# Dynamics of the waterbird fauna of Peery Lake, arid north-western New South Wales, after flooding

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Waterbirds were surveyed at the north-western end of Peery Lake, a large freshwater overflow lake on the Paroo River, between October 1990 and January 1994, following a major flood that filled the lake in April 1990. Before drying, the lake was recharged by a moderate flood in January 1993 and retained water throughout the study. The survey area comprised about 555 hectares or 11 percent of the lake, plus the adjacent shoreline. Over nine survey periods, a total of 54 waterbird species was recorded, of which eight species were recorded breeding, although only in low numbers. Species richness in individual survey periods ranged between 17 and 42 species. The number of waterbirds in the survey area varied greatly between survey periods, from 636 to 14 359. Two species, Pink-eared Duck *Malacorhynchus membranaceus* and Grey Teal *Anas gracilis*, accounted for about 60 percent of all waterbirds, but the common species varied between survey periods. The responses of waterbirds to the two flood events were markedly different. Waterbird numbers were initially low after the first flood, peaking 27 months after flooding. By contrast, waterbird numbers were high in the first year after the second flood, but fell sharply 12 months after flooding. The abundance and diversity of waterbirds recorded on this small portion of Peery Lake affirmed the lake's importance to waterbirds. The study also showed the dynamic and highly variable nature of the waterbird fauna, whose response to particular flood cycles at the lake can differ widely and cannot be predicted by simple measures such as the size and salinity of the lake.

### **INTRODUCTION**

The Paroo River rises in south-western Queensland and enters arid north-western New South Wales as a single channel that disperses into an 'overflow' area of reticulate channels and wetlands before reaching the Darling River (Figure 1). The Warrego River to the east is connected to the Paroo in NSW via Cuttaburra Creek. Flows in the Paroo are intermittent and irregular, only reaching the Darling in major flood events as in 1990 and 2010 (Bureau of Meteorology 2011). Floods normally develop in the headwaters of the Paroo River in Queensland, but heavy local rainfall in the middle to lower reaches of the catchment can also produce floods. The Paroo and Warrego Rivers are the only rivers in the Murray-Darling Basin that are free of regulation or significant water extraction (Kingsford 1999).

Wetlands in the Paroo River catchment can be divided into seven broad types: river channels and waterholes; claypans and Canegrass *Eragrostis australasica* swamps; Blackbox *Eucalyptus largiflorens* swamps; Spike-rush *Eleocharis* species swamps; Lignum *Muehlenbeckia florulenta* swamps and overflow plains; salt lakes; and freshwater lakes (Goodrick 1984; Kingsford and Porter 1999). Inundation of the wetlands by floodwaters from the upper Paroo or by local heavy rain occurs infrequently. Peery Lake is the largest of the freshwater overflow lakes, generally filling every two to ten years (Goodrick 1984) and taking up to three years to dry (G. Barlow, pers. comm.).

Surveys, mainly from the air, have established the importance of the Paroo wetlands to waterbirds in eastern Australia (Maher and Braithwaite 1992; Kingsford *et al.* 1994; Kingsford and Porter 1999, 2009; Kingsford and Lee 2010; Timms 1997, 2008, 2009; Timms and McDougall 2004). Lignum swamps provide breeding habitat, while freshwater overflow lakes, such as Peery Lake, hold water for longer than other wetlands and maintain populations between floods (Maher and Braithwaite 1992). Overall, at least 63 species of waterbirds have been recorded on the Paroo, including 38 species recorded breeding (Kingsford and Porter 1999). Peery Lake is one of the most significant lakes in the Paroo River catchment (Kingsford and Porter 1999) and in north-western New South Wales (Kingsford *et al.* 1994) in terms of the number of waterbird species and individuals it supports.

The international conservation significance of the Paroo wetlands was recognised in 2007 when some of the major wetlands, including Peery Lake, were listed under the Ramsar Convention (wetlands listed were those within conservation reserves). Reasons for the listing included the diversity and abundance of waterbirds, the presence of threatened waterbird species, and the importance of the wetlands as waterbird breeding sites and drought refuges (Kingsford and Lee 2010).

Proposals to divert water from the Paroo for irrigation have been raised periodically. Such water withdrawals would likely impact adversely on the Paroo wetlands and their waterbirds (Kingsford 1999). In 2003 an agreement between the New South Wales and Queensland governments not to develop the Paroo was formalised in an *Intergovernmental Agreement for the Paroo River*. This agreement recognises the significance of the Paroo wetlands and their biodiversity as well as the value of research and monitoring to guide management of the area. However, the agreement is subject to on-going review and may not necessarily preclude future developments affecting wetland ecology and waterbirds on the Paroo.

The distribution and persistence of temporary wetlands across arid inland Australia is highly variable, reflecting the irregularity in timing, location and amount of rainfall (Roshier et al. 2001b). Rainfall in the Australian arid zone is extremely variable, even when compared with other arid regions of the world (Morton et al. 2011). Nevertheless, hindcasting of past wetland filling events suggests that there was no period greater than 12 months during the 20<sup>th</sup> century when wetland filling did not occur at least somewhere in the arid zone (Roshier et al. 2001b). This allows populations of mobile waterbirds to persist in the arid zone, even during droughts, by utilising a mosaic of wetlands, most of which are only suitable for brief periods (Roshier et al. 2001a; Kingsford and Norman 2002). Despite its low rainfall, arid Australia supports extraordinary numbers of waterbirds (Maher and Braithwaite 1992; Halse et al. 1998; Kingsford and Porter 2009), contrary to earlier perceptions that the mesic regions of Australia were more important (e.g. Frith 1963; Norman 1970). During the years from 1986 to 1997, which included the current study period, the most persistent temporary wetlands in inland Australia were mainly in the Paroo River catchment and the adjacent Lake Eyre Basin (Roshier et al. 2001b).

To further understand the dynamics of waterbird populations in arid Australia, we describe the results of ground surveys of waterbirds in the north-western portion of Peery Lake in 1990–94, following a major flood on the Paroo in April 1990. We describe changes in abundance and species composition as the lake progressively dried and became more saline and then re-charged in January 1993 when moderate flooding occurred, largely due to run-off from local rain.

### **STUDY AREA**

Peery Lake (30°46'S, 143°36'E) covers 5026 hectares (Kingsford *et al.* 1994) in arid north-western New South Wales and is approximately 100 kilometres north of the junction of the Paroo and Darling Rivers near Wilcannia (Figure 1). At the time of our study Peery Lake was within a grazing leasehold, Peery Station. It was subsequently (2000) included in Paroo-Darling National Park.

In early 1990 heavy rain falling on saturated catchments in south-western Queensland caused major flooding on the Paroo River, with river heights approaching record levels (Bureau of Meteorology 2010). By April 1990, floodwater flowed into the southern end of Peery Lake, completely filling the lake. Subsequent drying was interrupted following torrential local rain between November 1992 and January 1993, when nearby White Cliffs and Wilcannia received between three and five times their average rainfall for these months (Bureau of Meteorology records), and local run-off re-charged the lake. The lake varied in size but held water throughout the study (October 1990 – January 1994).

Waterbirds were observed at the north-western end of the lake (Figure 2). Here, the lake adjoins open sandy flats and stony hills. Its perimeter is sparsely lined by trees or shrubs including River Red Gum *Eucalyptus camaldulensis*, Black Box, River Cooba *Acacia stenophylla*, Whitewood *Atalaya hemiglauca* and Boobialla *Myoporum montanum*. The sedge Pinrush *Cyperus gymnocaulos* is common along the lake margin. Three ephemeral creeks fringed by narrow bands of eucalypt riverine



Figure 1. Location of Peery Lake and the Paroo River.

woodland enter the lake along this north-western perimeter. As the lake receded, its bed supported extensive patches of short-lived chenopods and herbs, including the Pop Saltbushes *Atriplex holocarpa* and *A. spongiosa*, Black-seeded Samphire *Tecticornia pergranulata*, Blue-rod *Morgania floribunda*, Desert Sneezeweed *Centipeda thespidioides* and Creeping Monkey-flower *Mimulus repens*. A number of extinct and active artesian springs, commonly referred to as mound springs, occur within this portion of the lake. The larger mounds became islands when the lake filled and supported sparse River Red Gums and Black Box (Figure 2). Smaller springs were submerged and treeless.

### METHODS

Waterbirds (species of Anseriformes, Podicipediformes, Phalacrocoraciformes, Ciconiiformes, Gruiformes and Charadriiformes) were surveyed in nine periods between October 1990 and January 1994: 10 October–7 November 1990 (28 days), 2–23 July 1991 (22 days), 1–21 October 1991 (21 days), 29 June–23 July 1992 (25 days), 22 September–15 October 1992 (24 days), 7–22 April 1993 (16 days), 12–29 July 1993 (18 days), 28 September–20 October 1993 (23 days) and 18–26 January 1994 (9 days).



Figure 2. Peery Lake study area (outlined in red). Reference point for measurement of water recession distances shown by white star. Air photo taken in August 1992.

The survey area comprised about 555 hectares of the lake (11% of the lake's total area), plus the adjacent land around the shoreline when the lake was full (Figure 2). The waterbird species present within the survey area were identified and counted using binoculars. Birds flying over the survey area were included in counts. For large congregations of birds, numbers were estimated. In each survey period, counts were made opportunistically on a daily basis while surveying terrestrial birds in the vicinity. However, on some days of each survey period not all parts of the survey area were visited. Data analysed comprised the maximum number of individuals of each species recorded in each survey period, regardless of whether the maximum was derived from counts of all or part of the survey area. Evidence of breeding (birds nesting or tending young away from the nest) was also recorded.

The conductivity of the lake water, which is indicative of salinity, was measured in each survey period with a portable conductivity meter with a resolution of 100  $\mu$ S/cm. Samples beyond the range of the meter (19 900  $\mu$ S/cm) were diluted with distilled water to allow measurement. The horizontal distance that the water had receded from the April 1990 peak flood line was measured in each survey period from a fixed point on the lake perimeter (Figure 2). Regardless of changing water levels in the lake, the survey area remained constant throughout the study.

# RESULTS

A total of 54 waterbird species was recorded during the study (Table 1). Four other wetland-associated bird species were also recorded but not analysed, including a small passerine (Little Grassbird Megalurus gramineus) and three raptors (Swamp Harrier Circus approximans, White-bellied Sea-Eagle Haliaeetus leucogaster and Whistling Kite Haliastur sphenurus). Pink-eared Duck (scientific names of waterbird species given in Table 1) (36%) and Grey Teal (24%) accounted for over half the total waterbirds recorded. Other common species were Red-necked Avocet (11%), Eurasian Coot (6%), Hoary-headed Grebe (4%) and Red-capped Plover (2%). Australasian Shoveler, Hardhead, Australian Wood Duck, Black Swan, Freckled Duck, Australian Pelican, Black-tailed Native Hen and Whiskered Tern each contributed about one percent to the total count, while the other 40 species each contributed less than one percent (Table 1). A large flock of about 500 unidentified migratory shorebirds seen flying over the lake in October 1992 also represented about one percent of the total waterbird count.

After the major flood in April 1990, the lake was initially fresh (within the human drinking range) but increased in conductivity as the water evaporated and receded (Figure 3). Conductivity June 2015

### Table 1

Waterbirds at north-western end of Peery Lake, October 1990 – January 1994. Status of waterbirds of special conservation significance indicated as M = listed migratory species (Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*); E = endangered and V = vulnerable species (NSW *Threatened Species Conservation Act 1995*); C = species of concern at regional level (Smith *et al.* 1994). Numbers are the maximum counts/estimates for each species in each survey period. N = nesting, Y = tending young out of nest. % = contribution of each species to the total waterbird count.

Musk Duck       Biziura lobata       V.C       5       400       20       50       200       50       200       57       1.33         Black Swan       Cygnus arratus       55,Y       33       74       2       6       20       50       20.07       76       75       1.33         Australian Shothek <i>Mata tabonital indusi</i> 10       58       300       7       150       30       20       07.03       30.00       300       300       78.94       36.00         Australian Shothek <i>Mata transcripticitis</i> 28       9000       200       300       20.0       73.2       1.48         Grey Teal <i>Amax specifis</i> 2.0       70       7       20       10       2       70.07         Hardhead <i>Aprisa gracifis</i> 2.0       70       7       20       30       20       30       20       3       15       0.03         Hardhead <i>Aprisa gracifis</i> 2.0       100       2.5       3       4       10       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1       1	Common name	Scientific name	Status	Oct 1990	July 1991	Oct 1991	Jul 1992	Oct 1992	Apr 1993	July 1993	Oct 1993	Jan 1994	Total	%
Freekled Dack         Sitcometria macrosa         V.C         5         400         20         50         6.75         1.36           Black Swan         Crymer starting         S.Y         33         7         2         6         200         2001         6.75         1.33           Australina Nochterk         Tadorna tadorroniclas         10         S8         300         10         17.84         9         0.02           Australian Sincher         Anas gracitis         20.N         500         400         3000         00         17.8         1.84           Grey Teal         Anas gracitis         20.N         500         9         200         100         10         20         3         510         100         100         20         3         52         117         Biades         30         150         20         30         100         100         100         100         100         100         100         100         100         100         10         100         100         100         100         100         100         100         100         100         100         100         100         100         100         100         100         100	Musk Duck	Biziura lobata							1				1	< 0.01
Black Swam       Cygnus arrans       55, Y       33       74       2       6       20       20, 20, N       37       675       1, 33         Australian Shouveler       Ansar hynchotia       10       58       300       7       150       3       160       688       1, 39       36.00         Australian Shouveler       Anax strynchotia       12       28       9000       200       150       30       20       100       100       100       100       100       100       100       100       100       100       100       100       100       100       20       100       2       100       2       100       2       100       2       100       2       100       2       100       100       2       100       100       2       100       10	Freckled Duck	Stictonetta naevosa	V,C			5	400		20	50	200		675	1.36
Australian Shelduck         Tadorna tadornoides         3         2         2         2         2         9         0.02           Australian Shelduck         Choonetri jubata         12         28         9         8000         2500         0.00         300         300         7.849         36.00           Australianian Shelduck         Anax gracilis         200         500         400         3000         800         100         20         120         20         30         20         7.82         1.48           Grey Teal         Anax gracilis         CV         7         7         20         10         2         3         15         0.07           Hardhead         Ayrhya australisis         VC         -         10         2         3         15         0.03           Hoars-headed Grebe'         Poliocephalus poliocephalus         60         30         -         150         70         50         9         4         20         178         0.35           Little Biack Cornorant         Microcarbo melanolaccos         4         30         2         120         100         57         8         3         15         100         3         0.01	Black Swan	Cygnus atratus		55,Y	33	74	2		6	200	250,NY	37	657	1.33
Australian Wood Duck       Chenometra jubata       10       58       300       7       150       3       160       688       1.32         Pink-acerd Duck       Mata rhynchotis       12       28       9       8000       20       150       30       20       107.23       1.48         Grey Tcal       Anar sprecifis       20.N       500       900       800       1500       250       200       102       1.20       1.20       1.20       2.40       100       20       1.50       37.0       0.77       10       2       3       3       5       2       1       9       2.3       0.50       70.0       20       1.50       37.0       0.7       0.7       3       5       2       1       9       2.3       0.50       1.50       7.0       2.5       4       4       3.0       5       2       1       9       2.3       0.50       7.0       2.5       4       4       3.0       1.1       1.0       1.4       8.35       4       1.0       1.5       0.3       1.0       3.3       4       1.0       1.5       0.0       7.5       8.35       4       1.0       1.0       1.0       1.0 </td <td>Australian Shelduck</td> <td>Tadorna tadornoides</td> <td></td> <td>3</td> <td></td> <td></td> <td>2</td> <td></td> <td></td> <td>2</td> <td>2</td> <td></td> <td>9</td> <td>0.02</td>	Australian Shelduck	Tadorna tadornoides		3			2			2	2		9	0.02
Pink-eard Duck         Malacorhymous membranceus         12         28         9         8000         200         300 <t< td=""><td>Australian Wood Duck</td><td>Chenonetta jubata</td><td></td><td>10</td><td>58</td><td>300</td><td>7</td><td></td><td>150</td><td>3</td><td></td><td>160</td><td>688</td><td>1.39</td></t<>	Australian Wood Duck	Chenonetta jubata		10	58	300	7		150	3		160	688	1.39
Australian Shoveler       Anax stradius       1/2       500       20       1/0       20       1/0       20       1/0       20       1/0       200       1/0 <t< td=""><td>Pink-eared Duck</td><td>Malacorhynchus membranaceus</td><td></td><td>12</td><td>28</td><td>9</td><td>8000</td><td></td><td>2500</td><td>4000</td><td>3000</td><td>300</td><td>17,849</td><td>36.00</td></t<>	Pink-eared Duck	Malacorhynchus membranaceus		12	28	9	8000		2500	4000	3000	300	17,849	36.00
Grey Teal       Anax gracifis       20,N       500       400       400       800       100       10       200       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,02       24,00       11,00       10       2       10       20,00       21,00       11,00       10 <t< td=""><td>Australasian Shoveler</td><td>Anas rhvnchotis</td><td></td><td></td><td>12</td><td></td><td>500</td><td></td><td>20</td><td>150</td><td>30</td><td>20</td><td>732</td><td>1.48</td></t<>	Australasian Shoveler	Anas rhvnchotis			12		500		20	150	30	20	732	1.48
Pacific Black Dack         Anax supercillosa         7         7         7         20         1         2         1         37         0.07           Blue-billed Duck         Oxwara australis         V.C         -         100         2         3         15         0.03           Handy-backed Crebel         Philocephalus policicephalus         60         30         150         7         0.07         500         2.16         4.36           Reard Commorn         Mainzearbo melanoleacos         40         85         4         1.84         0.70         500         1.0         2.0         1.8         0.51           Creat Commorn         Phalacencorax sulcinstris         1.10         100         2.8         35         4         1.80         0.03           Australian Pelican         Peled Commorant         Phalacencorax sulcinstris         1.10         10         2         2         1         1.8         0.02           Australian Pelican         Peled Commorant         Phalacencorax sulcinstris         1         1         2         1         1         8         0.02           Eastern Great Egret         Arlea modesta         M         7         7         1         2         1 <t< td=""><td>Grev Teal</td><td>Anas gracilis</td><td></td><td>20.N</td><td>500</td><td>400</td><td>3000</td><td>800</td><td>1500</td><td>2500</td><td>2000</td><td>1200</td><td>11.920</td><td>24.04</td></t<>	Grev Teal	Anas gracilis		20.N	500	400	3000	800	1500	2500	2000	1200	11.920	24.04
Hardhead         Aydiya australis         S0         9         200         300         20         3         582         11.7           Bus-billed Ders-bile         Anhinger novachollandiae         3         3         5         2         1         9         23         0.03           Litle Piel Cornorant         Mininger novachollandiae         3         3         5         2         1         9         23         0.05           Little Piel Cornorant         Pienoceroarts acarbo         40         300         25         9         4         20         178         0.36           Creat Cornorant         Pienoceroarts varius         2         1         100         8         35         4         150         0.30         20         3         55         1.8         100         25         9         4         20         178         0.35         1.8         1         1         8.5         1.00         5.5         1.8         1.00         1         1         1         3.0         3.0         2.0         1.8         3.0         1.0         1.0         3.0         3.0         1.0         1.0         1.0         1.0         1.0         1.0         1.0         0	Pacific Black Duck	Anas superciliosa		,	7	7		20	1	2			37	0.07
Inte-Billed Duck         Oxyma maxmitis         V.C         Downshaded Gradel         150         10         2         3         5         15         0.03           Houry-headed Gradel         Anbingen novechollandiae         60         30         1500         70         500         2160         4.36           Little Piel Cornorant         Microcarbo melanulencos         40         83         5         2         1         9         2160         4.36           Creat Cornorant         Phalocencorax subcinostris         1         10         10         25         9         4         20         178         0.36           Field Cornorant         Phalocencorax subcinostris         2         1         100         0         8         35         4         150         0.30           Australian Pelican         Pelecarnis conspicillatus         30         32         120         100         57         58         3         1         1         4         0.02           Eastern Great Egret         Arieta amodesta         M         1         2         1         8         1         1         4         0.01           Straw-necked Ibis         Threskiornis spinincollis         2         2	Hardhead	Aythya australis			50	9			200	300	20	3	582	1 17
	Blue-billed Duck	Orvura australis	VC		50				10	200	3	5	15	0.03
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Hoary-headed Grebe <sup>1</sup>	Poliocenhalus poliocenhalus	1,0		60	30			1500	70	500		2160	4 36
$ \begin{array}{c} \mbox{restrainal balance}{ restrained} \begin{tabular}{ c c c c c c c } \hline Convertant $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$ $$$	Australasian Darter	Anhinger novaehollandiae			3	3			5	2	1	0	2100	0.05
	Little Died Cormorant	Miaroogrho malanolaucos			40	5			8	25	1	2	23	0.05
Great Cormorant       Phalocrecora carbo       4       300       25       9       4       1       343       0.10         Little Black Cormorant       Phalacrocorax varius       2       1       100       25       9       4       1       343       0.10         Australian Pelican       Pelecamus conspicibilizations       30       32       120       100       57       58       3       15       100       1.3       0.01         Multic-necked Heron       Ardea modesta       M       1       1       1       30       0.01         White-faced Heron       Spectra garzetta       1       2       7       1       6       2       1       1       4       0.01         Stastralian       Mite Bis       Treskiornis spinicollis       2       7       1       6       5       28       56       235       0.47         Stastralian White Ibis       Threskiornis spinicollis       2       2       4       13       65       4       1       6       95       0.10       0.00         Straw-necked Ibis       Threskiornis spinicollis       2       2       4       13       65       4       1       6.90       0.01	Character Connormation	Microcarbo metanoleucos			40	200			0	35	4	1	245	0.10
	Great Corniorant	Phalocrocorax carbo			4	300			25	30	4	1	343 179	0.70
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Little Black Cormorant	Phalocrocorax sulcirostris		2	110	10			25	9	4	20	1/8	0.30
Australian Pelican       Pelecanus conspicilitations       30       32       120       100       57       58       3       15       120       55       1.0       50       51       120       55       1.0       50       51       120       55       1.0       50       50       10       1       1       1       1       1       1       3       0.01         Eastern Great Egret       Ardea madesta       M       1       1       2       2       1       8       0.02       1       3       0.01         White-faced Heron       Nycticorax caledonicus       1       2       7       1       8       1       1       14       0.03         Starw-necked Bibis       Threskiornis spinicollis       2       25       63       6       55       2.8       56       2.0       9       0.01       0.00       10       0.00       10       0.00       10       0.00       10       0.00       10       0.00       10       10       0.00       10       10       0.00       10       10       0.02       10       10       0.00       10       10       10       10       10       10       10       10	Pied Cormorant	Phalacrocorax varius		2	1	100	100		8	35	4	100	150	0.30
	Australian Pelican	Pelecanus conspicillatus		30	32	120	100	57	58	3	15	120	535	1.08
Eastern Great Egret       Ardea modesta       M       1       1       1       1       3       0.01         White-faced Heron       Egretta avaehollandiae       2       7       1       6       2       1       2       0.01         Nankeen Night Heron       Nycticiorax caledonicus       1       2       7       1       8       1       1       4       0.01         Nankeen Night Heron       Nycticiorax caledonicus       1       2       1       8       1       1       4       0.01         Straw-necked Ibis       Threskiornis spinicallis       2       2.5       6.3       6       55       2.8       56       2.5       5.7       7       0.01         Straw-necked Ibis       Threskiornis spinicallis       2       2       4       13       6.5       4       1       6       9.5       0.19         Straw-necked Ibis       Threskiornis spinicallis       300       120       15.3       1       3       5.77       1.16         Eurasian Coot       Fulica atra       1       260       500       100       000       00       32.814       5.68         Back-fonted Dotterel       Elseyornis melanopus       M	White-necked Heron	Ardea pacifica		1	1				2	2	1	1	8	0.02
	Eastern Great Egret	Ardea modesta	Μ			1				1	1		3	0.01
Little Egret       Egretta garzetta $1$ $2$ $1$ $3$ $0.01$ Sdossy Ibis       Plegadis falcinellus       M       75       1       1 $4$ $0.01$ Australian White Ibis       Threskiornis molucca       2 $25$ $63$ $6$ $55$ $28$ $56$ $0.01$ Royal Spoonbil       Platalea regia $4$ $2$ $4$ $2$ $-1$ $6$ $95$ $0.01$ Royal Spoonbil       Platalea regia $4$ $2$ $4$ $2$ $-2$ $3$ $2$ $9$ $0.02$ Black-tailed Native Hen       Tribonyx ventrails $300$ $120$ $153$ $1$ $3$ $577$ $1.16$ Eurasian Coot       Fulica atra $1$ $200$ $300$ $50$ $40$ $20$ $50$ $1000$ $300$ $50$ $40$ $20$ $50$ $10$ $1$ $<0.01$ Brack-nexeld Avoct       Recurvincastra novaehollandiae $2$ $2000$ $300$ $50$ $40$ $2$ $2$ $2$ $2$ $2$	White-faced Heron	Egretta novaehollandiae		2	7	1			6	2	1	2	21	0.04
Nankeen Night Heron       Nycticorax caledonicus       1       2       1       8       1       1       14       0.03         Glossy Ibis       Plegadis falcinellus       M       75       2       1       3       0.01         Straw-necked Ibis       Threskiornis molucca       2       2       6       55       28       56       235       0.47         Royal Spoonbill       Pletatelea regia       4       2       4       13       65       4       1       6       95       0.19         Brolga       Grus rubicunda       VC       2       4       13       65       4       1       6       95       0.19         Black-traited Native Hen       Tribonyx ventralis       300       120       153       1       3       577       1.16         Eurasian Coot       Fulica atra       1       260       50       500       100       1000       3       28.14       5.58         Red-necked Avocet       Recurvirostra novaehollandiae       2       2       9       50       80.0       100       100       1       2       4.00         Red-anced Plover       Charadruis ruficapillus       4       14.N       150	Little Egret	Egretta garzetta									1		1	< 0.01
Glossy Ibis       Plegadis falcinellus       M       75       1       76       0.15         Australian White Ibis       Threskiornis spnicollis       2       25       63       6       55       28       56       235       0.47         Royal Spoonbill       Platatlea gregia       4       2       4       1       6       95       0.19         Royal Spoonbill       Platatlea favines       2       2       4       13       65       4       1       6       95       0.19         Brolga       Gruss rubicunda       V.C       2       2       3       2       9       0.02         Black-tailed Native Hen       Tribonyx ventralis       300       120       153       1       3       577       1.16         Red-acped Stilt       Himantopus himantopus       2       9       50,Y       1       2       9       73       0.15         Red-capped Plover       Charadius ruficapillus       4       14,N       150       200       19       300       50       80,N       200       101       1.0       1       2       4001       1.0       1       2       4001       1.0       1       2       0.00	Nankeen Night Heron	Nycticorax caledonicus		1		2		1	8		1	1	14	0.03
Australian White Ibis       Threskiornis molucca       2       2       1       3       0.01         Straw-necked Ibis       Threskiornis spinicollis       2       25       63       6       55       28       56       235       0.47         Royal Spoonbill       Platalea regia       4       2       4       13       65       4       1       6       95       0.19         Brolga       Grus rubicunda       VC       2       4       13       65       4       1       6       95       0.19         Black-tailed Native Hen       Tribonyx ventralis       300       120       153       1       3       29       73       0.15         Red-necked Avocet       Recurrinestrinantopus       2       9       500       1000       1000       3       2814       5.68         Red-caped Plover       Charadnis ruficapillus       4       14.N       150       2000       100       10       10       1       4001         Red-caped Plover       Charadnis ruficapillus       4       14.N       150       20.0       1       10       1       2.0       500       100       1       2.0       70.0       16       0.010	Glossy Ibis	Plegadis falcinellus	Μ	75					1				76	0.15
Straw-necked Ibis       Threskiornis spinicollis       2       25       63       6       55       28       56       235       0.47         Royal Sponbill       Platalea Iguipes       2       4       2       4       2       4       10       0.00         Vellow-billed Sponbill       Grus rubicunda       V,C       2       4       13       65       4       1       6       95       0.19         Brolga       Grus rubicunda       V,C       2       2       3       2       9       0.02         Black-tailed Native Hen       Tribonyx ventralis       300       120       153       1       3       577       1.16         Eurasian Coot       Fulica ara       1       260       50       500       100       1000       3       2814       5.6         Black-winged Stilt       Himantopus himantopus       4       14.N       150       200       300       50       80.1       11       1       0.01       1       10       1       2       9       73       0.15         Grup Plover       Charadius veredus       M       2       15       20.N       4       1       10       15       6	Australian White Ibis	Threskiornis molucca				2						1	3	0.01
Royal Spoonbill       Platalea regia       4       2       4       1       6       95       0.02         Yellow-billed Spoonbill       Platalea flavipes       2       4       13       65       4       1       6       95       0.19         Brolga       Grus rubicunda       V,C       2       3       2       9       0.02         Black-tailed Native Hen       Tribonyx ventralis       300       120       153       1       3       577       1.16         Eurasian Coot       Fulica atra       1       260       500       1000       1000       3       2814       5.68         Black-vinged Stilt       Himantopus himantopus       1       2000       3000       50       40       20       500       5610       11.31         Grey Plover       Chardarias rufcapillus       4       14.N       150       200       19       300       50       80.N       200       101       15       6       4       77       0.16         Red-aped Plover       Chardarias rufcapillus       M       2       14       9       2       7       2       4.01       2       8.06       0.07         Black-fronted Dotterel	Straw-necked Ibis	Threskiornis spinicollis		2		25	63	6	55		28	56	235	0.47
Yellow-billed Spoonbill BrolgaPlatalea flavipes2416950.19BrolgaGrus rubicundaV.C223290.02Black-tailed Native Hen Tribony ventralis300120153135771.16Eurasian CootFulica atra12605050010001000328.145.68Black-winged StiltHimantopus himantopus12605050010000005080,N205051011.31Grey PloverPluvialis squatarolaM2110112<0	Royal Spoonbill	Platalea regia		4	2	4							10	0.02
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Yellow-billed Spoonbill	Platalea flavipes		2	4	13	65		4		1	6	95	0.19
Black-tailed Native Hen       Tribonyx ventralis       300       120       153       1       3       577       1.16         Eurasian Coot       Fulica atra       1       260       50       500       1000       1000       3       2814       5.68         Black-unged Stilt       Himantopus himantopus       2       9       50.7       1       2       9       73       0.15         Red-necked Avocet       Recurvirostra novaehollandiae       M       1       1       2000       300       50       80.N       200       5610       11.31         Red-necked Avocet       Charadirus verdus       M       2       1       1       <0.01	Brolga	Grus rubicunda	V.C	2					2	3	2		9	0.02
Burasian CootFulica draFulica dra12500100010001000328141.68Black-winged StiltHimantopus himantopus2950,7129730.15Red-necked AvocetRecurvirostra novaehollandiae22000300050402050010172.05Grey PloverPluvialis squatarolaM111<0.01	Black-tailed Native Hen	Tribonyx ventralis	.,e	300		120			153	1	3		577	1 16
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Furasian Coot	Fulica atra		1	260	50			500	1000	1000	3	2814	5.68
	Black-winged Stilt	Himantopus himantopus		1	200	20	2	9	50 Y	1	2	9	73	0.15
$ \begin{array}{c} \mbox{Recharged} Recharged$	Red-necked Avocet	Recurvirostra novaehollandiae					2000	3000	50	40	20	500	5610	11 31
One yn loven       Thirdin's squathola       M       1       1       1       1       10	Gray Playar	Dhuialis squatarola	м				2000	3000	50	40	20	500	1	<0.01
Red-capted riverChardantas injectificasA1102005080,020010172.00Black-fronted DotterelElseyornis melanops21520,N41101564770.16Red-kneed DotterelErythrogonys cinctus6101101280.06Baded LapwingVanellus tricolor21,Y357360.07Masked LapwingVanellus miles214922724,N8500.10Lathan's SnipeGallinago hardwickiiM,C111<0.01	Pad conned Ployer	Charadruis squatarota	141	4	14 N	150	200	10	200	50	20 N	200	1017	2.05
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Orientel Player	Chana diya yana dya	м	4	14,19	150	200	19	300	50	00,11	200	2	2.05
Black-fronted Dotterel <i>Lskeyornis melanops</i> 21520,N411015647/0.16Red-kneed Dotterel <i>Erythrogonys cinctus</i> 6101101280.06Banded LapwingVanellus tricolor21,Y357260.07Masked LapwingVanellus miles214922724,N8500.10Latham's Snipe <i>Gallinago hardwickii</i> M,C111<0.01	Disels from to d Dotto and		IVI	2	15	20.11	4	1	10	15	(	4	2	< 0.01
Red-kneed DotterelErythrogonys cinctus6101101280.00Banded LapwingVanellus tricolor21,Y357360.07Masked LapwingVanellus miles214922724,N8500.10Latham's SnipeGallinago hardwickiiM,C111<0.01	Black-fronted Dotterel	Elseyornis melanops		2	15	20,N	4	1	10	15	0	4	11	0.16
Banded LapwingVanellus tricolor $21, Y$ $3$ $5$ $7$ $36$ $0.07$ Masked LapwingVanellus miles $2$ $14$ $9$ $2$ $7$ $2$ $4, N$ $8$ $50$ $0.10$ Latham's SnipeGallinago hardwickiiM,C $1$ $1$ $<0.01$ Black-tailed GodwitLimosa limosaM,V $1$ $1$ $<0.01$ Common SandpiperActitis hypoleucosM $1$ $1$ $<0.01$ Common GreenshankTringa nebulariaM $2$ $2$ $2$ $4$ Mask SandpiperTringa stagnatilisM $2$ $2$ $2$ $4$ Marsh SandpiperCalidris ruficollisM $13$ $3$ $7$ $15$ $1$ $30$ Sharp-tailed SandpiperCalidris acuminataM $60$ $20$ $80$ $43$ $100$ $30$ $0.61$ Curlew SandpiperCalidris ferrugineaM,E $500$ $2$ $20$ $72$ $0.15$ Unidentified migratory shorebirds $500$ $27$ $5$ $1$ $83$ $0.07$ Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.04$ Whiskered TernChlidonias hybrida $19$ $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leuco	Red-kneed Dotterel	Erythrogonys cinctus		0	2	10		1	10		1	-	28	0.06
Masked LapwingVanellus miles214922724,N8500.10Latham's SnipeGallinago hardwickiiM,C11 $<$ 1 $<$ 1 $<$ $<$ 0.01Black-tailed GodwitLimosa limosaM,V11 $<$ 1 $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ $<$ <td>Banded Lapwing</td> <td>Vanellus tricolor</td> <td></td> <td>21,Y</td> <td>3</td> <td>0</td> <td></td> <td></td> <td>5</td> <td></td> <td></td> <td>7</td> <td>36</td> <td>0.07</td>	Banded Lapwing	Vanellus tricolor		21,Y	3	0			5			7	36	0.07
Latham's SnipeGallinago hardwickiiM,C11 $< 0.01$ Black-tailed GodwitLimosa limosaM,V11 $< 0.01$ Common SandpiperActitis hypoleucosM1 $< 0.01$ Common GreenshankTringa nebulariaM224Marsh SandpiperTringa stagnatilisM973046Red-necked StintCalidris ruficollisM1337151Sharp-tailed SandpiperCalidris acuminataM602080431003030.61Curlew SandpiperCalidris ferrugineaM,E500220720.15Unidentified migratory shorebirdsSolo5005001.01Australian PratincoleStiltia isabella50,Y2751830.17Gull-billed TernGelochelidon nicotica331132130.03Caspian TernHydroprogne caspiaM429718310.06White-winged Black TernChlidonias hybrida19135001101506931.40White-winged Black TernChlidonias leucopteraM2002000.402000.40Silver GullChroicocephalus novaehollandiae35095611811411620.33Total weterking27263517 </td <td>Masked Lapwing</td> <td>Vanellus miles</td> <td></td> <td>2</td> <td>14</td> <td>9</td> <td>2</td> <td>2</td> <td>1</td> <td>2</td> <td>4,N</td> <td>8</td> <td>50</td> <td>0.10</td>	Masked Lapwing	Vanellus miles		2	14	9	2	2	1	2	4,N	8	50	0.10
Black-tailed GodwitLimosa limosaM,V11 $< 0.01$ Common SandpiperActitis hypoleucosM1 $< 0.01$ Common GreenshankTringa nebulariaM224Marsh SandpiperTringa stagnatilisM224Red-necked StintCalidris ruficollisM1337151Sharp-tailed SandpiperCalidris acuminataM60208043100Curlew SandpiperCalidris ferrugineaM,E500220720.15Unidentified migratory shorebirdsStiltia isabella50,Y2751830.17Gull-billed TernGelochelidon nicotica331132130.03Caspian TernHydroprogne caspiaM429718310.06Whiskered TernChlidonias hybrida19135001101506931.40White-winged Black TernChlidonias leucopteraM2002000.402000.40Silver GullChroicocephalus novaehollandiae35095611811411620.33Total species2726351718423042315450500500500500500	Latham's Snipe	Gallinago hardwickii	M,C					1					1	< 0.01
Common Sandpiper Common GreenshankActitis hypoleucos Tringa nebulariaM1 $<$ $<$ $1$ $<$ $<$ $0.01$ Common GreenshankTringa nebulariaM224 $0.01$ Marsh SandpiperTringa stagnatilisM97 $30$ $46$ $0.09$ Red-necked StintCalidris ruficollisM13 $3$ 7 $15$ $1$ $30$ $69$ $0.14$ Sharp-tailed SandpiperCalidris acuminataM $60$ $20$ $80$ $43$ $100$ $303$ $0.61$ Curlew SandpiperCalidris ferrugineaM,E $50$ $2$ $20$ $72$ $0.15$ Unidentified migratory shorebirds $50,Y$ $27$ $5$ $1$ $83$ $0.17$ Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.06$ Whiskered TernChlidonias hybrida19 $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $2$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total species $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$	Black-tailed Godwit	Limosa limosa	M,V						1				1	< 0.01
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	Common Sandpiper	Actitis hypoleucos	Μ			1							1	< 0.01
Marsh SandpiperTringa stagnatilisM9730460.09Red-necked StintCalidris ruficollisM133715130690.14Sharp-tailed SandpiperCalidris acuminataM602080431003030.61Curlew SandpiperCalidris ferrugineaM,E $50$ 220720.15Unidentified migratory shorebirds $50$ ,Y27 $5$ 1830.17Australian PratincoleStiltia isabella $50$ ,Y27 $5$ 1830.17Gull-billed TernGelochelidon nicotica331132130.03Caspian TernHydroprogne caspiaM429718310.06Whiskered TernChlidonias hybrida19135001101506931.40White-winged Black TernChlidonias leucopteraM2002002000.40Silver GullChroicocephalus novaehollandiae35095611811411620.33Total species2726351718422304223154	Common Greenshank	Tringa nebularia	Μ					2			2		4	0.01
Red-necked StintCalidris ruficollisM133715130690.14Sharp-tailed SandpiperCalidris acuminataM602080431003030.61Curlew SandpiperCalidris ferrugineaM,E $50$ 220720.15Unidentified migratory shorebirds $500$ $500$ $500$ $2$ 20720.15Australian PratincoleStiltia isabella $50,Y$ $27$ $5$ $1$ 830.17Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ 0.03Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ 0.06Whiskered TernChlidonias hybrida1913 $500$ $1$ 10150 $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $200$ $200$ $200$ $0.40$ Silver GullChroicocephalus novaehollandiae $3$ $50$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total woterbirds $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$	Marsh Sandpiper	Tringa stagnatilis	Μ						9		7	30	46	0.09
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	Red-necked Stint	Calidris ruficollis	Μ		13	3	7		15		1	30	69	0.14
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Sharp-tailed Sandpiper	Calidris acuminata	Μ			60		20	80		43	100	303	0.61
Unidentified migratory shorebirds500 $500$ 1.01Australian PratincoleStiltia isabella $50, Y$ $27$ $5$ $1$ $83$ $0.17$ Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.06$ Whiskered TernChlidonias hybrida $19$ $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $200$ $200$ $0.40$ Silver GullChroicocephalus novaehollandiae $3$ $50$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total species $27$ $26$ $35$ $17$ $18$ $422$ $30$ $42$ $31$ $54$ Total waterbirds $626$ $1521$ $114250$ $5001$ $17572$ $87252$ $27526$ $2052$	Curlew Sandpiper	Calidris ferruginea	M,E						50		2	20	72	0.15
shorebirds500 $500$ $1.01$ Australian PratincoleStiltia isabella $50, Y$ $27$ $5$ $1$ $83$ $0.17$ Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.06$ Whiskered TernChlidonias hybrida $19$ $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $200$ $200$ $0.40$ Silver GullChroicocephalus novaehollandiae $3$ $50$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total species $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$ Total waterbirds $626$ $1232$ $101$ $14$ $250$ $501$ $727$ $8529$ $7275$ $202$ $40$	Unidentified migratory													
Australian PratincoleStiltia isabella $50,Y$ $27$ $5$ $1$ $83$ $0.17$ Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.06$ Whiskered TernChlidonias hybrida $19$ $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $200$ $200$ $0.40$ Silver GullChroicocephalus novaehollandiae $3$ $50$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total species $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$ Total waterbirds $626$ $1232$ $1001$ $14$ $250$ $5001$ $7275$ $8202$ $40$ $520$	shorebirds							500					500	1.01
Gull-billed TernGelochelidon nicotica $3$ $3$ $1$ $3$ $2$ $13$ $0.03$ Caspian TernHydroprogne caspiaM $4$ $2$ $9$ $7$ $1$ $8$ $31$ $0.06$ Whiskered TernChlidonias hybrida19 $13$ $500$ $1$ $10$ $150$ $693$ $1.40$ White-winged Black TernChlidonias leucopteraM $200$ $200$ $0.40$ Silver GullChroicocephalus novaehollandiae $3$ $50$ $9$ $5$ $61$ $18$ $11$ $4$ $1$ $162$ $0.33$ Total species $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$ Total waterbrieds $636$ $1232$ $101$ $14$ $250$ $501$ $727$ $2528$ $2727$ $202$ $40$	Australian Pratincole	Stiltia isabella		50 Y		27					5	1	83	0.17
Caspian TernHydroprogne caspiaM429718310.06Whiskered TernChlidonias hybrida19135001101506931.40White-winged Black TernChlidonias leucopteraM2002000.40Silver GullChroicocephalus novaehollandiae35095611811411620.33Total species27263517184230423154Castel watershirds636123210114250500172758529275220520	Gull-billed Tern	Gelochelidon nicotica		3		3		1	1		3	2	13	0.03
CalibratianHydroprogne cuspitaHF2916510.00Whiskered TernChlidonias hybrida19135001101506931.40White-winged Black TernChlidonias leucopteraM2002002000.40Silver GullChroicocephalus novaehollandiae35095611811411620.33Total species27263517184230423154Total waterblieds62612231011425050017552727520240502	Caspian Terp	Hydronrogne caspia	м	4	2	o o		1	7	1	8	-	31	0.06
White-winged Black Tern Childonias leucoptera       M       200       200       0.40         Silver Gull       Chroicocephalus novaehollandiae       3       50       9       5       61       18       11       4       1       162       0.33         Total species       27       26       35       17       18       42       30       42       31       54	Whiskered Tern	Chlidonias hybrida	141	10	4	13		500	1	1	10	150	603	1 40
Silver Gull     Chroicocephalus novaehollandiae     3     50     9     5     61     18     11     4     1     162     0.33       Total species     27     26     35     17     18     42     30     42     31     54       Cotal species     27     26     35     17     18     42     30     42     31     54	White-winged Black Torn	Chlidonias laucontara	м	17		15		500	200		10	150	200	0.40
Sinversion       Chronococeptianus novaenonananae $5$ $50$ $9$ $5$ $01$ $16$ $11$ $4$ $1$ $102$ $0.55$ Total species $27$ $26$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$ Total waterbinds $636$ $1222$ $1001$ $14$ $250$ $5001$ $7557$ $8529$ $7275$ $2002$ $40$ $592$	Silver Gull	Chroicocanhalus novachollandian	141	2	50	0	5	61	19	11	1	1	162	0.40
10tal species $Z/$ $Z_6$ $35$ $17$ $18$ $42$ $30$ $42$ $31$ $54$ Total waterbirds62612021001142505001757200240592	Tatal and '	Chronococephanas novaenonanalae		3	30	9	J	10	10	11	4	1	102	0.55
DAD 1272 HULL TA ZALLAND TA	Total species			21	20	55 1001	1/	18	42 7557	50	42	31	54 40 592	

<sup>1</sup>The Hoary-headed Grebe counts may have included some Australasian Grebe (Tachybaptus novaehollandiae) but this was not confirmed.



Figure 3. Water recession distance, water conductivity, waterbird abundance and number of waterbird species recorded at north-western end of Peery Lake after floods in April 1990 (blue) and January 1993 (red).

peaked in October 1992 when the lake water was 64 percent of the typical value for sea water and the lake had receded about 750 metres from its flood peak. Conductivity decreased after local flooding in January 1993 and the lake water became fresh again. Conductivity increased in the year after the second flood, and particularly during the last three months, as the lake receded again (Figure 3). There was a significant positive relationship between the distance the water had receded from the April 1990 peak flood level and its conductivity (R = 0.88, P = 0.002).

The number of waterbirds recorded varied widely across surveys, from 636 to 14 359 (Table 1). Waterbird numbers were low but increased steadily during the first 18 months after the April 1990 flood, then rose dramatically to reach a maximum 27 months after the flood, before dropping rapidly over the next three months as the lake reached its lowest level and highest conductivity for the study (Figure 3). After the January 1993 flood, by contrast, waterbird numbers were high for the first nine months after the flood before falling in the next three months as the water level fell and conductivity increased during the hot months of late spring and summer. After the second flood, waterbird numbers were lowest 12 months after the flood. The water recession distance and conductivity at this time were similar to the measurements 27 months after the first flood, when, by contrast, waterbird numbers were higher than at any other time during the study (Figure 3).

The number of species recorded in each survey period ranged from 17 to 42 (Table 1). After both floods, species richness was lowest in the same survey period when waterbird abundance was highest. In both cases, this was a winter survey (July 1992 and July 1993), when migratory shorebird and tern species were absent. The lowest species richness for the study was in July 1992, 27 months after the first flood, when many species were absent that had been present in July 1991 and were present again in July 1993, after the second flood (Pacific Black Duck, Hardhead, Hoary-headed Grebe, Australasian Darter, Little Pied Cormorant, Great Cormorant, Little Black Cormorant, Pied Cormorant, White-necked Heron, White-faced Heron, Eurasian Coot and Caspian Tern) (Table 1). Species richness was highest for the study in the first year after the second flood (Figure 3). By comparison, after the first flood, species richness did not peak until 18 months after flooding, although at a similar stage to the second flooding cycle in terms of water recession distance and conductivity (Figure 3).

The populations of individual species peaked at different times during the study (Table 2), so that there were different combinations of common species in each survey period. As an example of the large fluctuations that occurred between surveys, there were about 8000 Pink-eared Ducks in the survey area during the July 1992 survey, the largest population of any species during the study, and yet no Pink-eared Ducks were recorded during the October 1992 survey period, only three months later (Table 1). Only six of the 54 waterbird species recorded were present in every survey period (Grey Teal, Australian Pelican, Red-capped Plover, Black-fronted Dotterel, Masked Lapwing and Silver Gull) (Table 1). Large daily fluctuations in numbers also occurred for individual species during survey periods. For example, during the October 1992 survey period, the number of Red-necked Avocets in the survey area each day varied from about 3000 to none.

Only eight waterbird species were recorded breeding in the survey area (Table 1), mostly in October 1990 (six months after the first flood) and October 1993 (nine months after the second flood). The numbers of birds involved were small, except for a colony of nesting Black Swans spread over four mound spring islands in October 1993 (37 nests in all).

### DISCUSSION

Over two flooding events (a major regional flood and subsequent local flooding), the north-western end of Peery Lake supported an abundant (up to 14 359 individuals recorded per survey period), rich (54 species recorded) and highly variable waterbird fauna, affirming its importance to waterbirds.

Maximum waterbird counts that have been recorded for Peery Lake in previous aerial surveys were 35 900 in March 1990 and 38 000 in March 1993 (Kingsford and Lee 2010). Our count of 14 359 waterbirds in the survey area in July 1992, covering only about 11 percent of the lake, represents a higher density of waterbirds than previously reported (26 birds/ha compared with 8/ha in March 1993), however, comparisons are tenuous for data

#### Table 2

Peak counts for waterbird species at north-western end of Peery Lake, October 1990 - January 1994. Species shown are those with maximum counts of at least 100 individuals during at least one survey period. The migratory shorebirds grouping includes Oriental Plover, Grey Plover, Common Sandpiper, Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint, Latham's Snipe, Black-tailed Godwit, Common Greenshank, Marsh Sandpiper and unidentified birds.

Species	Oct 90	Jul 91	Oct 91	Jul 92	Oct 92		Apr 93	Jul 93	Oct 93	Jan 94
Black-tailed Native Hen	300		120				153	1	3	
Little Black Cormorant		110	10				25	9	4	20
Pied Cormorant	2	1	100				8	35	4	
Great Cormorant		4	300					36	4	1
Australian Pelican	30	32	120	100	57		58	3	15	120
Australian Wood Duck	10	58	300	7	_	Q	150	3		160
Freckled Duck			5	400		00	20	50	200	
Grey Teal	20	500	400	3000	800	Ē	1500	2500	2000	1200
Australasian Shoveler		12		500		93]	20	150	30	20
Pink-eared Duck	12	28	9	8000		19	2500	4000	3000	300
Red-necked Avocet				2000	3000	RY	50	40	20	500
Migratory shorebirds		13	66	7	523	NA)	155		56	180
Whiskered Tern	19		13		500	Ĩ	1		10	150
Hoary-headed Grebe		60	30			Jł	1500	70	500	
Red-capped Plover	4	14	150	200	19		300	50	80	200
White-winged Black Tern							200			
Hardhead		50	9				200	300	20	3
Eurasian Coot	1	260	50				500	1000	1000	3
Black Swan	55	33	74	2			6	200	250	37

derived using different counting methods (aerial versus ground based counts) and survey areas (part of lake close to shoreline versus entire lake). During our study, waterbird numbers and species richness varied on a daily basis as birds moved in and out of the survey area from other parts of Peery Lake or from other wetlands. Counts such as ours, combining maximum numbers of individuals per species over a prolonged survey period, are likely to provide higher measures of abundance and species richness than one-day counts. However, they provide a useful indication of the lake's potential to support waterbirds and allow for comparison between survey periods while taking account of daily fluctuations.

Large changes in waterbird species and numbers occurred between surveys. There was a regular seasonal component with 11 non-breeding migratory species from the Northern Hemisphere only present in spring-summer, including the White-winged Black Tern and 10 migratory shorebird species (Table 1). Whiskered Terns were also absent during winter surveys (Table 1). However, these migratory species represented only about four percent of the total waterbird count. Most variations in waterbirds at Peery Lake related to flooding cycles and the irregular movement of waterbirds between wetlands as conditions change, especially food availability (Timms and McDougall 2004). There was similar high variation between waterbird surveys only three months apart in north-western New South Wales over a study period (1987-93) that overlapped with the present study, and this variation was evident not only for individual wetlands, but also for the Paroo catchment as a whole (Roshier et al. 2002).

Waterbird numbers were lowest at the north-western end of Peery Lake in October 1990, six months after the major flood in April 1990 when, paradoxically, there was more water in the lake than in any other survey period. Elsewhere in the Paroo system, at this time, water was present in widespread ephemeral wetlands, notably the Lignum swamps, the most important waterbird breeding habitat on the Paroo (Maher and Braithwaite 1992). The Lake Eyre Basin to the west also experienced a major flood and in December 1990 an estimated half a million waterbirds were present along the lower Cooper Creek, including Lake Hope, Lake Blanche and Lake Eyre (Kingsford *et al.* 1999). Under such conditions, Peery Lake was probably of only minor significance as waterbird habitat. Despite this, large numbers of waterbirds (about 35 900) were recorded in aerial surveys of Peery Lake in March 1990, when the lake was filling (Kingsford and Lee 2010).

The importance of Peery Lake lies mainly in the prolonged period for which it holds water, for an inland wetland. As more ephemeral wetlands dry out, waterbirds concentrate on Peery Lake and other freshwater overflow lakes, which act as refuges for waterbirds on the Paroo between floods (Maher and Braithwaite 1992). The highest waterbird numbers recorded during the study were in July 1992, 27 months after the lake had filled, when most other Paroo wetlands had dried, and waterbirds had moved to Peery Lake. Waterbirds are also likely to have come from other drainage systems, especially the Lake Eyre system. Over the period 1987–93, the best predictor of waterbird abundance in the Paroo River catchment was large changes in wetland area in the Lake Eyre Basin and its component catchments rather than changes in wetland area in the Paroo catchment itself (Roshier *et al.* 2002).

After major flooding filled Peery Lake to capacity in April 1990, the lake was used by a succession of waterbirds. Common species whose numbers peaked in the first 18 months after the flood, while the lake was fresh and relatively full, included deep-water species feeding on fish, frogs and invertebrates (Australian Pelican, Great Cormorant, Little Black Cormorant and Pied Cormorant), and lakeside grazing species (Blacktailed Native Hen and Australian Wood Duck). In the following year, as the lake receded rapidly and became more saline, dabbling ducks feeding on a mixture of plants and invertebrates dominated (Pink-eared Duck, Grey Teal, Australasian Shoveler and Freckled Duck). Species diversity declined, but waterbird numbers increased dramatically, due mainly to very large populations of both Pink-eared Ducks and Grey Teal. By October 1992, 30 months after the lake had filled, when the water level was lowest and salinity highest, waterbird numbers had declined again, particularly dabbling ducks. However, at this time, wading and shoreline species that feed on invertebrates in saline habitats reached peak numbers (Red-necked Avocet and migratory shorebirds), together with Whiskered Terns flying over the water searching for small fish and invertebrates (waterbird diets based on Kingsford 1991).

The response of waterbirds to the second flood was markedly different to the first flood. Waterbird numbers were high for the first nine months after the second flood (higher than in all survey periods after the first flood except for July 1992), but had declined greatly by January 1994, only 12 months after the flood. After the first flood, waterbird numbers were initially low and peaked 27 months after the flood, before falling sharply in the next three months. The survey period after the second flood when waterbird numbers were lowest (January 1994) roughly corresponded, in terms of wetland area and salinity, to the survey period after the first flood when waterbird numbers were highest (July 1992).

The most common waterbirds after the second flood were again the Pink-eared Duck and Grey Teal. Other common waterbirds were two deep-water species, the Hoary-headed Grebe and Eurasian Coot (the former feeding on invertebrates, the latter on plants), both of which were less numerous after the first flood. Other species more common after the second than the first flood included two more deep-water species (Black Swan and Hardhead), a shoreline species (Red-capped Plover) and a tern (White-winged Black Tern). Another pronounced difference between the floods was the greater diversity of waterbird species present in the first year after the second flood than at any stage after the first flood (allowing for the lower number of species in winter, when migratory species were absent).

These differences between the two floods may be due to differences in food resources or other factors at Peery Lake, or differences in wetland availability, locally, regionally or nationally. The dynamic and highly variable nature of the lake's waterbird fauna shows that responses of waterbirds to particular flood cycles vary considerably and cannot be predicted by simple measures such as the amount of water in the lake and its salinity.

Despite the large numbers of waterbirds recorded, only eight species represented by only a few individuals bred in the study area (Table 1). The paucity of breeding records probably reflects a lack of suitable breeding habitat, especially areas of Lignum swamp (Maher and Braithwaite 1992). The several small islands within the study area, created by mound springs (Figure 2), were not major nesting sites during the survey periods, except for a colony of 37 Black Swan nests in October 1993. Australian Pelicans have also nested colonially on these islands in the past (G. Barlow, pers. comm.) and breed elsewhere on the lake (Maher 1991). Additional species that have been reported breeding on Peery Lake, although only in low numbers, include Pacific Black Duck, Hardhead, Pink-eared Duck, Yellow-billed Spoonbill, Royal Spoonbill, Australian White Ibis and Eurasian Coot (Kingsford *et al.* 1994). The spoonbill and ibis nests were presumably outside of our survey area at the southern end of the lake, which supports better breeding habitat, including large areas of Canegrass and Lignum (Kingsford *et al.* 1994).

Seventeen species recorded have special conservation significance at national, state or regional level (Table 1). One of the nationally listed migratory species, the Oriental Plover, which was recorded during the October 1991 survey period (two individuals), was only the third record for inland New South Wales and the first for the Upper Western region (Morris 1994). The Freckled Duck, listed as a vulnerable species in NSW, was recorded in substantial numbers after both floods, with about 400 in July 1992 and 200 in October 1993. Non-breeding Freckled Duck favour large, open, freshwater wetlands with little aquatic vegetation (Martindale 1984). Few places support large numbers of Freckled Duck, but include four lakes in the Paroo catchment: Numalla Lake (maximum count 9720), Lake Wyara (5540), Yantabangee Lake (2114) and Peery Lake (1373) (Kingsford and Porter 1999).

Inland waterbirds are mobile and nomadic (Lawler and Briggs 1991; Briggs 1992), moving widely between dispersed wetlands as conditions change in the boom and bust arid environment. Movements occur at local, regional and continental scales, resulting in rapid and irregular fluctuations in the numbers and species of waterbirds present on an individual wetland, of which this study is an example. Ultimately, the conservation of waterbirds in Australia depends not only on the reservation of a selection of important wetlands such as Peery Lake, but also on a landscape-scale approach to wetland and waterbird conservation on and off reserves. Major conservation measures are needed to address threats both within the Paroo catchment, such as potential increased extraction of water for irrigated agriculture (Kingsford 1999), and more widely, such as the potential future impact of climate change in inland Australia. Climate change impacts, exacerbated by extraction of water for irrigation, could be catastrophic for waterbirds relying on a mosaic of inland wetlands for survival.

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