

The birds of Kurrawang Nature Reserve – observations of avifaunal change in the eastern goldfields of Western Australia

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SUMMARY

Examination of the avifauna at a locality in the eastern goldfields of Western Australia indicates that there have been both additions and deletions of species between 1904 and 1996. It is hypothesized that the primary agent of change is the widespread provision of water points by the pastoral industry, thus favouring a small suite of relatively powerfully flying, abundant, gregarious and sometimes aggressive honeyeaters which both drink water and eat insects. Their abundance either puts pressure on the invertebrate food source or there is an interspecific competitive interaction which disadvantages smaller resident insectivores. The effect of timber removal on the structure of semi-arid woodlands appears to be a secondary factor. The possible scarcity of invertebrate food would be exacerbated by the shortage of standing and fallen timber in semi-arid woodlands that have been cut over. Data on the relative abundance of presently occurring bird species tend to support this hypothesis.

INTRODUCTION

The decline of medium-sized mammals in the Australian arid zone is well documented and although the likely factors have been identified, there is still debate whether introduced predators or habitat change are the primary causes of change. Recher and Lim (1990) suggested that the decline of mammals is the 'first wave' of faunal attrition in Australia and that birds and reptiles will follow: in particular, they predicted major losses of bird species would first occur in agricultural and pastoral regions of southern Australia. Recher (1999) elaborated this view and drew attention to the widespread decline of woodland and ground-foraging and ground-nesting birds. Robinson (1993) listed species that are declining at least somewhere in southern Australia but are not listed as threatened.

Recent studies on the impact of European settlement on the avifauna of the arid zone vary in their conclusions depending on their geographical location. In the western division of New South Wales, which has been under pastoral management since the 1830s, Smith *et al.* (1994) considered 60 taxa threatened and in decline. A study of an area in arid Western Australia that is also under pastoral management, although not for as long as the area in the NSW study, indicates a lesser rate of decline that has stabilized (Saunders and Curry 1990). In their review, Reid and Fleming (1992) reported that one half of the arid zone avifauna has changed since European settlement and that there are continuing threats to avian biodiversity in the arid zone. Recher (1999) indicated that if the presence of increaser species is also indicative of ecological instability, then changes to avifauna are considerably underestimated by these regional studies.

The purpose of this paper is to examine changes to the avifauna in a small area of the eastern Goldfields of Western Australia over a period of 92 years, identify the likely causes of change and see whether a pattern consistent with other studies can be discerned. In addition, the results of 63 Australian Bird Counts conducted between 1990–95 at the same site are reported.

STUDY AREA

This study was undertaken in Kurrawang Nature Reserve, located between 13 and 17 km south-west of Kalgoorlie-Boulder in the eastern goldfields of Western Australia. Although the reserve is relatively small (621 ha) it is largely surrounded by vegetation that is in a more or less natural state. The reserve takes its name from the former Kurrawang town site, which was immediately to the north of it, although some town site clearing extended into what is now the reserve.

Kurrawang town was the centre for timber operations, known locally as 'woodlines', which provided timber for fuel and structural purposes for the mining industry between 1905 and 1938. Accordingly, most of the large timber on the reserve and surrounds was felled and, owing to the proximity to Kalgoorlie, it is likely that felling commenced as early as 1899 (Tom Newbey¹, personal

¹ Tom Newbey, former woodline locomotive driver.

communication). It is not recorded when felling ceased, but it is likely to have been *c.* 1910. Climatically the reserve is located between the arid and semi-arid zones. The annual average rainfall at Kalgoorlie is 256 mm and, although it is considered a winter rainfall area, on average approximately equal amounts of rain are recorded in all months.

Kurrawang is also of interest as the site at which retired army officer G.C. Shortridge collected birds for the British Museum between 2 September and 4 October 1904. Shortridge collected 52 species of bird at Kurrawang in 1904 (Ogilvie-Grant 1909). More recent work on the nature reserve includes a biological survey in 1988 (Chapman *et al.* 1991) and 63 Royal Australasian Ornithologists Union (RAOU - now Birds Australia) Australian Bird (AB) Counts by AC. In spite of limitations, which are discussed below, these studies provide an opportunity to assess changes to the avifauna over the period 1904–1996.

In broad terms, the reserve occupies a ridge on a watershed between two salt lake systems. Much of the vegetation is eucalypt woodland: its structure and species composition is determined by landform and surface geology.

Salmon gum (*Eucalyptus salmonophloia*) woodland on a Quaternary alluvial broad valley occupies the western third of the reserve and mixed eucalypt woodlands, with *E. lesouefii*, *E. griffithsii*, *E. clelandii*, *E. grassbyi*, *E. transcontinentalis*, and *E. oleosa*, occupy undulating plain of Archaen age over most of the remainder. A small but distinctive lateritic ridge with *E. griffithsii* woodland and *Acacia acuminata* shrubland is between the two main woodland types. Sites used for AB counts were as follows:

Site 1. *Eucalyptus salmonophloia* woodland at 121° 20'00"E, 30° 49'45"S

Site 2. *Eucalyptus transcontinentalis* / *E. salubris* woodland at 121° 21'15"E, 30° 49'30"S

Site 3. *Eucalyptus griffithsii* woodland at 121° 22'00"E, 30° 49'00"S.

METHODS

The bird data for 1904 are from Ogilvie-Grant (1909, 1910). Attempts to locate Shortridge's field notes or further details of his collecting at Kurrawang in both the British Museum and the Kaffrarian Museum in South Africa, where Shortridge was the Director until his death in 1949, were unsuccessful.

Methods for AB counts required searching areas of 10 ha for 20 minutes four times per year. At Kurrawang nature reserve, AC recorded birds at the three sites described above on the same day in each season between January 1990 and March 1995, a total of 63 counts.

Woodland densities on Kurrawang nature reserve and at the closest uncut woodland on Kambalda timber reserve, 60 km south of Kalgoorlie, were measured by selecting 10 points at random and counting all stems greater than 10 cm diameter at breast height within a 30 m radius.

Dead wood densities were measured by walking standard 1 km transects at Kurrawang, Kambalda, and Jaurdi pastoral lease which also has cut and uncut woodlands and is 110 km west of Kalgoorlie, and counting all logs greater than 10 cm diameter and longer than 3 m occurring 30 m either side of the transect lines.

Description of Changes to Goldfields Environments with Settlement

There have been many influences on the vegetation, flora and fauna of Goldfields woodlands since European settlement of the region including: timber extraction; development of the pastoral industry with extensive selective grazing of natural vegetation and provision of water points where previously there were only very few; introduction of feral predators, herbivores and weeds, and town site and industrial development, particularly infrastructure and pollution associated with the mining industry.

The changes brought about by timber extraction have attracted considerable attention owing to the magnitude of the operation: an estimated 30 million tonnes of timber were removed from 3.4 million ha at 7–9 tonnes/ha between 1900 and 1960 (Kealley 1991). The differences identified in the present study between cut and uncut woodlands is that the former have greater numbers of trees per unit area which are of lesser diameter but comparable height and, perhaps more significantly, there are very few standing dead trees in regenerated cut woodlands. Tree density in cut woodland at Kurrawang varies between 7 and 289 stems/ha (mean=101.7). The wide variation is dependent upon the dominant species of eucalypt present. At Kambalda, uncut woodland varies between 14 and 59.5 stems/ha (mean=31.5). Siemon and Kealley (1999) also record increased average stems/ha and increased average basal area in cut Goldfields woodlands. Additionally, in cut woodlands, there is significantly less fallen dead timber because it too was removed, or recycled by termites or fungal decay.

On Jaurdi pastoral lease standard traverses of cut and uncut woodlands had 6.1 and 15.2 dead logs/ha respectively. At Kambalda the figures are 7.6 and 20.5 dead logs/ha. At Kurrawang the figure is 0.6 dead logs/ha owing to the presence of the former town site and more recently to illegal cutting and scavenging of dead timber for firewood. Shrubland density in semi-arid zone woodlands is not diminished by timber removal but by other factors including grazing history, micro-topography and soil depth. Measurements on Jaurdi pastoral lease suggest that cut woodlands have increased shrub density and clumping in comparison with uncut woodlands of similar tree species composition (Rob Thomas² personal communication).

Which are the agents of change to semi-arid woodland avifaunas in the Goldfields generally and at Kurrawang in particular? The procedure for timber extraction was to allocate coupes measuring one chain by one mile (20 m x 1609 m) to individual cutters who would then fell,

² Rob Thomas, Leader, Nature Conservation Program, CALM, Kalgoorlie.

using an axe and cross-cut saw, all suitable timber and cut it into billets 1.2 m long. The billets were loaded onto horse-drawn drays and taken to the nearest narrow gauge railway, or 'woodline', where they were loaded onto railway wagons. This was effectively a clear-felling operation: where it occurred the small understorey tree *Melaleuca pauperiflora* was also cut. The requirement for timber of a certain size and the location of the 'woodlines' meant that, in some cases, although large areas were cleared in total they were usually cleared in tongues with a large linear interface between cleared and uncleared patches. This situation probably pertained more generally elsewhere than at Kurrawang which would have been extensively cleared owing to its proximity to both Kalgoorlie and Kurrawang town sites. Although slow, regeneration would have been vigorous because once the parent seed trees had been cut, there would have been reduced competition for light, moisture and nutrients while the allelopathic effect that inhibits germination ceased.

Cut trees also frequently coppiced vigorously and developed a multi-stemmed habit further increasing the density of regrowth woodland.

The pastoral industry came to the Kalgoorlie area in the early 1900s with the grant of pastoral leases at Mungari in 1907 and Hampton Hill in 1909. Mungari presently adjoins some of the reserve and was clearly an early lease, as in 1916 Elder's Stock and Station Company listed 10 stations on the eastern Goldfields: of these only Halford's (Black Flag) and Black's (Mungari) were near Kalgoorlie (Webb and Webb 1993). In the case of Mungari, the Department of Land Administration records that 189 ha, which is now the eastern third of the reserve, was relinquished from the pastoral lease in 1968. Until 1968 at least some of the reserve was under pastoral lease. However, whether lands were held under lease does not necessarily determine whether they were grazed or not. A better approach is to examine the past and present distribution of watering points and fences as there is a finite point, usually taken to be 10 km beyond a watering point, at which sheep grazing has a minimal effect on vegetation (see Landsberg *et al.* 1997 for a review of this topic). Examination of the 'Kalgoorlie' 1:100 000 map indicates that the reserve falls within 5 km of four dams, between 5–10 km of two more, and one in the old Kurrawang town site is near the reserve's north boundary. Eighty per cent of the reserve falls within a 2 km grazing radius of this dam, which is the distance from a watering point in which significant changes to vegetation by grazing can occur (Landsberg *et al.* 1997). Most of these dams are maintained and provide water to stock today. The old Kurrawang town site dam is not now maintained and only holds water after heavy rain.

Thus, although the reserve vegetation does not show the usual signs of degradation of vegetation owing to close proximity to a watering point, it is likely that the vegetation has been grazed in the past and that there have been changes to relative abundance of some species.

The abundance of increaser species *Senna artemisioides* var. *filifolia* and *Eremophila granitica* (see Curry and Hacker 1990) here, is indicative of this.

Rabbits arrived in the Kalgoorlie vicinity between 1900–1910 and foxes between 1915–1920. These dates are inferred from Figures 2 in Williams *et al.* (1995) and Saunders *et al.* (1995) respectively. Feral cats were almost certainly present before then and probably pre-dated settlement as, for example, explorer David Carnegie recorded them in the Gibson Desert in 1896. No doubt European settlement, which followed the discovery of gold in Coolgardie in 1892 and in Kalgoorlie in 1893, provided a major fillip to feral cat numbers in the region.

RESULTS

The birds of Kurrawang nature reserve listed from Ogilvie-Grant (1909, 1910), Chapman *et al.* (1991) and the AB counts are in Table 1, which indicates a total of 74 species. Status in Table 1 is derived from relative abundance at Kurrawang and whether species are permanently present in the Goldfields, subject to regular seasonal movement (migrants) or irregular movement determined by seasonal conditions (nomads). In some cases it was not possible to allocate this latter category. Fifty-two species were recorded in 1904 and 65 in 1988–96. With the exception of Purple-gaped Honeyeater, all species lost to the avifauna are residents. Red-backed Kingfisher, Straw-necked Ibis and Brown Falcon were recorded in 1904 but not in 1988–96 although they are still locally present.

Those species formerly present but not recorded between 1988–1996 are: Southern Boobook, Rufous Tree-creeper, Golden Whistler, Shy Heathwren, Blue-breasted Fairy-wren and Purple-gaped Honeyeater.

Birds recorded between 1988 and 1996 but not in 1904, which are believed to be additions, are: Common Bronzewing Pigeon, Galah, Crested Pigeon and Magpie lark.

An additional 13 species listed in Table 1 were almost certainly part of the avifauna in 1904 but were not recorded then, probably owing to either their nomadic or migratory nature, or scarcity. In addition, elements of chance omission are always present in once-off surveys.

Table 2 lists the 50 species recorded during AB counts, their seasonal occurrence as well as number of sightings and total number of individuals observed. It reveals that Weebill and Striated Pardalote are presently the most frequently recorded birds at Kurrawang both in number of sightings and number of individuals. They are both very common resident species invariably recorded in the canopies of eucalypts. The next most frequently recorded are Yellow-throated Miner, Spiny-cheeked Honeyeater and Red Wattlebird.

DISCUSSION

There are several constraints in comparing data sets derived from the same place at different times, including how and why the data were obtained. In the case of the 1904 data, all records were of specimens obtained for a museum collection, and all data were from the same season.

TABLE 1

The past and present birds of Kurrawang Nature Reserve and their current residency status

NAME	1904	1988–96	STATUS
Emu <i>Dromaius novaehollandiae</i>	YES	YES	common nomad
Straw-necked Ibis <i>Threskiornis spinicollis</i>	YES	NO	
Black-shouldered Kite <i>Elanus notatus</i>	NO	YES	uncommon nomad
Square-tailed Kite <i>Lophoictinia isura</i>	NO	YES	uncommon nomad
Spotted Harrier <i>Circus assimilis</i>	NO	YES	uncommon nomad
Little Eagle <i>Hieraaetus morphnoides</i>	NO	YES	uncommon nomad
Wedge-tailed Eagle <i>Aquila audax</i>	NO	YES	uncommon nomad
Australian Hobby <i>Falco longipennis</i>	NO	YES	uncommon nomad
Brown Falcon <i>Falco berigora</i>	YES	NO	
Nankeen Kestrel <i>Falco cenchroides</i>	YES	YES	uncommon nomad
Little Button-quail <i>Turnix velox</i>	NO	YES	rare nomad
Common Bronzewing <i>Phaps chalcoptera</i>	NO	YES	uncommon nomad
Crested Pigeon <i>Ocyphaps lophotes</i>	NO	YES	common resident
Purple-crowned Lorikeet <i>Glossopsitta porphyrocephala</i>	YES	YES	common nomad
Australian Ringneck <i>Barnardius zonarius</i>	YES	YES	common resident
Mulga Parrot <i>Psephotus varius</i>	YES	YES	uncommon resident
Galah <i>Cacatua roseicapilla</i>	NO	YES	common resident
Pallid Cuckoo <i>Cuculus pallidus</i>	YES	YES	common migrant
Horsfield's Bronze-Cuckoo <i>Chrysococcyx basalis</i>	NO	YES	common migrant
Southern Boobook <i>Ninox novaeseelandiae</i>	YES	NO	
Tawny Frogmouth <i>Podargus strigoides</i>	YES	YES	rare resident
Australian Owlet-nightjar <i>Aegotheles cristatus</i>	NO	YES	uncommon resident
Red-backed Kingfisher <i>Todirhamphus pyrrophygia</i>	YES	NO	
Rainbow Bee-eater <i>Merops ornatus</i>	NO	YES	common migrant
Rufous Treecreeper <i>Climacteris rufa</i>	YES	NO	
Splendid Fairy-wren <i>Malurus splendens</i>	NO	YES	uncommon resident
Blue-breasted Fairy-wren <i>Malurus pulcherrimus</i>	YES	NO	
White-winged Fairy-wren <i>Malurus leucopterus</i>	YES	YES	common resident
Striated Pardalote <i>Pardalotus striatus</i>	YES	YES	common resident
Shy Heathwren <i>Hylacola cauta</i>	YES	NO	
Redthroat <i>Pyrholaemus brunneus</i>	YES	YES	rare residency status unknown
Weebill <i>Smicrornis brevirostris</i>	YES	YES	very common resident
Inland Thornbill <i>Acanthiza apicalis</i>	YES	YES	common resident
Chestnut-rumped Thornbill <i>Acanthiza uropygialis</i>	YES	YES	uncommon resident
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	YES	YES	common resident
Southern Whiteface <i>Aphelocephala leucopsis</i>	YES	YES	rare resident
Red Wattlebird <i>Anthochaera carunculata</i>	YES	YES	common resident
Spiny-cheeked Honeyeater <i>Acanthagenys rufogularis</i>	YES	YES	common resident
Yellow-throated Miner <i>Manorina flavigula</i>	YES	YES	common resident
Singing Honeyeater <i>Lichenostomus virescens</i>	NO	YES	uncommon resident
White-eared Honeyeater <i>Lichenostomus leucotis</i>	YES	YES	uncommon resident
Purple-gaped Honeyeater <i>Lichenostomus cratitius</i>	YES	NO	
Yellow-plumed Honeyeater <i>Lichenostomus ornatus</i>	YES	YES	common resident
Brown-headed Honeyeater <i>Melithreptus brevirostris</i>	NO	YES	uncommon residency status unknown
Brown Honeyeater <i>Lichmera indistincta</i>	NO	YES	common nomad
White-fronted Honeyeater <i>Phylidonyris albifrons</i>	YES	YES	common nomad

Crimson Chat <i>Epthianura tricolor</i>	YES	YES	rare nomad
White-fronted Chat <i>Epthianura albifrons</i>	YES	YES	uncommon nomad
Jacky Winter <i>Microeca fascinans</i>	YES	YES	common resident
Red-capped Robin <i>Petroica goodenovii</i>	YES	YES	uncommon resident
Hooded Robin <i>Melanodryas cucculata</i>	YES	YES	rare residency status unknown
White-browed Babbler <i>Pomatostomus suericilius</i>	YES	YES	common resident
Chestnut Quail-thrush <i>Cinlosoma castanotum</i>	NO	YES	uncommon resident
Varied Sitella <i>Daphoenositta chrysoptera</i>	YES	YES	uncommon residency status unknown
Crested Bellbird <i>Oreoica gutturalis</i>	YES	YES	common resident
Golden Whistler <i>Pachycephala pectoralis</i>	YES	NO	
Grey Shrike-thrush <i>Colluricincla harmonica</i>	YES	YES	common resident
Magpie-lark <i>Grallina cyanoleuca</i>	NO	YES	uncommon nomad
Willie Wagtail <i>Rhipidura leucophrys</i>	YES	YES	uncommon resident
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>	YES	YES	uncommon resident
Ground Cuckoo-shrike <i>Coracina maxima</i>	YES	YES	uncommon nomad
White-winged Triller <i>Lalage sueurii</i>	YES	YES	uncommon nomad
Masked Woodswallow <i>Artamus personatus</i>	YES	YES	uncommon nomad
Black-faced Woodswallow <i>Artamus cinereus</i>	NO	YES	common resident
Dusky Woodswallow <i>Artamus cyanopterus</i>	YES	YES	uncommon residency status unknown
Grey Butcherbird <i>Cracticus torquatus</i>	YES	YES	common resident
Pied Butcherbird <i>Cracticus nigrogularis</i>	YES	YES	common resident
Australian Magpie <i>Gymnorhina tibicen</i>	YES	YES	common resident
Grey Currawong <i>Strepera versicolor</i>	YES	YES	common resident
Australian Raven <i>Corvus coronoides</i>	YES	YES	uncommon residency status unknown
Little Crow <i>Corvus bennetti</i>	NO	YES	common resident
Richard's Pipit <i>Anthus novaeseelandiae</i>	YES	YES	uncommon resident
Mistletoebird <i>Dicaeum hirundinaceum</i>	YES	YES	uncommon nomad
Brown Songlark <i>Cincloramphus cruralis</i>	NO	YES	uncommon nomad

TABLE 2

AB counts, percentage occurrence by season with total numbers of sightings and individuals.

NAME	SUMMER	AUTUMN	WINTER	SPRING	No. of SIGHTINGS	No. of INDIV
Wedge-tailed Eagle	0	100	0	0	1	1
Little Eagle	100	0	0	0	1	1
Common Bronzewing	100	0	0	0	1	1
Crested Pigeon	77	8	P	15	6	13
Galah	P	65	0	35	5	20
Purple-crowned Lorikeet	33	67	P	0	3	12
Australian Ringneck	39	33	19	9	15	36
Mulga Parrot	66	34	P	0	2	6
Pallid Cuckoo	34	0	0	66	3	3
Horsfield's Bronze-Cuckoo	29	29	P	42	6	7
Rainbow Bee-eater	20	76	0	4	6	28
Splendid Fairy-wren	50	30	P	20	5	10
Striated Pardalote	13	28	42	17	39	122
Redthroat	34	66	P	0	3	3
Weebill	31	24	19	26	44	153
Inland Thornbill	20	40	40	P	3	5
Chestnut-rumped Thornbill	0	46	P	54	4	13
Yellow-rumped Thornbill	38	15	25	22	6	48
Southern Whiteface	0	100	0	0	1	1
Red Wattlebird	11	31	30	28	29	78
Spiny-cheeked Honeyeater	46	30	14	10	28	88
Yellow-throated Miner	28	26	22	24	25	101
Singing Honeyeater	25	0	25	50	4	4
White-eared Honeyeater	10	60	20	10	10	10
Yellow-plumed Honeyeater	38	30	17	15	17	63
Brown-headed Honeyeater	44	0	66	0	2	9
Brown Honeyeater	75	25	P	P	3	4
White-fronted Honeyeater	25	59	4	12	17	71
Crimson Chat	0	100	0	0	1	3
Jacky Winter	37	16	16	31	13	19
Red-capped Robin	40	P	0	60	7	10
White-browed Babbler	0	30	P	70	3	10
Chestnut Quail-thrush	17	42	P	41	8	12
Varied Sitella	0	0	100	0	1	2
Crested Bellbird	50	25	8	17	24	25
Grey Shrike-thrush	38	25	25	12	6	8
Magpie-lark	83	0	P	17	3	6
Willie Wagtail	50	50	P	P	2	2
Black-faced Cuckoo-shrike	14	38	7	41	9	14
White-winged Triller	100	0	0	0	1	1
Masked Woodswallow	0	0	0	100	1	30
Dusky Woodswallow	38	23	P	39	5	13
Grey Butcherbird	25	33	21	21	20	24
Pied Butcherbird	14	43	29	14	6	7
Australian Magpie	60	40	0	0	2	5
Grey Currawong	36	36	P	28	9	11
Australian Raven	7	50	14	29	10	14
Little Crow	79	14	4	3	12	28
Mistletoe bird	100	0	0	0	1	1
Brown Songlark	0	0	0	100	1	1

P – Indicates seasonal presence established by other than AB counts.

These considerations militate against nomadic species as well as those whose numbers fluctuate, and some raptors that are difficult to collect. As a museum collector Shortridge was probably selective in his collecting: for example, although he did not collect Singing Honeyeater, it was possibly present as he records it 'inland as far as Laverton' and Gibson (1909) describes it as 'fairly common right through'. The strength of the historical comparison is in evaluating which species formerly present are no longer rather than *vice versa*.

In spite of these constraints the data do indicate some avifaunal change at Kurrawang over the 92 years between 1904 and 1996. The pertinent questions are, which of the indicated changes are real, and what are the causative factors? The first question has been tentatively answered; it appears above that six species have been lost from the avifauna and four have been added. The additional species have elsewhere benefitted from establishment of reliable water supplies or more favourable food supply, sometimes involving land use change or even introduced plants particularly crops.

Of birds lost to the region, Southern Boobook and Rufous Tree-creeper are almost certainly owing to changes to woodland structural complexity and changed age structure resulting from timber extraction.

Southern Boobook is dependent upon old trees with hollows for nesting and in the Goldfields Rufous Tree-creeper is invariably present in woodlands with logs that they use as perching sites. A reduction of dead timber on the ground is one feature of cut-over semi-arid woodland (see above). The loss of the other four species is more problematical: Golden Whistler, Shy Heathwren and Blue-breasted Fairy-wren are all shrub-dependent 'resident insectivores'. Purple-gaped Honeyeater is a non-resident nectivore. What these species have in common is that they are all on the edge of their range at Kurrawang.

They are predominantly south-western species whose range only extends east of Kalgoorlie in the denser vegetation of the Mallee and Esperance Plains, Interim Biogeographic Regionalisation of Australia (IBRA) Regions (see Thackway and Cresswell 1995).

That resident insectivores are the most adversely affected of the avifauna at Kurrawang is in broad agreement with the observations of Reid and Fleming (1992) who list sedentary passerines that feed on the ground or in low shrubs including wrens, quail-thrushes, thornbills and allies as among declining species in the arid zone.

The situation of birds declining on the edge of their range has occurred elsewhere in the Goldfields: for example, Moriarty (1972) records that both Grey Currawong and Mallee Fowl were present at Kathleen Valley station, which is now Wanjarri nature reserve, 450 km north of Kalgoorlie, in the 1960s. Mallee Fowl has not been recorded since then in parts of the reserve which were formerly grazed and Grey Currawong appears to have declined since the 1960s as 80 person days recording between 1988 and 1996 have only recorded one pair (CALM unpublished data).

Reid and Fleming (1992) recognized that 'species with a southern distribution associated with mallee and chenopods have declined in the north.' Although they were referring to arid zone species, which the Kurrawang decliners are not, it may be that this is a more widely applicable principle, i.e. that on the edge of their range species are particularly vulnerable to agents of attrition. Therefore, changes to the habitat requirements of Southern Boobook and Rufous Tree-creeper and their decline at Kurrawang are likely to be directly attributable to timber extraction.

Other factors need to be examined to explain the loss of other species that are predominantly dense shrub understorey dependent, as shrub density is unlikely to have been diminished by extraction of timber at Kurrawang (see above).

Although the number of arid and semi-arid zone birds that are obligate drinkers is relatively small, there are other species that certainly will drink if water is available. For example, Davies (1972) recorded 24 species that drank, including 13 that drank regularly even in cool weather at Wanjarri.

Although Wanjarri is very different from Kurrawang – being drier with an annual average rainfall of 200 mm, and with vegetation dominated by spinifex and mulga – of the 24 species that drink at Wanjarri 19 also currently occur at Kurrawang. They include Yellow-throated Miner and Spiny-cheeked Honeyeater, which at Kurrawang are among the most frequently recorded species and are known arid zone increasers (Reid and Fleming 1992).

The other frequently recorded species at Kurrawang is Red Wattlebird which certainly does drink in eucalypt woodlands of the eastern Goldfields and elsewhere (CALM unpublished data) and is presently very common but was described by Gibson (1909) as 'a few only in the Salmon barked country'. Although these three species were all present at Kurrawang in 1904, the Shortridge data are too generalized to draw any firm conclusion as to abundance. It is interesting, however, that Spiny-cheeked Honeyeater is noted by Shortridge in Ogilvie-Grant (1909) as being 'the water-bird of the colonists...seldom far from a waterhole' and Yellow-throated Miner is described as 'very abundant on the Gascoyne River'.

These observations suggest that even before it became widely available, water was a factor in the abundance of two of these species. However, in contrast, Gibson (1909) describes Yellow-throated Miner as 'very common right through'.

It is suggested that Red Wattlebird and Spiny-cheeked Honeyeater in particular and possibly Yellow-throated Miner, which are all powerfully flying, gregarious and sometimes aggressive species that do drink, or eat insects, have increased in numbers at Kurrawang and elsewhere. Their increase is possibly at the expense of smaller, territorial and resident obligate insectivores, which are much less vagile. The competitive interaction could either be through direct competition for insect food, albeit possibly at different stages of insects' life cycles. There could also be behavioural interactions involving the aggressive and gregarious nature of these species, as they

no longer have to move as far to meet their moisture requirements, thereby making resident insectivores' territories uninhabitable.

James *et al.* (1999) report that species that become abundant may cause aggressive displacement of other species that do not need water.

Although the hypothesis reported here pertains particularly to a specific locality the effects of provision of water in pastoral rangelands is likely to be widespread as Landsberg *et al.* (1997) indicate that nearly all the pastoral rangelands are within less than 10 km of an artificial water point and that only 3 per cent of water points are natural.

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