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A survey of waterbirds on the Elizabeth Macarthur Agricultural Institute demonstration site, Menangle, New South Wales

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The management of wetlands in Australia has environmental and socio-economic implications, especially with respect to their status as foraging and breeding sites for waterbirds. A broad range of waterbirds have increasingly adjusted to modified and artificial wetlands as natural wetlands decline, including wetlands on agricultural land. This paper reports on a three-year study of waterbird assemblages on the Elizabeth Macarthur Agricultural Institute demonstration farm site, southwest of Sydney, New South Wales. Fortnightly surveys recorded the presence of 28 species, with more than 90% of them being recorded by the tenth month of the study. The species recorded were members of 10 families (Anatidae, Podicipedidae, Rallidae, Recurvirostridae, Charadriidae, Ardeidae, Threskiornithidae, Pelicanidae, Phalacrocoracidae, Anhingidae). Most species were recorded in more than 90% of surveys and considered to be resident. Waterbird occupation of farm dams and riverine habitats was less variable than that of floodplains. Waterbird assemblages on floodplains were highly variable, with the largest species array and highest overall abundance occurring in periods after rainfall when waters were receding, leaving shallow sections of ephemeral wetland. Observations of a rare visitor, the Great Crested Grebe, using the site for breeding particularly highlighted the conservation value of the site.

INTRODUCTION

Natural freshwater wetlands are one of the most threatened habitats globally (Froneman *et al.* 2001). Several anthropogenic factors have caused the degradation or loss of natural wetlands, including agricultural intensification and urbanisation. Changes in hydrological connectivity result from diverting and damming rivers and disconnecting floodplains (Brinson and Malvárez 2002). In drier climates, crop irrigation competes with wildlife for water resources (Lemly *et al.* 2000). Eutrophication is widespread globally (Calero *et al.* 2015; Grygoruk *et al.* 2015; Franzén *et al.* 2016), and reduces biological diversity when combined with impacts such as invasive species (Yarwood *et al.* 2016) and livestock grazing (Teuber *et al.* 2013; Epele and Miserendino 2015). Draining and filling virtually eliminate natural wetlands (Black *et al.* 2016). The management of our wetlands has significant environmental and socio-economic implications because Australia is one of the world's driest continents.

Globally, wetlands and grasslands have high conservation value for waterbirds, as they are important habitats for foraging and breeding (Higgins *et al.* 2002; Bregnballe *et al.* 2014; Smart *et al.* 2014). Many studies have shown that a broad range of waterbird species can adjust to modified and artificial wetlands (e.g. Chafer and Brandis 2004; González-Gajardo *et al.* 2009; Santoul *et al.* 2009). In fact, waterbirds' use of agricultural and urban wetlands has increased in parallel with the decline of natural wetlands (Czech and Parsons 2002; Murray *et al.* 2013). In response to this trend, research has particularly focused on resource availability for waterbirds in artificial wetlands (Manley *et al.* 2004; Taft and Haig 2005). Current management of many waterbirds, especially migratory shorebirds, emphasises identifying important habitats and sites (Watkins 1993; Bamford *et al.* 2008; Stralberg *et al.* 2011; Sutherland *et al.* 2012; Commonwealth of Australia 2015).

The Elizabeth Macarthur Agricultural Institute (EMAI) demonstration site is a 1600ha property in Menangle (34.1273° S, 150.7387° E), southwest of Sydney, New South Wales (NSW) (Fig. 1). Situated between the Nepean River and the Razor Back Range, the property has an array of wetland habitats, including riverine, floodplains, natural lagoons and farm dams. It has been managed as a demonstration farm for sustainable agriculture for almost three decades. Vegetation restoration works have progressively established conservation corridors throughout the property.

The use of wetlands on agricultural land by waterbirds in Australia is not well documented. This paper reports a three-year study of the species composition of waterbird assemblages on the EMAI demonstration site. The aims were: (1) to develop a waterbird species inventory for this agricultural site containing several types of wetland, and (2) to document the habitat use and persistence over three years of all waterbird species at the site.

METHODS

Study site

The EMAI demonstration site has been owned by the New South Wales Department of Primary Industries since 1990. It consists mainly of livestock paddocks on undulating terrain, and a small institute site. A comprehensive flora survey has been carried out (Cuneo *et al.* 2008), and information on the fauna has been compiled by various observers (Ridgeway 2015). Where historical ring barking has occurred, canopy trees have not recovered, resulting in expanses of native pastures, which cover most of the site, and fertilised exotic pastures. Open-woodland remnants vary

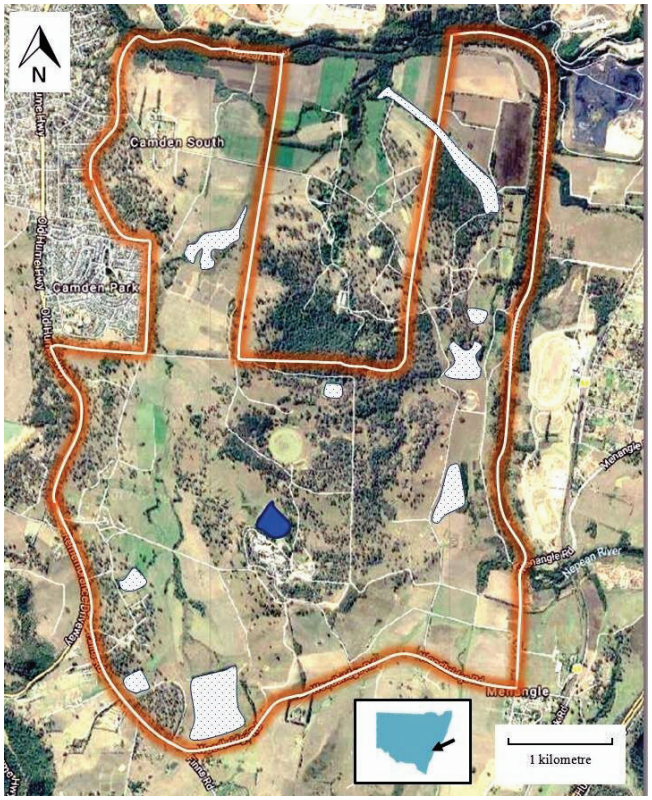

Figure 1. *Layout of the Elizabeth Macarthur Agricultural Institute demonstration site, with major dams, lagoons and floodplains highlighted (the Institute Dam is shown in blue).*

in size and structure, but are dominated by Shale Hills Woodland, characterised by Narrow-leaved Ironbark *Eucalyptus crebra*, Forest Red Gum *E. tereticornis* and Grey Box *E. moluccana*, particularly in elevated areas (Starr *et al.* 2004; Ridgeway 2015; Mo 2017). Small sections of Shale Plains Woodland also occur on lower areas. The undergrowth of these grassy woodlands is dominated by wire grasses *Aristida* spp. and Kangaroo Grass *Themeda australis*. The banks of the Nepean River are dominated by riparian forest, much of which is derived from rehabilitation vegetation planted after sand mining and is heavily infested with exotic weeds (Ridgeway 2015). The riverbank habitat is dominated by River Apple *Angophora subvelutina*, River Peppermint *Eucalyptus elata*, Bangalay *E. botryoides* x *saligna*, Sally Wattle *Acacia floribunda*, Bracken *Pteridium esculentum*, Slender Bamboo Grass *Austrostipa ramosissma* and Weeping Meadow Grass *Microlaena stipoides* var. *stipoides*.

The eastern section of the site retains natural lagoons. There are also farm dams, which vary in area up to 50 000m^2 (Fig. 2). Some were fenced off from livestock in the 1990's to prevent bank destabilisation and high turbidity. The vegetation around some of these dams had been replanted from seedlings in tubestock, with the overall aim of improving water quality and providing wildlife refuges. Dominant vegetation around dams includes River She-oak *Casuarina cunninghamiana*, Prickly Paperbark *Melaleuca styphelioides*, Willow Bottlebrush *Callistemon salignus*, White Sally Wattle *Acacia floribunda*, Tantoon *Leptospermum flavescens* and Spiny-head Mat-rush *Lomandra longifolia*. There are also several floodplains providing areas of shallow water and ephemeral habitats (Fig. 3).

Figure 2. *A typical dam on the Elizabeth Macarthur Agricultural Institute demonstration site, situated in a paddock with a sparse scattering of adjacent living and dead trees and some adjacent woodland remnants.*

Photograph by M. Mo.

Figure 3. *Floodplains on the study site, photographed after heavy rains.*

Photograph by M. Mo.

During the study, mean annual precipitation was 697mm (Menangle Bridge [Nepean River] weather station) and monthly mean precipitation varied from 103mm (January) to 15mm (May). Mean maximum temperatures were highest in January (29.3°C) and mean minimum temperatures were lowest in July (4.0°C) (Mount Annan weather station). Floodplains swelled with water after periods of heavy rain and dried after extended periods of little to no precipitation and high temperatures.

Waterbird surveys

Surveys were conducted by a single observer fortnightly between February 2014 and January 2017. Minimum search effort was 40 min per survey, which covered line transects of at least 1.6 km. There is one large dam situated 50m from the institute buildings, hereinafter referred to as the Institute Dam (Fig. 1), which was included in at least one survey per month. A minimum of five other dams and lagoons, three floodplains and three river sites were visited per survey. Survey locations were

chosen randomly for any given survey, but the entire site was surveyed each year.

Waterbirds were observed using binoculars through a range of techniques, such as examining grassy banks for resting birds, scanning the water surface and tree branches, watching for retreating birds when approaching watercourses, and locating nests. Species were recorded on a presence/absence basis. Counts and observations of nesting birds and broods were recorded on occasion. Species were classed as resident if they were recorded in > 90% of surveys, intermittent if recorded in 20-90% of surveys and rare if recorded in < 20% of surveys. Linnaean names of all waterbird species recorded are given in Table 1.

RESULTS AND DISCUSSION

Twenty-eight waterbird species in 10 families were recorded in this study. More than half (54%) were considered resident (Table 1), seven were intermittent and seven were rare visitors. More than 60% of species were recorded by the second month of the study (Fig. 4) and more than 90% after 10 months. Fourteen species were observed at some stage of breeding.

The Institute Dam's waterbird assemblage was representative of the whole study site, with all recorded species being seen there except the White-headed Stilt, Black-fronted Dotterel and Yellow-billed Spoonbill. The Institute Dam and the Nepean River were the only wetland habitats that were continuously occupied by waterbirds. The floodplains varied in their waterbird assemblages and numbers. The most prolific times were after rainfall as waters receded, providing shallow sections of ephemeral wetland on which waterbirds were regularly observed. In contrast, few waterbirds were present during dry conditions when the floodplains dried up completely or immediately after heavy rains when the floodplains lacked shallow water in non-vegetated areas. During the latter events, islands that normally provided refuges for waterbirds were submerged. Smaller wetlands, such as isolated farm dams which constituted most of the remaining wetlands on the study site, had high daily variability in species recorded (c.f. Kingsford *et al.* 2008).

Waterbird families represented

a) Anatidae:

Represented by six species, four of which were recorded in every survey (Chestnut Teal, Grey Teal, Pacific Black Duck and Australian Wood Duck) (Table 1). Distributions of these species were focused around dams, lagoons, floodplains and the Nepean River, except for the Australian Wood Duck which favoured managed lawns. This species can be prolific when farm dams are present (Kingsford 1992; Saunders 1993) and is regarded as a pest in cropping landscapes (Curtin and Kingsford 1997; Bomford and Sinclair 2002).

A fifth duck species, the Hardhead, was only recorded in 31% of surveys and just at the Institute Dam and Nepean River. A diving duck, this species generally prefers to forage in deeper water (Hamilton and Taylor 2006), but can be found in shallow water bodies in peri-urban areas (pers. obs.). The Musk Duck had also been observed in larger dams at the site prior to the present study (M. Turner, pers. comm.). This species prefers deep-water wetlands (McCracken *et al.* 2003) and its absence

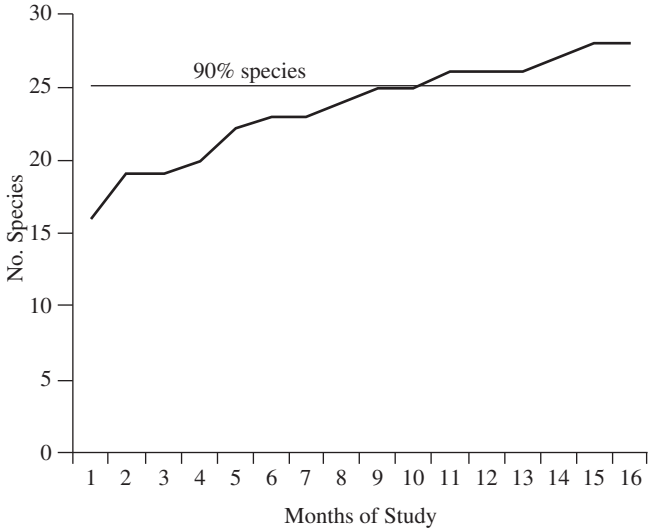

Figure 4. *Species accumulation curve covering the first 16 months of the study, with a representation of 90 percent of species recorded marked.*

Figure 5. *Two adult Great Crested Grebes flank an immature grebe in the Institute Dam.*

Photograph by M. Mo.

during the study period may indicate recent shifts in habitat availability, as sedimentation has not been managed for several years due to resource limitations.

Black Swans were also intermittent in their occurrence, being present in 35% of surveys on two floodplains, one lagoon and the Institute Dam. They require at least 40m of water to take off (Kingsford 1991), which explains their preference for larger watercourses and observed absence from smaller dams.

b) Podicipedidae

Represented by all three species of Australian grebes, most frequently by Australasian Grebes which were present in 95% of surveys and observed at five dams and on two floodplains. Historically, this species has been the most commonly observed grebe in Greater Sydney (Hoskin *et al.* 1991; Keast 1995; Mo and Waterhouse 2015a, b). Hoary-headed Grebes were recorded in 45% of surveys at the Institute Dam and on one floodplain.

Table 1

Waterbird species observed on the Elizabeth Macarthur Agricultural Institute demonstration site. *indicates observations of breeding.

	Persistence		Habitat use					
	No. surveys	Status	Institute Dam	Small dams	Natural lagoons	Flood plains	River	Pasture
Anseriformes								
Anatidae								
Chestnut Teal *Anas castanea**	234	Resident	Yes	Yes	Yes	Yes	Yes	
Grey Teal *Anas gracilis**	234	Resident	Yes	Yes	Yes	Yes	Yes	
Pacific Black Duck *Anas superciliosa**	234	Resident	Yes	Yes	Yes	Yes	Yes	
Hardhead *Aythya australis*	73	Intermittent	Yes				Yes	
Australian Wood Duck *Chenonetta jubata**	234	Resident	Yes	Yes	Yes	Yes	Yes	Yes
Black Swan *Cygnus atratus**	82	Intermittent	Yes		Yes	Yes		
Podicepiformes								
Podicipedidae								
Australasian Grebe *Tachybaptus novaehollandiae**	222	Resident	Yes	Yes		Yes	Yes	
Hoary-headed Grebe *Poliocephalus poliocephalus**	105	Intermittent	Yes		Yes	Yes		
Great Crested Grebe *Podiceps cristatus**	3	Rare visitor	Yes					
Gruiformes								
Rallidae								
Purple Swamphen *Porphyrio porphyria**	234	Resident	Yes	Yes	Yes		Yes	Yes
Dusky Moorhen *Gallinula tenebrosa**	234	Resident	Yes	Yes	Yes		Yes	
Eurasian Coot *Fulica atra**	234	Resident	Yes					
Charadriiformes								
Charadriidae								
Black-fronted Dotterel *Elseyornis melanops*	89	Intermittent				Yes		
Masked Lapwing *Vanellus miles**	234	Resident	Yes	Yes	Yes	Yes		Yes
Recurvirostridae								
White-headed Stilt *Himantopus leucocephalus*	75	Intermittent				Yes		
Pelecaniformes								
Ardeidae								
Eastern Great Egret *Ardea modesta*	1	Rare visitor		Yes				
Intermediate Egret *Ardea intermedia*	1	Rare visitor			Yes			
White-necked Heron *Ardea pacifica*	2	Rare visitor				Yes		
Cattle Egret *Bubulcus ibis*	234	Resident		Yes				Yes
White-faced Heron *Egretta novaehollandiae*	6	Rare visitor		Yes				
Threskiornithidae								
Australian White Ibis *Threskiornis molucca*	234	Resident	Yes	Yes				Yes
Straw-necked Ibis *Threskiornis spinicollis*	234	Resident				Yes		Yes
Yellow-billed Spoonbill *Platalea flavipes*	3	Rare visitor		Yes				
Pelicanidae								
Australian Pelican *Pelecanus conspicillatus*	6	Rare visitor	Yes			Yes		
Phalacrocoracidae								
Little Pied Cormorant *Microcarbo melanoleucos**	234	Resident	Yes	Yes	Yes	Yes	Yes	
Great Cormorant *Phalacrocorax carbo*	82	Intermittent	Yes		Yes			
Little Black Cormorant *Phalacrocorax sulcirostris**	234	Resident	Yes		Yes	Yes	Yes	
Pied Cormorant *Phalacrocorax varius**	234	Resident	Yes			Yes	Yes	
Anhingidae								
Australasian Darter *Anhinga novaehollandiae*	73	Intermittent			Yes	Yes		

Prior to the 1950's, the species was considered a rare visitor to Greater Sydney, but then individuals began to be recorded in the eastern and north-western parts of the metropolis (McGill 1955; Keast 1995). The Macarthur region may be the local stronghold for this species, but numbers are also present at the time of writing at the Mount Annan Botanic Garden (pers. obs.). Between April and June each year, mixed-species flocks of Hoary-headed and Australasian Grebes occurred, numbering up to 16 individuals. The Great Crested Grebe was only recorded in three surveys and only at the Institute Dam. Preferring large, open watercourses (Marchant and Higgins 1990), it is unlikely to use the other wetland habitats at the site, except the natural lagoons and the Nepean River. This species is only observed in Greater Sydney infrequently, with the most reliable location being Prospect Reservoir (Roberts 2009). However, one brood was recorded in this study, with chicks being observed over two consecutive surveys in February 2016 (Fig. 5).

Rallidae

Represented by three rails (Dusky Moorhen, Eurasian Coot and Purple Swamphen), which were recorded in all surveys. They were present consistently at the Institute Dam, which was the only part of the site where the Eurasian Coot was recorded, usually in numbers between 65 and 97. Individual and paired Dusky Moorhens were also recorded in other small dams, on floodplains and at the Nepean River. Individual or small family groups of Purple Swamphen were also recorded at small dams and the river.

Charadriidae

Represented by two species. The Black-fronted Dotterel was recorded in 38% of surveys, always on the islands or edges of floodplains. Dotterels preferred to forage in areas of moist mud that facilitated high prey capture rates and abandoned the wetlands after flooding obliterated these exposed areas (c.f. Taylor 2004). They were absent from small dams, in contrast to the situation in other locations in Greater Sydney (pers. obs.).

Masked Lapwings were recorded in all surveys, mostly in paddocks and on mowed lawns (c.f. Giese and Jones 1996; Woodall 1999; Loyn *et al.* 2001; Cardilini *et al.* 2013). Their distribution was generally not related to water sources. During the study, 24 nests detected either by observing a bird in a sitting posture or noticing the birds' defensive displays. Non-breeding individuals may form nomadic flocks in the breeding season (Thomas 1969), and this appeared to occur at one floodplain in April 2016 (Fig. 6).

Recurvirostridae

Represented by one species, the White-headed Stilt which was recorded in 32% of surveys. Counts ranged from 12 to 25 birds/survey. They resided on the same floodplain between March and July in 2015 and 2016, during which the water levels provided large expanses of shallow water. Ephemeral wetlands are most suitable for stilts as water levels recede (Halse *et al.* 2005; Iqbak 2008; Gönner *et al.* 2014), which was apparent in the present study. The floodplain that the stilts used varied in water depth from being completely dry in midsummer to several metres deep in spring and late summer. During the latter conditions, shallow water areas overlay fringes of dense vegetation and stilts were absent.

Figure 6. *An aggregation of Masked Lapwings circling a floodplain after being disturbed.*

Photograph by M. Mo.

Ardeidae

Represented by five species. Despite being a recent coloniser and not being found in Greater Sydney until 1960 (Hewitt 1961), the Cattle Egret was the most common egret at EMAI demonstration site, occurring in approximately 94% of surveys. Cattle Egrets occurred where cattle and sheep were located, rather being seen near water sources. Flocks of roosting Cattle Egrets were observed perching on dead trees in the early morning and late afternoon. Although elsewhere their roost sites have been associated with water (Siegfried 1971), roosts in the present study were all more than 100m from the nearest water body. The Eastern Great Egret and Intermediate Egret were each seen only once. The White-necked Heron was recorded twice at the same floodplain. The White-faced Heron was also considered a rare visitor to the study site, although it was very common in surrounding towns (pers. obs.). Three related species (Little Egret, *Egretta garzetta*, Australian Little Bittern, *Ixobrychus dubius* and Nankeen Night Heron, *Nycticorax caledonicus*) have also been recorded in the Macarthur region (Dimitriadis *et al.* 2013), but were not recorded in the present study.

Threskiornithidae

Represented by three species. The Australian White Ibis was recorded in all surveys, either foraging on lawns or at dams. In urban and peri-urban areas of eastern Australia, aggregations of these ibises are considered pests due to noise pollution and fouling at nesting colonies (Corben and Munro 2006), threats to aircraft safety, and scavenging in public places (Ross 2004; Martin *et al.* 2007). In the present study, sightings were limited to lone birds or small flocks, which do not present such problems. Prior to the present study, counts on the study site showed a 10% reduction between 1996 and 2003, which was anecdotally attributed to improvements to the management of a nearby landfill site (Ridgeway 2015). Currently, there is still a long-established breeding colony in Lake Annan 3km northeast of the study site (Martin *et al.* 2010; Martin and Major 2010) and other major breeding colonies exist elsewhere in the Macarthur region.

The Straw-necked Ibis was also recorded in all surveys, usually foraging in paddocks or resting on floodplain islands.

Their preference for cultivated pastures such as those present in the study site has led to their 'success' in agricultural areas (Dawson *et al.* 1991). Flock sizes ranged from four to 67 birds and were small compared with the flock sizes of several hundred (Carrick 1962; McKilligan 1979; Marchant and Higgins 1990) and thousands recorded elsewhere (Hamilton *et al.* 2004).

Yellow-billed Spoonbills were recorded only as lone birds at the same small dam over three surveys. This dam appeared to be shallow, as one of the birds was seen foraging. The Royal Spoonbill, *Platalea regia* was not recorded, despite being the more abundant spoonbill in Greater Sydney (Burgin 2010; Harris *et al.* 2010; Schulz and Magarey 2012; Mo and Waterhouse 2015b).

Pelicanidae

The Australian Pelican was recorded in six surveys, mostly as single birds in the Institute Dam and one floodplain, although one flock of four pelicans was recorded in April 2016. Although pelicans exploit farm dams for short periods, they prefer larger water bodies (Gosper 1981; Fjeldsa 1985) and this was reflected in the present study. It has been suggested that they use agricultural wetlands for roosting, but feed elsewhere (Hamilton *et al.* 2017), and this pattern is a likely factor in the species' variability in occurrence at the study site. In eastern Australia, pelicans also disperse from the coast during inland rainfall events (Marchant and Higgins 1990); a widespread departure from coastal areas has sometimes been noted at such times (Woodall 1985), although such dramatic departures are not known for Greater Sydney.

Phalacrocoracidae

The Little Pied Cormorant, Little Black Cormorant and Pied Cormorant were recorded in all surveys, being observed in various river habitats, dams, lagoons and floodplains. Cormorants commonly used farm dams, especially when suitable roosting trees were also present (Barlow and Bock 1984; Hamilton *et al.* 2017). Nesting was recorded in River She-oaks at the Institute Dam, where all species were recorded foraging. Little Pied Cormorants tended to forage in groups in larger watercourses, while lone individuals also foraged in small dams (Carlson 2015). Islands formed in floodplains by retreating waters provided refuge for mixed aggregations of Little Black and Little Pied Cormorants exceeding 90 birds. The Great Cormorant was recorded in 35% of surveys, mainly at the Institute Dam.

Anhingidae

The Australasian Darter was observed in 31% of surveys. Apart from one on a floodplain, all sightings were made in the Nepean River. Although this species exploits artificial watercourses, it prefers larger water bodies and apparently avoids those that are narrow, turbid and dense with weeds (Broome and Jarman 1983). On this basis, the only suitable habitats on the study site were the river, Institute Dam and water-filled floodplains.

CONCLUSIONS

The waterbird assemblages recorded here encompassed the 26 species identified by Ridgeway (2015) in an earlier investigation at the same site, indicating some constancy of species' occurrence. However, three species (Great-crested Grebe, Pied Cormorant and Australasian Darter) that were not recorded by Ridgeway (2015) were present during my investigation, albeit in fewer than 40% of surveys. Observations of breeding by the Great-crested Grebe, a scarce species in the Greater Sydney region, particularly highlight the conservation importance of wetland habitats conserved on the EMAI demonstration site.

Acquiring knowledge of the status of waterbird assemblages in Greater Sydney is important as the metropolitan area expands and the loss of farm dams reduces wetland availability (Hull 2016). Patterns in waterbird occurrence and abundance are difficult to determine in the absence of long-term monitoring, but studies such as the present one can be helpful through documenting habitat use by waterbirds on an agricultural site containing wetlands, which in general is poorly documented. Wetland selection by waterbirds may be based on several factors, such as size, habitat complexity, connectivity to other wetlands and resource quality (Sebastián-González *et al.* 2010). One component of the wetland complex, farm dams, plays varying roles for different bird species, for example as foraging or roosting sites and/or as refuges during drought (Hamilton *et al.* 2017), and movements between farm dams and other habitats result in a local redistribution of species. The short-term composition of waterbird assemblages may be influenced by factors beyond the immediate geographical context, such as availability of similar resource areas nearby and the dynamics of large-scale, dispersal movements in response to inland flooding (Woodall 1985; Marchant and Higgins 1990). It should be emphasised that the present three-year study, whilst providing a valuable contribution on waterbirds' occurrence in Greater Sydney, covers only a brief 'snapshot' in time.

Many authors point out that agricultural intensification and expansion has had a major impact on habitat availability for birds (Sutherland *et al.* 2012; Smith *et al.* 2013; Hamilton *et al.* 2017). In the Greater Sydney region, wetlands formerly impacted by agricultural expansion are now under threat from urban sprawl (Burgin *et al.* 2016), which highlights the high conservation value of existing parks, reserves and government-owned sites such as the EMAI demonstration site. The role that an agricultural institute can play in conserving biodiversity and providing ecosystem services is therefore of interest in wildlife management (Czech and Parsons 2002; Wilson *et al.* 2010; Kandziora *et al.* 2013). This study also highlights how the local persistence of waterbirds varies with habitat availability, such that agricultural lands can potentially be managed to maximize the diversity of their waterbird assemblages through providing a broad range of habitats.

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