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Riparian bird assemblages of Cooper Creek, South Australia

J.R.W. Reid and J.S. Gillen

RIPARIAN BIRD ASSEMBLAGES OF COOPER CREEK, SOUTH AUSTRALIA, APRIL-MAY 2012

J.R.W. Reid[1] and J.S. Gillen[2]

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Report to the South Australian Arid Lands Natural Resources Management Board

[1 2] Fenner School of Environment and Society, Australian National University

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Cover image:

L) Map of North West Branch of Cooper Creek, Innamincka Regional Reserve

R) Poorly surveyed coolibah-lignum swamps along the North West Branch, upstream of Mudrangie Waterhole, important for nesting waterbirds when inundated (as shown here in May 2004) and for the riparian birds of Cooper Creek generally. Photograph by Trish Hill.

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EXECUTIVE SUMMARY

Fourteen riparian and 13 adjacent off-river bird assemblages were censused in the Cooper Creek region, South Australia, in April-May 2012. This section of the river is characterised by a steep gradient of declining discharge with distance downstream. In upper parts of the study area around Innamincka and the Coongie Lakes, annual flows from Queensland parts of the catchment are the norm and there is a well-formed, structurally complex, diverse strand of riparian vegetation that supports diverse bird communities and highly significant breeding raptor populations. Lower parts of the study area, by comparison, are saline, arid and receive infrequent flows, and woody riparian vegetation is sparse with only the coolibah present at variable and low densities. Towards the mouth of Cooper Creek near Lake Eyre even coolibahs cannot persist. Birds were censused once along 500 x 100 m belt transects.

Bird species richness (alpha diversity) was highest in upper and middle sections of the gradient surveyed, particularly around Tirrawarra and Kudriemitchie Waterholes on the North West Branch with upward of 40 landbird species detected in riparian sites. Diversity declined rapidly downstream of Parachirrinna Waterhole in the middle portion of the study area. Because of access problems a long stretch of the Cooper Creek environment could not be surveyed between there and Lake Appadare. Riparian bird species richness was significantly lower at the four sites below Lake Appadare. Riparian community abundance followed the same trend with very high bird abundances recorded in upper parts (27-46 indiviudals ha^{-1}) declining to 18-22 birds ha^{-1} at the four downstream sites. Species richness and community abundance were significantly greater in riparian habitats than adjacent off-river habitats. Rank cover-abundance of coolibah explained **79%** of the variance in resident bird species richness across the 27 sites, and **70%** of resident bird community abundance. A combined rank cover-abundance score for the region's three dominant riparian tree species – river red gum, coolibah and Queensland bean-tree – explained **75%** of the variance in community abundance, with coolibah being the most influential of these three species.

Compositional turnover in bird communities, a measure of beta diversity, varied laterally away from the river channels and longitudinally in the Cooper Creek region. A dramatic shift in the composition of riparian bird assemblages occurred between Parachirrinna Waterhole and the lakes Appadare-Hope area, coincident with the marked reduction in species richness. While the loss of upstream bird species explained some of the shift in assemblage composition at this point, a second process was equally important. Several species more characteristic of open-structured floodplain environments in upper parts of the study area, e.g. Blue Bonnet, Yellow-throated Miner, Singing Honeyeater, Black-faced Woodswallow and Australian Magpie, were found to be prominent members of the downstream riparian communities. Riparian bird species absent from the four most downstream sites included Peaceful Dove, Australian Ringneck, Brown Treecreeper, Jacky Winter and Grey Shrike-thrush, while others were much less abundant than in upstream areas, e.g. Little Corella, Red-rumped Parrot and Spiny-cheeked and White-plumed Honeyeaters. Rank cover-abundance of coolibah explained over **80%** of the variance in a two-dimension NMDS ordination of bird assemblages (n = 27), and the major axis of differentiation in community composition separated the 10 upstream riparian bird communities from the other 17 sites with the cover of small trees (e.g. plumbush, Broughton willow, river coobah and native orange) being most directly aligned with this axis). These small (to medium-sized) trees add much structural complexity to the riparian vegetation in upper and middle portions of the study area, but are generally absent from the channel margins in downstream sections. Both vegetation structure and floristic composition of the riparian vegetation were significantly correlated with turnover in bird communities, but floristic variation was the much more influential variable (from Mantel tests and Procrustes rotation analyses).

Nomadic and transient bird species are a significant component of bird communities in arid Australia, and they were prominent to varying degrees in this snapshot survey across a large study area. Their idiosyncratic distribution, which presumably results from diverse interactions with food resources and landscape features at multiple spatial (and temporal) scales, made pattern detection in these bird communities problematic and, as expected, the removal of 21 mobile species from the data set sharpened the patterns described above appreciably. Furthermore, the 14 riparian bird communities did not show significant nested subset structure with the inclusion of the nomadic birds (under a stringent null model test), but with analyses confined to the resident bird species significant nested structure was observed in these assemblages. Significant results were obtained when the 14 assemblages were ordered by longitudinal river position (and assumed rank of mean long-term annual flow), but nestedness was more evident (as indicated by lower matrix temperature) when the assemblages were ordered by bird species richness. Species richness and longitudinal position were not significantly rank correlated – a surprising result – because bird diversity was greatest in middle sections of the gradient. Further and more intensive research is required to determine whether riparian bird communities are actually more diverse in the swamp-dominated mid sections of the study area (between the disjunction of the Cooper into its two main distributaries and the Coongie Lakes on the North West Branch and Narie Waterhole on the Main Branch) than the higher volume environments around Innamincka, as single bird censuses at a limited number of sites could generate misleading results.

While coolibah is the most influential plant species in the region in terms of controlling most of the variation in bird species richness and compositional turnover, the restricted distribution of river red gums is also highly significant as the distribution of six bird species, including the Barking Owl, a nationally threatened species, is largely confined to areas where the red gum occurs. Research is required into the factors that affect the distribution, recruitment and mortality of these two key trees, and also into the ecological links between them and the associated bird species.

1. INTRODUCTION

The composition of bird communities in arid lands of the world tend to be more dynamic than those of other climatic zones in response to rainfall and resource-provisioning uncertainty and unpredictability, and nowhere is the between-year rainfall unpredictability and dynamism more pronounced than in inland Australian ecosystems (Morton *et al.* 2011). Shifts in assemblage composition unrelated to predictable seasonal changes in temperature (time of year) pose special challenges for ecological monitoring and assessment of ecosystem health and condition, as data interpretation has to take account of prevailing and antecedent conditions. Accordingly, Reid and Fleming (1992), recognising these challenges with respect to assessment of the conservation status of birds in arid Australia, recommended that sedentary birds tied to define habitats offered the best prospects for ecological monitoring, and their insight is extended here to issues of measuring ecosystem health and condition. Riparian bird communities in the Far North East of South Australia are diverse and constructed largely from sedentary species (Reid and Gillen 1988; Reid *et al.* 1990), a situation exemplified in the Cooper Creek riparian zones. Other studies in arid Australia have found that sedentary bird species dominate the assemblages of habitats in run-on environments and fertile soils having a preponderance of long-lived woody perennial tree and tall shrub species (e.g. Stafford Smith and Morton 1990; Reid *et al.* 1993; Burbidge and Fuller 2007).

The distribution and relative abundance of birds in the Far North East of South Australia are well documented and understood in general terms, due to historical accounts in the nineteenth and early twentieth centuries (e.g. Sturt 1849; White 1917; Morgan 1930; a series of bird notes published by L.R. Reese in the 1920s and 1930, summarised in Reid 1984 and Badman 1989), and more contemporary accounts and reviews since the 1970s (Cox and Pedler 1977; Parker 1980; Blakers *et al.* 1984; Reid 1984, 1992, 2000; May 1986; Reid and Gillen 1988; Badman 1989; Reid *et al.* 1990; Schodde and Mason 1999). Birds along South Australian sections of Cooper Creek have been particularly well studied by Badman, May and Reid, and the distributional (geographic) limits of those species that do not range broadly across the Far North East have received particular attention. There are two main biogeographic patterns of interest in this regard (e.g. Reid *et al.* 1990). First, in line with continental gradients in mean annual rainfall whereby the most arid core of Australia is centred on Lake Eyre and the southern Simpson Desert (median annual rainfall <= 100 mm, e.g. McMahon *et al.* 2008a), a large number of species with broad ranging distributions over much of inland Australia have gaps in their geographic ranges in this region or reach their geographic limits outside of the region in response to the aridity and lack of favoured vegetation types, particularly mulga *Acacia aneura* communities. Second, a smaller number of bird species that favour riparian (or floodplain) woodland either extend their distribution west along the Cooper Creek corridor from their main centres of distribution in higher rainfall regions to the east or have disjunct linear distributions along parts of Cooper Creek, separated from larger populations to the south, east or north, e.g. Barking Owl *Ninox* *connivens*, Australian Ringneck *Barnardius zonarius barnardi*, Red-rumped Parrot *Psephotus heamatonotus caeruleus*, Brown Treecreeper *Climacteris picumnus*, Golden-backed form of the Black-chinned Honeyeater *Melithreptus gularis laetior*, and Jacky Winter *Microeca fascinans pallida*. This linear and/or disjunct pattern of bird distribution along river corridors in semi-arid environments has been documented in some other parts of Australia, such as in the southern Gulf of Carpentaria region (Woinarski *et al.* 2000) and along the Murray and Darling Rivers (Joseph and Reid 1981). In the Far North East, the above six species are restricted to the upper half of Cooper Creek, or largely so – the Red-rumped Parrot appears to have colonised adjacent parts of the Diamantina River drainage between Goyders Lagoon and Roseberth, south-west Queensland, only since the early 1990s. Several other species which are more widely distributed in the region are encountered frequently along the Upper Cooper but have local range limits in the middle or lower portions of Cooper Creek, apparently being unable to cope with the decrease in density of riparian trees and increasing aridity and salinity that occurs with increasing distance downstream (in response to the regional trends in declining streamflow and frequency of flooding in lower reaches: McMahon *et al.* 2008b), and as documented by Badman (1989) – examples include Peaceful Dove *Geopelia striata*, Tawny Frogmouth *Podargus strigoides*, Yellow-rumped Thornbill *Acanthiza chrysorrhoa*, Grey Shrike-thrush *Colluricincla harmonica* and Restless Flycatcher *Myiagra inquieta*. Badman (1989) observed that after the Coolibahs *Eucalyptus coolabah* cut out at Cuttapirra Waterhole many bird species dependent on large timber did not occur further downstream to Lake Eyre. The importance of longitudinal connectivity in rivers of arid zones is emphasised by the foregoing examples of bird distribution patterns.

Another feature of interest in the region is the tendency for several bird species to have evolved paler colouring than subspecies and populations in wetter parts of Australia (Schodde 1982). Examples include the Red-rumped Parrot and Blue Bonnet, and the Lake Eyre Basin population of the latter is sometimes recognised as the distinct subspecies *Northiella haematogaster pallescens* (Parker 1980); the former is an isolated well-differentiated subspecies. Cooper Creek populations of Jacky Winter and Grey Shrike-thrush are also distinctly more pallid than their south-eastern Australian counterparts, as are Lake Eyre Basin Cinnamon Quail-thrush *Cinclosoma cinnamomeum tirariensis* (Schodde and Mason 1999) and Black-faced Woodswallow, but only the first two are birds of the riparian zone, particularly the shrike-thrush. The evolution of pale, 'washed-out' plumage, being common to several species, is thought to represent ecophenotypic, genetically-based, adaptation to the high levels of sunlight, bleached soils and openness of the vegetation and terrain in the Lake Eyre Basin, and only occurs in sedentary species.

Riparian zones are important ecotones between fluvial aquatic ecosystems and the surrounding terrestrial environment (Naiman and Decamps 1997). In large floodplain rivers such as Cooper Creek the entire floodplain is a significant dry-wet ecotone. The vital role of maintenance of lateral connectivity between the river and its floodplain was emphasised by Junk *et al.* (1989), but their 'flood pulse concept' (FPC) model straitjacketed rivers into the restricted situations of in-channel flows punctuated by large floods when the entire floodplain would be inundated. Puckridge *et al.* (1998, 2000) extended the concept to account for the greater hydrological variability of dryland rivers such as Cooper Creek, accounting for periods of no-flow, and various sizes of flows and floods that inundated and connected various parts and extents of the floodplain. The research by Puckridge and colleagues also identified the links between the ENSO climate phenomenon and hydrological variability in Lake Eyre Basin rivers, and erected the flood cluster hypothesis (Puckridge *et al.* 2000), which propounded that a succession of years of above-average rainfall and flood size might generate an enormous boom in aquatic fauna, e.g. native fish, and that in the inevitable bust periods exotic species might be disadvantaged compared with the native species, i.e. that native species might have an evolutionary advantage over exotics and that this interaction of climate, hydrology and biology might offer some natural protection to these boom-bust rivers provided the natural variability of the rivers was retained. Costelloe *et al.* (2010) found some evidence allowing cautious support for this hypothesis, in the different responses of exotic and native fishes to flooding and drying cycles in Lake Eyre Basin rivers.

The studies of fish in South Australian sections of the Cooper Creek by Puckridge *et al.* (1998, 2000, 2010) and Costelloe *et al.* (2010) revealed the significance of strong connectivity between the floodplain and main channels for fish movements and reproduction. Riparian zones are highly significant mediators of connectivity between river and floodplain, and are important in a variety of ways, namely, filtering nutrients and organic and inorganic sediment inputs into the channel, direct contribution of organic matter as log and litter fall and indirect contributions from terrestrial fauna, in providing terrestrial and aquatic habitat, and in providing shading and bank stability (Naiman and Decamps 1997; Sheldon *et al.* 2005). In relation to birds, the focus of this report, riparian vegetation in drylands is known to provide habitat for diverse communities (Shurcliff 1980; Naiman *et al.* 1993), and the Cooper's riparian zone supports diverse local bird communities and is an important factor in elevating regional diversity (Reid *et al.* 1990). The waterholes and riparian vegetation in the Cooper Creek region are significant for birds in many respects: as sheltered water sources for landbirds that need to drink regularly; for the richness and abundance of the landbird communities; as breeding (and foraging) habitat for diverse and abundant raptor assemblages; breeding, feeding and shelter habitat for a wide range of waterbirds; as habitat for birds of conservation significance at the national and South Australian level. Riparian vegetation along Cooper Creek provides important breeding habitat for the nationally Vulnerable species, Grey Falcon *Falco hypoleucos*, while the Cooper floodplain is important habitat for the Endangered and little-known Night Parrot *Pezoporus occidentalis* (e.g. Parker 1980; Reid and Gillen 1988; Badman 1989; Reid 2000; status assignments after Garnett *et al.* 2011).

Few quantitative surveys of birds in riparian vegetation along Cooper Creek have been documented – the South Australian National Parks and Wildlife Service has gathered quadrat-based observations of birds during biological survey projects (e.g. Reid 1984), J. Reid and colleagues obtained density estimates using transects at a handful of riparian sites around the Coongie Lakes and North West Branch in 1996 (Reid 1999), and J. Reid and colleagues collected similar density data at several riparian sites in each of the Christmas Creek and Lake Appadare districts in 2005 (Gillen and Reid 2010). Transect counts of the same duration and length were undertaken for this study to investigate the condition and health of riparian bird communities at significant waterholes along Cooper Creek after an extended period of above-average rainfall.

The aims of the project overall were to develop an understanding of ecosystem processes of the Cooper Creek catchment (SA section), and to document the natural values of and management issues facing the high ecological value aquatic ecosystems of the system (from project brief). The following project objectives were of relevance to bird surveys: identification of the biophysical processes that influence ecosystem health, sustain biodiversity and inform environmental water requirements; assessment of the importance of waterbodies (i.e. waterholes and lakes) as biological refugia; improvement of the understanding of ecological (including but not confined to riverine) connectivity; identification of any aquatic pest threats, their distribution and infestation pathways, and consideration of management approaches to combat identified threats; and, more broadly, assessment of other potential threats to the ecological integrity of Cooper Creek. These issues are addressed in relation to birds, in terms of 1) the habitat template (particularly vegetation) as the major biophysical entity supporting avian diversity; 2) connectivity; and 3) drought-refuge significance, and climate uncertainty more generally.

It is argued that assessments of condition and health can only be made in the context of prevailing climatic conditions and longitudinal position of sites. The mobility of birds and variability of rainfall and flooding in arid Australia have allowed nomadism – spatial and temporal shifts in populations in response to variations in habitat and food resources, unpredictable by location and calendar – to develop as a major movement strategy in many inland Australian species of birds (Keast 1968; Schodde 1982), while the overriding influence of hydrological regime on the composition and structure of riparian vegetation, that in turn directly affects bird community composition and structure, has led to systematic changes in the potential bird species pool with distance downstream (reviewed above). The habitat template (or 'templet') model of Southwood (1977, 1988), as applied by Block and Brennan (1993) to the control of climate, vegetation and vital resources on bird distribution and population dynamics, assumes there are multiple-scales at which birds interact with the environment, and that these relationships may vary temporally, with life-cycle stage and with environmental variability. It is believed there is a hierarchical component to habitat selection in birds (e.g. Johnson 1980; Saab 1999; Lee and Rotenberry 2005), whereby coarse structural features are selected first, followed by finer selection based on floristic details. For the purpose of broad surveys as in this project, where detailed life-history studies of the species cannot be undertaken, descriptions of the floristic variation in the habitat and structural characteristics, along with the judicious use of multivariate statistical analyses, allow relationships between bird community composition and habitat features to be investigated, and the results can be interpreted in terms of trophic structure, allowing insights into the type and variety of resources different habitats provide. The two aspects of vegetation, floristics and structure, independently, have been found by most studies to be significant correlates of bird assemblage structure and composition (e.g. Rotenberry 1985; Mac Nally 1990; Fleishman *et al.* 2003; Lee and Rotenberry 2005), and their influence was investigated here.

2. METHODS

2.1 Site Descriptions

Fourteen sites in riparian habitat were surveyed for birds using belt transect approaches. Cuttapirie Corner and Cuttapirra Waterholes were not surveyed. At all of these sites apart from Muckeranna Waterhole (MUCKr), upstream of Lake Killalpaninna, an additional 'off-river' site from three to four hundred metres distance from the riparian site was surveyed, to enable comparisons of bird communities in the riparian zone with those in adjacent habitats (Table 1).

Table 1a. Brief habitat descriptions of 14 riparian sites; RRG = River Red Gum.

Site	Habitat Description
Cullyamurra Waterhole	RRG-Coolibah riparian woodland, S bank
Minkie Waterhole	RRG-Coolibah riparian woodland, S bank
Scrubby Camp Waterhole	RRG-Coolibah-*Acacia salicina* riparian woodland, E bank
Tirrawarra Waterhole	RRG-Coolibah riparian woodland, E bank
Kudriemitchie Waterhole	Coolibah +/- RRG-*Acacia salicina* riparian woodland, E bank
Embarka Waterhole	Coolibah riparian woodland, S bank
Apachirie-DAER channel waterhole	Coolibah riparian woodland, minor channel, N bank
North West Branch, Coongie Waterhole	RRG-Coolibah riparian woodland, W bank
Narie Waterhole	Coolibah +/- Queensland Beantree riparian woodland, N bank
Parachirrinna Waterhole	narrow Coolibah riparian woodland strand, N bank
Lake Appadare downstream channel	sparse Coolibah riparian woodland, W bank
Lake Hope south-western shore	sparse Coolibah fringing woodland over sandy *Acacia ligulata*, SW shore
Lake Killalpaninna south-eastern shore	patchy *Acacia salicina* fringing tall shrubland, with emergent Coolibah, SE shore
Muckeranna Waterhole	open Coolibah riparian woodland, E bank

Table 1b. Brief habitat descriptions of 13 off-river sites.

Off-river Site	Habitat Description
Cullyamurra Waterhole	open Coolibah floodplain woodland, stony-clay soils
Minkie Waterhole	very open Coolibah-Queensland Beantree-Whitewood floodplain woodland, sandy veneer
Scrubby Camp Waterhole	open Coolibah outer floodplain woodland, low fringing dune adjacent
Tirrawarra Waterhole	open Coolibah +/- Whitewood woodland on low fringing dunes
Kudriemitchie Waterhole	Spinifex hummock grassland and ephemeral herb/grassland, dunes
Embarka Waterhole	Lignum-*Chenopodium* spp shrubland swamp, with emergent Coolibah
Apachirie-DAER channel waterhole	sparse Whitewood & Needlewood tall shrubland on fringing dunes, with emergent Coolibah
North West Branch, Coongie Waterhole	sparse Coolibah clumps over inundated Lignum shrubland, floodplain
Narie Waterhole	open Queensland Bluebush shrubland, cracking clay floodplain, with one clump emergent Coolibah
Parachirrinna Waterhole	sparse Lignum-Queensland Bluebush-Old Man Saltbush shrubland, with emergent Coolibah, sandy puffy-clay floodplain
Lake Appadare downstream channel	*Acacia ligulata* open shrubland over Sandhill Canegrass on

	pale orange dunes
Lake Hope south-western shore	*Acacia ligulata-A. murrayana* tall open shrubland on orange dunes
Lake Killalpaninna south-eastern shore	mixed *Acacia* tall shrubland on white dunes, +/- Sandhill Canegrass

Table 1c. AMG location data for midpoints of 27 bird transects.

Site	Riparian	Site Code	UTME	UTMN
Cullyamurra Waterhole		CULLr	488056	6935230
Minkie Waterhole		MINKr	464029	6927291
Scrubby Camp Waterhole		SCRCr	438985	6940415
Tirrawarra Waterhole		TIRRr	416908	6964171
Kudriemitchie Waterhole		KUDRr	421299	6972626
Embarka Waterhole		EMBAr	421103	6937828
Apachirie-DAER channel waterhole		APDAr	410495	6990778
North West Branch, Coongie Waterhole		NWBRr	415768	6993160
Narie Waterhole		NARIr	408168	6963106
Parachirrinna Waterhole		PARAr	371113	6959340
Lake Appadare downstream channel		APPAr	320823	6878565
Lake Hope south-western shore		HOPEr	328313	6859363
Lake Killalpaninna south-eastern shore		KILLr	260927	6834133
Muckeranna Waterhole		MUCKr	261492	6831668
Off-river				
Cullyamurra Waterhole		CULLo	488025	6934850
Minkie Waterhole		MINKo	463830	6926838
Scrubby Camp Waterhole		SCRCo	439370	6940933
Tirrawarra Waterhole		TIRRo	417109	6964700
Kudriemitchie Waterhole		KUDRo	421757	6973124
Embarka Waterhole		EMBAo	420561	6937393
Apachirie-DAER channel waterhole		APDAo	410311	6991230
North West Branch, Coongie Waterhole		NWBRo	415350	6993143
Narie Waterhole		NARIo	408365	6963790
Parachirrinna Waterhole		PARAo	371275	6959750
Lake Appadare downstream channel		APPAo	320325	6878490
Lake Hope south-western shore		HOPEo	327715	6859353
Lake Killalpaninna south-eastern shore		KILLo	261278	6834114

Transect methods were used to estimate the abundance of birds rather than point counts (or other techniques such as territory mapping) because they are flexible and applicable to most habitats. Experience in the Far North East of SA (Reid 1984) had exposed the limitations of point count techniques in open environments, since many birds flee at the observer's approach in the absence of sheltering/screening vegetation cover. Adopting the methods of Bibby *et al.* (1992), fixed-distance belt transects of 500 m length and 100 m width were established at each site. Because bird abundance varied considerably among but not within sites, a fixed time per transect was not strictly observed, but a 30-minute count was aimed for, walking steadily along transects, but at sites where birds were in abundance the time was extended to allow more complete detection of birds on the transect. One transect count was completed at each site. All individual birds seen or heard along transects were identified to species, or went unrecorded - very few individuals could not be identified. The perpendicular distance from the transect midline to the point of detection was estimated. A distinction was made for birds observed flying – between those passing through or over the site seemingly without stopping or foraging in the habitat being surveyed ('Out'), and those engaged in foraging activities ('In'). The former detections, although recorded and entered into a database, were excluded from analysis prior to estimating densities.

Densities of individual species were calculated as the sum of individuals detected within the 100-m belt (and not flying over/through), expressed as number of individuals per hectare. Where a species was detected at the distance 50-100 m from the transect midline, but not within the central 100-m belt, the species was arbitrarily assigned a density of 0.1 birds/ha (calculated as one bird in the 10 ha surveyed in this case), regardless of how many individuals may have been counted in this distance band. Bird species observed at distances greater than 100 m from the transect midline, even if observed in the surveyed habitat during a transect count, were excluded from density estimation procedures. The density estimates of two flocking species – Tree Martin Petrochelidon nigricans and Little Corella Cacatua *sanguine* – were restricted to a maximum of 6 birds/ha at a few sites where their abundance was deemed unrealistically large; these deflated estimates were used for subsequent analyses and summary estimates of landbird assemblage abundance across all species. Multivariate and nested subset analyses were restricted to landbird species, and also excluded raptors, nocturnal species and 'quails', as diurnal raptors operate at spatial scales greater than the transects deployed here, while nocturnal and quail-like species (true quails and button-quails) could not be censused efficiently due to their cryptic behaviour. The methods used are briefly described in the Results.

Taxonomy and nomenclature follow Christidis and Boles (2008).

3. RESULTS

3.1 Significant and General Bird Observations

Waterbirds are not the focus of this report, and generally abundance and diversity of waterbirds were low at the survey sites. A complete list is given in Appendix 3. A small flock of Little Pied Cormorants *Microcarbo melanoleucos* at Lake Hope was of interest, probably the remnants of an influx that occurred during the previous two to three years, as this species can be absent from the region outside of big flood years. A small flock of 15 Black-tailed Godwits *Limosa limosa* and two White-winged Black Terns *Chlidonias leucopterus* were seen on the southern pan of the Lake Mundooroounie complex (*ca* 2 km NE Kudriemitchie Outstation) – the first species is classified as 'Near Threatened' by Garnett *et al.* (2011), and both are protected under international migratory birds treaties (*EPBC Act*). Between 50 and 100 Plumed Whistling-Duck *Dendrocygna eytoni* were heard flying over the Kudriemitchie campsite at night, and smaller numbers were heard at night on one or two other occasions.

Barking Owls *Ninox connivens* were heard at all sites camped at between Cullyamurra Waterhole and Coongie Lake, namely CULLr, SCRUr, TIRRr, KUDR and NWBRr. Eastern Barn Owls *Tyto javanica* were common at most sites camped at, indicating a great abundance of rodents (confirmed by tracks on sandy soils). Two individuals of Brown Quail *Coturnix ypsilophora* were seen at the eastern end of Cullyamurra Waterhole (on the transect site but outside of the census period); a native species, it has colonised much of arid Australia and the study region only since about 2000, favouring swampy, well grassed areas and grassy riparian habitats; two were also seen at Scrubby Camp Waterhole and one around Narie Waterhole. Over the previous winter, a party of Plum-headed Finches *Neochmia modesta* had occupied the Cullyamurra Waterhole site (Dennis 2012), being the first known record of the species in South Australia. A flock of *ca* 20 Bourke Parrots was seen around Cullyamurra and two at Tirrawarra Waterholes – the species is usually restricted to stony country in the Far North East. Two species not recorded at sites but seen in gibber habitat in the survey region were Gibberbird *Ashbyia lovensis* and Horsfield's Bushlark *Mirafra javanica*.

Small numbers of Flock Bronzewing *Phaps histrionica* were seen in the Upper Cooper region mainly, and a flock of 55 on the floodplain south of Gidgealpa Homestead. Male Flock Bronzewings were giving their flight breeding display over 'greened-up' floodplain in this area to the south of Embarka Swamp. Small numbers were also about Lake Hope and the Cooper Crossing near Etadunna. Three Yellow Chats *Epthianura crocea* were seen in shrubby floodplain 10 km S Gidgealpa Homestead; this species has a very restricted (known) distribution within the Far North East of South Australia (Black *et al.* 1983), and this centralian population occurs patchily to the north in the Channel Country of south-west Queensland and on the Barkly Tableland (Reynolds *et al.* 1982; Strong and Fleming 1987; Jaensch 2004). The dryland shorebird (or wader) Banded Lapwing *Vanellus tricolor* was locally common on the green floodplain in the Embarka Swamp and Waterhole district, and at a few other locations in the study area, and a nest with four eggs was found near Lake Toontoowaranie by G. Tomlinson. Australian Bustards *Ardeotis australis* were scattered across the survey area, as were family parties of Emus *Dromaius novaehollandiae*.

One Black-breasted Buzzard *Hamirostra melanosternon* was seen at the APDAr site, One White-bellied Sea-Eagle *Haliaeetus leucogaster* were seen downstream of Minkie Waterhole and around Coongie. A Grey Falcon *Falco hypoleucos* was seen twice in the Lake Hope region. Little Eagles were widely distributed at waterholes along the Upper Cooper, two Black Falcons *Falco subniger* were seen over floodplains in the Upper Cooper, and the fish survey crew saw two Letter-winged Kites *Elanus scriptus*, *ca* 15 km SE Kudriemitchie Outstation (Dave Schmarr, pers. comm.). Several Swamp Harriers *Circus approximans* were seen hunting around Embarka Swamp, where Australian Spotted Crakes *Porzana fluminea*, Black-tailed Native-hen *Tribonyx ventralis*, shorebirds and ducks were common. Spotted Harriers *C. assimilis* were also common in this habitat/locale, and more generally across the study area. The Golden-backed form of Black-chinned Honeyeater, an Upper Cooper specialist, was not recorded during the survey, but this is not unusual as the species appears to be thinly spread along the riparian strands in the region, and often goes unrecorded in surveys of this type: there are records from the past 35 years at Cuttapirrie Corner Waterhole, Tirrawarra Swamp, the NWBR (Coongie) site, and from between Cullyamurra Waterhole and Innamincka (Reid and Gillen 1988; Badman 1989). One party of Ground Cuckoo-shrikes *Coracina maxima* was encountered in the Upper Cooper.

Appendix 1 identifies 18 or 19 species that are wide-ranging nomads in arid and semi-arid Australia. Under different climatic conditions to those prevailing in April-May 2012, and in the six to twelve months leading into the survey period, nomadic species could be more speciose and abundant than, less so, or in different proportions to their abundances found on this survey. Great fluctuations in abundance of several of the diurnal raptors, e.g. Black Kite, Black-shouldered Kite, Spotted Harrier, Nankeen Kestrel and Brown Falcon, and the Barn Owl, also occur in the study area in response to rainfall variability, but usually at least some individuals of Black Kite and the last two species remain even under the driest conditions. Despite the favourable conditions, one widespread nomadic species, Black Honeyeater *Sugomel niger*, was not seen in April-May 2012. Other nomadic species observed away from the sites or outside the transect periods included Flock Bronzewing and Yellow Chat. Three winter visitors and one breeding summer visitor, identified in Appendix 1, were observed during the survey, although as Badman (1989) has observed, it is always possible for some of these species to occur in the study region at other times of year, and for instance, there is probably a small resident population of Red-capped Robins augmented in winter by birds from the south. At the time of the survey, higher than usual numbers of this species, Rufous Whistler and Black-eared Cuckoo were seen, compared with recent historical observations (Reid 1984; Reid and Gillen 1988; Reid *et al.* 1990), and it is suspected that the increased numbers may refer at least partly to birds on passage given the time of year, and the cuckoo is thought to be mainly a passage migrant in the region (the

Spotted Nightjar perhaps also). Other rare passage migrants that have been recorded in the region, one each historically, were Fan-tailed Cuckoo *Cacomantis flabelliformis* (Reid and Gillen 1988) at the North West Branch 'Coongie' site in May 1987, and Olive-backed riole *Oriolus sagittatus* at Tirrawarra Waterhole in September 1982 (Pedler 1984). Willie Wagtails were abundant at most sites, probably also as a result of augmentation by wintering birds from the south – although debated, it is generally agreed that some portion of the southern Australian breeding population moves north in winter (Higgins *et al.* 2006) and into the Cooper Creek region (Reid 1984; Badman 1989), while there are resident birds in the Far North East as well. A fourth non-breeding winter visitor, Blue-winged Parrot *Neophema chrysostoma* was also observed at several locations, outside of the transect limits or while travelling between sites. However, one regular winter visitor to the region, the Striated Pardalote *Pardalotus striatus*, was not recorded. While the summer breeding migrant, Sacred Kingfisher, was still in the region at time of survey, seen at several Upper Cooper riparian sites, another common breeding migrant, the Rainbow Bee-eater *Merops ornatus*, had vacated the region already.

Density estimates of bird species across the 27 sites are presented in Appendix 2, and scientific names of most species observed at sites are presented in Appendix 1, and are only used in the next section if not previously given; English names are used otherwise.

The only introduced species recorded was the House Sparrow. It has been established at Innamincka for as long as anyone knows, and is common in the township of Moomba. There was a small flock in residence at the western Coongie shelter (NWBRr) site. The species does not usually persist away from permanent human habitations in the region.

3.2 Waterbody Results – summary of richness and abundance at riparian sites

Table 1d shows that bird species richness was highest at Tirrawarra and Kudriemitchie Waterholes on the North West Branch (see also Fig. 3a). Excluding nocturnal, raptorial and quail-like birds, there were 33 species recorded at these two sites. This is a high diversity of landbirds from a single census of a five-ha patch, comparable to the most diverse habitats Australia wide. Restricting the comparisons to resident and spring-summer migratory bird species only, four sites had the highest richness, the above two waterholes and Embarka and Narie Waterholes on the Main Branch (20-24 species: Table 1d). These results were a little unexpected, as we had thought that bird species richness at Cullyamurra and Minkie Waterholes would be among the highest, given the greater annual flows that this stretch of the Cooper receives being upstream of the major disjunction. Because of the once-off nature of the survey, we should not read too much into these results, but they point to the possibility that the highest riparian bird diversity may occur in the well-watered, flatter great expanse of floodplain crossed with distributary channels and swamps in the lower half of the North West Branch and adjacent sections of the Main Branch – a landscape-level, mass effect. More intensive sampling, and ideally repeated counts, are required to investigate this phenomenon.

Abundance, expressed as densities in Table 1d (number of individuals/ha) were also very high at some riparian sites. In nearly all cases, both community abundance and species richness were greater at the riparian sites than the paired off-river sites. Also the proportion of resident species comprising the list of all bird species at sites was greater at riparian than the paired off-river sites, except in one instance, around Lake Appadare. The rank cover-abundance score of coolibah was highly correlated with all measures of bird species richness and abundance, but particularly with resident landbirds, i.e. having excluded mobile species. Coolibah explained 79% of the variance in resident bird species richness across 27 sites, and 70% of the variance in abundance of the resident bird communities. A combined rank cover-abundance score for the region's three dominant riparian tree species – river red gum, coolibah and Queensland bean-tree – explained 75% of the variance in community abundance, with coolibah being the most influential species.

Table 1d. Summary of bird species richness (Rich) and community abundance (Abun: number of individuals/ha) for all species (excluding nocturnal birds, raptors and quail-like species: All) and resident only (Res.) species at 14 locations on Cooper Creek. Sites are placed in rank decreasing order of estimated long-term) annual discharge.

	Riparian All spp		Res. Spp		Off-river All spp		Res. Spp	
Site	**Rich**	**Abun**	**Rich**	**Abun**	**Rich**	**Abun**	**Rich**	**Abun**
Cullyamurra	22	32.5	17	26.7	18	8.8	13	7.3
Minkie	21	27.3	17	26.1	20	14.1	15	11.1
Scrubby Camp	24	40.4	17	33.0	32	23.5	20	14.1
Tirrawarra	33	45.7	24	40.3	23	21.9	14	11.8
Kudriemitchie	33	34.3	22	27.0	7	4.2	4	1.6
Embarka	26	37.7	20	30.0	17	12.0	11	8.2
Narie	27	30.9	21	28.9	15	9.8	6	5.0
Coongie	23	29.5	17	27.0	21	25.7	13	18.1
DAER channel	26	22.0	18	16.3	11	12.4	6	5.4
Parachirrinna	25	35.2	17	29.8	19	12.8	12	8.3
Appadare	26	20.9	14	10.3	12	5.5	9	3.7
Hope	15	16.1	10	8.3	14	11.1	9	8.9
Muckeranna	25	22.0	17	13.8	-	-	-	-
Killalpaninna	26	20.0	15	14.9	22	18.7	12	12.6

3.3 Waterbody Results – individual sites

3.3.1 Cullyamurra Waterhole

The most abundant species in the riparian vegetation were Little Corella (3.2 birds/ha), Red-rumped Parrot (5.4), Budgerigar (4.8), Tree Martin (5.0) and White-plumed Honeyeater (5.4), and the site had intermediate levels of bird species richness (22 species) and community abundance (32.5 birds/ha). The last two species were also the most abundant at the off-river site: Tree Martin (2.4 birds/ha) and White-plumed Honeyeater (1.8), and the site had intermediate bird species richness (18 species) and low community abundance (8.8 birds/ha). Cumulative species richness (33) across both sites was low compared with most other sites.

Australian Ringneck, Brown Treecreeper and Jacky Winter were three Upper Cooper species observed on the transects, and Restless Flycatcher and Barking Owl others around the site.

CB08	Code	English Name	Scientific Name	CULLr	CULLo
66	B043	Crested Pigeon	*Ocyphaps lophotes*	2	
72	B031	Diamond Dove	*Geopelia cuneata*	1	3
73	B030	Peaceful Dove	*Geopelia striata*	4	2
241	B228	Whistling Kite	*Haliastur sphenurus*	4	1
245	B222	Collared Sparrowhawk	*Accipiter cirrocephalus*	1	
254	B240	Nankeen Kestrel	*Falco cenchroides*		1
415	B273	Galah	*Eolophus roseicapillus*	14	2
418	B271	Little Corella	*Cacatua sanguinea*	16	402
441	B294	Australian Ringneck	*Barnardius zonarius*	1	
445	B295	Red-rumped Parrot	*Psephotus haematonotus*	27	20
452	B310	Budgerigar	*Melopsittacus undulatus*	24	
497	B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*		2
498	B326	Sacred Kingfisher	*Todiramphus sanctus*	1	
514	B555	Brown Treecreeper	*Climacteris picumnus*	3	
531	B535	White-winged Fairy-wren	*Malurus leucopterus*		3
532	B536	Variegated Fairy-wren	*Malurus lamberti*	3	
596	B570	Red-browed Pardalote	*Pardalotus rubricatus*	1	2
623	B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	27	11
628	B635	Yellow-throated Miner	*Manorina flavigula*		3
688	B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	1
707	B408	Grey Shrike-thrush	*Colluricincla harmonica*	8	1
712	B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
715	B546	Black-faced Woodswallow	*Artamus cinereus*		1
722	B705	Australian Magpie	*Cracticus tibicen*		1
733	B364	Willie Wagtail	*Rhipidura leucophrys*	2	2
737	B930	Australian Raven	*Corvus coronoides*	2	
740	B691	Little Crow	*Corvus bennetti*		1
753	B415	Magpie-lark	*Grallina cyanoleuca*	6	2
763	B377	Jacky Winter	*Microeca fascinans*		4
793	B509	Rufous Songlark	*Cincloramphus mathewsi*		1
808	B359	Tree Martin	*Petrochelidon nigricans*	41	12
829	B564	Mistletoebird	*Dicaeum hirundinaceum*	2	1
831	B653	Zebra Finch	*Taeniopygia guttata*	1	13
			Total	**194**	**492**
			RichAll	**24**	**24**

3.3.2 Minkie Waterhole

The most abundant species in the riparian vegetation were Little Corella (5.0 birds/ha), Tree Martin (5.0) and White-plumed Honeyeater (4.6), and the site had intermediate levels of bird species richness (21 species) and community abundance (27.3 birds/ha). The two species most abundant at the off-river site were Black-faced Woodswallow (2.0 birds/ha) and White-plumed Honeyeater (3.8), and the site had intermediate bird species richness (20 species) and community abundance (14.1 birds/ha). Cumulative species richness (37) across both sites was intermediate compared with most other sites.

Australian Ringneck and Brown Treecreeper were two Upper Cooper species observed on the transects (and Jacky Winter off). A White-bellied Sea-Eagle was observed (G. Tomlinson) downstream of Minkie.

Code	English Name	Scientific Name	MINKr	MINKo
B043	Crested Pigeon	*Ocyphaps lophotes*	2	4
B031	Diamond Dove	*Geopelia cuneata*	2	1
B030	Peaceful Dove	*Geopelia striata*	9	
B228	Whistling Kite	*Haliastur sphenurus*	3	1
B229	Black Kite	*Milvus migrans*	105	84
B240	Nankeen Kestrel	*Falco cenchroides*		1
B273	Galah	*Eolophus roseicapillus*	6	5
B271	Little Corella	*Cacatua sanguinea*	64	4
B274	Cockatiel	*Nymphicus hollandicus*		5
B294	Australian Ringneck	*Barnardius zonarius*	3	
B295	Red-rumped Parrot	*Psephotus haematonotus*	10	
B310	Budgerigar	*Melopsittacus undulatus*	1	20
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*		2
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*		1
B326	Sacred Kingfisher	*Todiramphus sanctus*	1	
B555	Brown Treecreeper	*Climacteris picumnus*	2	2
B535	White-winged Fairy-wren	*Malurus leucopterus*		7
B466	Southern Whiteface	*Aphelocephala leucopsis*		3
B570	Red-browed Pardalote	*Pardalotus rubricatus*		2
B608	Singing Honeyeater	*Lichenostomus virescens*		2
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	23	21
B635	Yellow-throated Miner	*Manorina flavigula*	3	3
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	2	
B866	Chirruping Wedgebill	*Psophodes cristatus*		2
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	2	2
B408	Grey Shrike-thrush	*Colluricincla harmonica*	7	1
B543	White-breasted Woodswallow	*Artamus leucorynchus*	1	
B544	Masked Woodswallow	*Artamus personatus*	2	
B546	Black-faced Woodswallow	*Artamus cinereus*		12
B705	Australian Magpie	*Cracticus tibicen*		1
B364	Willie Wagtail	*Rhipidura leucophrys*	10	3
B930	Australian Raven	*Corvus coronoides*	4	3
B691	Little Crow	*Corvus bennetti*	1	
B415	Magpie-lark	*Grallina cyanoleuca*	6	2
B359	Tree Martin	*Petrochelidon nigricans*	35	
B564	Mistletoebird	*Dicaeum hirundinaceum*	1	1
B653	Zebra Finch	*Taeniopygia guttata*		9
		Total	**305**	**204**
		RichAll	**25**	**28**

3.3.3 Scrubby Camp Waterhole

The most abundant species in the riparian vegetation were Peaceful Dove (2.8 birds/ha), Red-rumped Parrot (5.6), Tree Martin (5.0) and White-plumed Honeyeater (7.8), and the site had intermediate bird species richness (24 species) and high community abundance (40.4 birds/ha). The four most abundant species at the off-river site were Black-faced Woodswallow (2.6 birds/ha), White-plumed Honeyeater (2.2), Yellow-throated Miner (2.0) and Zebra Finch (4.0), and the site had high bird species richness (32 species) and intermediate community abundance (23.5 birds/ha). Cumulative species richness (44) across both sites was high compared with most other sites.

Australian Ringneck, Brown Treecreeper and Jacky Winter were three Upper Cooper species observed on the transects.

Code	English Name	Scientific Name	SCRCr	SCRCo
B034	Common Bronzewing	*Phaps chalcoptera*	3	
B043	Crested Pigeon	*Ocyphaps lophotes*	4	8
B031	Diamond Dove	*Geopelia cuneata*	15	8
B030	Peaceful Dove	*Geopelia striata*	15	
B228	Whistling Kite	*Haliastur sphenurus*	3	
B229	Black Kite	*Milvus migrans*	1	2
B273	Galah	*Eolophus roseicapillus*	6	3
B271	Little Corella	*Cacatua sanguinea*	22	4
B274	Cockatiel	*Nymphicus hollandicus*		3
B294	Australian Ringneck	*Barnardius zonarius*	3	
B297	Blue Bonnet	*Northiella haematogaster*		2
B295	Red-rumped Parrot	*Psephotus haematonotus*	28	2
B310	Budgerigar	*Melopsittacus undulatus*	16	3
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*		1
B249	Eastern Barn Owl	*Tyto javanica*	1	
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	1	2
B555	Brown Treecreeper	*Climacteris picumnus*	2	
B535	White-winged Fairy-wren	*Malurus leucopterus*		7
B481	Chestnut-rumped Thornbill	*Acanthiza uropygialis*		2
B466	Southern Whiteface	*Aphelocephala leucopsis*		2
B570	Red-browed Pardalote	*Pardalotus rubricatus*		4
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	39	13
B635	Yellow-throated Miner	*Manorina flavigula*		14
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	7	4
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*		2
B866	Chirruping Wedgebill	*Psophodes cristatus*	1	
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	4	2
B401	Rufous Whistler	*Pachycephala rufiventris*		4
B408	Grey Shrike-thrush	*Colluricincla harmonica*	11	2
B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
B544	Masked Woodswallow	*Artamus personatus*	8	11
B546	Black-faced Woodswallow	*Artamus cinereus*		23
B705	Australian Magpie	*Cracticus tibicen*	3	2
B364	Willie Wagtail	*Rhipidura leucophrys*	6	1
B930	Australian Raven	*Corvus coronoides*	3	2
B691	Little Crow	*Corvus bennetti*		1
B415	Magpie-lark	*Grallina cyanoleuca*	6	5
B377	Jacky Winter	*Microeca fascinans*		1
B381	Red-capped Robin	*Petroica goodenovii*		1
B509	Rufous Songlark	*Cincloramphus mathewsi*		4
B360	Fairy Martin	*Petrochelidon ariel*		2
B359	Tree Martin	*Petrochelidon nigricans*	57	
B564	Mistletoebird	*Dicaeum hirundinaceum*	5	1
B653	Zebra Finch	*Taeniopygia guttata*	2	22
		Total	**274**	**170**
		RichAll	**28**	**35**

3.3.4 Tirrawarra Waterhole

The most abundant species in the riparian vegetation were Galah (4.0 birds/ha), Red-rumped Parrot (3.2), Tree Martin (5.6) and White-plumed Honeyeater (8.8), and the site had moderately high bird species richness (33 species) and high community abundance (45.7 birds/ha). The five most abundant species at the off-river site were Budgerigar (4.0 birds/ha), White-winged Fairy-wren (3.2), Black-faced Woodswallow (2.6 birds/ha), White-plumed Honeyeater (2.0) and Zebra Finch (3.2), and the site had intermediate bird species richness

(23 species) and community abundance (21.9 birds/ha). Cumulative species richness (45) across both sites was high compared with most other sites.

Brown Treecreeper and Jacky Winter were two Upper Cooper species observed on the transects, and Little Eagle was observed on site.

Code	English Name	Scientific Name	TIRRr	TIRRo
B034	Common Bronzewing	*Phaps chalcoptera*	1	
B043	Crested Pigeon	*Ocyphaps lophotes*	8	4
B031	Diamond Dove	*Geopelia cuneata*	2	
B030	Peaceful Dove	*Geopelia striata*	5	
B331	Spotted Nightjar	*Eurostopodus argus*		1
B317	Australian Owlet-nightjar	*Aegotheles cristatus*	1	
B228	Whistling Kite	*Haliastur sphenurus*	11	
B229	Black Kite	*Milvus migrans*	22	7
B225	Little Eagle	*Hieraaetus morphnoides*	1	
B273	Galah	*Eolophus roseicapillus*	26	2
B271	Little Corella	*Cacatua sanguinea*	10	
B295	Red-rumped Parrot	*Psephotus haematonotus*	20	4
B310	Budgerigar	*Melopsittacus undulatus*	12	20
B304	Bourke's Parrot	*Neopsephotus bourkii*		2
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	1	
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	2	2
B326	Sacred Kingfisher	*Todiramphus sanctus*	2	
B555	Brown Treecreeper	*Climacteris picumnus*	5	
B535	White-winged Fairy-wren	*Malurus leucopterus*		16
B536	Variegated Fairy-wren	*Malurus lamberti*	4	
B481	Chestnut-rumped Thornbill	*Acanthiza uropygialis*		2
B570	Red-browed Pardalote	*Pardalotus rubricatus*	2	2
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	44	14
B635	Yellow-throated Miner	*Manorina flavigula*	2	3
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	8	7
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*	9	
B866	Chirruping Wedgebill	*Psophodes cristatus*	7	
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	
B430	White-winged Triller	*Lalage sueurii*	1	3
B401	Rufous Whistler	*Pachycephala rufiventris*		1
B408	Grey Shrike-thrush	*Colluricincla harmonica*	9	2
B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
B546	Black-faced Woodswallow	*Artamus cinereus*	5	14
B364	Willie Wagtail	*Rhipidura leucophrys*	6	4
B930	Australian Raven	*Corvus coronoides*	3	1
B691	Little Crow	*Corvus bennetti*		4
B415	Magpie-lark	*Grallina cyanoleuca*	10	
B377	Jacky Winter	*Microeca fascinans*	2	
B381	Red-capped Robin	*Petroica goodenovii*		3
B509	Rufous Songlark	*Cincloramphus mathewsi*	1	
B358	White-backed Swallow	*Cheramoeca leucosterna*		2
B360	Fairy Martin	*Petrochelidon ariel*	4	
B359	Tree Martin	*Petrochelidon nigricans*	28	
B564	Mistletoebird	*Dicaeum hirundinaceum*	2	1
B653	Zebra Finch	*Taeniopygia guttata*	6	22
		Total	**285**	**143**
		RichAll	**37**	**25**

3.3.5 Kudriemitchie Waterhole

The most abundant species in the riparian vegetation were Galah (2.8 birds/ha), Red-rumped Parrot (2.8), White-plumed Honeyeater (6.0) and Zebra Finch (3.6), and the site had moderately high bird species richness (33 species) and community abundance (34.3 birds/ha). The off-river site, a fringing sand dune had few birds – White-winged Fairy-wren (1.2) and Zebra Finch (2.2) – with only seven species and low community abundance (4.2 birds/ha), the minima across all sites. Cumulative species richness (44) across both sites was high.

Australian Ringneck, Restless Flycatcher and Jacky Winter were Upper Cooper species observed on transects (Brown Treecreeper off), while Little Eagle, Grey Fantail and Black-eared Cuckoo were also observed.

Code	English Name	Scientific Name	KUDRr	KUDRo
B043	Crested Pigeon	*Ocyphaps lophotes*	4	
B031	Diamond Dove	*Geopelia cuneata*	2	
B030	Peaceful Dove	*Geopelia striata*	7	
B228	Whistling Kite	*Haliastur sphenurus*	4	
B229	Black Kite	*Milvus migrans*	13	1
B225	Little Eagle	*Hieraaetus morphnoides*	1	
B240	Nankeen Kestrel	*Falco cenchroides*		1
B018	Little Button-quail	*Turnix velox*		1
B273	Galah	*Eolophus roseicapillus*	20	1
B271	Little Corella	*Cacatua sanguinea*	8	
B274	Cockatiel	*Nymphicus hollandicus*		2
B294	Australian Ringneck	*Barnardius zonarius*	2	
B295	Red-rumped Parrot	*Psephotus haematonotus*	18	
B310	Budgerigar	*Melopsittacus undulatus*	24	28
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	1	
B341	Black-eared Cuckoo	*Chalcites osculans*	1	
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	1	
B326	Sacred Kingfisher	*Todiramphus sanctus*	1	
B535	White-winged Fairy-wren	*Malurus leucopterus*		14
B536	Variegated Fairy-wren	*Malurus lamberti*	4	
B570	Red-browed Pardalote	*Pardalotus rubricatus*	2	1
B608	Singing Honeyeater	*Lichenostomus virescens*		1
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	36	
B635	Yellow-throated Miner	*Manorina flavigula*	2	2
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	7	
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*		5
B866	Chirruping Wedgebill	*Psophodes cristatus*	1	
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	1
B401	Rufous Whistler	*Pachycephala rufiventris*	1	1
B408	Grey Shrike-thrush	*Colluricincla harmonica*	2	1
B543	White-breasted Woodswallow	*Artamus leucorynchus*	3	
B546	Black-faced Woodswallow	*Artamus cinereus*		5
B705	Australian Magpie	*Cracticus tibicen*	3	
B364	Willie Wagtail	*Rhipidura leucophrys*	12	3
B930	Australian Raven	*Corvus coronoides*	5	
B691	Little Crow	*Corvus bennetti*	9	
B369	Restless Flycatcher	*Myiagra inquieta*	1	
B415	Magpie-lark	*Grallina cyanoleuca*	10	
B377	Jacky Winter	*Microeca fascinans*	2	
B381	Red-capped Robin	*Petroica goodenovii*		1
B360	Fairy Martin	*Petrochelidon ariel*	10	

B359	Tree Martin	*Petrochelidon nigricans*	18	
B564	Mistletoebird	*Dicaeum hirundinaceum*	2	
B653	Zebra Finch	*Taeniopygia guttata*	18	25
		Total	**256**	**94**
		RichAll	**36**	**18**

3.3.6 Embarka Waterhole

The most abundant species in the riparian vegetation were Galah (5.2 birds/ha), Budgerigar (4.2), Tree Martin (5.0), Fairy Martin (5.0) and White-plumed Honeyeater (7.0), and the site had intermediate bird species richness (26 species) and high community abundance (37.7 birds/ha). The five most abundant species at the off-river site, a Lignum-dominated swamp, were Budgerigar (1.2), Magpie-lark (1.2), White-winged Fairy-wren (2.0), White-plumed Honeyeater (1.2) and Zebra Finch (1.2), and the site had low bird species richness (17 species) and community abundance (12.0 birds/ha). Cumulative species richness (40) across both sites was high.

Brown Treecreeper and Jacky Winter were Upper Cooper species observed on transects, while Australian Hobby and Blue-winged Parrot were also observed.

Code	English Name	Scientific Name	EMBAr	EMBAo
B009	Stubble Quail	*Coturnix pectoralis*		1
B043	Crested Pigeon	*Ocyphaps lophotes*	3	1
B031	Diamond Dove	*Geopelia cuneata*	12	2
B030	Peaceful Dove	*Geopelia striata*	3	
B317	Australian Owlet-nightjar	*Aegotheles cristatus*	2	
B228	Whistling Kite	*Haliastur sphenurus*	2	3
B229	Black Kite	*Milvus migrans*	1	
B218	Spotted Harrier	*Circus assimilis*		1
B018	Little Button-quail	*Turnix velox*		1
B273	Galah	*Eolophus roseicapillus*	26	5
B271	Little Corella	*Cacatua sanguinea*	4	
B295	Red-rumped Parrot	*Psephotus haematonotus*	5	2
B310	Budgerigar	*Melopsittacus undulatus*	33	36
B306	Blue-winged Parrot	*Neophema chrysostoma*	4	6
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	2	2
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	2	
B555	Brown Treecreeper	*Climacteris picumnus*	2	
B535	White-winged Fairy-wren	*Malurus leucopterus*		12
B536	Variegated Fairy-wren	*Malurus lamberti*		3
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	38	6
B635	Yellow-throated Miner	*Manorina flavigula*	2	3
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	1	
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*	2	
B866	Chirruping Wedgebill	*Psophodes cristatus*	3	9
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	2	
B408	Grey Shrike-thrush	*Colluricincla harmonica*	5	1
B543	White-breasted Woodswallow	*Artamus leucorynchus*	3	
B546	Black-faced Woodswallow	*Artamus cinereus*	4	
B705	Australian Magpie	*Cracticus tibicen*	1	1
B364	Willie Wagtail	*Rhipidura leucophrys*	5	4
B930	Australian Raven	*Corvus coronoides*	4	4
B691	Little Crow	*Corvus bennetti*	2	4
B415	Magpie-lark	*Grallina cyanoleuca*	7	6
B377	Jacky Winter	*Microeca fascinans*	2	

B381	Red-capped Robin	*Petroica goodenovii*		1
B522	Little Grassbird	*Megalurus gramineus*		6
B360	Fairy Martin	*Petrochelidon ariel*	25	
B359	Tree Martin	*Petrochelidon nigricans*	36	
B564	Mistletoebird	*Dicaeum hirundinaceum*	2	
B653	Zebra Finch	*Taeniopygia guttata*	3	6
		Total	**248**	**126**
		RichAll	**33**	**25**

3.3.7 Apachirie-DAER channel waterhole

The most abundant species in the riparian vegetation were White-plumed Honeyeater (6.0) and Zebra Finch (2.6), and the site had low bird species richness (26 species) and community abundance (22.0 birds/ha) for riparian habitat. The four most abundant species at the off-river site were Budgerigar (2.4), White-winged Fairy-wren (1.6), White-plumed Honeyeater (2.2) and Zebra Finch (4.2), and the site had low bird species richness (11 species) and community abundance (12.4 birds/ha). Cumulative species richness (38) across both sites was moderately high.

Brown Treecreeper, Restless Flycatcher and Jacky Winter were Upper Cooper species observed on transects, while Black-breasted Buzzard was also observed.

Code	English Name	Scientific Name	APDAr	APDAo
B043	Crested Pigeon	*Ocyphaps lophotes*	8	
B030	Peaceful Dove	*Geopelia striata*	2	
B231	Black-breasted Buzzard	*Hamirostra melanosternon*		1
B228	Whistling Kite	*Haliastur sphenurus*	3	2
B229	Black Kite	*Milvus migrans*	8	
B240	Nankeen Kestrel	*Falco cenchroides*		2
B239	Brown Falcon	*Falco berigora*		1
B273	Galah	*Eolophus roseicapillus*	11	2
B271	Little Corella	*Cacatua sanguinea*	7	
B297	Blue Bonnet	*Northiella haematogaster*	2	2
B310	Budgerigar	*Melopsittacus undulatus*	2	57
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	5	2
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	1	
B555	Brown Treecreeper	*Climacteris picumnus*	2	
B535	White-winged Fairy-wren	*Malurus leucopterus*		10
B536	Variegated Fairy-wren	*Malurus lamberti*		5
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	32	15
B635	Yellow-throated Miner	*Manorina flavigula*	6	
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	6	
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	
B430	White-winged Triller	*Lalage sueurii*		1
B408	Grey Shrike-thrush	*Colluricincla harmonica*	4	2
B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
B544	Masked Woodswallow	*Artamus personatus*	1	2
B546	Black-faced Woodswallow	*Artamus cinereus*	1	2
B705	Australian Magpie	*Cracticus tibicen*		1
B364	Willie Wagtail	*Rhipidura leucophrys*	7	
B930	Australian Raven	*Corvus coronoides*	3	2
B691	Little Crow	*Corvus bennetti*	2	1
B369	Restless Flycatcher	*Myiagra inquieta*	4	
B415	Magpie-lark	*Grallina cyanoleuca*	5	
B377	Jacky Winter	*Microeca fascinans*	1	

B509	Rufous Songlark	*Cincloramphus mathewsi*	6	
B358	White-backed Swallow	*Cheramoeca leucosterna*		1
B360	Fairy Martin	*Petrochelidon ariel*	2	
B359	Tree Martin	*Petrochelidon nigricans*	2	
B564	Mistletoebird	*Dicaeum hirundinaceum*	2	1
B653	Zebra Finch	*Taeniopygia guttata*	13	25
		Total	**151**	**137**
		RichAll	**30**	**21**

3.3.8 North West Branch, Coongie Waterhole

The most abundant species in the riparian vegetation were Red-rumped Parrot (3.2 birds/ha), Tree Martin (5.0) and White-plumed Honeyeater (9.4), and the site had low bird species richness (23 species) and moderate community abundance (29.5 birds/ha) for riparian habitat. The four most abundant species at the off-river site were Willie wagtail (2.4), White-winged Fairy-wren (3.4), White-breasted Woodswallow (3.6), White-plumed Honeyeater (2.4) and Zebra Finch (3.4), and the site had moderate bird species richness (21 species) and community abundance (25.7 birds/ha). Cumulative species richness (34) across both sites was moderately high.

No Upper Cooper species were observed on transects, but White-bellied Sea-Eagle and Black-eared Cuckoo were observed at the site, as was the exotic House Sparrow.

Code	**English Name**	**Scientific Name**	**NWBRr**	**NWBRo**
B043	Crested Pigeon	*Ocyphaps lophotes*	4	3
B031	Diamond Dove	*Geopelia cuneata*	1	5
B030	Peaceful Dove	*Geopelia striata*	4	
B228	Whistling Kite	*Haliastur sphenurus*	4	
B229	Black Kite	*Milvus migrans*	3	4
B273	Galah	*Eolophus roseicapillus*	13	
B271	Little Corella	*Cacatua sanguinea*	2	
B295	Red-rumped Parrot	*Psephotus haematonotus*	20	
B310	Budgerigar	*Melopsittacus undulatus*	4	4
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	1	3
B341	Black-eared Cuckoo	*Chalcites osculans*	1	
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*		1
B535	White-winged Fairy-wren	*Malurus leucopterus*		17
B536	Variegated Fairy-wren	*Malurus lamberti*		4
B570	Red-browed Pardalote	*Pardalotus rubricatus*	1	
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	51	12
B635	Yellow-throated Miner	*Manorina flavigula*	2	4
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	6	3
B866	Chirruping Wedgebill	*Psophodes cristatus*		3
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	2	2
B430	White-winged Triller	*Lalage sueurii*		4
B408	Grey Shrike-thrush	*Colluricincla harmonica*	5	
B543	White-breasted Woodswallow	*Artamus leucorynchus*	3	18
B546	Black-faced Woodswallow	*Artamus cinereus*	2	4
B364	Willie Wagtail	*Rhipidura leucophrys*	8	12
B930	Australian Raven	*Corvus coronoides*	2	
B691	Little Crow	*Corvus bennetti*	1	
B415	Magpie-lark	*Grallina cyanoleuca*	4	4
B522	Little Grassbird	*Megalurus gramineus*	1	7
B360	Fairy Martin	*Petrochelidon ariel*	10	9
B359	Tree Martin	*Petrochelidon nigricans*	25	5

B564	Mistletoebird	*Dicaeum hirundinaceum*		2
B653	Zebra Finch	*Taeniopygia guttata*	4	46
B995	House Sparrow	*Passer domesticus*	4	
		Total	**188**	**176**
		RichAll	**28**	**23**

3.3.9 Narie Waterhole

Abundant species in the riparian vegetation were Galah (5.2 birds/ha) and White-plumed Honeyeater (7.6) and the site had moderate bird species richness (27 species) and community abundance (30.9 birds/ha). The most abundant species at the off-river site were White-winged Fairy-wren (1.4), Black-faced Woodswallow (1.2) and Zebra Finch (2.2), and the site had low bird species richness (15 species) and community abundance (9.8 birds/ha). Cumulative species richness (48) across both sites was the highest across the 13 locations.

Brown Treecreeper was the sole Upper Cooper species observed on transects.

Code	English Name	Scientific Name	NARIr	NARIo
B009	Stubble Quail	*Coturnix pectoralis*		6
B034	Common Bronzewing	*Phaps chalcoptera*	2	
B043	Crested Pigeon	*Ocyphaps lophotes*	11	
B031	Diamond Dove	*Geopelia cuneata*	7	
B030	Peaceful Dove	*Geopelia striata*	10	
B228	Whistling Kite	*Haliastur sphenurus*	2	
B229	Black Kite	*Milvus migrans*	4	1
B225	Little Eagle	*Hieraaetus morphnoides*	1	
B239	Brown Falcon	*Falco berigora*		1
B018	Little Button-quail	*Turnix velox*		2
B273	Galah	*Eolophus roseicapillus*	26	2
B271	Little Corella	*Cacatua sanguinea*	8	13
B274	Cockatiel	*Nymphicus hollandicus*	2	
B297	Blue Bonnet	*Northiella haematogaster*		2
B295	Red-rumped Parrot	*Psephotus haematonotus*	4	
B310	Budgerigar	*Melopsittacus undulatus*	10	
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*		1
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	1	
B326	Sacred Kingfisher	*Todiramphus sanctus*	1	
B555	Brown Treecreeper	*Climacteris picumnus*	2	
B535	White-winged Fairy-wren	*Malurus leucopterus*		9
B481	Chestnut-rumped Thornbill	*Acanthiza uropygialis*		2
B466	Southern Whiteface	*Aphelocephala leucopsis*		2
B570	Red-browed Pardalote	*Pardalotus rubricatus*	1	
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	40	8
B635	Yellow-throated Miner	*Manorina flavigula*	3	
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	14	
B450	Orange Chat	*Epthianura aurifrons*		4
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*	3	
B866	Chirruping Wedgebill	*Psophodes cristatus*	4	
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1	
B430	White-winged Triller	*Lalage sueurii*		2
B408	Grey Shrike-thrush	*Colluricincla harmonica*	9	
B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
B544	Masked Woodswallow	*Artamus personatus*		2
B546	Black-faced Woodswallow	*Artamus cinereus*		6
B705	Australian Magpie	*Cracticus tibicen*	2	
B364	Willie Wagtail	*Rhipidura leucophrys*	14	7

B930	Australian Raven	*Corvus coronoides*	3	
B691	Little Crow	*Corvus bennetti*	1	1
B415	Magpie-lark	*Grallina cyanoleuca*	3	
B381	Red-capped Robin	*Petroica goodenovii*		3
B509	Rufous Songlark	*Cincloramphus mathewsi*	1	
B508	Brown Songlark	*Cincloramphus cruralis*		1
B360	Fairy Martin	*Petrochelidon ariel*	6	
B359	Tree Martin	*Petrochelidon nigricans*	4	
B564	Mistletoebird	*Dicaeum hirundinaceum*	2	1
B653	Zebra Finch	*Taeniopygia guttata*		17
		Total	**204**	**93**
		RichAll	**33**	**22**

3.3.10 Parachirrinna Waterhole

The most abundant species in the riparian vegetation were Galah (6.0 birds/ha), Tree Martin (3.6) and White-plumed Honeyeater (6.0), and the site had intermediate bird species richness (25 species) and moderately high community abundance (35.2 birds/ha). The most abundant species at the off-river site were White-winged Fairy-wren (2.8), Black-faced Woodswallow (1.8) and Zebra Finch (3.0), and the site had moderate bird species richness (21 species) and community abundance (25.7 birds/ha). Cumulative species richness (34) across both sites was moderately high.

No Upper Cooper species were observed on transects, but this site marked the lower (downstream) limit of Red-rumped Parrots and the high abundance of White-plumed Honeyeater.

Code	English Name	Scientific Name	PARAr	PARAo
B043	Crested Pigeon	*Ocyphaps lophotes*	8	4
B031	Diamond Dove	*Geopelia cuneata*	4	2
B030	Peaceful Dove	*Geopelia striata*	7	
B228	Whistling Kite	*Haliastur sphenurus*	2	
B229	Black Kite	*Milvus migrans*	4	1
B018	Little Button-quail	*Turnix velox*		2
B273	Galah	*Eolophus roseicapillus*	34	
B271	Little Corella	*Cacatua sanguinea*	10	
B297	Blue Bonnet	*Northiella haematogaster*		1
B295	Red-rumped Parrot	*Psephotus haematonotus*	4	
B310	Budgerigar	*Melopsittacus undulatus*	21	3
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*		1
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	2	1
B535	White-winged Fairy-wren	*Malurus leucopterus*		16
B536	Variegated Fairy-wren	*Malurus lamberti*		3
B570	Red-browed Pardalote	*Pardalotus rubricatus*		1
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	30	5
B635	Yellow-throated Miner	*Manorina flavigula*	7	2
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	8	
B866	Chirruping Wedgebill	*Psophodes cristatus*		3
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	4	
B408	Grey Shrike-thrush	*Colluricincla harmonica*	4	
B543	White-breasted Woodswallow	*Artamus leucorynchus*	2	
B546	Black-faced Woodswallow	*Artamus cinereus*	2	9
B705	Australian Magpie	*Cracticus tibicen*	4	2
B364	Willie Wagtail	*Rhipidura leucophrys*	9	4
B930	Australian Raven	*Corvus coronoides*	1	

B691	Little Crow	*Corvus bennetti*	1	2
B415	Magpie-lark	*Grallina cyanoleuca*	12	2
B358	White-backed Swallow	*Cheramoeca leucosterna*	1	1
B360	Fairy Martin	*Petrochelidon ariel*	6	1
B359	Tree Martin	*Petrochelidon nigricans*	18	
B564	Mistletoebird	*Dicaeum hirundinaceum*	4	2
B653	Zebra Finch	*Taeniopygia guttata*	2	15
		Total	**211**	**83**
		RichAll	**27**	**23**

3.3.11 Lake Appadare downstream channel waterhole

The most abundant species in the riparian vegetation were Budgerigar (4.2 birds/ha) and Black-faced Woodswallow (2.0), and the site had intermediate bird species richness (26 species) and moderately low community abundance (20.9 birds/ha). The most abundant species at the off-river site were Budgerigar (1.0 birds/ha) and Singing Honeyeater (1.0), and the site had low bird species richness (12 species) and community abundance (5.5 birds/ha). Cumulative species richness (33) across both sites was moderately high.

Downstream sites were characterised by the greater occurrence of Pied Honeyeater and Singing Honeyeater, and the absence of Peaceful Dove, Red-rumped Parrot, Grey Shrike-thrush and the Upper Cooper species generally.

Code	English Name	Scientific Name	APPAr	APPAo
B043	Crested Pigeon	*Ocyphaps lophotes*	9	1
B031	Diamond Dove	*Geopelia cuneata*	5	
B228	Whistling Kite	*Haliastur sphenurus*	2	
B229	Black Kite	*Milvus migrans*	5	2
B018	Little Button-quail	*Turnix velox*		1
B273	Galah	*Eolophus roseicapillus*	2	
B271	Little Corella	*Cacatua sanguinea*	2	
B297	Blue Bonnet	*Northiella haematogaster*	2	4
B310	Budgerigar	*Melopsittacus undulatus*	29	7
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis*	3	
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius*	1	
B535	White-winged Fairy-wren	*Malurus leucopterus*	2	4
B515	Eyrean Grasswren	*Amytornis goyderi*		2
B570	Red-browed Pardalote	*Pardalotus rubricatus*	1	
B602	Pied Honeyeater	*Certhionyx variegatus*	5	1
B608	Singing Honeyeater	*Lichenostomus virescens*	5	7
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*	3	
B635	Yellow-throated Miner	*Manorina flavigula*	4	5
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	2	2
B449	Crimson Chat	*Epthianura tricolor*	6	
B450	Orange Chat	*Epthianura aurifrons*	2	
B866	Chirruping Wedgebill	*Psophodes cristatus*		2
B430	White-winged Triller	*Lalage sueurii*	2	
B546	Black-faced Woodswallow	*Artamus cinereus*	10	
B705	Australian Magpie	*Cracticus tibicen*	1	
B364	Willie Wagtail	*Rhipidura leucophrys*	8	1
B930	Australian Raven	*Corvus coronoides*	2	
B691	Little Crow	*Corvus bennetti*	3	
B415	Magpie-lark	*Grallina cyanoleuca*	6	
B358	White-backed Swallow	*Cheramoeca leucosterna*	2	2
B359	Tree Martin	*Petrochelidon nigricans*	6	

B564	Mistletoebird	*Dicaeum hirundinaceum*	1	
B653	Zebra Finch	*Taeniopygia guttata*	8	2
		Total	**139**	**43**
		RichAll	**30**	**15**

3.3.12 Lake Hope south-western shore

The most abundant species in the riparian vegetation were White-winged Fairy-wren (1.4 birds/ha), Variegated Fairy-wren (1.2), and Zebra Finch (5.8), and the site had low bird species richness (15 species) and community abundance (16.1 birds/ha). The most abundant species at the off-river site were Chestnut-crowned Babbler (2.2 birds/ha), Chirruping Wedgebill (1.0) and Singing Honeyeater (2.8), and the site had low bird species richness (14 species) and community abundance (11.1 birds/ha). Cumulative species richness (27) across both sites was low, and there was little difference in avian richness and abundance between the shore and adjacent dunefield habitats.

Grey Falcon was sighted twice in the Lake Hope region.

Code	English Name	Scientific Name	HOPEr	HOPEo
B043	Crested Pigeon	*Ocyphaps lophotes*	5	4
B031	Diamond Dove	*Geopelia cuneata*	2	5
B232	Black-shouldered Kite	*Elanus axillaris*		2
B228	Whistling Kite	*Haliastur sphenurus*	1	
B229	Black Kite	*Milvus migrans*	1	
B018	Little Button-quail	*Turnix velox*		1
B273	Galah	*Eolophus roseicapillus*		1
B271	Little Corella	*Cacatua sanguinea*	4	
B297	Blue Bonnet	*Northiella haematogaster*	4	6
B310	Budgerigar	*Melopsittacus undulatus*	13	
B535	White-winged Fairy-wren	*Malurus leucopterus*	7	8
B536	Variegated Fairy-wren	*Malurus lamberti*	6	4
B608	Singing Honeyeater	*Lichenostomus virescens*	5	15
B635	Yellow-throated Miner	*Manorina flavigula*	2	
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		1
B449	Crimson Chat	*Epthianura tricolor*		2
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*		11
B866	Chirruping Wedgebill	*Psophodes cristatus*	4	8
B705	Australian Magpie	*Cracticus tibicen*	1	1
B364	Willie Wagtail	*Rhipidura leucophrys*	6	3
B930	Australian Raven	*Corvus coronoides*	1	
B691	Little Crow	*Corvus bennetti*		2
B381	Red-capped Robin	*Petroica goodenovii*	1	
B358	White-backed Swallow	*Cheramoeca leucosterna*	2	2
B359	Tree Martin	*Petrochelidon nigricans*		1
B564	Mistletoebird	*Dicaeum hirundinaceum*		1
B653	Zebra Finch	*Taeniopygia guttata*	29	2
		Total	**94**	**80**
		RichAll	**18**	**20**

3.3.13 Lake Killalpaninna south-eastern shore

The most abundant species in the riparian vegetation at Muckeranna Waterhole were Diamond Dove (3.6 birds/ha), Budgerigar (2.4), Tree Martin (2.4), Willie Wagtail (2.0) and

White-plumed Honeyeater (1.6), and the site had moderate bird species richness (25 species) and community abundance (22.0 birds/ha). The most abundant species in the sparse riparian vegetation at Lake Killalpaninna were Variegated Fairy-wren (1.8 birds/ha), Singing Honeyeater (2.4) and Zebra Finch (1.6), and the site had moderate bird species richness (26 species) and moderately low community abundance (20.0 birds/ha). The most abundant species at the off-river site were White-winged Fairy-wren (2.2 birds/ha) and Singing Honeyeater (2.4), and the site had moderate bird species richness (22 species) and community abundance (18.7 birds/ha) for off-river habitat. Cumulative species richness (41) across the three sites was high; again there was little difference in richness and abundance between riparian and adjacent dunefield habitats. Grey Fantail was only observed here.

English Name	Scientific Name	KILLr	KILLo	MUCKr
Crested Pigeon	*Ocyphaps lophotes*	5		3
Diamond Dove	*Geopelia cuneata*	6	8	18
Whistling Kite	*Haliastur sphenurus*	1	1	4
Black Kite	*Milvus migrans*	7		1
Galah	*Eolophus roseicapillus*	5	2	6
Little Corella	*Cacatua sanguinea*			9
Blue Bonnet	*Northiella haematogaster*			4
Budgerigar	*Melopsittacus undulatus*	2	4	54
Blue-winged Parrot	*Neophema chrysostoma*	3		
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	2	1	1
Pallid Cuckoo	*Cacomantis pallidus*			1
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		1	1
White-winged Fairy-wren	*Malurus leucopterus*		11	
Variegated Fairy-wren	*Malurus lamberti*	9	10	4
Eyrean Grasswren	*Amytornis goyderi*		2	
Southern Whiteface	*Aphelocephala leucopsis*	3		
Red-browed Pardalote	*Pardalotus rubricatus*			2
Pied Honeyeater	*Certhionyx variegatus*		6	2
Singing Honeyeater	*Lichenostomus virescens*	14	12	6
White-plumed Honeyeater	*Lichenostomus penicillatus*			8
Yellow-throated Miner	*Manorina flavigula*	2		6
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	4	5	1
Crimson Chat	*Epthianura tricolor*	2		
Chestnut-crowned Babbler	*Pomatostomus ruficeps*		6	
Chirruping Wedgebill	*Psophodes cristatus*	2	1	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	1		
Rufous Whistler	*Pachycephala rufiventris*	1	2	
White-breasted Woodswallow	*Artamus leucorynchus*	13	2	2
Masked Woodswallow	*Artamus personatus*	10		
Black-faced Woodswallow	*Artamus cinereus*		4	3
Australian Magpie	*Cracticus tibicen*	2		5
Grey Fantail	*Rhipidura albiscapa*	1		
Willie Wagtail	*Rhipidura leucophrys*	13	6	10
Australian Raven	*Corvus coronoides*	3		4
Little Crow	*Corvus bennetti*	2	2	1
Magpie-lark	*Grallina cyanoleuca*	4		5
Red-capped Robin	*Petroica goodenovii*	1	1	
Fairy Martin	*Petrochelidon ariel*	2	2	
Tree Martin	*Petrochelidon nigricans*	4		12
Mistletoebird	*Dicaeum hirundinaceum*	1	2	2
Zebra Finch	*Taeniopygia guttata*	8	4	6
	Total	**133**	**95**	**181**
	RichAll	**30**	**23**	**28**

3.4 Multivariate analysis of landbirds at 27 sites

Multivariate analysis in PATN (Belbin 1995) of 56 bird species at paired transects on the 14 sites surveyed for landbirds showed the strong influence of longitudinal position in ordination space, and the stronger distinction between riparian (coded ‘r’) and floodplain (‘off-river’, coded with a trailing ‘o’) bird assemblages, even though the pairs of transects were separated by only three or four hundred metres. Dendrogram analysis (Figure 1) revealed two main clusters of sites, with upstream riparian sites downstream to Coongie Lake and Parachirrinna Waterhole separated from all off-river sites and the four most south-western riparian sites around lakes Hope and Killalpaninna. Unlike the results of the floristic analyses, the minor channel between lakes Apachirie and ‘DAER’ (APDAr) clustered with the other nine upstream riparian sites. Cuttapirie Corner Waterhole was not surveyed for birds, but Muckeranna Waterhole (MUCKr) upstream of Lake Killalpaninna was an additional riparian site surveyed (without an off-river site).

Ordination of sites, rotated to principal components (Fig. 2) revealed the two main trends in assemblage composition: the strongest axis of differentiation, aligned with the x-axis (PC SSH1) contrasted floodplain versus upstream riparian assemblages, while the orthogonal gradient reflected the influence of site downstream order and hydrological regime. Summary bird assemblage variables – summed density of all birds (Abundance) and species richness) – reflected the main trend in assemblage composition (Fig. 2b), with upstream riparian sites having the highest richness and abundance (Fig. 3). Figure 2a also showed that the composition of bird assemblages around lakes Hope and Killalpaninna were more similar to each other regardless of position on the floodplain, such that riparian transects clustered close to the off-river transects in that area, a result not apparent in the dendrogram. In Figure 2b envelopes are drawn around three clusters of transects to illustrate this point, and it can also be seen that assemblage composition in the upstream riparian transects is much tighter (smaller envelope), suggesting the powerful structuring influence of riparian vegetation on bird species composition: a rich, abundant and consistent assemblage of riparian bird species in the upper and central portions of the study area.

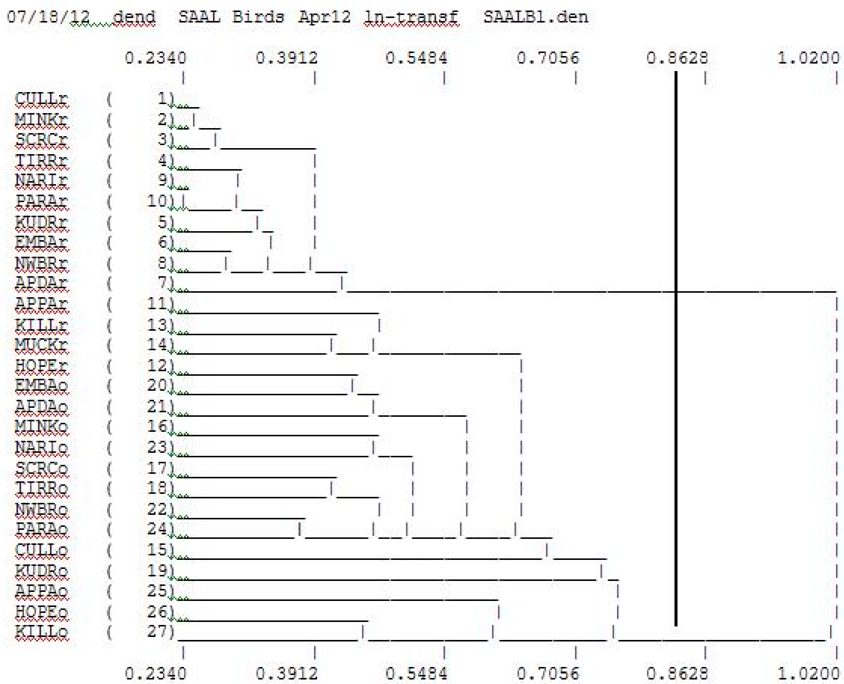

Table V. Waterbody codes.

Site Code	Waterbody Name
CULLr	Cullyamurra Waterhole
MINKr	Minkie Waterhole
SCRUr	Scrubby Camp Waterhole
TIRRr	Tirrawarra Waterhole
KUDRr	Kudriemitchie Waterhole
EMBAr	Embarka Waterhole ('Gidgealpa HS')
CUTTr	Cuttapirrie Corner Waterhole
APDAr	channel between Lakes Apachirie and 'DAER'
NWBRr	'Coongie Waterhole' (North West Branch)
NARIr	Narie Waterhole
PARAr	Parachirrinna Waterhole
APPAr	waterhole downstream of Lake Appadare
HOPEr	Lake Hope
KILLr	Lake Killalpaninna

Figure 1. Dendogram of 14 pairs of sites using Bray-Curtis distance of landbird density estimates for 56 species.

Cut-off shows two main groups of sites, separating upstream riparian transects from the rest.

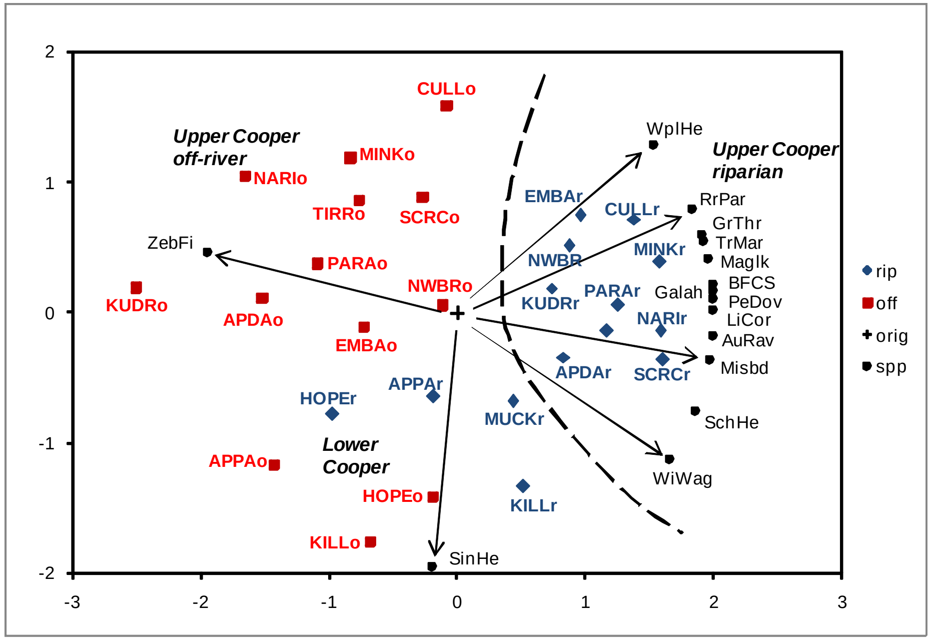

Figure 2a. NMDS ordination (2d ssh) of 27 bird transects using Bray-Curtis distance based on density of 56 species, rotated to principal components; stress = 0.18.

The main division between sites from the dendrogram is shown by the dashed line; influential bird species are shown as abbreviations, and there were few species characteristic of floodplain assemblages (Zebra Finch) and the lower Cooper (Singing Honeyeater).

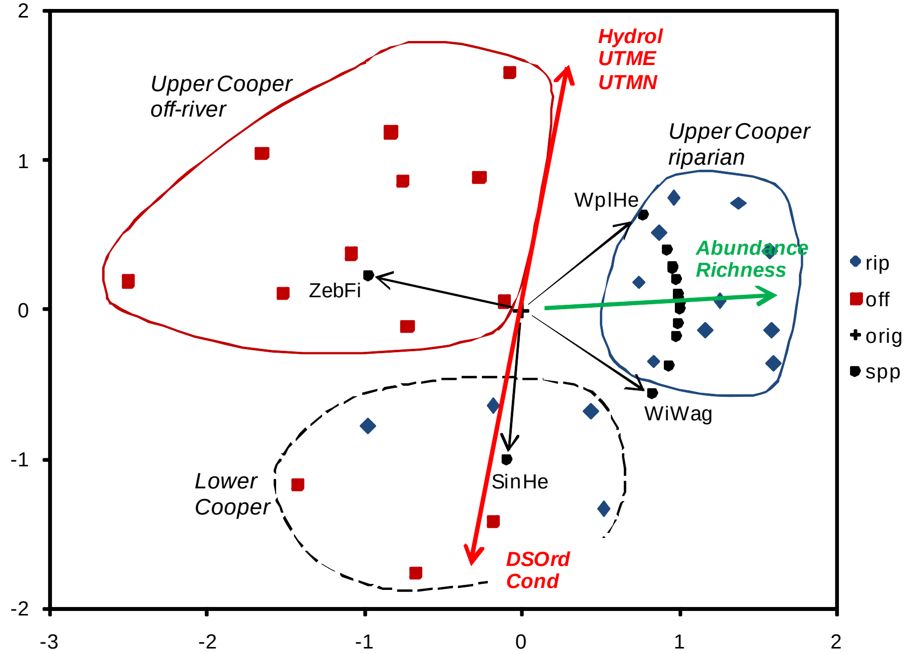

Figure 2b. Vectors of bird assemblage summary variables (species richness and community abundance, in green) and hydrology and site location (red) superimposed on the ordination of sites in Fig. Ba.

Willie Wagtail and White-plumed Honeyeater span the wide range of species characteristic of the upstream riparian bird assemblages.

To investigate the role that particular plant species (floristics) and structural characteristics of the vegetation might play in determining assemblage composition of the region's bird communities, the cover of woody perennial plants was scored in modified Braun-Blanquet classes (31 species across 27 sites) while groundlayer vegetation was divided among hummock 'grasses' (*Triodia basedowii*, *Zygochloa paradoxa* and the dune-crest sub-shrub, *Cynanchum floribundum*), bunch grasses (all other grass species), sedges, and other mainly herbaceous forbs ('ephemerals'), and these categories as well as litter and bare ground were also assigned to cover classes. Some small woody perennial species were lumped with the ephemerals group, e.g. *Cressa cretica* and *Teucrium racemosum*, while samphire species were treated as one taxon, *Sclerolaena* species as one taxon, and *Enchylaena tomentosa* and *Einadia nutans* were also combined, to allow rapid assessment. All these variables were visually assessed at five points (plots of approximately 30-metre radius), 100 metres apart, along the bird transects. The mean height of woody perennials was also estimated at each plot, and subsequently each species was assigned to a structural growth form based on height, namely trees, small trees, tall shrubs, medium-height shrubs and low shrubs, such that the vertical structure of the vegetation could be described by these categories. The floristic dataset consisted of cover estimates of the 31 species and taxa averaged across the five plots at each site, using the midpoint of each cover class, and these mean cover estimates were subsequently log-transformed. The structure dataset consisted of the 11 grouping variables described above, averaged and log-transformed in the same manner for the 27 transects, after summing midpoint cover estimates for all woody perennial species in each of the five height classes.

Relationships between landbird assemblages and features of the vegetation were investigated using three distinct correlative approaches. First the relationship of each vegetation variable (mean species cover and 11 grouping variables) with the landbird ordination was assessed individually, *post-hoc*, using the *pcc* routine in PATN, with significance of each multiple axis correlation assessed by 999 Monte Carlo randomisations (routine *mcao*). Second, simple Mantel correlation tests were performed using the *q*-mode (sites) Bray-Curtis association matrix for landbirds, floristics and structure, with significance assessed by 999 Monte Carlo randomisations (option 14 in routine *trna* in PATN), preserving the original structure of the data matrixes, i.e. 27 sites by *n* attributes, with *n* varying across the three datasets. Greater size of the Pearson correlation coefficient was interpreted as indicating a stronger relationship, given all tests were significant at $P = 0.001$. Third, Procrustes rotation and Monte Carlo randomisation tests (function *protest*, with 9999 permutations) were used to assess how similar the two-dimensional ordinations were for the three datasets, implemented in the vegan package on the R statistical platform (Oksanen 2011). Procrustes rotation, after standardisation of the scores (position of sites in ordination space), involves rotation and dilation of the second ordination to match as closely as possible the spatial arrangement of sites in the target ordination, minimising root mean square error (rmse) in the resulting lack of fit. Peres-Neto and Jackson (2001) considered that Procrustes methods might be more informative than Mantel tests. PATN implements

Procrustes rotation, after standardisation of the scores, without testing for significance, simply outputting the rmse value, with a smaller value indicating better fit between the two ordinations. Because PATN implements the semi-strong hybrid (SSH) form of Non-metric MultiDimensional Scaling (NMDS), different to the NMDS ordination algorithm implemented in vegan, Procrustes analyses were run in both packages, with significance testing confined to the vegan results, that also included a correlation value as a measure of fit between the spatial arrangements of sites in the two ordinations being compared.

Principal axis correlation analysis revealed that the cover of Coolibah had the strongest influence of any plant separating riparian bird communities from their off-river counterparts (Table 2a), i.e. along the longest axis of assemblage compositional change; as a vector representation on the bird ordination it aligned closely with the Upper and Middle Cooper riparian bird assemblages (Fig. 2c). *Acacia ligulata*, Umbrella (or Sandhill) Wattle, had the next highest correlation between the ordination and a plant species, with R = 0.85, and its vector was oriented on the diagonal away from the Upper Cooper bird communities and towards the off-river and lakes Hope and Appadare riparian bird communities (Table 2a; Fig. 2c). The two other (large) tree species, River Red Gum and Queensland Bean-Tree, were also highly significant correlates of the ordination, and higher cover was again associated with the Upper and Middle Cooper riparian bird assemblages ($P < 0.01$). Two small trees, Creek Wilga and Broughton Willow, had an even stronger relationship with these rich and abundant bird assemblages ($P <= 0.003$). The shrub, Lignum, was also highly significantly correlated with riparian bird assemblages of the Upper Cooper, forming a diagonal vector indicating its greater cover at sites in the upper-right quadrant of the bird ordination and less prominence at the four riparian sites in the Lower Cooper region. Most of the other species significantly correlated with the ordination had a similar vector to Umbrella Wattle (i.e. lower left quadrant: Fig. 2c), with the dune crest plant, *Cynanchum floribundum*, being the most significant of these (P = 0.001; Table 2a), but the vector direction of the Needlewood, *Hakea leucoptera*, although only weakly correlated with the ordination (P = 0.034), was towards the upper-left quadrant, discriminating between the Upper and Middle Cooper off-river bird assemblages, and the seven sites in the Lower Cooper (Fig. 2c).

Table 2a. Principal axis correlations of 13 plant species with the rotatedbird ordination and randomisation tests of significance.
Only significantly correlated species with $R > 0.45$ shown (n = 27 sites).

Species	R	PC SSH1	PC SSH2	P
Eucalyptus coolabah	0.904	0.956	0.292	0.001
Acacia ligulata	0.848	-0.355	-0.935	0.001
Acacia salicina	0.786	0.924	-0.382	0.001
Cynanchum floribundum	0.732	-0.522	-0.853	0.001
Enchylaena-Einadia	0.652	0.338	-0.941	0.001
Eremophila bignoniiflora	0.630	0.988	0.156	0.003
Ptilotus atriplicifolius	0.630	-0.052	-0.999	0.003
Bauhinia gilva	0.615	0.956	0.293	0.004
Eucalyptus camaldulensis	0.609	0.958	0.288	0.007
Muehlenbeckia florulenta	0.588	0.745	0.668	0.004
Zygochloa paradoxa	0.583	-0.441	-0.897	0.005

Acacia murrayana	0.470	-0.413	-0.911	0.043
Hakea leucoptera	0.468	-0.644	0.765	0.034

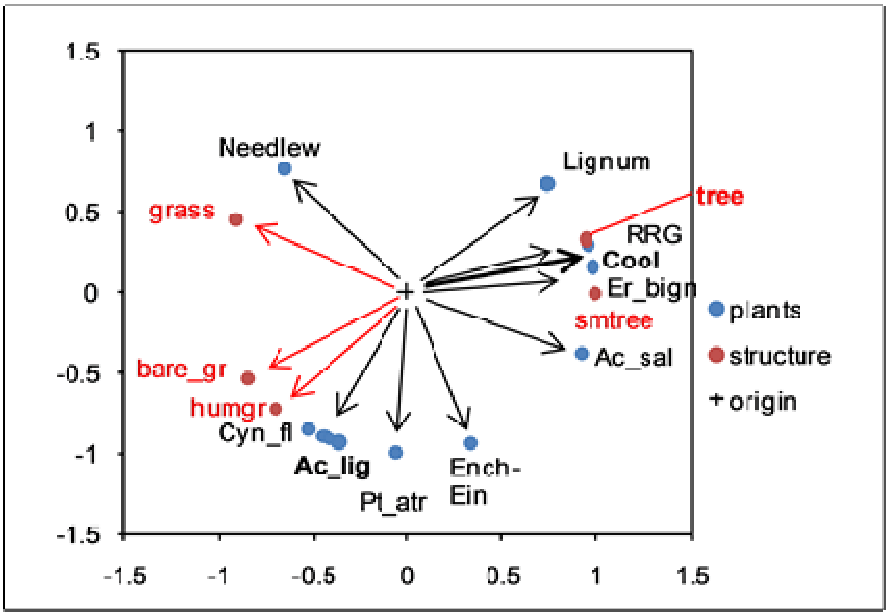

Figure 2c. Floristics (plants, blue) and Structure (red) *pcc* vectors.

The combined cover estimates of the three large tree species (‘tree’ structural class in Table 2b) had a stronger association with the bird ordination than Coolibah (R = 0.92 vs 0.90), and the variance explained by this variable (R^2 = 0.85) was more than double of any other structural class, e.g. the next highest correlate, bare ground, explained 42% variance in the arrangement of the 27 sites (along one axis of differentiation, i.e. in one dimension only) in the ordination, although this variable and hummock grass cover still had highly significant relationships (P <= 0.003), and trending in the opposite direction, broadly, to that of tree cover (Fig. 2c). These three structural classes clearly separated the 10 Upper and Middle Cooper riparian bird assemblages from the remainder, the other 17 sites being characterised by the presence of hummock grasses (some sites only), more bare ground and less tree cover. The 10 Upper and Middle Cooper off-river bird assemblages were associated with a higher cover of bunch grasses (R = 0.56, P = 0.011; Table 2b), and this structural variable served to discriminate between these sites and those in the Lower Cooper region.

These *pcc* results demonstrate that individually both plant species and vegetation structure variables exert considerable control over the composition of bird assemblages in the study region, but tell us little about whether floristics or structure are the more powerful predictor of bird assemblage structure and composition. Table 2c presents the results of the Mantel tests and Procrustes analyses, and show that while both floristics and structure have very strong relationships with bird assemblage compositional variation in the region (all P <= 0.001), floristics were a slightly better predictor than structure using both sets of analyses in PATN, i.e. higher Mantel correlation coefficient and smaller Procrustes rmse values for the bird-floristics comparisons. However, with the different NMDS ordination solutions obtained in vegan for the three data sets (all using log-transformed data and the Bray-Curtis distance measure, i.e. the Bray-Curtis association matrices were the same in both packages), Procrustes analysis in vegan resulted in virtually identical values for rmse and Procrustes correlation coefficients (Table 2c: vegan results), i.e. the ordinations of floristics and structure were similar in their ability to predict the spatial arrangement of sites in the bird ordination. The difference in vegan's results for Procrustes analyses was due to the ordination of vegetation structure being more similar to the bird ordination, as shown by the improvement in fit indicated by the lower rmse value (0.148 in vegan, compared with 0.154 in PATN). In fact by running Procrustes rotation and *protest* comparing the two vegetation ordinations in vegan, the results showed that the similarity between the floristic and structure ordinations was slightly less than the comparisons between the bird ordinations and the two vegetation ordinations – Procrustes R = 0.6057, rmse = 0.153 (compare with results in Table 2c). This result suggests that there is some additional or independent predictive information contained in the two vegetation datasets, probably due to the inclusion of variables like bare ground, litter and herbaceous ground cover in the structure dataset, but with corresponding better discriminatory power of some species in the floristic dataset.

Table 2b. Principal axis correlations of 11 structural variables with the rotated bird ordination and tests of significance.

Structure class	R	PC SSH1	PC SSH2	P
tree	0.924	0.946	0.324	0.001
bare ground	0.646	-0.842	-0.540	0.003
hummock grass	0.641	-0.691	-0.723	0.001
small tree	0.633	1.000	-0.007	0.006
bunch grass	0.562	-0.897	0.443	0.011
tall shrub	0.543	0.945	0.327	0.012
litter	0.417	1.000	0.022	0.094
ephemerals	0.402	0.847	0.532	>0.1
sedges	0.385	0.030	-0.999	>0.1
low shrub	0.379	0.754	-0.657	>0.1
medium shrub	0.200	0.987	0.160	>0.1

Table 2c. Tests of Mantel correlations between association matrices and Procrustes rotation of two-dimensional NMDS solutions, between birds and vegetation, n = 27.

Software	Test	Floristics	Structure
PATN	Mantel R	0.648	0.607
PATN	Mantel P	0.001	0.001
PATN	Procrustes rmse	0.147	0.154
vegan	Procrustes rmse	0.148	0.148
vegan	Procrustes R	0.6418	0.6423
vegan	Procrustes P	0.0001	0.0001

Partial Mantel correlation tests were used to investigate the joint effects of floristics and structure on bird assemblage composition in vegan. In these tests the controlling effects of one vegetation variable are partialled out of both the bird Bray-Curtis association matrix and the other vegetation matrix, and then the partial correlation between the residual of the bird matrix and residual of the other vegetation matrix is obtained, and tested for significance with 999 permutations. In this way, first structure then floristics were controlled for, in two separate tests. The size of the partial Mantel correlation coefficient indicates the strength of the relationship between birds and the other dataset, having controlled for the first vegetation variable. These analyses revealed that the partial correlation between Bray-Curtis distances of birds and floristics (partial Mantel R = 0.366, P = 0.001) was significantly stronger than that of birds and structure (partial Mantel R = 0.241, P = 0.004), and importantly, confirmed that both vegetation sets of attributes – species cover estimates, and structural or life-form cover classes – contain independently predictive information which suggests causes for the ways bird assemblage composition varies in the study area.

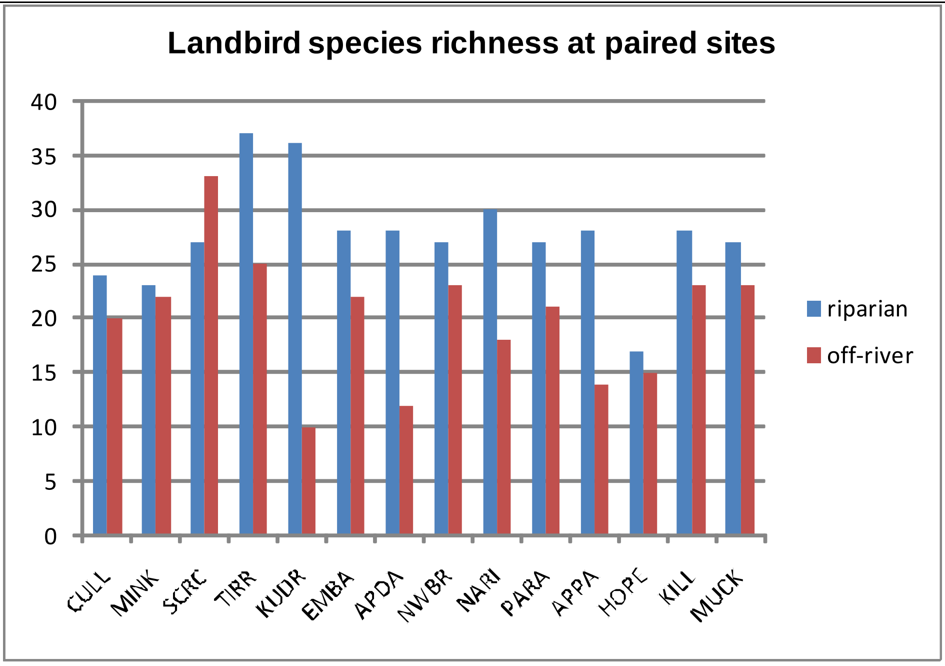

Figure 3a. Histogram of landbird species richness (raptors and quails excluded) from single transect counts at 14 pairs of sites.

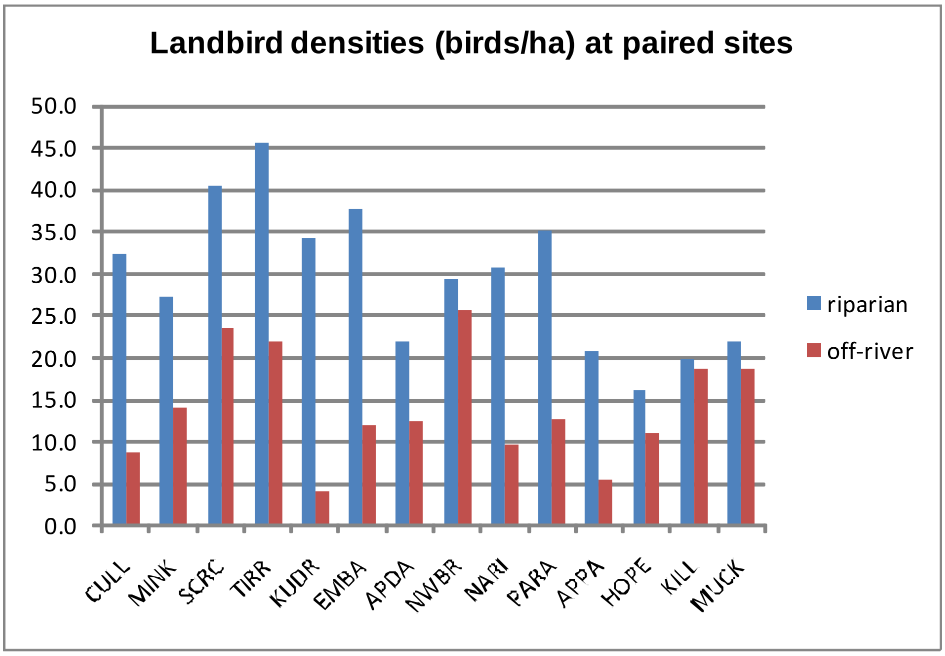

Figure 3b. Histogram of assemblage abundance (birds ha^{-1}; raptors and quails excluded) from single transect counts at 14 pairs of sites.

Landbird species richness – only including observations of birds made on the single half-hour, 500-metre transect count undertaken at each site – peaked at Kudriemitchie and Tirrawarra Waterholes (36 and 37 species, respectively) in riparian vegetation, while at most other riparian sites richness ranged from 20 to 30 species; only Lake Hope had a lower richness of 17 species (Fig. 3a). At all but one pair of sites – Scrubby Camp – riparian bird species richness was higher than that on the off-river transects: 33 species off-river on the adjacent floodplain and low fringing dune, compared with 27 species in the riparian vegetation. Otherwise, richness varied from 10 to 25 species at off-river sites (mean = 19.8 species, SD = 6.1), while mean richness at riparian sites was 27.6 species (SD = 4.9). A paired *t*-test of the hypothesis that mean species richness varied between riparian and off-river environments could not be undertaken because of the missing off-river observation for Muckeranna Waterhole, but a simple *t*-test returned a significant result ($t = 3.66$, $P = 0.001$, $n = 27$). Little support was gained for the expectation that bird species richness would decline substantially with downstream order of sites ($P = 0.65$, $n = 26$; generalised log-linear mixed model, with site as random effect, downstream order as the independent variate tested, habitat included as a fixed covariate factor with two levels, dispersion parameter = 2.04; MUCKr excluded), as is apparent from inspection of Figure Ca where apart from a small spike in richness around Scrubby Camp, Tirrawarra waterhole and Kudriemitchie, it can be seen that the values were reasonably equitable across sites.

Landbird assemblage abundance varied greatly across sites and habitat (Fig. 3b), from a minimum of 4.2 birds ha^{-1} (Kudriemitchie off-river) to 45.7 birds ha^{-1} at Tirrawarra waterhole (riparian), and abundance was greater on the riparian transects (mean = 29.6, SD = 8.7) than on the paired off-river transect (mean = 13.9, SD = 6.7) across all sites. A *t*-test on log-transformed abundance data confirmed that landbirds were significantly more numerous in the riparian habitat (t = 4.99, P < 0.001, n = 27), but again there was no support for the expectation that abundance declined significantly and linearly with downstream order of sites, accounting for the habitat effect as a random term (P = 0.50, n = 26; general linear mixed model or REML, with site as a random effect, downstream order as the independent variate tested, and habitat included as a fixed covariate factor with two levels), despite riparian abundance of the four most downstream sites, around lakes Hope and Killalpaninna, being less than at any upstream riparian sites (Fig. Cb). A randomisation test of the hypothesis that these four lower Cooper riparian sites had lower bird abundance than the 10 upstream riparian sites returned a significant result (P = 0.0027; 10,000 randomisations, two-sided test), a result which agrees approximately with the exact probability of selecting the four most extreme values from a sample of 14 numbers (P = 4/14 * 3/13 * 2/12 * 1/11 = 1/1001 or 0.000999). It was concluded that landbird abundance was significantly less in the riparian vegetation of the most arid and saline lower parts of the study region than in the denser and broader riparian vegetation communities surveyed upstream of Lake Appadare, i.e. the effect was of the threshold, change in state variety rather than a simple, continuous trend of declining abundance with distance downstream, but noting the caveat that a large section of Cooper Creek could not be accessed for survey between Parachirrinna Waterhole and Lake Appadare, a straight-line distance of 95 km.

There was a change in assemblage composition coincident with the decline in landbird assemblage abundance downstream of Parachirrinna Waterhole, as described in earlier sections (the grouping of the four most southern sites evident in the ordination in Fig. 2a), both as a result of lower abundances of individual species (e.g. Galah, Red-backed Kingfisher, Spiny-cheeked Honeyeater, White-plumed Honeyeater, Mistletoebird and Tree Martin) and the absence of several species at the four lower Cooper sites (e.g. Common Bronzewing, Peaceful Dove, Red-rumped Parrot, Sacred Kingfisher, Brown Treecreeper and Grey Shrike-thrush), and these compositional trends are shown in Table 3. Most of the species having a preference for upstream riparian sites were highly correlated with this portion of the ordination in Figure 2a as revealed by *pcc* analysis. All of the seven species that were proportionately more frequent or more abundant at downstream sites occur in the Upper Cooper region of South Australia, but tend to occupy open floodplain habitats with scattered Coolibahs (e.g. Blue Bonnet and Black-faced Woodswallow) or dune environments (e.g. White-winged Fairy-wren, Singing Honeyeater and Red-capped Robin). In contrast, several of the upstream bird species do not occur in the Lower Cooper region, such as the Australian Ringneck and Jacky Winter, and there are other species not observed during the transect counts that are confined to the Upper Cooper reaches (e.g. Barking Owl and 'Golden-backed' subspecies of Black-chinned Honeyeater: Reid 1984; Badman 1989; Reid and Gillen 1988; Reid *et al.* 1990).

Table 3. Frequency of site occurrence and densities (birds ha^{-1}) of selected species at upstream (US, *n* = 10) and downstream (DS, *n* = 4) riparian sites.
Final two columns give mean densities calculated only over those sites at which the species was observed.

English Name	US Freq	DS Freq	US Mean Density	DS Mean Density	US Mean_D If	DS Mean_D If
Upstream Preference						
Peaceful Dove	**10**	0	1.16	0.00	1.16	-
Common Bronzewing	**3**	0	0.07	0.00	0.23	-
Little Corella	**10**	2	1.74	0.40	1.74	0.80
Galah	**10**	3	2.88	0.40	2.88	0.53
Australian Ringneck	**4**	0	0.16	0.00	0.40	-
Red-rumped Parrot	**9**	0	2.36	0.00	2.62	-
Red-backed Kingfisher	**6**	2	0.13	0.05	0.22	0.10
Sacred Kingfisher	**5**	0	0.12	0.00	0.24	-
Tree Martin	**10**	3	3.70	1.00	3.70	1.33
Fairy Martin	**7**	1	1.26	0.10	1.80	0.40
Jacky Winter	**4**	0	0.12	0.00	0.30	-
Grey Shrike-thrush	**10**	0	1.00	0.00	1.00	-
Black-faced Cuckoo-shrike	**10**	1	0.38	0.05	0.38	0.20
Chestnut-crowned Babbler	**3**	0	0.24	0.00	0.80	-
Rufous Songlark	**3**	0	0.10	0.00	0.33	-
Brown Treecreeper	**7**	0	0.24	0.00	0.34	-
Mistletoebird	**9**	3	0.44	0.18	0.49	0.23
White-plumed Honeyeater	**10**	2	6.86	0.55	6.86	1.10
Spiny-cheeked Honeyeater	**9**	3	0.99	0.28	1.10	0.37
Downstream Preference						
Blue Bonnet	1	**3**	0.01	0.40	0.10	0.53
Red-capped Robin	0	**2**	0.00	0.10	-	0.20
Crimson Chat	0	**2**	0.00	0.40	-	0.80
White-winged Fairy-wren	0	**2**	0.00	0.45	-	0.90
Black-faced Woodswallow	5	**2**	0.26	0.65	0.52	1.30
Singing Honeyeater	0	**4**	0.00	1.30	-	1.30
Zebra Finch	8	**4**	0.98	2.55	1.23	2.55

3.5 Multivariate analysis of 14 riparian bird assemblages

In order to focus on riparian bird assemblages, the 13 off-river observations were removed, leaving 14 sites and 51 bird species (log of density estimates) for MVA. A similar analytical approach was used as before, first presenting the dendrogram (cluster) analysis and simple NMDS ordination of sites in two dimensions.

The dendrogram (Fig. 4) revealed two main groups of sites, corresponding to the upper and middle portions of the study area (n = 10) on the one hand, and the four sites on the Lower Cooper around lakes Appadare, Hope and Killalpaninna, characterised by the relative scarcity of Coolibahs. In this respect the cluster analysis of bird data generated similar patterns to that of the complete floristic set of vegetation data (using cover estimates of 64 plant species), the only difference being that the minor channel between lakes Apachirie and 'DAER' (APDA in the figures above) in the Coongie Lakes district was clustered with the Upper Cooper sites here, but with the Lower Cooper in the analysis of floristic data. This sole divergent result is thought to reflect the different spatial scales at which these two groups of organism are distributed through landscapes, with individual (mobile) birds interacting with their environment over much larger spatial scales than (rooted) plants, particularly small herbaceous species and shrubs. It is postulated that plants at this site were probably responding more directly to the long-term flooding and hydrological regime (infrequently flooded, low mean annual discharge) that was similar to sites on the main flowpaths in lower portions of Cooper Creek, whereas the bird assemblage was heavily influenced by the rich and abundant birdlife around the North West Branch and the Coongie Lakes less than 10 km to the east. Within the Upper and Middle Cooper group, two sub-groups and a singleton site were recognised in the dendrogram, with the bird assemblages of Cullyamurra, Minkie and Scrubby Camp Waterholes being more similar to each other, and reflecting their longitudinal position (three most upstream sites surveyed) and all having River Red Gum present, compared with the other sub-group that comprised a mix of sites with and without red gums and distributed along both the Main and North West Branches. The singleton, APDA, was distinguished from other sites in this group by the absence of Red-rumped Parrots and the presence of Blue Bonnets.

Ordination (Fig. 5a) revealed the same trends as described for the dendrogram, with longitudinal position of sites reflected in a diagonal gradient from lower-right to upper-left quadrants: sub-group 1 sites being placed in the lower-right portions of the plot and representing the upstream pole, sub-group 2 sites next, and with the Lower Cooper cluster in the upper-left quadrant. Because, the SSH solution was rotated to principal components, to maximise the variation in assemblage composition among sites along the first axis, the downstream ordering of sites only partly corresponds to this main axis of assemblage differentiation. Multiple axis correlation (*pcc*) of bird species revealed 14 species that contributed strongly (R > 0.7, P <= 0.01) to the ordination (Fig. 5b), and three species were most strongly associated with the main axis of differentiation, namely Tree Martin and Red-rumped Parrot (positively loaded on the *x*-axis) and Red-capped Robin (negative). Red-rumped Parrot, White-plumed Honeyeater, Grey Shrike-thrush and Peaceful Dove were most strongly aligned (upstream) with the diagonal upstream-downstream trend in arrangement of sites, and Blue Bonnet, Yellow-throated Miner, Singing Honeyeater and Zebra Finch in the opposite direction (downstream sites). Orthogonal to these trends, Budgerigar and Black-faced Woodswallow were better represented at more open sites (placed towards the top of the ordination), while Spiny-cheeked Honeyeater was more abundant at sites in the lower half, thought to be associated with a greater density of small trees in the riparian vegetation. However, *pcc* analysis of independent environmental variables (hydrology, location, longitudinal order of sites along the river, soil) and vegetation (floristics, i.e. species, and structural classes), did not reveal any significant relationships in the oblique diagonal direction from lower-left to upper-right quadrants (Fig. 5c). Rather all significant variables were in a fairly tight arc consistent with the longitudinal position of sites down the Cooper, and so the structuring forces, if any, responsible for the separation of sites in the orthogonal direction (representing the shift from Budgerigar and Black-faced Woodswallow at the top of the ordination, to Spiny-cheeked Honeyeater at bottom) cannot be confirmed. Of the vectors shown in Figure 5c, downstream order of sites, electrical conductivity (Cond) and soil pH increased downstream, and the sand dune plant species, Umbrella Wattle (*Ac_lig*) and *Cynanchum floribundum* were also highly associated with the bird assemblages at the four riparian sites on the Lower Cooper, while the log of large tree cover (as measured quantitatively by JG) and log of long-term mean annual flow (lnDSH), as well as the cover of litter, trees, Coolibah and Lignum, increased at sites representing bird assemblages in sub-group 1, i.e. the most upstream sites. All of these environmental variables are considered to be under the ultimate control of the regional hydrology and geomorphological processes, such that landscapes in the Lower Cooper are more saline, sandier and support shorter and more sparse riparian vegetation (and so soil pH increases as there is less organic material/litter) – composition of riparian bird communities shifts accordingly.

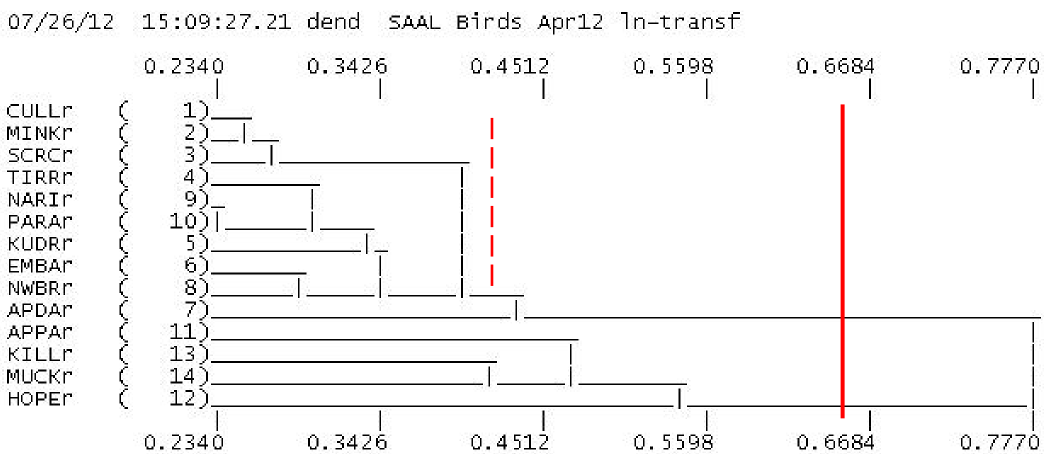

Figure 4. Dendrogram of 14 riparian bird assemblages using Bray-Curtis distance of landbird density estimates for 51 species; cut-off shows two main groups

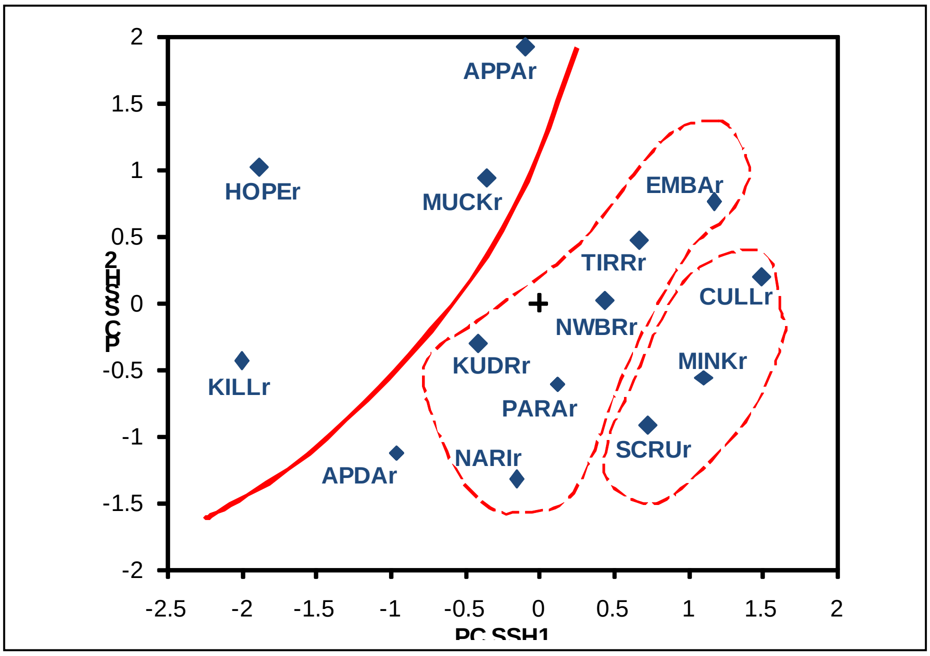

Figure 5a. 2-dim. SSH NMDS ordination of riparian birdof sites, separating upstream transects from the rest; the minor cut-off splits transects, with groups from dendrogram shown.

The Upper and Middle Cooper into two groups and a singleton (APDA) Stress = 0.20, rotated to principal components.

A similar set of Mantel, partial Mantel and Procrustes correlation analyses as described above for all bird samples was undertaken to investigate the relationships between the riparian bird assemblages alone and vegetation characteristics, particularly to see if both floristic and structural datasets describing the riparian vegetation were significantly related to the bird assemblages and whether floristics had greater, independent, explanatory power (as the partial Mantel tests revealed for n = 27 bird observations). Most analyses were conducted in vegan due to its greater efficiency and the facility to test Procrustes rotation results with the function *protest*. The (simple) Mantel tests were also carried out in PATN to check that identical results were obtained in both packages (which they were). Because the vegetation ecologist surveyed the riparian vegetation at 13 sites where bird observations were obtained, relationships were explored using four sets of vegetation data, namely the floristic and structural datasets collected by J. Reid (as described above, but restricted to the 14 riparian sites), and the more complete floristic dataset collected by J. Gillen at 13 sites, as well as the quantitatively measured cover data of 14 woody perennial species also gathered by Gillen at 13 sites. Because the vegetation data obtained by Gillen at Lake Killalpaninna were apposite to both sets of bird observations made by Reid (at Muckeranna Waterhole and Lake Killalpaninna), these observations were represented twice in the data used for Mantel tests exploring the relationships between bird assemblage composition and Gillen's vegetation data, and also for the Procrustes rotation analyses undertaken in PATN (by duplicating the ordination scores for KILLr and MUCKr). However, to run Procrustes analyses and tests in vegan, the bird observations at Muckeranna Waterhole were excluded to enable automation of the implementation of its NMDS ordination routine, reducing the sample size to 13.

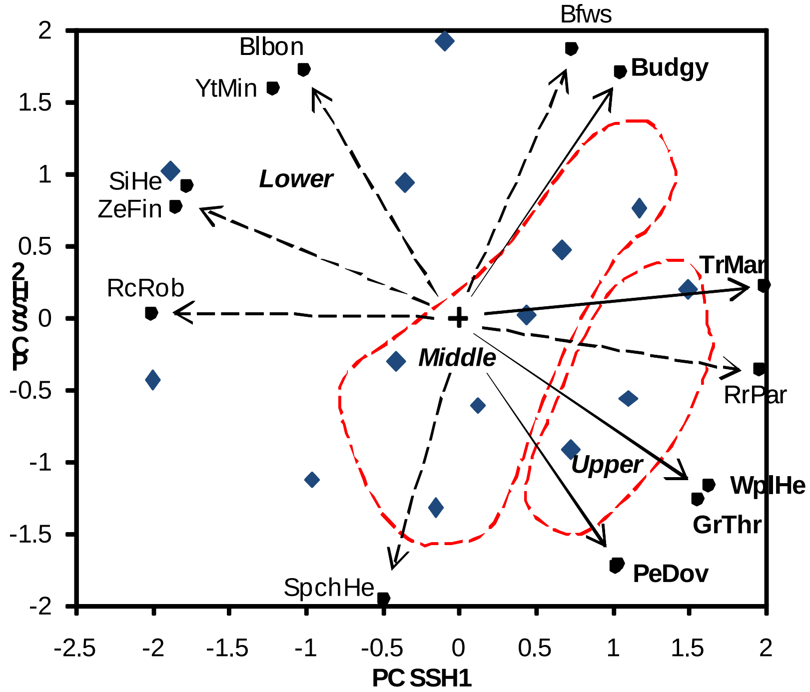

Figure 5b. Significant bird species positions in relation to ordination of sites from *pcc* analysis – bold font denotes species with multiple *R* > 0.85.

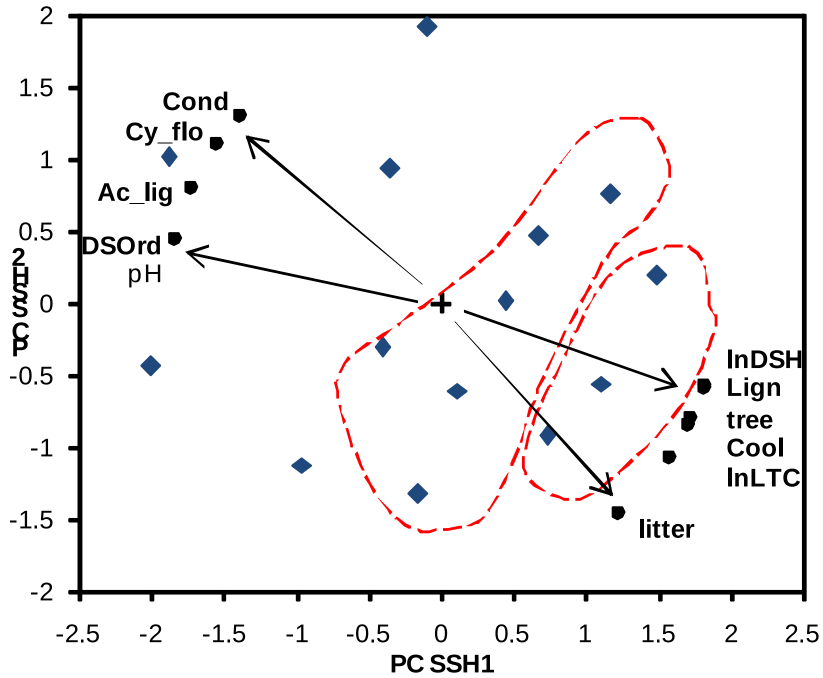

Figure 5c. Significant environmental vectors and plants in relation to ordination from *pcc* analysis – bold font denotes variables with multiple *R* > 0.80.

All tests of the relationship between bird assemblage composition at riparian sites and single vegetation data sets were highly significant, regardless of observer or correlation technique (all $P <= 0.0006$; Table 4). However, the woody perennials quantitative structural data set gathered by Gillen had the weakest correlation in simple Mantel tests – Mantel $R = 0.47$, compared with $R >= 0.66$ – and with vegan's implementation of NMDS ordination, the root mean square error of the Procrustes rotation correlation between birds and quantitative perennial structure was slightly greater (rmse = 0.189, compared with rmse <= 0.172 for the other three Procrustes tests in vegan) indicating a poorer fit between the ordinations, while still being a highly significant relationship ($P = 0.0003$). Curiously using PATN's SSH ordination results, Procrustes rotation results indicated that Gillen's floristic data had a slightly poorer fit to bird assemblages in two-dimensional ordination space (Table 4: rmse of FlorGillen = 0.209, versus rmse of StrGillen = 0.183). Mantel tests and vegan's implementation of ordination and Procrustes analyses suggested that the habitat data gathered by Reid were more informative in their predictive capability of bird assemblage composition than Gillen's data, but this was not true for Procrustes analysis undertaken with PATN's SSH ordinations – the root mean square errors were similar across both observers. However, these SSH Procrustes results obtained in PATN were also contrary in indicating that structure was a slightly better predictor of bird assemblage composition than floristics, whereas the opposite result was obtained in all other tests. One compelling and unambiguous result was obtained with partial Mantel tests, in that when controlling for the effects of floristics, the partial correlation between birds and structure was weak and not significant ($P > 0.2$, for both Reid and Gillen datasets). In comparison, the partial correlation between assemblage composition of the bird and both floristic datasets, was strong and highly significant when controlling for the effects of structure (Table 4: partial Mantel $R >= 0.44$, $P <= 0.0003$). The evidence is compelling that when restricting observations to the riparian environment alone, gathering floristic data has additional predictive power for interpreting the patterns of variation in bird assemblages in the Cooper Creek study region compared with vegetation structure, and this conclusion agrees with previous findings of Rotenberry (1985) in bird communities across a continental gradient of North American grasslands. The reason for the generally greater predictive power of Reid's habitat observations compared with those of Gillen is almost certainly due to the fact that the former observations were gathered precisely along the length of the bird transects, whereas some of Gillen's vegetations surveys were conducted up to 500 metres away.

Table 4. Tests of Mantel and partial Mantel correlations between association matrices and Procrustes rotation of two-dimensional NMDS solutions, between birds and four sets of vegetation data as described in body of text; *n* = 14 sites for all Mantel tests and Procrustes analyses in PATN, *n* = 13 for Procrustes analyses in vegan.

Software	Test	FloristReid	StructReid	FlorGillen	StrGillen
vegan	Mantel *R*	0.822	0.777	0.660	0.473
vegan	Mantel *P*	0.0001	0.0001	0.0001	0.0006
vegan	partial Mantel *R*	0.442	0.124	0.523	0.028
vegan	partial Mantel *P*	0.0002	0.1979	0.0003	0.4171
PATN	Procrustes rmse	0.201	0.189	0.209	0.183
vegan	Procrustes rmse	0.152	0.157	0.172	0.189
vegan	Procrustes *R*	0.8236	0.8085	0.7858	0.7309
vegan	Procrustes *P*	0.0002	0.0001	0.0003	0.0003

3.6 Nested subsets

Despite the obvious changes in assemblage composition between the 10 upstream riparian sites (Cullyamurra to Parachirrinna) and four downstream sites, with Red-rumped Parrot, White-plumed Honeyeater, Grey Shrike-thrush and Peaceful Dove associated with upstream sites, and Blue Bonnet, Yellow-throated Miner, Singing Honeyeater and Zebra Finch at downstream sites, uncovered in the above multivariate statistical analyses, the species-poorer downstream riparian assemblages formed significantly nested subsets of the richer assemblages in upper sections of the Cooper, when analyses were restricted to resident species. Nested subsets describe a pattern of community organisation in which smaller faunas (less species-rich) comprise a subset of the species occurring in larger faunas within the study system (Patterson and Atmar 1986; Atmar and Patterson 1993, 1995). Classically the theory and investigations have been applied to fragmented habitat isolates in biogeographic settings, such as an archipelago of islands or Pleistocene mountain-top refuges (Patterson and Brown 1991), but its expression has implications for conservation biology in that all species are represented in the largest fragments in a perfectly nested set of assemblages (Patterson 1987; Cutler 1991): in highly nested systems one would argue for having a ‘single large’ reserve rather than ‘several small’ reserves (the old SLOSS debate: Higgs and Usher 1980). Perfectly nested sets are rare in nature except for restricted groups of species distributed across a small number of samples, with local examples being the distribution of fish in the mound springs of the Dalhousie Springs complex (Kodric-Brown and Brown 1993) and fish in the Coongie Lakes (Puckridge *et al.* 2010). For diverse groups like birds, perfect nestedness is unlikely, and so various randomisation procedures (null methods) have been devised to test whether the degree of nesting is significant. The choice of appropriate null model is contentious (Fischer and Lindenmayer 2002; Rodríguez-Gironés and Santamaría 2006; Ulrich and Gotelli 2007; Almeida-Neto *et al.* 2008), and only null models that fix the site totals (richness) and species totals (frequency) to those observed, while conservative – prone to Type 2 errors, i.e. that retain the null hypothesis when the samples really are nested – do not suffer from being overly liberal in detecting nestedness (Ulrich and Gotelli 2007).

Table 5. Tests of faunal nestedness and co-occurrence (Cscore) patterns, for all landbird species (All, excluding raptors, nocturnal; *n* = 51) and resident landbirds (Res, *n* = 30).

Absolute *Z* scores (Zsc) > 2 indicate significant community structure; negative *Z* scores for the first eight metrics would indicate nestedness, positive scores anti-nestedness or disorder (compositional turnover); reverse for the three NODF metrics. The large positive *Z* scores for Cscore indicate highly significant disassociation between pairs of species, which contributes to anti-nestedness. The null model used was the swap and fill algorithm that preserves observed richness and species frequencies in simulations (Ulrich 2008). Bolded *Z* scores without italics indicate significant nestedness; italics indicate significant anti-nestedness for these metrics. Matrices were converted to presence-absence responses for analyses.

PrAbAll.ss.out.txt	**Fill:**	**0.49**	**30 spp**		**PrAbRes.ss.out.txt**	**Fill:**	**0.59**	**51 spp**	
Metric	**Obs**	**mean_Sim**	**sd_Sim**	**Zsc**	**Metric**	**Obs**	**mean_Sim**	**sd_Sim**	**Zsc**
N0	198.00	195.06	13.28	0.22	**N0**	101.00	88.04	7.65	1.69
N1	153.00	162.70	10.35	-0.94	**N1**	63.00	98.61	9.42	**-3.78**
UA	36.50	37.12	5.04	-0.12	**UA**	13.75	26.18	3.81	**-3.26**
UP	53.50	58.03	5.42	-0.84	**UP**	32.25	26.07	3.91	1.58
UT	90.00	95.15	3.13	-1.64	**UT**	46.00	52.25	2.32	**-2.70**
BR	71.00	69.75	2.37	0.53	**BR**	43.00	43.33	1.99	-0.67
Temp	25.85	25.56	0.38	0.75	**Temp**	20.82	22.67	0.81	**-2.30**
NODF	64.92	66.91	0.56	***-3.55***	**NODF**	69.64	72.40	0.60	***-4.62***
NODF_sites	68.97	69.64	0.37	-1.82	**NODF_sites**	65.46	68.10	0.57	***-4.65***
NODF_spp	64.64	66.71	0.59	***-3.52***	**NODF_spp**	70.52	73.30	0.70	***-3.95***
Cscore	4.35	3.98	0.04	***9.42***	**Cscore**	5.05	4.44	0.06	***10.49***

Tests using the conservative null model (swap and fill method of Ulrich and Gotelli 2007) are presented in Table 5 showing that significant nested structure was observed in assemblages only when nomadic species were excluded ('Res' data set). Four widely used nestedness metrics supported this conclusion, namely the N1, Ua, Ut and matrix temperature (Ulrich 2008a, 2012). The fact that the NODF metrics indicate significant anti-nestedness can be ignored (Almeida-Neto *et al.* 2008) as this is a general result when combining this class of measure with the swap and fill null model. By contrast, none of the metrics indicated significant nestedness structure when nomadic species were retained in the data set (PrAbAll: left-hand half of Table 5). In both data sets there were many checkerboard occurrences of species pairs, i.e. pairs of species that generally did not occur together (large positive *Z* scores for the Cscore index: Table 5). Several pairs of resident species were found to be significantly segregated or checkerboarded after running complementary co-occurrence analyses (Ulrich 2008b). Peaceful Dove, Red-rumped Parrot and Grey Shrike-thrush were each significantly segregated from Blue Bonnet and Singing Honeyeater, with the latter two species largely confined to downstream riparian sites. Also Brown Treecreeper, an upstream riparian indicator species, had a significant checkerboard distribution with both Singing Honeyeater and Australian Magpie, and the Australian Ringneck (upstream) and Black-faced Woodswallow were significantly segregated. Ulrich's (2008b) software uses Bayesian statistics to adjust probabilities upwards to account for the great many pairwise species comparisons.

The investigation of nested structures within the riparian bird communities along this section of Cooper Creek with its steep gradient of declining discharge neatly complemented the earlier multivariate analyses, confirming that while there was a significant component of faunal turnover between the rich upstream sites and the four lowest sites, there were sufficient instances of species dropping out of upstream assemblages in an ordered manner with distance downstream to generate significant nested structures within the set of 14 assemblages analysed here. Further investigation of the behaviour of matrix temperature (Temp in Table 5) indicated that nested structure in this suite of assemblages was maximised by ordering the sites differently to that defined by longitudinal position along the river. Ordering by site richness (with Tirrawarra and Kudriemitchie first, i.e. waterholes in the middle section of the longitudinal gradient sampled) reduced matrix temperature to 19.78º (lower temperature indicates greater nestedness), whereas when sites were ordered in strict longitudinal order, Cullyamurra Waterhole first, matrix temperature rose to 35.42º while still indicating significant nested structure with the swap and fill null model (*Z* score = -2.27 for Temp; *Z* score = -3.22 for the N1 metric, the most sensitive indicator of nested subset structure with this stringent null model: Ulrich and Gotelli 2007). The NODFsites measure indicated that the bird assemblage at the mouth of the North West Branch immediately upstream of Coongie Lake was the most ordered of the 14 (NODFsites score = 0), and the four lowest sites contributed most to disorder (Table 6; NODFsites scores in the range 2.1-7.6). Among the 10 upstream sites, Cullyamurra and Scrubby Camp contributed moderately to disorder having NODFsites scores > 1 (Table 6). The species that contributed most to nestedness order (lower temperatures) and disorder (> 40º) are also shown in Table 6. Perhaps the most surprising entry in Table 6 is the Australian Ringneck, with its moderately high temperature indicating that it promoted disorder, and this reflected its occurrence mainly at the most upstream sites which were ordered in the middle of the sites when the matrix was packed to minimise temperature. Two other species with known hard distribution limits in the study area, Grey-Shrike-thrush and Jacky Winter, in contrast had low temperature scores in agreement with prior expectations that such species would promote nested subset structure in these communities.

Table 6. Resident species and sites that contributed most to nestedness order (lower matrix temperature scores for species and NODFsites scores for sites) and disorder or discrepancy (italics).

Species are ordered by Temp; sites in the order that minimised matrix temperature (*Z*score for the N1 metric = -3.63; *P* < 0.001, two-tailed test). Species that occurred at 13 or all riparian sites are excluded (all contributed strongly to nestedness structure).

Species	Freq	Temp(º)	Site	Res_Rich	NODFsites
White-breasted Woodswallow	12	0.00	TIRRr	24	0.33
Grey Shrike-thrush	10	0.00	KUDRr	22	0.46
Peaceful Dove	10	0.35	NARIr	21	0.76
White-plumed Honeyeater	12	0.49	EMBAr	20	0.50
Jacky Winter	4	4.92	APDAr	18	0.72
Little Corella	12	4.95	CULLr	17	1.59
Spiny-cheeked Honeyeater	12	5.04	MINKr	17	0.65
Chestnut-crowned Babbler	3	6.24	SCRCr	17	1.35
Red-rumped Parrot	9	8.10	NWBRr	17	**0.00**
Fairy Martin	8	8.72	PARAr	17	0.29
Variegated Fairy-wren	6	*43.36*	MUCKr	17	*2.06*

White-winged Fairy-wren	2	*44.61*	KILLr	15	*3.40*
Australian Ringneck	4	*44.83*	APPAr	14	*3.36*
Black-faced Woodswallow	7	*46.04*	HOPEr	10	***7.60***
Australian Magpie	4	***59.74***			
Blue Bonnet	4	***76.41***			
Singing Honeyeater	4	***88.82***			

4. CONCLUSIONS

The grass cover and general condition of browsable vegetation, e.g. Queensland Bluebush, were the best seen in 30 years of extensive travel through the Cooper Creek region in South Australia, particularly on the Innamincka and Gidgealpa runs. Whether the extensive Neverfail *Eragrostis setifolia* flats on the flats along the North West Branch, the rolling fields of Barley Mitchell Grass *Astrebla pectinata* in the Merninie Land System north-east of Innamincka Homestead, or the lush diverse herbage of the vast floodplains between Moomba and Embarka Swamp, the country had responded magnificently to the series of high-rainfall years, and was a credit to management. Birdlife was consequently diverse and abundant. As a consequence, the record of bird assemblage composition presented here can be thought of as representing reference condition, and if the same sites were resurveyed under droughty, or even just ‘usual’, conditions, the results could be quite different. Despite the general abundance of the birdlife, there were not the explosive numbers that tend to occur soon after major drought-breaking rains. For instance in a nearby region in the spring of 2008, over 12,000 Budgerigars were recorded at 32 survey sites in the Marqualpie Land System, representing more than 80% of all birds recorded (Neagle and Armstrong 2010). One nomadic species that might have been expected, the Black Honeyeater *Sugomel niger*, was not recorded on this survey, and these two example highlight the problems of attempting to use nomadic birds as indicators of condition of a region or ecosystem in arid Australia. For reasons that are not understood but presumably relate to the presence of better conditions elsewhere, nomadic bird species may be absent or in abundance below what might be expected. Sedentary members of the more stable riparian bird communities would be better candidates for comparing trends through time.

Species that maintain year-round defended territories or home ranges were thought to be the best candidates for ecological monitoring by Reid and Fleming (1992) in arid Australia, and the two main groups of birds that meet this criterion are the families Maluridae (fairy-wrens, grasswrens) and Acanthizidae (thornbills, whitefaces, fieldwrens), and a few other species within diverse families, e.g. Australian Owlet-nightjar, Barking Owl, Grey Shrike-thrush, Jacky Winter, Australian Magpie and Australian Raven. Populations (densities) of these kinds of species should be more stable through time, and so more amenable to detection of trends, than other species with more flexible spatial strategies. The breeding migrant, Sacred Kingfisher, is another species suited to long-term monitoring as it is thought to maintain defended home ranges while breeding, but only over the extended summer period. The two malurid species in the region – Variegated and White-winged Fairy-wren – both occur in riparian vegetation but are widespread and perhaps more abundant in other habitats. The two candidates within the Acanthizidae – Chestnut-rumped Thornbill and Southern Whiteface, as with the Jacky Winter – seem to be more abundant in open woodland habitats on the floodplain than in the dense riparian fringe. Grey Shrike-thrush, Sacred Kingfisher and Barking Owl may be the most suitable candidates for regular monitoring in riparian vegetation in the region, because of the relative ease of survey for the first two, and because of the conservation significance of the owl and because well-established survey protocols have been devised for its study in eastern Australia (e.g. Kavanagh *et al.* 1995; Debus 1995, 2001). However, rather than focussing on two or three bird species for monitoring, assemblage-wide monitoring of the riparian diurnal landbird community, including these and other focal species seems more efficient, using the same or similar transect census methods as used in this survey. In this way the presence and abundance of other riparian bird specialists, such as Peaceful Dove, Australian Ringneck, Red-rumped Parrot, White-plumed Honeyeater, Black-chinned Honeyeater and White-breasted Woodswallow could be monitored concurrently.

The primary influence of tall tree cover, particularly that of Coolibahs, on the structure and composition of bird communities in the region was emphasised in the foregoing results. Frequency of flooding, water retention times and salinity appear to determine the distribution, vigour and density of Coolibah stands in the region (e.g. Roberts 1993; Costelloe *et al.* 2008), and where the lowest reaches of the Cooper become hypersaline (west of the study region, e.g. Cuttapirra Waterhole) no trees occur (Badman 1989). Riparian tree cover declines longitudinally downstream along Cooper Creek in South Australia (Gillen 2010), and birds in the riparian zone become less abundant but, surprisingly, not substantially less diverse, as birds associated with outer floodplain and sand dune environments higher up the system move into the structurally simpler and more open habitats along the river frontage in the Lower Cooper region. Whether the transition in avian assemblage structure between Parachirrinna Waterhole and Lake Appadare is gradual or abrupt is presently unknown, and further sampling is required in the middle-lower reaches (the Kanowana and Mungeranie sections of the river) to ascertain this. Badman (1989) reported that waterholes remained fresh upstream of Eaglehawk Waterhole, whereas downstream from there waterholes became saline after flooding receded, presumably due to saline inflows or intersection with the regional Lake Eyre-centred saline water table. More intensive sampling is also required along all sections of the river, to determine if there are systematic differences between riparian bird assemblages of the North West and Main Branches downstream of the disjunction, whether communities are significantly different in the Nappa Merrie-Innamincka section of the Cooper where the river is bordered by stony tablelands and gibber compared with the dunefields and broad floodplains of sections downstream to Lake Killamperpunna. Longer-term research and monitoring of riparian bird communities in the upper and middle sections of the Coongie Lakes Ramsar Wetlands site would be required to determine if bird diversity is actually greatest in the area dominated by the extensive swamp system around Embarka, Tirrawarra and east to the main disjunction. Further bird surveys are required in the lowest portions of the Cooper, from Lake Appadare to Lake Eyre, to document how the composition of bird assemblages changes with increasing aridity and salinity and as riparian vegetation dwindles to virtually nothing. Badman (1989) described the riparian vegetation at Cuttapirra Waterhole as comprised mainly of the sedge, *Cyperus gymnocaulos*, and that Coolibah did not occur along the Cooper downstream of there, and in the absence of trees it would be expected that landbird communities are distinct from those documented in this study and perhaps imperceptibly different from the surrounding dunefield habitats. Finally, multidisciplinary surveys, including but not necessarily restricted to birds, vegetation, soils and hydrology, of several distributary flood pathways (minor channels and waterholes) are required in the middle sections of the river (Kanowana and Coongie lakes region), and along the major tributary creeks in the tablelands to the north of Innamincka.

A change in state of riparian bird community composition seems to occur west and south from the Coongie Overflow and Narie-Chilimookoo Waterholes area, marking the downstream limits of the typical Upper Cooper avian assemblages, although results were mixed in this respect. In favour of more continual change, ordering of sites by their relative downstream position proved to be strongly correlated with change in assemblage composition (e.g. Fig. 5c). However, ecological distance between riparian and paired off-river sites did not steadily decrease with increasing downstream position (Fig. 6: simple linear regression: $R = -0.45$, $P > 0.1$, $n = 14$). A resampling (non-parametric) test of the proposition that the four most downstream sites had a smaller Bray-Curtis distance than the 10 pairs upstream was marginally upheld ($P = 0.0456$; 5000 randomisations), weakly supporting the notion that off-river bird assemblages become more similar to their riparian counterparts in the lower reaches of the Cooper. Any assessments of bird assemblage condition could only be interpreted in light of the regional trends in community compositional change. More intensive sampling would be required to set the biophysical (and geographical) bounds around these patterns, and the bird observations should only be interpreted in terms of the floristic and structural attributes of the riparian vegetation. In the meantime security of water – ensuring that the hydrology of Cooper Creek remains natural, i.e. preventing major water diversions and/or dam building upstream, and protection of the riparian vegetation from physical clearance or other processes that might prevent regeneration of the key species is essential.

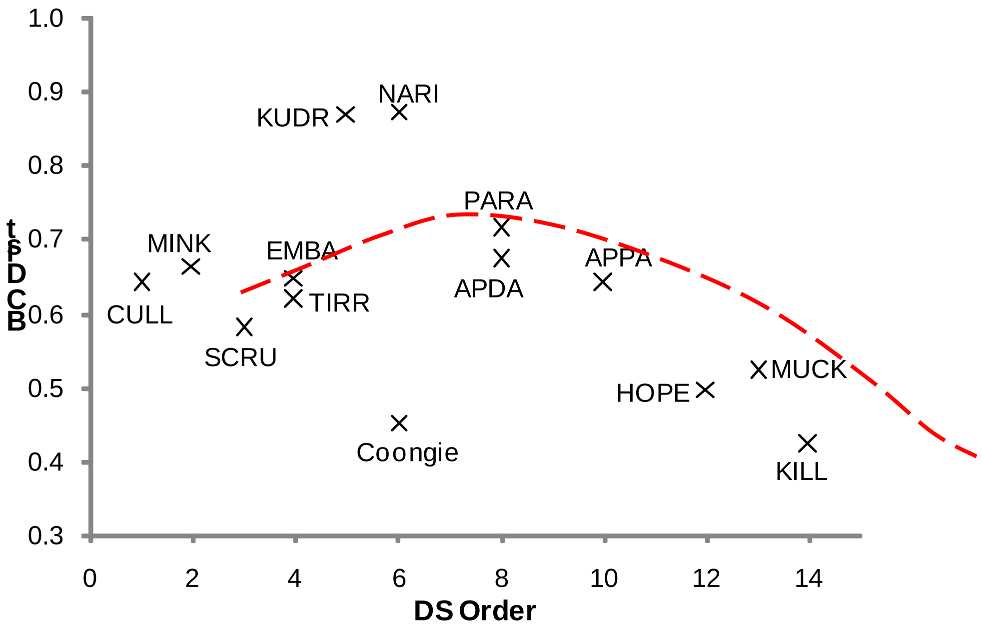

Figure 6. Ecological (BC) distance between pairs of sites vs site longitudinal order; red dashed curve indicates possible functional form of the relationship, noting the outlier of the North West Branch near Coongie Lake.

Apart from unexpectedly low abundances of Variegated Fairy-wren in Lignum-dominated sections of riparian vegetation, the bird assemblages surveyed along Cooper Creek in April-May 2012 seemed to be within the expected bounds of variability, and no imminent threatening processes were detected. Targeted surveys of the rarer riparian bird species, e.g. Black-chinned Honeyeater (not detected this survey) and Barking Owl (seemingly at its usual abundance), would be needed to make a more informed assessment of their population sizes.

A conceptual diagram illustrating most of the significant findings and conclusions regarding the distribution of bird species and communities in the South Australian Cooper Creek region is presented below (Fig. 7.). The importance of the distribution of river red gum in the upper and upper-mid sections of the study area is highlighted, but the greater species richness of the riparian bird communities in the mid sections is also noted. The overriding importance of the distribution and abundance of coolibahs across the floodplain, and as a key component of the riparian vegetation, should also be noted.

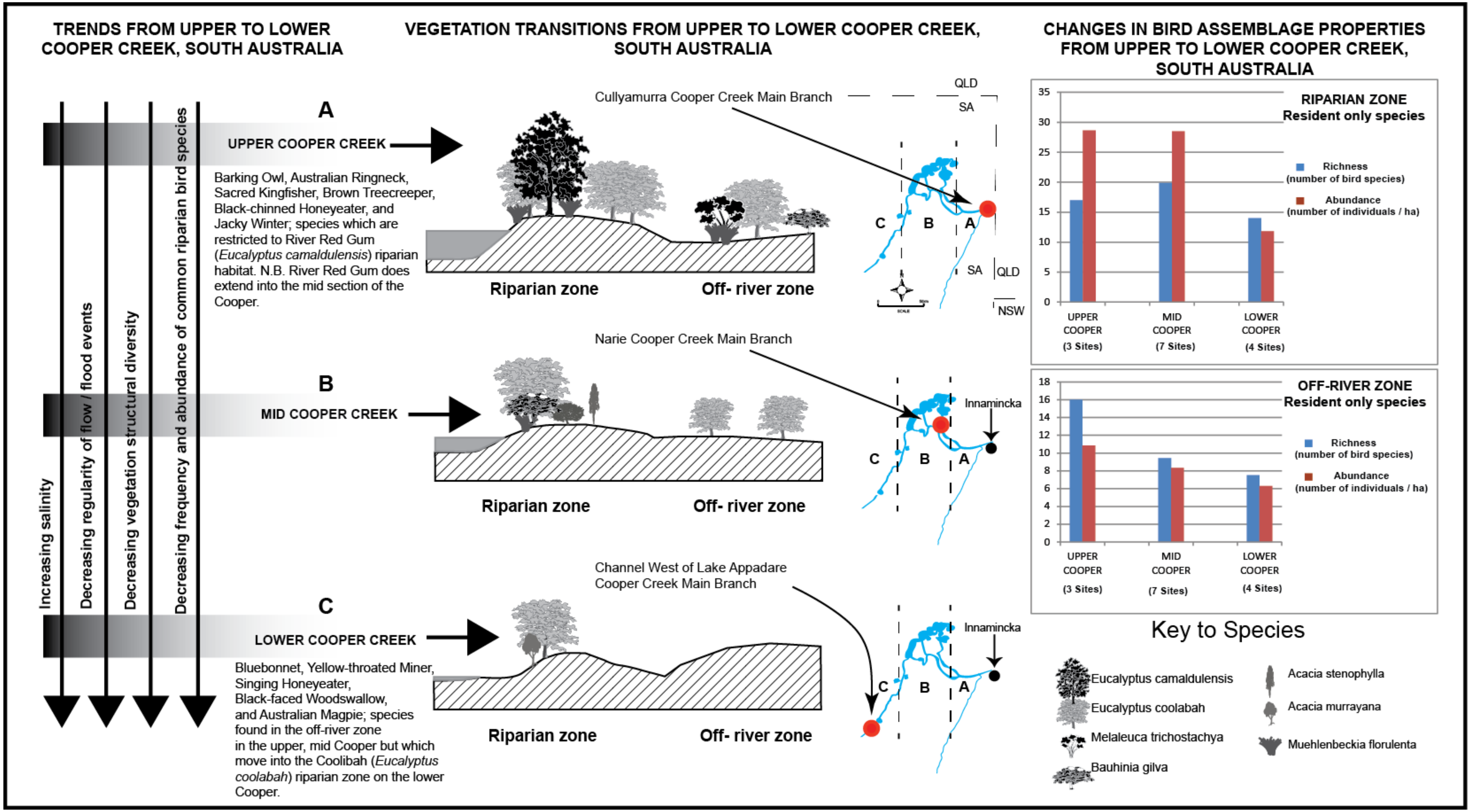

Figure 7. Conceptual diagram and summary data relating to bird species and communities on South Australian sections of Cooper Creek.

5. REFERENCES

Almeida-Neto M., Guimarães P., Guimarães Jr P.R., Loyola R.D. and Ulrich W. 2008. A consistent metric for nestedness analysis in ecological systems: reconciling concept and quantification. *Oikos* **120**:1227-1239.

Atmar W. and Patterson B.D. 1993. The measure of order and disorder in the distribution of species in fragmented habitat. *Oecologia* **96**:373-382.

Atmar W. and Patterson B.D. 1995. *The Nestedness Temperature Calculator: A Visual Basic Program, Including 294 Presence-Absence Matrices.* AICS Research Incorporate and The Field Museum, Chicago.

Badman F.J. 1989. *The Birds of Middle and Lower Cooper Creek in South Australia.* Nature Conservation Society of South Australia Inc., Adelaide.

Belbin L. 1995. *PATN Reference Manual.* CSIRO Division of Wildlife and Ecology, Canberra.

Bibby C.J., Burgess N.D. and Hill D.A. 1992. *Bird Census Techniques.* Academic Press, London.

Black A.B., Duggan G., Pedler J.A. and Pedler L.P. 1983. The Yellow Chat *Ephthianura crocea* at Pandiburra Bore, north-eastern South Australia. *South Australian Ornithologist* **29**:42-45.

Blakers M., Davies S.J.J.F. and Reilly P.N. 1984. *The Atlas of Australian Birds*. Melbourne University Press.

Block W.M. and Brennan L.A. 1993. The habitat concept in ornithology. Theory and applications. *Current Ornithology* **11**:35-91.

Burbidge A.A. and Fuller P.J. 2007. Gibson Desert birds: responses to drought and plenty. *Emu* **107**:126-134.

Christidis L. and Boles W.E. 2008. *Systematics and Taxonomy of Australian Birds.* CSIRO, Melbourne.

Costelloe J.F., Payne E., Woodrow I.E., Irvine E.C., Western A.W. and Leaney F.W. 2008. Water sources accessed by arid zone riparian trees in highly saline environments, Australia. *Oecologia* **156**:43-52.

Costelloe J.F., Reid J.R.W., Pritchard J.C., Puckridge J.T., Bailey V.E. and Hudson P.J. 2010. Are alien fish disadvantaged by extremely variable flow regimes in arid zone rivers? *Marine and Freshwater Research* **61**:857-863.

Cox J.B. and Pedler L.P. 1977. Birds recorded during three visits to the far north-east of South Australia. *South Australian Ornithologist* **27**:231-250.

Debus S.J.S. 1995. Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella* **19**:38-50.

Debus S.J.S. 2001. Surveys of the Barking Owl and Masked Owl on the North-west Slopes of New South Wales. *Corella* **25**:5-11.

Dennis T. 2012. Recent record of Plum-headed Finch on Cooper Creek in the north-east of South Australia. *S. Aust. Orn.* **38**:28-29.

Fischer J. and Lindenmayer D.B. 2002. Treating the nestedness temperature calculator as a ‘‘black box” can lead to false conclusions. *Oikos* **99**:193-199.

Fleishman E., McDonal N., Mac Nally R., Murphy D.D., Walters J. and Floyd T. 2003. Effects of floristics, physiognomy and non-native vegetation on riparian bird communities in a Mojave Desert watershed. *Journal of Animal Ecology* **72**:484-490.

Garnett S.T., Szabo J.K. and Dutson G. 2011. *The Action Plan for Australian Birds 2010.* CSIRO Publishing, Melbourne.

Gillen J.S. 2010. *An Ecological Study of the Landscape, Perennial Plants and Soils of the Cooper Creek Floodplain, South Australia.* PhD Thesis, Australian National University, Canberra.

Gillen J.S. and Reid J.R.W. 2010. *A Landscape Ecological Investigation of the Soils, Vegetation and Birds of the Cooper Creek Floodplain, South Australia.* The Fenner School of Environment and Society, Australian National University, Canberra.

Griffin G.F., Stafford Smith D.M., Morton S.R., Allan G.E. and Masters K.A. 1989. Status and implications of the invasion of Tamarisk (*Tamarix aphylla*) on the Finke River, Northern Territory, Australia. *Journal of Environmental Management* **29**:297-315.

Higgins P.J., Peter J.M. and Cowling S.J. (eds) 2006. *Handbook of Australian, New Zealand and Antarctic Birds. Volume 7. Boatbill to Starlings.* Oxford University Press, Melbourne.

Higgs A.J. and Usher M.B. 1980. Should nature reserves be large or small? *Nature* **285**:568-569.

Jaensch R.P. 2004. Yellow Chat *Epthianura crocea* in natural wetlands of the Georgina and Diamantina Channel Country. *Sunbird* **34**:58-65.

Johnson D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. *Ecology* **61**:65-71.

Joseph L. and Reid J. 1981. The Crested Shrike-tit on the Murray and Darling Rivers. *S. Aust. Orn.* **28**:157-159.

Junk W.J., Bayley P.B. and Sparks R.E. 1989. The flood pulse concept in river-floodplain systems. *Canadian Special Publication of Fisheries and Aquatic Sciences* **106**:110-127.

Kavanagh R.P., Debus S.J.S., Rose A.B. and Turner R.J. 1995. Diet and habitat of the Barking Owl *Ninox connivens* in New South Wales. *Australian Bird Watcher* **16**:137-144.

Keast A. 1968. Seasonal movements in the Australian honeyeaters (Meliphagidae) and their ecological significance. *Emu* **67**:159-209.

Kodric-Brown A. and Brown J.H. 1993. Highly structured fish communities in Australian desert springs. *Ecology* **74**:1847-1855.

Lee P. and Rotenberry J.T. 2005. Relationships between bird species and tree species assemblages in forested habitats of eastern North America. *Journal of Biogeography* **32**:1139-1150.

Mac Nally R.C. 1990. The roles of floristics and physiognomy in avian community composition. *Australian Journal of Ecology* **15**:321-327.

May I.A. 1986. Appendix V Birds. Pp. 123-137 *In* Dept Lands (compiler) *Rangeland Assessment Manual. Innamincka Station.* SA Dept Lands, Adelaide.

McMahon T.A., Murphy R.E., Peel M.C., Costelloe J.F. and Chiew F.H.S. 2008a. Understanding the surface hydrology of the Lake Eyre Basin: Part 1. Rainfall. *Journal of Arid Environments* **72**:1853-1868.

McMahon T.A., Murphy R.E., Peel M.C., Costelloe J.F. and Chiew F.H.S. 2008b. Understanding the surface hydrology of the Lake Eyre Basin: Part 2. Streamflow. *Journal of Arid Environments* **72**:1869-1886.

Morgan A.M. 1930. A trip to the Diamantina. *South Australian Ornithologist* **10**:263-274.

Morton S.R., Stafford Smith D.M., Dickman C.R., Dunkerley D.L., Friedel M.H., McAllister R.R.J., Reid J.R.W., Roshier D.A., Smith M.A., Walsh F.J., Wardle G.M., Watson I.W. and Westoby M. 2011. A fresh framework for the ecology of arid Australia. *Journal of Arid Environments* **75**:313-329.

Naiman R.J. and Decamps H. 1997. The ecology of interfaces: riparian zones. *Annual Review of Ecology and Systematics* **28**:621-658.

Naiman R.J., Decamps H. and Pollock M. 1993. The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications* **3**:209-212.

Neagle N. and Armstrong D. 2010. *A Biological Survey of the Marqualpie Land System, South Australia, 2008.* South Australian Department of Environment and Natural Resources, Adelaide.

Oksanen J. 2011. *Vegan: R Functions for Vegetation Ecologists.* Community Ecology Package. http://cc.oulu.fi/~jarioksa/softhelp/vegan.html

Palmer G.C. and Bennett A.F. 2006. Riparian zones provide for distinct bird assemblages in forest mosaics of south-eastern Australia. *Biological Conservation* **130**:447-457.

Parker S.A. 1980. Birds and conservation parks in the north-east of South Australia. *South Australian Parks and Conservation* **3**:11-18.

Patterson B.D. 1987. The principle of nested subsets and its implication for biological conservation. *Conservation Biology* **1**:323-334.

Patterson B.D. and Atmar W. 1986. Nested subsets and the structure of insular mammalian faunas and archipelagos. *Biological Journal of the Linnaean Society* **28**:65-82.

Patterson B.D. and Brown J.H. 1991. Regionally nested patterns of species composition in granivorous rodent assemblages. *Journal of Biogeography* **18**:395-402.

Pedler L.P. 1984. An Olive-backed Oriole in north-eastern South Australia. *South Australian Ornithologist* **29**:118.

Peres-Neto P.R. and Jackson D.A. 2001. How well do multivariate data sets match? The advantages of a Procrustean superimposition approach over the Mantel test. *Oecologia* **129**:169-178.

Price R., Thoms M., Capon S. and Watkins D. 2009. *LEBRA Implementation Plan.* Final report to LEB Ministerial Forum. Kiri-ganai Research Pty Ltd, Canberra.

Puckridge J.T., Costelloe J.F. and Reid J.R.W. 2010. Ecological responses to variable water regimes in arid zone wetlands: Coongie Lakes, Australia. *Marine and Freshwater Research* **61**:832-841.

Puckridge J.T., Sheldon F., Walker K.F. and Boulton A.J. 1998. Flow variability and the ecology of large rivers. *Marine and Freshwater Research* **49**:55-72.

Puckridge J.T., Walker K.F. and Costelloe J.F. 2000. Hydrological persistence and the ecology of dryland rivers. *Regulated Rivers: Research and Management* **16**:385-402.

Reid J.R.W. 1984 [Bird sections *In*] Mollenmans F.H., Reid J.R.W., Thompson M.B., Alexander L. and Pedler L.P. 1984. *Biological Survey of the Cooper Creek Environmental Association (8.4.4), North Eastern South Australia.* Consultancy report to NPWS, Dept of Environment and Planning, Adelaide.

Reid J. 1992. *Terrestrial Monitoring of Coongie after Flood. An Assessment of the Effects of Flooding on the Terrestrial Biota in the Coongie Lakes District.* Unpubl. final report to the Reserves Advisory Committee, SANPWS, Adelaide.

Reid J.R.W. 1999. *Monitoring Bird Populations of the Coongie Lakes, Innamincka Regional Reserve.* Final Report to Department of Environment, Heritage and Aboriginal Affairs, South Australia, Adelaide, 224 pp.

Reid J.R.W. 2000. Birds of Cooper Creek and the Far North East in South Australia. Pp. 209-227 *In* Collier R., Hatch J., Matheson B. and Russell T. (eds), *Birds, Birders and Birding in South Australia.* South Australian Ornithological Association, Adelaide.

Reid J.R.W., Badman F.J. and Parker S.A. 1990. Birds. Ch. 14, pp., 169-182 *In* Tyler M.J., Twidale C.R., Davies M. and Wells C.B. (eds), *The Natural History of the North East Deserts.* The Royal Society of South Australia, Adelaide.

Reid J. and Fleming M. 1992. The conservation status of birds in arid Australia. *Rangelands Journal* **14**:65-91.

Reid J. and Gillen J. (eds) 1988. *The Coongie Lakes Study.* Department of Environment and Planning, Adelaide.

Reid J.R.W., Kerle J.A. and Morton S.R. (eds) 1993. Uluṟu fauna. The distribution and abundance of vertebrate fauna of Uluṟu (Ayers Rock-Mount Olga) National Park, N.T. *Kowari* **4**. Australian National Parks and Wildlife Service, Canberra.

Reid J.R.W. and Puckridge J.T. 1990. The Coongie Lakes. Ch. 10, pp. 119-131 *In* Tyler M.J., Twidale C.R., Davies M. and Wells C.B. (eds), *The Natural History of the North East Deserts*. The Royal Society of South Australia, Adelaide.

Reynolds I.S., Walter I.C. and Woodall P.F. 1982. Observations on Yellow Chats (*Epthianura crocea*) in western Queensland. *Sunbird* **12**:21-29.

Roberts J. 1993. Regeneration and growth of coolibah, *Eucalyptus coolabah* subsp. *arida*, a riparian tree, in the Cooper Creek region of South Australia. *Austral Ecology* **18**:345-350.

Rodríguez-Gironés M.A. and Santamaría L. 2006. A new algorithm to calculate the nestedness temperature of presence-absence matrices. *Journal of Biogeography* **33**:924-935.

Rotenberry J.T. 1985. The role of habitat in avian community composition: physiognomy or floristics? *Oecologia* **67**:213-217.

Saab V. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: a hierarchical analysis. *Ecological Applications* **9**:135-151.

Schodde R. 1982. Origin, adaptation and evolution of birds in arid Australia. Ch. 22, pp. 191-224 *In* Barker W.R. and Greenslade P.J.M. (eds), *Evolution of the Flora and Fauna of Arid Australia*. Peacock, Adelaide.

Schodde R. and Christidis L. 1987. Genetic differentiation and subspeciation in the Grey Grasswren *Amytornis barbatus* (Maluridae). *Emu* **87**:188-192.

Schodde R. and Mason I.J. 1999. *The Directory of Australian Birds: Passerines.* CSIRO Publishing, Melbourne.

Sheldon F., McKenzie-Smith F., Brunner P., Hoggett A., Shephard J., Bunn S., McTainsh G., Bailey V. and Phelps D. 2005. *Lake Eyre Basin Rivers Assessment Methods Development Project Methods for Assessing the Health of Lake Eyre Basin Rivers.* Final report to Land & Water Australia. LWA, Canberra.

Shurcliff K.S. 1980. Vegetation and bird community characteristics in an Australian arid mountain range. *Journal of Arid Environments* **3**:331-348.

Silcock J. 2009. *Identification of Permanent Refuge Waterbodies in the Cooper Creek & Georgina-Diamantina River Catchments for Queensland and South Australia.* Final Report to South Australian Arid Lands Natural Resource Management Board. Queensland Herbarium, Department of Environment and Resource Management, Longreach.

Southwood T.R.E. 1977. Habitat, the templet for ecological strategies? *Journal of Animal Ecology* **46**:337-365.

Southwood T.R.E. 1988. Tactics, strategies and templets. *Oikos* **52**:3-18.

Stafford Smith D.M. and Morton S.R. 1990. A framework for the ecology of arid Australia. *Journal of Arid Environments* **18**:255-278.

Strong B.W. and Fleming M.R. 1987. Recent observations of the distribution and habitat of the Yellow Chat *Epthianura crocea* in the Northern Territory. *South Australian Ornithologist* **30**:98-102.

Sturt C. 1849. *Narrative of an Expedition into Central Australia.* 2 vols. T. & W. Boone, London (facsimile ed., 1965).

Ulrich W. 2008a. *Nestedness – a FORTRAN Program for Measuring Order and Disorder in Ecological Communities. Version 2.0.* Nicolaus Copernicus University, Torun, Poland.

Ulrich W. 2008b. *Pairs – a FORTRAN Program for Studying Pair Wise Species Associations in Ecological Matrices. Version 1.0.* Nicolaus Copernicus University, Torun, Poland.

Ulrich W. 2012. *NODF – a FORTRAN Program for Nestedness Analysis. Version 2.0.* Nicolaus Copernicus University, Torun, Poland.

Ulrich W. and Gotelli N.J. 2007. Null model analysis of species nestedness patterns. *Ecology* **88**:1824-1831.

White S.A. 1917. Aves. *In* Results of the South Australian museum expedition to Strzelecki and Cooper Creeks, September and October, 1916. *Transactions of the Royal Society of South Australia* **41**:405-658.

Woinarski J.C.Z., Brock C., Armstrong M., Hempel C., Cheal D. and Brennan K. 2000. Bird distribution in riparian vegetation in the extensive natural landscape of Australia's tropical savanna: a broad-scale survey and analysis of a distributional data base. *Journal of Biogeography* **27**:843-868.

Wyndham E. 1978. Birds of the Milparinka district and Cooper Creek basin. *Emu* **78**:179-187

6. APPENDICES

.6.1 Appendix 1. List of 69 landbird species and scientific names

Code	English Name	Scientific Name
B009	Stubble Quail	*Coturnix pectoralis* **N**
B034	Common Bronzewing	*Phaps chalcoptera*
B043	Crested Pigeon	*Ocyphaps lophotes*
B031	Diamond Dove	*Geopelia cuneata* **N**
B030	Peaceful Dove	*Geopelia striata*
B331	Spotted Nightjar	*Eurostopodus argus* ?**N**
B317	Australian Owlet-nightjar	*Aegotheles cristatus*
B228	Whistling Kite	*Haliastur sphenurus*
B229	Black Kite	*Milvus migrans*
B222	Collared Sparrowhawk	*Accipiter cirrocephalus*
B218	Spotted Harrier	*Circus assimilis*
B225	Little Eagle	*Hieraaetus morphnoides*
B240	Nankeen Kestrel	*Falco cenchroides*
B018	Little Button-quail	*Turnix velox* **N**
B273	Galah	*Eolophus roseicapillus*
B271	Little Corella	*Cacatua sanguinea*
B274	Cockatiel	*Nymphicus hollandicus* **N**
B294	Australian Ringneck	*Barnardius zonarius*
B297	Blue Bonnet	*Northiella haematogaster*
B295	Red-rumped Parrot	*Psephotus haematonotus*
B310	Budgerigar	*Melopsittacus undulates* **N**
B304	Bourke's Parrot	*Neopsephotus bourkii*
B342	Horsfield's Bronze-Cuckoo	*Chalcites basalis* **N**
B341	Black-eared Cuckoo	*Chalcites osculans*
B337	Pallid Cuckoo	*Cacomantis pallidus* **N**
B249	Eastern Barn Owl	*Tyto javanica*
B325	Red-backed Kingfisher	*Todiramphus pyrrhopygius* **N**
B326	Sacred Kingfisher	*Todiramphus sanctus* **S**
B555	Brown Treecreeper	*Climacteris picumnus*
B535	White-winged Fairy-wren	*Malurus leucopterus*
B536	Variegated Fairy-wren	*Malurus lamberti*
B515	Eyrean Grasswren	*Amytornis goyderi*
B481	Chestnut-rumped Thornbill	*Acanthiza uropygialis*
B466	Southern Whiteface	*Aphelocephala leucopsis*
Code	**English Name**	**Scientific Name**
B570	Red-browed Pardalote	*Pardalotus rubricatus*
B602	Pied Honeyeater	*Certhionyx variegates* **N**
B608	Singing Honeyeater	*Lichenostomus virescens*
B625	White-plumed Honeyeater	*Lichenostomus penicillatus*

B635	Yellow-throated Miner	*Manorina flavigula*
B640	Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
B449	Crimson Chat	*Epthianura tricolor* **N**
B450	Orange Chat	*Epthianura aurifrons* **N**
B446	Chestnut-crowned Babbler	*Pomatostomus ruficeps*
B866	Chirruping Wedgebill	*Psophodes cristatus*
B424	Black-faced Cuckoo-shrike	*Coracina novaehollandiae* **N**
B430	White-winged Triller	*Lalage sueurii* **N**
B401	Rufous Whistler	*Pachycephala rufiventris* **W**
B408	Grey Shrike-thrush	*Colluricincla harmonica*
B543	White-breasted Woodswallow	*Artamus leucorynchus*
B544	Masked Woodswallow	*Artamus personatus* **N**
B546	Black-faced Woodswallow	*Artamus cinereus*
B705	Australian Magpie	*Cracticus tibicen*
B361	Grey Fantail	*Rhipidura albiscapa*
B364	Willie Wagtail	*Rhipidura leucophrys*
B930	Australian Raven	*Corvus coronoides*
B691	Little Crow	*Corvus bennetti* **N**
B369	Restless Flycatcher	*Myiagra inquieta*
B415	Magpie-lark	*Grallina cyanoleuca*
B377	Jacky Winter	*Microeca fascinans*
B381	Red-capped Robin	*Petroica goodenovii* **W**
B522	Little Grassbird	*Megalurus gramineus* **N**
B509	Rufous Songlark	*Cincloramphus mathewsi* **N**
B508	Brown Songlark	*Cincloramphus cruralis* **N**
B358	White-backed Swallow	*Cheramoeca leucosterna*
B360	Fairy Martin	*Petrochelidon ariel*
B359	Tree Martin	*Petrochelidon nigricans*
B564	Mistletoebird	*Dicaeum hirundinaceum* **W**
B653	Zebra Finch	*Taeniopygia guttata*
B995	House Sparrow	*Passer domesticus*

N: nomadic; **W**: non-breeding winter visitor (mainly); **S**: summer breeding visitor.

6.2 Appendix 2a. Density estimates of 51 landbird species from transect counts at 14 riparian sites.

English and scientific names of the species identified here by Code can be found in Appendix1.

Code	CULLr	MINKr	SCRCr	TIRRr	KUDRr	EMBAr	APDAr	NWBRr	NARIr	PARAr	APPAr	HOPEr	KILLr	MUCKr
B034	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
B043	0.4	0.4	0.8	1.6	0.8	0.6	1.0	0.8	1.8	1.6	1.0	1.0	1.0	0.6
B031	0.2	0.4	2.6	0.2	0.4	2.0	0.0	0.2	1.0	0.8	0.2	0.4	1.2	3.6
B030	0.8	1.8	2.8	1.0	1.2	0.4	0.4	0.4	1.8	1.0	0.0	0.0	0.0	0.0
B273	1.2	1.2	1.2	4.0	2.8	5.2	1.4	0.6	5.2	6.0	0.4	0.0	0.4	0.8
B271	3.2	5.0	2.4	1.6	0.1	0.8	1.0	0.1	1.6	1.6	0.0	0.8	0.0	0.8
B294	0.2	0.4	0.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B297	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.8	0.0	0.4
B295	5.4	1.2	5.6	3.2	2.8	1.0	0.0	3.2	0.4	0.8	0.0	0.0	0.0	0.0
B310	4.8	0.2	0.8	2.4	0.8	4.2	0.4	0.8	0.0	1.8	4.2	1.0	0.4	2.4
B342	0.0	0.0	0.0	0.2	0.2	0.1	1.0	0.1	0.0	0.0	0.6	0.0	0.4	0.2
B341	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
B337	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
B325	0.0	0.0	0.2	0.4	0.1	0.0	0.1	0.0	0.1	0.4	0.1	0.0	0.0	0.1
B326	0.2	0.2	0.0	0.4	0.2	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
B555	0.4	0.2	0.1	1.0	0.0	0.4	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0
B535	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.4	0.0	0.0
B536	0.6	0.0	0.0	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.8	0.8
B466	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0
B570	0.1	0.0	0.0	0.2	0.4	0.0	0.0	0.1	0.1	0.0	0.2	0.0	0.0	0.2
B602	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
B608	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.0	2.4	1.0
B625	5.4	4.6	7.8	8.8	6.0	7.0	6.0	9.4	7.6	6.0	0.6	0.0	0.0	1.6
B635	0.0	0.6	0.0	0.4	0.4	0.4	1.0	0.4	0.6	1.0	0.4	0.4	0.4	0.4
B640	0.0	0.4	1.4	1.2	1.4	0.1	1.0	0.8	2.0	1.6	0.1	0.0	0.8	0.2
B449	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.4	0.0
B450	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
B446	0.0	0.0	0.0	1.8	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
B866	0.0	0.0	0.1	1.4	0.1	0.2	0.0	0.0	0.1	0.0	0.0	0.6	0.1	0.0

B424	0.2	0.4	0.8	0.2	0.2	0.4	0.2	0.4	0.2	0.8	0.0	0.0	0.2	0.0
B430	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0
B401	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
B408	1.4	1.2	1.8	1.4	0.4	0.6	0.6	0.8	1.2	0.6	0.0	0.0	0.0	0.0
B543	0.4	0.1	0.4	0.4	0.2	0.6	0.4	0.6	0.4	0.4	0.0	0.0	2.6	0.4
B544	0.0	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B546	0.0	0.0	0.0	0.8	0.0	0.8	0.2	0.4	0.0	0.4	2.0	0.0	0.0	0.6
B705	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.4	0.6
B361	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
B364	0.4	2.0	1.0	1.2	2.2	0.6	1.2	1.4	2.4	1.8	1.6	1.0	2.6	2.0
Code	**CULLr**	**MINKr**	**SCRCr**	**TIRRr**	**KUDRr**	**EMBAr**	**APDAr**	**NWBRr**	**NARIr**	**PARAr**	**APPAr**	**HOPEr**	**KILLr**	**MUCKr**
B930	0.4	0.8	0.6	0.4	1.0	0.1	0.2	0.4	0.6	0.2	0.4	0.1	0.4	0.8
B691	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.1	0.2	0.4	0.0	0.1	0.1
B369	0.0	0.0	0.0	0.0	0.2	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B415	1.2	1.0	1.0	2.0	1.2	0.4	0.6	0.6	0.4	1.6	1.2	0.0	0.2	0.2
B377	0.0	0.0	0.0	0.2	0.4	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B381	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0
B509	0.0	0.0	0.0	0.2	0.0	0.0	0.6	0.0	0.2	0.0	0.0	0.0	0.0	0.0
B358	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.0	0.0
B360	0.0	0.0	0.0	0.8	2.0	5.0	0.4	2.0	1.2	1.2	0.0	0.0	0.4	0.0
B359	5.0	5.0	5.0	5.6	1.6	5.0	0.4	5.0	0.8	3.6	0.8	0.0	0.8	2.4
B564	0.4	0.2	1.0	0.4	0.4	0.4	0.4	0.0	0.4	0.8	0.1	0.0	0.2	0.4
B653	0.2	0.0	0.4	1.2	3.6	0.6	2.6	0.8	0.0	0.4	1.6	5.8	1.6	1.2
Abun	**32.5**	**27.3**	**40.4**	**45.7**	**34.3**	**37.7**	**22.0**	**29.5**	**30.9**	**35.2**	**20.9**	**16.1**	**20.0**	**22.0**
Rich	**22**	**21**	**24**	**33**	**33**	**26**	**26**	**23**	**27**	**25**	**26**	**15**	**26**	**25**

6.3 Appendix 2b. Density estimates of 46 landbird species from transect counts at 13 off-river sites.

English and scientific names of the species identified here by Code can be found in Appendix1.

Code	CULLo	MINKo	SCRCo	TIRRo	KUDRo	EMBAo	APDAo	NWBRo	NARIo	PARAo	APPAo	HOPEo	KILLo
B043	0.0	0.8	1.2	0.4	0.0	0.2	0.0	0.6	0.0	0.4	0.2	0.0	0.0
B031	0.4	0.2	1.2	0.0	0.0	0.4	0.0	1.0	0.0	0.4	0.0	0.8	1.6
B273	0.1	0.6	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4
B274	0.0	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B297	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.1	0.4	0.0
B295	0.1	0.0	0.4	0.8	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B310	0.0	0.0	0.6	4.0	0.2	1.2	2.4	0.8	0.0	0.2	1.0	0.0	0.8
B304	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B342	0.0	0.2	0.2	0.0	0.0	0.4	0.2	0.6	0.2	0.2	0.0	0.0	0.2
B325	0.1	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.1
B555	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B535	0.6	1.4	1.4	3.2	1.2	2.0	1.6	3.4	1.4	2.8	0.8	0.8	2.2
B536	0.0	0.0	0.0	0.0	0.0	0.6	1.0	0.8	0.0	0.6	0.0	0.8	2.0
B515	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.4
B481	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
B466	0.0	0.6	0.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
B570	0.4	0.1	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
B602	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
B608	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.0	2.8	2.4
B625	1.8	3.8	2.2	2.0	0.0	1.2	2.2	2.4	0.6	1.0	0.0	0.0	0.0
B635	0.4	0.2	2.0	0.1	0.0	0.6	0.0	0.4	0.0	0.1	0.6	0.0	0.0
Code	CULLo	MINKo	SCRCo	TIRRo	KUDRo	EMBAo	APDAo	NWBRo	NARIo	PARAo	APPAo	HOPEo	KILLo
B640	0.0	0.0	0.8	1.0	0.0	0.0	0.0	0.4	0.0	0.0	0.2	0.1	1.0
B450	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0

B446	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	1.2
B866	0.0	0.1	0.0	0.0	0.0	0.6	0.0	0.1	0.0	0.2	0.2	1.0	0.2
B424	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0
B430	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.8	0.2	0.0	0.0	0.0	0.0
B401	0.0	0.0	0.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
B408	0.1	0.2	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B543	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.4
B544	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
B546	0.1	2.0	2.6	2.4	0.2	0.0	0.1	0.8	1.2	1.8	0.0	0.0	0.8
B705	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0
B364	0.4	0.6	0.2	0.6	0.1	0.8	0.0	2.4	1.0	0.8	0.2	0.6	1.2
B930	0.0	0.0	0.4	0.1	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B691	0.0	0.0	0.0	0.8	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.4	0.4
B415	0.4	0.1	0.6	0.0	0.0	1.2	0.0	0.4	0.0	0.1	0.0	0.0	0.0
B377	0.4	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B381	0.0	0.0	0.1	0.6	0.2	0.2	0.0	0.0	0.4	0.0	0.0	0.0	0.2
B509	0.2	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B508	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
B358	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.2	0.4	0.4	0.0
B360	0.0	0.0	0.1	0.0	0.0	0.0	0.0	1.8	0.0	0.2	0.0	0.0	0.4
B359	2.4	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
B564	0.2	0.2	0.2	0.1	0.0	0.0	0.1	0.4	0.2	0.4	0.0	0.2	0.4
B653	0.6	1.4	4.0	3.2	2.2	1.2	4.2	3.4	2.2	3.0	0.4	0.4	0.8
Abun	**8.8**	**14.1**	**23.5**	**21.9**	**4.2**	**12.0**	**12.4**	**25.7**	**9.8**	**12.8**	**5.5**	**11.1**	**18.7**
Rich	**18**	**20**	**32**	**23**	**7**	**17**	**11**	**21**	**15**	**19**	**12**	**14**	**22**

6.4 Appendix 3a. Observations of all species including waterbirds recorded at the 13 main waterbodies surveyed for birds in the survey area.

English and scientific names of 13 species seen elsewhere in the study region are presented in Appendix3b. Numbers greater than one are counts from transects.

English Name	CULL	MINK	SCRC	TIRR	KUDR	EMBA	APDA	NWBR	NARI	PARA	APPA	HOPE	KILL
Stubble Quail	0	0	0	0	0	1	0	0	6	0	0	0	0
Brown Quail	1	0	1	0	0	0	0	0	1	0	0	0	0
Plumed Whistling-Duck	0	0	0	0	1	0	0	1	0	0	0	0	0
Musk Duck	0	0	0	0	0	0	0	2	0	0	0	0	0
Black Swan	0	0	0	0	4	0	0	1	0	0	1	1	1
Australian Shelduck	0	0	0	0	0	0	0	0	0	0	4	0	0
Australian Wood Duck	1	4	1	1	1	1	2	1	3	1	200	0	40
Pink-eared Duck	0	0	0	0	0	1	1	0	1	0	0	0	1
Grey Teal	0	0	0	0	304	4	1	4	0	6	100	0	4
Pacific Black Duck	1	0	4	2	6	12	0	14	2	0	4	0	0
Hardhead	0	0	0	10	0	6	0	20	0	0	0	0	0
Australasian Grebe	0	0	0	0	0	1	0	0	0	0	0	0	1
Common Bronzewing	0	0	3	1	0	0	0	0	2	0	0	0	0
Flock Bronzewing	0	0	0	0	0	1	0	0	0	0	0	2	0
Crested Pigeon	2	6	12	12	4	4	8	7	11	12	10	9	8
Diamond Dove	4	3	23	2	2	14	1	6	7	6	5	7	32
Peaceful Dove	6	9	15	5	7	3	2	4	10	7	0	0	0
Tawny Frogmouth	0	0	1	1	0	0	0	0	0	0	0	0	0
Spotted Nightjar	0	0	0	1	0	0	1	0	0	0	0	0	0
Australian Owlet-nightjar	1	1	1	1	1	2	1	1	1	1	1	0	0
Australasian Darter	3	2	2	4	5	6	0	8	0	4	0	0	12
Little Pied Cormorant	0	0	0	0	0	0	0	0	0	0	0	15	0

Great Cormorant	24	0	5	1	6	1	2	12	4	4	0	0	1
Little Black Cormorant	4	0	0	1	2	2	0	2	0	60	0	1	150
Pied Cormorant	8	88	1	1	4	4	2	10	20	4	2	1	22
Australian Pelican	0	0	1	1	0	0	1	16	0	0	1	1	1
White-necked Heron	3	1	0	1	2	1	1	1	0	0	0	0	0
Eastern Great Egret	0	0	0	0	0	0	0	2	0	0	0	0	1
White-faced Heron	1	1	0	0	5	0	0	1	0	2	1	0	2
Nankeen Night-Heron	1	0	0	0	0	1	0	1	1	1	0	0	0
Australian White Ibis	0	0	0	0	1	0	0	1	0	0	0	0	0
Straw-necked Ibis	0	0	0	0	0	0	0	1	0	0	0	0	1
Royal Spoonbill	0	0	0	0	0	0	0	1	0	0	0	0	0
Yellow-billed Spoonbill	0	0	0	3	0	0	1	1	0	0	8	0	0

English Name	**CULL**	**MINK**	**SCRC**	**TIRR**	**KUDR**	**EMBA**	**APDA**	**NWBR**	**NARI**	**PARA**	**APPA**	**HOPE**	**KILL**
Black-shouldered Kite	0	0	0	0	0	0	1	0	0	0	1	2	1
Black-breasted Buzzard	0	0	0	0	0	0	1	0	0	0	0	0	0
White-bellied Sea-Eagle	0	0	0	0	0	0	0	1	0	0	0	0	0
Whistling Kite	5	4	3	11	4	5	5	4	2	2	2	1	6
Black Kite	1	189	3	29	14	1	8	7	5	5	7	1	8
Brown Goshawk	0	1	0	0	0	0	0	0	0	0	0	0	0
Collared Sparrowhawk	1	0	1	0	0	0	0	0	0	0	0	0	0
Spotted Harrier	0	0	0	0	0	1	1	0	0	0	0	0	0
Swamp Harrier	0	0	0	0	0	1	0	1	0	0	0	0	0
Wedge-tailed Eagle	0	0	0	0	0	0	0	1	0	0	0	0	0
Little Eagle	1	0	0	1	1	0	1	0	1	0	0	0	0
Nankeen Kestrel	1	1	1	1	1	0	2	1	0	0	1	0	0
Brown Falcon	1	0	1	1	1	1	1	1	1	0	1	1	0
Australian Hobby	1	0	0	0	0	1	0	0	0	0	0	0	0
Grey Falcon	0	0	0	0	0	0	0	0	0	0	0	1	0
Black Falcon	0	0	0	0	0	0	0	1	0	0	0	0	0
Brolga	0	0	0	0	0	0	0	0	0	0	4	0	1
Purple Swamphen	0	0	0	0	0	0	0	1	0	0	0	0	0

Australian Spotted Crake	0	0	0	0	0	6	0	4	0	0	0	0	0
Black-tailed Native-hen	0	0	0	0	0	11	0	1	0	0	0	0	1
Dusky Moorhen	0	0	0	0	0	0	0	6	0	0	0	0	0
Eurasian Coot	1	0	0	1	0	0	0	1	0	0	1	1	5
Black-fronted Dotterel	1	0	1	0	0	1	1	1	0	0	8	0	2
Red-kneed Dotterel	0	0	0	2	0	0	0	1	0	0	0	0	0
Banded Lapwing	0	0	0	0	0	1	0	1	0	7	0	1	0
Masked Lapwing	0	0	0	0	0	0	0	1	0	1	6	0	2
Little Button-quail	0	0	0	0	1	1	1	1	2	2	1	1	0
Gull-billed Tern	0	0	0	0	0	0	0	0	0	0	0	0	1
Caspian Tern	0	0	0	2	0	1	1	3	0	3	20	0	1
Whiskered Tern	0	0	0	0	0	0	0	1	0	0	0	0	0
Silver Gull	0	0	0	0	0	0	0	0	0	0	0	0	4
Galah	16	11	9	28	21	31	13	13	28	34	2	1	13
Little Corella	418	68	26	10	8	4	7	2	21	10	2	4	9
Cockatiel	1	5	3	0	2	0	1	0	2	0	0	0	0
Australian Ringneck	1	3	3	0	2	0	0	0	0	0	0	0	0
Blue Bonnet	1	0	2	0	0	0	4	0	2	1	6	10	4
Red-rumped Parrot	47	10	30	24	18	7	0	20	4	4	0	0	0
Budgerigar	24	21	19	32	52	69	59	8	10	24	36	13	60

English Name	**CULL**	**MINK**	**SCRC**	**TIRR**	**KUDR**	**EMBA**	**APDA**	**NWBR**	**NARI**	**PARA**	**APPA**	**HOPE**	**KILL**
Bourke's Parrot	1	0	0	2	0	0	0	0	0	0	0	0	0
Blue-winged Parrot	0	0	0	0	0	10	0	0	0	0	0	2	3
Horsfield's Bronze-Cuckoo	0	3	2	1	1	4	7	4	2	1	3	0	4
Black-eared Cuckoo	0	0	0	0	1	0	0	1	0	0	0	0	0
Pallid Cuckoo	1	0	0	0	0	0	0	0	1	1	1	0	1
Barking Owl	1	0	1	1	1	0	0	1	1	0	0	0	0
Eastern Barn Owl	1	0	1	1	1	0	0	1	1	1	1	0	1
Red-backed Kingfisher	2	1	3	4	1	2	1	1	1	3	1	0	2
Sacred Kingfisher	1	1	0	2	1	1	0	0	1	0	0	0	0
Brown Treecreeper	3	4	2	5	1	2	2	0	2	0	0	0	0

English Name	CULL	MINK	SCRC	TIRR	KUDR	EMBA	APDA	NWBR	NARI	PARA	APPA	HOPE	KILL
White-winged Fairy-wren	3	7	7	16	14	12	10	17	9	16	6	15	11
Variegated Fairy-wren	3	4	1	4	4	3	5	4	0	3	1	10	23
Eyrean Grasswren	0	0	0	0	0	0	0	0	0	0	2	0	2
Chestnut-rumped Thornbill	0	0	2	2	0	0	0	0	2	0	0	0	0
Southern Whiteface	0	3	2	0	0	0	0	1	2	0	0	0	3
Red-browed Pardalote	3	4	4	4	3	1	1	1	1	1	1	0	2
Pied Honeyeater	0	0	0	0	0	0	0	0	0	0	16	0	8
Singing Honeyeater	0	2	1	0	1	1	0	0	0	0	12	20	32
White-plumed Honeyeater	38	44	52	58	36	44	47	63	48	35	3	0	8
Yellow-throated Miner	3	6	14	5	4	5	6	6	3	9	9	2	8
Spiny-cheeked Honeyeater	0	2	11	15	7	1	6	9	14	8	4	1	10
Crimson Chat	1	0	0	0	0	0	0	0	0	0	6	2	2
Orange Chat	0	0	0	0	0	1	0	0	4	0	2	0	0
Chestnut-crowned Babbler	0	0	2	9	5	2	1	1	3	1	0	11	6
Cinnamon Quail-thrush	1	0	0	0	0	0	0	0	0	0	0	0	0
Chirruping Wedgebill	0	4	1	7	1	12	1	3	4	3	2	12	3
Black-faced Cuckoo-shrike	2	4	6	1	2	2	1	4	1	4	0	0	1
White-winged Triller	0	0	1	4	0	1	2	4	2	0	2	0	0
Rufous Whistler	0	0	4	1	2	1	0	0	0	0	0	0	3
Grey Shrike-thrush	9	8	13	11	3	6	6	5	9	4	0	0	0
White-breasted Woodswallow	2	2	2	2	3	3	2	21	2	2	0	0	17
Masked Woodswallow	0	2	19	0	1	0	3	0	2	0	0	0	10
White-browed Woodswallow	0	1	0	0	0	0	0	0	0	0	0	0	0
Black-faced Woodswallow	1	12	23	19	5	4	3	6	6	11	10	0	7
Australian Magpie	1	3	5	1	3	3	2	1	2	6	1	2	7
Grey Fantail	0	0	0	0	1	1	0	0	0	0	0	0	1
Willie Wagtail	4	13	7	10	15	9	7	20	21	13	9	9	29
Australian Raven	2	7	5	4	5	8	5	2	3	1	2	1	7
Little Crow	1	1	1	4	9	6	3	1	2	3	3	2	5
Restless Flycatcher	1	0	0	0	1	0	4	0	0	0	0	0	0

Magpie-lark	8	8	11	10	10	13	5	8	3	14	6	0	9
Jacky Winter	4	1	3	2	2	2	2	0	0	0	0	0	0
Red-capped Robin	0	0	1	3	1	1	0	0	3	0	0	1	2
Australian Reed-Warbler	0	0	0	0	0	0	0	1	0	0	0	0	0
Little Grassbird	0	0	0	0	0	6	0	8	0	0	0	0	0
Rufous Songlark	1	2	4	1	0	0	6	0	1	1	0	0	0
Brown Songlark	0	0	0	0	0	0	0	0	1	0	1	0	0
White-backed Swallow	0	0	0	2	1	0	1	1	0	2	4	4	1
Fairy Martin	0	0	2	4	10	25	2	19	6	7	0	0	4
Tree Martin	53	35	57	28	18	36	2	30	4	18	6	1	16
Mistletoebird	3	3	6	3	2	2	3	2	3	6	1	1	5
Zebra Finch	14	14	24	28	43	9	38	50	17	17	10	31	18
House Sparrow	0	0	0	0	0	0	0	4	0	0	0	0	0
Australasian Pipit	1	0	0	0	0	0	0	1	0	0	1	0	0

6.5 Appendix 3b. Bird species seen away from sites in study area

Code	English Name	Scientific Name
B001	Emu	*Dromaius novaehollandiae*
B062	Hoary-headed Grebe	*Poliocephalus poliocephalus*
B233	Letter-winged Kite	*Elanus scriptus*
B176	Australian Bustard	*Ardeotis australis*
B146	Black-winged Stilt	*Himantopus himantopus*
B148	Red-necked Avocet	*Recurvirostra novaehollandiae*
B152	Black-tailed Godwit	*Limosa limosa*
B158	Common Greenshank	*Tringa nebularia*
B109	White-winged Black Tern	*Chlidonias leucopterus*
B451	Yellow Chat	*Epthianura crocea*
B452	Gibberbird	*Ashbyia lovensis*
B423	Ground Cuckoo-shrike	*Coracina maxima*
B648	Horsfield's Bushlark	*Mirafra javanica*
B357	Welcome Swallow	*Hirundo neoxena*