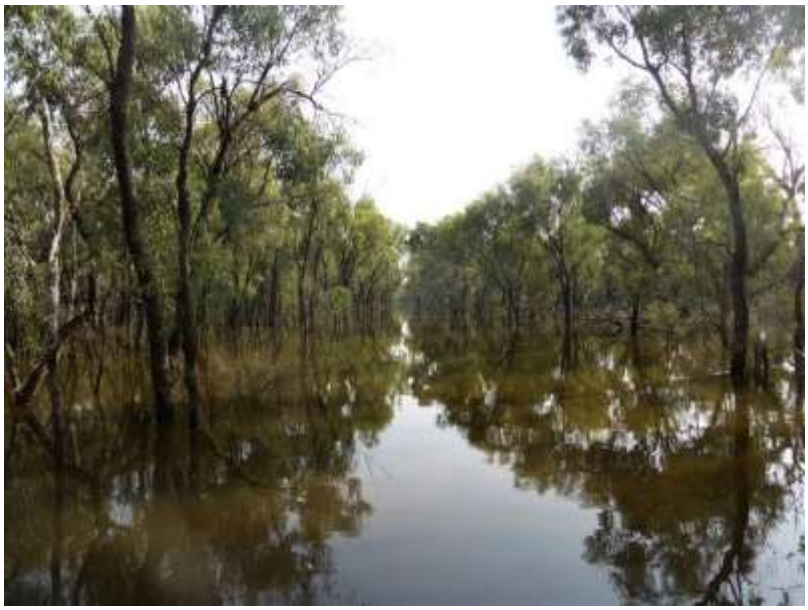
# Birds in Black Box woodlands and associated habitats along the Murray River from Hattah-Kulkyne NP to Lindsay Island, spring 2019 to autumn 2020

Final report from surveys November 2019 to April 2020, with notes on waterbirds and mammals

Richard Loyn, Dan Eyles and Garry Cheers

Eco Insights



Prepared for the Mallee Catchment Management Authority

mallee
catchment management authority

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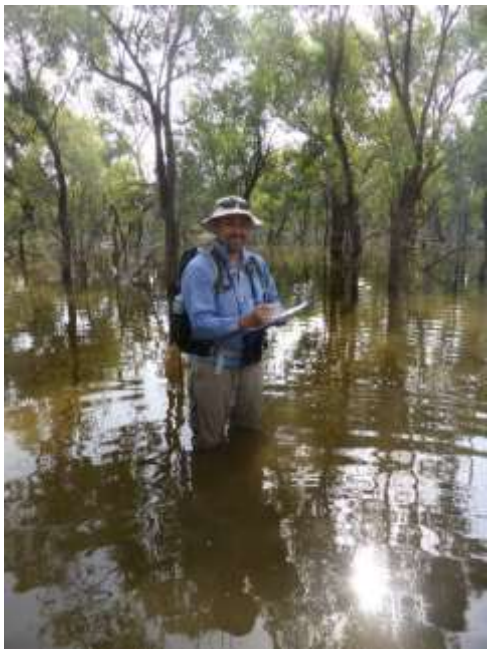
Photos: cover, flooded black box woodland near Lake Kramen, January 2020;
below, Dan Eyles doing bird surveys in that area January 2020 (©Richard Loyn).



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# Executive Summary

Surveys of birds were conducted in black box *Eucalyptus largiflorens* woodland and associated habitats in Hattah-Kulkyne National Park, Nangiloc, Kings Billabong and the Lindsay-Mulcra-Wallpolla Icon site (Mulcra Island and Lindsay Island, in the Murray-Sunset National Park) in spring 2019, summer 2019 and autumn 2020, with 228 sites surveyed (mostly in autumn 2020 with 19 of them also in spring 2019 and 40 in summer 2020). The surveys recognise that woodland birds can serve as indicators of ecosystem health. The main objectives were to assess short-term effects of environmental flows into part of Hattah-Kulkyne National Park (Lake Kramen and surrounding woodland) in spring-summer 2019; to strengthen our knowledge of bird communities in a range of habitats on Mulcra Island, Lindsay Island and adjacent areas as a baseline for proposed manipulations; and to gather further data on changes over time in all these regions and two others (Nangiloc and Kings Billabong) that we monitored in autumn 2020 as part of a program that has continued since 2014. The sites included 55 sites in Hattah-Kulkyne National Park, six sites at Nangiloc, 17 sites at Kings Billabong near Mildura, 104 sites on Mulcra Island and 51 sites on or near Lindsay Island. Area-searches of 1 ha in 10 minutes were used to survey bush birds on these sites.

At Hattah, land birds increased in abundance in woodland near Lake Kramen when it was flooded in summer 2020, and they increased further as waters receded in autumn 2020 (to 173% of previous levels). This shows the short-term benefits of environmental flows. Regent Parrots participated in this increase, becoming twice as numerous as on any of our assessments since 2014. In the area surrounding Lake Mournpall, land bird abundance declined as nearby lakes became dry, to 57% of previous levels on sites that had been flooded in 2017-18, and even further in sites that had not been flooded (to 19%). This contrast shows that the benefits of environmental flows can persist after floodwaters have receded. The declines were probably due to hot dry weather as well as the drying of floodwaters. Despotic Noisy Miners (an influential bird species) increased slightly at Lake Kramen (but only occupied five out of 14 sites) and decreased substantially elsewhere (to 60% of previous levels on sites that had been flooded 2017-18, and 4% on sites that had not been flooded). Flocks of waterbirds were recorded in flooded woodland near Lake Kramen, at higher densities than on open water at Lake Kramen or receding lakes elsewhere.

In other locations, land bird abundance declined between autumn 2019 and autumn 2020 (to 52% of previous levels in black box woodlands at Kings Billabong, and 71% in a wide range of habitats at Mulcra Island and Lindsay Island). Surveys at subsets of sites in spring 2019 (on Lindsay Island) and summer 2020 (at Hattah) suggest the main declines happened over the hot dry summer period from November 2019 to January 2020. Declines were least in river red gum woodland (which have access to water from the river) and mallee (where soils and vegetation have intrinsic resilience). Greater declines were observed in black box woodland, reflecting their dependence on periodic flooding.

The main recommendation is to continue providing environmental flows to black box woodlands. Further investigation is needed on interactions between flooding, grazing, despotic miners and other birds. Continued strategic monitoring of bush birds as well as waterbirds is recommended, as they provide windows on ecological changes that last longer than the waters themselves.

## Introduction

This report describes the work done on woodland birds from spring 2019 to autumn 2020, in the context of previous work on floodplain woodlands in the Mallee, with a focus on two icon sites (Hattah Lakes and Lindsay-Mulcra-Wallpolla). The study was requested by the Mallee CMA, recognising that woodland birds can provide a useful indicator of floodplain habitat condition. The study focused on five locations that had been surveyed in the previous autumn (2019) along with other occasions since 2014 (Hattah-Kulkyne National Park; Nangiloc-Colignan; Kings Billabong (near Mildura); Mulcra Island and Lindsay Island). The main objectives of the current study were:

1. to assess short-term effects of environmental flows (in spring 2019) to part of the Hattah Lakes (Lake Kramen and surrounding black box *Eucalyptus largiflorens* woodlands), and concurrent drying of other black box woodlands in the west of Hattah-Kulkyne National Park (near Lakes Mournpall, Bitterang and Woterap);
2. to strengthen our knowledge of bird communities in a range of habitats on Mulcra Island and Lindsay Island to provide a quality baseline for proposed manipulations or any future delivery of environmental water. These may include new infrastructure to be built under the Victorian Murray Floodplain Restoration Project, and changes to weir pools resulting from weir lowering and raising activities at Weirs 7 and 8; and
3. to provide more information on changes over time in black box and other woodlands at all five locations, to help understand and manage these dynamic ecosystems.

As indicated in previous reports, the series of studies over six years from 2014 to 2020 represents a rare example of a sustained program examining effects of environmental flows on woodland birds, which provide a valuable window on changes to ecosystem health in various components of the ecosystem, from the ground to the canopy. The focus on black box woodlands is useful as they form a large but poorly studied component of the floodplain vegetation of the Murray-Darling Basin, which covers a large part of south-eastern Australia, including some of the most productive agricultural land and many areas of high environmental and cultural significance. The major rivers in the Basin distribute water over vast distances, sustaining human populations, agriculture and iconic ecosystems in a region with generally low and intermittent rainfall. The rivers have been regulated for many decades, and important decisions need to be made about allocating water for economic and environmental purposes (MDBA 2011, 2012): these decisions can often be controversial. The current set of studies helps provide new information about one of the extensive but poorly known natural features of the Basin (black box woodlands), to help government agencies make informed decisions about conserving their natural values and vitality.

In the period under review, major changes in water distribution occurred in the Hattah Lakes, in response to environmental flows. Lakes in the west of the Park (e.g. Mournpall, Bitterang and Woterap) had been flooded in 2017-18 and waters gradually receded over time. Most of our black box sites were already dry in autumn 2019, but water remained in nearby lakes and river red gum woodland (Loyn et al. 2019a). However, when we surveyed these sites in January and March-April 2020 they were all completely dry, usually with no standing water in sight. Lake Mournpall continued to hold water, but the shoreline was >100m from fringing stands of river red gum *Eucalyptus camaldulensis*. In contrast, Lake Kramen was full and our sites in the adjacent woodland were all flooded, up to ~1m in depth when we surveyed them in January 2020, as a result of

environmental flows delivered from August to November 2019. Water levels dropped substantially before our surveys at Lake Kramen in late March 2020, but all sites there remained wet with standing water visible in nearby channels or on parts of many sites.

Apart from the irrigated sites near Lake Kramen, all our sites in the current study had been affected by dry local conditions through much of 2018 and 2019, as part of a drought that affected most of south-eastern Australia and culminated in severe bushfires in more heavily forested parts of the country in spring and summer 2019-20. This was expected to have generally adverse effects on bird populations. However, drought can also cause birds to move from the most severely affected parts of their range to seek more benign conditions elsewhere. In spring 2019 some bird species that normally inhabit the arid interior of Australia (e.g. Budgerigar *Melopsittacus undulatus* and Crimson Chat *Epthianura tricolor*)[1] (Emison et al. 1987; Higgins 1999; Higgins et al. 2001; Barrett et al. 2003), were reported in Victoria at sites from Kerang (200 km south-east from Hattah) to Chiltern in north-east Victoria (unpublished data from various sources). This prompted us to conduct an unscheduled set of surveys on Lindsay Island (the most north-western of our study locations) to see if these species were occupying suitable habitats in that area.

The period also coincided with a national emergency, the covid-19 virus crisis. Associated travel restrictions and the need for social distancing disrupted our plans to have three observers doing fieldwork in late March and early April. Instead, two observers completed the fieldwork, working independently and either camping remotely or returning to a home base in Mildura, with appropriate safety procedures such as regular reporting.

[1] Scientific names of species observed during our surveys are listed in Appendix 1.

# Methods

## Study Areas

*Hattah-Kulkyne National Park and associated locations (Nangiloc and Kings Billabong)*

Hattah-Kulkyne National Park is a large National Park (48,000 ha) 50 km south-east of Mildura in north-west Victoria. The Park contains important representations of the Murray Mallee, as well as woodlands of black box and river red gum. Most of the black box woodland has been classed as Riverine Chenopod Woodland, in terms of Ecological Vegetation Class (the vegetation classification adopted by the Victorian Government) (White et al. 2003). Further details are given in our earlier reports (Loyn and Dutson 2015; 2016a, b; 2017a, b, c; 2018; Loyn et al. 2019a, b), and in Appendix 2.

Our initial sites had been selected in two parts of Hattah-Kulkyne National Park, each with extensive areas of black box woodland. One was in the north-west of the Park, mainly east of Mournpall Track near Lake Bitterang. The other was in the south-east of the Park, in the vicinity of Lake Kramen. Environmental flows were delivered to the Mournpall area in 2014, 2016 (supplementing a natural flood) and 2017, and to the Lake Kramen area in 2014 and now in spring 2019.

On each assessment we surveyed small numbers of supplementary sites in various habitats in the Park, and nearby Nangiloc, and at Kings Billabong near Mildura, to strengthen the data, address new questions and provide contextual data (Table 1). For our 2019-20 surveys, we focused mainly on black box woodlands at Hattah, to compare the newly flooded sites near Lake Kramen with the

drying sites in the Mournpall area. In January 2020 we assessed 14 flooded sites near Lake Kramen, about three weeks after the flood peaked in December 2019, along with 18 dry sites in the Mournpall area (11 of them having been flooded in 2017-18, and seven of them that had not been flooded in recent years). The water was up to ~1m deep on the flooded sites near Lake Kramen during this assessment. Second searches were made on some sites when it was logistically feasible to visit them a second time. Waterbirds were counted on Lake Kramen and Lake Mournpall, in addition to those observed on our woodland sites. We also conducted surveys at two sites in mallee, two on dunes and one in river red gum, in the Mournpall area.

In autumn 2020 we assessed the same 14 flooded sites near Lake Kramen, along with 36 dry sites in the Mournpall area (26 of them having been flooded in 2017-18, and ten that had not been flooded in recent years). Only shallow water remained on the flooded sites around Lake Kramen, but the lake remained full. The increased sampling effort in autumn had been planned as comparable data were available from previous years at that season, whereas the main aim of the summer sample was to obtain data from flooded sites near Lake Kramen soon after peak flood, and a sample of dry sites for comparison.

In autumn 2020 we also assessed five sites in sparse black box woodland near Nangiloc, one in riverside river red gum near Nangiloc and 17 sites in black box woodland at Kings Billabong.

*Mulcra Island and Lindsay Island (Lindsay-Mulcra-Wallpolla Icon Site)*

Lindsay Island and Mulcra Island cover ~6000 ha adjacent to the south bank of the Murray River, 80-120 km west of Mildura. Natural channels run through and around the islands, potentially isolating them from drier treeless plains and agricultural land to the south, but those channels only carry water intermittently. New regulators have been built on some of these channels to deliver water more effectively as part of The Living Murray initiative (MDBA 2011, 2013).

Vegetation includes various types of woodland dominated by river red gum *Eucalyptus camaldulensis* and black box *Eucalyptus largiflorens*, and treeless flats with tall shrubs of tangled lignum *Duma florulenta* (in flood-prone areas), hedge saltbush *Rhagodia spinescens*, herbs and low chenopods. Twelve main Ecological Vegetation Classes (EVCs) have been mapped for the area and they were used as the initial basis for site selection. Many variations and gradations between these EVCs were found in the field, and our analysis focused on eight vegetation types: forest stands dominated by river red gum (sometimes mixed with black box); black box woodland with a middle storey including moonah *Melaleuca lanceolata*; sparse black box woodland; other types of black box woodland; mallee vegetation; herbland in beds of ephemeral lakes or billabongs (usually with fringing river red gums); tall shrubland dominated by lignum or hedge saltbush; and low shrubland dominated by chenopods. Most of the black box woodland was classed as Riverine Chenopod Woodland EVC. Chenopods were the main understorey shrubs represented in most black box woodlands and in mallee vegetation. Mallee vegetation was represented mainly on elevated sandy soils south of Lindsay Island (near Lake Wallawalla) and was classed as Mallee Chenopod EVC. Extensive stands of mallee cover huge areas in the Murray-Sunset National Park further south.

Lindsay Island and Mulcra Island are managed by Parks Victoria as part of the Murray-Sunset National Park. Annual rainfall is low (261 mm), substantially less than at Mildura or the Hattah-Kulkyne National Park (~300 mm). Environmental flows were delivered to Lake Wallawalla in 2014

and 2017/18, and both Lindsay Island and Mulcra Island received extensive natural floods in winter and spring 2016, with peak flooding over ~70% of their area in December 2016. They remained dry after those floods receded, except for creeks that run year-round (Mullaroo Creek) or seasonally in spring (Lindsay North & South and Potterwalkagee) (C. Green pers. comm.).

For our 2019-20 surveys, we focused mainly on repeating the sites surveyed in autumn 2019, in autumn 2020 (Appendix 2). We conducted repeat surveys at 155 of the 175 sites surveyed on Lindsay Island and Mulcra Island the previous year. We also undertook an opportunistic survey of 19 of those sites on Lindsay Island in November 2019, to see if some of the inland-breeding birds recorded further upstream in the Murray Valley (notably Budgerigar and Crimson Chat) might have sought refuge from the 2019 drought in this dry corner of far north-western Victoria. Eight of the 19 sites were in black box with moonah, and eleven were in mallee chenopods.

### Field methods

Birds were surveyed on each site using timed area-searches (1 ha, 10 minutes) after Loyn (1986, 1998). All surveys were undertaken by individual observers in mild weather, with light wind and temperatures <35 °C. This is higher than our usual limit of 32 °C (Loyn et al. 2019a), but this summer and autumn were unusually hot (as was the previous autumn) and we needed to do a few counts in hotter weather than usual, and again found that birds were surprisingly active despite the heat. Each survey was conducted by an individual observer, with appropriate protocols for communication to ensure safety. During peak flood near Lake Kramen, pairs of observers worked simultaneously on separate sites close to each other as an added safety precaution while wading through shallow water.

On each search, an observer walked around the site, recording numbers of individual birds of each species seen or heard. Birds observed off the site were recorded separately and not considered further in the analysis. Birds flying over the site were considered as off-site unless they were species that typically search for prey in open air (swallows, martins, woodswallows and birds of prey). Birds flying below the canopy were considered as on-site, unless it was obvious that they were making long-distance movements with no intention of stopping in the site. Indirect signs of birds (scats, feathers or footprints) were scored as 0.1 in analysis. Observations or indirect signs of mammals and reptiles were treated in the same way as birds.

### Data presentation

Data were collated for each session (spring, summer and autumn). Values were calculated for various guilds of species, by summing corresponding values for each species in the guild. As in previous reports (e.g. Loyn et al. 2019a), this was done for total native bush birds, water birds, introduced birds (of which there were none) and a range of groupings based on food, nest-site or migratory status (Appendix 1). For the current report, our main aims were to compare changes on parts of Hattah-Kulkyne National Park that were newly flooded or drying, and to document changes at all sites compared with the previous autumn (i.e. to compare bird numbers in autumn 2020 with those from autumn 2019). Mean values were tabulated for woodland bird species and guilds by habitat and region. Ratios of mean abundances in autumn 2020 compared with autumn 2019 were considered where appropriate. For the 19 sites on Lindsay Island surveyed in three seasons (autumn 2019, spring 2019 and autumn 2020) results were tabulated and compared for those three seasons.

For the sites at Hattah that were newly flooded in 2019, or drying out from previous floods in 2017-18, results were compared with predictions based on earlier modelling (Loyn et al. 2019a).

# Results

The species composition of land birds was broadly similar to previous years (Appendix 3, Tables A1-A4), as was the structure of guilds for feeding, nesting and migration (Tables 1-5). As usual, no introduced birds were observed on any of the sites. This report focuses on land birds, but selected information on waterbirds and mammals is presented in Appendix 4 (waterbirds) and Appendix 5 (mammals).

### Effects of environmental flows at Hattah (Kramen in flood vs Mournpall now dry)

Land birds near Lake Kramen were 126% as abundant when it was flooded in January 2020 as they had been the previous autumn, and 173% as abundant in autumn 2020 as in the previous autumn (Table 1). These increases were evident for most guilds (Table 1), with the exception of seed-eaters that feed close to the ground (reduced to 5.7%) and carnivores (reduced to 37%). Many guilds were more than twice as abundant as they had been the previous autumn (Table 1). Despotic miners had almost tripled in abundance, but they were only found on five of the 14 sites (compared with three sites the previous autumn when it was dry). Small birds (often excluded by miners) had almost doubled in abundance, and they were mainly found on sites not occupied by miners. Regent Parrots doubled in abundance in woodland near Lake Kramen as floodwaters receded in autumn 2020, becoming more numerous than on any of our assessments since 2014, with groups up to 30 resting in trees on individual sites. Other species attracted by the environmental flows included Sacred Kingfisher and Rainbow Bee-eater (on the summer assessment), Little Friarbird, Magpie-lark and a range of small birds (Table A1, Appendix 3).

In contrast, land birds in sites near Mournpall Track that had been flooded in 2017-18, had declined to 57% of levels observed the previous autumn (Table 1), and no guilds showed increases over this period. The declines were evident (at substantial levels) for most feeding guilds except seed-eaters that feed close to the ground (95%), canopy-foraging insectivores (79%) and seed-eaters that feed at all levels (74%). Among nesting guilds, large hollow-nesters showed no substantial decline (97%). The most severe declines were for large or small insectivores that feed from open ground among trees: these proved scarce in summer 2020 and none were found two months later in autumn 2020. Shrub-foraging insectivores also disappeared in autumn 2020, after a temporary increase in summer 2020 (Table 1). Despotic miners had decreased to 60% of previous levels, and small birds had decreased to 52% of previous levels, in line with the overall average declines (Table 1).

Land birds in sites near Mournpall Track that had not been flooded in the last ten years showed even greater declines (to 19%) from autumn 2019 to autumn 2020 (Table 1). The declines involved all feeding guilds except shrub-foraging insectivores, which increased fourfold after a temporary disappearance in summer 2020 (Table 1). This guild was represented on these occasions by a single species, Chestnut-rumped Thornbill (Table A1, Appendix 3). Nectarivores other than miners had disappeared completely; despotic miners had declined to 3.9% of previous levels and small birds had declined to 55% of previous levels (Table 1).

One uncommon land bird was found near Lake Kramen in autumn 2020: a Black-chinned Honeyeater heard calling near BB40/41 (off-site). This species generally occurs on the inland slopes of the Great Dividing Range, and more widely in woodland further north in Australia, but it is rare in the Mallee (Emison et al. 1987; Barrett et al. 2003).

As expected, waterbirds became common in woodlands near Lake Kramen when they were flooded, with 4.8 waterbirds recorded per hectare in January 2020, dropping to 0.4 when most water had receded in March 2020 (Table 1). The density of waterbirds in January 2020 was almost twice as high as on the open waters of fully flooded Lake Kramen, which in turn was many times higher than on the open waters of drying Lake Mournpall (Appendix 4).

### Changes in bird communities in other habitats at Hattah

Land birds in mallee and dune vegetation at Hattah showed little change in abundance compared with autumn 2019, just a small increase to 116% of previous levels (Table 2). There were some apparent changes in species composition. Small and mid-sized birds had increased (respectively to 148% or 163% of previous levels) whereas large birds had decreased (to 35% of previous levels). The increase in small birds involved insectivores that feed from open ground or low shrubs, whereas insectivores that feed from tall shrubs or the canopy showed little change (Table 2). Nectarivores (most of which are small) had bucked the trend and declined to 8% of previous levels, and despotic miners were not recorded on these surveys (Table 2).

The decline in large birds was driven mainly by changes in three feeding guilds, which were not observed on these sites during the current surveys. These were carnivores (previously represented mainly by Grey and Pied Butcherbird), insectivores that feed from open ground among trees (White-winged Chough) and seed-eaters that feed mainly in trees (Australian Ringneck and other parrots). Some of these species were observed off-site during the current surveys.

Our surveys in mallee and dune vegetation were conducted in January 2020 compared with March 2019, and some of the differences described above may be due to this seasonal difference, and to the small number of sites surveyed.

### Changes in bird communities at Nangiloc and Kings Billabong

Land birds in sparse black box woodland at Nangiloc appeared more abundant than in autumn 2019 (Table 2), but this may be partly because the surveys at these sites in autumn 2019 were conducted in suboptimal hot conditions, and fewer birds than usual were found. The levels observed in autumn 2020 were similar to longer-term averages at these sites. The location continues to support at least one species that is rarely found in black box woodland at Hattah (Chestnut-crowned Babbler). A group of another species that only occurs at Hattah in open country and dune vegetation (Southern Whiteface) was observed at Nangiloc during these surveys (Table 2). Two species of fairy-wren that have often been observed at Nangiloc on past surveys (Variegated and White-winged Fairy-wrens) were not observed there during the current surveys.

Land birds at Kings Billabong were about half as abundant as in autumn 2019 (51%, Table 2). The trend was more evident for large birds (dropping to 16.4%) than small birds (56%), while mid-sized birds showed no change in abundance (99%) (Table 2). Most feeding guilds followed the general trend, and greater declines were evident for seed-eaters that feed mainly in trees (to 19.5%),

generalist insectivores (to 13.7%) and carnivores (to 10.3%). The main species involved were Yellow Rosella, Grey Shrike-thrush and both Grey and Pied Butcherbird (Table 2). Seed-eaters that feed close to the ground bucked the trend, increasing to 113% of previous levels (Table 2): this was mainly due to increased numbers of Red-rumped Parrots. Despotic Noisy Miners appeared to have increased (to 126% of previous levels) but had not expanded their range: they were observed only on four of the 17 sites surveyed (vs 5/19 in 2019).

Some species of small bird that are usually found at Kings Billabong, were not encountered on-site during the current surveys. They included Spotted Pardalote, Blue-faced honeyeater, Varied Sittella, Golden Whistler, Grey Fantail, Red-capped Robin, Hooded Robin and Silvereye. Four of those species are believed to be mainly winter visitors from forests in the Victorian ranges further south (Spotted Pardalote, Golden Whistler, Grey Fantail and Silvereye).

### Changes in bird communities at Mulcra Island and Lindsay Island

*Sites on Lindsay Island that were surveyed in spring 2019 as well as autumns 2019 & 2020*

On the subset of 19 sites at Lindsay Island that were surveyed in spring 2019 as well as autumn 2019 and 2020, land birds appeared to have increased in abundance in spring 2019 but then decreased substantially by autumn 2020 (to 54% of previous levels) (Table 3). In general, large birds appeared to have increased and small birds had decreased. Among feeding guilds, substantial declines were observed for canopy-foraging insectivores and shrub-foraging insectivores. Aerial insectivores and bark-foraging insectivores had disappeared from these sites in autumn 2020 (Table 3).

On the other hand, four feeding guilds showed substantial increases in autumn 2020 compared with the previous autumn (Table 3). These were despotic miners, large insectivores that feed from open ground among trees, seed-eaters that feed mainly close to the ground and carnivores. The miners on these sites were mainly Yellow-throated Miners; the large insectivores were White-winged Choughs; the seed-eaters were mainly Galahs and Blue Bonnets; and the increase in carnivores was mainly due to increases in Australian Ravens and Pied Butcherbirds, with Grey Butcherbirds showing little change (Appendix 3, Table A4).

*Larger set of sites on Mulcra Island and Lindsay Island that were surveyed in autumns 2019 and 2020*

With the much larger set of data from 186 sites surveyed in autumn 2019 and 158 sites surveyed in autumn 2020, the decline seemed to be less (to 71% of previous levels) (Table 4). Large birds increased over this period (to 127%) and small birds decreased (to 52%). Among feeding guilds, the steepest declines were for aerial insectivores (to 10.8% of previous levels) and small insectivores that forage from open ground among trees (to 37%). Despotic miners increased (to 139%), involving both Noisy Miner (in river red gum and some black box sites) and Yellow-throated Miner (in mallee and some black box sites) (Table 4). Nevertheless, miners were only represented on 15 of the 158 sites surveyed in autumn 2020. Carnivores (mainly butcherbirds) and generalist insectivores (Grey Shrike-thrush) also showed substantial increases over this period (Table 4).

Land bird abundance varied between habitats, being highest in river red gum woodland and lowest in low chenopod shrublands (Table 4). Black box woodlands supported generally high populations, followed by mallee and lignum. Some species showed strong associations with particular habitats

while others were widely distributed across habitats, depending on the availability of resources including tree and shrub cover.

Four bird species were found at Lindsay Island or Mulcra Island during these surveys that are notable because they are uncommon in the region. The birds were a Red-backed Kingfisher on Lindsay Island near LI14 in spring 2019, and a Diamond Dove on Mulcra Island at MI2, a Western Gerygone on Mulcra Island at MI9, and two Diamond Firetails on Lindsay Island at LI1, all in autumn 2020. The Red-backed Kingfisher and Diamond Dove are both species with inland distributions. However, there was no sign of a large-scale influx of irruptive inland-breeding birds (such as Budgerigars and Crimson Chats) that prompted the spring surveys, on any of the three assessments.

# Discussion

### Effects of environmental water at Hattah

The observed increases in land bird abundance at Lake Kramen (by 26% when flooded and by 73% as waters receded the following autumn) accord with the 60% increase predicted from previous modelling (Loyn et al. 2019a). The increases demonstrate the short-term value of environmental flows for bush birds, and indicate a general increase in ecosystem productivity, with evidence from bird guilds inhabiting all strata of the black box woodlands (ground, shrubs, bark, flowers and canopy).

Regent Parrots were among the land bird species to benefit from the flows, becoming more numerous than on any of our previous surveys. The south-eastern subspecies of Regent Parrots is listed as Vulnerable in Victoria and nationally (Garnett et al. 2011), and we have observed flocks feeding on seeds of native and introduced plants round the margins of receding lakes, and in previously flooded black box woodland. Regent Parrots have benefitted from land use changes such as planting of vegetation corridors and almond orchards (Luck et al. 2014), but it is clear that environmental flows are also providing a positive benefit to this threatened subspecies.

The observed decreases in land bird abundance in the Mournpall area (by 43%, two and a half years after flooding) were greater and sooner than predicted by those models, and consistent with predictions for more than three years after a flood (Loyn et al. 2019a). The declines may have been exacerbated by the hot and dry conditions which prevailed for much of 2019. This idea is supported by the even greater declines in land bird abundance (by 82%) observed on sites in the Mournpall area that had not flooded since we began our surveys in 2014; those sites are known not to have been inundated for at least ten years. In comparison, the sites that had flooded in 2017/18 and were now dry were able to support more birds (two years after the floods receded from those sites) than if they had not been flooded. This demonstrates a benefit from environmental flows that lasts longer than the actual floodwaters. This may reflect the productivity of the sites that had been flooded, perhaps through continuing access to ground water. Also, extended saturation of the sub-surface soil may have facilitated faster and more effective recharge from local rainfall (D. Wood, pers. comm.). Some of the sites were within a kilometre or so of drying lakes that still contained standing water (e.g. Lake Bitterang), and those lakes may have been used for drinking by some of the more wide-ranging birds.

### Effects of despotic miners

Previous reports have identified the strong role of despotic miners in reducing populations of small birds, as have many studies elsewhere. Miners exclude smaller birds from their communal territories (Dow 1977; Loyn 1987; Grey et al. 1997, 1998), affecting community structure and earning them the title of despotic species (Mac Nally et al. 2012; Maron et al. 2013; Thomson et al. 2014). Noisy Miners have recently been recognised as having a strong influence in black box woodlands in New South Wales, just as they do here, contributing to the complex dynamics of floodplain woodlands (McGinness et al. 2018).

Our analyses last year showed that both miners and small birds benefit from environmental flows, but not on the same sites at the same time (Loyn et al. 2019a). The current observations from Lake Kramen support the conclusion that Noisy Miners benefit from environmental flows, increasing in number and occupying five of the 14 newly flooded sites compared with three the previous autumn when they were dry. But happily the other nine newly flooded sites remained unoccupied by miners, and they attracted a substantial influx of small woodland birds.

Numbers of Noisy Miners in the Mournpall area had plummeted with the recession of water from the lakes and the general dry conditions, declining by 40% on sites that had been flooded in 2017-18, and by 96% on sites that had not flooded. In some cases, the birds appeared to have moved into nearby river red gum stands as waters receded, and birds were heard or seen calling off-site from those habitats. It is likely that movement, mortality and low breeding success all played a part in the retreat of these birds from black box woodland where they had previously been dominant. With any of these mechanisms, it is likely that reduced productivity of the black box woodlands (due to the retreat of floodwaters and hot dry conditions) precipitated the decline in miners. This idea is supported by the weak response of small birds to the retreat of the miners, suggesting a general decline in woodland productivity.

### Effects of vegetation type on Mulcra Island and Lindsay Island

The new set of data from Mulcra Island and Lindsay Island provided a very similar picture to that reported previously (Loyn et al. 2019b), with land birds being most common in river red gum woodland and least common in low chenopod shrubland. This pattern reflects the structural diversity of each vegetation type (with treed habitats supporting more birds than low shrubland) and also the assumed productivity (with river gum woodland generally having access to water from the river).

Notwithstanding this general trend, each vegetation type had its own characteristics and made its own contribution to the regional bird fauna. Some species that favour tall shrublands were more likely to be found in stands of lignum or low chenopod shrublands than in the more productive red gum or black box woodlands. Mallee is known to support a distinctive fauna, although few of its specialist species were observed on the small number of sites examined in this study.

### Changes over time in all locations (autumn 2019 to 2020)

The most dramatic changes observed for land birds were the increases in abundance at Lake Kramen, due to the environmental flow, and the decreases at all other locations (with the exception of Nangiloc, where the sample size was small and surveys the previous year had been done under

suboptimal conditions). The surveys at Lindsay Island in spring 2019 showed that on those sites the decline had not yet happened, whereas the surveys in the Mournpall area showed that bird numbers had declined there by January 2020. It is very likely that the hot dry weather throughout 2019 contributed to declines in all unirrigated areas, and perhaps the biggest change was in the November-January period.

The data from Mulcra Island and Lindsay Island allow changes over time (autumn 2019 to autumn 2020) to be compared between a range of different habitats. These comparisons show that the smallest observed changes were in mallee chenopods (5% decline) and river red gum woodlands (14% decline), compared with an average decline of 29% across all habitats. The greatest declines were in black box woodland with moonah mid-storey (57% decline) and sparse black box woodland (45%). This variation is undoubtedly a function of the habitat not the individual bird species, as many of the bird species are common to all these treed habitats. The evident resilience of river red gum woodland is easily explained as these woodlands are mainly close to the Murray River, and the trees can be assumed to have access to permanent water from the river, including groundwater pools that may extend inland from the river or along channels. The resilience of mallee may be a function of the hydrology of the sandy soils on which they grow, with moisture retained on dunes, and the adaptations of the plants that grow there, and their ability to survive and thrive under hot dry conditions. The lower resilience of black box woodlands may reflect their dependence on periodic flooding, and their distribution in parts of the landscape without access to permanent water. This highlights the importance of environmental flows in maintaining the health of black box woodlands.

### Recommendations for management

The current results reinforce previous conclusions that environmental flows make an important contribution to maintaining the health of black box woodlands. They also provide a new perspective on the sensitivity of various bird communities (and by implication their woodland habitats) to hot dry conditions, with black box appearing to be more sensitive than others. Hence our main recommendations are:

1. to continue to provide environmental flows to black box woodlands at ecologically appropriate seasons, frequencies and durations, when it is feasible;
2. to conduct further investigations into the interactions between flooding, grazing, despotic miners and other birds, so that flood regimes and herbivore management (kangaroos and introduced species) can be tailored to provide benefits to the woodland species whose needs are greatest; and
3. to continue to include bush birds as well as waterbirds in monitoring programs, as they provide windows on ecological changes that last longer than the waters themselves.

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**Table 1.** Mean relative abundance (birds observed per standard 10-minute search of 1 ha per survey) of bird guilds in black box woodland in Hattah-Kulkyne National Park 2019-20, on sites near Lake Kramen (LK) that were flooded with environmental flows in 2019-20 (having been dry since 2015), sites near Mournpall Track (MP) that had been flooded in 2017-18 but were now dry, and sites near Mournpall Track that had not been flooded for >10 years. Note that the feeding guilds are comprehensive for land birds observed, whereas only a selection of other groupings are shown (e.g. hollow nesters). See Table A1 in Appendix 3 for equivalent data on bird species.

| Region at Hattah | LK | LK | LK | MP | MP | MP | MP | MP | MP |
|---|---|---|---|---|---|---|---|---|---|
| Floods recorded in last 10 years? | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Flood status at time | Dry | Flooded | Receding | Dry | Dry | Dry | Receded | Dry | Dry |
| Date | Aut 2019 | Sum 2020 | Aut 2020 | Aut 2019 | Sum 2020 | Aut 2020 | Aut 2019 | Sum 2020 | Aut 2020 |
| Number of sites | 14 | 14 | 14 | 9 | 7 | 10 | 20 | 11 | 26 |
| **Bird guild for feeding (all land birds were assigned to one of these categories)** | | | | | | | | | |
| Aerial insectivores | 0.00 | 0.71 | 0.21 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 |
| Bark-foraging insectivores | 0.00 | 0.00 | 0.36 | 0.56 | 0.00 | 0.00 | 0.05 | 0.18 | 0.00 |
| Canopy-foraging insectivores | 2.24 | 4.88 | 2.79 | 2.22 | 0.43 | 1.60 | 3.05 | 2.00 | 2.42 |
| Carnivores (taking vertebrates & large invertebrates) | 0.77 | 0.88 | 0.29 | 1.22 | 0.00 | 0.20 | 0.60 | 0.82 | 0.23 |
| Generalist insectivores | 0.29 | 0.18 | 0.50 | 0.00 | 0.00 | 0.00 | 0.10 | 0.09 | 0.04 |
| Miners (despotic nectarivores) | 0.41 | 1.18 | 1.14 | 2.56 | 0.00 | 0.10 | 3.20 | 0.55 | 1.92 |
| Nectarivores (other than miners) | 0.35 | 0.35 | 1.14 | 1.22 | 0.00 | 0.00 | 0.80 | 0.27 | 0.08 |
| Open-ground insectivores (may be far from cover) | 0.94 | 0.71 | 1.07 | 1.11 | 1.00 | 0.00 | 0.65 | 1.09 | 0.27 |
| Large open-ground insectivores (among trees or shrubs) | 0.00 | 0.00 | 1.00 | 1.78 | 0.43 | 0.00 | 1.20 | 1.73 | 0.00 |
| Small open-ground insectivores (among trees or shrubs) | 0.06 | 0.18 | 0.43 | 0.00 | 0.00 | 0.20 | 0.25 | 0.09 | 0.00 |
| Open-ground insectivores (among trees or shrubs) | 0.06 | 0.18 | 1.43 | 1.78 | 0.43 | 0.20 | 1.45 | 1.82 | 0.00 |
| Seed-eaters (feeding mainly close to ground) | 1.25 | 0.43 | 0.07 | 3.93 | 0.01 | 0.30 | 0.86 | 0.81 | 0.81 |
| Seed-eaters (feeding at all levels, often in trees) | 2.35 | 2.24 | 5.50 | 1.22 | 0.29 | 0.10 | 2.65 | 0.73 | 1.96 |
| Shrub-foraging insectivores (all favouring tall shrubs) | 0.71 | 0.24 | 1.79 | 0.11 | 0.00 | 0.50 | 0.15 | 0.64 | 0.00 |

| Region at Hattah | LK | LK | LK | MP | MP | MP | MP | MP | MP |
|---|---|---|---|---|---|---|---|---|---|
| Floods recorded in last 10 years? | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Flood status at time | Dry | Flooded | Receding | Dry | Dry | Dry | Receded | Dry | Dry |
| Date | Aut 2019 | Sum 2020 | Aut 2020 | Aut 2019 | Sum 2020 | Aut 2020 | Aut 2019 | Sum 2020 | Aut 2020 |
| **Groups of land birds (other than miners) based on size in relation to despotic miners (60-70g)** | | | | | | | | | |
| Large land birds (>70g) | 5.01 | 3.90 | 7.64 | 9.16 | 1.73 | 0.60 | 5.31 | 4.99 | 3.12 |
| Small land birds (<60g) | 3.47 | 6.47 | 6.64 | 4.22 | 0.43 | 2.30 | 4.90 | 3.18 | 2.54 |
| Mid-sized land birds other than miners (60-70g) | 0.47 | 0.24 | 0.79 | 0.00 | 0.00 | 0.00 | 0.20 | 0.27 | 0.15 |
| **Selected bird guilds for nesting and migration** | | | | | | | | | |
| Large hollow-nesters | 2.94 | 2.35 | 5.50 | 3.67 | 0.29 | 0.40 | 2.70 | 0.73 | 2.62 |
| Small hollow-nesters | 1.59 | 1.94 | 2.07 | 1.11 | 0.00 | 0.50 | 1.75 | 1.82 | 0.27 |
| Hollow-nesters | 4.53 | 4.29 | 7.57 | 4.78 | 0.29 | 0.90 | 4.45 | 2.55 | 2.88 |
| Summer migrant land birds | 0.18 | 1.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 |
| **Total land birds (all were native)** | **9.36** | **11.78** | **16.21** | **15.93** | **2.16** | **3.00** | **13.66** | **8.99** | **7.73** |
| Total water birds | 0.01 | 5.12 | 0.36 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |

**Table 2.** Mean relative abundance of bird guilds in black box woodland at Kings Billabong (near Mildura) and Nangiloc (on Murray River near Hattah-Kulkyne National Park) in autumn 2019 and autumn 2020; and in mallee and dune vegetation at Hattah-Kulkyne National Park, autumn 2019 and summer 2020 (birds observed per standard 10-minute search of 1 ha). Note that the feeding guilds are comprehensive for land birds observed, whereas only a selection of other groupings are shown (e.g. hollow nesters). See Table A2 in Appendix 3 for equivalent data on bird species.

| Location | Kings Billabong | Kings Billabong | Nangiloc | Nangiloc | Hattah (mallee & dune) | Hattah (mallee & dune) |
|---|---|---|---|---|---|---|
| Date | Autumn 2019 | Autumn 2020 | Autumn 2019 | Autumn 2020 | Autumn 2019 | Summer 2020 |
| Sites | 19 | 17 | 5 | 5 | 13 | 4 |
| **Bird guild for feeding (all land birds were assigned to one of these categories)** | | | | | | |
| Aerial insectivores | 0.71 | 0.35 | 0.00 | 0.00 | 0.00 | 1.75 |
| Bark-foraging insectivores | 0.19 | 0.12 | 0.00 | 0.00 | 0.00 | 0.25 |
| Canopy-foraging insectivores | 4.52 | 2.29 | 1.40 | 2.20 | 2.62 | 2.75 |
| Carnivores | 1.14 | 0.12 | 1.00 | 0.00 | 0.46 | 0.00 |
| Frugivores | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Generalist insectivores | 0.43 | 0.06 | 0.00 | 0.00 | 0.00 | 0.25 |
| Miners (despotic nectarivores) | 0.48 | 0.59 | 0.00 | 0.40 | 0.23 | 0.00 |
| Nectarivores (other than miners) | 2.57 | 1.35 | 0.20 | 0.00 | 3.15 | 0.25 |
| Open-ground insectivores (may be far from cover) | 1.14 | 0.41 | 0.20 | 0.80 | 0.69 | 3.00 |
| Large open-ground insectivores (among trees or shrubs) | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 |
| Small open-ground insectivores (among trees or shrubs) | 0.00 | 0.18 | 0.00 | 0.00 | 0.38 | 0.50 |
| Seed-eaters (feeding mainly close to ground) | 0.52 | 0.59 | 0.20 | 0.60 | 0.44 | 2.03 |
| Seed-eaters (feeding at all levels, often in trees) | 0.90 | 0.18 | 0.00 | 0.00 | 1.00 | 0.00 |
| Shrub-foraging insectivores (low shrubs) | 0.00 | 0.00 | 0.82 | 0.20 | 0.23 | 0.50 |
| Shrub-foraging insectivores (tall shrubs) | 1.10 | 0.94 | 0.00 | 2.60 | 1.15 | 1.00 |

| Location | Kings Billabong | Kings Billabong | Nangiloc | Nangiloc | Hattah (mallee & dune) | Hattah (mallee & dune) |
|---|---|---|---|---|---|---|
| Date | Autumn 2019 | Autumn 2020 | Autumn 2019 | Autumn 2020 | Autumn 2019 | Summer 2020 |
| **Groups of land birds (other than miners) based on size in relation to despotic miners (60-70g)** | | | | | | |
| Large land birds (>70g) | 3.24 | 0.53 | 1.40 | 0.40 | 2.21 | 0.78 |
| Small land birds (<60g) | 9.19 | 5.24 | 2.42 | 5.60 | 7.62 | 11.25 |
| Mid-sized land birds other than miners (60-70g) | 0.71 | 0.71 | 0.00 | 0.40 | 0.15 | 0.25 |
| **Selected bird guilds for nesting and migration** | | | | | | |
| Large hollow-nesters | 0.95 | 0.18 | 0.00 | 0.00 | 1.31 | 0.00 |
| Small hollow-nesters | 4.24 | 1.06 | 0.40 | 3.00 | 1.77 | 3.25 |
| Hollow-nesters | 5.19 | 1.24 | 0.40 | 3.00 | 3.08 | 3.25 |
| Summer migrant land birds | 0.67 | 0.53 | 0.00 | 0.00 | 0.38 | 1.75 |
| **Total land birds (all were native)** | **13.67** | **7.06** | **3.82** | **6.80** | **10.59** | **12.28** |
| Total water birds | 0.29 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 3.** Mean relative abundance of bird guilds on Mulcra Island and Lindsay Island in autumn 2019 and autumn 2020 (158 sites), and on a subset of 19 sites on Lindsay Island surveyed also in spring 2019 (birds observed per standard 10-minute search of 1 ha). See Table A3 in Appendix 3 for equivalent data on bird species.

| Date: | Aut 2019 | Aut 2020 | Aut 2019 | Spr 2019 | Aut 2020 |
|---|---|---|---|---|---|
| Location (MI = Mulcra Is, LI = Lindsay Is, S = subset): | MI, LI | MI, LI | LI-S | LI-S | LI-S |
| Sites: | 186 | 158 | 19 | 19 | 19 |
| Aerial insectivores | 0.65 | 0.07 | 0.21 | 0.21 | 0.00 |
| Bark-foraging insectivores | 0.18 | 0.11 | 0.37 | 0.63 | 0.00 |
| Canopy-foraging insectivores | 2.41 | 1.58 | 4.68 | 6.79 | 0.84 |
| Carnivores (taking vertebrates, etc) | 0.42 | 0.74 | 0.32 | 0.16 | 1.00 |
| Frugivores | 0.04 | 0.00 | 0.00 | 0.05 | 0.00 |
| Generalist insectivores | 0.19 | 0.27 | 0.16 | 0.37 | 0.11 |
| Miners | 0.36 | 0.50 | 0.53 | 0.00 | 1.21 |
| Nectarivores (other than miners) | 1.80 | 1.18 | 0.84 | 0.16 | 0.53 |
| Open-ground insectivores (may be far from cover) | 0.53 | 0.45 | 0.68 | 0.74 | 0.21 |
| Large open-ground insectivores (among trees or shrubs) | 0.12 | 0.13 | 0.26 | 0.00 | 0.42 |
| Small open-ground insectivores (among trees or shrubs) | 0.32 | 0.12 | 0.21 | 0.84 | 0.21 |
| Open-ground insectivores (among trees or shrubs) | 0.44 | 0.25 | 0.47 | 0.84 | 0.63 |
| Seed-eaters (feeding mainly close to ground) | 1.11 | 1.06 | 0.18 | 0.89 | 0.84 |
| Seed-eaters (feeding at all levels) | 0.59 | 0.52 | 0.42 | 0.00 | 0.32 |
| Shrub-foraging insectivores (low shrubs) | 0.58 | 0.28 | 0.63 | 0.47 | 0.00 |
| Shrub-foraging insectivores (tall shrubs) | 1.58 | 0.75 | 1.47 | 3.37 | 0.21 |
| Large hollow-nesters | 0.85 | 0.99 | 0.53 | 0.42 | 1.05 |
| Small hollow-nesters | 2.53 | 1.51 | 2.42 | 4.26 | 0.42 |
| Hollow-nesters | 3.39 | 2.50 | 2.95 | 4.68 | 1.47 |
| Summer migrant land birds | 0.91 | 0.39 | 0.74 | 0.47 | 0.11 |
| **Total land birds (all were native)** | **10.82** | **7.65** | **10.92** | **14.68** | **5.89** |
| Water birds | 0.84 | 0.16 | 0.05 | 0.00 | 0.00 |
| Native mammals | 0.27 | 0.14 | 0.43 | 0.00 | 0.26 |
| Introduced mammals | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |

**Table 4.** Mean relative abundance of bird guilds in various habitats on Mulcra Island and Lindsay Island, spring 2019 to autumn 2020 (birds observed per standard 10-minute search of 1 ha). The values for BB moonah and Mallee chenopod include data from spring 2019 as well as autumn 2020. BB = black box, Mal = Mallee, Moon = moonah, RG = river red gum, Herb = herbland, C = chenopod shrubs, LTC = Low treeless chenopods. See Table A4 in Appendix 3 for equivalent data on bird species.

| | BB, C | BB, Moon | BB, C sparse | BB all | Herb | Lignum | LTC | Mal C | RG |
|---|---|---|---|---|---|---|---|---|---|
| Sites | 47 | 22 | 9 | 78 | 6 | 29 | 4 | 23 | 38 |
| **Bird guild for feeding (all land birds were assigned to one of these categories)** | | | | | | | | | |
| Aerial insectivores | 0.04 | 0.18 | 0.00 | 0.08 | 0.00 | 0.07 | 0.00 | 0.00 | 0.18 |
| Bark-foraging insectivores | 0.11 | 0.00 | 0.22 | 0.09 | 0.00 | 0.00 | 0.00 | 0.52 | 0.29 |
| Canopy-foraging insectivores | 1.98 | 2.91 | 1.33 | 2.17 | 0.50 | 0.83 | 0.25 | 4.13 | 2.26 |
| Carnivores (taking vertebrates, big invertebrates, etc) | 0.79 | 0.41 | 0.67 | 0.67 | 0.00 | 0.52 | 0.50 | 0.70 | 0.95 |
| Frugivores | 0.00 | 0.05 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Generalist insectivores | 0.34 | 0.27 | 0.44 | 0.33 | 0.17 | 0.21 | 0.00 | 0.22 | 0.32 |
| Miners (despotic nectarivores) | 0.11 | 0.05 | 0.00 | 0.08 | 0.00 | 0.00 | 0.75 | 0.96 | 1.26 |
| Nectarivores (other than miners) | 1.40 | 0.55 | 0.67 | 1.08 | 1.50 | 0.83 | 0.50 | 0.26 | 1.68 |
| Open-ground insectivores (may be far from cover) | 0.68 | 0.18 | 0.78 | 0.55 | 0.00 | 0.31 | 0.50 | 0.61 | 0.45 |
| Large open-ground insectivores (among trees or shrubs) | 0.26 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 |
| Small open-ground insectivores (among trees or shrubs) | 0.21 | 0.55 | 0.00 | 0.28 | 0.00 | 0.07 | 0.00 | 0.35 | 0.08 |
| Seed-eaters (feeding mainly close to ground) | 0.91 | 0.18 | 0.78 | 0.69 | 1.83 | 0.59 | 0.00 | 1.43 | 1.89 |
| Seed-eaters (feeding at all levels, often in trees) | 0.47 | 0.32 | 0.22 | 0.40 | 1.00 | 0.07 | 0.00 | 0.17 | 1.03 |
| Shrub-foraging insectivores (low shrubs) | 0.47 | 0.64 | 0.00 | 0.46 | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 |
| Shrub-foraging insectivores (tall shrubs) | 1.51 | 0.91 | 0.78 | 1.26 | 0.00 | 0.55 | 0.00 | 2.48 | 0.39 |

| | BB, C | BB, Moon | BB, C sparse | BB all | Herb | Lignum | LTC | Mal C | RG |
|---|---|---|---|---|---|---|---|---|---|
| Sites | 47 | 22 | 9 | 78 | 6 | 29 | 4 | 23 | 38 |
| **Groups of land birds (other than miners) based on size in relation to despotic miners (60-70g)** | | | | | | | | | |
| Large land birds (>70g) | 2.13 | 0.95 | 1.56 | 1.73 | 1.67 | 1.24 | 1.00 | 2.61 | 4.05 |
| Small land birds (<60g) | 6.09 | 5.86 | 3.67 | 5.74 | 1.50 | 3.07 | 0.75 | 8.26 | 4.71 |
| Mid-sized land birds other than miners (60-70g) | 0.53 | 0.32 | 0.67 | 0.49 | 1.83 | 0.21 | 0.00 | 0.35 | 0.58 |
| **Selected bird guilds for nesting, migration & habitat** | | | | | | | | | |
| Large hollow-nesters | 0.60 | 0.32 | 0.44 | 0.50 | 1.00 | 0.14 | 0.00 | 1.22 | 2.34 |
| Small hollow-nesters | 2.15 | 1.09 | 1.11 | 1.73 | 2.00 | 0.79 | 0.25 | 3.57 | 1.87 |
| Hollow-nesters | 2.74 | 1.41 | 1.56 | 2.23 | 3.00 | 0.93 | 0.25 | 4.78 | 4.21 |
| Summer migrant land birds | 0.43 | 0.45 | 0.11 | 0.40 | 0.00 | 0.41 | 0.00 | 0.13 | 0.63 |
| **Total land birds (all were native)** | **9.04** | **7.18** | **5.89** | **8.15** | **5.00** | **4.62** | **2.50** | **12.17** | **10.63** |
| Total water birds | 0.23 | 0.00 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 |

**Table 5.** Changes in mean relative abundance of bird guilds in various habitats on Mulcra Island and Lindsay Island in autumn 2020 (birds observed per standard 10-minute search of 1 ha), expressed as percentages of values recorded the previous year (autumn 2019). Data are not shown for two habitats represented by few sites (herbland and low treeless chenopods) but they are included in the totals for all habitats. BB = black box, RG = river red gum. Lignum includes some treeless sites with similar structure dominated by spiny saltbush *Rhagodia spinescens*. NA signifies habitats where the guild was not recorded in either year.

| Bird guild | BB | BB & Moonah | BB sparse | Lignum | Mallee | RG | All habitats |
|---|---|---|---|---|---|---|---|
| Number of sites (autumn 2019) | 51 | 17 | 13 | 34 | 11 | 46 | 186 |
| Number of sites (autumn 2020) | 47 | 14 | 9 | 29 | 11 | 38 | 158 |
| Aerial insectivores | 17 | 0 | 0 | 17 | NA | 27 | 11 |
| Bark-foraging insectivores | 54 | NA | 96 | 0 | 0 | 121 | 64 |
| Canopy-foraging insectivores | 61 | 38 | 40 | 176 | 20 | 91 | 65 |
| Carnivores (taking vertebrates, etc) | 309 | 162 | 96 | 293 | 433 | 112 | 177 |
| Generalist insectivores | 109 | 91 | NA | 352 | NA | 112 | 145 |
| Miners (despotic native honeyeaters) | 271 | NA | 0 | NA | 220 | 114 | 139 |
| Nectarivores (other than miners) | 46 | 46 | 54 | 48 | 100 | 114 | 65 |
| Open-ground insectivores (may be far from cover) | 79 | 0 | 92 | 96 | 57 | 114 | 84 |
| Open-ground insectivores (among trees or shrubs) | 109 | 121 | NA | 8 | 111 | 18 | 56 |
| Seed-eaters (feeding mainly close to ground) | 52 | 202 | 62 | 67 | 517 | 134 | 96 |
| Seed-eaters (feeding at all levels, often in trees) | 66 | 71 | 32 | 33 | NA | 107 | 88 |
| Shrub-foraging insectivores | 60 | 26 | 126 | 65 | 0 | 19 | 48 |
| Large land birds (>70g) | 120 | 91 | 71 | 97 | 378 | 124 | 127 |
| Small land birds (<60g) | 52 | 34 | 50 | 56 | 15 | 66 | 52 |
| Mid-sized land birds other than miners (60-70g) | 62 | 121 | 108 | 176 | NA | 74 | 94 |
| Hollow-nesters | 74 | 48 | 44 | 62 | 95 | 88 | 74 |
| Summer migrant land birds | 80 | 32 | 5 | 78 | NA | 63 | 42 |
| **Total land birds (all were native)** | **62.3** | **42.9** | **54.9** | **67.2** | **95.3** | **86.2** | **70.6** |

**Appendix 1.** Bird species observed in flood-plain woodlands from Hattah to Lindsay Island during surveys of woodland birds 2014-20, with scientific names and their guilds for feeding, nesting, migration and status (see key below). Species are listed in two groups (land birds and waterbirds) in taxonomic order following Christidis and Boles 2008.

| Species (land bird) | Scientific name | Feed | Nest | Migrtn | Status |
|---|---|---|---|---|---|
| Emu | *Dromaius novaehollandiae* | SG | G | N | N |
| Brown Quail | *Coturnix ypsilophora* | SG | G | N | N |
| Feral Pigeon | *Columba livia* | SG | L | N | I |
| Common Bronzewing | *Phaps chalcoptera* | SG | N | N | N |
| Crested Pigeon | *Ocyphaps lophotes* | SG | N | N | N |
| Diamond Dove | *Geopelia cuneata* | SG | N | N | N |
| Peaceful Dove | *Geopelia placida* | SG | N | N | N |
| Tawny Frogmouth | *Podargus strigoides* | V | N | N | N |
| Australian Owlet-nightjar | *Aegotheles cristatus* | OT2 | SH | N | N |
| Black-breasted Buzzard | *Hamirostra melanosternon* | V | N | S | N |
| White-bellied Sea-Eagle # | *Haliaeetus leucogaster* | W | W | N | N |
| Whistling Kite # | *Haliastur sphenurus* | W | W | N | N |
| Black Kite | *Milvus migrans* | V | N | N | N |
| Brown Goshawk | *Accipiter fasciatus* | V | N | N | N |
| Collared Sparrowhawk | *Accipiter cirrhocephalus* | V | N | N | N |
| Swamp Harrier | *Circus approximans* | V | G | N | N |
| Wedge-tailed Eagle | *Aquila audax* | V | N | N | N |
| Little Eagle | *Hieraaetus morphnoides* | V | N | N | N |
| Nankeen Kestrel | *Falco cenchroides* | V | N | N | N |
| Brown Falcon | *Falco berigora* | V | N | N | N |
| Australian Hobby | *Falco longipennis* | V | N | N | N |
| Peregrine Falcon | *Falco peregrinus* | V | N | N | N |
| Major Mitchell's Cockatoo | *Cacatua leadbeateri* | SG | LH | N | N |
| Galah | *Cacatua roseicapilla* | SG | LH | N | N |
| Little Corella | *Cacatua sanguinea* | SG | LH | N | N |
| Sulphur-crested Cockatoo | *Cacatua galerita* | SG | LH | N | N |
| Rainbow Lorikeet | *Trichoglossus moluccanus* | N | LH | N | N |
| Regent Parrot | *Polytelis anthopeplus* | ST | LH | N | N |
| Yellow Rosella | *Platycercus elegans* | ST | LH | N | N |
| Australian Ringneck | *Barnardius zonarius* | ST | LH | N | N |
| Blue Bonnet | *Northiella haematogaster* | SG | LH | N | N |
| Red-rumped Parrot | *Psephotus haematonotus* | SG | SH | N | N |
| Mulga Parrot | *Psephotus varius* | SG | SH | N | N |
| Horsfield's Bronze-Cuckoo | *Chrysococcyx basalis* | C | BP | S | N |
| Pallid Cuckoo | *Cuculus pallidus* | OT1 | BP | S | N |
| Southern Boobook | *Ninox novaeseelandiae* | V | LH | N | N |
| Laughing Kookaburra | *Dacelo novaeguineae* | V | LH | N | N |
| Red-backed Kingfisher | *Todiramphus pyrrhopygia* | V | SH | S | N |
| Sacred Kingfisher | *Todiramphus sanctus* | V | SH | S | N |
| Rainbow Bee-eater | *Merops ornatus* | A | B | S | N |

| Species (land bird) | Scientific name | Feed | Nest | Migrtn | Status |
|---|---|---|---|---|---|
| White-throated Treecreeper | *Cormobates leucophaeus* | B | SH | N | N |
| Brown Treecreeper | *Climacteris picumnus* | B | SH | N | N |
| Superb Fairy-wren | *Malurus cyaneus* | OT2 | N | N | N |
| Splendid Fairy-wren | *Malurus splendens* | OT2 | N | N | N |
| White-winged Fairy-wren | *Malurus leucopterus* | LS | N | N | N |
| Variegated Fairy-wren | *Malurus lamberti* | LS | N | N | N |
| Mallee Emu-wren | *Stpiturus mallee* | LS | N | N | N |
| Shy Heathwren | *Hylacola cauta* | OT2 | N | N | N |
| Weebill | *Smicrornis brevirostris* | C | N | N | N |
| Western Gerygone | *Gerygone fusca* | C | N | N | N |
| Yellow Thornbill | *Acanthiza nana* | TS | N | N | N |
| Yellow-rumped Thornbill | *Acanthiza chrysorrhoa* | OG | N | N | N |
| Chestnut-rumped Thornbill | *Acanthiza uropygialis* | TS | SH | N | N |
| Inland Thornbill | *Acanthiza apicalis* | TS | N | N | N |
| Southern Whiteface | *Aphelocephala leucopsis* | OG | SH | N | N |
| Spotted Pardalote | *Pardalotus punctatus* | C | B | N | N |
| Striated Pardalote | *Pardalotus striatus* | C | SH | N | N |
| Singing Honeyeater | *Lichenostomus virescens* | N | N | N | N |
| White-eared Honeyeater | *Lichenostomus leucotis* | N | N | N | N |
| Yellow-plumed Honeyeater | *Lichenostomus ornatus* | N | N | N | N |
| White-plumed Honeyeater | *Lichenostomus penicillatus* | N | N | N | N |
| White-fronted Honeyeater | *Purnella albifrons* | N | N | N | N |
| Noisy Miner | *Manorina melanocephala* | N | N | N | N |
| Yellow-throated Miner | *Manorina flavigula* | N | N | N | N |
| Spiny-cheeked Honeyeater | *Acanthagenys rufogularis* | N | N | N | N |
| Red Wattlebird | *Anthochaera carunculata* | N | N | N | N |
| White-fronted Chat | *Epthianura albifrons* | OG | N | N | N |
| Black Honeyeater | *Certhionyx niger* | N | N | N | N |
| Black-chinned Honeyeater | *Melithreptus gularis* | N | N | N | N |
| Brown-headed Honeyeater | *Melithreptus brevirostris* | N | N | N | N |
| Blue-faced Honeyeater | *Entomyzon cyanotis* | N | N | N | N |
| Noisy Friarbird | *Philemon corniculatus* | N | N | N | N |
| Little Friarbird | *Philemon citreogularis* | N | N | S | N |
| Striped Honeyeater | *Plectorhyncha lanceolata* | N | N | N | N |
| White-browed Babbler | *Pomatostomus superciliosus* | TS | N | N | N |
| Chestnut-crowned Babbler | *Pomatostomus ruficeps* | LS | N | N | N |
| Chestnut Quail-thrush | *Cinclosoma castanotum* | OT1 | G | N | N |
| Varied Sittella | *Daphoenositta chrysoptera* | B | N | N | N |
| Ground Cuckoo-shrike | *Coracina maxima* | OG | N | S | N |
| Black-faced Cuckoo-shrike | *Coracina novaehollandiae* | C | N | N | N |
| Gilbert's Whistler | *Pachycephala inornata* | TS | N | N | N |
| Golden Whistler | *Pachycephala pectoralis* | TS | N | N | N |
| Rufous Whistler | *Pachycephala rufiventris* | C | N | S | N |

| Species (land bird) | Scientific name | Feed | Nest | Migrtn | Status |
|---|---|---|---|---|---|
| Grey Shrike-thrush | *Colluricincla harmonica* | G | N | N | N |
| Crested Bellbird | *Oreoica gutturalis* | OT2 | N | N | N |
| White-breasted Woodswallow | *Artamus leucorynchus* | A | L | S | N |
| Masked Woodswallow | *Artamus personatus* | A | L | S | N |
| White-browed Woodswallow | *Artamus superciliosus* | A | L | S | N |
| Dusky Woodswallow | *Artamus cyanopterus* | A | L | S | N |
| Grey Butcherbird | *Cracticus torquatus* | V | N | N | N |
| Pied Butcherbird | *Cracticus nigrogularis* | V | N | N | N |
| Australian Magpie | *Gymnorhina tibicen* | OG | N | N | N |
| Grey Currawong | *Strepera versicolor* | V | N | N | N |
| Grey Fantail | *Rhipidura fuliginosa* | C | N | N | N |
| Willie Wagtail | *Rhipidura leucophrys* | OG | N | N | N |
| Australian Raven | *Corvus coronoides* | V | N | N | N |
| Little Raven | *Corvus mellori* | V | N | N | N |
| Little Crow | *Corvus bennetti* | V | N | N | N |
| Restless Flycatcher | *Myiagra inquieta* | OT2 | N | N | N |
| Magpie-lark | *Grallina cyanoleuca* | OG | N | N | N |
| White-winged Chough | *Corcorax melanorhamphos* | OT1 | N | N | N |
| Apostlebird | *Struthidea cinerea* | OT1 | N | N | N |
| Jacky Winter | *Microeca fascinans* | OT2 | N | N | N |
| Red-capped Robin | *Petroica goodenovii* | OT2 | N | N | N |
| Hooded Robin | *Melanodryas cucullata* | OT2 | N | N | N |
| Australian Reed-Warbler # | *Acrocephalus australis* | W | W | S | N |
| Little Grassbird # | *Megalurus gramineus* | W | W | N | N |
| Silvereye | *Zosterops lateralis* | F | N | N | N |
| White-backed Swallow | *Cheramoeca leucosternus* | A | N | N | N |
| Welcome Swallow | *Hirundo neoxena* | A | L | N | N |
| Fairy Martin | *Hirundo ariel* | A | L | S | N |
| Tree Martin | *Hirundo nigricans* | A | SH | S | N |
| Mistletoebird | *Dicaeum hirundinaceum* | F | N | N | N |
| Diamond Firetail | *Stagonopleura guttata* | SG | N | N | N |
| Australasian Pipit | *Anthus novaeseelandiae* | OG | G | N | N |
| **Species (water bird)** | | | | | |
| Musk Duck | *Biziura lobata* | W | W | N | N |
| Black Swan | *Cygnus atratus* | W | W | N | N |
| Australian Shelduck | *Tadorna tadornoides* | W | W | N | N |
| Australian Wood Duck | *Chenonetta jubata* | W | W | N | N |
| Pink-eared Duck | *Malacorhynchus membranaceus* | W | W | N | N |
| Australasian Shoveler | *Anas rhynchotis* | W | W | N | N |
| Grey Teal | *Anas gracilis* | W | W | N | N |
| Pacific Black Duck | *Anas superciliosa* | W | W | N | N |
| Hardhead | *Aythya australis* | W | W | N | N |
| Blue-billed Duck | *Oxyura australis* | W | W | N | N |

| Species (water bird) | Scientific name | Feed | Nest | Migrtn | Status |
|---|---|---|---|---|---|
| Australasian Grebe | *Tachybaptus novaehollandiae* | W | W | N | N |
| Hoary-headed Grebe | *Poliocephalus poliocephalus* | W | W | N | N |
| Great Crested Grebe | *Podiceps cristatus* | W | W | N | N |
| Australasian Darter | *Anhinga novaehollandiae* | W | W | N | N |
| Little Pied Cormorant | *Phalacrocorax melanoleucos* | W | W | N | N |
| Great Cormorant | *Phalacrocorax carbo* | W | W | N | N |
| Little Black Cormorant | *Phalacrocorax sulcirostris* | W | W | N | N |
| Pied Cormorant | *Phalacrocorax varius* | W | W | N | N |
| Australian Pelican | *Pelecanus conspicillatus* | W | W | N | N |
| White-necked Heron | *Ardea pacifica* | W | W | N | N |
| Eastern Great Egret | *Ardea modesta* | W | W | N | N |
| Intermediate Egret | *Ardea intermedia* | W | W | N | N |
| Cattle Egret | *Ardea ibis* | W | W | N | N |
| White-faced Heron | *Egretta novaehollandiae* | W | W | N | N |
| Little Egret | *Egretta garzetta* | W | W | N | N |
| Nankeen Night Heron | *Nycticorax caledonicus* | W | W | N | N |
| Glossy Ibis | *Plegadis falcinellus* | W | W | N | N |
| Australian White Ibis | *Threskiornis molucca* | W | W | N | N |
| Straw-necked Ibis | *Threskiornis spinicollis* | W | W | N | N |
| Royal Spoonbill | *Platalea regia* | W | W | N | N |
| Yellow-billed Spoonbill | *Platalea flavipes* | W | W | N | N |
| Purple Swamphen | *Porphyrio porphyrio* | W | W | N | N |
| Australian Spotted Crake | *Porzana fluminea* | W | W | N | N |
| Black-tailed Native-hen | *Gallinula ventralis* | W | W | N | N |
| Dusky Moorhen | *Gallinula tenebrosa* | W | W | N | N |
| Eurasian Coot | *Fulica atra* | W | W | N | N |
| Black-winged Stilt | *Himantopus himantopus* | W | W | N | N |
| Black-fronted Dotterel | *Elseyornis melanops* | W | W | N | N |
| Red-kneed Dotterel | *Erythrogonys cinctus* | W | W | N | N |
| Masked Lapwing | *Vanellus miles* | W | W | N | N |
| Australian Painted Snipe | *Rostratula australis* | W | W | S | N |
| Common Greenshank | *Tringa nebularia* | W | X | SNH | N |
| Sharp-tailed Sandpiper | *Calidris acuminata* | W | X | SNH | N |
| Caspian Tern | *Sterna caspia* | W | W | N | N |
| Whiskered Tern | *Chlidonias hybridus* | W | W | S | N |
| Silver Gull | *Larus novaehollandiae* | W | W | N | N |

# Four species have been classed as waterbirds (Whistling Kite, White-bellied Sea-Eagle, Australian Reed-Warbler and Little Grassbird) but are grouped here with land birds to accord with taxonomic affinities and common practice.

**Key:**

| | **Feeding guild** |
|---|---|
| A | Aerial insectivores (mainly above canopy or over water) |
| B | Bark-foraging insectivores |
| C | Canopy-foraging insectivores |
| DG | Damp-ground insectivores |
| F | Frugivores |
| G | Generalist insectivores |
| LS | Low-shrub-foraging insectivores |
| Miners | Miners (despotic honeyeaters) |
| N | Nectarivores (other than miners) |
| OG | Open-ground insectivores (may be far from cover) |
| OT1 | Large open-ground insectivores (among trees or shrubs), >70g |
| OT2 | Small open-ground insectivores (among trees or shrubs), <70g |
| OT ( = OT1 + OT2) | Open-ground insectivores (among trees or shrubs) |
| SG | Seed-eaters (feeding mainly close to ground) |
| ST | Seed-eaters (feeding mainly in trees) |
| TS | Tall-shrub-foraging insectivores |
| TSLS (= LS + TS) | Shrub-foraging insectivores |
| V | Carnivores (taking vertebrates & large invertebrates, etc) |
| | **Nesting guilds for land birds** |
| B | Burrow nester |
| BP | Brood parasite (lays in other birds' nests) |
| G | Ground nester |
| H (= LH + SH) | Hollow nester |
| L | Ledge nester |
| LH | Large hollow-nester |
| N | Normal nester (builds nests in shrubs or tree branches) |
| SH | Small hollow-nester |
| X | Not nesting locally (eg nests overseas) |
| | **Migration guilds** |
| S | Summer migrant (absent or scarce in winter; may breed locally) |
| SNH | Summer migrant (breed in Northern Hemisphere) |
| W | Winter migrant (breeds mainly in forests and hills) |
| | **Status guilds** |
| I | Introduced to Australia |
| N | Native to Australia |

**Appendix 2.** Sites surveyed in flood-plain woodlands from Hattah to Lindsay Island during surveys of woodland birds 2019-20, with coordinates (datum 54H), flood history (flooded or not during current surveys and in last ten years), vegetation (BB = black box, RG = river red gum, etc), and seasons surveyed in 2019-20. Locations are arranged east to west (LK=Lake Kramen, MP=Mournpall).

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| BB33 | Hattah LK | wet | yes | BB | 635242 | 6149405 | Sum & Aut 20 |
| BB34 | Hattah LK | wet | yes | BB | 635402 | 6149756 | Sum & Aut 20 |
| BB35 | Hattah LK | wet | yes | BB | 635548 | 6149798 | Sum & Aut 20 |
| BB36 | Hattah LK | wet | yes | BB | 635572 | 6149952 | Sum & Aut 20 |
| BB37 | Hattah LK | wet | yes | BB | 635581 | 6150177 | Sum & Aut 20 |
| BB38 | Hattah LK | wet | yes | BB | 635776 | 6150207 | Sum & Aut 20 |
| BB39 | Hattah LK | wet | yes | BB | 635812 | 6150339 | Sum & Aut 20 |
| BB40 | Hattah LK | wet | yes | BB | 636027 | 6150695 | Sum & Aut 20 |
| BB40a | Hattah LK | wet | yes | BB | 636024 | 6150619 | Sum 20 |
| BB40b | Hattah LK | wet | yes | BB | 635990 | 6150658 | Sum 20 |
| BB40/41 | Hattah LK | wet | yes | BB | 636116 | 6150742 | Sum & Aut 20 |
| BB41 | Hattah LK | wet | yes | BB | 636181 | 6150932 | Sum & Aut 20 |
| BB41a | Hattah LK | wet | yes | BB | 636138 | 6151089 | Sum & Aut 20 |
| BB42 | Hattah LK | wet | yes | BB | 636025 | 6151312 | Sum & Aut 20 |
| BB42a | Hattah LK | wet | yes | BB | 635940 | 6151198 | Aut 20 |
| BB44 | Hattah LK | dry | yes | BB | 635434 | 6149972 | Aut 20 |
| BB1 | Hattah MP | dry | yes | BB | 627682 | 6162203 | Aut 20 |
| BB2 | Hattah MP | dry | yes | BB | 624552 | 6163792 | Sum & Aut 20 |
| BB3 | Hattah MP | dry | yes | BB | 625789 | 6164768 | Aut 20 |
| BB4 | Hattah MP | dry | no | BB | 626543 | 6165225 | Sum & Aut 20 |
| BB5 | Hattah MP | dry | no | BB | 626354 | 6165260 | Sum & Aut 20 |
| BB6 | Hattah MP | dry | no | BB | 626166 | 6165331 | Sum & Aut 20 |
| BB7 | Hattah MP | dry | no | BB | 626796 | 6165198 | Sum & Aut 20 |
| BB8 | Hattah MP | dry | no | BB | 626869 | 6165261 | Sum & Aut 20 |
| BB9 | Hattah MP | dry | no | BB | 626965 | 6165248 | Sum & Aut 20 |
| BB10 | Hattah MP | dry | yes | BB | 624714 | 6163930 | Sum & Aut 20 |
| BB11 | Hattah MP | dry | yes | BB | 625182 | 6163760 | Aut 20 |
| BB12 | Hattah MP | dry | yes | BB | 625482 | 6163698 | Aut 20 |
| BB13 | Hattah MP | dry | yes | BB | 624854 | 6164016 | Aut 20 |
| BB13a | Hattah MP | dry | yes | BB | 625019 | 6164136 | Sum 20 |
| BB14 | Hattah MP | wet | yes | BB | 624963 | 6163946 | Sum & Aut 20 |
| BB15 | Hattah MP | dry | yes | BB | 625311 | 6164005 | Aut 20 |
| BB15a | Hattah MP | dry | yes | BB sparse | 625160 | 6164197 | Aut 20 |
| BB16 | Hattah MP | dry | yes | BB | 625556 | 6163887 | Aut 20 |
| BB17 | Hattah MP | dry | yes | BB | 623995 | 6163451 | Sum & Aut 20 |
| BB18 | Hattah MP | wet | yes | BB | 624195 | 6163415 | Sum & Aut 20 |

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| BB19 | Hattah MP | dry | no | BB | 623810 | 6163457 | Sum & Aut 20 |
| BB20 | Hattah MP | dry | yes | BB | 623810 | 6163005 | Sum & Aut 20 |
| BB21 | Hattah MP | dry | yes | BB | 623846 | 6162886 | Sum & Aut 20 |
| BB26 | Hattah MP | wet | yes | BB | 625560 | 6164590 | Aut 20 |
| BB27 | Hattah MP | dry | yes | BB | 625339 | 6164452 | Aut 20 |
| BB28 | Hattah MP | dry | yes | BB | 625599 | 6164059 | Aut 20 |
| BB29 | Hattah MP | dry | yes | BB | 625558 | 6163783 | Aut 20 |
| BB30 | Hattah MP | dry | yes | BB | 625239 | 6163688 | Aut 20 |
| BB31 | Hattah MP | dry | yes | BB | 625295 | 6163833 | Aut 20 |
| BB32 | Hattah MP | dry | yes | BB | 623654 | 6162479 | Sum & Aut 20 |
| BB32a | Hattah MP | dry | yes | BB | 623533 | 6162416 | Aut 20 |
| BB32/43 | Hattah MP | dry | yes | BB | 623620 | 6162333 | Sum & Aut 20 |
| BB43 | Hattah MP | dry | yes | BB | 623586 | 6162186 | Sum & Aut 20 |
| BB43a | Hattah MP | dry | no | BB | 623446 | 6162177 | Aut 20 |
| M2 | Hattah MP | dry | no | Mallee | 625670 | 6165054 | Sum 20 |
| M3 | Hattah MP | dry | no | Mallee | 625675 | 6165177 | Sum 20 |
| RG1 | Hattah MP | dry | yes | RG | 622409 | 6158860 | Sum 20 |
| X1 | Hattah MP | dry | no | Dune | 623554 | 6162910 | Sum 20 |
| X5 | Hattah MP | dry | no | Dune | 627332 | 6165170 | Sum 20 |
| KB4 | Kings Billabong | dry | no | BB sparse | 613110 | 6109188 | Aut 20 |
| KB5 | Kings Billabong | dry | no | BB sparse | 613120 | 6109435 | Aut 20 |
| KB5a | Kings Billabong | dry | no | BB sparse | 612998 | 6109538 | Aut 20 |
| KB6 | Kings Billabong | dry | no | BB | 613211 | 6109660 | Aut 20 |
| KB7 | Kings Billabong | dry | no | BB | 613496 | 6109686 | Aut 20 |
| KB8 | Kings Billabong | dry | no | BB | 613727 | 6109752 | Aut 20 |
| KB9 | Kings Billabong | dry | no | BB | 613956 | 6109818 | Aut 20 |
| KB10 | Kings Billabong | dry | no | BB | 614071 | 6109854 | Aut 20 |
| KB11 | Kings Billabong | dry | no | BB | 613249 | 6111274 | Aut 20 |
| KB12 | Kings Billabong | dry | no | BB | 613159 | 6111440 | Aut 20 |
| KB13 | Kings Billabong | dry | no | BB | 613254 | 6111490 | Aut 20 |
| KB14 | Kings Billabong | dry | no | BB | 613388 | 6111108 | Aut 20 |
| KB20 | Kings Billabong | dry | no | BB | 613939 | 6109845 | Aut 20 |
| KB21 | Kings Billabong | dry | no | BB | 614032 | 6109918 | Aut 20 |
| KB22 | Kings Billabong | dry | no | BB | 613005 | 6109300 | Aut 20 |
| KB23 | Kings Billabong | dry | no | BB | 613120 | 6108950 | Aut 20 |
| KB24 | Kings Billabong | dry | no | BB | 613339 | 6108975 | Aut 20 |
| BB45 | Nangiloc | dry | yes | BB sparse | 624509 | 6185795 | Aut 20 |
| BB46 | Nangiloc | dry | yes | BB sparse | 624546 | 6186064 | Aut 20 |
| BB47 | Nangiloc | dry | yes | BB sparse | 624501 | 6186170 | Aut 20 |
| BB48 | Nangiloc | dry | yes | BB sparse | 624620 | 6186015 | Aut 20 |
| BB49 | Nangiloc | dry | yes | BB sparse | 624639 | 6185854 | Aut 20 |

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| BB51 | Nangiloc | dry | yes | BB sparse | 624684 | 6186252 | Aut 20 |
| RG5 | Nangiloc | dry | yes | RG | 624666 | 6185749 | Aut 20 |
| MI17 | Mulcra Is east | dry | no | BB & moonah | 539871 | 6219828 | Aut 20 |
| MI18 | Mulcra Is east | dry | no | BB & moonah | 539840 | 6219643 | Aut 20 |
| MI19 | Mulcra Is east | dry | no | BB | 539900 | 6219661 | Aut 20 |
| MI21 | Mulcra Is east | dry | no | BB | 539568 | 6219996 | Aut 20 |
| MI22 | Mulcra Is east | dry | no | BB | 539740 | 6219742 | Aut 20 |
| MI23 | Mulcra Is east | dry | no | Lignum | 540980 | 6218918 | Aut 20 |
| MI24 | Mulcra Is east | dry | no | Lignum | 541166 | 6218801 | Aut 20 |
| MI25 | Mulcra Is east | dry | no | Lignum | 541415 | 6218991 | Aut 20 |
| MI39 | Mulcra Is east | dry | no | RG | 538683 | 6218384 | Aut 20 |
| MI40 | Mulcra Is east | dry | no | RG | 538713 | 6218287 | Aut 20 |
| MI41 | Mulcra Is east | dry | no | RG | 538801 | 6218553 | Aut 20 |
| MI42 | Mulcra Is east | dry | no | RG | 538681 | 6218576 | Aut 20 |
| MI43 | Mulcra Is east | dry | no | BB | 539303 | 6219070 | Aut 20 |
| MI44 | Mulcra Is east | dry | no | BB | 539303 | 6218959 | Aut 20 |
| MI46 | Mulcra Is east | dry | no | BB | 538855 | 6218756 | Aut 20 |
| MI48 | Mulcra Is east | dry | no | BB | 538940 | 6219076 | Aut 20 |
| MI49 | Mulcra Is east | dry | no | BB | 538772 | 6219063 | Aut 20 |
| MI50 | Mulcra Is east | dry | no | BB | 539132 | 6218919 | Aut 20 |
| MI51 | Mulcra Is east | dry | no | BB | 539248 | 6219073 | Aut 20 |
| MI52 | Mulcra Is east | dry | no | BB & wattles | 539546 | 6220402 | Aut 20 |
| MI53 | Mulcra Is east | dry | no | BB | 539527 | 6222842 | Aut 20 |
| MI54 | Mulcra Is east | dry | no | BB | 539734 | 6220305 | Aut 20 |
| MI55 | Mulcra Is east | dry | no | BB | 539691 | 6220098 | Aut 20 |
| MI56 | Mulcra Is east | dry | no | BB | 539771 | 6220007 | Aut 20 |
| MI1 | Mulcra Is west | dry | yes | RG & BB | 531983 | 6221188 | Aut 20 |
| MI2 | Mulcra Is west | dry | yes | RG & BB | 532131 | 6220962 | Aut 20 |
| MI3 | Mulcra Is west | dry | yes | RG & BB | 531851 | 6221475 | Aut 20 |
| MI5 | Mulcra Is west | dry | yes | Lignum | 532160 | 6221209 | Aut 20 |
| MI6 | Mulcra Is west | dry | yes | Lignum | 532088 | 6221446 | Aut 20 |
| MI7 | Mulcra Is west | dry | no | BB | 531921 | 6222642 | Aut 20 |
| MI8 | Mulcra Is west | dry | no | BB | 531827 | 6222568 | Aut 20 |
| MI9 | Mulcra Is west | dry | no | BB | 531926 | 6223348 | Aut 20 |
| MI10 | Mulcra Is west | dry | no | BB | 531915 | 6223543 | Aut 20 |
| MI11 | Mulcra Is west | dry | no | BB | 532143 | 6223522 | Aut 20 |
| MI12 | Mulcra Is west | dry | no | BB | 532200 | 6223631 | Aut 20 |
| MI13 | Mulcra Is west | dry | no | BB & lignum | 532243 | 6222979 | Aut 20 |
| MI14 | Mulcra Is west | dry | no | BB & lignum | 532394 | 6223008 | Aut 20 |
| MI15 | Mulcra Is west | dry | no | BB & lignum | 532482 | 6223176 | Aut 20 |
| MI16 | Mulcra Is west | dry | no | BB & lignum | 532590 | 6223228 | Aut 20 |

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| MI57 | Mulcra Is west | dry | no | RG | 537382 | 6222842 | Aut 20 |
| MI58 | Mulcra Is west | dry | no | RG | 537293 | 6222726 | Aut 20 |
| MI59 | Mulcra Is west | dry | no | RG | 537539 | 6222829 | Aut 20 |
| MI60 | Mulcra Is west | dry | no | RG | 537504 | 6222687 | Aut 20 |
| MI61 | Mulcra Is west | dry | no | RG | 536999 | 6223150 | Aut 20 |
| MI62 | Mulcra Is west | dry | no | RG | 537171 | 6223058 | Aut 20 |
| MI63 | Mulcra Is west | dry | no | RG | 537243 | 6223256 | Aut 20 |
| MI64 | Mulcra Is west | dry | no | RG | 537288 | 6223197 | Aut 20 |
| MI65 | Mulcra Is west | dry | no | Lignum | 536619 | 6222943 | Aut 20 |
| MI66 | Mulcra Is west | dry | no | Lignum | 536586 | 6222829 | Aut 20 |
| MI67 | Mulcra Is west | dry | no | Lignum | 536441 | 6223011 | Aut 20 |
| MI68 | Mulcra Is west | dry | no | Lignum | 536530 | 6223077 | Aut 20 |
| MI69 | Mulcra Is west | dry | no | BB | 536341 | 6222658 | Aut 20 |
| MI71 | Mulcra Is west | dry | no | BB | 536101 | 6222585 | Aut 20 |
| MI72 | Mulcra Is west | dry | no | BB | 536058 | 6222640 | Aut 20 |
| MI73 | Mulcra Is west | dry | no | RG | 534311 | 6224454 | Aut 20 |
| MI74 | Mulcra Is west | dry | no | RG | 534533 | 6224364 | Aut 20 |
| MI75 | Mulcra Is west | dry | no | RG | 534808 | 6224266 | Aut 20 |
| MI76 | Mulcra Is west | dry | no | RG | 534150 | 6224361 | Aut 20 |
| MI77 | Mulcra Is west | dry | no | RG | 534183 | 6224244 | Aut 20 |
| MI78 | Mulcra Is west | dry | no | RG | 534243 | 6224186 | Aut 20 |
| MI79 | Mulcra Is west | dry | yes | Lignum | 532988 | 6222395 | Aut 20 |
| MI80 | Mulcra Is west | dry | yes | Lignum | 533031 | 6222596 | Aut 20 |
| MI81 | Mulcra Is west | dry | yes | Lignum | 532884 | 6222497 | Aut 20 |
| MI82 | Mulcra Is west | dry | yes | Lignum | 532762 | 6222397 | Aut 20 |
| MI83 | Mulcra Is west | dry | yes | Lignum | 532863 | 6222293 | Aut 20 |
| MI84 | Mulcra Is west | dry | yes | Lignum | 533056 | 6222113 | Aut 20 |
| MI85 | Mulcra Is west | dry | yes | Lignum | 532648 | 6222520 | Aut 20 |
| MI86 | Mulcra Is west | dry | no | RG & BB | 533450 | 6224783 | Aut 20 |
| MI86 | Mulcra Is west | dry | no | RG | 533450 | 6224783 | Aut 20 |
| MI87 | Mulcra Is west | dry | no | RG & BB | 533394 | 6225149 | Aut 20 |
| MI88 | Mulcra Is west | dry | no | RG & BB | 533062 | 6225405 | Aut 20 |
| MI89 | Mulcra Is west | dry | yes | Herbland | 533582 | 6223409 | Aut 20 |
| MI90 | Mulcra Is west | dry | no | RG & BB | 533622 | 6223830 | Aut 20 |
| MI91 | Mulcra Is west | dry | no | Herbland | 533301 | 6223883 | Aut 20 |
| MI92 | Mulcra Is west | dry | no | RG & BB | 533638 | 6223963 | Aut 20 |
| MI93 | Mulcra Is west | dry | no | RG & BB | 533878 | 6223829 | Aut 20 |
| MI94 | Mulcra Is west | dry | no | BB | 533198 | 6225059 | Aut 20 |
| MI95 | Mulcra Is west | dry | no | RG & BB | 533545 | 6224215 | Aut 20 |
| MI96 | Mulcra Is west | dry | yes | Herbland | 533104 | 6223346 | Aut 20 |
| MI97 | Mulcra Is west | dry | yes | Herbland | 532962 | 6223566 | Aut 20 |

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| MI98 | Mulcra Is west | dry | yes | Herbland | 533343 | 6223210 | Aut 20 |
| MI99 | Mulcra Is west | dry | yes | Herbland | 533472 | 6223274 | Aut 20 |
| MI100 | Mulcra Is west | dry | yes | Low chenopods | 533590 | 6222160 | Aut 20 |
| MI101 | Mulcra Is west | dry | yes | Low chenopods | 533636 | 6221933 | Aut 20 |
| MI102 | Mulcra Is west | dry | yes | RG & BB | 534037 | 6222015 | Aut 20 |
| MI103 | Mulcra Is west | dry | yes | Lignum | 533874 | 6222108 | Aut 20 |
| MI104 | Mulcra Is west | dry | yes | Lignum | 533793 | 6222399 | Aut 20 |
| MI105 | Mulcra Is west | dry | yes | Lignum | 534044 | 6222386 | Aut 20 |
| MI106 | Mulcra Is west | dry | yes | RG & BB | 534162 | 6222246 | Aut 20 |
| MI107 | Mulcra Is west | dry | no | Lignum | 534430 | 6222259 | Aut 20 |
| MI108 | Mulcra Is west | dry | no | Lignum | 534462 | 6222143 | Aut 20 |
| MI109 | Mulcra Is west | dry | no | Lignum | 534305 | 6222108 | Aut 20 |
| MI110 | Mulcra Is west | dry | yes | Lignum | 534607 | 6222921 | Aut 20 |
| MI111 | Mulcra Is west | dry | yes | Lignum | 534657 | 6223113 | Aut 20 |
| MI112 | Mulcra Is west | dry | no | RG | 537231 | 6222410 | Aut 20 |
| MI113 | Mulcra Is west | dry | no | RG | 537404 | 6222514 | Aut 20 |
| MI116 | Mulcra Is west | dry | yes | Lignum | 537957 | 6220734 | Aut 20 |
| MI117 | Mulcra Is west | dry | yes | Lignum | 538021 | 6220619 | Aut 20 |
| MI118 | Mulcra Is west | dry | yes | Lignum | 537998 | 6220868 | Aut 20 |
| MI119 | Mulcra Is west | dry | yes | Lignum | 537980 | 6220943 | Aut 20 |
| LI1 | Lindsay Is | dry | yes | BB | 519088 | 6225345 | Aut 20 |
| LI2 | Lindsay Is | dry | no | BB sparse | 519074 | 6225438 | Aut 20 |
| LI3 | Lindsay Is | dry | yes | BB | 519152 | 6225517 | Aut 20 |
| LI5 | Lindsay Is | dry | yes | BB & moonah | 517899 | 6227517 | Spr19&Aut20 |
| LI6 | Lindsay Is | dry | yes | BB & moonah | 518021 | 6227540 | Spr19&Aut20 |
| LI7 | Lindsay Is | dry | yes | BB | 518054 | 6227429 | Aut 20 |
| LI8 | Lindsay Is | dry | yes | BB | 518141 | 6227374 | Aut 20 |
| LI9 | Lindsay Is | dry | yes | BB | 518218 | 6227348 | Aut 20 |
| LI10 | Lindsay Is | dry | yes | BB & moonah | 517790 | 6227615 | Spr19&Aut20 |
| LI11 | Lindsay Is | dry | yes | BB & moonah | 517699 | 6227641 | Spr19&Aut20 |
| LI12 | Lindsay Is | dry | yes | BB & moonah | 517537 | 6227656 | Spr19&Aut20 |
| LI13 | Lindsay Is | dry | yes | BB & moonah | 517377 | 6227583 | Spr19&Aut20 |
| LI14 | Lindsay Is | dry | yes | BB & moonah | 517261 | 6227478 | Spr19&Aut20 |
| LI15 | Lindsay Is | dry | yes | BB & moonah | 517515 | 6227199 | Spr19&Aut20 |
| LI22 | Lindsay Is | dry | yes | RG | 525371 | 6226939 | Aut 20 |
| LI23 | Lindsay Is | dry | yes | BB & moonah | 525239 | 6227051 | Aut 20 |
| LI24 | Lindsay Is | dry | yes | BB & moonah | 525226 | 6226932 | Aut 20 |
| LI25 | Lindsay Is | dry | yes | BB & moonah | 525301 | 6226823 | Aut 20 |
| LI26 | Lindsay Is | dry | no | BB sparse | 519573 | 6229201 | Aut 20 |

| Site | Location | Flood status 2020 | Flood in last 10 years? | Vegetation | Easting | Northing | Seasons surveyed 2019-20 |
|---|---|---|---|---|---|---|---|
| LI27 | Lindsay Is | dry | no | BB sparse | 519672 | 6229210 | Aut 20 |
| LI29 | Lindsay Is | dry | yes | Lignum | 519824 | 6229717 | Aut 20 |
| LI32 | Lindsay Is | dry | no | BB | 520005 | 6230114 | Aut 20 |
| LI33 | Lindsay Is | dry | no | BB sparse | 519975 | 6230224 | Aut 20 |
| LI34 | Lindsay Is | dry | no | BB sparse | 520585 | 6229116 | Aut 20 |
| LI35 | Lindsay Is | dry | no | BB | 520522 | 6229206 | Aut 20 |
| LI36 | Lindsay Is | dry | no | BB | 521134 | 6229529 | Aut 20 |
| LI37 | Lindsay Is | dry | yes | BB | 521004 | 6229655 | Aut 20 |
| LI38 | Lindsay Is | dry | no | BB sparse | 521730 | 6229322 | Aut 20 |
| LI39 | Lindsay Is | dry | yes | BB & moonah | 521768 | 6229245 | Aut 20 |
| LI41 | Lindsay Is | dry | no | BB sparse | 516410 | 6218360 | Aut 20 |
| LI42 | Lindsay Is | dry | no | BB | 516310 | 6218221 | Aut 20 |
| LI43 | Lindsay Is | dry | no | BB sparse | 516202 | 6218086 | Aut 20 |
| LI44 | Lindsay Is | dry | yes | RG | 516352 | 6218073 | Aut 20 |
| LI45 | Lindsay Is | dry | yes | RG | 516541 | 6218258 | Aut 20 |
| LI47 | Lindsay Is | dry | yes | RG | 522302 | 6230142 | Aut 20 |
| LI48 | Lindsay Is | dry | yes | Lignum | 521371 | 6228124 | Aut 20 |
| LI50 | Lindsay Is | dry | yes | Lignum | 521360 | 6228283 | Aut 20 |
| LI52 | Lindsay Is | dry | no | Low chenopods | 519371 | 6229179 | Aut 20 |
| LI53 | Lindsay Is | dry | no | Low chenopods | 519486 | 6228975 | Aut 20 |
| LI55 | Lindsay Is | dry | no | Mallee | 515028 | 6211768 | Spr19&Aut20 |
| LI56 | Lindsay Is | dry | no | Mallee | 514741 | 6211723 | Spr19&Aut20 |
| LI57 | Lindsay Is | dry | no | Mallee | 514575 | 6211732 | Spr19&Aut20 |
| LI58 | Lindsay Is | dry | no | Mallee | 514659 | 6211629 | Spr19&Aut20 |
| LI59 | Lindsay Is | dry | no | Mallee | 514831 | 6211744 | Spr19&Aut20 |
| LI60 | Lindsay Is | dry | no | Mallee | 514846 | 6211612 | Spr19&Aut20 |
| LI61 | Lindsay Is | dry | no | Mallee | 514831 | 6211440 | Spr19&Aut20 |
| LI62 | Lindsay Is | dry | no | Mallee | 510892 | 6212147 | Spr19&Aut20 |
| LI63 | Lindsay Is | dry | no | Mallee | 514733 | 6212528 | Spr19&Aut20 |
| LI64 | Lindsay Is | dry | no | Mallee | 514502 | 6212338 | Spr19&Aut20 |
| LI65 | Lindsay Is | dry | no | Mallee | 514720 | 6212346 | Spr19&Aut20 |

**Appendix 3.** Tables of species-level data on birds observed in flood-plain woodland along the Murray River from Hattah-Kulkyne National Park to Lindsay Island during surveys of woodland birds from spring 2019 to autumn 2020 (and relevant previous data from autumn 2019). Equivalent data at the guild level are presented in Tables 1-3 in the main text.

**Table A1.** Mean relative abundance (birds observed per standard 10-minute search of 1 ha per survey) of bird species in black box woodland in Hattah-Kulkyne National Park 2019-20, on sites near Lake Kramen that were flooded with environmental flows in 2019-20 (having been dry since 2015), sites near Mournpall Track that had been flooded in 2017-18 but were now dry, and sites near Mournpall Track that had not been flooded for >10 years . See Table 1 in main text for equivalent data on bird guilds.

| Region at Hattah | Kramen | Kramen | Kramen | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall |
|---|---|---|---|---|---|---|---|---|---|
| Floods recorded in last 10 years? | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Flood status at time | Dry | Flooded | Receding | Dry | Dry | Dry | Receded | Dry | Dry |
| Date | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 |
| Number of sites | 14 | 14 | 14 | 9 | 7 | 10 | 20 | 11 | 26 |
| **Species (land bird)** | | | | | | | | | |
| Emu | 0.07 | 0.02 | 0.07 | 0.04 | 0.01 | 0.00 | 0.06 | 0.08 | 0.00 |
| Common Bronzewing | 0.06 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.09 | 0.00 |
| Crested Pigeon | 0.24 | 0.12 | 0.00 | 1.44 | 0.00 | 0.00 | 0.35 | 0.45 | 0.04 |
| Peaceful Dove | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 |
| Australian Owlet-nightjar | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| Australian Hobby | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Whistling Kite | 0.01 | 0.18 | 0.07 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 0.00 |
| Major Mitchell's Cockatoo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| Galah | 0.59 | 0.00 | 0.00 | 0.89 | 0.00 | 0.00 | 0.05 | 0.00 | 0.58 |
| Sulphur-crested Cockatoo | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Regent Parrot | 1.76 | 2.24 | 5.14 | 0.00 | 0.00 | 0.00 | 0.10 | 0.00 | 1.04 |
| Yellow Rosella | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.00 | 0.30 | 0.00 | 0.19 |
| Australian Ringneck | 0.59 | 0.00 | 0.36 | 1.22 | 0.00 | 0.10 | 2.25 | 0.73 | 0.73 |
| Blue Bonnet | 0.00 | 0.00 | 0.00 | 1.56 | 0.00 | 0.30 | 0.00 | 0.00 | 0.00 |
| Red-rumped Parrot | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.10 | 0.18 | 0.12 |
| Mulga Parrot | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 |
| Sacred Kingfisher | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rainbow Bee-eater | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Region at Hattah | Kramen | Kramen | Kramen | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall |
|---|---|---|---|---|---|---|---|---|---|
| Floods recorded in last 10 years? | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Flood status at time | Dry | Flooded | Receding | Dry | Dry | Dry | Receded | Dry | Dry |
| Date | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 |
| Brown Treecreeper | 0.00 | 0.00 | 0.36 | 0.56 | 0.00 | 0.00 | 0.05 | 0.18 | 0.00 |
| Superb Fairy-wren | 0.00 | 0.18 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Weebill | 1.47 | 3.35 | 2.43 | 1.67 | 0.43 | 1.60 | 2.00 | 1.27 | 2.19 |
| Yellow Thornbill | 0.00 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yellow-rumped Thornbill | 0.00 | 0.00 | 0.43 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chestnut-rumped Thornbill | 0.71 | 0.24 | 1.64 | 0.11 | 0.00 | 0.50 | 0.15 | 0.64 | 0.00 |
| Spotted Pardalote | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Striated Pardalote | 0.59 | 1.41 | 0.07 | 0.44 | 0.00 | 0.00 | 1.05 | 0.73 | 0.15 |
| White-eared Honeyeater | 0.24 | 0.00 | 0.00 | 0.33 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 |
| Yellow-plumed Honeyeater | 0.00 | 0.00 | 0.00 | 0.56 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-plumed Honeyeater | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.10 | 0.09 | 0.00 |
| White-fronted Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 |
| Noisy Miner | 0.41 | 1.18 | 1.14 | 2.33 | 0.00 | 0.10 | 3.05 | 0.55 | 1.92 |
| Yellow-throated Miner | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 |
| Spiny-cheeked Honeyeater | 0.00 | 0.00 | 0.07 | 0.11 | 0.00 | 0.00 | 0.15 | 0.18 | 0.04 |
| Brown-headed Honeyeater | 0.00 | 0.18 | 0.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Little Friarbird | 0.00 | 0.06 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Striped Honeyeater | 0.12 | 0.12 | 0.14 | 0.11 | 0.00 | 0.00 | 0.35 | 0.00 | 0.04 |
| Black-faced Cuckoo-shrike | 0.00 | 0.00 | 0.21 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| Rufous Whistler | 0.18 | 0.06 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Grey Shrike-thrush | 0.29 | 0.18 | 0.50 | 0.00 | 0.00 | 0.00 | 0.10 | 0.09 | 0.04 |
| Grey Butcherbird | 0.29 | 0.06 | 0.14 | 0.22 | 0.00 | 0.10 | 0.40 | 0.55 | 0.08 |
| Pied Butcherbird | 0.00 | 0.12 | 0.00 | 0.56 | 0.00 | 0.10 | 0.10 | 0.27 | 0.04 |
| Australian Magpie | 0.76 | 0.18 | 0.14 | 0.78 | 0.14 | 0.00 | 0.10 | 0.91 | 0.08 |

| Region at Hattah | Kramen | Kramen | Kramen | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall | Mournpall |
|---|---|---|---|---|---|---|---|---|---|
| Floods recorded in last 10 years? | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Flood status at time | Dry | Flooded | Receding | Dry | Dry | Dry | Receded | Dry | Dry |
| Date | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 | Autumn 2019 | Summer 2020 | Autumn 2020 |
| Willie Wagtail | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.20 | 0.00 | 0.12 |
| Australian Raven | 0.12 | 0.35 | 0.07 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| Little Raven | 0.18 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Little Crow | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Restless Flycatcher | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 | 0.00 |
| Magpie-lark | 0.18 | 0.53 | 0.50 | 0.11 | 0.86 | 0.00 | 0.35 | 0.18 | 0.08 |
| White-winged Chough | 0.00 | 0.00 | 1.00 | 0.44 | 0.43 | 0.00 | 0.50 | 0.27 | 0.00 |
| Apostlebird | 0.00 | 0.00 | 0.00 | 1.33 | 0.00 | 0.00 | 0.70 | 1.45 | 0.00 |
| Red-capped Robin | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 | 0.00 |
| Welcome Swallow | 0.00 | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tree Martin | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 |
| **Species (water bird)** | | | | | | | | | |
| Grey Teal | 0.00 | 1.94 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-faced Heron | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Australian White Ibis | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Straw-necked Ibis | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Australian Spotted Crake | 0.00 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Black-tailed Native-hen | 0.00 | 2.41 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Masked Lapwing | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table A2.** Mean relative abundance of bird species in black box woodland at Kings Billabong (near Mildura) and Nangiloc (on Murray River near Hattah-Kulkyne National Park) in autumn 2019 and autumn 2020; and in mallee and dune vegetation at Hattah-Kulkyne National Park, autumn 2019 and summer 2020 (birds observed per standard 10-minute search of 1 ha). Two species sometimes listed with waterbirds (Whistling Kite and Australian Reed Warbler) are listed here with land birds to accord with taxonomic affinities. Waterbirds seen offsite on Kings Billabong are not shown. See Table 2 in main text for equivalent data on bird guilds.

| Location | Kings Billabong | Kings Billabong | Nangiloc | Nangiloc | Hattah (mallee & dune) | Hattah (mallee & dune) |
|---|---|---|---|---|---|---|
| Date | Autumn 2019 | Autumn 2020 | Autumn 2019 | Autumn 2020 | Autumn 2019 | Summer 2020 |
| Sites | 19 | 17 | 5 | 5 | 13 | 4 |
| **Species (land bird)** | | | | | | |
| Emu | 0.00 | 0.00 | 0.00 | 0.20 | 0.05 | 0.03 |
| Common Bronzewing | 0.14 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Crested Pigeon | 0.05 | 0.00 | 0.20 | 0.00 | 0.08 | 0.50 |
| Peaceful Dove | 0.05 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Australian Owlet-nightjar | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 |
| Collared Sparrowhawk | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Whistling Kite | 0.14 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yellow Rosella | 0.52 | 0.18 | 0.00 | 0.00 | 0.08 | 0.00 |
| Australian Ringneck | 0.38 | 0.00 | 0.00 | 0.00 | 0.92 | 0.00 |
| Blue Bonnet | 0.00 | 0.00 | 0.00 | 0.00 | 0.31 | 0.00 |
| Red-rumped Parrot | 0.29 | 0.47 | 0.00 | 0.40 | 0.00 | 0.00 |
| Mulga Parrot | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.50 |
| Laughing Kookaburra | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rainbow Bee-eater | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 1.25 |
| White-throated Treecreeper | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brown Treecreeper | 0.14 | 0.12 | 0.00 | 0.00 | 0.00 | 0.25 |

| Location | Kings Billabong | Kings Billabong | Nangiloc | Nangiloc | Hattah (mallee & dune) | Hattah (mallee & dune) |
|---|---|---|---|---|---|---|
| Date | Autumn 2019 | Autumn 2020 | Autumn 2019 | Autumn 2020 | Autumn 2019 | Summer 2020 |
| Weebill | 1.95 | 2.29 | 1.00 | 2.00 | 1.85 | 2.25 |
| Yellow Thornbill | 0.00 | 0.24 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yellow-rumped Thornbill | 0.10 | 0.00 | 0.00 | 0.00 | 0.46 | 0.00 |
| Chestnut-rumped Thornbill | 1.10 | 0.12 | 0.00 | 2.60 | 1.00 | 1.00 |
| Inland Thornbill | 0.00 | 0.59 | 0.00 | 0.00 | 0.00 | 0.00 |
| Southern Whiteface | 0.00 | 0.00 | 0.00 | 0.80 | 0.00 | 1.50 |
| Spotted Pardalote | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 |
| Striated Pardalote | 2.43 | 0.00 | 0.40 | 0.00 | 0.69 | 0.50 |
| Singing Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 |
| White-eared Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.62 | 0.00 |
| Yellow-plumed Honeyeater | 0.76 | 0.00 | 0.00 | 0.00 | 0.77 | 0.00 |
| White-plumed Honeyeater | 1.33 | 0.88 | 0.20 | 0.00 | 0.00 | 0.00 |
| White-fronted Honeyeater | 0.05 | 0.00 | 0.00 | 0.00 | 0.38 | 0.00 |
| Noisy Miner | 0.48 | 0.59 | 0.00 | 0.40 | 0.23 | 0.00 |
| Spiny-cheeked Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.46 | 0.25 |
| Red Wattlebird | 0.24 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| Brown-headed Honeyeater | 0.10 | 0.00 | 0.00 | 0.00 | 0.54 | 0.00 |
| Little Friarbird | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 |
| Striped Honeyeater | 0.10 | 0.24 | 0.00 | 0.00 | 0.31 | 0.00 |
| White-browed Babbler | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 |
| Chestnut-crowned Babbler | 0.00 | 0.00 | 0.02 | 0.20 | 0.00 | 0.50 |
| Black-faced Cuckoo-shrike | 0.05 | 0.00 | 0.00 | 0.20 | 0.00 | 0.00 |
| Rufous Whistler | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Grey Shrike-thrush | 0.43 | 0.06 | 0.00 | 0.00 | 0.00 | 0.25 |
| Crested Bellbird | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 |

| Location | Kings Billabong | Kings Billabong | Nangiloc | Nangiloc | Hattah (mallee & dune) | Hattah (mallee & dune) |
|---|---|---|---|---|---|---|
| Date | Autumn 2019 | Autumn 2020 | Autumn 2019 | Autumn 2020 | Autumn 2019 | Summer 2020 |
| Grey Butcherbird | 0.19 | 0.00 | 0.40 | 0.00 | 0.23 | 0.00 |
| Pied Butcherbird | 0.62 | 0.00 | 0.60 | 0.00 | 0.23 | 0.00 |
| Australian Magpie | 0.62 | 0.12 | 0.20 | 0.00 | 0.08 | 0.25 |
| Willie Wagtail | 0.19 | 0.18 | 0.00 | 0.00 | 0.15 | 1.25 |
| Australian Raven | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Magpie-lark | 0.24 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-winged Chough | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 |
| Jacky Winter | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.50 |
| Red-capped Robin | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 |
| Australian Reed-Warbler | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-backed Swallow | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Welcome Swallow | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Tree Martin | 0.24 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mistletoebird | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table A3.** Mean relative abundance of bird species on Mulcra Island and Lindsay Island in autumn 2019 and autumn 2020 (158 sites), and on a subset of 19 sites on Lindsay Island surveyed also in spring 2019 (birds observed per standard 10-minute search of 1 ha). See Table 3 in main text for equivalent data on bird guilds.

| **Season:** | Aut 2019 | Aut 2020 | Aut 2019 | Spr 2019 | Aut 2020 |
|---|---|---|---|---|---|
| **Location:** | Both islands | Both islands | Lindsay Is | Lindsay Is | Lindsay Is |
| **Sites:** | 186 | 158 | 19 | 19 | 19 |
| Emu | 0.09 | 0.05 | 0.07 | 0.00 | 0.05 |
| Common Bronzewing | 0.10 | 0.08 | 0.00 | 0.16 | 0.05 |
| Crested Pigeon | 0.17 | 0.16 | 0.00 | 0.00 | 0.00 |
| Diamond Dove | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Peaceful Dove | 0.23 | 0.23 | 0.00 | 0.00 | 0.00 |
| Tawny Frogmouth | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Australian Owlet-nightjar | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 |
| White-faced Heron | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 |
| Black-breasted Buzzard | off | 0.00 | 0.00 | 0.00 | 0.00 |
| Whistling Kite | 0.04 | 0.11 | 0.05 | 0.00 | 0.00 |
| Brown Goshawk | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Wedge-tailed Eagle | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 |
| Australian Hobby | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Galah | 0.17 | 0.35 | 0.11 | 0.11 | 0.53 |
| Sulphur-crested Cockatoo | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 |
| Regent Parrot | 0.02 | 0.07 | 0.00 | 0.00 | 0.00 |
| Yellow Rosella | 0.38 | 0.34 | 0.11 | 0.00 | 0.11 |
| Australian Ringneck | 0.20 | 0.11 | 0.32 | 0.00 | 0.21 |
| Blue Bonnet | 0.02 | 0.05 | 0.00 | 0.32 | 0.21 |
| Red-rumped Parrot | 0.32 | 0.10 | 0.00 | 0.00 | 0.00 |
| Mulga Parrot | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 |
| Southern Boobook | 0.00 | off | 0.00 | 0.00 | 0.00 |
| Laughing Kookaburra | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 |
| Red-backed Kingfisher | 0.00 | off | 0.00 | 0.00 | 0.00 |
| Sacred Kingfisher | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Rainbow Bee-eater | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| Brown Treecreeper | 0.16 | 0.06 | 0.37 | 0.47 | 0.00 |
| Superb Fairy-wren | 0.09 | 0.04 | 0.00 | 0.42 | 0.00 |
| Splendid Fairy-wren | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-winged Fairy-wren | 0.03 | 0.06 | 0.00 | 0.00 | 0.00 |
| Variegated Fairy-wren | 0.30 | 0.09 | 0.37 | 0.47 | 0.00 |
| Fairy-wren sp. | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |
| Shy Heathwren | 0.01 | 0.00 | 0.05 | 0.00 | 0.00 |
| Weebill | 1.62 | 0.56 | 3.16 | 4.42 | 0.53 |
| Western Gerygone | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Yellow Thornbill | 0.38 | 0.08 | 0.00 | 0.47 | 0.00 |
| Yellow-rumped Thornbill | 0.11 | 0.15 | 0.21 | 0.37 | 0.00 |
| Chestnut-rumped Thornbill | 1.12 | 0.58 | 1.16 | 1.74 | 0.21 |
| Inland Thornbill | 0.05 | 0.00 | 0.32 | 1.16 | 0.00 |

| Season: | Aut 2019 | Aut 2020 | Aut 2019 | Spr 2019 | Aut 2020 |
|---|---|---|---|---|---|
| Location: | Both islands | Both islands | Lindsay Is | Lindsay Is | Lindsay Is |
| Southern Whiteface | 0.10 | 0.06 | 0.16 | 0.32 | 0.00 |
| Spotted Pardalote | 0.00 | 0.03 | 0.00 | 0.11 | 0.00 |
| Striated Pardalote | 0.33 | 0.70 | 0.79 | 1.74 | 0.21 |
| Singing Honeyeater | 0.01 | 0.00 | 0.05 | 0.11 | 0.00 |
| White-eared Honeyeater | 0.02 | 0.02 | 0.05 | 0.00 | 0.00 |
| Yellow-plumed Honeyeater | 0.11 | 0.02 | 0.00 | 0.00 | 0.16 |
| White-plumed Honeyeater | 0.68 | 0.47 | 0.00 | 0.00 | 0.00 |
| White-fronted Honeyeater | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| Noisy Miner | 0.25 | 0.34 | 0.00 | 0.00 | 0.05 |
| Yellow-throated Miner | 0.11 | 0.16 | 0.53 | 0.00 | 1.16 |
| Spiny-cheeked Honeyeater | 0.48 | 0.31 | 0.47 | 0.05 | 0.32 |
| White-fronted Chat | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 |
| Blue-faced Honeyeater | 0.04 | 0.09 | 0.00 | 0.00 | 0.00 |
| Little Friarbird | 0.01 | 0.10 | 0.00 | 0.00 | 0.05 |
| Striped Honeyeater | 0.19 | 0.10 | 0.26 | 0.00 | 0.00 |
| White-browed Babbler | 0.02 | 0.06 | 0.00 | 0.00 | 0.00 |
| Chestnut-crowned Babbler | 0.25 | 0.12 | 0.26 | 0.00 | 0.00 |
| Varied Sittella | 0.02 | 0.05 | 0.00 | 0.16 | 0.00 |
| Ground Cuckoo-shrike | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| Black-faced Cuckoo-shrike | 0.03 | 0.10 | 0.11 | 0.11 | 0.05 |
| Gilbert's Whistler | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Golden Whistler | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| Rufous Whistler | 0.25 | 0.15 | 0.63 | 0.42 | 0.05 |
| Grey Shrike-thrush | 0.19 | 0.27 | 0.16 | 0.37 | 0.11 |
| Crested Bellbird | 0.00 | 0.01 | 0.00 | 0.05 | 0.11 |
| Dusky Woodswallow | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Grey Butcherbird | 0.16 | 0.19 | 0.26 | 0.00 | 0.16 |
| Pied Butcherbird | 0.09 | 0.13 | 0.00 | 0.05 | 0.26 |
| Australian Magpie | 0.13 | 0.18 | 0.16 | 0.00 | 0.21 |
| Grey Fantail | 0.18 | 0.04 | 0.00 | 0.00 | 0.00 |
| Willie Wagtail | 0.11 | 0.01 | 0.16 | 0.05 | 0.00 |
| Australian Raven | 0.05 | 0.16 | 0.00 | 0.11 | 0.37 |
| Little Raven | 0.00 | 0.04 | 0.00 | 0.00 | 0.21 |
| Little Crow | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| Restless Flycatcher | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Magpie-lark | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 |
| White-winged Chough | 0.12 | 0.13 | 0.26 | 0.00 | 0.42 |
| Red-capped Robin | 0.14 | 0.05 | 0.11 | 0.26 | 0.11 |
| Hooded Robin | 0.01 | 0.00 | 0.05 | 0.11 | 0.00 |
| Welcome Swallow | 0.04 | 0.01 | 0.11 | 0.16 | 0.00 |
| Tree Martin | 0.60 | 0.04 | 0.11 | 0.00 | 0.00 |
| Mistletoebird | 0.04 | 0.00 | 0.00 | 0.05 | 0.00 |
| Diamond Firetail | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |

**Table A4.** Mean relative abundance of bird species in various habitats on Mulcra Island and Lindsay Island, spring 2019 to autumn 2020 (birds observed per standard 10-minute search of 1 ha). The values for BB moonah and Mallee chenopod include data from spring 2019 as well as autumn 2020. See Table 4 in main text for equivalent data on bird guilds. BB = black box, RG = river red gum.

| | BB chenopod | BB moonah | BB sparse | BB all | Herbland | Lignum | Low treeless chenopods | Mallee chenopod | RG |
|---|---|---|---|---|---|---|---|---|---|
| Sites | 47 | 22 | 9 | 78 | 6 | 29 | 4 | 23 | 38 |
| Emu | 0.06 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.04 | 0.11 |
| Common Bronzewing | 0.17 | 0.14 | 0.00 | 0.14 | 0.00 | 0.03 | 0.00 | 0.09 | 0.03 |
| Crested Pigeon | 0.15 | 0.00 | 0.11 | 0.10 | 0.00 | 0.34 | 0.00 | 0.00 | 0.18 |
| Diamond Dove | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| Peaceful Dove | 0.28 | 0.05 | 0.22 | 0.21 | 0.17 | 0.14 | 0.00 | 0.00 | 0.39 |
| Tawny Frogmouth | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Australian Owlet-nightjar | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 | 0.00 | 0.00 | 0.03 |
| White-faced Heron | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| Black-breasted Buzzard | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | off | 0.00 | 0.00 |
| Whistling Kite | 0.23 | 0.00 | 0.00 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| Brown Goshawk | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| Wedge-tailed Eagle | 0.00 | 0.00 | 0.22 | 0.03 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 |
| Australian Hobby | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 |
| Galah | 0.09 | 0.00 | 0.22 | 0.08 | 0.00 | 0.00 | 0.00 | 0.52 | 1.05 |
| Sulphur-crested Cockatoo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| Regent Parrot | 0.06 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 |
| Yellow Rosella | 0.32 | 0.18 | 0.00 | 0.24 | 1.00 | 0.07 | 0.00 | 0.00 | 0.68 |
| Australian Ringneck | 0.09 | 0.14 | 0.22 | 0.12 | 0.00 | 0.00 | 0.00 | 0.17 | 0.13 |
| Blue Bonnet | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.07 | 0.00 | 0.52 | 0.00 |
| Red-rumped Parrot | 0.09 | 0.00 | 0.22 | 0.08 | 1.67 | 0.00 | 0.00 | 0.00 | 0.00 |
| Mulga Parrot | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 | 0.00 |
| Laughing Kookaburra | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| Red-backed Kingfisher | 0.00 | off | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sacred Kingfisher | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rainbow Bee-eater | 0.00 | 0.05 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Birds in Black Box woodlands in Hattah-Kulkyne NP, Nangiloc & Kings Billabong October 2019 to March 2020

| | BB chenopod | BB moonah | BB sparse | BB all | Herbland | Lignum | Low treeless chenopods | Mallee chenopod | RG |
|---|---|---|---|---|---|---|---|---|---|
| Brown Treecreeper | 0.04 | 0.00 | 0.22 | 0.05 | 0.00 | 0.00 | 0.00 | 0.39 | 0.16 |
| Superb Fairy-wren | 0.13 | 0.36 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| White-winged Fairy-wren | 0.21 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Variegated Fairy-wren | 0.09 | 0.41 | 0.00 | 0.17 | 0.00 | 0.38 | 0.00 | 0.00 | 0.00 |
| Weebill | 0.98 | 1.86 | 0.56 | 1.18 | 0.00 | 0.24 | 0.00 | 2.48 | 0.42 |
| Western Gerygone | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yellow Thornbill | 0.23 | 0.41 | 0.00 | 0.26 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| Yellow-rumped Thornbill | 0.49 | 0.00 | 0.00 | 0.29 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 |
| Chestnut-rumped Thornbill | 1.23 | 0.50 | 0.00 | 0.88 | 0.00 | 0.52 | 0.00 | 1.52 | 0.26 |
| Inland Thornbill | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.96 | 0.00 |
| Southern Whiteface | 0.00 | 0.18 | 0.44 | 0.10 | 0.00 | 0.21 | 0.00 | 0.09 | 0.00 |
| Spotted Pardalote | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.11 |
| Striated Pardalote | 0.70 | 0.59 | 0.67 | 0.67 | 0.33 | 0.24 | 0.25 | 1.39 | 1.29 |
| Singing Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| White-eared Honeyeater | 0.06 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yellow-plumed Honeyeater | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 |
| White-plumed Honeyeater | 0.60 | 0.00 | 0.44 | 0.41 | 0.83 | 0.17 | 0.00 | 0.00 | 0.87 |
| Noisy Miner | 0.11 | 0.05 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 1.26 |
| Yellow-throated Miner | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.75 | 0.96 | 0.00 |
| Spiny-cheeked Honeyeater | 0.34 | 0.41 | 0.22 | 0.35 | 0.00 | 0.48 | 0.50 | 0.04 | 0.16 |
| White-fronted Chat | 0.15 | 0.00 | 0.00 | 0.09 | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 |
| Blue-faced Honeyeater | 0.04 | 0.00 | 0.00 | 0.03 | 0.50 | 0.00 | 0.00 | 0.00 | 0.24 |
| Little Friarbird | 0.11 | 0.05 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.26 |
| Striped Honeyeater | 0.11 | 0.09 | 0.00 | 0.09 | 0.17 | 0.07 | 0.00 | 0.00 | 0.16 |
| White-browed Babbler | 0.00 | 0.00 | 0.78 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 |
| Chestnut-crowned Babbler | 0.17 | 0.23 | 0.00 | 0.17 | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 |
| Varied Sittella | 0.06 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.13 | 0.13 |
| Black-faced Cuckoo-shrike | 0.15 | 0.09 | 0.00 | 0.12 | 0.17 | 0.10 | 0.00 | 0.04 | 0.11 |

Birds in Black Box woodlands in Hattah-Kulkyne NP, Nangiloc & Kings Billabong October 2019 to March 2020

| | BB chenopod | BB moonah | BB sparse | BB all | Herbland | Lignum | Low treeless chenopods | Mallee chenopod | RG |
|---|---|---|---|---|---|---|---|---|---|
| Gilbert's Whistler | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| Golden Whistler | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Rufous Whistler | 0.09 | 0.36 | 0.11 | 0.17 | 0.00 | 0.24 | 0.00 | 0.13 | 0.24 |
| Grey Shrike-thrush | 0.34 | 0.27 | 0.44 | 0.33 | 0.17 | 0.21 | 0.00 | 0.22 | 0.32 |
| Crested Bellbird | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 |
| Dusky Woodswallow | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 | 0.00 |
| Grey Butcherbird | 0.28 | 0.09 | 0.11 | 0.21 | 0.00 | 0.07 | 0.00 | 0.13 | 0.26 |
| Pied Butcherbird | 0.11 | 0.23 | 0.11 | 0.14 | 0.00 | 0.21 | 0.50 | 0.09 | 0.03 |
| Australian Magpie | 0.17 | 0.00 | 0.22 | 0.13 | 0.00 | 0.10 | 0.50 | 0.17 | 0.26 |
| Grey Fantail | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 |
| Willie Wagtail | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 |
| Australian Raven | 0.06 | 0.09 | 0.00 | 0.06 | 0.00 | 0.17 | 0.00 | 0.30 | 0.29 |
| Little Raven | 0.00 | 0.00 | 0.22 | 0.03 | 0.00 | 0.00 | 0.00 | 0.17 | 0.00 |
| Little Crow | 0.02 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Magpie-lark | 0.00 | 0.00 | 0.11 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.16 |
| White-winged Chough | 0.26 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.35 | 0.00 |
| Red-capped Robin | 0.06 | 0.18 | 0.00 | 0.09 | 0.00 | 0.03 | 0.00 | 0.13 | 0.05 |
| Hooded Robin | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 |
| Welcome Swallow | 0.00 | 0.14 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 |
| Tree Martin | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 |
| Mistletoebird | 0.00 | 0.05 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Diamond Firetail | 0.04 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Appendix 4. Notes on waterbirds observed during bird surveys at Hattah, Nangiloc, Kings Billabong, Mulcra Island and Lindsay Island, spring 2019 to autumn 2020.**

Waterbirds were scarce in the dry conditions that prevailed in 2019-20, except in areas that had been newly flooded (Lake Kramen and surrounding black box woodlands) and lakes or creeks that still retained water (e.g. Lake Mournpall, where water levels had fallen to reveal a muddy shore of 1-200m in width) (Table A5).

Table A5. Waterbirds counted on Lake Kramen and Lake Mournpall January 2020, with notes on others observed elsewhere (mainly in black box woodland BB near Lake Kramen when the woodland was flooded summer and autumn 2020).

| Site | Lake Kramen (150 ha) | Lake Mournpall (180 ha) | Elsewhere |
|---|---|---|---|
| % full of water | 100 | 70 | |
| Date | 14/1/20 | 15/1/20 | |
| **Species** | | | |
| Black Swan | 1 | 0 | |
| Australian Wood Duck | 0 | 0 | Small groups Mulcra Island (22 and 9) |
| Pink-eared Duck | 100 | 0 | 20+ in flooded BB Kramen |
| Australasian Shoveler | 1 | 0 | |
| Grey Teal | 200 | 0 | 150+ in flooded BB Kramen |
| Pacific Black Duck | 5 | 0 | 80+ in flooded BB Kramen; 2 on creek Mulcra Island |
| Hardhead | 6 | 0 | At least one in flooded BB Kramen |
| Australasian Grebe | 1 | 0 | |
| Hoary-headed Grebe | 30 | 0 | |
| Australasian Darter | 0 | 0 | Several Murray River |
| Little Pied Cormorant | 0 | 0 | A few Murray River |
| Australian Pelican | 1 | 44 | A few Murray River, creeks or overhead |
| White-faced Heron | 0 | 0 | A few along creeks |
| Australian White Ibis | 0 | 0 | A few in flooded BB Kramen |
| Straw-necked Ibis | 0 | 0 | A few in flooded BB Kramen |
| Yellow-billed Spoonbill | 0 | 8 | |
| Australian Spotted Crake | 0 | 0 | One with 2 large chicks BB40/41, calling often |
| Black-tailed Native-hen | 0 | 0 | Several groups in flooded BB Kramen, up to 26 together |
| Eurasian Coot | 50 | 0 | Singles in flooded BB Kramen |
| Black-winged Stilt | 0 | 15 | |
| Black-fronted Dotterel | 0 | 1 | |
| Masked Lapwing | 0 | 7 | At least one pair in flooded BB Kramen |
| Caspian Tern | 0 | 0 | Singles along Murray River |
| **Total waterbirds** | **395** | **75** | |
| **Waterbirds/ha water** | **2.6** | **0.6** | **4.8** |

Lake Kramen supported a reasonably diverse collection of waterbird species soon after peak flood (Table A5), from a range of guilds (Table A6). In contrast, the waterbird community at drying Lake Mournpall comprised fewer species (Table A5) representing just three guilds (Table A6). These guilds were fish-eating birds (Australian Pelicans on this occasion), long-legged wading birds (Yellow-billed Spoonbills, which may have been taking small fish and crustaceans) and shorebirds (taking invertebrates from shallow water or muddy shores). A visiting fisherman reported that he had observed Australian Pelicans feeding on tortoises as well as fish. The drying conditions appeared to favour fish-eating birds and shorebirds but not other waterbird guilds.

Flooded black box woodland supported a diverse collection of species and guilds (Tables A5 and A6). Waterbird density appeared to be almost twice as high in flooded black box woodland as on the open waters of Lake Kramen, which in turn was several times higher than on the drying open waters of Lake Mournpall (Table A6). Notable records included a flock of 26 Black-tailed Native-hens in a flooded patch of black box on an otherwise treeless plain (BB35); and an Australian Spotted Crake calling repeatedly at another site (BB40/41), and then seen with two well-grown chicks. The current flood appears to have attracted more of these species to the woodlands, but had not attracted as many diving ducks to Lake Kramen as the 2014 flood event (Loyn et al. 2017; Loyn and Cheers 2018).

Table A6. Waterbird densities in flooded black box near Lake Kramen, and on Lake Kramen and Lake Mournpall in January 2020, expressed as birds of each guild observed per square kilometre of water surface, or percent of total waterbirds observed.

| **Site** | **Black box near Kramen** | **Lake Kramen** | **Lake Mournpall** |
|---|---|---|---|
| Area when full (ha) | N/A | 150 | 180 |
| % full of water | 100 | 100 | 70 |
| Water area (ha surveyed) | 17 | 150 | 126 |
| Date | Jan-20 | 14/01/2020 | 15/01/2020 |
| **Species** | **Birds per km$^2$** | **Birds per km$^2$** | **Birds per km$^2$** |
| **Total waterbirds** | **482** | **263** | **60** |
| Fish-eaters (pelicans & cormorants) | 6 | 21 | 35 |
| Herbivores (mainly native-hens & coot) | 241 | 34 | 0 |
| Dabbling ducks (teal & black duck) | 194 | 137 | 0 |
| Diving ducks (hardhead) | # | 4 | 0 |
| Filter-feeding ducks (pink-eared & shoveler) | # | 67 | 0 |
| Long-legged wading birds (herons, ibis, etc) | 47 | 0 | 6.3 |
| Shorebirds (lapwings, dotterel & stilts) | # | 0 | 18.3 |
| *Fish-eaters as %* | 1.2 | 8.1 | 58.7 |
| *Herbivores as %* | 50.0 | 12.9 | 0 |
| *Dabbling ducks as %* | 40.2 | 51.9 | 0 |
| *Diving ducks as %* | # | 1.5 | 0 |
| *Filter-feeding ducks as %* | # | 25.6 | 0 |
| *Long-legged wading birds as %* | 9.8 | 0 | 10.7 |
| *Shorebirds as %* | # | 0 | 30.7 |

# denotes guilds represented by species that were seen off-site only during woodland bird surveys in black box: they are likely to constitute small proportions of the waterbird community.

**Appendix 5. Notes on mammals observed during bird surveys at Hattah, Nangiloc, Kings Billabong, Mulcra Island and Lindsay Island, spring 2019 to autumn 2020.**

Mammals were observed mainly through incidental records (during bird surveys and while travelling between sites), and observation of signs (mainly scats). These records have not been subject to quantitative analysis.

As usual, Western Grey Kangaroos *Macropus fuliginosus* were common throughout these areas, though our impression was that in summer 2020 there may not have been as many at Hattah as there had been in previous years (R.Loyn pers. obs.). Red Kangaroos *Macropus rufus* were also seen quite commonly, mainly in open plains with sparse tree cover (and quite rarely on our sites in black box woodland). Scats or signs of introduced species (European Rabbit *Oryctolagus cuniculus*, Brown Hare *Lepus europeaus*, Red Fox *Vulpes vulpes,* Feral Pig *Sus scrofa* and Feral Goat *Capra hircus*) were found on a few sites.

Three additional species of native mammal were recorded in low numbers, and these deserve further comment as they are sometimes considered uncommon or rare in the Mallee region.

Eastern Grey Kangaroos *Macropus giganteus* were identified at one site on Lindsay Island (LI10), two sites on Mulcra Island (MI13 and MI15) and one site at Kings Billabong (KB5), all in autumn 2020. This species was considered to be outside its normal range in these north-western parts of the Mallee, although kangaroo shooters apparently encounter them quite often in addition to the more common Western Grey Kangaroos and Red Kangaroos (G. Cheers, pers. comm.), and their range is now known to extend downstream along the Murray River into South Australia (Menkhorst 1995; Menkhorst and Knight 2004). We had recorded the species previously at Kings Billabong.

A Black Wallaby *Wallabia bicolor* was seen and photographed at one of the river red gum sites in Hattah-Kulkyne National Park (RG1, beside Lake Mournpall) in summer 2020. This species was virtually unknown from the Mallee region until the 1990s, when its range began to expand dramatically in northern and western Victoria (Venn 1993; Menkhorst 1995), but it remains a rare species as far inland as this record (Menkhorst and Knight 2004). Park rangers have also observed the species occasionally (K. Mott pers. comm.).

A Short-beaked Echidna *Tachyglossus aculeatus* was seen on Mulcra Island at MI56 in autumn 2020, surprisingly only the second record of this species during our surveys (the first being indirect observations of scratchings on Mulcra Island at MI36 in March 2016). Records of this species are sparser in the Mallee region than in lowland forests or woodlands elsewhere in Victoria, despite their wide distribution throughout Australia (Menkhorst 1995; Menkhorst and Knight 2004).