

Waterbirds and other birds of the Arcoona Lakes, arid South Australia, 2022–2023

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Abstract. The waterbirds of the Arcoona Lakes in central northern parts of South Australia have previously been studied following large rainfall events in 1989 and 2007. These ephemeral wetlands refilled in 2022, providing an opportunity to study the lakes for a third time. Unlike the previous rainfall events, where much of south-eastern Australia was relatively dry, there was extensive and widespread rainfall across Australia throughout 2022. Despite the widespread availability of habitat, waterbirds still flocked to the Arcoona Lakes. We recorded 48 species, with total abundance comparable to the 2007 rainfall event, but lower than the 1989 event. Single-day abundance at Coorlay Lagoon exceeded 20,000 individuals, highlighting these wetlands as Nationally Important (international Ramsar Criterion 5, adopted by BirdLife Australia for identifying nationally important bird sites). Across all three studies, 64 species of waterbird have been recorded using the Arcoona Lakes, including migrants from the Northern Hemisphere, as well as large congregations of Blue-billed Duck *Oxyura australis* and Freckled Duck *Stictonetta naevosa*. In total, 25 species have been recorded breeding at the lakes. Inland wetlands remain relatively understudied; our surveys provide important data on the use of inland wetlands by waterbirds, and continue the longitudinal research at the Arcoona Lakes that now spans more than three decades. Since the Arcoona Lakes are seldom visited, we also include records, and some photographs, of bird species other than waterbirds.

Introduction

Central northern parts of South Australia are among the driest areas on the Australian continent, with mean annual rainfall <200 mm for much of the region (Bureau of Meteorology 2024). Nevertheless, large rainfall events – typically resulting from summer monsoonal troughs – transiently fill various waterbodies, providing important water sources in the ecosystem. Ephemeral wetlands are highly productive and support a range of migratory and nomadic species (Davies 1984; Kingsford 1995; Kingsford & Norman 2002), with numbers at coastal wetlands at times declining while inland wetlands hold water (Breed *et al.* 2023). Given that Australia’s arid inland wetlands are less well studied than other habitats, documenting the health, breeding activity, and abundance of waterbird populations at these sites is vital for these species’ conservation, as these records help estimate national population sizes and track broader ecological trends across the continent.

The Arcoona Tableland is characterised by stony plains and low sand dunes, with the vegetation dominated by chenopod shrublands. Within this landscape, there are 11 large waterbodies and many smaller swamps. The main waterbodies are basins with no drainage that benefit from high runoff; they can fill to considerable depth (up to 6 m) and hold water for years (Read & Ebdon 1998; Pedler & Kovac 2013). The lakes vary substantially in size (~50–600 ha), depth (up to 6 m), salinity (sodium chloride ~170–60,000 ppm), and vegetation (Read & Ebdon 1998; Pedler & Kovac 2013). Across the last 3–4 decades, the Arcoona Lakes have filled substantially just a few times. In 1989, a severe monsoonal incursion caused extreme flooding that filled the larger waterbodies for >5 years (Read & Ebdon 1998). This was estimated to be the most rainfall in well over a century, as it drowned old White Cypress Pine *Callitris glaucophylla* trees (Read & Ebdon 1998). In

2007, a summer monsoon trough caused localised rainfall (50–200 mm) that refilled the lakes for c. 3 years. This was a significant event because south-eastern Australia was very dry throughout 2006–2007 (Bureau of Meteorology 2024). Following the 1989 and 2007 rainfall events, waterbirds were surveyed. More than 150,000 waterbirds from 56 species were recorded across 5 years following the 1989 rainfall event (Read & Ebdon 1998). In the 3 years after the 2007 rainfall event, 46 species were recorded, with the regional total (the number of birds recorded on 1 day, across multiple lakes) being 31,500 birds (Pedler & Kovac 2013). Both these studies reported many species breeding at the lakes, underlining the importance of these ephemeral waterbodies for populations of waterbirds.

In October 2022, 134 mm of rain fell at Roxby Downs (mean annual rainfall ~150 mm: Bureau of Meteorology 2024), and an additional 73 mm fell in November 2022–January 2023, comparable with that observed in 2007 (Pedler & Kovac 2013). This rainfall was largely caused by slow-moving low-pressure systems rather than monsoonal troughs, and Australia experienced rainfall very much above average throughout 2022 (Appendix 1). This extensive difference in habitat availability across the region after the 2022 rainfall offered an interesting point of comparison for these studies.

Here, we surveyed two small swamps and two large waterbodies within the Arcoona Lakes system over the 12-month period from December 2022 to December 2023. The swamps (Purple Swamp and Chances Swamp, ~25 km south of the Roxby Downs township: Figure 1) were not surveyed by Read & Ebdon (1998), and only once by Pedler & Kovac (2013). They dried out rapidly, providing an opportunity to focus on how the bird community changed across a brief 4-month period. By contrast, the larger waterbodies (Lake Mary and Coorlay Lagoon, ~30 km and 15 km south of the Roxby Downs township, respectively:

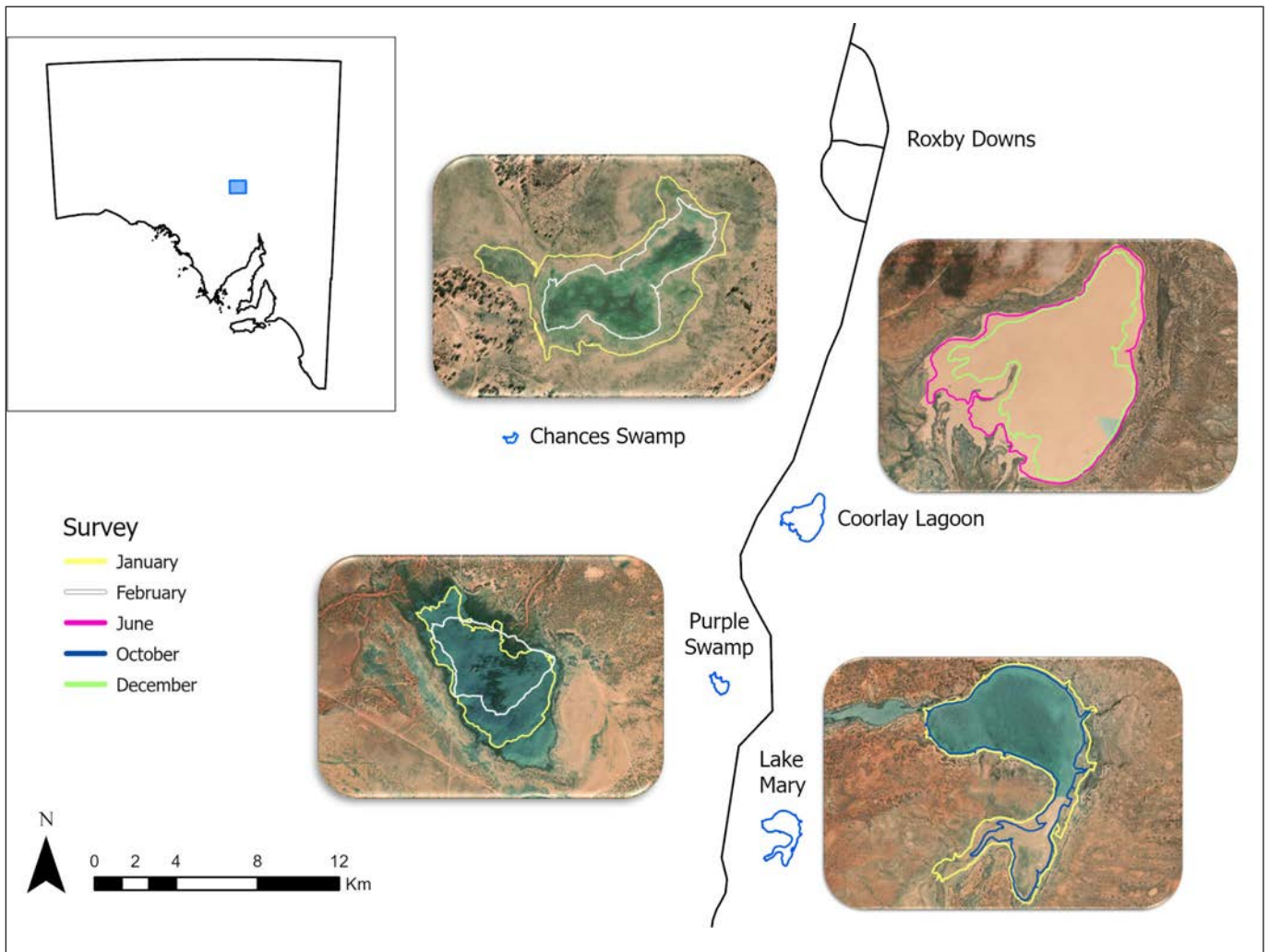


Figure 1. Surveyed waterbodies at the Arcoona wetlands. Top left inset shows the South Australian border and coastline, with the blue polygon indicating the location of the enlarged area. The black line is the major road (Olympic Dam Highway) to the waterbodies, and the blue lines on the primary map show the perimeters of the four surveyed waterbodies. The insets are satellite images of each waterbody, with the different coloured lines showing our tracked movement across different surveys throughout 2023 to demonstrate how the water level changed through time. Map, https://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer (December 2022–June 2023)

Figure 1) held water for the duration of the study period. They were surveyed extensively in the two earlier studies. Our results add to the knowledge of the Arcoona wetlands, and their importance in supporting many waterbirds.

Methods

Sites

The four surveyed waterbodies are in the Arcoona Tableland, on pastoral, rangelands country, ~25 km south of the Roxby Downs township in central South Australia (Figure 1). The average annual rainfall at Roxby Downs is ~150 mm (Bureau of Meteorology 2024), though rainfall is highly sporadic. Our surveyed sites have been described in detail previously (Read & Ebdon 1998; Pedler & Kovac 2013). Briefly, they are within the Arcoona Tableland, an area dominated by stony plains and low sand dunes, with low shrubs (predominantly saltbush *Atriplex* spp. and bluebush *Maireana* spp.) and few trees. Purple Swamp (30°79'S, 136°89'E) had abundant shrubs (Cotton Bush *Maireana aphylla* and Tangled Lignum *Duma florulenta*) with some

fringing trees (Figure 2) but Chances Swamp (30°70'S, 136°77'E) was essentially an open mudflat with very few fringing trees (Figure 3). Thus, although relatively similar in size and depth, these two swamps had contrasting habitat complexities. This contrast was somewhat reflected in the larger waterbodies. Coorlay Lagoon (30°71'S, 136°92'E) essentially resembled an open freshwater mudflat (Read & Ebdon 1998); it was very sparsely vegetated, with only a few fringing Boree *Melaleuca pauperiflora* and shrubs. The substrate was uncompacted silty sand and sandstone outcrops (Read & Ebdon 1998). Conversely, Lake Mary (30°84'S, 136°93'E) is relatively saline (Read & Ebdon 1998), surrounded by sand dunes, and has considerably more fringing vegetation (predominantly White Cypress Pine trees and various *Acacia* species: Read & Ebdon 1998) (Figure 4). Public access to Coorlay Lagoon is prohibited, but access to Lake Mary is only discouraged; our surveys were on private land.

We surveyed Purple Swamp and Chances Swamp from December 2022 to March 2023, with one survey conducted in each month. Both swamps were completely dry by March 2023 (Figures 2–3). We surveyed Lake Mary from January 2023 to October 2023 and Coorlay Lagoon



Figure 2. Representative images from Purple Swamp across surveys in December 2022 (top left), January 2023 (top right), February 2023 (bottom left) and March 2023 (bottom right). Photos: Genevieve L.T. Hayes

from June 2023 to December 2023. We surveyed each of the four waterbodies four times, and made additional surveys of the two larger lakes to record breeding activity. Representative photographs of three of the sites across the study period are presented as Figures 2–4.

Bird counts

Our survey method involved walking together around the entire perimeter of each waterbody and recording and counting all waterbirds. All other birds at the sites were also recorded but not counted. When the swamps were dry and/or water was patchy, we walked throughout the swamp bed to view the whole swamp area. We did not use kayaks to reach the islands within Coorlay Lagoon, in contrast with the earlier studies of Read & Ebdon (1998) and Pedler & Kovak (2013).

Birds were counted and identified with the aid of 10 x 42 binoculars (GLTH) and a Canon DSLR camera with a 100–400-mm lens (RJD) (species identity was often confirmed using photographs). Maximum counts for each month for all waterbirds were determined. Where bird density was very high, we each counted the number of birds and then used the mean as the approximate total number. We scanned and recorded approximate estimates

for common species (large groups tended to be dominated by a few, highly abundant species) and specific counts for rarer species. We then photographed the birds in groups, and used the photographs to identify and count. We amalgamated these estimates to generate our final count. Counts at the two swamps were always on the same day.

We attempted to minimise disturbance and subsequent double-counting, but some error was inevitable, particularly on two occasions (October 2023 surveys of Lake Mary and Coorlay Lagoon) when a Peregrine Falcon *Falco peregrinus* was present. In addition, birds were often far away, and heat shimmer made counting and identification (using photographs or binoculars) essentially impossible at longer distances.

We visited Coorlay Lagoon multiple times in each of September and October 2023 to record breeding activity but did not approach nests when birds were present, and in areas containing nests (e.g. where birds were performing distraction displays) we moved through as quickly and cautiously as possible to minimise disturbance.

Results

Counts of all waterbirds are presented in Appendix 2 and all other birds are listed in Appendix 3. Taxonomy and



Figure 3. Representative images from Chances Swamp across surveys in December 2022 (top left), January 2023 (top right), February 2023 (bottom left) and March 2023 (bottom right). The white oval identifies the same post in each (of three) survey. Photos: Genevieve L.T. Hayes

scientific names follow AviList Core Team (2025) and common names follow BirdLife Australia Working List v 4.3. We also present images of some of the waterbirds (Figures 5–6) and other birds (Appendix 4) at the Arcoona wetlands.

Overview

Across all four surveys of each of the four waterbodies, we recorded waterbirds from 48 species using the Arcoona Lakes (Appendices 2, 5 and 6), with the highest single-survey count exceeding 22,000 individuals. At Purple Swamp, we recorded 30 species of waterbirds, of which nine were breeding (Appendix 5), and the maximum count in a single survey was 1351. We recorded 26 species of waterbirds at Chances Swamp (Appendix 5), where breeding was limited, and the maximum count in a single survey was 431. Both these swamps were dry by March 2023 (Figures 2–3), holding water for 5 months, comparable with that observed by Pedler & Kovac (2013). At Lake Mary, we recorded waterbirds from 33 species, with 9192 being the most individuals recorded in a single survey (Appendix 6). Total abundance increased five-fold between January and April (Appendix 6), possibly because of an influx of birds from the smaller, drying swamps,

although total abundance fluctuated substantially across the four surveys. In our four main surveys of Coorlay Lagoon, we recorded 40 waterbird species (Appendix 6), including 22,558 birds counted in a single survey in December 2023. Although the final surveys of Lake Mary and Coorlay Lagoon were performed in separate months, summing these counts suggests that >30,000 waterbirds were using these Arcoona Lakes.

Shorebirds and other waterbirds that breed in Australia

Eurasian Coot *Fulica atra* (35.3%) and Grey Teal *Anas gracilis* (31.3%) were the most abundant waterbirds recorded, accounting for approximately two-thirds of all waterbirds. Hardhead *Aythya australis* (13.3%), Pink-eared Duck *Malacorhynchus membranaceus* (3.8%), Black Swan *Cygnus atratus* (3.5%), Hoary-headed Grebe *Poliiocephalus poliocephalus* (3.3%) and Red-capped Plover *Anarhynchus ruficapillus* (2.8%) were the only other species with >1000 records (Figures 5–6). Typically, Black Swan, Hardhead and Eurasian Coot were together in very large congregations of hundreds or thousands of each at Lake Mary and Coorlay Lagoon, and Grey Teal was often seen in large, mixed flocks with Pink-eared Duck. Freckled



Figure 4. Lake Mary tree photographed in January (left), April (middle) and October (right) 2023. Photos: Robert J. Dugand

Duck *Stictonetta naevosa* was recorded at three locations, and was increasing in abundance in later surveys at Coorlay Lagoon (Appendix 6). Musk Duck *Biziura lobata* and Blue-billed Duck *Oxyura australis* were observed sporadically and in low numbers. Plumed Whistling-Duck *Dendrocygna eytoni* (Figure 5) was recorded at Purple Swamp. Baillon's Crake *Zapornia pusilla* (Coorlay Lagoon and Purple Swamp) and Australian Spotted Crake *Porzana fluminea* (Coorlay Lagoon) (Figures 5–6) were rare. Black-tailed Native-hen *Tribonyx ventralis* was recorded in most surveys in low numbers, except once at Purple Swamp where 180 individuals were recorded. We also recorded a single Buff-banded Rail *Gallirallus philippensis* in the Roxby Downs township, but never at the Arcoona Lakes.

Of the shorebird species that breed in Australia, Red-capped Plover (Figure 5) was the most common, often in flocks of tens or hundreds, dominated by subadults, and mixed flocks with migratory shorebirds when the latter were present. Pied Stilt *Himantopus himantopus* and Red-kneed Dotterel *Erythrogonys cinctus* (Figures 5–6) were abundant at Purple Swamp and Coorlay Lagoon. At the latter, adult Red-kneed Dotterels were commonly seen jostling for position beneath small shrubs, where a single adult seemed to hold territory. Banded Stilt *Cladorhynchus leucocephalus* was commonly observed during, but not after, January–February 2023. Separate flocks of Banded Lapwings *Vanellus tricolor* and Australian Pratincoles *Glareola isabella* were recorded at Purple Swamp when it was largely dry; the former were recorded in most surveys, but in low numbers. Little Button-quail *Turnix velox* was present, but were not making use of the wetlands.

We observed flocks of Australian Gull-billed Terns *Gelochelidon macrotarsa* (Figure 6) and Whiskered Terns *Chlidonias hybrida* sporadically. We commonly saw the former with dragonflies (Odonata) and reptiles, and recorded pellets with remains of semi-digested lizards (*Ctenotus* spp., *Ctenophorus* spp. and Central Bearded Dragon *Pogona vitticeps*: Figure 6). Whiskered Terns flew low over the water and were observed diving into the water at Purple Swamp and Coorlay Lagoon.

Breeding

We recorded breeding for a total of 15 species (Table 1, Appendices 5-6). Purple Swamp – the most vegetated site with abundant lignum – had the most breeding activity, with Musk Duck, Pink-eared Duck, Black Swan, Hardhead, Grey Teal, Hoary-headed Grebe, Black-tailed Native-hen,

Eurasian Coot and Red-kneed Dotterel all breeding. Most of the 200 Red-kneed Dotterels recorded there in January 2023 were juvenile. On two occasions at Purple Swamp, Australian Gull-billed Terns were seen taking Red-kneed Dotterel chicks and being mobbed by adult Dotterels (Figure 6). At Chances Swamp, Australian Wood Duck *Chenonetta jubata*, Grey Teal and Pink-eared Duck were breeding (only one clutch per species), possibly supported by the few fringing trees. We also recorded a few Hoary-headed Grebes carrying chicks, and a single juvenile Black-fronted Dotterel *Thinornis melanops*.

Blue-billed Ducks were once recorded breeding at Lake Mary, a finding that has been documented again in October 2024 (<https://ebird.org/checklist/S207593802>). Red-capped Plovers bred prolifically at Lake Mary and Coorlay Lagoon, and we frequently observed adults performing distraction displays (Figure 6). At all four waterbodies, Hoary-headed Grebes were often observed with subadults or carrying chicks. Black Swans were breeding prolifically, except at Chances Swamp, where we recorded only one individual in each of two separate surveys. At Purple Swamp, they used vegetation to build nests, but at Lake Mary and Coorlay Lagoon, where vegetation is sparse, most of their nests were built by mounding stones (Figure 6). Purple Swamp dried too fast for many Black Swan cygnets, and we recorded >10 carcasses in February–March 2023. Masked Lapwings *Vanellus miles* and Silver Gulls *Chroicocephalus novaehollandiae* were breeding at Coorlay Lagoon; we witnessed a Silver Gull poach an egg of a Masked Lapwing (Figure 6).

In addition to the confirmed breeding activity, there were signs that other species might have been breeding, or were breeding but not at the surveyed sites. Male Freckled Ducks often had bright-red bills, indicative of breeding. Vegetation at Purple Swamp might have supported breeding, though we suspect Freckled Ducks were breeding at nearby sites and not at the surveyed lakes (see Read & Ebdon 1998). In addition to the confirmed breeding of Musk Ducks at Purple Swamp, males were performing mating and competition displays at Lake Mary. One Pied Stilt was observed performing a distraction display (Figure 6), suggesting nesting activity. We also recorded many juvenile Australian Gull-billed and Whiskered Terns, but did not identify any breeding sites. Following the 2007 rainfall event, Australian Gull-billed Terns arrived within 24 hours of the rainfall, started breeding immediately at four of the Arcoona Lakes (not lakes surveyed in the current assessment: Pedler & Kovac 2013), and chicks left the nests soon after hatching. Here, we first surveyed the



Figure 5. Waterbirds at Arcoona Wetlands. Top left to bottom right: Baillon's Crake, Australian Spotted Crake, Australian Gull-billed Tern, Curlew Sandpiper, Red Knot, Red-kneed Dotterel, Pectoral Sandpiper, Plumed Whistling-Duck, Red-necked Avocet, Red-necked Stint, Hoary-headed Grebe and Pink-eared Duck, Red-capped Plover, Pied Stilt, Black Swan, Sharp-tailed Sandpiper, all photographed at the Arcoona Wetlands 2022–2023. Photos: Robert J. Dugand

lakes c. 2 months after the October rainfall, and thus might have missed breeding activity of Australian Gull-billed Terns if it occurred. Ducklings of Plumed Whistling-Duck were seen at a nearby dam, but not at the surveyed sites.

Migratory shorebirds

We recorded 11 species of migratory shorebirds. Sharp-tailed Sandpiper *Calidris acuminata* (Figure 5) was the

most commonly observed (12/16 surveys; seen at all four sites) and the most abundant with a maximum count of 122. Outside of Coorlay Lagoon, the only other migratory shorebirds present were Oriental Plover *Anarhynchus veredus* (two individuals in one survey at Chances Swamp), Common Greenshank *Tringa nebularia* (all three other waterbodies), Curlew Sandpiper *Calidris ferruginea* (once at Lake Mary) and Red-necked Stint *C. ruficollis* (Chances Swamp and Lake Mary) (Figure 5). Curlew Sandpiper and Red-necked Stint were more commonly observed and

more abundant at Coorlay Lagoon than at the other lakes, and Common Greenshank was not recorded at Coorlay Lagoon. The remaining six species (Common Sandpiper *Actitis hypoleucos*, Marsh Sandpiper *Tringa stagnatilis*, Wood Sandpiper *T. glareola*, Red Knot *Calidris canutus*, Long-toed Stint *C. subminuta* and Pectoral Sandpiper *C. melanotos*) were recorded only at Coorlay Lagoon, on the large, open mudflats. Marsh Sandpiper and Wood Sandpiper were recorded twice, but the remaining four species were recorded only once (predominantly in October 2023), and represented by a single individual in each case. A few Red-necked Stints overwintered at the lakes, but there was no sign of other migratory shorebirds through winter.

At Coorlay Lagoon in September 2023, one Sharp-tailed Sandpiper had an orange flag (possibly AXZ) on the right tibia, indicating that it had been flagged in Victoria, likely at the Western Treatment Plant; we reported this to the Australasian Wader Studies Group.

Comparisons with previous studies

Across the three studies (the present study and the earlier studies of Read & Ebdon 1998 and Pedler & Kovac 2013), in total 64 waterbird species (including a Domestic Duck that was recorded at Arcoona Lake by Read & Ebdon 1998) have now been recorded using the Arcoona Lakes. Overall, we recorded similar total abundances to the 2007 study, but substantially fewer birds than the 1989 study. As with the previous two studies, the four most common species (Pink-eared Duck, Hardhead, Grey Teal and Eurasian Coot) accounted for >80% of the total number of waterbirds.

Five species had not been recorded in the previous studies. Plumed Whistling-Duck was present at the highly vegetated Purple Swamp, and was also recorded at nearby dams. Baillon's Crake was observed at Purple Swamp and Coorlay Lagoon. The remaining three species (Red Knot, Long-toed Stint and Pectoral Sandpiper) were all single records from Coorlay Lagoon. We also recorded Australian Spotted Crake and Australian Pratincole, which were not listed in either of the previous studies, although both were identified by Read & Ebdon (1998), and were breeding, at smaller waterbodies.

We did not record 16 species that were recorded in the previous studies. Among these, Great Crested Grebe *Podiceps cristatus*, Australasian Darter *Anhinga novaehollandiae*, Great Pied Cormorant *Phalacrocorax varius* and Australian Pelican *Pelecanus conspicillatus* were predominantly recorded by Read & Ebdon (1998) when fish were deliberately introduced into Coorlay Lagoon and Lake Mary by the local community. Read & Ebdon (1998) also recorded other obligate and facultative piscivorous species (Australian Gull-billed Tern, Little Pied Cormorant *Microcarbo melanoleucos*, Great Cormorant *Phalacrocorax carbo*, Little Black Cormorant *P. sulcirostris*) in higher numbers than the other two studies (Appendices 2, 5 and 6). We did not record any ibises or spoonbills but, in the previous studies, these mostly arrived >1 year after flooding. A suite of predominantly coastal-feeding migratory shorebirds has been recorded across these studies: Grey Plover *Pluvialis squatarola*, Far Eastern Curlew *Numenius madagascariensis*, Black-tailed Godwit *Limosa limosa*

Table 1. Records of breeding (x) across all Arcoona Lakes from the three studies (R & E = Read & Ebdon 1998; P & K = Pedler & Kovac 2013; D & H = this study). * denotes records of breeding, but not specifically at the surveyed lakes. We observed a Pied Stilt performing a distraction display (Figure 6), but could not confirm breeding.

Species	R & E	P & K	D & H
Ducks, swans and geese			
Plumed Whistling-Duck			*
Musk Duck			x
Blue-billed Duck			x
Pink-eared Duck		x	x
Black Swan	x	x	x
Australian Wood Duck			x
Hardhead			x
Grey Teal	x	x	x
Grebes			
Australasian Grebe	x		
Hoary-headed Grebe	x	x	x
Rails, gallinules and coots			
Black-tailed Native-hen		x	x
Australian Spotted Crake	*		
Eurasian Coot	x	x	x
Stilts and avocets			
Red-necked Avocet		x	
Pied Stilt	x	x	
Plovers and lapwings			
Black-fronted Dotterel	x		x
Masked Lapwing	x	x	x
Red-kneed Dotterel		x	x
Red-capped Plover	x	x	x
Pratincoles			
Australian Pratincole	*		
Terns and gulls			
Australian Gull-billed Tern	x	x	
Silver Gull	x	x	x
Cormorants			
Little Pied Cormorant	x		
Great Cormorant	x		
Little Black Cormorant	x		

and Ruddy Turnstone *Arenaria interpres* were recorded previously, and we recorded a Red Knot. These species pass across the continent during migration, explaining their rare but ongoing scatter of records far inland. We did not record Australian Shelduck *Tadorna tadornoides*, a species that was rare in the previous studies.

Across all three studies, we have collectively recorded 25 waterbird species breeding (Table 1), and Plumed Whistling-Duck breeding nearby. We report new breeding records for Australian Wood Duck at Chances Swamp, Musk Duck at Purple Swamp, and Blue-billed Duck at Lake Mary, each on single occasions.



Figure 6. Waterbirds at Arcoona Wetlands: bird behaviours. Top left to bottom right: Australian Gull-billed Tern with a dragonfly, part-digested agamid lizard from an Australian Gull-billed Tern, Australian Gull-billed Tern with a skink, Australian Gull-billed Tern pellet, Australian Gull-billed Tern being mobbed by Red-kneed Dotterel, Baillon's Crake with a dragonfly, Pied Stilt distraction display, Red-capped Plover distraction display, Black-fronted Dotterel swooping a Red-capped Plover, Silver Gull with the stolen egg of a Masked Lapwing, Black Swan nest made of stones at Coorlay Lagoon, Black Swan nest made of vegetation at Purple Swamp, all photographed at the Arcoona Wetlands 2022–2023. Photos: Robert J. Dugand

Discussion

Our study of the waterbird assemblages at the Arcoona Lakes continues intermittent monitoring that now spans >30 years. Despite the widespread availability of habitat across Australia throughout our surveys, high numbers of waterbirds were still recorded at the Arcoona lakes. With >20,000 waterbirds recorded on a single day, including 122 Sharp-tailed Sandpipers, and 10 other trans-equatorial migrant species (recorded in different surveys), data from Coorlay Lagoon alone highlight the value of these wetlands to migratory and nomadic waterbirds.

Comparison with the previous rainfall events

The three studies of waterbirds of the Arcoona Lakes followed vastly different rainfall events and applied different

sampling effort. For both previous studies, sampling continued until the lakes were dry, over a period of 3–5 years, whereas the present study was performed across a 12-month period from December 2022 to December 2023. This limits the scope for direct comparisons or identifying subtle changes in waterbird abundance. In 1989 (the first event studied: Read & Ebdon 1998), rainfall was very much above average, in a band that largely spanned the arid and semi-arid areas of South Australia (Appendix 1). In 2007 (the second event: Pedler & Kovac 2013), rainfall was localised and followed a very dry 2006 for south-eastern Australia (Appendix 1). In 2022 (current study), rainfall was extensive across south-eastern Australia (Appendix 1), and we surveyed for only the first year after the rain. With these contrasts in mind, we discuss some of the main outcomes from our study, including contrasts with the previous studies.

First, we anticipated that the vast differences in habitat availability at a broad national scale might have resulted in differences in species richness and total abundance, with a smaller influx in the current study. However, this was not supported by the data, as overall richness and abundance were similar between the 2007 and 2022 studies. In each of the three studies, the same four most common species (Pink-eared Duck, Hardhead, Grey Teal and Eurasian Coot) accounted for >80% of total abundance.

Second, a few species were dramatically more abundant following the 2007 rainfall event. The 950 Blue-billed Ducks recorded by Pedler & Kovac (2013) far exceed the number reported here (maximum 20) or by Read & Ebdon (1998) (maximum 50). At the time, it was anticipated that 950 individuals represented ~8% of the Australian population of Blue-billed Duck (Garnett & Crowley 2000; Pedler & Kovac 2013); however, >12,000 (the previous national estimate) have been recorded at the Western Treatment Plant, Victoria, on one occasion (Loyn *et al.* 2014; Menkhorst *et al.* 2021), demonstrating that the national abundance can be higher. Pedler & Kovac (2013) also regularly recorded flocks of several thousand Banded Stilts, including at Coorlay Lagoon. Read & Ebdon (1998) recorded 1100 once at Lake Richardson, and we recorded a maximum of only 60 at Lake Mary. Sharp-tailed Sandpiper abundance peaked at 741 at Coorlay Lagoon in November 2009, compared with maximum counts of 100–200 in the other two studies. Nevertheless, we note that the 122 individuals recorded at Coorlay Lagoon in one of our surveys exceeds the threshold of 85 required to meet the criterion for a Nationally Important Site if this many individuals are regularly supported (as defined by the *Environment Protection and Biodiversity Conservation Act 1999*). The localised rainfall recorded in 2007 might have concentrated these species at the Arcoona Lakes, whereas they might have been distributed more broadly throughout the other studies.

Third, Curlew Sandpipers were nearly absent from the Arcoona Lakes following the 2007 rain (maximum count of three) but were commonly recorded by Read & Ebdon (1998), with up to 100 individuals, and in most of our surveys at Coorlay Lagoon, with 50 individuals in one survey. Like many migratory shorebird species experiencing catastrophic population declines over the past few decades (Close 2008; Nebel *et al.* 2008; Wilson *et al.* 2011; Clemens *et al.* 2016; Studds *et al.* 2017; Garnett & Baker 2021), Curlew Sandpiper abundance has declined rapidly within the East Asian–Australasian Flyway (Lisovski *et al.* 2021) and within Australia (Clemens *et al.* 2016; Studds *et al.* 2017; Rogers *et al.* 2023), precipitating a federal listing of Critically Endangered. Although the primary threats to migratory shorebirds largely come from outside Australia (Murray *et al.* 2014), and Curlew Sandpipers are predominantly coastal feeders, shorebird survival generally may be improved while inland lakes provide suitable habitat (Clemens *et al.* 2021).

Fourth, Read & Ebdon (1998) recorded substantially higher numbers of piscivorous birds (grebes, darters, cormorants and pelicans) than in the subsequent studies. These largely arrived 1 year after the rain, and followed the deliberate release of fish into some of the waterbodies, including Lake Mary and Coorlay Lagoon. Hence, the low numbers of these birds recorded in our 2022 study is unsurprising, as there might not have been time for their

prey species to have bred up in response to inundation. Read & Ebdon (1998) also recorded considerably more Australian Gull-billed Terns (facultative piscivores), which might have been exploiting the availability of fish, despite their diet predominantly consisting of terrestrial animals (Pedler & Kovac 2013; Mo 2025; Mo *et al.* 2025), as we observed (e.g. Central Bearded Dragon *Pogona vitticeps* and other lizards *Ctenophorus* spp., *Ctenotus* spp.).

Fifth, there were contrasts in the presence of a few rarely recorded, trans-continental migrant species. Far Eastern Curlew (previous study), Ruddy Turnstone (previous study) and Red Knot (this study) specialise in feeding from intertidal mudflats at the coast (Menkhorst *et al.* 2017), with these rare records likely reflecting cross-continental stopovers. We also had single records of Long-toed Stint and Pectoral Sandpiper, which frequent inland wetlands and are occasionally reported in South Australia. Likewise, the previous studies recorded Black-tailed Godwits, which are known to feed from both tidal and freshwater wetlands (Higgins & Davies 1996). These accumulating records for rare and transient migratory shorebirds (e.g. Ruddy Turnstone and Red Knot), as well as records for shorebirds that frequent inland wetlands (e.g. Marsh Sandpiper, Wood Sandpiper and Pectoral Sandpiper: Menkhorst *et al.* 2017), underscore the importance of sustained monitoring across these understudied habitats, and highlight the role that inland wetlands play in supporting a diversity of shorebird species.

Finally, we recorded some species in lower numbers than in the previous studies. We recorded fewer Freckled Ducks, but their abundance was increasing at Coorlay Lagoon in later surveys, peaking at 200 in our final survey. Both previous studies reported peak abundance at least 2 years after the rainfall event, and our increasing trend suggests no cause for concern. Similarly, >1000 Black-tailed Native-hens were recorded at Coorlay Lagoon in the two previous studies (Read & Ebdon 1998; Pedler & Kovac 2013), compared with just 35 in our surveys of this site. However, Black-tailed Native-hen abundance is known to fluctuate substantially (Matheson 1978; Moore & Cresswell 2024), as we saw at Purple Swamp, where this species was breeding prolifically and where we recorded 180 in one survey. It is worth noting that, unlike the previous studies, we did not use kayaks to access islands. Large congregations of waterfowl and other waterbirds were present on islands where they were sometimes difficult to identify, suggesting that we might have overlooked or undercounted rarer waterbirds (e.g. Freckled Duck and Curlew Sandpiper).

Management implications

Impacts from Cattle *Bos taurus* were observed at all four waterbodies, primarily in the form of localised pugging. However, impacts appeared relatively low, and Kokatha Pastoral actively manages livestock to minimise ecological disturbance. Nutrient input (from cattle in this case) may also enhance wetland productivity (Loyn *et al.* 2023). Public access is restricted at Coorlay Lagoon, and Lake Mary – historically used for recreational activities like powerboating and four-wheel driving – is now subject to stricter management controls. Apart from the obvious issue of water regime, the most significant ecological concern

is feral Cats *Felis catus*, which were abundant in the landscape throughout these surveys (Arid Recovery pers. comm.), including at the lakes (tracks, scats, presence, and carcasses of their prey).

In conclusion, the high productivity of the Arcoona Lakes, despite the widespread rainfall across the country at the time of this study, underlines the value of these wetlands for many bird species. Longitudinal monitoring of waterbird assemblages at inland wetlands is important for interpreting changes in population distribution and abundance, particularly as climate change magnifies the variability and intensity of inland rainfall events, which are clearly the main driver of value for these ephemeral wetlands.

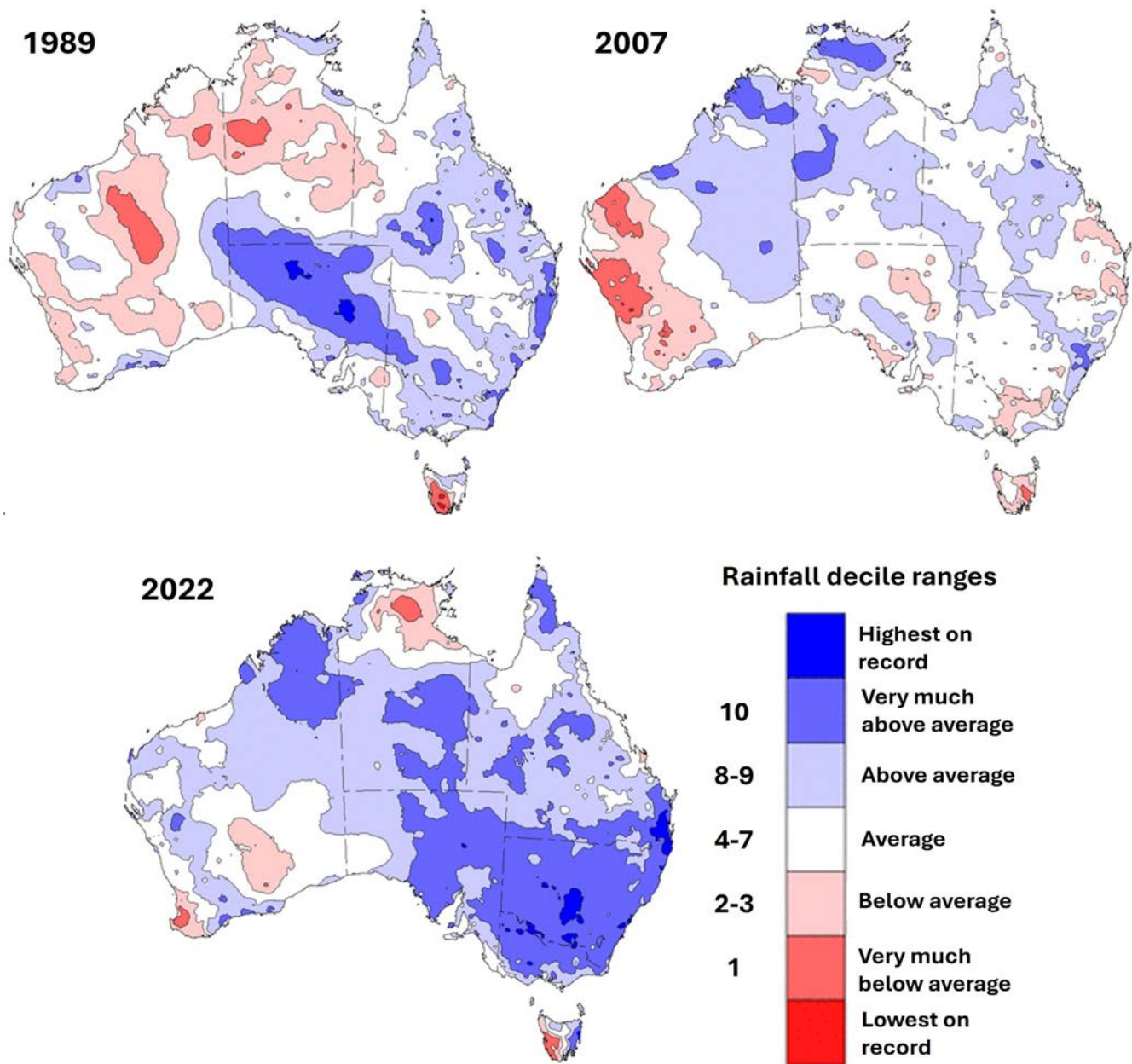
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Appendix 1. Rainfall deciles for the surveyed years. Images from <http://www.bom.gov.au/climate/history/rainfall/>.

Appendix 2. List of all waterbirds recorded in three studies at the Arcoona Lakes. Maximum counts (across all four waterbodies: Purple Swamp, Chances Swamp, Lake Mary and Coorlay Lagoon) for each study are presented, along with the percentage of surveys in which the species was recorded per study, in parentheses. R & E = Read & Ebdon (1998), P & K = Pedler & Kovac (2013), D & H = this study. Conservation status follows listing under the EPBC Act 1999, and Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) species are shown in bold. Survey methods and effort varied across the three studies (see text for details). Taxonomy and scientific names follow AviList Core Team (2025) and common names follow BirdLife Australia Working List v 4.3. *Domestic Duck was not recorded in our surveys but was at a different Arcoona lake (see text).

Species		Max. count (% surveys recorded)		
		R & E	P & K	D & H
Duck, swans & geese (Anatidae)				
Plumed Whistling-Duck	<i>Dendrocygna eytoni</i>			28 (13)
Musk Duck	<i>Biziura lobata</i>	200 (49)	20 (24)	15 (44)
Freckled Duck	<i>Stictonetta naevosa</i>	700 (35)	615 (64)	200 (44)
Blue-billed Duck	<i>Oxyura australis</i>	50 (15)	950 (29)	20 (19)
Pink-eared Duck	<i>Malacorhynchus membranaceus</i>	11,000 (59)	2000 (88)	800 (81)
Black Swan	<i>Cygnus atratus</i>	2000 (89)	2,122 (95)	650 (81)
Australian Shelduck	<i>Tadorna tadornoides</i>	2 (2)	2 (12)	
Australian Wood Duck	<i>Chenonetta jubata</i>	100 (42)	275 (26)	200 (81)
Hardhead	<i>Aythya australis</i>	14,000 (42)	2500 (68)	3600 (75)
Australasian Shoveler	<i>Spatula rhynchotis</i>	5 (11)	19 (42)	10 (13)
Pacific Black Duck	<i>Anas superciliosa</i>	200 (49)	17 (51)	25 (63)
Chestnut Teal	<i>Anas castanea</i>	2 (21)	8 (13)	10 (31)
Grey Teal	<i>Anas gracilis</i>	11,000 (92)	7500 (95)	9000 (88)
Domestic Duck*				
Grebes (Podicipedidae)				
Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	30 (27)		10 (19)
Hoary-headed Grebe	<i>Poliiocephalus poliocephalus</i>	2200 (63)	2000 (73)	1000 (81)
Great Crested Grebe	<i>Podiceps cristatus</i>	25 (19)	1 (5)	
Rails, gallinules and coots (Rallidae)				
Black-tailed Native-hen	<i>Tribonyx ventralis</i>	1400 (27)	1525 (27)	180 (75)
Australian Spotted Crake	<i>Porzana fluminea</i>			1 (6)
Eurasian Coot	<i>Fulica atra</i>	18,000 (88)	9750 (76)	8000 (75)
Baillon's Crake	<i>Zapornia pusilla</i>			1 (13)
Stilts and avocets (Recurvirostridae)				
Banded Stilt	<i>Cladorhynchus leucocephalus</i>	200 (31)	1750 (20)	60 (31)
Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	160 (33)	68 (49)	200 (63)
Pied Stilt	<i>Himantopus himantopus</i>	80 (70)	338 (88)	250 (69)
Plovers and lapwings (Charadriidae)				
Grey Plover (VU)	<i>Pluvialis squatarola</i>	2 (1)		
Black-fronted Dotterel	<i>Thinornis melanops</i>	40 (60)	10 (29)	60 (81)
Banded Lapwing	<i>Vanellus tricolor</i>	2 (4)	18 (13)	40 (56)
Masked Lapwing	<i>Vanellus miles</i>	50 (81)	26 (39)	16 (75)
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>	50 (28)	64 (37)	200 (81)
Oriental Plover	<i>Anarhynchus veredus</i>		6 (2)	2 (6)
Red-capped Plover	<i>Anarhynchus ruficapillus</i>	200 (46)	970 (49)	550 (75)
Sandpipers and allies (Scolopacidae)				
Far Eastern Curlew (CR)	<i>Numenius madagascariensis</i>	1 (1)		
Black-tailed Godwit (EN)	<i>Limosa limosa</i>	8 (14)	1 (2)	
Common Sandpiper	<i>Actitis hypoleucos</i>	1 (5)	3 (2)	1 (6)
Marsh Sandpiper	<i>Tringa stagnatilis</i>	20 (16)	6 (8)	2 (13)
Wood Sandpiper	<i>Tringa glareola</i>	3 (7)	3 (5)	5 (13)

Appendix 2 continued

Species		Max. count (% surveys recorded)		
		R & E	P & K	D & H
Sandpipers and allies (Scolopacidae) continued				
Common Greenshank	<i>Tringa nebularia</i>	12 (34)	6 (27)	3 (25)
Ruddy Turnstone (VU)	<i>Arenaria interpres</i>	2 (1)		
Red Knot (VU)	<i>Calidris canutus</i>			1 (6)
Sharp-tailed Sandpiper (VU)	<i>Calidris acuminata</i>	100 (26)	741 (32)	122 (75)
Curlew Sandpiper (CR)	<i>Calidris ferruginea</i>	100 (4)	3 (8)	50 (25)
Red-necked Stint	<i>Calidris ruficollis</i>	250 (11)	6 (8)	60 (50)
Long-toed Stint	<i>Calidris subminuta</i>			1 (6)
Pectoral Sandpiper	<i>Calidris melanotos</i>			1 (6)
Practincoles (Glareolidae)				
Australian Pratincole	<i>Glareola isabella</i>			40 (13)
Terns and gulls (Laridae)				
Caspian Tern	<i>Hydroprogne caspia</i>	5 (9)	2 (5)	1 (6)
Australian Gull-billed Tern	<i>Gelochelidon macrotarsa</i>	300 (28)	100 (36)	65 (69)
Whiskered Tern	<i>Chlidonias hybrida</i>	80 (27)	45 (27)	80 (44)
Silver Gull	<i>Chroicocephalus novaehollandiae</i>	100 (76)	218 (80)	120 (50)
Darters (Anhingidae)				
Australasian Darter	<i>Anhinga novaehollandiae</i>	10 (13)		
Cormorants (Phalacrocoracidae)				
Little Pied Cormorant	<i>Microcarbo melanoleucos</i>	100 (51)	3 (2)	3 (6)
Great Cormorant	<i>Phalacrocorax carbo</i>	100 (14)	1 (5)	2 (6)
Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	100 (20)		10 (6)
Great Pied Cormorant	<i>Phalacrocorax varius</i>	9 (5)		
Ibises and spoonbills (Threskiornithidae)				
Glossy Ibis	<i>Plegadis falcinellus</i>	14 (17)	3 (5)	
Yellow-billed Spoonbill	<i>Platalea flavipes</i>	25 (24)		
Australian White Ibis	<i>Threskiornis molucca</i>	3 (17)	1 (2)	
Straw-necked Ibis	<i>Threskiornis spinicollis</i>	3 (15)	13 (10)	
Pelicans (Pelecanidae)				
Australian Pelican	<i>Pelecanus conspicillatus</i>	52 (21)	8 (10)	
Hérons and egrets (Ardeidae)				
White-faced Heron	<i>Egretta novaehollandiae</i>	28 (48)	8 (31)	8 (56)
Little Egret	<i>Egretta garzetta</i>	1 (4)		
Nankeen Night-Heron	<i>Nycticorax caledonicus</i>	3 (2)		
White-necked Heron	<i>Ardea pacifica</i>	2 (5)	2 (2)	1 (13)
Great Egret	<i>Ardea alba</i>	11 (28)	2 (5)	1 (6)

Appendix 3. Birds other than waterbirds recorded across the four surveyed waterbodies (Purple Swamp, Chances Swamp, Lake Mary and Coorlay Lagoon) at the Arcoona Lakes. For each waterbody, we included presence data for four surveys, with data in chronological order, the leftmost being the first survey; x = presence in that survey, - = none recorded. For Emu and birds of prey, counts rather than just presence are presented. Fairy-wren and corvid species are lumped together within each group as we could not always identify to species level. Conservation status follows listing under the EPBC Act 1999, and Vulnerable (VU) species are shown in bold. Superscript ¹ on common name indicates that breeding was observed.

Species		Purple Swamp	Chances Swamp	Lake Mary	Coorlay Lagoon
Emu (Casuariidae)					
Emu	<i>Dromaius novaehollandiae</i>	--- 10	--- 9	--- 1	-- 7 -
Cuckoos (Cuculidae)					
Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>	- x --	----	--- x	----
Doves and pigeons (Columbidae)					
Common Bronzewing	<i>Phaps chalcoptera</i>	----	----	----	-- x x
Diamond Dove	<i>Geopelia cuneata</i>	x x x -	----	x - x x	x ----
Crested Pigeon	<i>Ocyphaps lophotes</i>	x x x -	x x x x	x x x x	x x x x
Button-quail (Turnicidae)					
Little Button-quail	<i>Turnix velox</i>	-- x -	----	----	- x x -
Kites, eagles and hawks (Accipitridae)					
Black-shouldered Kite	<i>Elanus axillaris</i>	----	----	----	- 1 --
Letter-winged Kite	<i>Elanus scriptus</i>	----	----	----	--- 1
Wedge-tailed Eagle	<i>Aquila audax</i>	1 ---	-- 2 2	-- 1 3	-- 1 2
Collared Sparrowhawk	<i>Tachyspiza cirrocephala</i>	--- 1	----	----	----
Brown Goshawk	<i>Tachyspiza fasciata</i>	-- 1 -	----	----	----
Swamp Harrier	<i>Circus approximans</i>	1 ---	----	----	- 1 --
Whistling Kite	<i>Haliastur sphenurus</i>	----	----	----	- 1 --
Black Kite	<i>Milvus migrans</i>	----	----	-- 1 3	- 2 2 -
Bee-eaters (Meropidae)					
Rainbow Bee-eater	<i>Merops ornatus</i>	----	----	x ----	----
Kingfishers (Alcedinidae)					
Red-backed Kingfisher	<i>Todiramphus pyrrhopygius</i>	----	----	-- x -	----
Falcons (Falconidae)					
Nankeen Kestrel	<i>Falco cenchroides</i>	2 1 1 -	-- 2 -	- 1 - 2	1 7 2 1
Brown Falcon	<i>Falco berigora</i>	----	----	--- 1	- 1 --
Australian Hobby	<i>Falco longipennis</i>	- 1 --	----	2 ---	1 1 --
Peregrine Falcon	<i>Falco peregrinus</i>	----	----	--- 1	-- 1 -
Cockatoos (Cacatuidae)					
Cockatiel	<i>Nymphicus hollandicus</i>	-- x -	- x x -	----	----
Galah	<i>Eolophus roseicapilla</i>	x x x -	x x x -	x x x x	x x x x
Little Corella	<i>Cacatua sanguinea</i>	----	--- x	- x - x	----
Old World Parrots (Psittaculidae)					
Bourke's Parrot	<i>Neopsephotus bourkii</i>	----	----	-- x -	-- x -
Bluebonnet	<i>Northiella haematogaster</i>	x ----	-- x -	x - x -	- x x x
Mulga Parrot	<i>Psephotellus varius</i>	x x --	----	x x x x	x -- x
Budgerigar ¹	<i>Melopsittacus undulatus</i>	x x x -	- x x -	x x x x	- x x x
Fairy-wrens (Maluridae)					
Fairy-wren species		x x x x	x x x x	x x x x	x x x x
Purple-backed Fairy-wren	<i>Malurus assimilis</i>				
Splendid Fairy-wren	<i>Malurus splendens</i>				
White-winged Fairy-wren	<i>Malurus leucopterus</i>				

Appendix 3 continued

Species		Purple Swamp	Chances Swamp	Lake Mary	Coorlay Lagoon
Thornbills and allies (Acanthizidae)					
Southern Whiteface (VU)	<i>Aphelocephala leucopsis</i>	x x x -	-----	-----	-----
Inland Thornbill	<i>Acanthiza apicalis</i>	-----	-----	- x x x	-----
Chestnut-rumped Thornbill	<i>Acanthiza uropygialis</i>	-----	-----	x x x x	-- x -
Honeyeaters (Meliphagidae)					
Crimson Chat	<i>Epthianura tricolor</i>	-----	-----	-----	- x --
Orange Chat ¹	<i>Epthianura aurifrons</i>	- x x x	-- x x	x x - x	x x x x
White-fronted Chat	<i>Epthianura albifrons</i>	x x x -	-- x -	-----	x x --
Singing Honeyeater	<i>Gavicalis virescens</i>	x - x -	-----	x x x x	- x - x
Spiny-cheeked Honeyeater ¹	<i>Acanthagenys rufogularis</i>	x ---	-----	x x x x	-- x x
Yellow-throated Miner	<i>Manorina flavigula</i>	-----	-----	x x - x	x - x x
Australasian babblers (Pomatostomidae)					
White-browed Babbler	<i>Pomatostomus superciliosus</i>	x - x x	-----	x x x -	- x --
Cuckoo-shrikes (Campephagidae)					
Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	-----	-----	---- x	-----
White-winged Triller ¹	<i>Lalage tricolor</i>	x ---	-----	-----	-----
Woodswallows and allies (Artamidae)					
White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	x ---	-----	-----	-----
Masked Woodswallow	<i>Artamus personatus</i>	x - x -	-----	x ---	-----
White-browed Woodswallow	<i>Artamus superciliosus</i>	-- x -	-----	-----	-----
Black-faced Woodswallow	<i>Artamus cinereus</i>	- x x x	- x --	x x x x	x x x x
Australian Magpie	<i>Gymnorhina tibicen</i>	-----	-- x -	x x x x	- x x x
Grey Butcherbird	<i>Cracticus torquatus</i>	--- x	--- x	x x x x	- x x x
Fantails (Rhipiduridae)					
Willie Wagtail	<i>Rhipidura leucophrys</i>	x x x x	x - x x	x x x x	x x x x
Grey Fantail	<i>Rhipidura albiscapa</i>	-----	-----	- x --	-----
Monarch flycatchers (Monarchidae)					
Magpie-lark	<i>Grallina cyanoleuca</i>	x x x -	x x x -	x x x x	x x x x
Crows (Corvidae)					
Corvid species		x x x x	-- x x	-- x x	-- x x
Australian Raven	<i>Corvus coronoides</i>				
Little Raven	<i>Corvus mellori</i>				
Little Crow	<i>Corvus bennetti</i>				
Australasian robins (Petroicidae)					
Red-capped Robin	<i>Petroica goodenovii</i>	-- x -	-----	-----	x ----
Hooded Robin	<i>Melanodryas cucullata</i>	-----	-----	---- x	-----
Reed-Warblers (Acrocephalidae)					
Australian Reed-Warbler	<i>Acrocephalus australis</i>	x ---	-----	-----	-----
Grassbirds and allies (Locustellidae)					
Little Grassbird ¹	<i>Poodytes gramineus</i>	-- x -	-----	-----	- x --
Brown Songlark	<i>Cincloramphus cruralis</i>	x ---	x ---	-- x -	- x --
Swallows (Hirundinidae)					
White-backed Swallow	<i>Cheramoeca leucosterna</i>	-----	-----	x -- x	- x x x
Welcome Swallow ¹	<i>Hirundo neoxena</i>	x x x x	x x x x	x x x -	x x - x
Tree Martin	<i>Petrochelidon nigricans</i>	-----	-----	-- x -	-----
Fairy Martin	<i>Petrochelidon ariel</i>	x x x -	x - x x	- x --	-----

Appendix 3 continued

<i>Species</i>		<i>Purple Swamp</i>	<i>Chances Swamp</i>	<i>Lake Mary</i>	<i>Coorlay Lagoon</i>
Finches (Estrildidae)					
Zebra Finch ¹	<i>Taeniopygia guttata</i>	x x x x	x x x x	x x x x	x x x x
Pipits (Motacillidae)					
Australasian Pipit	<i>Anthus australis</i>	x x x x	x x x x	x x x x	x x x x
Total species count		40	24	43	42
Regional total species count	65				



Appendix 4. Other birds at Arcoona Wetlands. Top left to bottom right: Whistling Kite, juvenile Black Kite, Black-shouldered Kite, juvenile Brown Goshawk, Australian Hobby, Letter-winged Kite, Mulga Parrot, White-breasted Woodswallow, Zebra Finch, Bourke's Parrot, Budgerigar flock, Cockatiel flock, Horsfield's Bronze-Cuckoo, Emus, Chestnut-rumped Thornbill, all photographed at the Arcoona Wetlands 2022-2023. Photos: Robert J. Dugand

Appendix 5. Counts of waterbirds at Purple Swamp and Chances Swamp in December–March, 2022–2023. Survey dates (month and year) and waterbody perimeter (km) are shown at each survey time point. Conservation status follows listing under the EPBC Act 1999, and Vulnerable species (VU) are shown in bold. Superscripts indicate breeding: 1 = nesting, 2 = dependent chicks. Data from one of the previous studies [the only survey of these swamps by Pedler & Kovac (2013)] are also included (P & K).

Species	Purple Swamp					Chances Swamp				
	P & K	Dec. 22	Jan. 23	Feb. 23	Mar. 23	P & K	Dec. 22	Jan. 23	Feb. 23	Mar. 23
		4.35 km	3.81 km				2.71 km	2.40 km	1.65 km	
Duck, swans and geese										
Plumed Whistling-Duck		1		28						
Musk Duck	3	3 ²								
Freckled Duck	6	4	1							
Blue-billed Duck				1						
Pink-eared Duck	8	19 ²	100 ²	6		6	28 ²	10	50	
Black Swan	9	50 ^{1,2}	90 ²	30 ²		1	1			
Australian Wood Duck	43		6	200			4	26 ²	4	
Hardhead	30	9	35 ²	3			1			
Australasian Shoveler	1									
Pacific Black Duck	12	1	1					1		
Chestnut Teal	2							5		
Grey Teal	167	100 ²	220 ²	25		25	9 ²	15	50	
Grebes										
Australasian Grebe			10							
Hoary-headed Grebe	30	3	90 ²	13 ²			16 ²	6 ²		
Rails, gallinules and coots										
Black-tailed Native-hen	10	15	45 ²	180		16	8	5		
Eurasian Coot	120	15 ²	150 ²	23 ²				1		
Baillon's Crake				1						
Stilts and avocets										
Banded Stilt			2					3	17	
Red-necked Avocet	3		11	30		4	50	50	20	
Pied Stilt	12	250	150	10		2	25			
Plovers and lapwings										
Black-fronted Dotterel		40	30	60		2	47 ²	32	40	
Banded Lapwing				40	10		16	4	20	2
Masked Lapwing	4	16	11	4			3	3		
Red-kneed Dotterel	15	160 ²	200	30		2	49	4	17	
Oriental Plover									2	
Red-capped Plover				8			70	47	160	
Sandpipers and allies										
Common Greenshank			3					2		
Sharp-tailed Sandpiper (VU)	1	40	80	11			50	3	36	
Red-necked Stint							3		1	
Practincoles										
Australian Pratincole				40					6	
Terns and gulls										
Australian Gull-billed Tern	6	9	65	1			40	18	4	
Whiskered Tern		30	45						1	
Pelicans										
Australian Pelican						1				
Herons and egrets										
White-faced Heron	1	2	6	1					3	
White-necked Heron		1								
Total count	483	768	1351	745	10	59	420	236	431	2
No. species (no. breeding)	20	20 (6)	22 (7)	22 (3)	1 (0)	9	17 (4)	19 (2)	16 (0)	1 (0)
Total no. species (no. breeding)			30 (9)					26 (4)		

Appendix 6. Counts of waterbirds at Lake Mary and Coorlay Lagoon. For the two previous studies (R & E = Read & Ebdon 1998; P & K = Pedler & Kovac 2013), maximum counts are presented along with the percentage of surveys in which the species was recorded in parentheses. Raw data are presented for the surveys conducted through 2023 (D & H), with the date (month and year) of the survey in each column heading. Conservation status follows listing under the EPBC Act 1999, and Vulnerable (VU), Endangered (EN) and Critically Endangered (CR) species are shown in bold. Superscripts indicate breeding: 1 = nesting, 2 = dependent chicks. Black-fronted Dotterel and Whiskered Tern were recorded at Lake Mary by Read & Ebdon (1998) but no abundance data are available (x).

Species	Lake Mary					Coorlay Lagoon				
	R & E		P & K		D & H	R & E		P & K		D & H
	Jan. 23	Apr. 23	Aug. 23	Oct. 23	Jan. 23	Jun. 23	Sep. 23	Oct. 23	Dec. 23	
Ducks, swans and geese										
Musk Duck	1 (22)	15	11	8	6	200 (63)	4	1		
Freckled Duck	200 (22)	148 (29)			6	700 (42)	4	19	50	200
Blue-billed Duck	2 (2)	20 ²				50 (21)	3			
Pink-eared Duck	11,000 (69)	75	800		6	5000 (54)	400	200	750	500
Black Swan	2000 (86)	1157 (88)	120	350	309 ¹	1,850 (90)	240	445 ^{1,2}	345 ^{1,2}	650 ^{1,2}
Australian Shelduck	2 (2)	2 (6)				2 (2)	2 (17)			
Australian Wood Duck	8 (19)	40 (35)	180	17	6	100 (54)	275 (19)	16	10	20
Hardhead	2000 (33)	950 (59)	6	3050	800	14,000 (46)	2500 (75)	300	100	2500
Australasian Shoveler	3 (8)	19 (41)	2			5 (12)	16 (42)	10		
Pacific Black Duck	200 (41)	15 (47)	4	2	5	50 (53)	17 (54)	25	20	2
Chestnut Teal	2 (36)	2 (12)			1	2 (14)	8 (13)	10	2	1
Grey Teal	11,000 (91)	2238 (94)	150 ²	825	600	10,000 (92)	7500 (96)	330	4500	7500
Grebes										
Australasian Grebe	2 (27)			1		30 (27)			1	
Hoary-headed Grebe	800 (50)	450 (53)	350 ²	200	50	2200 (69)	2000 (88)	35	100	350
Great Crested Grebe	1 (2)	1 (6)				25 (27)	1 (4)			
Rails, gallinules and coots										
Black-tailed Native-hen	14 (25)		25	5	4	1400 (28)	1525 (46)	35	1	2
Australian Spotted Crane									1	
Eurasian Coot	18,000 (83)	435 (59)	27	3600	500	5000 (90)	9750 (88)	7600	4000	8000
Baillon's Crane									1	
Stilts and avocets										
Banded Stilt	200 (27)	64 (12)	60	3		35 (33)	1750 (25)			
Red-necked Avocet	160 (44)	58 (53)	200			22 (28)	68 (46)	3	2	4
Pied Stilt	60 (83)	75 (88)	25	15	13	80 (64)	338 (88)	1	120	150

Appendix 6 continued

Species	Lake Mary				Coorlay Lagoon						
	R & E		P & K		R & E		P & K		D & H		
	Jan. 23	Apr. 23	Aug. 23	Oct. 23	Jun. 23	Sep. 23	Oct. 23	Dec. 23			
Plovers and lapwings											
Grey Plover (VU)	2 (2)										
Black-fronted Dotterel	x (27)	10 (29)	1	5	12	40 (77)	9 (29)	1	40	23	3
Banded Lapwing	2 (5)	1 (12)	2	10		2 (4)	18 (13)	2			
Masked Lapwing	6 (72)	8 (41)	10	2	8	50 (85)	26 (38)	2	9 ¹	4	15
Red-kneed Dotterel	7 (27)	11 (24)	25	1	2	50 (28)	64 (46)	1	40	75	60
Oriental Plover							6 (4)				
Red-capped Plover	60 (47)	148 (47)	400	50	100 ¹	200 (46)	970 (50)	20	185 ^{1,2}	550 ^{1,2}	300
Sandpipers and allies											
Far Eastern Curlew (CR)	1 (1)										
Black-tailed Godwit (EN)	3 (11)										
Common Sandpiper						1 (7)	3 (4)			1	
Marsh Sandpiper	1 (5)					20 (21)	6 (13)	2	2	1	
Wood Sandpiper	1 (2)					3 (9)	3 (8)	1			5
Common Greenshank	2 (25)	6 (24)	1	3		12 (39)	6 (29)				
Ruddy Turnstone (VU)	2 (1)										
Red Knot (VU)	1 (1)										
Sharp-tailed Sandpiper (VU)	5 (8)										
Curlew Sandpiper (CR)	15 (2)										
Red-necked Stint	20 (2)	7	7	25	14	250 (16)	6 (13)	10	60	35	
Long-toed Stint											1
Pectoral Sandpiper											1
Terns and gulls											
Caspian Tern	2 (5)	2 (6)		1		5 (11)	1 (4)				
Australian Gull-billed Tern	1 (13)	100 (47)	60	2	12	300 (36)	60 (29)	7	40		
Whiskered Tern	x (16)	21 (24)				80 (33)	45 (29)	11	10	80	5
Silver Gull	26 (72)	125 (76)	120	20	6	100 (78)	218 (83)	3	40 ¹	20 ¹	10

Appendix 6 continued

Species	Lake Mary				Coorlay Lagoon				
	R & E		P & K		R & E		P & K		
	Jan. 23	Apr. 23	Aug. 23	Oct. 23	Jun. 23	Sep. 23	Oct. 23	Dec. 23	
Darters									
Australasian Darter					10 (19)				
Cormorants									
Little Pied Cormorant	40 (33)	3 (6)			100 (60)		3		
Great Cormorant	3 (11)	1 (6)	2		100 (16)	1 (4)			
Little Black Cormorant	1 (3)	10			100 (29)				
Great Pied Cormorant					9 (7)				
Ibises and spoonbills									
Glossy Ibis	14 (8)				3 (22)	3 (8)			
Yellow-billed Spoonbill					25 (36)				
Australian White Ibis	1 (5)	1 (6)			3 (23)				
Straw-necked Ibis					3 (23)	13 (17)			
Pelicans									
Australian Pelican					52 (32)	3 (8)			
Herons and egrets									
White-faced Heron	20 (36)	3 (29)	8	2	28 (54)	8 (33)	1	4	
Little Egret	1 (3)				1 (5)				
White-necked Heron					2 (8)	2 (4)	1		
Great Egret		2 (6)			11 (42)	1 (4)	1		
Total count		1709	9192	2250	7488	8779	10,095	12,435	22,558
No. species (no. breeding)	44	33	23 (1)	18 (1)	22 (2)	22 (0)	29 (4)	32 (3)	24 (1)
Total no. species (no. breeding)				33 (5)			40 (4)		