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Bird Responses to Targeted Revegetation: 40 Years of Habitat Enhancement at Clarkesdale Bird Sanctuary, Central-western Victoria

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Summary

A program of planting Australian shrubs and trees has been conducted in degraded farmland at the Clarkesdale Bird Sanctuary (central-western Victoria) since the 1960s, to address the issue of declining native birds, as perceived by the late landowner Gordon Clarke. The shrubs and trees were selected to attract birds, and included many species that were not native to the region. This form of management is often practised by private landholders (at various scales), but its effects are rarely documented. Bird surveys were conducted for this study between 1999 and 2001 at 27 sites: 11 in native eucalypt forest on ridges and slopes, 13 in planted areas on ridges and slopes, and three in planted areas on river-flats and a small gully (with three supplementary sites in a pine plantation). Total bird abundance and species per count were highest in the planted sites on river-flats and gully, and higher in the planted sites on ridges and slopes than in native forest on similar topography. Honeyeaters (Meliphagidae), Superb Fairy-wrens *Malurus cyaneus*, open-country birds, seed-eating birds and five insectivorous guilds reached their maximum abundance in planted sites. Bark-foraging insectivores, canopy-foraging insectivores, frugivores and a generalist insectivore were marginally more common in native forest than in planted sites. Introduced birds were uncommon. Generalised linear modelling showed that total bird abundance was positively related to the cover of planted native vegetation, native low shrubs and young wattles *Acacia* spp. and to the presence of indigenous Cherry Ballart *Exocarpos cupressiformis*. Various guilds showed positive relationships with the cover of planted native vegetation, native low shrubs, young wattles, original old wattles, original old eucalypts and trees with small or large hollows. The planting program has provided new habitat for many native forest birds. A greater challenge is to address the needs of some uncommon species that have declined locally, such as the Brown Treecreeper *Climacteris picumnus* and Speckled Warbler *Chthonicola sagittata*.

Introduction

In recent years much effort has been devoted to revegetating parts of the rural landscape, to address a range of issues including erosion, salinity and biodiversity conservation (Salt *et al.* 2004; Youl *et al.* 2006; Munro *et al.* 2007). Relatively little effort has been devoted to assessing the effects of these initiatives on biodiversity, with some exceptions, such as recent work on fauna in commercial eucalypt plantations (Hobbs *et al.* 2003; Kavanagh *et al.* 2005; Loyn *et al.* 2007) and in agricultural landscapes (Kavanagh *et al.* 2007; Barrett *et al.* 2008; Selwood *et al.* 2009). Many revegetation initiatives are taken by individual landholders or local Landcare groups, and develop their own characteristics and idiosyncrasies, which may differ from those expected in commercial operations or larger government-sponsored programs. It is important to understand how biodiversity responds to individual revegetation efforts, because these all contribute to changes in the rural landscape and its associated biodiversity.

Many private landholders recognise a need to revegetate parts of their land with trees and shrubs for a wide range of purposes (Reid & Wilson 1985), often with a desire to provide habitat for native birds and other wildlife, especially in gardens or home-paddocks. They may select trees and shrubs partly for that purpose, including species not indigenous to the local area, but effects of such management have rarely been documented. One of the early landowners to adopt this philosophy was the late Gordon John Clarke of Linton, near Ballarat in central-western Victoria. He realised his vision by buying land and initiating a vigorous revegetation program in the 1960s, coming to fruition as the Clarkesdale Bird Sanctuary.

The main aim of this study was to compare assemblages across the main habitats currently represented at the Sanctuary, and in particular to compare revegetated sites with remnant native eucalypt forest. This could help to assess whether planting had helped restore a bird fauna that resembled that of native forest, and identify any differences. This was seen as a useful benchmark, while recognising that the planting program had broader aims. The benefits of the planting program could also be assessed, if it were assumed that the initial bird populations of degraded sites were extremely low. No attempt was made to conduct surveys on cleared pasture or paddocks infested with Gorse *Ulex europaeus*, as these habitats are no longer evident in the Sanctuary. However, data on such sites are available from companion studies in the region (our unpubl. data), and populations of forest and woodland birds in such habitats are indeed known to be generally low.

This paper presents an analysis of data collected by volunteers from 27 sites and three broad habitats on seven occasions between 1999 and 2001. The data are of general interest, because they shed light on the effects of a visionary but controversial approach to bird-habitat enhancement, which deliberately avoided the constraints of many modern programs that insist on using plant species native to the area in question (i.e. indigenous).

Study area

The Clarkesdale Bird Sanctuary covers 535 ha of land at Piggoreet south-east of Linton (Anon. 1999), at an altitude of 500 m at the south-western end of the Great Dividing Range. Most of the land is owned by Bird Observation and Conservation Australia (BOCA) and the Trust for Nature (Victoria), together with the adjacent Linton Flora and Fauna Reserve under Parks Victoria's jurisdiction. Its management is overseen by a strategy committee appointed by BOCA, including representatives from these and other organisations, with input from the Clarkesdale Advisory Committee.

The Sanctuary owes its existence to the visionary conservationist and grazier Gordon Clarke, who grew up at Piggoreet, near Linton, and farmed the land over many decades. From the 1950s he was among the first to recognise that populations of woodland birds were declining and new approaches to rural land management were needed to reverse these declines. He developed a program to buy degraded land locally, including land supporting extensive Gorse infestations, and restore some of its value as bird habitat by a vigorous program of planting Australian native trees and shrubs. He eschewed the purist philosophy of solely planting species indigenous to the local area, and aimed to improve on nature by selecting plants with special characteristics favoured by birds. Many of the shrubs selected were Western Australian species known for their capability to produce prolific nectar and attract honeyeaters.

The work continued to include other areas of cleared or partly cleared land, with varying levels of initial weed infestation. Gordon Clarke made special efforts to involve the community in his work, and the Bird Observers Club of Australia (BOCA, now Bird Observation and Conservation Australia) became an active participant at an early stage, in planting and recording bird species present. Formal reservation of the Sanctuary was achieved in 1975, and the Gordon Clarke Trust was established to provide funds for its management. A management plan was prepared (Anon. 1999). This defined the vision for the Sanctuary as being 'to optimise, manage and create habitat at Linton as a Sanctuary to increase the diversity and populations of native birds in perpetuity'. This reflected Gordon Clarke's focus on the needs of birds, rather than any attempt to restore vegetation to its pre-European form. One of the needs identified in the management plan was to conduct surveys of birds to determine how bird populations may have responded to the planting program, hence this study.

The Sanctuary consists of a mosaic of native eucalypt forest and planted areas, together with a Monterey Pine *Pinus radiata* plantation (25+ years old), small remaining cleared areas and several small and medium-sized wetlands. Most sites in native forest were within ~200 m of planted sites. Examination of maps of Ecological Vegetation Classes (EVC) (estimated for the pre-European state, Department of Sustainability & Environment) revealed that the river-flats would be classed as Creek-line Herb-rich Woodland EVC. Most planted sites (including the pine plantation) would have supported Valley Grassy Forest EVC, which grows on fertile soils and has been extensively cleared. The revegetated areas contained a few relict (i.e. original) trees that survived initial clearing, but were essentially dominated by planted trees and shrubs, including many flowering shrubs endemic to Western Australia (e.g. *Hakea* spp., *Grevillea* spp., *Melaleuca* spp., etc.). The native forest was classed as Heathy Dry Forest, with dominant trees including Messmate *Eucalyptus obliqua*, Narrow-leaved Peppermint *E. radiata*, Candlebark *E. rubida*, Red Stringybark *E. macrorhyncha*, Scent-bark *E. aromaphloia*, Swamp Gum *E. ovata* and Broad-leaved Peppermint *E. dive*s forming an open overstorey ~20 m tall. A relatively low, sparse shrub layer included Myrtle Wattle *Acacia myrtifolia*, Black Wattle *A. mearnsii*, Golden Bush-pea *Pultenaea gunnii*, Bitter-pea *Daviesia* sp., Drooping Cassinia *Cassinia arcuata*, Heath Tea-tree *Leptospermum myrsinoides*, Common Heath *Epacris impressa* and Small Grass-tree *Xanthorrhoea minor*. Austral Bracken *Pteridium esculentum* and Grey Tussock-grass *Poa sieberiana* were common components of the understorey. The native forest has been subject to selective logging and other disturbance over many years, as have most forests in this region. The native forest has not been burnt for a long period (>20 years).

Methods

Field methods

A total of 27 sites was used for this study (along with three in pine plantations that are not included in the analysis). They included 11 sites in native forest, 13 in areas of similar topography where native trees and shrubs had been planted as part of the program of habitat restoration, and three in planted areas on river-flats and a small gully (Table 1). One of the latter sites was next to one of the small dams. Observers surveyed each site on seven occasions: 19 October, 2 November 1999 (spring), 14 December 1999 (summer), 8 March, 22 March 2000 (autumn), 24 January 2001 (summer) and 7 March 2001 (autumn). An active timed area search method was used (after Loyn 1986, 1998) in which an area of 1 ha was searched for 10 minutes. The observer walked through each area, and recorded numbers of all species observed (seen or heard). Birds observed off-site were recorded separately, and not considered further in the current analysis.

Basic habitat data (Table 1) were collected from each site on the initial visit. Habitat variables were assessed visually and scored on a scale of 0 (absent) to 3 (dominant, or for native vegetation as in uncleared forest). The presence or absence of Cherry Ballart *Exocarpos cupressiformis* and trees bearing mistletoe *Amyema* spp. was noted.

Note that this study did not consider nocturnal birds, of which at least four species (Tawny Frogmouth *Podargus strigoides*, Australian Owlet-nightjar *Aegotheles cristatus*, Powerful Owl *Ninox strenua* and Southern Boobook *N. novaeseelandiae*) inhabit the Sanctuary.

Analysis

Mean abundances of each species were calculated across the seven visits for each site. Sites were grouped according to the three main habitats (native forest on ridges and slopes, planted sites on similar topography, and planted river-flats and gully). Mean abundances of

Table 1

Mean values for selected habitat features of the 27 study sites at Clarkesdale Bird Sanctuary, central-western Victoria, 1999–2001. Numerical scores are on a scale of 0 (none) to 3 (dominant, or for native vegetation as in uncleared forest).

Habitat feature	*Native eucalypt forest*	*Planted sites on similar topography*	*Planted river-flats and gully*
Native vegetation cover (unplanted)	2.45	1.08	1.67
Planted native vegetation cover	0.45	2.23	2.33
Exotic vegetation (weeds)	0.36	0.38	1.00
Trees with large hollows	1.09	0.31	1.00
Trees with small hollows	1.45	0.54	1.00
Original eucalypts (>50 years old)	1.91	1.08	1.67
Original wattles (>50 years old)	0.45	0.38	0.67
Young eucalypts (0–50 years old)	1.55	1.69	1.33
Young wattles (0–50 years old)	1.36	1.46	1.33

each species were then calculated and tabulated for each of these three habitats. Analysis of variance was used to compare mean abundances of common species between native forest and planted sites on similar topography. Logistic regression was used to compare occurrence of less common species between sites in each of those two habitats.

Species were classified into a number of guilds based on feeding ecology, preferred nest-site, migratory status, status (native or introduced) in Victoria or habitat (Appendix 1). The abundance of each guild was calculated for each visit to each site by summing the numbers of individuals of the respective species observed at the site on that visit. Numbers of individual birds in each guild per site per visit were taken as the dependent variable for subsequent analysis. The total numbers of individual birds per visit, and the numbers of species observed on each visit, were also considered as dependent variables.

Analyses of variance were then conducted to assess variation between seasons and habitats, and their interactions. Square-root transformations were found necessary in some cases to meet the assumptions of the analysis. Visit sessions and sites were taken as random variables, and seasons and habitats as fixed variables. The three habitats were as already described (native forest on ridges and slopes, planted sites on similar topography, and planted river-flats and gully). Generalised linear modelling was used to relate the same dependent variables (i.e. total bird abundance, abundance of bird guilds) to habitat variables (i.e. explanatory variables) collected in the field.

Results

Seventy-nine bird species were recorded on the 27 sites during the seven visits, including 13 waterbird species associated with the dam (Appendix 1). In terms of species per count, the sites in native forest appeared less diverse than the planted sites on similar topography, which in turn were less diverse than the planted river-

Table 2

Mean abundances (birds per 10 counts) of bird guilds in three main habitats (native eucalypt forest on ridges and slopes, planted sites on similar topography, and planted river-flats and gully) at Clarkesdale Bird Sanctuary, central-western Victoria, 1999–2001, including waterbirds. The planted sites were planted with native Australian trees and shrubs (many of them not indigenous to the local area) from the 1960s. Number of bird species recorded in each guild is shown in parentheses.

Guild type	*Guild*	*P value*	*Mean birds per 10 counts*		
	Broad habitat:	*Native forest vs planted sites on similar topography*	*Native forest*	*Planted sites on similar topography*	*Planted river-flats and gully*
Number of sites:			**11**	**13**	**3**
Bird species per count:			**4.3**	**6.0**	**8.1**
Feeding	Aerial insectivores (4)	–	2.1	2.4	21.0
	Bark-foraging insectivores (4)	0.123	4.4	3.1	2.9
	Canopy-foraging insectivores (10)	0.187	17.9	12.6	25.2
	Damp-ground or understorey insectivores (5)	0.152	4.2	9.8	13.8
	Generalist insectivores (1)	0.976	2.9	2.1	1.4
	Mid-storey insectivores (3)	0.031	4.3	7.4	6.7
	Open-ground-among-trees insectivores (7)	0.150	13.8	22.4	27.1
	Open-ground insectivores (5)	0.032	2.1	7.6	5.2
	Nectarivores (honeyeaters) (7)	<0.001	27.9	69.3	64.8
	Frugivores (2)	–	0.4	0	0
	Seed-eaters close to ground (8)	0.044	2.5	5.2	10.5
	Seed-eaters at all levels (2)	0.084	5.3	6.9	9.5
	Carnivores (9)	0.420	1.6	2.7	3.3
	Waterbirds (12)	–	0.1	0.2	11.4
Nesting	Brood-parasites (cuckoos) (4)	–	0.5	1.4	0.5
	Hole in ground (1)	–	2.3	0.5	0.5
	Ground (3)	–	0	0.2	11.0
	Ledge on tree or building (3)	–	3.0	2.3	3.8
	Large hollow in tree (7)	0.104	7.0	8.5	16.7
	Small hollow in tree (7)	0.136	7.7	4.9	25.2
	Branch of tree or shrub (45)	–	68.8	133.0	145.2
	Not nesting in Australia (1)	–	0	0.9	0
Migrant	Non-migrant (62)	–	74.7	135.2	166.7
	Summer migrant (17)	–	14.7	16.6	36.2
Status	Introduced to Australia (3)	–	0.4	1.8	3.8
	Native (76)	–	89.0	150.0	199.1
Habitat	Forest or woodland birds (49)	–	82.1	109.0	143.8
	Heathland birds (2)	–	1.7	31.5	31.0
	Open-country birds (15)	–	5.5	11.0	13.8
	Waterbirds (13)	–	0.1	0.2	14.3

flats and gully (Appendix 2). The mean abundance of each species in these three habitats is also shown in Appendix 2, and the mean abundance of each guild in each habitat is shown in Table 2. Total bird abundance (mean birds of all species per site per visit) was highest on planted river-flats and gully sites, and higher in the planted sites on ridges and slopes than in native forest on similar topography (Appendix 2, Table 2). The differences were highly significant ($P < 0.001$). The same trend was evident in species per count (Appendix 2). At conventional significance levels ($P < 0.05$), just two species (White-throated Treecreeper and Spotted Pardalote; see Appendix 1 for scientific names) were more common in native forest than planted sites on similar topography. Black-faced Cuckoo-shrikes were recorded only in native forest during the study, and White-winged Choughs were present more consistently in native forest than elsewhere. Five species (Superb Fairy-wren, New Holland Honeyeater, Red Wattlebird, Australian Magpie and Australian Raven) were significantly more common in planted sites on ridges and slopes than in native forest on similar topography. Two others (White-browed Scrubwren and Eastern Spinebill) showed the same trend but at a lower level of significance ($0.1 > P > 0.05$). Red-browed Finches were recorded only at planted sites.

Habitat modelling showed that total bird abundance was positively related to the cover of native low shrubs, planted native vegetation, young wattles and Cherry Ballart (Table 3).

Feeding guilds

Four feeding guilds appeared more common in native forest than in planted sites on similar topography, but the differences were not statistically significant at conventional levels ($P < 0.05$). Apparent preference for native forest was greatest among bark-foraging insectivores (Table 2). Honeyeaters, Superb Fairy-wrens and birds regarded as open-country species were substantially more abundant at planted sites (on ridges and slopes as well as on river-flats and gully) than elsewhere (Appendix 2). Five insectivorous and both seed-eating guilds were particularly common at planted sites (Table 2).

Aerial insectivores

The relative abundance of aerial insectivores was highest over planted river-flats (Table 2), particularly at the site near the dam, where Tree Martins were the

Table 3

Generalised linear models for abundance of bird guilds in relation to habitat variables at Clarkesdale Bird Sanctuary, central-western Victoria, 1999–2001.

Dependent variable (square root)	*Coefficient*	*Variable*	*Significance*	*% variance explained by model*
Total bird abundance		Regression model	<0.001	66.8
	1.871	[constant]		
	0.349	Native low shrubs	0.012	
	0.500	Planted native vegetation	<0.001	
	0.345	Young wattles	0.019	
	0.781	If *Exocarpos* is present	0.028	

Table 3 continued

Dependent variable (square root)	*Coefficient*	*Variable*	*Significance*	*% variance explained by model*
Bark-foraging insectivores		Regression model	<0.001	49.0
	0.374	[constant]		
	–0.095	Native tall shrubs	0.04	
	0.246	Original old eucalypts	<0.001	
Canopy-foraging insectivores		Regression model	0.029	13.0
	0.891	[constant]		
	0.166	Native vegetation	0.029	
Damp-ground or understorey insectivores		Regression model	0.024	18.4
	0.807	[constant]		
	–0.146	Native tall shrubs	0.07	
	0.160	Planted native vegetation	0.017	
Generalist insectivores		Regression model	<0.001	50.2
	0.264	[constant]		
	0.133	Native low shrubs	0.006	
	–0.168	Original old eucalypts	0.006	
	0.277	Trees with small hollows	<0.001	
Mid-storey insectivores		Regression model	0.007	20.4
	0.586	[constant]		
	0.166	Native low shrubs	0.007	
Open-ground-among-trees insectivores		Regression model	0.015	16.5
	0.940	[constant]		
	0.335	Native low shrubs	0.015	
Open-ground insectivores		Regression model	0.017	15.7
	0.233	[constant]		
	0.176	Planted native vegetation	0.017	
Nectarivores (honeyeaters)		Regression model	<0.001	54.9
	0.762	[constant]		
	0.455	Planted native vegetation	<0.001	
	0.447	Young wattles	0.008	
Seed-eaters close to ground		Regression model	0.003	30.9
	0.336	[constant]		
	0.142	Native low shrubs	0.045	
	0.288	Original old wattles	0.009	
Seed-eaters at all levels		Regression model	<0.001	40.5
	0.093	[constant]		
	0.342	Original old eucalypts	0.001	
	0.278	Planted native vegetation	<0.001	
	–0.600	If mistletoe is present	0.002	
Carnivores		Regression model	0.004	28.9
	–0.114	[constant]		
	0.188	Weeds	0.006	
	0.280	Young wattles	0.001	
Birds that nest in large tree-hollows		Regression model	0.002	33.3
	0.340	[constant]		
	0.249	Trees with large hollows	0.005	
	0.183	Planted native vegetation	0.007	
Birds that nest in small tree-hollows		Regression model	<0.001	31.9
	0.476	[constant]		
	0.318	Trees with small hollows	<0.001	

dominant species. They were particularly common there in spring, nesting in old eucalypts and feeding over open country and the dam. Tree Martins were observed in smaller numbers but more widely in other seasons, along with a few Dusky Woodswallows, Welcome Swallows and White-throated Needletails.

Bark-foraging insectivores

Bark-foraging insectivores showed little difference in abundance between the three habitats, although they tended to be most common in native forest (Table 2). No significant differences were found between habitat type ($P = 0.551$) or season ($P = 0.676$), and there was no interaction between habitat type and season ($P = 0.395$). The commonest species in the group, the White-throated Treecreeper, occurred in all habitat types (including pines), although it was most numerous in native forest ($P = 0.031$, Appendix 2). Crested Shrike-tits and Varied Sittellas were recorded in low numbers mainly in planted sites. Red-browed Treecreepers were recorded only at planted river-flats and in native forest; this species occurs here at the extreme western limit of its range.

Habitat modelling showed that the abundance of original old eucalypts made a positive contribution, and native tall shrubs made a negative contribution (Table 3). The latter effect may be because most shrubs had been planted on the most degraded sites with few remaining old trees; that is to say, relatively intact treed areas had not been targeted for extensive shrub plantings. In general, Heathy Dry Forest EVC does not support an extensive cover of shrubs, particularly of tall shrubs.

Canopy-foraging insectivores

No significant difference was found between the sites in native forest on ridges and slopes and planted sites on similar topography (Table 2). Two species in the group appeared to be more common in native forest than elsewhere (Spotted Pardalote and Black-faced Cuckoo-shrike), although the difference was significant only for the Spotted Pardalote (Appendix 2). The guild was more common in spring or summer than in autumn ($P = 0.019$), and no interaction was found between habitat type and season ($P = 0.315$). It was virtually absent from the pine plantation (our unpubl. data).

A habitat model showed that the cover of native vegetation made a weak positive contribution (Table 3).

Damp-ground or understorey insectivores

Species that feed from the understorey or from damp ground were common at planted sites and somewhat less common in native forest (Table 2). No significant differences were found between these habitats ($P = 0.165$) or seasons ($P = 0.438$), and there was no interaction between them ($P = 0.179$). The most common species in the guild, the White-browed Scrubwren, was particularly common in planted river-flats and gully (Appendix 2).

A habitat model indicated a weak positive contribution from the cover of planted native vegetation, with a paradoxical and nearly significant negative contribution from native tall shrubs (Table 3).

Generalist insectivores

This guild was represented by a single species, the Grey Shrike-thrush, which takes invertebrates and small vertebrates from the canopy, bark and open ground. Grey Shrike-thrushes were widespread in all habitats (Table 2), and no significant differences were found between habitats ($P = 0.785$). Fewer were observed in autumn than in spring or summer ($P = 0.045$), and there was no interaction between season and habitat ($P = 0.825$).

Habitat modelling showed that the cover of native low shrubs and the abundance of trees with small hollows made positive contributions, while (paradoxically) the abundance of original old eucalypts made a negative contribution (Table 3).

Insectivores that feed from tall shrubs (mid-storey insectivores)

Two of the species that feed from tall shrubs (Brown Thornbill and Golden Whistler) were about equally common on planted river-flats and other planted sites (Appendix 2). The third member of the guild, the Fan-tailed Cuckoo, was uncommon, and was found only on planted ridge and slope sites. No significant differences were found between habitats across the 27 sites ($P = 0.105$), although there was a trend for lower abundance in native forest (Table 2). When native forest was compared directly with planted sites on similar topography, the guild proved to be significantly more common in the latter ($P = 0.031$). There was no evidence for any seasonal difference ($P = 0.764$) or interaction between season and habitat ($P = 0.711$).

A habitat model showed that the cover of native low shrubs made a weak positive contribution, whereas tall shrubs did not (Table 3).

Insectivores that feed from open ground among trees (open-ground-among-trees insectivores)

This guild was common in planted sites, including river-flats and gully and other sites, and appeared to be less common in native forest (Table 2). The differences between habitats were not significant ($P = 0.150$). Three of the species in the guild (Scarlet Robin, Buff-rumped Thornbill and White-winged Chough) were common among pines and in native forest. Superb Fairy-wrens dominated the guild at planted sites. This insectivorous guild was less common in autumn than in spring or summer ($P < 0.001$), and no interaction was found between season and habitat ($P = 0.310$).

Habitat modelling showed a weak positive response to the cover of native low shrubs (Table 3).

Insectivores that feed from open ground, often not among trees (open-ground insectivores)

This guild showed the same trend as for insectivores that feed from open ground among trees. Significant differences were found between habitats ($P = 0.032$), but not between seasons ($P = 0.632$), and there was no interaction between habitat and season ($P = 0.596$). The most common species in the group were Australian Magpie and Yellow-rumped Thornbill, and these were particularly common in planted sites away from river-flats (Appendix 2). Magpie-larks and Common Starlings were recorded in low numbers, and Masked Lapwings were observed near the dam. Some open-country species in this guild were notable by their absence, with Willie Wagtail *Rhipidura leucophrys* being a prominent example.

Habitat modelling showed a weak positive response to planted native vegetation (Table 3).

Nectarivores

Honeyeaters were the only nectarivorous species observed (Appendix 2). They were much more numerous at planted sites than in native forest (Table 2) and the differences were highly significant (P <0.001). They were more common in spring than autumn (P = 0.022), and intermediate numbers were found in summer. An interaction was found between habitat and season (P = 0.045), with both classes of planted sites showing less of a reduction in numbers in summer than did native forest.

Seven species of honeyeater were recorded during the study, and three (Eastern Spinebill, New Holland Honeyeater and Red Wattlebird) appeared much more abundant at planted sites than in native forest. This difference was significant for the latter two species (P = 0.006 and 0.031, respectively) but not for Eastern Spinebills (P = 0.068) at conventional levels. White-eared Honeyeaters appeared more common in native forest (although the difference was not significant), and the remaining three species (White-naped Honeyeater, Brown-headed Honeyeater and Yellow-faced Honeyeater) were similarly common in native forest and planted sites on similar topography (Appendix 2).

Habitat models showed that nectarivore abundance was positively related to the cover of planted native vegetation and young wattles (Table 3).

Frugivores

Only two frugivorous species (Silvereye and Mistletoebird) were recorded, and they were found in low numbers and only in native forest (Table 2).

Seed-eaters that take food from the ground or low vegetation (seed-eaters close to ground)

This guild was more abundant in planted river-flats and gully than in other planted sites, and generally more common in the latter than in native forest sites (Table 2; P = 0.044). Eastern Rosellas and Long-billed Corellas showed a preference for planted river-flats, whereas up to seven Blue-winged Parrots were observed at several other planted sites and in native forest. The most common small seed-eater, the Red-browed Finch, was recorded at both groups of planted sites, and not found elsewhere during these surveys (Appendix 2). There was no seasonal effect for the guild (P = 0.831). Weak evidence was found for an interaction between season and habitat (P = 0.071), with numbers apparently increasing in native forest in autumn and decreasing elsewhere in autumn.

Habitat modelling identified positive responses to the cover of native low shrubs and old wattles (Table 3).

Seed-eaters that take seeds and other food at all levels (seed-eaters at all levels)

This guild was widely distributed in all habitats (Table 2). Effects of habitat were not significant at conventional levels ($P = 0.084$). No significant effects were found for season ($P = 0.305$), and there was no interaction between season and habitat ($P = 0.934$). The guild was dominated by Crimson Rosellas, with smaller numbers of Yellow-tailed Black-Cockatoos, and no other species.

Habitat modelling identified positive responses to the cover of original old eucalypts and planted native vegetation, and a negative response to mistletoe (Table 3).

Carnivores (birds that take vertebrates as an important part of their diet)

Carnivores were widely distributed in low numbers in all habitats (Table 2), but there were no significant differences between habitats ($P = 0.478$), and no interaction between season and habitat ($P = 0.934$). The guild was substantially more common in spring and summer than in autumn ($P < 0.001$) because its most common species, the Sacred Kingfisher, is a summer migrant to these forests.

Habitat modelling identified positive responses to the cover of weeds and young wattles (Table 3).

Other guilds

The following accounts deal with groups of birds that overlap with the feeding guilds already discussed. Separate analysis was warranted for the guilds of birds that nest in small or large tree-hollows. Birds that make nests on branches formed the vast majority of birds recorded, and generally followed the same pattern as described for total bird abundance. Brood-parasites and birds that nest in special situations were represented by too few species and individuals to warrant statistical analysis.

Birds that nest in large tree-hollows

This guild was most abundant in planted sites on the river-flats and gully ($P = 0.024$), and showed little difference between native forest and planted sites on similar topography (Table 2, $P = 0.104$). The abundance of trees with large hollows made a significant positive contribution when included as a covariate ($P < 0.005$). Parrots, cockatoos and the Laughing Kookaburra constituted the guild.

Habitat modelling showed positive responses to large hollow-bearing trees and the cover of planted native vegetation (Table 3).

Birds that nest in small tree-hollows

This guild was most abundant on planted river-flats and gully (Table 2; $P = 0.033$) and showed little difference in abundance between other habitats. The abundance of trees with small hollows made a significant positive contribution when included as a covariate ($P < 0.001$). The guild contained a wide range of species (Appendix 1), with White-throated Treecreeper, Striated Pardalote and Tree Martin being the most common. The species differed widely in their apparent responses to habitat (Appendix 2).

Habitat modelling showed a positive response to numbers of trees with small hollows (Table 3).

Waterbirds

Waterbirds were found almost exclusively near dams in the planted river-flats (Table 2). Two species (Australian Shelduck and White-faced Heron) were observed occasionally in native forest in spring, and may have been nesting there at the time. The distribution of these species was too restricted for statistical analysis to be useful.

Introduced birds

Three species were recorded during the study (Appendix 1). Common Blackbirds and European Goldfinches were observed regularly at planted sites, and Common Starlings were seen there infrequently in low numbers (Appendix 2). In addition, Goldfinches were observed regularly in pines, and Blackbirds were observed occasionally in native forest. Altogether, introduced birds formed 0.4% of the individual birds recorded in native forest, 1.1% of those on planted sites on similar topography and 1.9% of those on planted river-flats and gully; they also formed 7.5% of those in pines (our unpubl. data). Numbers were too low for useful analysis beyond that level.

Discussion

The study has given a snapshot of the bird assemblages of three main habitats at the Clarkesdale Bird Sanctuary. In general the results accord well with what might be expected from general experience and work elsewhere in Victoria (e.g. Loyn 1985; Emison *et al.* 1987), with minor anomalies as noted in Appendix 2, arising when species were observed on few occasions. Several uncommon forest or woodland birds could be expected to occur intermittently at the Sanctuary, mainly in native forest rather than planted sites. Species that might be expected to occur at times in this sort of forest include Painted Button-quail *Turnix varius*, Chestnut-rumped Heathwren *Hylacola pyrrhopygia*, Spotted Quail-thrush *Cinclosoma punctatum*, Leaden Flycatcher *Myiagra rubecula* and lorikeets. These species are known to occur in surrounding forest areas and occasionally at the Sanctuary, but each has specific habitat requirements. Historical records show that some woodland birds (notably Brown Treecreeper *Climacteris picumnus*, Speckled Warbler *Chthonicola sagittata*, Hooded Robin *Melanodryas cucullata* and Diamond Firetail *Stagonopleura guttata*) occurred formerly at the Clarkesdale Bird Sanctuary (up until early 1990s), but have not been recorded for many years and are now very rarely recorded in the wider landscape (our unpubl. data).

The models developed in this study identify several variables that contribute positively to the abundance of particular bird guilds. These include the cover of planted native vegetation, native low shrubs, young wattles, original old wattles, Cherry Ballart, original old eucalypts and trees with small or large hollows. Such features, including large old trees and shrub cover, have also been found to be important in other studies investigating the biodiversity benefits of revegetation (e.g. Kavanagh *et al.* 2007; Selwood *et al.* 2009). If landholders wish to enhance habitat for particular guilds of birds, they could do so by enhancing these habitat elements through planting or retention of existing vegetation. Retention is the most practical strategy for elements that take many decades to develop (such as hollow-bearing trees, discussed on p. 66) or which pose practical difficulties for planting (such as Cherry Ballart, a root hemi-parasite).

Studies of birds in revegetation have often found these sites to support fewer species or only a subset of the species found in nearby remnant vegetation (e.g. Martin *et al.* 2004; Jansen 2005; Kavanagh *et al.* 2007). This result has been attributed to lower structural complexity in plantings (Kavanagh *et al.* 2007), age of vegetation (Selwood *et al.* 2009) and low floristic richness (Kavanagh *et al.* 2007). Although many of these studies investigated revegetation established for biodiversity purposes, few of these revegetation projects could be considered to be designed specifically to enhance bird communities. The plantings undertaken at Clarkesdale were heavily weighted towards the establishment of bird-attractant plants, and the benefits of such plantings (using non-indigenous native plants) are poorly understood (Munro *et al.* 2007). This study has shown that by expressly targeting the habitat requirements of a range of birds, revegetation of this kind can restore and enhance many components of bird communities, with benefits for the landscape avifauna.

Confounding variables (site fertility, EVC)

A general problem with retrospective studies is that the current pattern of habitats may be confounded with other factors that have a direct or indirect influence on the subjects of interest. In this case, many of the planted sites were originally on cleared paddocks, and still retained many of the features of grazed pasture, including introduced grasses and weeds and associated birds typical of open country (e.g. Australian Magpies and various cockatoos). When land is cleared for farming, the most fertile land is usually selected first (McIntyre *et al.* 2002), and this will have various habitat features not represented in the remaining native forest. Examination of pre-European vegetation maps (not available at the start of the study) confirmed that most of the planted sites would have been originally classed as Valley Grassy Forest, an EVC that grows on fertile soils and has been extensively cleared. This EVC is no longer represented at Clarkesdale and its bird fauna is not well known. It is often included with Heathy Dry Forest in a 'dry forests' grouping of EVCs, but the remaining stands of Heathy Dry Forest are an imperfect benchmark, representing a less fertile state on the fertility gradient. Valley Grassy Forest is one of many EVCs that have been extensively cleared, which need further work to document their values as habitat for fauna.

The fertility of cleared sites may have been further enhanced by agricultural practices including fertiliser application. Some forest birds and mammals are known to respond positively to natural site-fertility (Braithwaite *et al.* 1984), and fertiliser application can reduce plant diversity in pastures (McIntyre *et al.* 2002; Dorrough *et al.* 2006). Creeklines and gullies provide high-quality habitats for birds in agricultural landscapes (Jansen & Robertson 2001) and in intact forest landscapes (Loyn 1985; Mac Nally *et al.* 2000; Palmer & Bennett 2006). In our study, natural fertility, history of fertiliser application and similar confounding variables may have combined to drive some of the observed differences between planted sites and native forest. Nevertheless, the main structural and floristic features of the planted sites are a product of deliberate management (shrub establishment). Hence, it seems likely that most of the observed differences were influenced predominantly by this aspect of management history.

Positive effects of restoration planting

No sites were located entirely on cleared land, as little of it remains in the Sanctuary. Cleared pasture usually attracts few forest or woodland birds, and open-country specialists such as cockatoos and Australian Magpies dominate the bird fauna, at low density (Loyn 1985; Hobbs *et al.* 2003; Kavanagh *et al.* 2007; Loyn *et al.* 2007). A greater range of species may occur near the edge of woody vegetation, including Yellow-rumped Thornbills (recorded here on planted sites) and Willie Wagtails. Willie Wagtails were recorded previously at the Sanctuary (Anon. 1999; our unpubl. data), and may have disappeared in response to the reduced area of cleared land, and lack of domestic stock that produce dung and hence insects attractive to this species (Loyn 2002). Recent surveys in gorse-infested paddocks nearby revealed higher densities of forest or woodland birds than in cleared paddocks, but much lower densities than at the planted sites or native forest in the Sanctuary (our unpubl. data).

If the planted sites initially consisted of cleared pasture, they would have supported few forest or woodland birds. Hence at least 90% of the current bird population on these sites has probably benefitted directly from the management efforts. Many of the shrubs planted were not indigenous to the local area, and include Australian native plants mainly from Western Australia (Anon. 1999). Nevertheless, the effect of this planting has been to restore habitat for many of the forest birds that would have been present before clearing. Some species may not be as common as in adjacent native forest (e.g. treecreepers) and some have undoubtedly benefitted more than others. It seems clear that honeyeaters have benefitted greatly from the planting, and two or three species (New Holland Honeyeater, Red Wattlebird, and probably Eastern Spinebill) are now much more common than in native forest. It is reasonable to conclude that the planting of native trees and shrubs has resulted in greatly increased populations of honeyeaters and other bird species, to levels at least comparable with native forest and far exceeding those that are generally found in open or gorse-infested paddocks.

When Gordon Clarke embarked on his planting program, his vision was to establish something even richer as bird habitat than native forest. He refused to plant stringybarks and scent-barks (Anon. 1999), focussing instead on shrubs and trees that would be highly attractive to a wide range of bird species. This study shows that the planting has succeeded in moving towards his stated vision for Clarkesdale Bird Sanctuary. At the same time, it allows us to recognise some additional measures that would help achieve further conservation benefits as discussed opposite.

Tree-hollows

Tree-hollows are among the most difficult habitat elements to restore to cleared land, because useful hollows are usually found in large old trees and they take many decades to develop (Mackowski 1984; Wormington & Lamb 1999; Gibbons *et al.* 2000; Whitford 2002; Vesk & Mac Nally 2006). Many of the hollow-nesting birds that made use of planted sites at the Clarkesdale Bird Sanctuary are wide-ranging species such as parrots and cockatoos, and would have been able to gain access to nest-sites at various distances in nearby native habitat. A shortage of hollows in the planted sites could have contributed to the low numbers of treecreepers and Striated Pardalotes. However, treecreepers generally prefer larger trees for feeding, and select rough-barked species such as those that remain dominant in native forest (Loyn 1985; Noske 1985). They have proved to be scarce in eucalypt plantations elsewhere (Hobbs *et al.* 2003; Kavanagh *et al.* 2005; Loyn *et al.* 2007). Experiments with artificial hollows (nest-boxes) could help clarify whether hollows are limiting the abundance of these birds on the planted sites, and some nest-boxes have now been installed. One generalist species, the Grey Shrike-thrush, showed a positive response to trees with small hollows, despite not being an obligate hollow-nester (Higgins & Peter 2002). However, crevices and complex structures of bark and branches are among the wide range of sites used by this species both for nesting and foraging (Recher 1991; Higgins & Peter 2002). Such structures are more likely to be found in old trees (many of which contain hollows) than in young planted trees.

Any negative effects of restoration planting?

A more difficult question is to consider whether the planting has had any negative effects. Honeyeaters are notoriously aggressive, and some species habitually exclude a range of other bird species (e.g. Ford 1989; Clarke 1995). The most pugnacious species are the miners *Manorina* spp. (Dow 1977; Loyn 1987; Higgins *et al.* 2001) and these were absent from the survey sites. Noisy Miners *M. melanocephala* prefer structurally simple treed habitats and are known to be disadvantaged by the presence of dense shrubs and small trees (Hastings & Beattie 2006). The nature of the plantings undertaken would not provide favourable habitat for the Noisy Miner, which does occur in the Piggoreet district. Other species that were recorded, notably Red Wattlebirds and smaller honeyeaters, can have similar effects to miners (Higgins *et al.* 2001; Loyn 2002). A monitoring program has been initiated to monitor bird abundance on this set of sites to document any further changes in abundance of honeyeaters, small insectivorous birds or other species. Three species of honeyeater were more numerous in the planted sites than in native forest. One of these (Red Wattlebird) has become one of the most common and conspicuous birds in suburban gardens, where it has been blamed for reducing numbers of small insectivorous birds. Another (New Holland Honeyeater) is primarily a bird of heathlands, heathy forest or locally in parks and gardens where it specialises at feeding on nectar of proteaceous plants (Emison *et al.* 1987; Higgins *et al.* 2001). Small numbers enter other forest types erratically to feed on prolific nectar sources, with mistletoe often being favoured (Loyn 1985). However, it is unlikely that native forest at the Sanctuary would have supported resident populations of this species at anywhere near the levels observed at the planted sites. If the management aim had been to re-establish natural vegetation with a natural bird fauna, it may have been necessary to reduce the plantings of proteaceous species or other plants attractive to this group of honeyeaters.

Woodland decliners: An opportunity to do more?

There has been concern expressed that revegetation in many cases is not arresting the declines in species that are most vulnerable to and have been most affected by habitat loss (Selwood *et al.* 2009), although this may be a function of the young age of much of the revegetation previously investigated (e.g. Kavanagh *et al.* 2007; Loyn *et al.* 2007; Barrett *et al.* 2008). For example, in an agricultural landscape in southern New South Wales, young plantings ($<$3 years old) of native trees and shrubs were rarely occupied by ground-foraging insectivores, and such species were considered to be slipping through the revegetation safety net (Barrett *et al.* 2008). The observation that ground-foraging insectivorous species (e.g. Restless Flycatcher, Jacky Winter, Scarlet Robin and Buff-rumped Thornbill) were commonly recorded at planted sites at Clarkesdale Bird Sanctuary provides some grounds for optimism that as recent or future plantings mature they may come to provide habitat requirements of ground-foraging insectivores (see Antos & Bennett 2006, 2008).

Many bird species typical of woodland or open-forest environments have declined substantially in south-eastern Australia in recent decades (Robinson 1993; Ford *et al.* 2001). These include four woodland species that have disappeared from the Sanctuary in historical times (Brown Treecreeper, Speckled Warbler, Hooded Robin and Diamond Firetail). All four species inhabit dry forests with an open understorey, although Speckled Warblers and Hooded Robins also make use of shrub thickets. It is tempting to speculate that all may have been associated with Valley Grassy Forest, the lost EVC at this location. The management efforts at the Clarkesdale Bird Sanctuary have not been targeted explicitly at these species. Any attempt to restore habitat for these birds would need to consider their detailed requirements (see Antos & Bennett 2006, 2008), including hollows and fallen timber for Brown Treecreepers, grass seed for Diamond Firetails, and open spaces among trees and shrubs for Hooded Robins. Some woodland birds remain at the Sanctuary despite declines elsewhere, and make use of planted sites (e.g. Restless Flycatcher and Jacky Winter). Both require open areas with scattered trees, and may benefit from deliberate planning to provide appropriate mixtures and configurations of trees, shrubs, open spaces and other habitat elements. Coarse woody debris is likely to be an important requirement for Restless Flycatchers, as they often search for spiders and insects among fallen branches (Higgins *et al.* 2006). Sustainable supplies of coarse woody debris are likely to increase as plantings mature, and to depend greatly on management of fire and other human interventions (Mac Nally *et al.* 2001). Specific attention to the needs of these species may be helpful in avoiding further species loss, or restoring habitat for these declining species. For example, where dense grass cover may deter species such as the Brown Treecreeper and Hooded Robin, managed grazing may provide a potential mechanism to reduce grass cover and increase habitat suitability.

We conclude that planting programs such as this one can contribute positively at least for some species, but a range of approaches over many spatial scales will be needed to provide for the complex needs of the full suite of species. An important general message is to emphasise the importance (and difficulty) of recognising the nature of original vegetation on a site, and the habitat features in greatest need of restoration in the broader landscape.

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References

Anon. (1999), *Clarkesdale Bird Sanctuary Draft Management Plan*, facilitated by M. Henderson, Trust for Nature, Melbourne.

Antos, M.J. & Bennett, A.F. (2006), 'Foraging ecology of ground-feeding woodland birds in temperate woodlands of southern Australia', *Emu* **106**, 29–40.

Antos, M.J. & Bennett, A.F. (2008), 'Where exactly do ground-foraging woodland birds forage? Foraging sites and microhabitat selection in temperate woodlands in southern Australia', *Emu* **108**, 201–211.

Barrett, G.W., Freudenberger, D., Drew, A., Stol, J., Nicholls, A.O. & Cawsey, E.M. (2008), 'Colonisation of native tree and shrub plantings by woodland birds in an agricultural landscape', *Wildlife Research* **35**, 19–32.

Braithwaite, L.W., Turner, J. & Kelly, J. (1984), 'Studies on the arboreal marsupial fauna of eucalypt forests being harvested for wood pulp at Eden, NSW. 3: Relationships between faunal densities, eucalypt occurrence and foliage nutrients, and soil parent materials', *Australian Wildlife Research* **11**, 41–48.

Clarke, M.F. (1995), 'Co-operative breeding in Australian birds: A review of hypotheses and evidence', *Corella* **19**, 73–90.

Dorrough, J., Moxham, C., Turner, V. & Sutter, G. (2006), 'Soil phosphorus and tree cover modify the effects of livestock grazing on plant species richness in Australian grassy woodland', *Biological Conservation* **130**, 394–405.

Dow, D.D. (1977), 'Indiscriminate interspecific aggression leading to almost sole occupancy of space by a single species of bird', *Emu* **77**, 115–121.

Emison, W.B., Beardsell, C.M., Norman, F.I., Loyn, R.H. & Bennett, S.C. (1987), *Atlas of Victorian Birds*, Dept Conservation, Forests & Lands and Royal Australasian Ornithologists Union, Melbourne.

Ford, H.A. (1989), *Ecology of Birds: An Australian Perspective*, Surrey Beatty, Sydney.

Ford, H.A., Barrett, G.W., Saunders, D.A. & Recher, H.F. (2001), 'Why have birds in the woodlands of southern Australia declined?', *Biological Conservation* **97**, 71–88.

Gibbons, P., Lindenmayer, D.B., Barry, S.C. & Tanton, M.T. (2000), 'The formation of hollows in eucalypts from temperate forests', *Pacific Conservation Biology* **6**, 218–228.

Hastings, R.A. & Beattie, A.J. (2006), 'Stop the bullying in the corridors: Can including shrubs make your revegetation more Noisy Miner free?', *Ecological Management & Restoration* **7**, 105–112.

Higgins, P.J. & Peter, J.M. (Eds) (2002), *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 6, Oxford University Press, Melbourne.

Higgins, P.J., Peter, J.M. & Cowling, S.J. (Eds) (2006), *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 7, Oxford University Press, Melbourne.

Higgins, P.J., Peter, J.M. & Steele, W.K. (Eds) (2001), *Handbook of Australian, New Zealand and Antarctic Birds*, vol. 5, Oxford University Press, Melbourne.

Hobbs, R., Catling, P.C., Wombey, J.C., Clayton, M., Atkins, L. & Reid, A. (2003), 'Faunal use of Blue Gum (*Eucalyptus globulus*) plantations in southwestern Australia', *Agroforestry Systems* **58**, 195–212.

Jansen, A. (2005), 'Avian use of restoration plantings along a creek linking rainforest patches on the Atherton Tablelands, North Queensland', *Restoration Ecology* **13**, 275–283.

Jansen, A. & Robertson, A.I. (2001), 'Riparian bird communities in relation to land management practices in floodplain woodlands of southeastern Australia', *Biological Conservation* **100**, 173–185.

Kavanagh, R., Law, B., Lemckert, F., Stanton, M., Chidel, M., Brassil, T., Towerton, A. & Herring, M. (2005), *Biodiversity in Eucalypt Plantings Established to Reduce Salinity*, Joint Venture Agroforestry Program, Canberra.

Kavanagh, R.P., Stanton, M.A. & Herring, M.W. (2007), 'Eucalypt plantings on farms benefit woodland birds in south-eastern Australia', *Austral Ecology* **32**, 635–650.

Loyn, R.H. (1985), 'Ecology, distribution and density of birds in Victorian forests', pp. 33–46 in Keast, A., Recher, H.F., Ford, H.A. & Saunders, D. (Eds), *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management*, Surrey Beatty, Sydney.

Loyn, R.H. (1986), 'The 20 minute search — A simple method for counting forest birds', *Corella* **10**, 58–60.

Loyn, R.H. (1987), 'Effects of patch area and habitat on bird abundances, species numbers and tree health in fragmented Victorian forests', pp. 65–75 in Saunders, D.A., Arnold, G.W., Burbidge, A.A. & Hopkins, A.J.M. (Eds), *Nature Conservation: The Role of Remnants of Native Vegetation*, Surrey Beatty, Sydney.

Loyn, R.H. (1998), 'Birds in patches of old-growth ash forest, in a matrix of younger forest', *Pacific Conservation Biology* **4**, 111–121.
Loyn, R.H. (2002), 'Patterns of ecological segregation among forest and woodland birds in south-eastern Australia', *Ornithological Science* **1**, 7–27.
Loyn, R.H., McNabb, E.G., Macak, P. & Noble, P. (2007), 'Eucalypt plantations as habitat for birds on previously cleared farmland in south-eastern Australia', *Biological Conservation* **137**, 533–548.
Mackowski, C.M. (1984), 'The ontogeny of hollows in Blackbutt (*Eucalyptus pilularis*) and its relevance to the management of forests for possums, gliders and timber', pp. 553–567 in Smith, A.P. & Hume, I.D. (Eds), *Possums and Gliders*, Surrey Beatty, Sydney.
Mac Nally, R., Parkinson, A., Horrocks, G., Conole, L. & Tzaros, C. (2001), 'Relationships between terrestrial vertebrate diversity, abundance and availability of coarse woody debris on south-eastern Australian floodplains', *Biological Conservation* **99**, 191–205.
Mac Nally, R., Soderquist, T. & Tzaros, C.L. (2000), 'The conservation value of mesic gullies in dry woodland landscapes: Avian communities in the box-ironbark system of southern Australia', *Biological Conservation* **93**, 293–302.
Martin, W.K., Eyears-Chaddock, M., Wilson, B.R. & Lemon, J. (2004), 'The value of habitat reconstruction to birds at Gunnedah, New South Wales', *Emu* **104**, 177–189.
McIntyre, S., McIvor, J.G. & Heard, K.M. (2002), *Managing and Conserving Grassy Woodlands*, CSIRO, Melbourne.
Munro, N.T., Lindenmayer, D.B. & Fischer, J. (2007), 'Faunal response to revegetation in agricultural areas of Australia: A review', *Ecological Management & Restoration* **8**, 199–207.
Noske, R. (1985), 'Habitat use by three bark-foragers of eucalypt forests', pp. 193–204 in Keast, A., Recher, H.F., Ford, H.A. & Saunders, D. (Eds), *Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management*, Surrey Beatty, Sydney.
Palmer, G.C. & Bennett, A.F. (2006), 'Riparian zones provide for distinct bird assemblages in forest mosaics of south-east Australia', *Biological Conservation* **130**, 447–457.
Recher, H.F. (1991), 'The conservation and management of eucalypt forest birds: Resource requirements for nesting and foraging', pp. 25–34 in Lunney, D. (Ed.), *Conservation of Australia's Forest Fauna*, Royal Zoological Society of NSW, Sydney.
Reid, R. & Wilson, G. (1985), *Agroforestry in Australia and New Zealand*, Goddard & Dobson, Box Hill, Vic.
Robinson, D. (1993), '*Valé* Toolern Vale: The loss of our woodland birds', *Wingspan* **9**, 1–3, 20–21.
Salt, D., Lindenmayer, D.B. & Hobbs, R.J. (2004), *Trees and Biodiversity: A Guide for Farm Forestry*, Rural Industries Research & Development Corporation, Canberra.
Selwood, K., Mac Nally, R. & Thomson, J. (2009), 'Native bird breeding in a chronosequence of revegetated sites', *Oecologia* **159**, 435–466.
Vesk, P.A. & Mac Nally, R. (2006), 'The clock is ticking – Revegetation and habitat for birds and arboreal mammals in rural landscapes of southern Australia', *Agriculture Ecosystems & Environment* **112**, 356–366.
Whitford, K.R. (2002), 'Hollows in Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) trees. I: Hollow sizes, tree attributes and ages', *Forest Ecology & Management* **160**, 201–214.
Wormington, K. & Lamb, D. (1999), 'Tree hollow development in wet and dry sclerophyll eucalypt forest in south-east Queensland, Australia', *Australian Forestry* **62**, 336–345.
Youl, R., Marriott, S. & Nabben, T. (2006), *Landcare in Australia*, 5th edn, SILC.

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Appendix 1

Bird species recorded during bird surveys at 27 sites and seven dates at Clarkesdale Bird Sanctuary, central-western Victoria, 1999–2001, with the guilds for feeding, nesting, migration, status and habitat to which they have been assigned. See p. 73 for key to guild codes.

Species	*Scientific name*	*Feed*	*Nest*	*Migr.*	*Status*	*Hab.*
Common Bronzewing	*Phaps chalcoptera*	SG	N	N	N	F
Purple Swamphen	*Porphyrio porphyrio*	W	G	N	N	W
Eurasian Coot	*Fulica atra*	W	G	N	N	W
Australasian Grebe	*Tachybaptus novaehollandiae*	W	G	N	N	W
Little Black Cormorant	*Phalacrocorax sulcirostris*	W	N	N	N	W
Little Pied Cormorant	*Microcarbo melanoleucos*	W	N	N	N	W
Masked Lapwing	*Vanellus miles*	OG	G	N	N	W
Black-fronted Dotterel	*Elseyornis melanops*	W	G	N	N	W
White-faced Heron	*Egretta novaehollandiae*	W	N	N	N	W
Black Swan	*Cygnus atratus*	W	G	N	N	W
Australian Shelduck	*Tadorna tadornoides*	W	G	N	N	W
Pacific Black Duck	*Anas superciliosa*	W	G	N	N	W
Swamp Harrier	*Circus approximans*	V	G	N	N	O
Brown Goshawk	*Accipiter fasciatus*	V	N	N	N	F
Wedge-tailed Eagle	*Aquila audax*	V	N	N	N	F
Whistling Kite	*Haliastur sphenurus*	V	N	N	N	O
Brown Falcon	*Falco berigora*	V	N	N	N	O
Yellow-tailed Black-Cockatoo	*Calyptorhynchus funereus*	ST	LH	N	N	F
Sulphur-crested Cockatoo	*Cacatua galerita*	SG	LH	N	N	O
Long-billed Corella	*Cacatua tenuirostris*	SG	LH	N	N	O
Galah	*Eolophus roseicapillus*	SG	LH	N	N	O
Crimson Rosella	*Platycercus elegans*	ST	LH	N	N	F
Eastern Rosella	*Platycercus eximius*	SG	LH	N	N	O
Blue-winged Parrot	*Neophema chrysostoma*	SG	SH	S	N	F
Laughing Kookaburra	*Dacelo novaeguineae*	V	LH	N	N	F
Sacred Kingfisher	*Todiramphus sanctus*	V	SH	S	N	F
White-throated Needletail	*Hirundapus caudacutus*	A	X	S	N	F
Pallid Cuckoo	*Cacomantis pallidus*	OT	BP	S	N	O
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	M	BP	S	N	F
Horsfield's Bronze-Cuckoo	*Chalcites basalis*	C	BP	S	N	H
Shining Bronze-Cuckoo	*Chalcites lucidus*	C	BP	S	N	F
Welcome Swallow	*Hirundo neoxena*	A	L	N	N	O
Tree Martin	*Petrochelidon nigricans*	A	SH	S	N	F
Grey Fantail	*Rhipidura albiscapa*	C	N	S	N	F
Satin Flycatcher	*Myiagra cyanoleuca*	C	N	S	N	F
Restless Flycatcher	*Myiagra inquieta*	OT	N	N	N	F
Jacky Winter	*Microeca fascinans*	OT	N	N	N	F
Scarlet Robin	*Petroica boodang*	OT	N	N	N	F
Eastern Yellow Robin	*Eopsaltria australis*	DG	N	N	N	F

Appendix 1 continued

Species	*Scientific name*	*Feed*	*Nest*	*Migr.*	*Status*	*Hab.*
Golden Whistler	*Pachycephala pectoralis*	M	N	N	N	F
Rufous Whistler	*Pachycephala rufiventris*	C	N	S	N	F
Grey Shrike-thrush	*Colluricincla harmonica*	G	N	N	N	F
Magpie-lark	*Grallina cyanoleuca*	OG	N	N	N	O
Crested Shrike-tit	*Falcunculus frontatus*	B	N	N	N	F
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	C	N	S	N	F
White-winged Triller	*Lalage sueurii*	C	N	S	N	F
Striated Thornbill	*Acanthiza lineata*	C	N	N	N	F
Brown Thornbill	*Acanthiza pusilla*	M	N	N	N	F
Buff-rumped Thornbill	*Acanthiza reguloides*	OT	L	N	N	F
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	OG	N	N	N	O
White-browed Scrubwren	*Sericornis frontalis*	DG	N	N	N	F
Little Grassbird	*Megalurus gramineus*	W	N	N	N	W
Australian Reed-Warbler	*Acrocephalus australis*	W	N	S	N	W
Superb Fairy-wren	*Malurus cyaneus*	OT	N	N	N	F
Dusky Woodswallow	*Artamus cyanopterus*	A	L	S	N	F
Varied Sittella	*Daphoenositta chrysoptera*	B	N	N	N	F
White-throated Treecreeper	*Cormobates leucophaea*	B	SH	N	N	F
Red-browed Treecreeper	*Climacteris erythrops*	B	SH	N	N	F
Mistletoebird	*Dicaeum hirundinaceum*	F	N	N	N	F
Spotted Pardalote	*Pardalotus punctatus*	C	B	N	N	F
Striated Pardalote	*Pardalotus striatus*	C	SH	N	N	F
Silvereye	*Zosterops lateralis*	F	N	S	N	F
White-naped Honeyeater	*Melithreptus lunatus*	N	N	N	N	F
Brown-headed Honeyeater	*Melithreptus brevirostris*	N	N	N	N	F
Eastern Spinebill	*Acanthorhynchus tenuirostris*	N	N	N	N	F
Yellow-faced Honeyeater	*Lichenostomus chrysops*	N	N	S	N	F
White-eared Honeyeater	*Lichenostomus leucotis*	N	N	N	N	F
New Holland Honeyeater	*Phylidonyris novaehollandiae*	N	N	N	N	H
Red Wattlebird	*Anthochaera carunculata*	N	N	N	N	F
Red-browed Finch	*Neochmia temporalis*	SG	N	N	N	F
White-winged Chough	*Corcorax melanorhamphos*	OT	N	N	N	F
Grey Currawong	*Strepera versicolor*	DG	N	N	N	F
Australian Magpie	*Cracticus tibicen*	OG	N	N	N	O
Bassian Thrush	*Zoothera lunulata*	DG	N	N	N	F
Common Blackbird	*Turdus merula*	DG	N	N	I	F
Australian Raven	*Corvus coronoides*	V	N	N	N	F
Little Raven	*Corvus mellori*	V	N	N	N	O
European Goldfinch	*Carduelis carduelis*	SG	N	N	I	O
Common Starling	*Sturnus vulgaris*	OG	SH	N	I	O

Key to guild codes

Feeding guilds

Insectivores taking insects mainly from open air (A), bark (B), tree-canopy (C), damp ground below shrubs or low understorey (DG), generally broad range of substrates (G), tall shrubs (i.e. mid-storey insectivores: M), open ground among trees (OT) or open ground often not among trees (OG).
Nectarivores taking nectar as a major part of their diet (N).
Frugivores taking fruit as a major part of their diet (F).
Seed-eaters taking small seeds close to the ground (SG) or feeding on seed and other food (e.g. gall insects) at all levels (ST).
Carnivores taking vertebrate prey as a major part of their diet (V).
Waterbirds (W).

Nesting guilds

Brood-parasites (BP); species nesting in burrows (B), on the ground (G), on ledges (L), in large or medium-sized hollows in trees (LH), in small hollows in trees (SH) or in 'normal' situations among branches of trees or shrubs (N). Migratory species that do not nest in Australia are marked X.

Migratory status

Summer visitors (S) are rare or absent from these forests for a predictable period each winter. Others are classed as non-migratory (N), although portions of the population may migrate or move nomadically. (Grey Fantail is an intermediate case, and was classed as a summer migrant for this analysis.)

Status

Species that were introduced to Australia (I) or native (N).

Habitat

Forest or woodland birds (F); heathland birds (H); open-country birds (O); or waterbirds (W).

Appendix 2

Mean abundances (birds per 10 counts) of bird species, and mean numbers of species per count, in three main habitats at the Clarkesdale Bird Sanctuary, central-western Victoria, 1999–2001. Waterbirds are excluded unless observed on sites away from small dams. Probability *P* values are shown where $P < 0.1$, bracketed if $0.1 > P > 0.05$. Species are marked – where data were too sparse or skewed for useful statistical comparisons between native forest on ridges and slopes and planted sites on similar topography, NS if differences were not significant ($P > 0.1$).

Species	*Broad habitat*	*P value*	*Mean birds per 10 counts*		
		Native forest vs planted sites on similar topography	*Native forest*	*Planted sites on similar topography*	*Planted river-flats and gully*
Number of sites:			**11**	**13**	**3**
Common Bronzewing		NS	0.3	1.1	1.0
Purple Swamphen		–	0	0	0.5
White-faced Heron		–	0.1	0	1.9
Australian Shelduck		–	0	0.2	0
Swamp Harrier		–	0	0	0.5

Appendix 2 continued

Species *Broad habitat*	*P value* Native forest vs planted sites on similar topography	*Mean birds per 10 counts* Native forest	*Planted sites on similar topography*	*Planted river-flats and gully*
Brown Goshawk	–	0.1	0.1	0
Wedge-tailed Eagle	–	0.1	0	0
Whistling Kite	–	0	0.1	0
Brown Falcon	–	0	0.1	0
Yellow-tailed Black-Cockatoo	NS	0.5	1.2	3.3
Sulphur-crested Cockatoo	NS	0.5	0.1	0.5
Long-billed Corella	NS	0.4	0	2.9
Galah	–	0	0.2	1.0
Crimson Rosella	NS	4.8	5.7	6.2
Eastern Rosella	NS	0.6	0.9	2.9
Blue-winged Parrot	NS	0.6	0.9	0
Laughing Kookaburra	–	0.1	0.3	0
Sacred Kingfisher	–	0.6	0.1	1.4
White-throated Needletail	–	0	0.9	0
Pallid Cuckoo	–	0.1	0.5	0
Fan-tailed Cuckoo	–	0	0.4	0
Horsfield's Bronze-Cuckoo	–	0	0.2	0
Shining Bronze-Cuckoo	–	0.4	0.2	0.5
Welcome Swallow	NS	1.3	0.2	1.9
Tree Martin	–	0	0.7	18.1
Grey Fantail	NS	5.5	5.1	9.0
Satin Flycatcher	–	0.4	0.2	1.0
Restless Flycatcher	NS	0.4	0.9	1.4
Jacky Winter	NS	1.0	1.3	0.5
Scarlet Robin	NS	1.0	0.3	0.5
Eastern Yellow Robin	NS	1.3	3.5	2.9
Golden Whistler	NS	0.8	1.5	1.9
Rufous Whistler	NS	2.3	2.4	4.3
Grey Shrike-thrush	NS	2.9	2.1	1.4
Magpie-lark[a]	–	0.3	0	0
Crested Shrike-tit	–	0.1	0.3	0
Black-faced Cuckoo-shrike	NS	0.8	0	0
White-winged Triller	–	0	0.1	0
Striated Thornbill	NS	4.2	2.9	7.6
Brown Thornbill	NS	3.5	5.4	4.8
Buff-rumped Thornbill	NS	0.9	1.4	1.0
Yellow-rumped Thornbill	NS	0.9	2.7	0
White-browed Scrubwren	(0.086)	1.6	4.1	8.6
Little Grassbird	–	0	0	0.5

Appendix 2 continued

Species / *Broad habitat*	*P value*	*Mean birds per 10 counts*		
	Native forest vs planted sites on similar topography	*Native forest*	*Planted sites on similar topography*	*Planted river-flats and gully*
Australian Reed-Warbler	–	0	0	0.5
Superb Fairy-wren	0.001	3.8	17.4	23.8
Dusky Woodswallow	NS	0.8	0.7	1.0
Varied Sittella	–	0	0.5	0
White-throated Treecreeper	0.031	4.2	2.2	2.4
Red-browed Treecreeper	–	0.1	0	0.5
Mistletoebird	–	0.3	0	0
Spotted Pardalote	0.037	2.3	0.5	0.5
Striated Pardalote	NS	2.1	1.0	2.4
Silvereye[b]	–	0.1	0	0
White-naped Honeyeater	NS	17.5	18.0	20.0
Brown-headed Honeyeater	NS	2.3	1.9	3.3
Eastern Spinebill	(0.068)	0.6	2.2	1.9
Yellow-faced Honeyeater	NS	3.0	4.2	0.5
White-eared Honeyeater	NS	1.7	1.2	0
New Holland Honeyeater	0.006	1.7	31.3	31.0
Red Wattlebird	0.031	1.0	10.5	8.1
Red-browed Finch	NS	0	1.8	1.0
White-winged Chough	–	6.5	0.5	0
Grey Currawong	NS	0.9	0.5	0.5
Australian Magpie	0.023	0.9	4.7	1.9
Bassian Thrush	–	0	0.2	0
Common Blackbird	NS	0.4	1.4	1.9
Australian Raven	0.038	0.1	1.0	1.0
Little Raven	NS	0.4	1.0	0.5
European Goldfinch	–	0	0.2	1.4
Common Starling	–	0	0.1	0.5
Total (including all waterbirds)		89.4	151.8	202.9
Total (excluding all waterbirds)		89.3	151.6	186.7
Introduced birds		0.4	1.7	3.8
Introduced as %		0.4	1.1	1.9
Bird species per count:		**4.3**	**6.0**	**8.1**

[a]Magpie-larks usually inhabit treed farmland and open woodland on river-flats, and avoid extensive areas of forest. The few records in this study happened to come from native forest.

[b]Flocks of Silvereyes often move into artificial habitats (including gardens and orchards) to feed on fruit, nectar or insects. They were remarkably rare during this study, and could be expected to occur erratically in planted sites when suitable foods are available. ■