Penguin *Eudyptula minor*	30.8	22.2	38.1	Y
Brown Falcon *Falco berigora*	20.5	33.3	9.5	
Double-banded Plover *Anarhynchus bicinctus*	20.5	44.4	0.0	
Aust. Golden Whistler *Pachycephala pectoralis*	20.5	38.9	4.8	
Brahminy Kite *Haliastur indus*	17.9	27.8	9.5	
Nankeen Kestrel *Falco cenchroides*	17.9	22.2	14.3	
Ruddy Turnstone *Arenaria interpres*	17.9	16.7	19.0	
Pied Oystercatcher *Haematopus longirostris*	15.4	16.7	14.3	Y
Australian Pelican *Pelecanus conspicillatus*	12.8	11.1	14.3	
Little Black Cormorant *Phalacrocorax sulcirostris*	12.8	5.6	19.0	
Shining Bronze-cuckoo *Chalcites lucidus*	12.8	22.2	4.8	
Australasian Darter *Anhinga novaehollandiae*	10.3	11.1	9.5	
Channel-billed Cuckoo *Scythrops novaehollandiae*	10.3	0.0	19.0	
White-throated Needletail *Hirundapus caudacutus*	10.3	0.0	19.0	
Caspian Tern *Hydroprogne caspia*	7.7	16.7	0.0	
Fan-tailed Cuckoo *Cacomantis flabelliformis*	7.7	16.7	0.0	
Spangled Drongo *Dicrurus bracteatus*	7.7	16.7	0.0	
Tree Martin *Petrochelidon nigricans*	7.7	0.0	14.3	

However, the Golden-headed Cisticola population is in decline, seemingly because of habitat changes (Stuart 2021).

Two cryptic species, Buff-banded Rail *Gallirallus philippensis* and Lewin's Rail *Lewinia pectoralis*, were detected mainly when they were calling, although there were several sightings, and there were some breeding records for Buff-banded Rail (S. Callaghan pers. comm.; M. Schulz pers. comm.). Buff-banded Rails were not detected in the surveys until October 2016, nor during the handful of pre-2012 visits by birdwatchers. For both rail species, the Reporting Rates from Broughton Island were considerably higher than for the Hunter Region and for NSW (Williams 2020; Cooper *et al*. 2014). The Reporting Rate for Lewin's Rail in NSW is 0.21% overall, and 1.80% for Buff-banded Rail (Cooper *et al*. 2014). Clearly, the habitat on Broughton Island suits these two species.

Fraser (2021b) reported the Whistling Kite *Haliastur sphenurus* to be the second-most common raptor on Broughton Island. That situation has changed in recent times, such that birds are not always present and the overall reporting rate has dipped below 80%. This is in line with the trend reported for Whistling Kite in Port Stephens, (Stuart 2024). Autumn-winter records have become more typical for both Port Stephens and Broughton Island.

Usually only 1-2 White-faced Herons were recorded (when present), but sometimes there were larger flocks: 11 birds in April 2016; 13 in March 2024; and 39 in February 2023.

Uncommon visitors/residents

Ten species had Reporting Rates of 30-60%. Three of those are seabirds which are known to breed or roost on Broughton Island – Wedge-tailed Shearwater *Ardenna pacifica*, Gould's Petrel *Pterodroma leucoptera* and Little Penguin *Eudyptula minor* (Carlile *et al*. 2012). Their relatively low Reporting Rates are likely to have been affected by the diurnal focus for the survey effort. Wedge-tailed Shearwater and Gould's Petrel had some autumn records because chicks were usually still present in March and April visits. A fourth seabird, Australasian Gannet *Morus serrator*, was regularly seen foraging over the inshore waters of Providence Beach in autumn and winter. The difference in autumn/winter and spring/summer records (16; 1) for Australasian Gannet was statistically highly significant (χ^2 value 9.59). It is known to be a winter migrant to the Hunter Region (Williams 2020).

Although the overall Reporting Rate for Red-browed Finch *Neochmia temporalis* was below 40%, this species was never detected on Broughton Island until May 2021. Since then, it has been recorded on 15 of the 16 visits, often in total numbers of 20-30 birds and with a probable breeding record (an old nest). It might have become resident; however, there have been no retraps or resightings of any of six birds which have been banded on the island since 2021. The absence of repeat records suggests that Red-browed Finches move freely between Broughton Island and the mainland.

The Pheasant Coucal *Centropus phasianinus* had more spring/summer records but the difference to the autumn/winter records (13; 4) was not statistically significant (χ^2 value 2.65). Pheasant Coucals breed in spring/summer and are more vocal in their breeding season (Higgins 1999). Although their numbers have decreased (Stuart 2021), 1-2 birds continued to be recorded.

Occasional visitors

Seventeen species each had 3-8 records (corresponding to Reporting Rates below 30%). The list includes two threatened species (Pied Oystercatcher *Haematopus longirostris*, with a breeding record, and White-throated Needletail *Hirundapus caudacutus*) and two migratory shorebirds (the autumn/winter-visiting Double-banded Plover *Anarhynchus bicinctus*, and the spring/summer-visiting Ruddy Turnstone *Arenaria interpres*). There is no evidence to suggest that any of the 17 species is resident on the island. Indeed, several of the species are known to be spring-summer migrants to the Hunter Region (Williams 2020), and their seasonal patterns on Broughton Island matched the known regional behaviour.

Autumn/winter visitors

Four species had statistically significantly more records in autumn/winter than in spring/summer – Willie Wagtail *Rhipidura leucophrys* (17; 7; χ^2 value 4.93), Brown Goshawk *Tachyspiza fasciatus* (16; 5; χ^2 value 6.46), and Grey Fantail *Rhipidura albiscapa* (12; 1; χ^2 value 9.36), and the Australasian Gannet, as discussed above. The only spring/summer record for Grey Fantail was of an individual in September 2013 – perhaps a late-departing bird.

The records for Australian Golden Whistler *Pachycephala pectoralis* and White-faced Heron *Egretta novaehollandiae* also exhibited seasonal patterns. There were seven autumn/winter records for Australian Golden Whistler, with single birds present on the island annually over 2016-2020, and also in 2023 and 2025, and just one spring record (in October 2019). There were not enough records for statistical analysis to be valid, but the pattern seems clear. This seasonal pattern was unexpected, as seasonal movements within the Hunter Region have not previously been documented (Williams 2020). However, Higgins & Peter (2002) noted that some seasonal movements occur within its range in Australia, especially in winter. The White-faced Heron had 16 autumn/winter records and nine spring/summer ones – the Reporting Rate was about halved. However, the difference was not statistically significant (χ^2 value 2.53). Commensurate with the pattern of visits, the three times that larger flocks of White-faced Herons appeared were in late summer and early autumn.

The pattern might have changed for Willie Wagtails and Brown Goshawks. Willie Wagtails were recorded in six of the seven spring/summer visits from October 2022 onwards, whereas there had been only one prior spring/summer record (in October 2017). Brown Goshawks were recorded in all three of the spring/summer visits from October 2024 onwards, whereas there had been only two prior spring/summer records (in September 2013 and October 2019).

Beach Stone-curlew

Although there was only one sighting of Beach Stone-curlews *Esacus magnirostris* (a pair together at Esmeralda Cove, in August 2020), on two other occasions there were fresh footprints on Providence Beach. These are important records for a species which is critically endangered in NSW. As Beach Stone-curlews are crepuscular/nocturnal feeders (Marchant & Higgins 1993), they are likely to be overlooked in the diurnal survey effort. Two pairs of them breed at locations within Port Stephens, within 15-20 km of Broughton Island (Fraser & Stuart 2018; Murray 2019). It seems feasible that they sometimes would venture to the island, or that their dispersing progeny might visit. Mo (2016) has described how this species is expanding its range southwards.

Changes since removal of feral animals

It is beyond the scope of this report to discuss in detail the changes that have occurred on Broughton Island since rabbits and rats were removed, as that requires an analysis of the results from individual site surveys followed by comparisons for various time periods. That work is underway and will be reported in due course (Stuart in preparation). However, some of the changes seem obvious.

I have previously described the decline of the Golden-headed Cisticola population due to the vegetative changes (Stuart 2021). It has now become uncommon to find them in the central parts of the island although they continue to be present in the windswept grassland areas in the southern and eastern parts of the island. Conversely, Carlile *et al.* (2022) reported that the population of Wedge-tailed Shearwater increased after feral animals were removed.

Several species have become regular on Broughton Island since feral animals were removed – Silvereye *Zosterops lateralis* (first recorded 2011), Yellow-faced Honeyeater *Caligavis chrysops* (first recorded April 2009, regular since 2012), Brown Goshawk (first recorded 2013), Little Wattlebird *Anthochaera chrysoptera* (first recorded 2014), and Red-browed Finch (first recorded 2021).

Unlike the other bush bird arrivals, Little Wattlebirds have not been present in large numbers – the maximum count of them was four birds and during 2024/25 there were only occasional records of a single bird. Similarly, Brown Goshawk sightings have involved single birds, although three individuals have now been banded on the island, including a female and a male on the same day (Little & Stuart 2022).

The Yellow-faced Honeyeater record of two birds in April 2009 was during the known migration period for that species. The species appears not to have been resident or regularly present on the island prior to 2012, as it was not recorded in visits to the island in December 2009, November 2010 or November 2011.

Grey Fantails were not recorded until 2013 although autumn and winter visits to Broughton Island were infrequent prior to 2012. There were no records of Lewin's Rail before the surveys started, and none of Buff-banded Rail until 2016. These cryptic species might have been overlooked in earlier visits. However, since both species nest on the ground or at low elevations, e.g. in grassy tussocks (Marchant & Higgins 1993), it seems plausible that they have benefited from the removal of Black Rats.

The first confirmed breeding record for Ospreys on Broughton Island was in 2016 (Fraser 2021b), hence this might be another benefit from the removal of rats. Fraser (2021a) also speculated that Sooty Oystercatcher breeding success was improved because of the absence of rats.

CONCLUSIONS

Although Broughton Island is better known as a seabird island, because of its large breeding population of Wedge-tailed Shearwaters and other seabirds, it also supports many terrestrial and waterbird or shorebird species. Twenty-six species were recorded in systematic surveys over 2012-2025 and a further 27 species had less frequent records. Most of the common species were recorded all year round. Four species had distinctly autumn/winter patterns for their visits to the island or to its inshore waters.

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Waterbird utilisation of Ross Wallbridge Reserve, Raymond Terrace, New South Wales

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INTRODUCTION

Ross Wallbridge Reserve is a small recreational reserve located on the northern fringe of the Raymond Terrace Central Business District (32º45'28"S, 151º45'00"E). It has an area of 9.5 ha and comprises two small, shallow ponds, each with internal islands. The largest island (1.6 ha) is located in the eastern pond and two smaller islands are present in the western pond. The islands and the surrounds of the ponds are covered mainly by dense stands of Swamp Oak *Casuarina glauca* and Broad-leaved Paperbark *Melaleuca quinquenervia.* Historic aerial photography shows the ponds were constructed from open, marshy land in the early 1980s and since then, the planted vegetation has become thicker and more extensive, covering more than half of the reserve (https://maps.six.nsw.gov.au/).

The reserve is surrounded by busy arterial roads on three sides, and has a residential area and sporting facilities on the fourth. The confluence of the Hunter and Williams Rivers is located 500 m west of the reserve (**Figure 1**) and Irrawang Swamp is 2 km to the north. A concrete walking path heading northeast towards the adjacent residential area is present between the ponds. Despite a nationally significant number of the vulnerable Grey-headed Flying Fox *Pteropus poliocephalus* roosting at the reserve (Port Stephens Council 2025), it remains open to public access. In late August 2025 the reserve appeared poorly maintained. The area surrounding the ponds was covered by rank grass and exposed muddy areas with large amounts of litter.

Figure 1. Location map for Ross Wallbridge Reserve, Raymond Terrace, NSW.
(Image Google Earth accessed 2/09/2025)

The reserve is a major roosting and breeding location for a large number of mainly common waterbirds. It has been recorded as a significant diurnal roost for Nankeen Night Heron *Nycticorax caledonicus*, with as many as 85 birds present (Herbert 2007). Other species recorded as significant by Herbert were Chestnut Teal *Anas castanea*, Australian White Ibis *Threskiornis molucca*, Straw-necked Ibis *T. spinicollis* and Latham's Snipe *Gallinago hardwickii*.

This article describes the waterbird activity at the reserve in late August 2025, and presents a summary of historical waterbird records from the site.

METHODS

Survey counts and breeding records for waterbird species were downloaded from the Birdata (https://birdata.birdlife.org.au/explore#) and eBird (https://ebird.org/region/AU) online databases. Additional records were obtained from the Annual Bird Reports (1993-2019) of the Hunter Bird Observers Club (https://www.hboc.org.au/publications/annual-bird-report/).

The data were analysed for maximum species counts and Reporting Rates were calculated. Reporting Rate (RR%) is the ratio of the number of records to the total number of surveys, expressed as a percentage.

A field survey of the reserve was conducted on 29 August 2025 to determine the current breeding and roosting activity by waterbirds.

RESULTS

The summarised data from 82 Birdata and 91 eBird entries is shown in **Table 1**, together with maximum counts, Reporting Rates and reported breeding activity. The reserve has been surveyed irregularly since 1995; however, most of the Birdata surveys dated from 2016 and most eBird surveys from 2020. The data revealed 38 endemic and migratory waterbird species were present in the reserve at various times. Ten species had recorded breeding activity.

Current activity in the reserve

A large colony of Australian White Ibis were breeding in the reserve at the end of August 2025. An estimated 1,000 birds were nesting or roosting on the island in the eastern pond. The majority of the nests were on the ground or slightly above it, as most of the trees on the island have died. A further *c*. 500 birds were nesting or roosting in the lower branches of trees around both ponds. We estimated there were 450 nesting pairs on the island and a further 100 nesting pairs in the surrounding trees. A number of immature birds were present amongst the colony. Some ibis were foraging in the mud around the ponds, while others were flying in and out of the reserve, mainly to and from the north.

No eggs were seen in the nests that could be viewed. Only one chick, about 10-14 days old, was observed but others could be heard calling. Several birds that had been predated by avian predators were present on the ground below the nests. Avian predators and scavengers seen in the area were a Peregrine Falcon *Falco peregrinus* and a pair of Whistling Kites *Haliastur sphenurus*.

A colony of 40 Nankeen Night Herons was roosting in Swamp Oak on the island in the western pond and in surrounding trees. No nests were observed. Around 30 Eastern Cattle Egrets *Ardea coromanda* were roosting in trees to the south of the western pond.

A colony of several thousand Grey-headed Flying Fox were roosting in the reserve, mainly in trees not used by the ibis for nesting, but in some instances they were roosting directly above the nests.

DISCUSSION

Almost all of the species recorded are common in the Hunter Region (Williams 2020). Two uncommon species were the Magpie Goose *Anseranas semipalmata* (33 records) and the Glossy Ibis *Plegadis falcinellus* (one record). The Magpie Goose and the migratory Latham's Snipe are listed as vulnerable in NSW (*Biodiversity Conservation Act 2016*).

Australian White Ibis were present at Ross Walbridge Reserve year round, with a maximum count of 1600 birds in May 2024. Highest numbers were recorded August to October during the peak of the breeding season. Breeding activity extended from August to January, plus there were some nesting records from May and June. The numbers of birds using the site has been increasing steadily since 1995.

Nankeen Night Herons were also present at the site year-round, with a maximum count of 96 birds in December 2013. Highest numbers were present May to October. Breeding activity was recorded in

September, October and April. The numbers of birds on site appear to have increased since 1995.

Table 1. Waterbird species 1995-2025, maximum count, reporting rate and breeding activity, Ross Wallbridge Reserve, Raymond Terrace, NSW.

Common Name	Scientific Name	Max count	RR%	Breeding
Australian White Ibis	*Threskiornis molucca*	1600	93.1%	Yes
Nankeen Night Heron	*Nycticorax caledonicus*	96	80.9%	Yes
Dusky Moorhen	*Gallinula tenebrosa*	50	79.2%	Yes
Maned Duck	*Chenonetta jubata*	36	56.6%	Yes
Royal Spoonbill	*Platalea regia*	51	52.6%	
Pacific Black Duck	*Anas superciliosa*	37	49.1%	Yes
Purple Swamphen	*Porphyrio Porphyrio*	10	47.4%	Yes
Little Black Cormorant	*Phalacrocorax sulcirostris*	80	47.4%	
Eurasian Coot	*Fulica atra*	16	37.6%	
Masked Lapwing	*Vanellus miles*	20	37.0%	Yes
Chestnut Teal	*Anas castanea*	19	32.9%	Yes
Australasian Grebe	*Tachybaptus novaehollandiae*	5	31.2%	Yes
Great Egret	*Ardea alba*	7	28.3%	
Grey Teal	*Anas gracilis*	32	26.6%	
Straw-necked Ibis	*Threskiornis spinicollis*	1636	24.9%	
Little Pied Cormorant	*Microcarbo melanoleucos*	7	19.7%	
Magpie Goose	*Anseranas semipalmata*	93	19.1%	
Eastern Cattle Egret	*Ardea coromanda*	200+	19.1%	
Australian Pelican	*Pelecanus conspicillatus*	10	15.0%	
Black Swan	*Cygnus atratus*	4	12.1%	Yes
Hardhead	*Aythya australis*	20+	11.0%	
White-faced Heron	*Egretta novaehollandiae*	6	9.8%	
Australasian Darter	*Anhinga novaehollandiae*	3	7.5%	
Plumed Egret	*Ardea plumifera*	4	5.8%	
Mallard	*Anas platyrhynchos*	10	4.6%	
Little Egret	*Egretta garzetta*	2	2.9%	
Latham's Snipe	*Gallinago hardwickii*	2	2.3%	
Great Cormorant	*Phalacrocorax carbo*	2	1.7%	
Silver Gull	*Chroicocephalus novaehollandiae*	2	1.7%	
White-necked Heron	*Ardea pacifica*	1	1.7%	
Australasian Shoveler	*Anas rhynchotis*	1	1.2%	
Australian Pied Cormorant	*Phalacrocorax varius*	1	1.2%	
Pied Stilt	*Himantopus leucocephalus*	1	1.2%	
Black-fronted Dotterel	*Elseyornis melanops*	1	0.6%	
Buff-banded Rail	*Hypotaenidia philippensis*	1	0.6%	
Glossy Ibis	*Plegadis falcinellus*	1	0.6%	
Greater Crested Tern	*Thalasseus bergii*	1	0.6%	
Plumed Whistling Duck	*Dendrocygna eytoni*	2	0.6%	

Magpie Geese were first recorded at the reserve in May 2019, when a flock relocated from the Hunter Wetlands Centre at Sandgate (Stewart 2020). The birds subsequently returned to the Wetlands Centre in May 2020. The maximum number recorded at Wallbridge Reserve during this period was 55 birds. Small numbers continued to be irregularly recorded until December 2023 when a large flock arrived. Birds were regularly recorded on site until March 2024, with the maximum number recorded being 86 birds. A large flock was again present on site from September to December 2024 with a highest count of 56 birds. Highest counts were recorded from

October to March. There was no observed breeding activity by the species at the site.

Straw-necked Ibis roosted at the site year-round with a maximum count of 1636 birds in July 2025. Highest numbers were present in May and June. Eastern Cattle Egret also roosted at the site year-round with a maximum count of 200+ birds in June 2007. Highest counts were present from February to July. Neither species has used the site for breeding.

CONCLUSION

Ross Wallbridge Reserve supports a rich diversity of waterbirds, some of which are present at times in large numbers. Despite the presence of the adjacent commercial business district and the busy surrounding arterial roads, the small reserve provides a relatively safe and secure breeding site for large numbers of Australian White Ibis and lesser numbers of Nankeen Night Heron. The reserve also provides a safe year-round roosting site for a diverse range of other waterbird species including Eastern Cattle Egret, Straw-necked Ibis and Magpie Goose. The availability of extensive nearby areas of wetlands and river floodplains for foraging is undoubtedly a major factor influencing the birds' utilisation of the reserve.

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Nankeen Night Herons regularly roost at the Ross Wallbridge Reserve near Raymond Terrace, and their numbers have been increasing (photo: Rebecca Citroni)

Can Brahminy Kites survive the urbanisation challenge? A review of the factors affecting Brahminy Kites in the Hunter Region and beyond

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The return of the Brahminy Kite *Haliastur indus* to the Hunter Region coastline after an absence of almost two centuries offers an opportunity to expand our knowledge of this wide-ranging but understudied raptor. The species favours coastal habitat, a region rapidly succumbing to dramatic changes in native biodiversity as a result of the unprecedented growth of urbanisation. Raptors, due to their position at the top of the food chain, are particularly susceptible to habitat change, and for many raptor species, urbanisation has meant significant population decline and possible extinction. The global Brahminy Kite population is also trending downward, but range-wide observations indicate that the species shows a tolerance for human proximity, and adaptability in the face of habitat change. These qualities, in conjunction with appropriate conservation measures, may help the species to maintain a viable population throughout its extensive geographic range, and ensure continued recolonisation success along the Hunter Region coast, and beyond.

INTRODUCTION

Urbanisation, the expansion of commercial, industrial and residential land use associated with concentrated human presence, dramatically alters natural ecosystem patterns and processes (Chace & Walsh 2004; Kettel *et al.* 2018). It is predicted that by 2050, 68% of the world's human population will live in urban areas (mostly coastal), a reality that no amount of habitat protection or habitat restoration will change; therefore, native species must either avoid, adapt or exploit the conditions of life in extremely modified, human-dominated environments (Marzluff & Rodewald 2008; Kettel *et al.* 2018; United Nations 2018; Patankar *et al.* 2021). Urban development typically occurs near large waterbodies (rivers, estuaries, coastlines and lakes); therefore, all coastal avian species face some degree of habitat change, but raptors are particularly challenged (Melles *et al.* 2003; Chace & Walsh 2004).

Raptors are emblematic of the global biodiversity crisis. One out of five raptor species is threatened with extinction, over half have declining populations, and coastal raptors like Brahminy Kites *Haliastur indus* are especially challenged by the rapid and relentless urbanisation of their natural environment (Melles *et al.* 2003; Chace & Walsh 2004; O'Bryan *et al.* 2022). The global distribution of Brahminy Kites (~ 43,300,000 km²) extends from peninsular India and Sri Lanka, east through tropical continental Asia, and southern China, then south through south-east Asia, New Guinea and the Solomon Islands to its current southern range limit, approximately the mid-coastal regions of south-eastern and south-western Australia (Marchant & Higgins 1993; BirdLife DataZone 2024). Throughout this vast geographic range, the species is constantly faced with on-going anthropogenically-generated habitat modification at multiple scales and levels, and while the species is not yet flagged as "Threatened" a decreasing population trend has been detected (BirdLife Data Zone 2024).

The following discussion is based upon findings garnered from an extensive search of literature pertaining to current and historic Brahminy Kite range data, literature associated with the effects of urbanisation on avian species in general, and observations by the author.

The paper's objective is to heighten awareness of the challenges faced by Brahminy Kites, as a result of rapid urban growth, and endeavour to identify at least some of the drivers of raptor population decline which must be addressed if species population stability is to be achieved.

DISCUSSION

Coastal topography and regional economic factors can dictate the size and shape of shoreline urbanisation, but urban development usually follows a common format: a high-density, metropolitan core (administration and commerce) surrounded by irregular rings of diminishing commercial and industrial activity interspersed with suburban housing (Melles *et al.* 2003; Chace & Walsh 2004). This type of urban matrix tends to generate a graduated (native to urban) filter that favours some species, and selects against others, thereby creating a systemic catalyst that triggers species drop-out when the type and amount of land-use reconfiguration becomes intolerable, a situation that leads to food-web imbalance, reduced biological richness and inevitable raptor population decline (Chace & Walsh 2004; MacGregor-Fors & Schondube 2012; Sumasgutner *et al.* 2014).

Predicting the negative effects of habitat change for avian populations is not a new phenomenon. One of Australia's earliest ornithologists, Alfred J. North, expressed fears for the future of coastal avifauna as far back as 1901, citing urban growth and human activity as major concerns **(**North 1901**)**. In more recent decades, calls to address the problem of decreasing avian diversity in urban areas have become more frequent and increasingly urgent.

Birds have attracted public and professional attention for centuries. Raptors are generally long-lived and difficult to monitor, but today's combination of electronically accessible data sourced from community science projects and professional research provide a measurable taxon upon which to model avian trait-shifts in an urban context. The emerging evidence of worldwide raptor population decline is worrying (3% status unknown; 27% of least concern; 52% in decline; 18% threatened with extinction) (McClure *et al.* 2018; Patankar *et al.* 2021; Hamdan & Misman 2020).

Raptors contribute critical ecosystem services. Declining populations could disrupt these services and eventually trigger a cascade of events that negatively affect human well-being **(**McClure et *al.* 2018; Patankar *et al.* 2021; O'Bryan *et al.* 2022; Schenk *et al.* 2022).

1. Pest and disease control: control of invasive faunal species and carriers of disease (Patankar *et al.* 2021; O'Bryan *et al.* 2022).
2. Recycling: scavenging of carrion and garbage (Patankar *et al.* 2021).
3. Provisioning: an indirect aid to plant regeneration via ingestion of seed-eating prey (Patankar *et al.* 2021).
4. Cultural services: a connecting link between nature and increasingly nature-deprived environments (Patankar *et al.* 2021).

As apex predators, raptors are positioned at the top of the ecological food web, making them highly susceptible, directly and indirectly, to the effects of land-use change; therefore, studies relating to urban raptors are thought to be essential if management and conservation measures are to succeed (McClure *et al.* 2018; Patankar *et al.* 2021; O'Bryan *et al.* 2022).

Brahminy Kites are thought to have undergone a northern range retraction in NSW very shortly after First European Settlement (1788) (Marchant & Higgins 1993; Cooper *et al.* 2014). Records for Sydney Cove appear to cease by the late 1700s, and Hunter records for the same time period are similarly rare (Hindwood 1970). Gould, during his time in NSW (1839-1842), only recorded one Brahminy Kite sighting, a bird flying in the lower reaches of the Hunter Estuary (Gould 1848). In the 1700s, 30ºS latitude may have been the southernmost edge of the Brahminy Kite's range in south-eastern Australia (Marchant & Higgins 1993). Populations at the edge of a range tend to be small and vulnerable; therefore, it's possible that late 18th century Brahminy Kites in southeast NSW succumbed to the challenges of Australia's first urbanisation experiment (Verberk 2011; Connallon & Sgrò 2018).

The 2016 Red List Index classifies the species as a raptor "of least concern" and the species has also been cited as "the most commonly observed bird of prey in the Indonesian Archipelago", and "Australia's most urban-tolerant raptor" (Iqbal *et al.* 2009; Headland *et al.* 2023; BirdLife DataZone 2024). While these facts would seem to assuage concerns for the future of the species, an earlier baseline study of NSW raptors clearly sounds the alarm and draws attention to Brahminy Kites as a species specifically threatened by coastal habitat destruction and pollution, a warning now constantly echoing throughout the literature (Debus 1992). The vast tropical and subtropical range of the Brahminy Kite spans many countries and cultures, all of which have the potential to drastically modify local native habitats in ways that may expose the species to significant hazards. Continued survival, throughout their range, will require a high degree of behavioural plasticity.

During the past 15 years (2010-2025) Brahminy Kites have slowly returned to the Hunter coast. Increased sightings, successful nests and territories have led to regional species reclassification from Category 3 (1993) "rare; vagrant" to Category 1 (2018) "common breeding resident" (Stuart 1994; Williams 2019). The convergence of three factors: habitat change (restricted hunting and nesting), stress (related to human activity), and climate change (increasing frequency and severity of weather events) present the current generation of Brahminy Kites with challenges of far greater magnitude than those faced by their ancestral counterparts (Kettel *et al.* 2018; Sergio *et al.* 2022) (**Figures 1 & 2**).

Habitat and range

Shoreline modification throughout the Brahminy Kite's range (mainland southeast Asia to Australia) has been extensive. Commerce, shipping, recreational boating, wild and farmed fishing, shrimp ponds, logging, charcoal burning, housing, and tourism are just some of the anthropogenic enterprises that have contributed to the removal of native coastal habitat (Khaleghizadeh & Anuar 2014a). Population decline of the species has now been noted in India, Thailand, Laos, Cambodia, Indonesia, Malaysia and the Philippines (Van Balen *et al.* 1993; Duckworth & Hedges 1998; Indrayanto *et al.* 2011).

In the Hunter, Brahminy Kites tend to establish territories in sheltered estuarine areas with easy access to calm water for fishing and large, mature trees for nesting (Wooding 2017, 2019). Unsurprisingly, such locations also constitute prime human habitat, a scenario with the potential to spawn contentious situations in which nature seldom prevails.

Breeding landscape and nests

Even though there has been intense development of the Hunter's shorelines, relatively un-urbanised terrain may still be found around coastal lakes and rivers (Lake Macquarie; the Myall Lakes and river system), two major estuaries (Port Stephens Estuary; the Hunter Estuary), low-profile coastline, a scattering of offshore islands, and in areas protected by national parks. Due to lack of access, the number of Brahminy Kite nests in these areas is unknown, with the possible exception of Broughton Island (Stuart 2020).

Tree removal regulation has helped retain native trees, including mature Blackbutts *Eucalyptus pilularis*, which appear to be the nest-tree species of choice for Hunter Brahminy Kites (Port Stephens Council 2016; Wooding 2017, 2019**).** In tropical and sub-tropical regions there are records of nests in a wide variety of tree species and, occasionally, on artificial structures (Marchant & Higgins 1993; Indrayanto *et al.* 2011; Riddell 2017) (**Table 1**). Regional nest-tree adaptation augers well for breeding success.

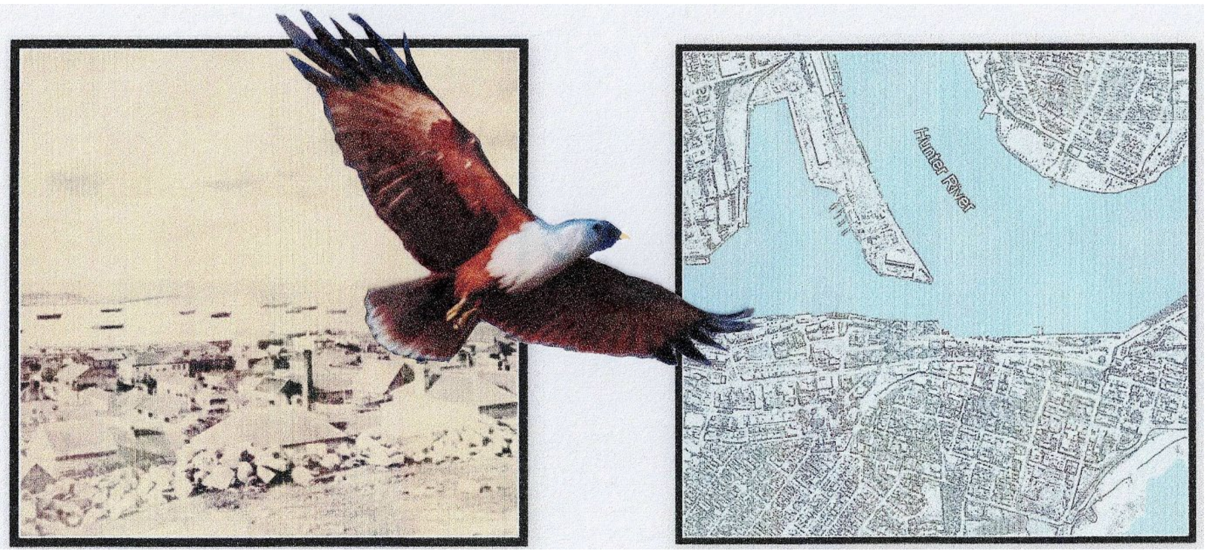

Figure 1. Newcastle Harbour (approx.1860).
Photo: Newcastle Public Library Archives (Photographer unknown).

Figure 2. Newcastle Harbour 2021.
Adapted from Google Earth 2021.

Table 1. Known Brahminy Kite nest trees

Common Name	Scientific Name	Region
African Mahogany	*Khya ivorensis*	Southern India
Blackbutt	*Eucalyptus pilularis*	Coastal Australia (NSW, Qld)
Chilean Mesquite	*Prosopis chilensis*	Southern India
Coconut Palm	*Cocos nucifera*	Southern India
Drumstick Tree	*Maringa alifera*	Southern India
Grey Mangrove	*Avicennia marina*	Southern India
Gum Arabic	*Acacia arabica*	Southern India
Indian Horsetail	*Casuarina indica*	Malaysia
Indian Lilac	*Azadirachta indica*	India; South-east Asia
Indian Mulberry	*Morinda tinctona*	South-east Asia; Australasia
Mango	*Mangifera indica*	India; South-east Asia
Milkwood	*Astonia actinophylla*	Malaysia
Norfolk Island Pine	*Araucaria heterophylla*	Southern India (introduced)
Palmyra Palm	*Borassus flabellifer*	Malaysia; Coastal NSW; Qld
Pornupan Mangrove	*Sonneratia alba*	Malaysia; Northern Territory
Portia Tree	*Thespesia populnea*	Southern India; Malaysia
Rhu Tree (Horsetail She-oak)	*Casuarina equisetifolia*	Coastal NSW
Sacred Fig	*Ficus religiosa*	Southern India
Scribbly Gum	*Eucalyptus racemosa*	Coastal NSW; Qld
Scrubby Seablite	*Suaeda fruticosa*	Southern India
Tamarind	*Tamarindus indicus*	India; South-east Asia
Teak	*Tectone grandis*	South-east Asia

All Hunter Region nests known to the author were found close to houses in older residential neighbourhoods, located approximately 100-400 m back from the shoreline (Wooding 2017, 2019). However, in Darwin the species has been observed nesting in the seaward side of Pornupan mangrove forests (Riddell 2017). Older neighbourhoods with single unit dwellings may have greater numbers of exotic flora and fauna (cats, dogs and non-native plants), but these districts are less disturbed than inner-city locations. They also tend to have taller, more mature trees, and greater biodiversity due to embedded green space (parks, gardens, golf courses, vacant lots). This variety creates a situation where tolerance for human presence becomes an acceptable trade-off for access to desirable nest sites and hunting areas (Chace & Walsh 2004; Dykstra 2018; Kumar *et al.* 2019).

Nests located slightly inland may also reduce nest-defence conflicts with other local Hunter raptors (Osprey *Pandion haliaetus,* White-bellied Sea Eagles *Icthyophaga leucogaster* and Whistling Kites *Haliastur sphenurus*) that generally prefer nest sites closer to the shoreline (pers. obs.). Although fierce in nest defence, Brahminy Kites appear to have a relatively stoic disposition (pers. obs.) (**Figure 3**). They were not seen by the author to initiate aggression towards other raptors or other avian species. They gave ground to frequent attacks by Whistling Kites and Ospreys, they ignored mobbing by smaller species (e.g. Little Corellas *Cacatua sanguinea*) and flew steady, unswerving, parallel hunting transects with White-bellied Sea Eagles (Wooding 2017, 2019).

Figure 3. Female Brahminy Kite defending nest from Pied Butcherbird (photo: L. Wooding.)

Hunter Region nests vary from new nests (presumed first-time breeders), refurbished nests (occupied over consecutive breeding seasons), and replacement nests (constructed in close proximity to earlier nests irreparably storm-damaged or abandoned as a result of human disturbance). Persistent nesting within the same area would seem to support the theory of territorial faithfulness (Marchant & Higgins 1993; Indrayanto *et al.*2011; Khaleghizadeh & Anuar 2014a*;* Wooding 2017, 2019). Range-wide evidence also supports the hypothesis that Brahminy Kite nest-tree selection is directly related to the close proximity of inter-tidal mangrove forests. When mangroves were removed from known nesting areas local Brahminy Kite populations quickly declined (Van Balen *et al.* 1993; Indrayanto *et al* 2011; Khaleghizadeh & Anuar 2014b).

Mangroves may be of threefold importance to Brahminy Kites: nest-tree sites; a source of construction material for nest building and nest repair; and an indirect dietary source (North 1889; Khaleghizadeh & Anuar 2014b; Wooding 2017, 2019). Mangrove systems have a significant ability to absorb CO_2, a beneficial asset in the attempt to mitigate global warming and slow down climate-related habitat change (NSW Dept. of Primary Industry 2008**)**. They also protect shorelines from wave-action and storm-induced erosion, while providing vital nursery habitat for a wide variety of aquatic life forms, which in turn enrich the food-chain and, ultimately, the Brahminy Kite's diet (NSW Dept. of Primary Industry 2008; Hamdan & Misman 2020; Sabino & Macusi 2023). However, tidal barriers, uncontrolled stock access, off-road vehicles, dumping of rubbish, chemical spills, rising sea levels and shoreline development are just some of the threats jeopardizing mangrove forest health **(**NSW Dept. of Primary Industry 2008). In NSW, government regulation has helped protect mangrove forests, and as a result, the Hunter Region's Brahminy Kites, currently, have adequate mangrove access (NSW Dept. of Primary Industry 2008). However, this may not be the case range-wide. Over the past fifty years, approximately one-third of the world's mangrove forests has been lost, mostly in tropical and sub-tropical regions, to make way for shoreline development projects (Khaleghizadeh & Anuar 2014b; Sabino & Macusi 2023).

Diet

A Tolerance Index Score found that body mass was the only trait that significantly influenced a positive response to urbanisation among smaller raptors, particularly Brahminy Kites in Australia, making them more successful in urban landscapes than larger-bodied raptors **(**Headland *et al.* 2023). This trait may be driven by behavioural flexibility, particularly dietary flexibility **(**Headland *et al.* 2023). Smaller-bodied raptors often supplement their species-specific prey preference with smaller prey items (Headland *et al.* 2023). Although fish form the major component of the Brahminy Kite's diet, they are actually dietary generalists known to consume insects, small animals, small mammals, birds, reptiles, benthic species and carrion **(**Marchant & Higgins 1993; Debus 2012; Wooding 2019) (**Figure 4**).

Figure 4. Brahminy Kite fishing at Lemon Tree Passage NSW (photo: L. Wooding).

As dietary generalists, the species is more likely to profit from Australia's sprawl of suburban greenspace, which tends to attract a variety of small, but acceptable, supplementary prey options (Headland *et al.* 2023). Dietary flexibility, the ability to feed on whatever prey is locally present, makes smaller-bodied raptors, like Brahminy Kites, more likely to survive dietary change than dietary specialists (Chace & Walsh 2004; Sumasgutner *et al.* 2014; Patankar *et al.* 2021; Headland *et al.* 2023). Also, raptor home ranges are large; therefore, dietary restrictions can be alleviated to some extent by establishing territories that extend beyond the urban boundary, thereby eliminating the need to meet all ecological requirements within urban limits (Chace & Walsh 2004). However, the pressure of urban expansion constantly disrupts rural and native ecosystem patterns around the metropolitan fringe (Chace & Walsh 2004)**.**

Although dietary generalists may appear to have broader dietary options, the advantage of a wider prey base could be offset by the possibility of increased exposure to harmful chemicals (McClure *et al.* 2018). Chemical residue from agricultural pesticides, herbicides and a variety of urban pollutants run off into creeks, rivers and estuaries, and eventually reaches inshore coastal waters (all of which are preferred Brahminy Kite hunting areas) and permeates the food-web, becoming more concentrated via primary, secondary and tertiary ingestion (Chace & Walsh 2004).

Olsen's research on organochlorines (e.g. Dichlorodiphenyltrichloroethane - DDT) revealed the cumulative effects of that particular chemical on Australian raptors (Olsen & Olsen 1985; Olsen *et al.* 1993; Olsen & Marples 1993). These studies showed that the reproduction rate for Brahminy Kites became significantly lower due to smaller clutch size, eggshell thinning, and increased embryo death (Olsen & Olsen 1985; Olsen *et. al.,* 1993; Olsen & Marples 1993).

The use of DDT in Australia was banned in 1987 but not necessarily banned, or monitored, throughout the entirety of the Brahminy Kite's range (Australian Government 2023). DDT residue is long-lasting and may still be present in some regions; also, excessive use of pesticides and insecticides on rice fields and fish farms may still occur in tropical areas (Van Balen *et al.* 1993).

Pre-market chemical testing in Australia is now more rigorous; however, accumulations of compounds, popularly referred to as "forever" chemicals (~4000 per- and polyfluoroalkyl substances - PFAS) widely used over the past 70 years, are now thought to pose a threat to wildlife, along with highly toxic levels of second-generation anti-coagulant rodenticides (Vendl *et al.* 2023; Australian Government PFAS Taskforce 2024; BirdLife Australia 2024; Stuart 2024).

While the diffusion of chemical residue and its cumulative effects on upper trophic species is now better understood, a review of recent studies focussing on the effects of chemical residue on lower trophic species since the end of WWII, suggests that 40% of global insect species are threatened with extinction over the next few decades (Raven & Wagner 2021). Knowledge of Australian insect population trends and their drivers is poor; however, in 2019 a symposium hosted by the Australian societies for entomology, systematic biology and arachnology reviewed the current Australian literature and identified 10 major taxonomic orders (approx. 37% of species) that are experiencing rapid decline, and 18% of species with population increases (Braby *et al.* 2019). The species in decline included many beneficial species (e.g. pollinators) whereas the species showing population increase had very little conservation value (Braby *et al.* 2019). The interaction of urbanisation and climate change (water stress; heat waves; mega fires and land-use practices) were considered the most likely drivers for the more recent insect extirpations (Braby *et al.* 2019). Given that insects are largely representative of the food-web's foundation, these alarming predictions of insect decline, should they eventuate, would have repercussions for all life forms.

Hunting techniques

Brahminy Kite territories, regardless of extent or location, are directly or indirectly managed by humans, but fortunately the species does not appear to be strictly limited to provisioning from a coastal larder (Kumar *et al.* 2019). The Brahminy Kite's lazy flight, supposed lack of speed and manoeuvrability, and weak feet, were thought to make the species unsuited for active hunting (Bell 1985). This theory would seem to be dispelled by reports throughout tropical areas (including Queensland, Aust.) of hunting forays well inland from coasts (2 km - 20 km) over grasslands, agricultural land and forests, up to altitudes of 2400 m, where Brahminy Kites were seen to hunt in the manner of buteos *Buteo* spp., folding their wings and diving through the forest canopy with remarkable manoeuvrability to take locusts, phasmids and small birds on the wing (Gilliard & LeCroy 1966; Morris 1980, 1981; Bell 1985; Marchant & Higgins 1993; Olsen 1997; Olsen & Trost 2007). One report of this behaviour in NSW was found: a Brahminy Kite swooping to take a Noisy Miner *Manorina melanocephala* from a shrub (Lutter *et al.* 2006). A demonstrated flexibility in hunting range and hunting techniques (perch and swoop, pursuit and swoop) in tropical regions would seem advantageous traits that might well transfer to southern range environments should the warming climate bring about a tropical transformation of temperate zone vegetation (Headland *et al.* 2023). Successful attempts at kleptoparasitism of cormorants, requiring considerable flight manoeuvrability, were also observed by the author.

Some major drivers of urban raptor decline

Establishing a territory does not necessarily guarantee success. For Brahminy Kites, and other raptors, life in an urban landscape holds many anthropogenically-generated drivers of population decline (Chace & Walsh 2004; MacGregor-Fors & Schondube 2012).

Collisions: car strikes, window strikes, collisions with towers and masts, and powerline entanglement (Chace & Walsh 2004; McClure *et al.* 2018; Patankar *et al*. 2021).

Noise: cars, trucks, heavy-duty equipment, trains, aeroplanes, industrial and recreational activities produce noise that can initiate temporary or permanent nest abandonment **(**Wooding 2017; Patankar *et al*. 2021). Low-frequency noise, such as traffic noise, carries over long distances, masking bird song, and disrupting avian communication (Patankar *et al*. 2021).

Pollution: (in addition to insecticides and pesticides) airborne ingestion of emissions from cars, trucks, planes, shipping and industry, plus exposure to plastics and pollutants while scavenging human refuse (Isaksson *et al.* 2018). Notably, for coastal and aquatic raptors, entanglement in lost or discarded fishing gear (Thomson *et al.* 2020).

Artificial light pollution: Night-time disturbance from vehicle lights, street lights and illuminated signage produces stress (Isaksson *et al.* 2018; Patankar *et al*. 2021).

High temperatures: cities develop their own microclimate (the heat-island effect). Radiant heat from artificial surfaces generates higher temperatures than the temperatures experienced in the surrounding countryside and can produce heat stress. Also, lower trophic-level species may not respond to heat-induced early bud-burst and insect emergence, which may result in food chain disruption and fragmentation (Isaksson *et al.*2018; Patankar *et al*. 2021).

Exotic species: the introduction of exotic flora and fauna (pets and non-native plants). Replacing native trees and shrubs with exotic varieties can result in the modification of lower-trophic food options which, in turn, may decrease biodiversity within the food chain (Patankar *et al*. 2021).

Disease: inter-species transmission of diseases and parasites at gathering points (bird feeders and bird baths) increases the risk of disease transmission within the food chain. Raptors may identify these sites as easy hunting areas and become infected (Chace & Walsh 2004; Isaksson *et al.* 2018).

Flight Initiation Distance (FID): raptors that have become used to traffic and human presence tend to be bolder and exhibit shorter FID, increasing the risk of accidents due to distance misjudgement (Patankar *et al*. 2021).

Human cultural practices: legislation notwithstanding, shooting, poisoning (direct and indirect), trapping, caging, plumage collection, and egg collection still occur. Also, because of their size and beauty, stuffed raptors like Brahminy Kites are popular souvenirs in some quarters (Van Balen *et al.* 1993; Marzluff & Rodenwald 2008; McClure *et al.* 2018; Wooding 2019; Villegas *et al.* 2021).

Climate change: the frequency and severity of extreme weather events related to climate change may have direct effects on raptor breeding success, due to the destruction of nests, eggs and chicks, and may also be capable of reconstructing entire ecosystems, with consequences that substantially influence human and wildlife communities (Marzluff & Rodewald 2008; Sergio *et al.* 2022).

The outlook for Brahminy Kites

Between 2000 and 2030, the footprint of global urbanisation is predicted to triple, particularly in coastal areas (United Nations 2018**.** Increasing coastal urbanisation will escalate land-use imbalance and exacerbate negative issues affecting human/raptor interaction, the framework within which the fate of the Brahminy Kite will be decided (Dykstra 2018; Isaksson *et al.* 2018).

Brahminy Kites are an emblematic species symbolizing the ecological reality of all native, avian fauna currently facing life in coastal urban settings. Although the species is not yet globally recognised as "of concern" or "threatened" a downward population trend has been detected (BirdLife Data Zone 2024). Given that the species occupies a position at the top of the food web across a huge tropical and sub-tropical range comprised of many different countries and cultures, speedy consensus on management and conservation measures may prove difficult; therefore, the possibility of range-wide population fragmentation cannot be ignored.

It's thirty-five years since Debus (1992) warned about the negative effects of continued coastal habitat destruction for NSW raptors and the evidence for raptor population decline has become irrefutable. Awareness in the literature has become more vocal and more urgent, but scant public understanding of the challenges facing raptors is in danger of being totally submerged by public and political pressure focussed on the building of more houses in order to solve the current housing crisis, an exercise which will inevitably contribute to the extension of the urban footprint.

For their part, Brahminy Kites have demonstrated (so far) the behavioural plasticity needed to cope with anthropogenically-generated reconfiguration of native coastal habitat throughout their vast range, and, in Australia, all levels of government, to their credit, have introduced various conservation measures. However, for these apex predators burgeoning urbanisation may compromise or even overwhelm their prospects for future population success (McClure *et al.* 2018; Patankar *et al.* 2021; O'Bryan *et al*. 2022). Clearly, future urban design must take a multi-faceted, multi-disciplinary approach, involving input from both professionals and citizen scientists in many fields when addressing the complex mechanisms and ecological values of urban species that need to be understood in order to retain, protect and enhance their habitats. Issues involving the variety of the built environment, the manufacture, control, monitoring and eradication of dangerous chemicals, and the exploration of avenues that heighten public awareness must also be considered. Fostering connections between people and their natural heritage is key to the success of conservation and protection measures (Chace & Walsh 2004; Marzluff & Rodewald 2008).

CONCLUSION

Currently, Brahminy Kite recolonisation of the Hunter Region appears to be successful, but being a modern-day Brahminy Kite is not easy. Viewed through the prism of history, losing the Brahminy Kite the first time was sad, but understandable. From a 21st century viewpoint, losing this sentinel species, now recognised as Australia's most adaptable and human-tolerant raptor, for a second time could be the harbinger of much wider ecological adversity.

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Life on the edge of a flood plain – planting native vegetation to attract birds to a property on a rural subdivision.

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Monthly lists were used to generate an inventory of the bird species recorded on a small property at Woodville, near Paterson in the lower Hunter Valley of NSW. The property was located on recently subdivided grazing land situated between the Butterwick floodplain and adjacent woodlands, habitats that support different assemblages of birds.

The native plantings progressively attracted a number of woodland species to the property supplementing the wetland and open country species already present. In a 16-year period (1998-2013), 150 species were recorded. While a species list of this magnitude indicates high avian diversity, relatively few species were resident.

Woodland species attracted to the native plantings reflected the species abundance in nearby source populations and the extent to which the plantings provided suitable foraging habitat. The ability of species to move between habitat patches in a highly fragmented landscape, dominated by aggressive Noisy Miners *Manorina melanocephala*, was also important.

Only one species, the Fairy Martin *Petrochelidon ariel*, suffered local extirpation, but this was a regional phenomenon.

Monthly lists lacking standardised data collection protocols generated valuable information on the seasonal and temporal variations of the regularly recorded species.

INTRODUCTION

In 1993 I moved to a 2-ha property in a recently developed sub-division, at Woodville, located at the junction of Glenurie Close and Butterwick Road. The subdivision was on a narrow belt of pastoral land bordered by woodland on the higher ground to the north and the Butterwick flood plain, which abuts the Paterson River. The Butterwick flood plain is part of a large complex of flood plains bounded by the cities of Newcastle and Maitland and the townships of Raymond Terrace, Paterson and Seaham. These low-lying areas provide flood mitigation for the Hunter, Williams and Paterson rivers and are periodically inundated.

This paper discusses the changes in the bird population of our garden and its immediate surrounds between 2000 and 2013. A key factor influencing those changes was the establishment of a native garden on our property to attract woodland birds. Although BirdLife Australia actively promotes the importance of native gardens as bird habitat in urban and fragmented landscapes through its Birds in Backyards program, there are few studies assessing the success of these activities in the Hunter Region. For instance, there is only one prior paper in *The Whistler* on this topic (Carlton 2009).

Bird surveys were also conducted contemporaneously at two locations within 2 km of our property. One was on a small property on Green Wattle Creek, on which cattle were grazed (Newman 2007), and the other in woodland within a Crown Lands Reserve at Green Wattle Creek (Newman 2009; Newman & Cunningham 2018). These studies provided a basis for understanding the dynamics of the changes in the birds observed on our property as it transitioned from open pasture.

METHODS

Data collection

A monthly list was kept of all bird species seen, heard and flying over our property and the immediate surrounding area. Evidence of breeding included the presence of recently fledged juveniles which may not have been reared at the survey site. The surveys were submitted to BirdLife Australia's Birdata archive as

500 m radius area search surveys (survey point ID 2298753; coordinates 32.666ºS 151.641ºE). Most observations were opportunistic and the total observation time per month was highly variable.

Survey data was collected between 1998, at the beginning of the second Australian Atlas project (Barrett *et al*. 2003) and December 2013. During this period 142 monthly surveys were submitted to Birdata, while 137 (out of a possible 156) monthly surveys were submitted between 2000 and 2013.

Data analysis

Because there were only five surveys during 1998-1999, I limited the data analysis to the period 2000-2013. The analysis was based on presence data and evaluated as reporting rates (RRs), the frequency at which a species was observed. The temporal analysis for the period 2000-2013 involved 9 or more monthly surveys/annum, except for 2003 (8 surveys) and 2008 (4 surveys). The Pearson's Chi-Square test (Fowler & Cohen 1994) with a Yates correction for 1 degree of freedom was used to test the statistical significance of differences between the occurrence of species in the first and second seven-years of the period 2000-2013. Calculated Chi-Square (χ^2) values above 3.84 indicate a significant difference between the two periods, to at least 95% confidence level, while χ^2 values above 6.63 indicate the difference is highly significant, to at least 99% confidence level.

Habitat

Glenurie Close is located on a spur of higher ground protruding into the Butterwick flood plain (**Figure 1**). The property was located near the junction with Butterwick Road on a block that sloped gently uphill from a 75 m long dam fed by a creek which intermittently flowed through three other dams located on adjacent properties. The house was situated near the upper boundary of the block, 1 m above the 1-in-100-year flood level. The lower part of the block was occasionally inundated and in extreme instances Glenurie Close became inaccessible.

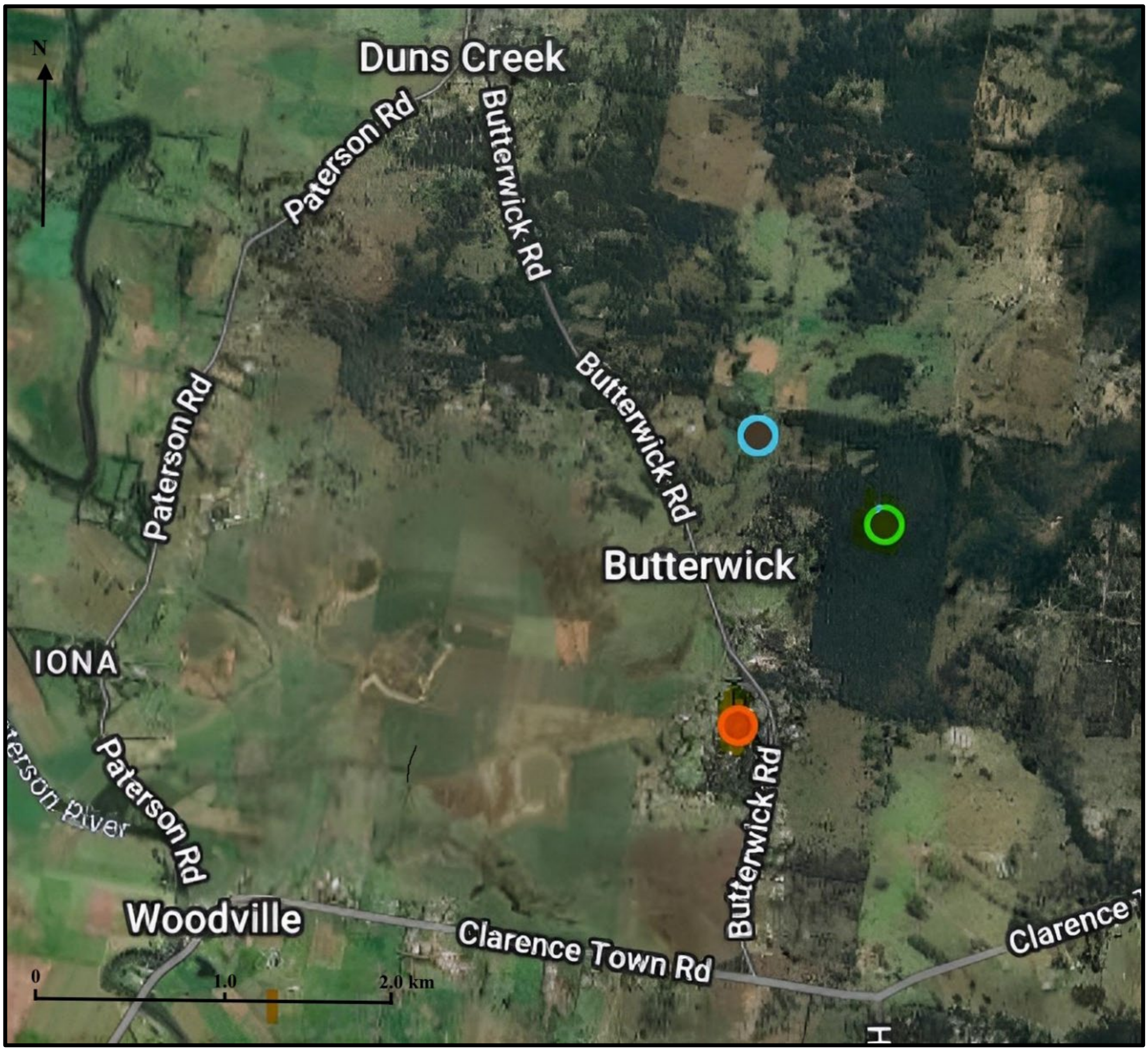


Figure 1. Location of the study area at Glenurie Close, Woodville (red) relative to other regularly monitored sites in woodland at Green Wattle Creek (green) and on an adjacent grazed property (blue).

The property that we purchased in 1993 was part of a recent subdivision of low-lying agricultural land, essentially pasture with a few plantings at the upper boundary and some casuarina trees surrounding the upper edge of the dam and along the creek line in surrounding properties. There were a number of large mature trees on adjacent properties, particularly on the higher ground. Native shrub beds were established surrounding the house with a mix of small trees and a variety of flowering species, particularly grevilleas and hakeas. Larger trees were planted along the boundaries and on the lower ground above the dam.

RESULTS

One hundred and fifty species were recorded, of which 103 were present in five or more of the 142 months in which records were kept. There was breeding evidence for 27 species.

Frequently recorded species

The 26 most frequently recorded species (present in >67% of monthly surveys), were predominantly large species that forage in open country (**Table 1**). Six of these species were associated with wetland habitat (e.g. Purple Swamphen *Porphyrio porphyrio* and Dusky Moorhen *Gallinula tenebrosa*, both of which were breeding). Eastern Cattle Egrets *Ardea coromanda* established a nocturnal roost in trees at the edge of the dam in the non-breeding season.

The most frequently recorded species was the Grey-crowned Babbler *Pomatostomus temporalis* (RR 97.9%). Noisy Miners *Manorina melanocephala* (93.0%) and Blue-faced Honeyeaters *Entomyzon cyanotis* (89.4%) had a continual presence, which, as will be discussed, can impact on the diversity and abundance of other species. There were two introduced species, the Spotted Dove *Spilopelia chinensis* and Common Myna *Acridotheres tristis*. Only two small species, Eastern Spinebill *Acanthorhynchus tenuirostris* and Superb Fairywren *Malurus cyaneus* occurred regularly. Both of these species increased between 2000 and 2013 (**Figure 2**) with the Superb Fairywren becoming established as a breeding species.

Satin Bowerbirds *Ptilonorhynchus violaceus* were the first species to establish a regular presence and a bower was constructed near the house, but subsequently the bird moved it to another shrub-bed further away from the house. Co-habiting with birds provides unique insights into their lives as indicated by the following anecdotal observations. Among the blue trophies displayed in the bower were numbers from an educational toy belonging to a young girl living about 200 m away on Glenurie Close (the family had seen the bowerbird taking the numbers from their veranda). The male Satin Bowerbird subsequently suffered an injury that rendered it flightless. It continued to survive for an extended period of time and maintain its bower. However, its ability to acquire new trophies was limited and its collection gradually diminished as other bowerbirds raided the bower and added stolen objects to ornament their bowers. Our bowerbird developed an interesting survival mechanism that involved ascending trees by leaping from branch to branch and descending by volplaning stiff-winged to the ground, a strategy also used by Lyrebirds *Menura*.

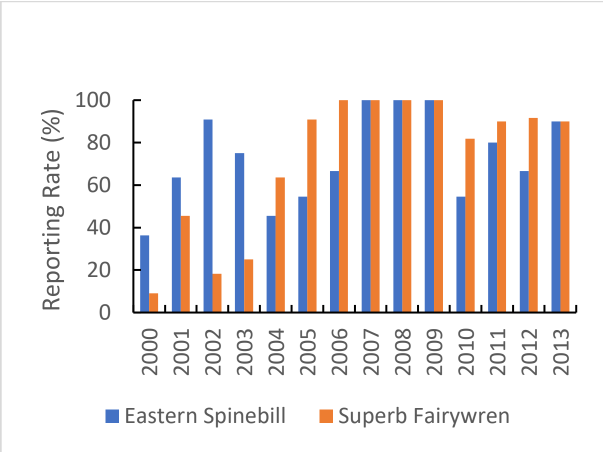


Figure 2. Annual variation in the frequency of occurrence of Eastern Spinebill and Superb Fairywren between 2000 and 2013.

Galahs *Eolophus roseicapilla* were another constant presence. A recently fledged juvenile, with a badly damaged wing, was rescued from fencing surrounding our neighbour's vegetable patch. While we were rehabilitating this bird, its parents responded to its calls and approached the house. When the injured bird was released to them it was promptly fed regurgitated food. This became a regular event where we fostered the bird and the parents periodically visited to feed it. The situation evolved in a remarkable manner, with the local Galahs forming a creche of recently fledged birds in our garden which our flightless bird joined, foraging on open ground and on one occasion joining them in a raid on the vegetable bed, climbing up plants to join in the action. When the flock was disturbed, our Galah tried to fly with them and fell to the ground. Sadly, the wing did not mend and eventually the bird was given to a local aviary owner who kept Galahs.

Table 1. Most frequently recorded species (reporting rates > 65%)

Common Name	Scientific Name	Months present	Reporting Rate (%)
Grey-crowned Babbler *	*Pomatostomus temporalis*	139	97.9
Australian Magpie *	*Gymnorhina tibicen*	137	96.5
Maned Duck *	*Chenonetta jubata*	132	93.0
Noisy Miner *	*Manorina melanocephala*	132	93.0
Galah *	*Eolophus roseicapilla*	130	91.6
Purple Swamphen *	*Porphyrio porphyrio*	129	90.9
Satin Bowerbird	*Ptilonorhynchus violaceus*	129	90.9
Eastern Rosella	*Platycercus eximius*	128	90.1
Red Wattlebird *	*Anthochaera carunculata*	128	90.1
Blue-faced Honeyeater	*Entomyzon cyanotis*	127	89.4
Crested Pigeon *	*Ocyphaps lophotes*	126	88.7
Magpie-lark *	*Grallina cyanoleuca*	126	88.7
Australian Raven	*Corvus coronoides*	122	85.9
Masked Lapwing *	*Vanellus miles*	121	85.2
White-faced Heron	*Egretta novaehollandiae*	117	82.4
Dusky Moorhen *	*Gallinula tenebrosa*	114	80.3
Willie Wagtail *	*Rhipidura leucophrys*	114	80.3
Pacific Black Duck *	*Anas superciliosa*	112	78.9
Laughing Kookaburra *	*Dacelo novaeguineae*	110	77.5
Common Myna	*Acridotheres tristis*	102	71.8
Australian King Parrot	*Alisterus scapularis*	98	69.0
Eastern Spinebill	*Acanthorhynchus tenuirostris*	98	69.0
Spotted Dove*	*Spilopelia chinensis*	97	68.3
Superb Fairywren *	*Malurus cyaneus*	97	68.3
Black-faced Cuckooshrike	*Coracina novaehollandiae*	95	66.9
Eastern Cattle Egret	*Ardea coromanda*	95	66.9

*Species with breeding evidence

Moderately common species

A further 44 species occurred regularly, with records in at least 30 months (RR in the range 15-61%) (**Table 2**). The mix of the types of species in this category was similar to that for the most frequently recorded species, except that there was an increased proportion of small passerine species. The reporting rate of these small species for the period 2007-2013 was greater than for 2000-2006 (**Figure 3**), which is attributed to the increasing maturity of the native vegetation plantings.

A number of species in this category were seasonal visitors, an example being Latham's Snipe *Gallinago hardwickii* that had a reporting rate of >70% in summer (**Figure 4a**). In contrast, Yellow-faced Honeyeaters *Lichenostomus chrysops* (**Figure 4b**) were most frequently recorded during August and September on spring passage south as they alighted briefly in tree canopies. There was also some evidence of a return passage in autumn. Eastern Spinebills occurred throughout the year but were more likely to be recorded in winter (**Figure 4c**). Four small woodland passerines (Golden Whistler *Pachycephala pectoralis*, Jacky Winter *Microeca fascinans,* Grey Fantail *Rhipidura albiscapa*, Striated Thornbill *Acanthiza lineata*) established a regular presence although they occurred predominately in the winter months (**Figure 5**).

Table 2. Regularly recorded species (reporting rates 15 – 62%) (* Species with breeding evidence)

Common Name	Scientific Name	Months present	Reporting Rate (%)
Long-billed Corella	*Cacatua tenuirostris*	87	61.3
Striated Pardalote	*Pardalotus striatus*	87	61.3
Welcome Swallow	*Hirundo neoxena*	86	60.6
Grey Butcherbird*	*Cracticus torquatus*	83	58.5
Little Lorikeet	*Parvipsitta pusilla*	81	57.0
Yellow-faced Honeyeater	*Caligavis chrysops*	80	56.3
Little Pied Cormorant	*Microcarbo melanoleucos*	79	55.6
Red-rumped Parrot	*Psephotus haematonotus*	79	55.6
Royal Spoonbill	*Platalea regia*	78	54.9
Rainbow Lorikeet	*Trichoglossus moluccanus*	77	54.2
Striped Honeyeater	*Plectorhyncha lanceolata*	74	52.1
Little Black Cormorant	*Phalacrocorax sulcirostris*	73	51.4
Oriental Dollarbird*	*Eurystomus orientalis*	67	47.2
Grey Fantail	*Rhipidura albiscapa*	63	44.4
Sulphur-crested Cockatoo	*Cacatua galerita*	63	44.4
Latham's Snipe	*Gallinago hardwickii*	62	43.7
Straw-necked Ibis	*Threskiornis spinicollis*	62	43.7
White-throated Gerygone*	*Gerygone olivacea*	61	43.0
Sacred Kingfisher*	*Todiramphus sanctus*	58	40.9
Olive-backed Oriole	*Oriolus sagittatus*	55	38.7
Yellow Thornbill	*Acanthiza nana*	55	38.7
Great Egret	*Ardea alba*	52	36.6
Australian Boobook	*Ninox boobook*	52	36.6
Channel-billed Cuckoo	*Scythrops novaehollandiae*	51	35.9
Pied Butcherbird	*Cracticus nigrogularis*	50	35.2
Australasian Grebe*	*Tachybaptus novaehollandiae*	48	33.8
Pacific Koel*	*Eudynamys orientalis*	48	33.8
Common Starling	*Sturnus vulgaris*	41	28.9
Noisy Friarbird	*Philemon corniculatus*	41	28.9
White-winged Chough*	*Corcorax melanorhamphos*	40	28.2
Brown Thornbill	*Acanthiza pusilla*	39	27.5
Yellow-tailed Black Cockatoo	*Zanda funerea*	36	25.4
Australian Golden Whistler	*Pachycephala pectoralis*	35	24.7
Jacky Winter	*Microeca fascinans*	33	23.2
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	33	23.2
Red-browed Finch	*Neochmia temporalis*	30	21.1
Whistling Kite	*Haliastur sphenurus*	30	21.1
Chestnut Teal	*Anas castanea*	28	19.7
Australian Hobby	*Falco longipennis*	24	16.9
Black Swan*	*Cygnus atratus*	23	16.2
Australasian Figbird	*Sphecotheres vieilloti*	22	15.5
Rufous Whistler	*Pachycephala rufiventris*	22	15.5
Tawny Frogmouth	*Podargus strigoides*	22	15.5
Wedge-tailed Eagle	*Aquila audax*	22	15.5

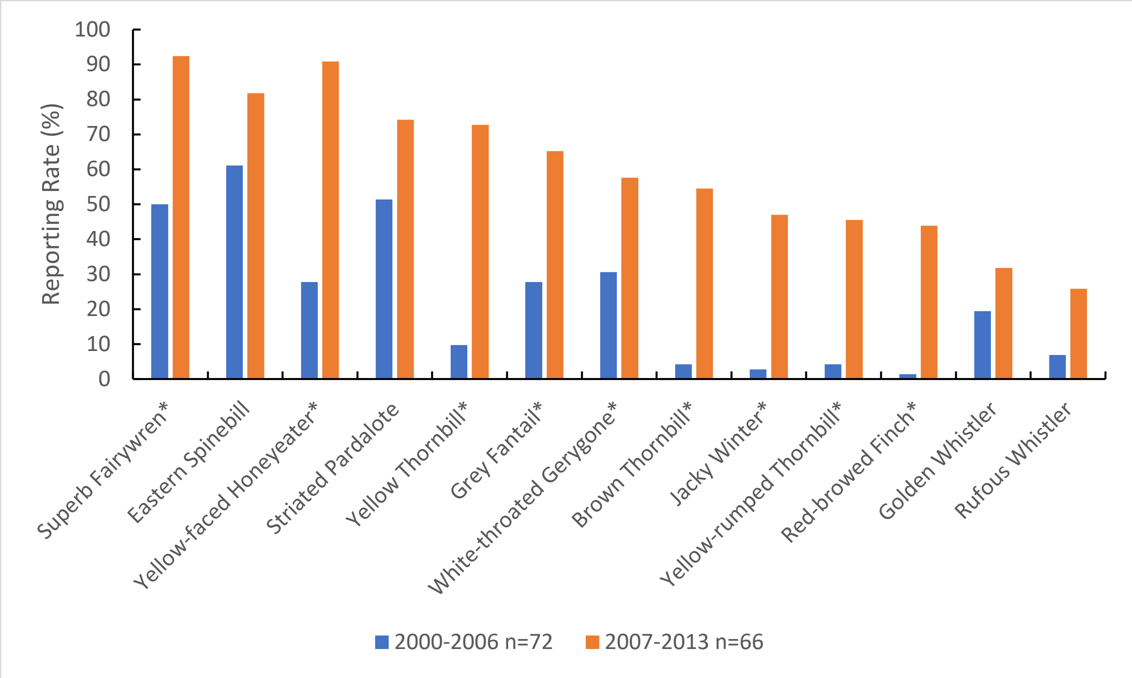
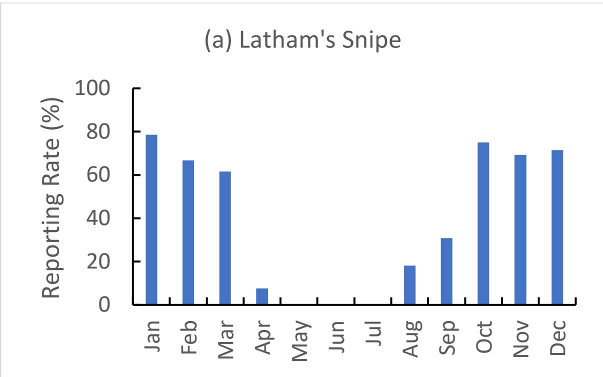
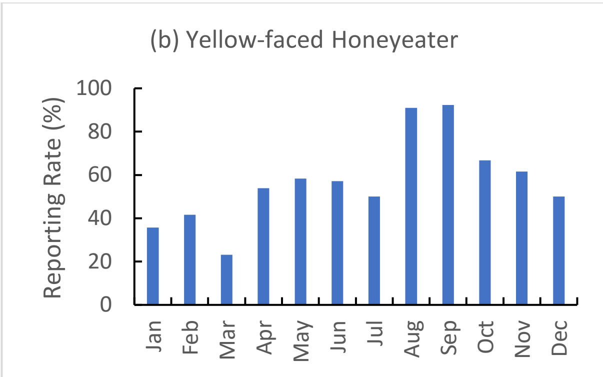


Figure 3. Increased occurrence of small woodland species in the 7-year period 2007-2013 compared with the previous 7 years, 2000-2006 (n=number of monthly surveys). The changes for species marked with an Asterix (e.g. Superb Fairywren*) were statistically significant.





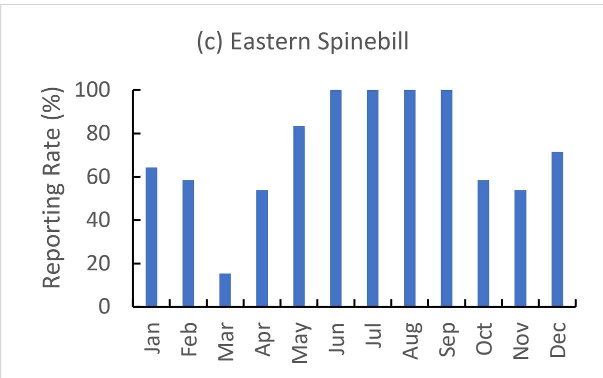


Figure 4. Monthly reporting rates, illustrating the seasonal occurrence of (a) Latham's Snipe (b) Yellow-faced Honeyeater and (c) Eastern Spinebill.

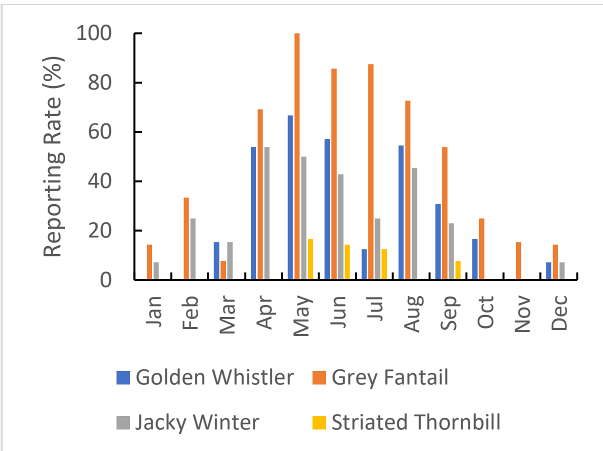


Figure 5. Monthly reporting rates, illustrating the seasonal occurrence of four species of woodland birds that occurred more frequently in winter.

Less frequently recorded species

A further 80 species were recorded in 22 or less months (RR<15%), and 42 species in three or less months. A detailed inventory of these species would add little value to this paper beyond the following examples and the reader is referred to the source data in Birdata for details of the other infrequently recorded species.

- A Black-tailed Native-hen *Tribonyx ventralis* was resident from May 2002 until the end of the year, with one additional record in 2003.
- A Baillon's Crake *Zapornia pusilla* present on our dam in February 2003, was subsequently recorded on a small dam during quarterly surveys of the adjacent cattle property (presumably the same bird).
- The White-throated Needletail *Hirundapus caudacutus*, a summer visitor, was recorded in a total of 12 months, sometimes forming spectacular mixed foraging flocks with Oriental Dollarbirds *Eurystomus orientalis*.

DISCUSSION

While the species list of 150 birds over the 14-year period 2000 to 2013 is indicative of the avian diversity of the area, relatively few species were resident or persistent visitors to the survey area. However, as discussed below, the gradual development of the native plantings caused a progressive increase in diversity with some woodland species becoming increasingly regular visitors.

Threatened Species

Three species classified as Vulnerable in NSW were regularly recorded. Two species lived on the property – Grey-crowned Babbler as a breeding resident and Latham's Snipe as a non-breeding summer visitor. The third, Little Lorikeet, regularly foraged in the mature trees on an adjacent property. Roderick & Stuart (2010) provide more details on the status of these species in NSW.

The Grey-crowned Babbler was resident and breeding nests were found on numerous occasions. Additional nests in small trees were used by non-breeding birds as communal night roosts, as has been described in other studies (McDonald 2008). The Paterson area is a hot-spot for this species which thrives in lightly timbered habitat, including that on large acreage properties.

Latham's Snipe were regular summer visitors to the dams on our and adjacent properties, which provided both shelter for loafing birds and foraging opportunities (Newman 2008).

Species attracted by native plantings

It is unfortunate the monthly survey lists were not initiated when we moved to Glenurie Close in 1993, but at that time Birdata did not exist. Hence, there is no baseline data other than my recollections plus inferences drawn from the trends for the period 2000-2013 as presented above.

Success in attracting birds to a newly established native garden is determined by a number of factors including:

1. Establishing habitat that provides not only foraging opportunities, but also shelter for small species which require understorey (e.g., Fairywrens at risk of predation);
2. A local source population; and
3. Vegetation corridors to facilitate movement from the source population to the garden.

The woodlands at Green Wattle Creek were the nearest source population to our property, but its avian population was undergoing dynamic change following the cessation of cattle grazing in the early 1990s. The dry open woodland rapidly developed dense understorey vegetation to the advantage of many small woodland species such the Superb Fairywren (Newman & Cunningham 2018). However, to reach our property the birds had to pass through lightly timbered country dominated by aggressive Noisy Miners. Fortunately, a combination of creek-side vegetation and plantings on other properties progressively established discontinuous vegetation links and improved the connectivity to source populations. These factors provide an explanation of the sequence in which different species established a regular presence on our property.

Of the smaller woodland species, one of the first colonists was the Eastern Spinebill, attracted to the numerous flowering shrubs. It was recorded throughout the year, but more frequently in the winter months. It is a fast-flying species adapted to a locally nomadic lifestyle, as are many honeyeaters, enabling it to opportunistically exploit a variety of seasonally available food resources. New Holland Honeyeaters *Phylidonyris* *novaehollandiae* have similar lifestyle traits but were only recorded on two occasions. This is attributed to the lack of a local source population as New Holland Honeyeaters were seldom recorded in the surveys at Green Wattle Creek.

Superb Fairywren and Grey Fantail *Rhipidura albiscapa*, two species that forage at habitat interfaces were among the next group of species to establish a regular presence. Brown Thornbills *Acanthiza pusilla* were slower to become established. These three species often associate when foraging (Ford *et al*. 1986) sharing a preference for habitat interfaces with understorey vegetation, but each with a distinct foraging niche. Superb Fairywrens, which foraged on the ground, required the shelter provided by ground and understorey vegetation. In contrast, Brown Thornbills mainly foraged in the shrub-layer and Grey Fantails foraged at the periphery of shrubs and small trees, including hawking insects over adjacent open ground. Super Fairywrens established a regular presence on our property before Grey Fantails and finally Brown Thornbills, possibly reflecting the slower development of a mature shrub layer

Five species were seldom recorded before 2007, 14 years after the native plantings commenced. These species include Yellow-rumped Thornbill *Acanthiza chrysorrhoa* and Red-browed Finch *Neochmia temporalis*, both of which foraged in sometimes substantial numbers on open ground, but took shelter in shrub-layer vegetation when disturbed.

Decreasing Species

The Fairy Martin *Petrochelidon ariel* was the only species that decreased. It bred regularly in the 1990s, with nests under the eaves of our house and in the culvert under the road, which was fed by the overflow from our dam. It ceased breeding in 2000 and was only recorded in one subsequent year. While it is possible that the expansion of the Glenurie Close subdivision contributed to the loss of this breeding colony, there were similar losses regionally (Newman & Lindsey 2014), suggesting a more widespread cause.

Strengths and limitations of monthly lists

Monthly lists with inconsistent survey effort lack the rigour of the standardised surveys I conducted at nearby local sites (Newman 2007; 2009). However, as demonstrated in an analysis of the occurrence of raptors (Newman 2023), monthly lists may provide unique insights on scarce species that are missed in shorter duration surveys.

An example is the Pallid Cuckoo, a relatively uncommon and decreasing species in the Hunter Region (Newman 2019). There were only 39 Hunter Region records of the Pallid Cuckoo in Birdata 2-ha 20-minute surveys between 2000 and 2013 (a reporting rate of 0.64%). In comparison, in the same period there were 13 records at a reporting rate of 9.2% from the monthly property lists. It can be concluded that Pallid Cuckoos intermittently frequent lightly timbered areas adjacent to wetlands, though the extent to which this is a preferred habitat is unclear because of the lack of studies with longer duration survey protocols.

CONCLUSIONS

The 150 bird species recorded on the property over a 16-year period reflected a combination of sub-sets of the birds of the adjacent flood plain and the nearby woodlands of the hinterland. However, the illusion of exceptionally high avian diversity in a relatively small space must be tempered by the realisation that few of these species were resident and many were occasional and temporary visitors.

Establishing a native garden attracted a number of woodland species that had not been observed in the first few years of our occupancy of the property. The types of woodland birds regularly attracted to the property and the sequence in which they became established was consistent with a combination of constraints including the extent to which the native plantings had matured sufficiently to provide species-specific foraging opportunities, and the existence of a local source population. Connectivity with the source population was another key factor: e.g., large species were more able than small species to commute in a highly fragmented landscape dominated by Noisy Miners.

Monthly species lists, lacking standardisation of survey effort, were effective in identifying seasonal and long-term temporal changes in the occurrence of the more frequently recorded species.

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Grey-crowned Babblers were regularly present in Mike Newman's garden in Woodville, and bred there (photo: Rob Palazzi)

Ecological determinants of birdlife on Stockton Beach and the associated dune complex

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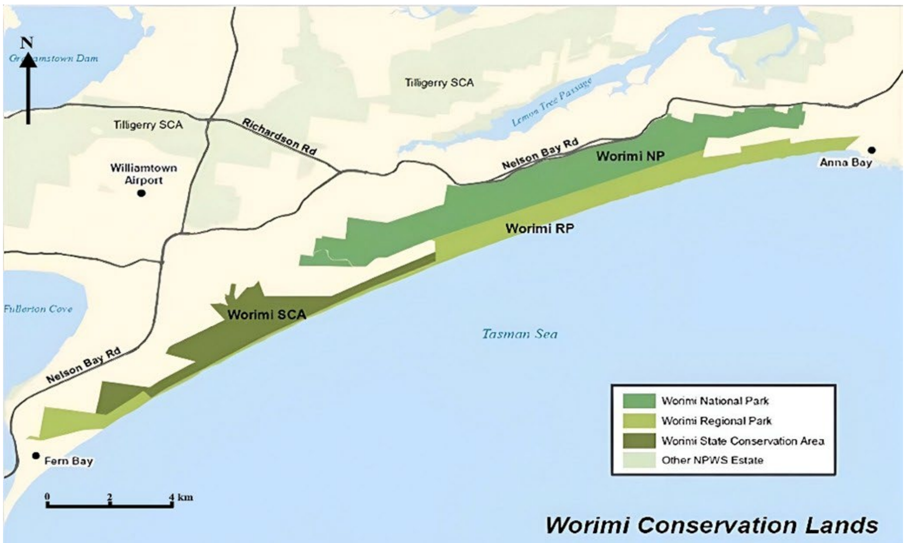
This study examines some of the complex interactions between the physical environment and the distribution of bird species from the ocean shore at Stockton Beach, through the sand dune system, to the associated coastal forests further inland. The study area, which is immediately north of Newcastle in NSW, displays a succession of ecological niches, which determine the bird species most likely to be found in each zone. This study examines each zone in terms of the determining factors and physical characteristics with a view to understanding the distribution of the various species of birds. Understanding these relationships helps planning for the protection of the birdlife, which is of paramount importance for endangered and vulnerable species such as the Pied Oystercatcher *Haematopus longirostris*, Little Tern *Sternula albifrons*, Bar-tailed Godwit *Limosa lapponica* and Sanderling *Calidris alba*.

INTRODUCTION

Much attention in birdwatching is given to identifying birds and recording their geographic distribution. Less attention is given to recording the habitat in which they live and hence identifying the many reasons for their spatial distribution. This study aims primarily to examine the ecological factors determining the distribution of birds within the following designated area: Stockton Beach, Stockton sand dunes and the associated coastal forests immediately further inland. This area lies immediately north of Newcastle Harbour in New South Wales (NSW) and extends 32 km further north-east to Birubi Point, which is 9 km south of Nelson Bay. The study area is bounded on the north-west by private property and Nelson Bay Rd and on the south-east by the ocean. It spans from latitude 32.77º S to 32.92º S. Most of this area is owned by the Worimi Conservation Lands and is leased to the National Parks and Wildlife Service (NPWS). It is covered by the Worimi Conservation Lands Management Plan (Office of Environment and Heritage 2014).

The birds of the shoreline in the study area have been well surveyed by members of the Hunter Bird Observers Club (HBOC), who have conducted monthly surveys with the National Parks and Wildlife Service (NPWS) since 2009 (Fraser & Lindsey 2018; Fraser 2023; Lindsey & Fraser 2024; Lindsey & Newman 2010; Lindsey & Newman



Map 1. Worimi Conservation Lands

2014; Russell & George 2012). However, it was recognised that the area further inland, which is not very accessible, has not been well studied. Factors for its relative inaccessibility include: 1) the beach and sand dunes are too long to walk easily (32km); 2) vehicles are generally not permitted behind the fore dunes; 3) the study area is bounded on the west by private property (and large uncompacted sandhills); and 4) it is bounded on the east by the ocean.

On 16 February 2025, two HBOC members, Andrew McIntyre and Neil Fraser, co-ordinated a team from the club to survey the birds of the swales (the depressions behind the foredunes) and the beach front simultaneously, with the aim of surveying the whole length of the beach. As part of the survey team, I surveyed some of the southern swales, along with Greg Little, another HBOC member. This was the stimulus for me to further study the plants and animals in the whole beach/sand dune/forest complex.

The undisturbed beaches of Australia display a natural progression of plant and animal life, starting at the ocean and extending inland to the coastal forests (Walker *et al*. 1981). The pattern of this progression can vary with latitude. Every stage of this progression has its own micro-climate and hence has plants and animals that are specialized for each of these habitats (Schlacher *et al*. 2008). Every species of bird has its own preference regarding habitat and hence there is a stratification of bird life along each zone from ocean to forest, determined by factors such as: sources of food and water; suitability for nesting; suitability for roosting; and safety from predators.

Stockton Beach and its dunes system can be considered as six discrete ecological zones:

- The ocean close to the beach
- The intertidal zone
- The foredune
- The swales
- The hind dunes
- The coastal forests

There had been a paucity of literature regarding the vegetation in the study area until the work done by Bell & Driscoll (2010). Because of the existence of a small number of sand mines on the western edge of the sand dunes, there have been environmental impact studies that have also examined the vegetation in the study area (HLA EnviroSciences Ptd Ltd 1995; Oroton 2009; Outline Planning Consultants 1995). There is very little published literature specific to the ecology of this beach and dune system (Pidgeon 1940).

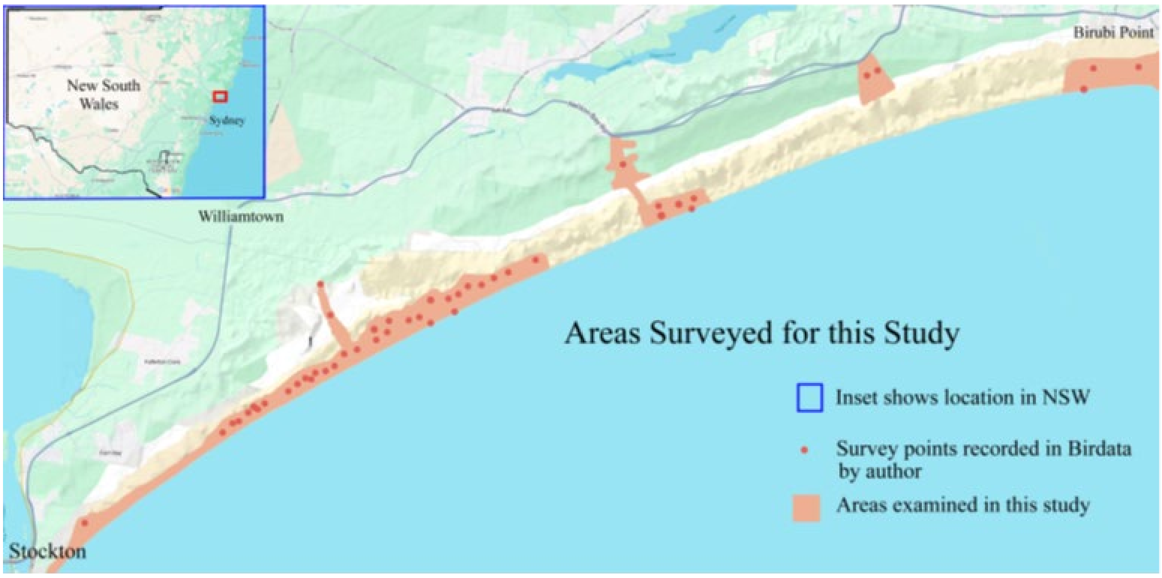
The southern section of Stockton Beach faces east to south-east. It is “reflective”, i.e. there is little protection from the full force of the waves. Here the beach is a little steeper and the sand is relatively coarser than the northern parts of this beach. It is less rich in microflora and micro-/macrofauna. Ocean currents tend to move sand in a north-easterly direction along the beach (Bluecoast Consulting Engineers 2020). In the most north-eastern section, the beach faces south-east, facing the dominant wave direction. Here the beach is “dissipative”, i.e. the wave energy is reduced by shallow ocean sand bars and the relatively flat topography. The sand tends to be finer. Species richness and total biomass of the micro-organisms living in these sands tend to be significantly increased in dissipative beaches compared to reflective beaches (Brown & McLachlan 2010) and this is an important factor in the distribution of the shorebirds.

The landform of Stockton Beach is dynamic. Winds generally drive sand inland, resulting in the dunes traveling westward at a rate of about 4 m per year. These dunes are slowly engulfing some of the coastal forests. The sand dunes are up to 40 m above sea level and the depressions between the sand dunes (swales) can be as low as sea level.

Whilst the Stockton sand dune system is unique in being the longest beach in NSW and having the largest active beach sand dune system in Australia, many findings from this study can be applicable to other NSW beaches.

Map 2 shows the study area.

This study has a companion document, published on the Hunter Bird Observers Website at https://www.hboc.org.au/publications/publications/ (Goswell 2025). The document provides much more detail than space allows in this article, in particular on the plant and animal life in each zone and specific details on the survey points (see Map 2).



Map 2. Demonstrating the coverage of this study

METHODS

This study recorded the birdlife using fifty-two data points surveyed by me between 16 February 2025 and 11 July 2025. The first nineteen of these were recorded together with Greg Little, as part of the HBOC bird survey of the swales on 16 February. I simultaneously recorded the vegetation in each swale. On 11 July 2025 I was partnered with Archie Brennan in the second bird survey of the swales. That survey covered sixteen swales (two overlapped with the February survey). Between these dates, I also targeted different sections of the beach/sand dune complex as well as the coastal forest in order to obtain representative information along the full length of the study area and have data from the differing ecological zones. At each survey point I examined the birds, animals and plant life as well as the physical characteristics of the area. Surveying was done by foot and hence all the areas between bird survey points were also examined. The birdlife in each survey point was recorded in Birdata.

Further information regarding the birds in the study area was obtained by searching Birdata and the published literature. The HBOC's publication, *The Whistler*, was an important source. Data on plant distributions obtained from the field surveys were cross-referenced against published information (Bell & Driscoll 2010; HLA EnviroSciences Ptd Ltd 1995; Oroton 2009; Outline Planning Consultants 1995). Information regarding microbiota in the surf zone and intertidal areas was obtained from publications (Brown *et al*. 2018; Baring 2014; Bruce 1986) and iNaturalist.

ECOLOGICAL ZONES OF STOCKTON BEACH

The Ocean Adjacent to the Beach

At first glance, this zone appears to be only saltwater and sand, but it is very biologically active. Brown *et al*. (2018) identified over 150,000 species of micro-organisms off the Australian coastline using DNA fingerprinting. As waves approach the shore they stir nutrients into suspension, mixing these with the microflora and microfauna. There is adequate light for photosynthesis by phytoplankton, which are the primary producers; they take basic chemicals and convert them into organic matter and oxygen. The action of the surf also provides rich oxygenation in the water for zooplankton. The zooplankton feed on bacteria and phytoplankton. Both phytoplankton and zooplankton become food for the filter feeders such as shellfish and crabs. Storms can break macro-algae (seaweed and kelp) from their seabed and drive them to the surf zone. As they float freely through the water, they attract invertebrates. Floating macro-algae also provides protection for small fish, who gain the added advantage of increased food from the co-habiting invertebrates (Baring 2014). As the macro-algae decays it becomes food for bristle worms (Polychaeta), amphipods, isopods and other crustaceans. All these, in turn, become food for small fish. A number of birds specialize in feeding on the fish and macrofauna in this zone (**Table 1**).

Table 1. Birds of the ocean adjacent to the beach

Common Name	Scientific Name	Occurrence	Diet	Nest
Great Cormorant	*Phalacrocorax carbo*	Common resident	Fish caught underwater	W
Little Black Cormorant	*Phalacrocorax sulcirostris*	Common resident	Fish caught underwater, crustaceans and also insects	W
Little Pied Cormorant	*Microcarbo melanoleucos*	Common resident	Fish caught underwater, crustaceans and also insects	W
Australian Pied Cormorant	*Phalacrocorax varius*	Common resident	Fish caught underwater and also on crustaceans (such as prawns and shrimp), molluscs and cephalopods.	W
Silver Gull	*Larus novaehollandiae*	Common resident	Surface fish, worms, insects and crustaceans	I
Greater Crested Tern	*Thalasseus bergii*	Common resident	Dive for small surface fish	I
Australasian Gannet	*Morus serrator*	Common resident	Fish which they catch and swallow whilst underwater	E
Wedge-tailed Shearwater	*Puffinus pacificus*	Common migrant August to April	Fish, squid and crustaceans	I
White-bellied Sea Eagle	*Icthyophaga leucogaster*	Common resident	Fish, turtles and sea snakes	T

Key: W - typically nest in wetland areas; I - nest on nearby offshore islands; E - nest on islands not local to the Hunter; T - nest in tall Eucalypts

The Intertidal Zone

This is the section of the beach covered by water at high tide and uncovered at low. Again, one would initially think that there was no life in this zone. It is a harsh environment with complete saltwater immersion for many hours. The “soil” is almost pure siliceous sand with a small amount of calcium carbonate from shell fragments and hence it is, by its own nature, nutrient poor. This zone has full sun exposure at low tide and can become very hot at times in the upper few centimetres. The wind can be harsh, with nothing to stop its effect. However, the surface of this zone is rich in oxygen. Water with dissolved oxygen (enhanced by the action of the waves) can travel well beneath the surface of the sand, providing conditions which are crucial to the availability of the scant nutrients and hence microbiological activity (McLachlan & Defeo 2017). Despite the apparent paucity of life in this zone, it is rich in biological forms. A study in California, using modern DNA fingerprinting techniques, logged almost one thousand different life-forms (taxa) in the intertidal zone (Boehm *et al*. 2014).

Feeding on the microscopic life forms are various invertebrates (McLachlan & Defeo 2017) such as shellfish (e.g. the pipi *Donax deltoides)* and surf crabs e.g. *Ovalipes australiensis*. Bristle worms (Polychaeta) and ribbon worms (Nemertea), crustaceans (Isopoda, Amphipoda, Stomatapoda, Mysidae) also live here and feed on micro-organisms and detritus. Beach worms, e.g. *Onuphidae spp.* also inhabit the wet sand and feed on seaweed and decaying organic matter. Many of these various animals then become food sources for those birds foraging in this zone.

Many shorebirds will forage day and night because their preferred foraging zones become available whenever the tide is low. Some birds use more than one type of roost area, e.g. Pied Oystercatchers *Haematopus longirostris* may roost on intertidal flats near their food or move to the rock platforms at Newcastle. There is a population of about 50 to 100 of these birds, mostly along the northern section of this beach (Fraser & Lindsey 2018). Small numbers nest in the swales behind the foredunes between September and January. Double-banded Plovers *Charadrius bicinctus* mostly roost above the high-tide mark (Lindsey & Newman 2014).

Some shorebirds are resident all year round while others migrate vast distances to nesting or feeding grounds on the other side of the globe – for example the Bar-tailed Godwits *Limosa lapponica* which breed in Alaska fly non-stop for up to 13,500 km in 11 days on return migration to Australia! (BirdLife Australia).

The list below includes those seen with an incidence of 10% or more on regular surveys undertaken by HBOC members.

Birds of the intertidal zone are listed in **Table 2**.

Table 2. Birds of the intertidal zone

Common Name	Scientific Name	Occurrence	Diet	Nest
Silver Gull	*Larus novaehollandiae*	Common resident	Fish, worms, insects and crustaceans	Offshore islands †
Pied Oystercatcher	*Haematopus longirostris*	Common resident	Pipis, worms, crabs and small fish	Swales
Greater Crested Tern	*Thalasseus bergii*	Common resident	Fish but will eat crustaceans and insects	Offshore islands †
White-fronted Tern	*Sterna striata*	Uncommon winter migrant	Fish, typically just beyond the surf zone.	New Zealand
Little Tern	*Sternula albifrons*	Aug. to March	Small fish, crustaceans, insects, worms and molluscs	Swales and foredunes
Australian Tern	*Gelochelidon macrotarsa*	Partial migration to inland	Small fish, crustaceans, insects, reptiles, amphibians, and small mammals	Inland
Red-capped Plover	*Anarhynchus ruficapillus*	Common resident	Molluscs, small crustaceans, worms and some vegetation	Swales and foredunes
Double-banded Plover	*Anarhynchus bicinctus*	Feb. to Sept.	Molluscs, crustaceans, insects, seeds and fruit	New Zealand
Ruddy Turnstone	*Arenaria interpres*	Uncommon on beach, migrant	Insects, crustaceans, molluscs and spiders. Wrack and/or associated detritivores (Kirkman & Kendrick 1997).	Northern hemisphere
Red-necked Stint	*Calidris ruficollis*	Uncommon migrant	Small invertebrates and small insects	Eurasian tundra
Bar-tailed Godwit	*Limosa lapponica*	Aug. to Oct. Uncommon on beach	Molluscs, worms and aquatic insects	Northern hemisphere
Sanderling	*Calidris alba*	Uncommon on beach Sept. - April	Invertebrates in the sand.	Arctic tundra

† These nest on nearby offshore islands such as Broughton Island and Moon Island.

Flat areas in the northern section of Stockton Beach – a prime zone for Pied Oystercatchers to feed on pipis. Note the tyre tracks close to the feeding areas.

There is a variation from south to north in the intertidal zone along Stockton Beach. In the south, the beachfront tends to be narrower and steeper, with coarser sand. This limits the zone in which pipis and beach worms can grow. Further north, the shallower ocean dissipates the wave energy before reaching the beach, and the flat sands result in broad wet areas at low tide. The finer sands in the north drain more slowly. These factors produce large areas for pipis and beach worms. Consequently, the northern section of the beach becomes a favoured area for oystercatchers to feed and breed.

The Foredune

Above the intertidal zone is the foredune: a rise of sand deposited by wind and waves. It is sometimes preceded by a lower incipient dune; however, the incipient dune may come and go more readily depending upon erosive and accretive surf conditions. In south-eastern Australia, foredunes form because the colonizing vegetation slows the wind and traps the wind-blown (aeolian) sand (Hesp 1988). Wrack (washed-up seaweed and kelp) and other debris can also trap aeolian sand and contribute to sand deposition. Along Stockton Beach there can be considerable debris following flooding in the Hunter River.

The foredune looks almost bare and barren. It is exposed to the full sun and becomes very hot during summer. The sun and the wind dry this sand, making it hard for anything to live there. The foredune is above the water table and there is little capacity to hold water. The dry sand is more easily moved by wind and this can cause relatively rapid shifts in dune topography, burying any plant life that has started to get a foothold. Any rainfall is quickly lost through the sand and there is essentially no humus to retain moisture. The sand is nutrient deficient. This region does get a little organic matter washed up by the waves, but this is limited. Few plants can tolerate these conditions. The prime colonizer is Beach Spinifex *Spinifex sericeus*, which is uniquely adapted to this zone. Its leaves have fine hairs that protect it from sand abrasion. The roots are long and extensive, allowing for the collection of water. These bind the dune sand to stabilize it. Beach Spinifex can survive various degrees of burial. In poor seasons it produces little seed but in good seasons can produce large amounts. This has been seen as an adaptive process in areas of poor nutrient and variable fresh water supply (Hesp 1991). The seeds have been observed to be eaten by Galahs *Eolophus roseicapilla* (Gosper 1999) so one would expect other birds to be using this food resource. Australian Pipits *Anthus novaeseelandiae* eat seeds as well as insects and so may well eat spinifex seeds as well as seeds from other plants growing in this zone, such as Pennywort *Hydrocotyle bonariensis* and Beach Primrose *Oenethera drumondii*, although published documentation of this appears to be lacking. Unseen to the naked eye, endomycorrhizal fungal hyphae spread in the sand, helping to bind it and stabilize the dune (Jehne & Thompson 1981). These fungi form symbiotic relationships with the dune plants by exchanging nutrients. Hanlon (2020) noted different species of endomycorrhizal fungi in the incipient dunes compared with established dunes, showing zonation at this level as well.

The foredune is important as it provides nesting sites for some birds. According to NPWS, six species of birds are known to nest along beaches. These are:

- Little Tern *Sternula albifrons* *
- Pied Oystercatcher *Haematopus longirostris**
- Red-capped Plover *Charadrius ruficapillus**
- Sooty Oystercatcher *Haematopus fuliginosus*
- Beach Stone-curlew *Esacus magnirostris*
- Hooded Plover *Charadrius cucullatus*

* These species have been recorded to nest on Stockton Beach.

Pied Oystercatchers would normally nest on the ocean side of the foredune but on Stockton Beach this is frequented by 4WDs. The birds have learned to nest on the west side of these dunes which adds extra work and stress for the birds when feeding their chicks (Fraser 2023; Russell & George 2012). Birds found in the foredune include those shown in **Table 3**.

Table 3. Birds found in the foredune zone

Common Name	Scientific Name	Occurrence	Diet	Nesting
Australian Magpie	*Gymnorhina tibicen*	Common resident	Small insects, frogs and seeds	In trees from August to January
Australian Raven	*Corvus coronoides*	Common resident	Small birds and will eat insects, and seeds Wrack invertebrates*	In tall trees from July to September
Silver Gull	*Larus novaehollandiae*	Common resident	Mostly fish, also worms, insects and crustaceans	On nearby islands
Australian Pipit	*Anthus novaeseelandiae*	Common resident	Insects and seeds	In spring on the ground
Pied Oystercatcher	*Haematopus longirostris*	Common resident	Pipis, but also eat worms, crabs and small fish	On the ground
Little Tern	*Sternula albifrons*	Aug. to March	Mainly fish but also on crustaceans, insects, worms and molluscs.	On the ground
Pacific Golden Plover	*Pluvialis fulva*	Uncommon Sept. to May	Insects, crabs and other invertebrates	In Alaska and Siberia
Australian Tern	*Gelochelidon macrotarsa*	Common resident, March to Dec. †	Insects taken in flight, amphibians, crustaceans and small mammals	On the ground

† Lindsey & Newman (2014)
* These are known to eat wrack and/or invertebrates feeding on wrack (Kirkman & Kendrick 1997).

The foredune and intertidal zone. The foredune is stabilized by *Spinifex sericeus*. Note the tyre tracks from multiple vehicles.

The Swales

In many places behind the foredunes and between transverse sandhills, there are depressions, called swales. Many of these swales hold fresh water: some only for a short period of time after rain but many with semi-permanent to permanent water. One would expect the presence of fresh water to be important for birds as a source of drinking water. Some of the swales are at sea level and some are below the level of the water table. According to Woolley *et al*. (1995), various factors contribute to the level of the water in these swales. Rainfall can raise the water level in the swales, particularly because some have developed a semi-permeable pan of sand, salts and organic matter, reducing drainage. Water in the swales can also be an outflow from the extensive water in the sand beds further inland, for example the Tomago sand beds. Between the two HBOC surveys, the region had 1009 mm of rain (Bureau of Meteorology, data for Williamtown), resulting in a rise in water levels of perhaps a metre at the time of the second survey (11 July 2025), with a marked increase in the surface area of the water in each swale.

Because the swales are depressed, dead vegetative material is unlikely to be blown away, allowing humus to build up in the soil. The presence of water and nutrients enable different plants to grow, providing food and shelter for birds. On rare occasions (such as late March and early April 2025), combinations of king tides, strong onshore winds and east coast low-pressure systems, can result in water over-topping the lowest of the foredunes, bringing floating debris into the swales. The swales support an increased diversity of life compared to the surrounding (mostly) bare dunes. The vegetated swales, more correctly called beach wetlands (Bell & Driscoll 2010), occur along most of Stockton Beach and vary in size and type, tending to be small in the south and broad and flat in the north.

With more persistent water there can be rushes (Typha species) and Phragmites. The combination of water and plants allows small animals to exist such as water snails, tadpoles/frogs, lizards, dragonflies, ants, grasshoppers and mosquitoes. These become food for a different subset of birds listed in **Table 4**.

Typical vegetation in the swales consists of an outer ring of Spinifex *Spinifex hirsutus* and Pennywort *Hydrocotyle bonariensis* with the occasional Sea Holly *Eryngium maritimum* and Beach Primrose *Oenethera drumondii.*

In swales where there is more water there is an inner ring of sedges: *Juncus acutus* and *Cyperus* species.

Table 4. Birds frequenting swales.

Common Name	Scientific Name	Occurrence	Diet
Superb Fairywren	*Malurus cyaneus*	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Australian Pipit	*Anthus novaeseelandiae*	Common resident	Insects and their larvae as well as seeds
White-fronted Chat	*Epthianura albifrons*	Common resident	Small insects and acacia seeds
Australian Raven	*Corvus coronoides*	Common resident	Small birds and will eat insects, and seeds
Australian Magpie	*Gymnorhina tibicen*	Common resident	Small insects, frogs and seeds
Pacific Golden Plover	*Pluvialis fulva*	September to April†	Insects, spiders, crustaceans, small lizards and seeds
Double-banded Plover	*Anarhynchus bicinctus*	February to September†	Molluscs, insects (both on land and in water), crustaceans and seeds
Little Tern	*Sternula albifrons*	August to March	Mainly fish but also on crustaceans, insects, worms and molluscs

† Lindsey & Newman 2014

Table 5. Some birds may be found primarily when water is present in swales.

Common Name	Scientific Name	Occurrence	Diet
White-faced Heron	*Egretta novaehollandiae*	Common	Fish, frogs, small reptiles and insects
Red-capped Plover	*Anarhynchus ruficapillus*	Common	Worms, snails, crustaceans, isopods, small crabs, insects, beetles, insects, insects, flies, bees and wasps
Masked Lapwing	*Vanellus miles*	Common	Insects, earthworms, snails, centipedes and plants
Black-fronted Dotterel	*Thinornis melanops*	Uncommon	Small molluscs, aquatic and terrestrial insects
Australian Tern	*Gelochelidon macrotarsa*	Common	Insects taken in flight, amphibians, crustaceans and small mammals
Welcome Swallow	*Hirundo neoxena*	Common	Insects in flight.

The vast exposed areas along the beach and sand dunes give good visibility for raptors to find food (**Table 6**).

Table 6. Raptors recorded along the beach and sand dunes.

Common Name	Scientific Name	Diet
White-bellied Sea Eagle	*Icthyophaga leucogaster*	Fish, turtles, sea snakes and small mammals and birds
Swamp Harrier	*Circus approximans*	Birds, eggs, large insects, rabbits and other small animals, reptiles, frogs, and fish
Australian Hobby	*Falco longipennis*	Small birds and large insects
Osprey	*Pandion haliaetus*	Fish, sea snakes, molluscs, crustaceans, reptiles, insects, birds and mammals
Whistling Kite	*Haliastur sphenurus*	Small mammals, birds, fish, reptiles, amphibians, crustaceans, insects and carrion
Black-shouldered Kite	*Elanus axillaris*	Rodents, small reptiles, small birds and insects
Nankeen Kestrel	*Falco cenchroides*	Mice and rats and other small mammals, reptiles, small birds and a variety of insects
Brown Falcon	*Falco berigora*	Mice and small mammals, small birds, lizards, snakes, caterpillars, grasshoppers, crickets, and beetles

Note that the small birds need to have a means of escaping predation. The following observations were noted and seem worthy of further research:

- Australian Pipits are well camouflaged even amongst the spinifex, so they can move around areas that have scant vegetation.
- Superb Fairywrens appear to need plants which are a little more raised, for example reeds.
- White-fronted Chats seem to prefer small bushes in which to hide, such as the Bitou Bush *Chrysanthemoides monilifera.* When disturbed they may land on a "lookout post" on a small bush to watch what is happening.

Nesting colonies of Little Terns were observed in a small number of locations on the upper beach and the swales from 2012 to 2023. Breeding success in 2023 was estimated to be 5.6% (6 fledglings from 53 nests and 107 eggs), reflecting a high rate of predation at the time the chicks hatch (Fraser 2023). In 2023 the main predator was thought to be Ghost Crabs *Ocypode cordimana*. Other potential predators included Red Fox *Vulpes vulpes*, Australian Ravens, Silver Gulls, Australian Terns, domestic dogs, feral cats, black rats, goannas, and raptors.

The Hind Dune

In some beach systems in NSW, such as at One Mile Beach immediately north of Stockton Beach, the hind dune merges with the foredune. In this situation there is a succession of plant life from the foredune spinifex to wind-tolerant shrubs such as Sydney Golden Wattle *Acacia longifolia* and Bitou Bush *Chrysanthemoides monilifera,* followed by Coastal Tea Tree *Gaudium laevigatum.* These form a protective wind barrier enabling larger species to grow further inland - Coastal Banksia *Banksia integrifolia,* and Black She-oak *Allocasuarina littoralis*. Further inland again is the coastal forest. This pattern has been interrupted on Stockton Beach. Blowouts in the foredunes have allowed the onshore winds to carve out the swales and push sand further inland, creating transverse sand dunes in the process, that is, dunes that run at ninety degrees to the foredunes. This process has buried many areas of dune vegetation and has left multiple small "islands" of remnant vegetation stranded in the bare dune system. Large areas of the dune system were also mined in the past for heavy mineral sands (rutile, zircon, monazite and ilmenite) causing further disruption to the dune system. The banksias provide food for nectivorous birds such as White-cheeked Honeyeaters *Phylidonyris niger*. Allocasuarinas and banksias potentially provide food for black cockatoos. This is clearly seen at nearby beaches, for example Blacksmiths Beach (pers. obs.), but it was not documented at Stockton Beach during this study.

The plants of the hind dune can form a dense barrier providing protection from aerial predators for small birds such as fairywrens and White-cheeked Honeyeaters.

The loss of the hind dune plant structure in most areas of the Stockton dunes means that sand is blown further inland, encroaching upon the coastal forest system.

Birds of the hind dune are listed in **Table 7**.

The hind dune encroaching on coastal forest in the Bobs Farm district.

Table 7. Birds of the hind dunes

Common Name	Scientific Name	Occurrence	Diet
Superb Fairywren	*Malurus cyaneus*	Common resident	Insects and arthropods, small quantities of seeds
Variegated Fairywren	*Malurus lamberti*	Common resident	Insects, small quantities of seeds
White-cheeked Honeyeater	*Phylidonyris niger*	Common in January to June†	Nectar but will sometimes eat insects
Yellow-faced Honeyeater	*Caligavis chrysops*	Common resident	Nectar, pollen, fruit, seeds, arthropods, insects, and their products
Silvereye	*Zosterops lateralis*	Common resident	Small insects, spiders, fruit and nectar
Little Wattlebird	*Anthochaera chrysoptera*	Common in January to June†	Nectar, insects, flowers, berries and some seeds
Brown Thornbill	*Acanthiza pusilla*	Common resident	Spiders, beetles, lerp insects, ants and grasshoppers. Sometimes seeds, fruit, or nectar
Eastern Spinebill	*Acanthorhynchus tenuirostris*	Common resident	Nectar supplemented with small insects and other invertebrates
Eastern Whipbird	*Psophodes olivaceus*	Common resident	Insects and other small invertebrates usually caught on the ground
Red-browed Finch	*Neochmia temporalis*	Common resident	Seeds and insects on the ground

† Associated with flowering banksias

The Coastal Forest

With protection from the harsh beach conditions by the wind-stopping cover of the hind dunes, conditions become suitable for trees to grow. Along Stockton Beach these include banksias (*Banksia integrifolia* and *Banksia serrata*), Coastal Red Gum *Angophora costata*, Blackbutt *Eucalyptus pilularis* and Swamp Mahogany *Eucalyptus robusta*. Bark and leaves from these provide significant coverage of the soil (5 cm thick in places),. Once decayed, the fallen material adds humus to the soil. The closed canopy shades the soil further, reducing surface temperatures and evaporation.

The surface soil has a dark grey appearance, with leached, whiter sand beneath (a podzol soil). The soil has better water holding abilities, enabling young trees to survive until they can get their roots down to the water table. The combination of shade, lower temperatures, more soil nutrients and greater availability of water, enables smaller plants (understorey) to survive. These include species such as Prickly Moses *Acacia ulicifolia*, Broad-leaved Geebung *Persoonia levis*, Bracken Fern *Pteridium esculentum*, Blady Grass *Imperata cylindrica*, Kangaroo Grass *Themeda triandra*, Burrawang *Macrozamia communis*, Lance Beard Heath *Leucopogon lanceolatus*, Guinea Flower *Hibbertia scandens*, Spiny Matt Rush *Lomandra longifolia*, Blue Flax Lily *Dianella caerulea*, Purple Coral Pea *Hardenbergia violacea*, Dusky Coral Pea *Kennedia rubicunda*, Common Hop Bush *Dodonaea triquetra*. These provide food, nesting sites and protection for the smaller birds. The larger trees provide food in the form of nectar, lerps and seeds. As will be seen from **Table 8**, this forest produces a wide variety of types of foods for a large number of bird species. The trees also provide roosting sites, tree hollows and branches for nests and arboreal termite nests for Laughing Kookaburras *Dacelo novaeguineae*.

Table 8. Commonly encountered birds in the coastal forests

Common Name	Scientific Name	Occurrence	Diet
Laughing Kookaburra	*Dacelo novaeguineae*	Common resident	Insects, worms, crustaceans, small snakes, mammals, frogs and birds
Superb Fairywren	*Malurus cyaneus*	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Variegated Fairywren	*Malurus lamberti*	Common resident	Insects, small quantities of seeds
Australian Magpie	*Gymnorhina tibicen*	Common resident	Small insects and small arthropods but will also eat a small quantity of seed and fruit
Little Lorikeet	*Parvipsitta pusilla*	†	Nectar and pollen, sometimes mistletoe
Yellow-tailed Black Cockatoo	*Zanda funerea*	†	Seeds and insects
Eastern Rosella	*Platycercus eximius*	Common	Seeds, fruits, buds, flowers, nectar and insects
Sulphur-crested Cockatoo	*Cacatua galerita*	†	Berries, seeds, nuts and roots
Brown Thornbill	*Acanthiza pusilla*	Common resident	Spiders, beetles, lerp insects, ants and grasshoppers. Sometimes seeds, fruit, or nectar
Rainbow Lorikeet	*Trichoglossus moluccanus*	†	Nectar and pollen, but also eats fruits, seeds and some insects
White-throated Treecreeper	*Cormobates leucophaea*	Common resident	Insectivorous (mainly ants) although will eat also nectar
Eastern Spinebill	*Acanthorhynchus tenuirostris*	Common resident partial migration	Insects and nectar
Golden Whistler	*Pachycephala pectoralis*	Common resident	Insects, spiders, small arthropods, sometimes berries
Yellow-faced Honeyeater	*Caligavis chrysops*	Common resident and migratory	Nectar, pollen, fruit, seeds, arthropods, insects, and their products
Rufous Whistler	*Pachycephala rufiventris*	Common in spring & summer	Insects, sometimes seeds, fruit or leaves
White-cheeked Honeyeater	*Phylidonyris niger*	†	Nectar but will sometimes eat insects
White-browed Scrubwren	*Sericornis frontalis*	Common resident	Insects and other small arthropods. Occasionally seeds.
Yellow-throated Scrubwren	*Sericornis citreogularis*	Common resident	Seeds, insects, small invertebrates
Willie Wagtail	*Rhipidura leucophrys*	Common resident	Insects
Australian Raven	*Corvus coronoides*	Common resident	Small birds and will eat insects, and seeds
Welcome Swallow	*Hirundo neoxena*	Common resident	Insects in flight
Pallid Cuckoo	*Heteroscenes pallidus*	Summer	Insects and their larvae
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	Resident	Insects and their larvae
Eastern Whipbird	*Psophodes olivaceus*	Common resident	Insects and other small invertebrates usually caught on the ground
Rock Dove	*Columba livia*	Common Introduced	Seeds
Noisy Miner	*Manorina melanocephala*	Common resident	Nectar, fruits and insects
Spotted Dove	*Spilopelia chinensis*	Common introduced	Seeds
Crested Pigeon	*Ocyphaps lophotes*		Seeds, leaves, insects
Grey Fantail	*Rhipidura albiscapa*	Common resident	Flying insects
Magpie Lark	*Grallina cyanoleuca*	Common resident	Insects and their larvae, earthworms and freshwater invertebrates.
Pied Currawong	*Strepera graculina*	Common resident	Small lizards, insects, caterpillars, berries and small birds

† These birds range over a wider area and their presence often reflects the seasonal availability of food.

Table 8. Commonly encountered birds in the coastal forests (cont.)

Common Name	Scientific Name	Occurrence	Diet
Black-faced Cuckooshrike	*Coracina novaehollandiae*	Common resident	Insects and other invertebrates, sometimes seeds and fruits
Rufous Fantail	*Rhipidura rufifrons*	Uncommon October to March	Small insects

CONSERVATION IMPLICATIONS

During this study, many conservation issues became apparent:

1. The importance of protecting the foredunes. Any damage to the foredunes, e.g. from 4-wheel drive activity, can lead to blowouts in the dune and exacerbate the movement of sand inland.
2. Some foredunes are quite low and have lost their Spinifex protection, allowing waves to over-top them under certain conditions. This could potentially result in the erosion of these foredunes leading to significant blow-outs.
3. Human activity, particularly in the north-east section of the beach, might considerably affect the activities of the shorebirds.
4. More study is needed regarding the breeding activity of birds in the swales.
5. Little information appears to be available regarding what some birds in the swales eat.
6. There appears to be little information on the effects of exotic plants on the ecology of Stockton Beach and dune complex. For example, Bitou Bush *Chrysanthemoides monilifera* may have replaced some of the native plants; however removal without establishing a suitable native replacement, may have deleterious effects on the stability of the dunes.

Many of these issues are addressed under the Worimi Conservation Lands Management Plan (Office of Environment and Heritage 2014).

CONCLUSIONS

The study area, Stockton Beach with its associated sand dunes and coastal forests, provides a number of distinctly different habitats. In each of these, the physical environment determines what plants will grow and hence what animals will live there. Every bird species has its own requirements in terms of food and water, nesting and roosting sites and protection from predators. This means that there are distinct differences in terms of which species are found in each zone. This study has examined these zones and the factors determining which plants (from phytoplankton to large eucalypts) grow in each zone.

This study was temporally limited. Ideally the study should be extended over all seasons of the year and over many years to account for seasonal and longer-term changes. As such, this study provides a snapshot for future comparisons.

The ecology of the Stockton Beach and dune complex has not been well studied, perhaps because of the difficulty of access. Members of the Hunter Bird Observers Club, in conjunction with the National Parks and Wildlife Service have extensive data on the birds of the foreshore and are now seeking to extend the observations into the swales behind the foredunes. Further studies of the birds, animals and plants are needed to better understand the intricate relationships amongst life forms in this dynamic landform.

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Andrew McIntyre and Neil Fraser, through the Hunter Bird Observers Club, organized two surveys with the aim of simultaneously examining the birdlife along all 32 km of Stockton Beach and the adjacent swales. These expeditions on 16 February 2025 and 11 July 2025 enabled me to examine, not only the birds, but also the plants and other animal life. In the first survey, I was partnered with Greg Little, who was kind enough to put up with the logging of plants as well as birds and was able to assist in identifying plants. On the second survey, I was with Archie Brennan, who managed to spot a Hooded Plover *Thinornis cucullatus* during the survey. This was a rare and important observation.

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Breeding success of Pied Oystercatchers on Corrie Island and Winda Woppa sandspit, Port Stephens NSW, summer 2024/25

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INTRODUCTION

This note describes the successful breeding of Pied Oystercatchers *Haematopus longirostris* on Corrie Island Nature Reserve and the adjacent Winda Woppa sandspit in the summer of 2024/25. Corrie Island (32º41'8"S, 152º08'15"E) and the Winda Woppa sandspit (32º40'46"S, 152º08'44"E) are located at the mouth of the Myall River in Port Stephens, New South Wales (NSW) (**Figure 1**). Corrie Island is a low, deltaic island of sand and shingle, covered largely by mangroves. It is a gazetted Nature Reserve, and part of the Myall Lakes Ramsar site. The Winda Woppa sandspit is a recreational reserve of the MidCoast Council. It is used as a stockpile site for dredged spoil from the eastern entrance to the Myall River.

Figure 1. Satellite image of Corrie Island and Winda Woppa sandspit showing 2024/25 nest sites (red circles) and nursery sites (white triangles) (Google Earth accessed 16/09/2025).

Pied Oystercatchers are known to have been present on Corrie Island and the Winda Woppa sandspit since 2000. Nests were first located on Corrie Island in September 2017 (Fraser & Stuart 2018). Another pair was found nesting on the Winda Woppa sandspit in October that year (Stuart 2018). Since then, nesting has been reported regularly at both sites (https://birdata.birdlife.org.au/explore). The Pied Oystercatcher is listed as Endangered in NSW (*Biodiversity Conservation Act 2016*).

METHODS

Corrie Island and the Winda Woppa sandspit were surveyed mainly by Trish Blair and Sharon Taylor. The surveys were done approximately weekly, from mid-August 2024 to mid-January 2025, weather permitting. Kayaks launched from Tea Gardens and Hawks Nest were used to access the eastern shore of Corrie Island, before proceeding on foot to the western end. Surveys were conducted using the 500 m area search protocol of Birdlife Australia. The surveys were conducted in the early morning when wind conditions were most favourable.

All avian species seen along the access route and the nesting sites were recorded. For the Pied Oystercatchers, monitoring was conducted as per the NSW Saving Our Species monitoring plan for beach-nesting birds: their numbers and locations were noted, and for breeding pairs, nest locations, numbers of eggs, chicks and fledglings were recorded. These observations were supplemented by incidental observations made remotely by NSW National Parks Wildlife Service (NPWS) personnel from trail cameras installed adjacent at some nest sites.

Records were entered into the NSW Saving Our Species NPWS Google drive data sheet for beach-nesting birds and the Birdlife Australia Birdata database.

RESULTS

Over the summer of 2024/25, five pairs of oystercatchers nested on Corrie Island and two pairs on the Winda Woppa sandspit. The locations of the nests are shown in **Figure 1**, and the dates of first nest observation, number of eggs, number of chicks and number of fledglings are summarised in **Table 1**. From eight nesting attempts, the seven pairs successfully raised eight fledglings. The Crab Cove pair at Winda Woppa had two unsuccessful nesting attempts, while the other six pairs each nested once.

Table 1. Details of Pied Oystercatchers breeding attempts at Corrie Island and Winda Woppa sandspit in summer 2024/25

Nest site	Date First Observed	Eggs	Chicks	Fledglings
Crab Cove Nest 1	10/10/24	2	0	0
Crab Cove Nest 2	14/11/24	2	0	0
Winda Woppa Nest	23/08/24	2	2	2
Northwest Nest	23/09/24	2	2	1
Northeast Nest	11/10/24	2	2	2
Southeast Nest	23/09/24	3	2	2
Lagoon Nest	11/10/24	2	1	1
Southwest Nest	23/09/24	2	1	0
		17	**10**	**8**

Figure 2. Left: Typical Pied Oystercatcher nest in a sand scrape (the Lagoon Nest, Corrie Island). Right: Crab Cove Nest 1, located amongst beach wrack.

All nest sites were widely spaced from one another, 180-720 m apart. Six of the nest sites on Corrie Island and the Winda Woppa sandspit were crudely lined scrapes made in sand with shell grit or shingle, often on slight mounds (**Figure 2**). The initial nest site for the Crab Cove pair was amongst beach wrack while the second one was amongst grass (**Figure 2**).

The Winda Woppa pair were the first to commence nesting, in late August, as they had done in previous years. The other six pairs began nesting about one month later, over a two- to three-week period from late September to early October (**Table 1**).

Four nursery sites were identified which were used by nesting pairs to raise chicks from day two through to fledging (locations shown in **Figure 1**). The nurseries were 50 m to more than 200 m from the nest sites and were characterised by thick beach vegetation that provided cover for the developing chicks. The westernmost nursery was shared by both the northwest and southwest pair initially, until the northwest chick disappeared.

DISCUSSION

Regular surveys of Port Stephens since 2004 have identified it as a NSW stronghold for Pied Oystercatcher with up to 150 birds regularly present (Stuart 2020). This is 30-40% of the estimated NSW population and 1-1.5% of the world population, making Port Stephens Internationally Significant for the species.

The nests on Corrie Island and one of the Winda Woppa nests were typical for the species (Marchant & Higgins 1994). However, the nest sites for the Crab Cove pair were atypical, which may have been a factor in their lack of success.

Although some eggs and chicks were lost from the Corrie Island nests (**Table 1**), no predation or potential predators were observed in the vicinity of the nest sites. At the Crab Cove site, either tidal inundation or a Lace Monitor *Varanus varius* may have been responsible for the losses of the eggs. Lace Monitors had been previously observed predating the eggs of Little Tern nesting on the Winda Woppa sandspit (Fraser 2017). The Crab Cove pair possibly were first-time breeders; if so, their inexperience may have contributed to the losses.

Signage prohibiting beach use due to the presence of nesting shore birds was installed on Corrie Island early in the breeding program. Despite this, boat users occasionally landed on the island's shores and on the sandspit, and fishermen frequented the island's eastern beach. Oyster farmers along the western shore also were a source of disturbance. On the Winda Woppa sandspit, heavy earth-moving equipment was actively moving the dredged spoil from the site.

There are pre-2024/25 breeding records for Pied Oystercatchers from six additional sites in Port Stephens, all in the western part of the port; Bato Bato Point, Tanilba (N. Karlson pers. comm.), Bushy Island (N. Karlson pers. comm.), Dowadee Island (T. Murray pers. comm.), One Tree Island (N. Karlson pers. comm.), Orobilbah Island (G. Little pers. comm.) and Snapper Island (T. Clarke pers. comm.). All these are on rocky islands or shorelines, which suggests they would be sub-optimal nesting locations (Marchant & Higgins 1994). All six breeding records involved single pairs, which highlights the importance of Corrie Island and the Winda Woppa sandspit which support multiple nesting pairs. Corrie Island's relative isolation undoubtedly also contributes to the species' breeding success.

The success of the 2024/25 breeding season on Corrie Island is in stark contrast to that of the 2023/24 season. Five pairs nested on Corrie Island, making a total of eight attempts, but only one pair managed to successfully raise a fledgling. All the other chicks disappeared and are presumed to have been predated. A pair at Winda Woppa also successfully raised two fledglings. The key difference between the two seasons was two wild dogs *Canis familiaris* (breed Dingo) that were resident on Corrie Island in 2023/24; they were removed from the island prior to the 2024/25 season. These dogs had been recorded predating both eggs and chicks, despite electric fencing being installed around nest sites.

CONCLUSIONS

Corrie Island and the Winda Woppa sandspit are the prime nesting sites for Pied Oystercatchers in Port Stephens. The 2024/25 season has shown that, with effective predator management and minimisation of disturbance, the breeding population can achieve high levels of fledging success.

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Nest prospecting Little Shearwater on Broughton Island

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Remote cameras are a useful tool in understanding aspects of biodiversity overlooked by conventional fauna survey techniques. One or more Little Shearwaters *Puffinus assimilis* were photographed on multiple occasions by trail cameras between May and August 2025 in the vicinity of artificial nest boxes for the Gould's Petrel *Pterodroma leucoptera* adjacent to the summit of Pinkatop Head, Broughton Island off the mid-north coast of New South Wales. It represents the first occasion the species has been documented nest-prospecting on inshore islands off the east coast of Australia.

INTRODUCTION

Nest-prospecting is characterised as visits of individuals to potential new locations where future breeding may occur (Reed *et al*. 1999). During such visits, juveniles or failed adult breeding individuals involved, glean social and environmental information to assess the quality of the potential breeding sites (Kralj *et al*. 2023). Such prospecting behaviour is critical to seabirds establishing new nesting locations on islands previously unoccupied by that species. Dispersal to new nesting locations may be associated with population increases as a result of active management eliminating key threatening processes on main breeding islands, such as the removal of predators.

The Little Shearwater *Puffinus assimilis* is not known to nest on any inshore islands off the east coast of Australia (e.g. Garnett *et al*. 2011; NSW Environment, Energy and Science 2024). The nearest breeding occurs in the Lord Howe Island group, some 600 km off the mid-north coast of New South Wales (Marchant & Higgins 1990). Individuals are infrequently sighted in the Tasman Sea throughout the year with most records between November and June and only 11% of sightings over the continental shelf (Reid *et al*. 2002). The species was considered eliminated from the main Lord Howe and Norfolk Islands by the Black Rat *Rattus rattus* and Feral Cat *Felis catus* (Hindwood 1940; Garnett *et al*. 2011). However, currently Little Shearwater breeding success has not increased significantly following rodent removal on the main Lord Howe Island although targeted surveys indicated an expansion of breeding distribution (Priddel *et al*. 2003; Lord Howe Island Board 2025).

Broughton Island (32^{0}37'S, 152^{0}19'E) is located 16 km north-east of Port Stephens and some 3 km off the mid-north coast of New South Wales. It supports a variety of nesting seabirds including the Wedge-tailed Shearwater *Ardenna pacifica*, Short-tailed Shearwater *A. tenuirostris*, Little Penguin *Eudyptula minor*, Crested Tern *Thalasseus bergii* and the Silver Gull *Chroicocephalus novaehollandiae* (Carlile *et al.* 2012). Additionally, a pair of Gould's Petrel *Pterodroma leucoptera* was found nesting on the island in 2009, leading to the subsequent installation of six artificial nest boxes and a call-playback system west of Pinkatop Head in mid-2017 (S. Callaghan, unpublished records). These nest boxes have resulted in a number of successful breeding events and led to the discovery of a Pycroft's Petrel *Pterodroma pycrofti* occupying one of the boxes in spring 2019 (Stuart *et al*. 2023; Stuart & Clarke 2023). Two species appear no longer to nest on the island: the Sooty Shearwater *Ardenna grisea*; and the White-faced Storm-petrel *Pelagodroma marina* (Hindwood & D'Ombrain 1960; Lane 1976; Carlile *et al.* 2012).

Remote Reconyx infra-red cameras were set around the periphery of Broughton Island as a result of a Black Rat incursion in August 2024, some 15 years after a successful rat eradication program was undertaken on the island in 2009 (Priddell *et al.* 2011). This camera deployment included setting one or two cameras adjacent to the entrances of the Gould's Petrel nest boxes and an additional camera some 30 m to the east. As a result of this camera deployment the Little Shearwater *Puffinus assimilis* was incidentally photographed on several occasions between May and August 2025 and this note summarises these occurrences.

OBSERVATIONS

A Little Shearwater was first photographed at 0415 hours on 13 May 2025 (**Figure 1**). The identity of this shearwater was confirmed by seabird authorities, Rohan Clarke and Mick Roderick. However, based on these photographs alone the specific subspecies could not be identified.

Single individuals were then subsequently photographed on four nights in June, 13 nights in July and seven nights in August (**Appendix 1**; **Figure 2**). It was last recorded at 0438 hours on 16 August. No further individuals were photographed in September. The majority of triggers (79%) were in the hours before dawn; with a smaller number of triggers (17%) following dusk and one in the middle of the night. On the majority of nights only a single trigger by the species was recorded (86% of nights). Interestingly, no nights had more than two triggers which suggested only limited time was spent exposed on the surface. On nights with two triggers, it could not be confirmed whether such activity represented one or two individuals.

Figure 1. The first photographs of the Little Shearwater taken by a remote camera near Pinkatop Head on 13 May 2025.

Figure 2. Later photographs of the Little Shearwater taken by a remote camera near Pinkatop Head on 2 June and 14 August 2025.

Daytime searches of the nest boxes and general surrounding area for burrow activity on 12 June, 26 August and 27 August 2025 failed to locate any individuals. Feathers potentially of this species were collected from one nest box in the first August visit. The absence of triggers after 16 August and through to mid-September suggested that nesting did not occur but was instead a result of sustained nest prospecting.

No Little Shearwaters were photographed by any of the other 49 remote cameras distributed elsewhere around the island.

The presence of the Little Shearwater on Broughton Island is significant in that it is the first time the species has been recorded on any near-shore islands off eastern Australia. This species is listed as Vulnerable under the NSW *Biodiversity Conservation Act 2016*. Therefore, it will be important to monitor potential nesting activity around the nest boxes between May and September in future years for confirmation of actual breeding.

The presence of this species on Broughton Island raises the question as to whether this species may be nesting on other islands in the Broughton Group or Cabbage Tree and Boondelbah Islands some 12 and 13 km to the south west respectively. Eight remote cameras and two song meters were set on Boondelbah in July 2025 to initially address this question but these have yet to be analysed. As sea temperatures change and as populations of various seabird populations increase (possibly to capacity) due to the elimination of predators such as rat species on some islands it would be expected that variations in the nesting range of such species will occur. Therefore, it is important that bird observers and seabird biologists visiting islands be aware that such changes may be happening and be alert to the potential arrival of any new nesting species.

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APPENDIX: Little Shearwater records

Date	Time	Date	Time
May records		23/7/25	0340 h
13/5/25	0415 h	23/7/25	0504 h
		24/7/25	0506 h
June records		25/7/25	2005 h
2/6/25	0426 h	26/7/25	0454 h
7/6/25	0043 h	27/7/25	0458 h
16/6/25	0435 h	31/7/28	1955 h
21/6/25	0501 h	31/7/25	0501 h
July records		*August records*	
5/7/25	1949 h	4/8/25	2116 h
7/7/25	0544 h	7/8/25	0508 h
15/7/25	0453 h	7/8/25	1829 h
18/7/25	0454 h	8/8/25	0458 h
19/7/25	0514 h	11/8/25	0406 h
19/7/25	0519 h	14/8/25	0434 h
20/7/25	0513 h	15/8/25	0431 h
21/7/25	0514 h	16/8/25	0438 h

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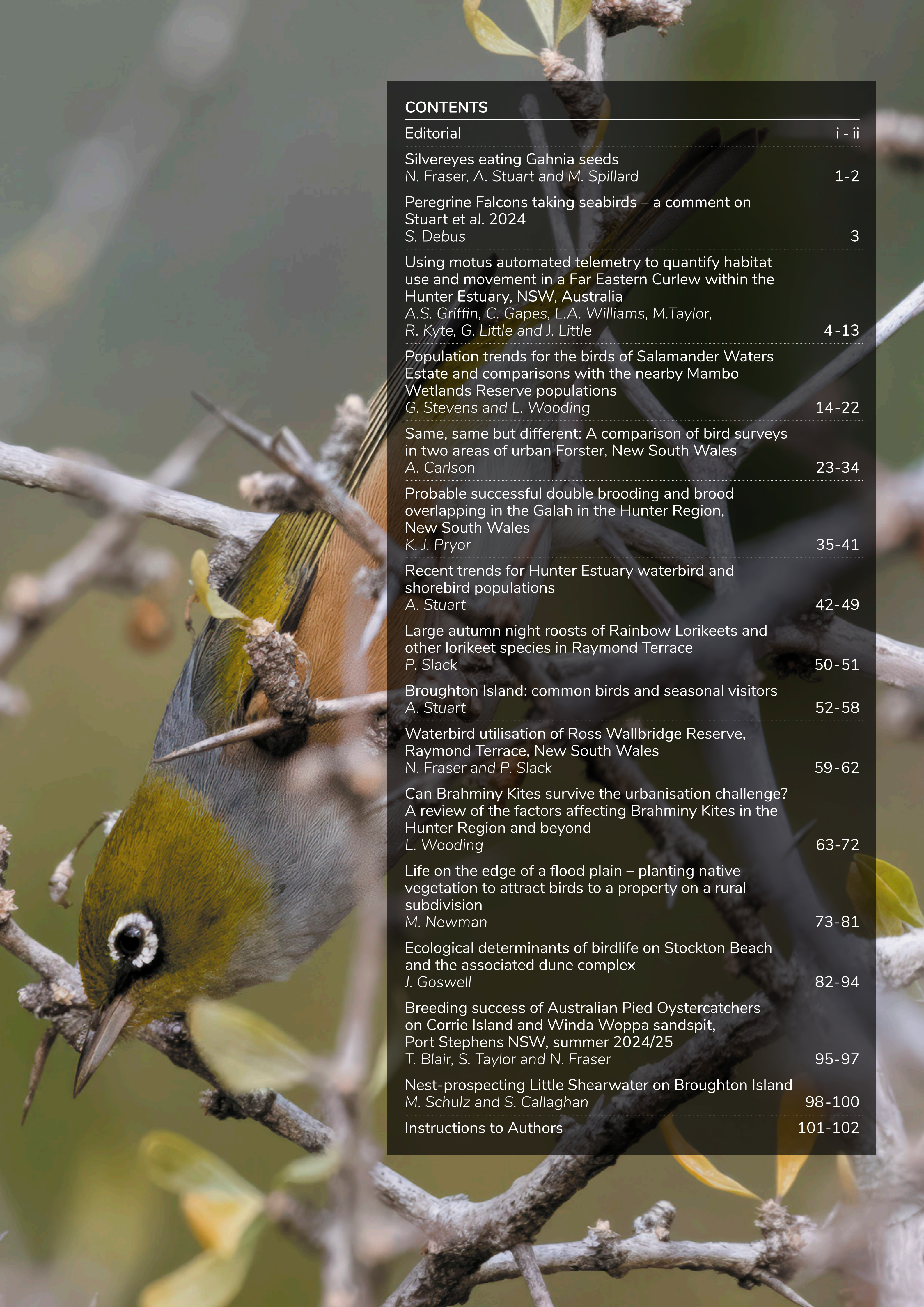

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