Bird communities in remnant woodland on the New England Tablelands, New South Wales

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We provide a geographic and landscape context for ongoing studies on bird communities in eucalypt woodland remnants on the New England Tablelands, New South Wales. We draw together several surveys that have not been published in the scientific literature, and integrate them with previously published material. A total of 142 woodland bird species, including 12 threatened species, was recorded in remnant woodland in the area above 900 m elevation from 50 km SSE to 100 km NNW of Armidale. There was a positive relationship between remnant size and bird species richness. Woodland reserves >300 ha supported significantly more species than remnants <100 ha on private land. Intensively surveyed reserves also had more species than remnants surveyed more casually. Threatened and other declining species occurred mainly in medium-sized (100–300 ha) and large reserves; foraging guilds of small to medium-sized, ground and above-ground insectivores were impoverished in degraded medium-sized and small remnants on private land. Almost the full range of woodland bird species was found at one or more sites, indicating their conservation value. However, some species were found in few sites or were only vagrants at a site. Active management will be needed to retain the current diversity of bird species in such heavily cleared landscapes.

Key words: Bird communities; Remnant woodland; Habitat complexity; Species richness.

INTRODUCTION

BIRD communities in eucalypt woodlands in New England have been substantially altered by extensive clearing, grazing and logging. There have been several community-level studies (Ford *et al.* 1985, 1986; Barrett *et al.* 1994; Oliver *et al.* 1999), and many studies on the ecology and biology of individual species of woodland birds, mainly passerines and raptors, in the region (see Ford *et al.* 2001). In addition, several surveys, or long-term observations, remain unpublished or have appeared only in reports or theses. The aim here is to draw together these unpublished surveys and integrate them with previously published work.

This paper provides the geographical and avifaunal context for ongoing studies on the ecology of some declining woodland passerines. The sites surveyed in the present study are complementary to those surveyed by Barrett *et al.* (1994) and Oliver *et al.* (1999), on the Northern Tablelands of New South Wales. They include Imbota and Yina Nature Reserves (formerly Eastwood and Hillgrove Creek State Forests), which have been the sites of ecological study over 20 years. In addition, we present bird lists from sites on private and public land that were visited briefly for faunal surveys, as well as more opportunistic data from sites of various tenures.

Studies of bird communities in relation to landscape and habitat variables typically involve a small number of visits to many small plots within remnants of various sizes. These often miss species that occur at low density. Long-term studies throughout remnants should detect all species in open habitats such as eucalypt woodlands, including migrants and nomadic species. They may also detect vagrants that are not part of the community of that remnant, but which may provide some insight into the mobility of species through the landscape.

The results of this study are considered in the light of earlier studies, and of Major *et al.* (2001), Seddon *et al.* (2003) and Watson *et al.* (2003) on the South-west Slopes and Southern Tablelands, with regard to bird species richness and patch characteristics. All these studies were concerned with the problem of threatened and declining land-birds in the heavily cleared and fragmented eucalypt woodlands of the sheep-wheat belt of New South Wales. The present study concerns woodland remnants above 900 metres elevation on the Great Dividing Range.

STUDY AREA AND METHODS

The study was centred on the Armidale Plateau previously described by Barrett *et al.* (1994), but mostly targetted different woodland remnants. The study area falls within the New England Tableland Bioregion (Thackway and Cresswell 1995). The present study sites were distributed from tableland woodland on the Macleay Gorges rim 20–50 km east-south-east of Armidale (30°30'S, 151°40'E), north-westwards in a band terminating at the 900 m contour at Kings Plains (29°37'S, 151°25'E), 100 km north-north-west of Armidale (Fig. 1).

The physiography, climate and vegetation of the study area are described elsewhere (Heatwole and Simpson 1986; Barrett *et al.* 1994; Heatwole *et al.* 1995, 2003; Benson and Ashby 2000). The

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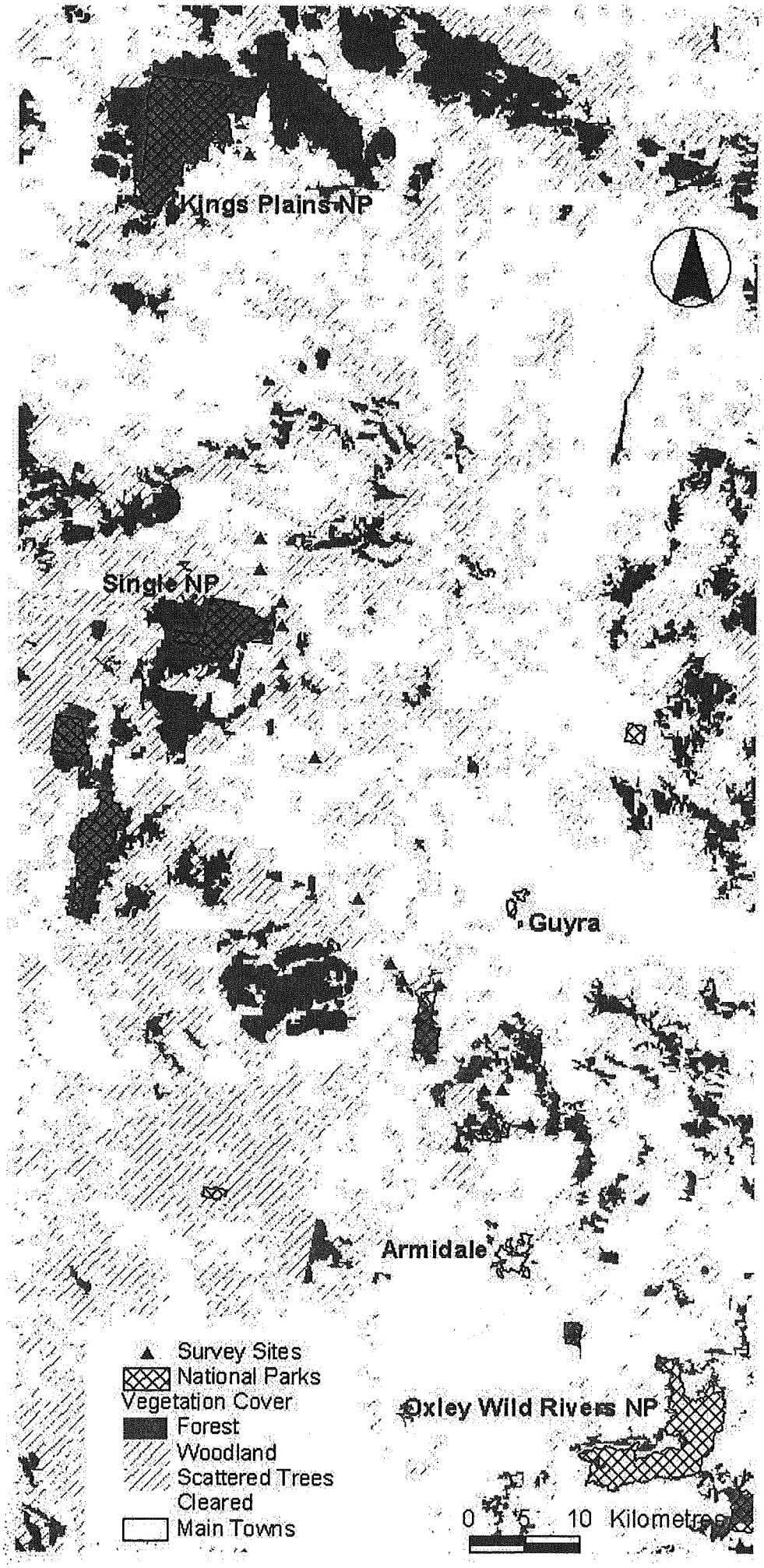

Fig. 1. Map of study area showing remnant woodland cover and survey sites.

undulating Armidale Plateau, at 900–1 300 m elevation on the Great Dividing Range, is a patchwork of three bedrock types giving rise to soils of varying fertility: basalt (richest), granite (poorest), and metasediments ("trap"). Summer-dominant rainfall averages about 800 mm per year, though it varies greatly between years; winters are cold (mean July minimum 0°C), with about 45 frost days and the occasional snowfall.

The vegetation of the Armidale Plateau, described by Benson and Ashby (2000), is a fragmented or "variegated" patchwork (McIntyre and Barrett 1992) of eucalypt open forest and woodland, native and introduced pasture, remnant paddock trees, and cultivation, with particular eucalypt alliances characteristic of the various soil types.

Woodland remnants were classified by size as large (>300 ha), medium (100–300 ha) or small (<100 ha), and by land tenure (national park or nature reserve versus private or other unprotected land). Long-term data, including formal counts, were collated for two large reserves, two medium-sized reserves and one medium-sized unprotected remnant around Armidale. "Snapshot" data from surveys conducted in 1995 were collated for two other large reserves, one of the aforementioned medium-sized reserves, and six medium-sized and 13 small patches on private land, between Armidale and Kings Plains (Table 1). Nocturnal survey included call-playback and spotlighting.

Long-term studies

Large reserves

A bird list was compiled for the Dangars Falls to Gara Gorge section of Oxley Wild Rivers National Park, and contiguous gorge-rim woodland (box/gum/stringybark) east to Metz Gorge and Hillgrove, deriving from systematic and non-systematic visits by SD of a day, part-day, evening or overnight (with nocturnal survey), irregularly (on average biannually, mainly to either Dangars Falls or Gara Gorge) from 1990 to 2003, covering all seasons.

Duval Nature Reserve (formerly State Forest), on Mt Duval, was described by NPWS (2002a). The site, including surrounding intact woodland of Newholme Field Laboratory (UNE), is approximately 1 000 ha of woodland marked by a permanent 200 × 200 m grid covering the whole property and reserve. The vegetation grades from gum–stringybark grassy open forest on the mountain, through stringybark shrubby open forest on the slopes, to box–gum grassy woodland on the lower slopes and flats. SD surveyed all wooded areas in 1986 by walking every second 200 m gridline once in winter, and repeating (on the alternate gridlines) in spring. Counts were conducted by SD also in October 1988 and 1989 on three adjacent, parallel gridlines on the lower slopes: each 2 km line was surveyed five times, on different mornings, in each year. Nocturnal birds were surveyed

Table 1. Survey period and method for each woodland remnant category (further details in text). NP = national park; NR = nature reserve; CR = Crown reserve; Newholme = Newholme Field Laboratory (UNE). Opportunistic includes non-systematic data; all other surveys were systematic counts. For medium and small remnants on private land, n = No. patches surveyed in total and by season.

Site	Survey period	Survey method
Large reserves:		
Oxley Wild Rivers NP	1990–2003	Opportunistic
Duval NR/Newholme	1987–2002	Opportunistic
	Winter + spring 1986	Transect counts
	Oct. 1988 and 1989	Transect counts
Boorolong NR	Mar. 1995	Area search
	Oct. 1995	Point counts
Single NP	Apr. 1995, Jan. 1997	Area search
Medium reserves:		
Imbota NR	1979–2003	Opportunistic
	1978–79, 1981–82	Transect counts
Yina NR	1980–98, 2001–03	Opportunistic
	1981–82	Transect counts
	Mar. 1995	Area search
	Oct. 1995	Point counts
Medium unprotected:		
Sunnyside CR	1980–96	Opportunistic
	1981–91	Quarterly area search
Medium private (n = 6)	Mar.–Apr. 1995 (n = 3)	Area search
	Oct. 1995 (n = 4)	Point counts
Small private (n = 13)	Mar.–Apr. 1995 (n = 6)	Area search
	Oct. 1995 (n = 9)	Point counts

opportunistically. Additional records were obtained from mist-netting and observational studies in spring–summer 1987–1991 and approximately annual opportunistic visits in various seasons to 2002.

Medium-sized reserves

Imbota Nature Reserve was described by Ford *et al.* (1985, 1986), NPWS (2002b) and Hunter (2003a). The vegetation is stringybark grassy woodland, with box codominant on ridges and box–gum codominant on lower slopes and flats, and a scattered midstorey mainly of bipinnate wattles. A comprehensive bird list was compiled by SD from sightings and mist-netting captures during intensive (almost daily) fieldwork from winter 2000 to autumn 2003, and from other fieldwork, including nocturnal birds, in spring–summer 1990–1999. Additional records, and formal count data, were obtained from Ford and Bell (1981) and Ford *et al.* (1985, 1986), and from intensive fieldwork by SD and HAF in this reserve since 1979.

Yina Nature Reserve was described by Ford *et al.* (1985), NPWS (2002c) and Hunter (2003b). The vegetation is similar to Imbota, though with a sparser midstorey. Records were obtained by SD from autumn 2001 to winter 2003 during monthly visits for fieldwork, and from opportunistic visits during 1980–1998. Additional species, and formal count data, were obtained from Ford *et al.* (1985). The reserve was visited by HAF and colleagues since 1980, but less frequently than Imbota. A snapshot survey was also conducted in Yina in 1995 (see below).

Medium-sized unprotected remnant

Sunnyside Crown Reserve, Armidale, is a public reserve for travelling livestock (intermittently grazed "common"). The vegetation is similar to Imbota and Yina, though more open with evidence of past clearing, and little midstorey. SD made occasional, opportunistic visits during 1980–1996, with one nocturnal survey. The main source of data was a bird list compiled by B. Williams at least quarterly from 1981 to 1991, using the RAOU Australian Bird Count method (3 × 20 minutes/1 ha search per survey day; Clarke *et al.* 1999).

Snapshot surveys

The snapshot surveys were conducted in 1995, in autumn, spring or both. Autumn (March–April) surveys consisted of area searches (circuitous transects) within the perimeter of each of one to four representative 1 km² cells (90 min each, 4 km per cell), depending on the size of the woodland remnant (20 cells across 12 remnants), conducted in the morning and late afternoon. All parts of each cell were visited, and deviations were made to specific habitat features (e.g., gullies, thickets). Spring (October) surveys consisted of between two and 20 half-hour point-counts at one to six points per site, depending on the size of the remnant, conducted by S. Trémont, A. Ley and J. Ford (30 points across 15 remnants). Nocturnal surveys were conducted at all sites and in both seasons, the number of evening surveys proportional to the size of the remnant.

All remnants visited in 1995 were within (or partly within) a 2–3 km wide easement corridor for a proposed public utility. Survey sites within the corridor were selected from aerial photographs on the basis of intact tree cover in patches >20 ha in size, regardless of tenure. All such accessible patches within the corridor were visited at least once. One small remnant was about 15 ha, but the others were >30 ha.

Cell-based autumn surveys in 1995 incorporated an informal stopping rule; that is, survey ceased when species accumulation was judged to be reaching a plateau. For point-based spring surveys in 1995, there was provision to include opportunistic records in the patch total. In view of the results and recommendations of Watson (2003a, 2004) and Possingham *et al.* (2004), it is likely that most species currently in small remnants would have been detected.

Large reserves

Boorolong Nature Reserve (formerly State Forest), described by NPWS (2002d), was surveyed in autumn and spring, and Single National Park (formerly State Forest) was surveyed in autumn and summer. The vegetation in each is similar to Mt Duval, Imbota and Yina. Autumn surveys consisted of four 1 km² cells in Boorolong NR surveyed once each, and one 1 km² cell in Single NP surveyed twice. Twenty counts were conducted across five points (four counts per point; 10 h) in Boorolong NR in spring. Single NP was surveyed in January 1997 by a series of 1-ha, 20-minute area searches (eight points surveyed twice each over two mornings).

Medium-sized reserve

Yina was surveyed in autumn and spring (March and October) 1995. The autumn survey consisted of a 90-minute, 4 km circuitous early-morning transect within the perimeter of the 1.5 km² reserve, with nocturnal survey on one evening. The spring survey consisted of two 30-minute morning point-counts at each of two points, with nocturnal survey on two evenings, conducted by S. Trémont.

Medium-sized remnants

Of six sites on private land between Armidale and Kings Plains, two were surveyed in autumn only, three in spring only, and one in both

seasons. Autumn sites each had two or three 1 km² cells surveyed. Spring surveys consisted of between two and 12 half-hour point-counts across one to six points per site, usually two counts per point (23 counts, 11 points; 11.5 h).

Small remnants

Of 13 sites on private land between Armidale and Kings Plains, four were surveyed in autumn only, seven in spring only, and two in both seasons. Autumn sites had the intact woodland within one 1 km² cell (or part thereof) surveyed. Spring surveys consisted of two half-hour point-counts at one or two points per site (22 counts, 12 points; 11 h).

Habitats

Habitat attributes were scored for sites having snapshot surveys conducted in spring 1995, by estimating vegetation cover at each point (Appendix 3). Large and medium-sized reserves were less grazed and so had more low and tall shrubs than small patches did, although these aspects were not quantified at more than a superficial level. This assumption about habitat structure, based on our results (Appendix 3), is supported by descriptions of the 1995 sites (Appendix 3) and by the work of Reid (2000), Hobbs (2001), Clarke (2003) and James (2003) on vegetation and grazing regimes. Large and medium remnants on public land had intact or recovering ground and shrub layers; they were also spatially diverse, with some open and some scrubby areas. Medium remnants on private land were grazed by stock, and small remnants were grazed to severely degraded. This trend matched that of bedrock type (i.e., soil nutrient status): granitic or metasediment (low-nutrient) on large and medium remnants, to basaltic (high-nutrient) on the smallest, most degraded remnants. Habitat attributes providing resources for woodland birds (e.g., tree cover, shrub cover, grass height, hollows, logs), tended on average to be more available in medium than in small patches on private land (Appendix 3). Shrub cover was greater in medium than in small patches. Open, grassy woodland with few shrubs tended to be on better soils and hence was grazed, fragmented and cleared. Reserves tended to be on the more rocky, infertile, scrubby sites.

Habitat types surveyed included the following.

Grassy or shrubby open forest or woodland on granitic soils: Messmate *Eucalyptus obliqua*–Forest Ribbon Gum *E. nobilis* on Mt Duval; New England Blackbutt *E. andrewsii* on ridges; Silvertop Stringybark *E. laevopinea*–Mountain Gum *E. dalrympleana*–Manna Gum *E. viminalis*–Rough-barked Apple *Angophora floribunda* in gullies.

Grassy or shrubby woodland on metasediments: Broad-leaved Stringybark *E. caliginosa* or Broad-leaved Stringybark–Apple Box *E. bridgesiana* on ridges; Yellow Box *E. melliodora*–Red Gum *E. blakelyi* on lower slopes and gullies.

Grassy woodland on basalt: Manna Gum.

Shrubby open forest on clay-enriched sandy soils: Mountain Gum–Yellow Box–Rough-barked Apple.

Grassy gallery forest: River She-oak *Casuarina cunninghamiana* on stream banks.

The shrub layer tended to be dominated by Blackthorn *Bursaria spinosa* or teatree *Leptospermum* on granite, and bipinnate wattles *Acacia*, daisy-bush *Olearia* or biddy bush *Cassinia* (with or without Blackthorn) on sediments, and was sparse to absent on basalt and beneath gallery forest.

Noisy Miners were present at most sites (Table 2). However, they tended to occur only or mainly on the periphery of large and medium reserves, whereas they penetrated or dominated most of the medium and small patches on unprotected land.

Analysis

Distance from neighbouring patches, and degree of isolation of subject patches, were not stratified. Data were collated as species presence/absence at each survey site. Only open-forest or woodland birds are considered here.

Survey intensity was variable within and between remnant categories, and having survey effort proportional to remnant size may have biased detection probability towards larger remnants (the "sampling effect"; Mac Nally and Horrocks 2002a). However, the large and medium remnants had a combination of snapshot and long-term surveys, and the snapshot-only nature of surveys in small remnants was offset by the large number of remnants in that category.

Only systematic data, from formal counts, were used in statistical analysis, although non-systematic data (including opportunistic records of vagrants) were used to complete the species lists for sites surveyed long term. Records of vagrants to Imbota and Yina before the main study period are listed separately (Appendix 1) and omitted from the analysis, to reduce bias from the disproportionate survey effort at those sites. Results for large reserves are also listed individually (Appendix 2).

Count-only data violate the "equal-time" rule for patches of different sizes (Mac Nally and Horrocks 2002a), because there were few repeat counts or replicate survey points per patch in

Table 2. Land-bird species recorded in each woodland remnant size category: I = Imbota, Y = Yina Nature Reserves; numbers in data field = number of remnants in which a species was recorded. Numbers in parentheses = number of sites sampled in each category. Bold = threatened species listed in NSW or federally, or by Garnett and Crowley (2000); E = endangered, V = vulnerable, NT = near-threatened. Underlined = other species declining or at risk from further habitat fragmentation and degradation in NSW woodlands (from Barrett *et al.* 1994; Reid 1999; Watson *et al.* 2003). [O] = open-country, [E] = edge species; [I] = increaser; [V] = vagrant; * = introduced. For details of large reserves >300 ha (Table 1), see Appendix 1.

Species	>300 ha reserves (4)	100–300 ha reserves (2)	100–300 ha private/TSR (7)	<100 ha private (13)
Pacific Baza *Aviceda subcristata*	1	IY[V]		
Square-tailed Kite *Lophoictinia isura* V		**I[V]**		
[O]Black Kite *Milvus migrans*		I[V]		
Whistling Kite *Haliastur sphenurus*	1	IY		
Brown Goshawk *Accipiter fasciatus*	3	IY	3	2
Collared Sparrowhawk *Accipiter cirrhocephalus*	3	IY		
Wedge-tailed Eagle *Aquila audax*	4	IY	2	3
Little Eagle *Hieraaetus morphnoides*	2	IY	1	1
[OI]Nankeen Kestrel *Falco cenchroides*			1	6
[O]Brown Falcon *Falco berigora*	2	IY	2	1
Australian Hobby *Falco longipennis*	1	IY		
Peregrine Falcon *Falco peregrinus*	2	I	2	
Painted Button-quail *Turnix varia*	2	IY	2	
Common Bronzewing *Phaps chalcoptera*	1	I	1	1
[OI]Crested Pigeon *Ocyphaps lophotes*			2	3
Diamond Dove *Geopelia cuneata*	1			
Peaceful Dove *Geopelia striata*	1	I		
Bar-shouldered Dove *Geopelia humeralis*			1	
Glossy Black-Cockatoo *Calyptorhynchus lathami* V	**1**	**I[V]**		
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*	3	IY	1	2
[OI]Galah *Cacatua roseicapilla*	4	IY	5	8
[I]Sulphur-crested Cockatoo *Cacatua galerita*	4	I	1	3
[OI]Cockatiel *Nymphicus hollandicus*				1
Rainbow Lorikeet *Trichoglossus haematodus*	2	I	3	3
Musk Lorikeet *Glossopsitta concinna*	3	I	4	3
Little Lorikeet *Glossopsitta pusilla*	3	IY	4	2
Australian King-Parrot *Alisterus scapularis*	4	I	3	4
Crimson Rosella *Platycercus elegans*	4	IY	7	11
[EI]Eastern Rosella *Platycercus eximius*	4	IY	5	12
Swift Parrot *Lathamus discolor* E		**I[V]**		
[OI]Red-rumped Parrot *Psephotus haematonotus*		IY	3	4
Turquoise Parrot *Neophema pulchella* V		**I[V]**		
Oriental Cuckoo *Cuculus saturatus*			1	
Pallid Cuckoo *Cuculus pallidus*	2	IY	4	3
Brush Cuckoo *Cacomantis variolosus*	3	I	2	2
Fan-tailed Cuckoo *Cacomantis flabelliformis*	3	IY	4	2
Black-eared Cuckoo *Chrysococcyx osculans*		I	1	
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	2	I	1	
Shining Bronze-Cuckoo *Chrysococcyx lucidus*	4	IY	4	4
Common Koel *Eudynamys scolopacea*				1
Channel-billed Cuckoo *Scythrops novaehollandiae*	3	I	4	1
Barking Owl *Ninox connivens* V	**1**	**I**		
Southern Boobook *Ninox novaeseelandiae*	4	IY	2	6
[O]Barn Owl *Tyto alba*				1
Tawny Frogmouth *Podargus strigoides*	3	IY	4	5
White-throated Nightjar *Eurostopodus mystacalis*				1
Australian Owlet-nightjar *Aegotheles cristatus*	4	IY	5	4
White-throated Needletail *Hirundapus caudacutus*	2	I	1	1
Azure Kingfisher *Alcedo azurea*			1	
Laughing Kookaburra *Dacelo novaeguineae*	4	IY	6	11
Sacred Kingfisher *Todiramphus sanctus*	4	IY	4	5
Rainbow Bee-eater *Merops ornatus*	2	I		
Dollarbird *Eurystomus orientalis*	3	IY	3	3
Superb Lyrebird *Menura novaehollandiae*	1			
White-throated Treecreeper *Cormobates leucophaeus*	4	IY	7	11
Red-browed Treecreeper *Climacteris erythrops*	4		4	1
Brown Treecreeper *Climacteris picumnus* V	**4**	**IY**	**3**	**4**
Superb Fairy-wren *Malurus cyaneus*	4	IY	7	9
Variegated Fairy-wren *Malurus lamberti*	1			
Spotted Pardalote *Pardalotus punctatus*	4	IY	6	9
Striated Pardalote *Pardalotus striatus*	4	IY	6	13
White-browed Scrubwren *Sericornis frontalis*	4		5	4
Speckled Warbler *Chthonicola sagittata* V	**3**	**IY**	**2**	**2**
Weebill *Smicrornis brevirostris*	1	IY	2	2
Brown Gerygone *Gerygone mouki*	1	I		
Western Gerygone *Gerygone fusca*			1	1
[E]White-throated Gerygone *Gerygone olivacea*	4	IY	5	8
Brown Thornbill *Acanthiza pusilla*	4	IY	6	5

Table 2 — *continued*

Species	>300 ha reserves (4)	100–300 ha reserves (2)	100–300 ha private/TSR (7)	<100 ha private (13)
Buff-rumped Thornbill *Acanthiza reguloides*	4	IY	6	9
[EI]Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	4	IY	3	6
Yellow Thornbill *Acanthiza nana*	2			1
Striated Thornbill *Acanthiza lineata*	4	IY	7	10
Southern Whiteface *Aphelocephala leucopsis*			1	1
Red Wattlebird *Anthochaera carunculata*	4	IY	6	10
Striped Honeyeater *Plectorhyncha lanceolata*			1[V]	
Noisy Friarbird *Philemon corniculatus*	4	IY	5	10
Regent Honeyeater *Xanthomyza phrygia* E		I[V]		
[EI]Noisy Miner *Manorina melanocephala*	4	IY	5	11
Yellow-faced Honeyeater *Lichenostomus chrysops*	4	IY	7	12
White-eared Honeyeater *Lichenostomus leucotis*	4	IY	6	6
Yellow-tufted Honeyeater *Lichenostomus melanops*	1			
Fuscous Honeyeater *Lichenostomus fuscus*	3	IY	4	3
[I]White-plumed Honeyeater *Lichenostomus penicillatus*				2
Brown-headed Honeyeater *Melithreptus brevirostris*	4	IY	5	6
White-naped Honeyeater *Melithreptus lunatus*	4	IY	5	10
Painted Honeyeater *Grantiella picta* V			I	
Eastern Spinebill *Acanthorhynchus tenuirostris*	4	IY	7	9
Scarlet Honeyeater *Myzomela sanguinolenta*	2	IY	1	
Jacky Winter *Microeca fascinans*	4	IY	2	2
Scarlet Robin *Petroica multicolor*	4	IY	3	7
Red-capped Robin *Petroica goodenovii*		I	2	
Flame Robin *Petroica phoenicea*	2			
Rose Robin *Petroica rosea*	1	IY	1	
Hooded Robin *Melanodryas cucullata* V	1	Y	1	
Eastern Yellow Robin *Eopsaltria australis*	3	IY	5	3
Spotted Quail-thrush *Cinclosoma punctatum*	2			
Varied Sittella *Daphoenositta chrysoptera*	4	IY	4	5
Crested Shrike-tit *Falcunculus frontatus*	4	IY	5	4
Golden Whistler *Pachycephala pectoralis*	4	IY	4	7
Rufous Whistler *Pachycephala rufiventris*	4	IY	7	9
Grey Shrike-thrush *Colluricincla harmonica*	4	IY	7	10
Black-faced Monarch *Monarcha melanopsis*		I[V]	1[V]	
Leaden Flycatcher *Myiagra rubecula*	4	IY	3	6
Satin Flycatcher *Myiagra cyanoleuca*	1	I	1	1
Restless Flycatcher *Myiagra inquieta*	3	IY	3	2
[OI]Magpie-lark *Grallina cyanoleuca*	4	IY	5	6
Rufous Fantail *Rhipidura rufifrons*	1	I	1	
Grey Fantail *Rhipidura fuliginosa*	4	IY	7	9
[I]Willie Wagtail *Rhipidura leucophrys*	4	IY	5	8
Spangled Drongo *Dicrurus bracteatus*	1		1	
[I]Black-faced Cuckoo-shrike *Coracina novaehollandiae*	4	IY	7	9
White-bellied Cuckoo-shrike *Coracina papuensis*		I	1	1
Cicadabird *Coracina tenuirostris*	4	I	2	2
White-winged Triller *Lalage sueurii*	2	I	1	3
Olive-backed Oriole *Oriolus sagittatus*	4	IY	4	5
Masked Woodswallow *Artamus personatus*		I		
White-browed Woodswallow *Artamus superciliosus*	1	I	1	
Dusky Woodswallow *Artamus cyanopterus*	3	IY	3	6
[EI]Grey Butcherbird *Cracticus torquatus*	4	IY	7	9
[OI]Pied Butcherbird *Cracticus nigrogularis*	2	IY[V]	2	6
[EI]Australian Magpie *Gymnorhina tibicen*	4	IY	7	12
[I]Pied Currawong *Strepera graculina*	4	IY	6	11
[OI]Australian Raven *Corvus coronoides*	4	IY	7	11
Forest Raven *Corvus tasmanicus* NT	3	IY	2	2
[OI]Little Raven *Corvus mellori*		I[V]		
[I]Torresian Crow *Corvus orru*	1	IY	3	4
White-winged Chough *Corcorax melanoramphos*	4	IY	5	4
Satin Bowerbird *Ptilonorhynchus violaceus*	1	I		
Double-barred Finch *Taeniopygia bichenovii*	1	IY	2	3
Plum-headed Finch *Neochmia modesta*			1	
Red-browed Finch *Neochmia temporalis*	4	I	6	3
Diamond Firetail *Stagonopleura guttata* V	3	IY	2	3
*[OI]European Goldfinch *Carduelis carduelis*		I		
Mistletoebird *Dicaeum hirundinaceum*	4	IY	5	9
[OI]Welcome Swallow *Hirundo neoxena*	3	I	3	4
Tree Martin *Hirundo nigricans*	3	IY	1	3
[OI]Fairy Martin *Hirundo ariel*		I	1	
Rufous Songlark *Cincloramphus mathewsi*	1	IY	3	1
Silvereye *Zosterops lateralis*	4	IY	5	7
*[I]Common Blackbird *Turdus merula*		Y		
Bassian Thrush *Zoothera lunulata*	1			
*[OI]Common Starling *Sturnus vulgaris*		IY	1	4
Total	111	116	110	97

small remnants, whereas the other categories had repeat counts and/or multiple survey points. However, there were many more small remnants surveyed. Count-only data were compared by means of by one-way ANOVA and Tukey's pair-wise comparisons test.

RESULTS

Not surprisingly, remnants studied long term had more species recorded than snapshot sites or sites visited casually. Overall, woodland remnants in the study area supported a diverse community of 142 bird species (Table 2). Large and medium public reserves tended to support more species than medium or small patches on private land (all data sources; Table 3). The intensively surveyed stock reserve (Sunnyside, 98 species) also supported a high total. The numerous small remnants collectively captured almost as many species as the other remnant categories, although there were more species of open country or edge (as classified by Barrett *et al.* 1994) in the small remnants (Table 2). The total for small remnants was boosted by one fairly intact road verge 1.3 km × 250 m supporting an exceptional 70 species, the others having fewer (18–56 species).

Using count-only data (total 109 species, Table 3) from the snapshot surveys for large remnants (Newholme in 1988–89, Boorolong NR, Single NP), formal counts for Imbota and Yina (Ford and Bell 1981; Ford *et al.* 1985; 1995 surveys in Yina), and snapshot surveys for medium remnants on private land (excluding the stock reserve), there was a significant difference in species richness among patch-size categories (one-way ANOVA: $F_{1,20} = 5.27$, $P < 0.001$). Large reserves had significantly more species than small remnants (Tukey's pair-wise comparisons test); medium reserves (Imbota and Yina) were not significantly different from the other categories. Despite the low totals per patch for most small remnants, the grand total for small remnants exceeded the count-only grand totals for the other remnant categories (Table 3).

Small remnants (n = 7) that had repeat counts, but low total numbers of species (<40 species), were among the smallest (mean 44 ha; five were 15–50 ha), were dominated by Noisy Miners, and had low shrub cover (<30%, n = 1; <10%, n = 6). Conversely, small remnants (n = 5) that had higher total numbers of species (40–70 species) were 30–100 ha (mean 61 ha; three were >60 ha), lacked Noisy Miners (n = 2), or were riparian sites (n = 2).

Eleven threatened and one near-threatened species (state or nationally listed) were recorded in the study sites (Table 2), though mostly as vagrants, probably owing to the high survey effort at those sites. Of these species, the vulnerable large or non-passerine species (raptors, parrots) or endangered species (Swift Parrot, Regent Honeyeater) were recorded only in large and medium public reserves. Of the vulnerable species in medium unprotected patches, two (Painted Honeyeater and Hooded Robin) were recorded only in the stock reserve. The remaining vulnerable (Brown Treecreeper, Speckled Warbler, Diamond Firetail) and near-threatened species (Forest Raven) were recorded across all tenures, but were poorly represented in medium and small patches on private land. Similarly, many of the other declining or potentially at-risk species (as defined in Table 2) were well represented in public reserves and the stock reserve, but poorly represented in medium and/or small patches on private land. The Southern Whiteface appears to be almost absent from the study area, but may never have been common.

Some species are also declining in medium reserves. The Hooded Robin and Double-barred Finch disappeared from Imbota in the 1980s after the 1980–81 drought, and several other species formerly recorded on counts (by Ford

Table 3. Number of bird species recorded by woodland patch size and tenure. L = large public reserve; MR = medium public reserve; MP = medium private or other unprotected land; S = small remnant on private land; n = number of remnants sampled in each category. Criteria as in Table 2. Range and mean refer to the number of species per patch in each category. Data sources in Table 1 and Methods.

Category	n	Total species	Range	Mean
All data sources:				
L	4	111	53–96	79
MR	2	116	80–114	97
MP	7	110	39–98	55
S	13	97	18–70	38
Formal counts only:				
L	3	86	53–73	64**
MR	2	78	61–66	64
MP	6	89	39–56	47
S	13	97	18–70	38**

**significantly different ($P < 0.001$).

and Bell 1981; Ford *et al.* 1985, 1986) are now usually absent from Imbota or their numbers have declined there, e.g., Peaceful Dove, White-eared Honeyeater, Red-browed Finch, Diamond Firetail (SD, HAF, pers. obs.). The Eastern Yellow Robin, Brown Treecreeper and Double-barred Finch disappeared from Yina in the 1980s or 1990s: they were formerly present (SD, pers. obs.; 1995 surveys), but in 2001 were not found during intensive searches for the Yellow Robin (Debus and Ford, unpubl. data). The Brown Treecreeper was reintroduced to Yina, but has since disappeared completely from this patch.

Avian foraging guilds, after Ford *et al.* (1986) and Watson *et al.* (2003), are defined by body size, foraging substrate (e.g., ground/foliage/air) and food type (e.g., insects/nectar/seeds). Foraging guilds tending to be poorly represented in medium and/or small remnants on private land included (Table 2):

(a) Small, ground (Speckled Warbler, Southern Whiteface, Jacky Winter) and/or above-ground insectivores (Weebill, *Petroica* robins, Varied Sittella, flycatchers);

(b) Medium-sized, ground (button-quail, Yellow and Hooded Robins) and/or above-ground insectivores (cuckoos, treecreepers, Crested Shrike-tit, flycatchers, small cuckoo-shrikes, White-winged Triller, woodswallows);

(c) Small and medium-sized, ground granivores (finches, doves);

(d) Medium-sized nectarivores (small lorikeets, Swift Parrot, Regent and Painted Honeyeaters, although the latter three species were mostly absent from all sites);

(e) Large or specialized carnivores (raptors and owls).

Declining species subject to ecological investigations being reported elsewhere, the Scarlet Robin and Eastern Yellow Robin (Debus and Ford, unpubl. data), were well represented in reserves, but moderately to poorly represented in medium and small remnants on private land (Table 2). The Pied Currawong, a predator of robin nests (Debus, unpubl. data), was prevalent in all remnant categories.

Some species found only in large reserves tended to be coastal and escarpment forest species that reach their inland limit on the Macleay Gorge rim or on Mt Duval near Armidale (Superb Lyrebird, Bassian Thrush), are localized at high elevation (>1 000 m) on Mt Duval (breeding Flame Robins), are locally habitat-specific (Spotted Quail-thrush), or occur on the Western Slopes (Yellow-tufted Honeyeater). Some others are inland species that barely reach the study area on the Western Slopes (Diamond Dove, Variegated Fairy-wren). Similarly, others that were occasionally recorded in the medium reserves (including Sunnyside) are eastern species of moist forest (Brown Gerygone, Black-faced Monarch, Spectacled Monarch, Rufous Fantail, Spangled Drongo, Satin Bowerbird) or species of the Western Slopes (Turquoise Parrot, Striped Honeyeater, Red-capped Robin, Masked Woodswallow). These species, and others such as the Glossy Black-Cockatoo and White-plumed Honeyeater, are not normally present at Imbota, Yina or Sunnyside, and occur there only as vagrants (Table 2; Appendix 2).

Species found only or mainly in small and medium remnants on private land (Table 2) tended to be common, adaptable species that are stable or increasing in the sheep-wheat belts in southern Australia. Examples include medium to large, ground granivores (Crested Pigeon, Galah, rosellas), and medium to large, ground or above-ground carnivores and omnivores (Nankeen Kestrel, Laughing Kookaburra, large artamids, corvids), that are tolerant of or frequently use open areas. Notable increasers include the Noisy Miner and Grey Butcherbird, which were not recorded during past counts in Imbota or Yina (though they did occur in these reserves), but have since become common there (1995 surveys and SD, HAF, pers. obs.). The miner did not normally occur at the sites where formal counts were conducted in Imbota.

DISCUSSION

The high total for large reserves is partly explained by the greater survey effort over many years in Oxley Wild Rivers National Park (96 species) and Newholme (92 species), as compared with snapshot surveys in Boorolong Nature Reserve (53 species) and Single National Park (73 species). The same caveat applies to the greater survey effort, over more years, in Imbota versus Yina Nature Reserves (114 vs 80 species). Of the medium remnants on unprotected land, only the stock reserve (98 species) had comparable survey effort to that in the intensively surveyed reserves. Historical records, mainly of vagrants (Appendix 2), increase the total for Imbota even further.

Despite the limitations of the approach taken in this study, and in particular the snapshot-only data for small remnants, the survey procedure made it likely that most species currently in small remnants were detected. Many of the species consistently missing from small patches were among the commonest and most readily detected in Imbota, such as Speckled Warbler, robins, Varied Sittella, flycatchers (SD, HAF, pers. obs.).

The results of this study support the conclusions of Barrett *et al.* (1994), Major *et al.* (2001), Mac Nally and Horrocks (2002a,b),

Seddon *et al.* (2003) and Watson *et al.* (2003) on the relationship between patch size, habitat complexity (e.g., shrub cover) and bird communities, and requirements of many species either for large reserves or medium-sized patches of healthy woodland. A common theme in these studies, including the present, is the connection between remnant size, tenure, land use, habitat health and complexity, bird species richness, and the impoverishment of, and dominance by Noisy Miners in small remnants. However, small remnants of high quality can support high bird diversity (Fischer and Lindenmayer 2002; Seddon *et al.* 2003), as found in the present study. A complicating factor is spatial heterogeneity in large patches, the natural gradient in vegetation type according to geology, and the correlation between remnant size and substrate, so that this study could not separate the effect of habitat structure and remnant size.

Imbota and Yina are the only reasonably sized (>100 ha) conservation reserves on fairly flat land at (locally) lower elevation, close to Armidale, in an otherwise heavily cleared and grazed landscape. They sample locally fairly rich habitat (Yellow Box–Blakely's Red Gum and stringybark grassy and shrubby woodland) on metasediments, with permanent water. Between them, they capture most of the regional woodland bird diversity, including all the threatened species (though many as vagrants) and the other declining species and guilds. However, the processes causing declines in woodland birds elsewhere are also affecting them, as evidenced by the loss of species from both reserves. Furthermore, these reserves may do little to help to conserve regionally the threatened species that occur there as vagrants; these are likely to depend on larger or better-quality patches elsewhere.

The regional total of 142 species essentially encompasses the 97 woodland species recorded by Barrett *et al.* (1994) within a smaller (40 km) radius of Armidale. Our total closely matches the 143 woodland species recorded by Oliver *et al.* (1999) on the western edge of the tablelands and higher parts of the North-west Slopes, west of Armidale. These bird assemblages are broadly similar, but differ in the representation of eastern and western species. Both studies recorded a similar suite of threatened woodland birds: only the Black-chinned Honeyeater *Melithreptus gularis* and Grey-crowned Babbler *Pomatostomus temporalis* were unrecorded in the present study, whereas Oliver *et al.* did not record Glossy Black-Cockatoo or Forest Raven.

Management implications

The results of this study support the conclusion of Barrett *et al.* (1994) that a network of healthy patches >20 ha on private land, complementing the few conservation reserves, would help to conserve woodland bird diversity in agricultural parts of the tablelands. Travelling stock reserves are an important part of such a network, and deserve appropriate management for their biodiversity values. However, several woodland bird species are declining regionally and disappearing from even quite large remnants, a process that may be ongoing given the low breeding success and population size of many of these species (Ford *et al.* 2001; Debus and Ford, unpubl. data).

The results of this study suggest that remnant woodland on the Armidale Plateau and wider tablelands >900 m elevation has conservation values similar to the more extensive woodlands and open forests farther west, studied by Oliver *et al.* (1999). Similar conclusions apply on the importance of larger/richer patches, particularly for threatened and other declining species, and the need for appropriate management to maintain avian diversity.

The situation of the Azure Kingfisher on the tablelands illustrates the pressing need for conservation and restoration of riparian zones (Oliver *et al.* 1999; Jansen and Robertson 2001), and improvement of water quality. We obtained only one record of the kingfisher, in an area where many of the watercourses on private land are treeless or otherwise severely degraded. Perhaps this species should be added to the list of decliners, and considered near-threatened in the sheep-wheat belt.

Patch-scale attributes such as habitat quality and complexity are emerging as at least as important as patch size and landscape context (Major *et al.* 2001; Mac Nally and Horrocks 2002b; Seddon *et al.* 2003; Watson 2003b; Watson *et al.* 2003). Small patches of high quality can be valuable (Fischer and Lindenmayer 2002; Seddon *et al.* 2003). Management for avian diversity on the tablelands, particularly in small, degraded patches in a heavily cleared landscape, will therefore need to address the issue of habitat quality in small patches, as patch quality is critical over the long term (Watson 2003b). Relevant aspects of habitat quality include the shrub layer, coarse woody debris and the abundance of Noisy Miners.

This study, particularly the long-term sites, sets a benchmark. Further neglect of habitat remnants is likely to see a decline in habitat quality and loss of bird species. Active management, such as tree planting, shrub enhancement and control of invasive species, is likely to be needed to retain the currently rich avifauna of this region.

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APPENDIX 1

Species recorded at each of the large reserves: O = Oxley Wild Rivers National Park; D = Duval Nature Reserve and Newholme Field Laboratory (UNE); B = Boorolong NR; S = Single NP. Other codes as in Table 2.

Species	O	D	B	S
Pacific Baza *Aviceda subcristata*		X		
Whistling Kite *Haliastur sphenurus*	X			
Brown Goshawk *Accipiter fasciatus*	X	X		X
Collared Sparrowhawk *Accipiter cirrhocephalus*	X	X	X	
Wedge-tailed Eagle *Aquila audax*	X	X	X	X
Little Eagle *Hieraaetus morphnoides*	X	X		
Brown Falcon *Falco berigora*	X	X		
Australian Hobby *Falco longipennis*		X		
Peregrine Falcon *Falco peregrinus*	X	X		
Painted Button-quail *Turnix varia*		X		X
Common Bronzewing *Phaps chalcoptera*				X
Diamond Dove *Geopelia cuneata*				X
Peaceful Dove *Geopelia striata*		X		
Glossy Black-Cockatoo *Calyptorhynchus lathami* V	X			
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*	X	X	X	
Galah *Cacatua roseicapilla*	X	X	X	X
Sulphur-crested Cockatoo *Cacatua galerita*	X	X	X	X
Rainbow Lorikeet *Trichoglossus haematodus*	X	X		
Musk Lorikeet *Glossopsitta concinna*	X	X		X
Little Lorikeet *Glossopsitta pusilla*	X	X		X
Australian King-Parrot *Alisterus scapularis*	X	X	X	X
Crimson Rosella *Platycercus elegans*	X	X	X	X
Eastern Rosella *Platycercus eximius*	X	X	X	X
Pallid Cuckoo *Cuculus pallidus*	X	X		
Brush Cuckoo *Cacomantis variolosus*	X	X	X	
Fan-tailed Cuckoo *Cacomantis flabelliformis*	X	X		X
Horsfield's Bronze-Cuckoo *Chrysococcyx basalis*	X	X		
Shining Bronze-Cuckoo *Chrysococcyx lucidus*	X	X	X	X
Channel-billed Cuckoo *Scythrops novaehollandiae*	X	X	X	
Barking Owl *Ninox connivens* V		X		
Southern Boobook *Ninox novaeseelandiae*	X	X	X	X
Tawny Frogmouth *Podargus strigoides*	X	X	X	
Australian Owlet-nightjar *Aegotheles cristatus*	X	X	X	X
White-throated Needletail *Hirundapus caudacutus*	X	X		
Laughing Kookaburra *Dacelo novaeguineae*	X	X	X	X
Sacred Kingfisher *Todiramphus sanctus*	X	X	X	X
Rainbow Bee-eater *Merops ornatus*	X	X		
Dollarbird *Eurystomus orientalis*	X	X		X
Superb Lyrebird *Menura novaehollandiae*	X			
White-throated Treecreeper *Cormobates leucophaeus*	X	X	X	X
Red-browed Treecreeper *Climacteris erythrops*	X	X	X	X
Brown Treecreeper *Climacteris picumnus* V	X	X	X	X
Superb Fairy-wren *Malurus cyaneus*	X	X	X	X
Variegated Fairy-wren *Malurus lamberti*				X
Spotted Pardalote *Pardalotus punctatus*	X	X	X	X
Striated Pardalote *Pardalotus striatus*	X	X	X	X
White-browed Scrubwren *Sericornis frontalis*	X	X	X	X
Speckled Warbler *Chthonicola sagittata* V	X	X	X	
Weebill *Smicrornis brevirostris*				X
Brown Gerygone *Gerygone mouki*	X			
White-throated Gerygone *Gerygone olivacea*	X	X	X	X

Appendix 1 — *continued*

Species	O	D	B	S
Brown Thornbill *Acanthiza pusilla*	X	X	X	X
Buff-rumped Thornbill *Acanthiza reguloides*	X	X	X	X
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	X	X	X	X
Yellow Thornbill *Acanthiza nana*				X
Striated Thornbill *Acanthiza lineata*	X	X	X	X
Red Wattlebird *Anthochaera carunculata*	X	X	X	X
Noisy Friarbird *Philemon corniculatus*	X	X	X	X
Noisy Miner *Manorina melanocephala*	X	X	X	X
Yellow-faced Honeyeater *Lichenostomus chrysops*	X	X	X	X
White-eared Honeyeater *Lichenostomus leucotis*	X	X	X	X
Yellow-tufted Honeyeater *Lichenostomus melanops*				X
Fuscous Honeyeater *Lichenostomus fuscus*	X	X		X
Brown-headed Honeyeater *Melithreptus brevirostris*	X	X	X	X
White-naped Honeyeater *Melithreptus lunatus*	X	X	X	X
Eastern Spinebill *Acanthorhynchus tenuirostris*	X	X	X	X
Scarlet Honeyeater *Myzomela sanguinolenta*	X	X		
Jacky Winter *Microeca fascinans*	X	X	X	X
Scarlet Robin *Petroica multicolor*	X	X	X	X
Flame Robin *Petroica phoenicea*	X	X		
Rose Robin *Petroica rosea*	X			
Hooded Robin *Melanodryas cucullata* V	X			
Eastern Yellow Robin *Eopsaltria australis*	X	X		X
Spotted Quail-thrush *Cinclosoma punctatum*	X			X
Varied Sittella *Daphoenositta chrysoptera*	X	X	X	X
Crested Shrike-tit *Falcunculus frontatus*	X	X	X	X
Golden Whistler *Pachycephala pectoralis*	X	X	X	X
Rufous Whistler *Pachycephala rufiventris*	X	X	X	X
Grey Shrike-thrush *Colluricincla harmonica*	X	X	X	X
Leaden Flycatcher *Myiagra rubecula*	X	X	X	X
Satin Flycatcher *Myiagra cyanoleuca*		X		
Restless Flycatcher *Myiagra inquieta*	X	X		X
Magpie-lark *Grallina cyanoleuca*	X	X	X	X
Rufous Fantail *Rhipidura rufifrons*	X			
Grey Fantail *Rhipidura fuliginosa*	X	X	X	X
Willie Wagtail *Rhipidura leucophrys*	X	X	X	X
Spangled Drongo *Dicrurus bracteatus*	X			
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	X	X	X	X
Cicadabird *Coracina tenuirostris*	X	X	X	X
White-winged Triller *Lalage sueurii*	X	X		
Olive-backed Oriole *Oriolus sagittatus*	X	X	X	X
White-browed Woodswallow *Artamus superciliosus*		X		
Dusky Woodswallow *Artamus cyanopterus*	X	X		X
Grey Butcherbird *Cracticus torquatus*	X	X	X	X
Pied Butcherbird *Cracticus nigrogularis*		X		X
Australian Magpie *Gymnorhina tibicen*	X	X	X	X
Pied Currawong *Strepera graculina*	X	X	X	X
Australian Raven *Corvus coronoides*	X	X	X	X
Forest Raven *Corvus tasmanicus* NT	X	X	X	
Torresian Crow *Corvus orru*			X	
White-winged Chough *Corcorax melanoramphos*	X	X	X	X
Satin Bowerbird *Ptilonorhynchus violaceus*	X			
Double-barred Finch *Taeniopygia bichenovii*	X			
Red-browed Finch *Neochmia temporalis*	X	X	X	X
Diamond Firetail *Stagonopleura guttata* V	X	X		X
Mistletoebird *Dicaeum hirundinaceum*	X	X	X	X
Welcome Swallow *Hirundo neoxena*	X	X	X	
Tree Martin *Hirundo nigricans*	X	X		X
Rufous Songlark *Cincloramphus mathewsi*	X			
Silvereye *Zosterops lateralis*	X	X	X	X
Bassian Thrush *Zoothera lunulata*		X		
Total	96	92	53	73

APPENDIX 2

Additional species recorded at Imbota in the 1970s and 1980s (HAF, pers. obs.), and at Yina (Y, *circa* 1990; J. Walters, pers. comm.). Symbols as in Table 2.

[OI]Nankeen Kestrel *Falco cenchroides* (flying over/edge only)
[OI]Crested Pigeon *Ocyphaps lophotes* (edge only)
[V]Bar-shouldered Dove *Geopelia humeralis*
White-browed Scrubwren *Sericornis frontalis* (before Blackberry *Rubus fruticosus* eradicated)
[V]Western Gerygone *Gerygone fusca*
Southern Whiteface *Aphelocephala leucopsis* (edge only)
[V]Striped Honeyeater *Plectorhyncha lanceolata*
[VI]White-plumed Honeyeater *Lichenostomus penicillatus*
[V]**Painted Honeyeater *Grantiella picta* V**
Flame Robin *Petroica phoenicea* (edge only, in winter)
Hooded Robin *Melanodryas cucullata* V (edge only)
[V]Spectacled Monarch *Monarcha trivirgatus*
Plum-headed Finch *Neochmia modesta*
[V]Red-browed Treecreeper *Climacteris erythrops* (Y; dispersing bird?)

APPENDIX 3

Habitat attributes of small and medium remnants on private land surveyed during the 1995 easement-corridor survey. Values based on visual estimate of cover in 30 m radius around point-count sites, averaged where >1 point per patch. Cover = estimated projected foliage cover. N = number of remnants in which an attribute class was recorded; numbers in parentheses = number of sites sampled in each category.

Attribute	Medium (5)	Small (10)	Attribute	Medium (5)	Small (10)
Tree cover (%):			Hollows (n):		
<10		1	0		1
10–30	1	4	1–5	4	6
31–50	4	3	6–10	1	3
51–70		2	Logs (n):		
Shrub cover (%):			1–5	1	3
<10	2	9	6–10	2	1
10–30	2	1	11–20	2	5
31–50	1		>20		1
Grass height (m):					
<0.5	4	9			
>0.5	1	1			
Grass cover (%):					
10–30	1	2			
31–50	1				
51–70	2	3			
>70	1	5			

REFERENCES

Barrett, G. W., Ford, H. A. and Recher, H. F., 1994. Conservation of woodland birds in a fragmented rural landscape. *Pac. Cons. Biol.* **1:** 245–56.

Benson, J. S. and Ashby, E. M., 2000. Vegetation of the Guyra 1:100 000 map sheet, New England Bioregion, New South Wales. *Cunninghamia* **6:** 747–872.

Clarke, M. F., Griffioen, P. and Loyn, R. H., 1999. Where do all the bush birds go? *Wingspan* **9**(4)**:** supplement.

Clarke, P. J., 2003. Composition of grazed and cleared temperate grassy woodlands in eastern Australia: patterns in space and inferences in time. *J. Veg. Sci.* **14:** 5–14.

Fischer, J. and Lindenmayer, D. B., 2002. Small patches can be valuable for biodiversity conservation: two case studies on birds in southeastern Australia. *Biol. Cons.* **106:** 129–36.

Ford, H. A. and Bell, H., 1981. Density of birds in eucalypt woodland affected to varying degrees by dieback. *Emu* **81:** 202–08.

Ford, H. A., Barrett, G. W., Saunders, D. A. and Recher, H. F., 2001. Why have birds in the woodlands of southern Australia declined? *Biol. Cons.* **97:** 71–88.

Ford, H. A., Bridges, L. and Noske, S., 1985. Density of birds in eucalypt woodland near Armidale, north-eastern New South Wales. *Corella* **9:** 97–107.

Ford, H. A., Noske, S. and Bridges, L., 1986. Foraging of birds in eucalypt woodland in north-eastern New South Wales. *Emu* **86:** 168–79.

Garnett, S. and Crowley, G. (eds), 2000. The Action Plan for Australian Birds 2000. Environment Australia, Canberra.

Heatwole, H. and Simpson, R. D., 1986. Faunal survey of New England. I. Introduction and general description of the area. *Mem. Qld Mus.* **22:** 107–13.

Heatwole, H., de Bavay, J., Webber, P. and Webb, G., 1995. Faunal survey of New England. IV. The frogs. *Mem. Qld Mus.* 38: 229–49.

Heatwole, H., de Bavay, J. and Webber, P., 2003. Faunal survey of New England. V. The lizards and snakes. *Mem. Qld Mus.* **49:** 299–325.

Hobbs, R. J., 2001. Synergisms among habitat fragmentation, livestock grazing, and biotic invasions in southwestern Australia. *Cons. Biol.* **15:** 1522–528.

Hunter, J. T., 2003a. Vegetation and Floristics of Imbota Nature Reserve. Report to NSW National Parks and Wildlife Service, Armidale.

Hunter, J. T., 2003b. Vegetation and Floristics of Yina Nature Reserve. Report to NSW National Parks and Wildlife Service, Armidale.

James, C. D., 2003. Response of vertebrates to fenceline contrasts in grazing intensity in semi-arid woodlands of eastern Australia. *Austral Ecol.* **28:** 137–51.

Jansen, A. and Robertson, A. I., 2001. Riparian bird communities in relation to land management practices in floodplain woodlands of south-eastern Australia. *Biol. Cons.* **100:** 173–85.

Mac Nally, R. and Horrocks, G., 2002a. Proportionate sampling and equal-time sampling of mobile animals: a dilemma for inferring areal dependence. *Austral Ecol.* **27:** 405–15.

Mac Nally, R. and Horrocks, G., 2002b. Relative influences of patch, landscape and historical factors on birds in an Australian fragmented landscape. *J. Biogeog.* **29:** 395–410.

McIntyre, S. and Barrett, G. W., 1992. Habitat variegation, an alternative to fragmentation. *Cons. Biol.* **6:** 31–37.

Major, R. E., Christie, F. J. and Gowing, G., 2001. Influence of remnant and landscape attributes on Australian woodland bird communities. *Biol. Cons.* **102:** 47–66.

NPWS, 2002a. Duval Nature Reserve Draft Plan of Management. National Parks and Wildlife Service, Sydney.

NPWS, 2002b. Imbota Nature Reserve Draft Plan of Management. National Parks and Wildlife Service, Sydney.

NPWS, 2002c. Yina Nature Reserve Draft Plan of Management. National Parks and Wildlife Service, Sydney.

NPWS, 2002d. Boorolong Nature Reserve Draft Plan of Management. National Parks and Wildlife Service, Sydney.

Oliver, D. L., Ley, A. J., Ford, H. A. and Williams, B., 1999. Habitat of the Regent Honeyeater *Xanthomyza phrygia* and the value of the Bundarra-Barraba region for the conservation of avifauna. *Pac. Cons. Biol.* **5:** 224–39.

Possingham, M. L., Field, S. A. and Possingham, H. P., 2004. Species richness and abundance of birds in Mt Lofty Ranges stringybark habitat: 1999–2000 survey. *S. Aust. Ornithol.* **34:** 153–69.

Reid, J., 1999. Threatened and Declining Woodland Birds in the New South Wales Sheep-Wheat Belt: I. Diagnosis, characteristics and management. Report to NSW National Parks and Wildlife Service. CSIRO Wildlife and Ecology, Canberra.

Reid, J., 2000. Threatened and Declining Woodland Birds in the New South Wales Sheep-Wheat Belt: II. Landscape relationships—modelling bird atlas data against vegetation cover. Report to NSW National Parks and Wildlife Service. CSIRO Sustainable Ecosystems, Canberra.

Seddon, J. A., Briggs, S. V. and Doyle, S. J., 2003. Relationships between bird species and characteristics of woodland remnants in the central wheat/sheep belt of New South Wales. *Pac. Cons. Biol.* **8:** 95–119.

Thackway, R. and Cresswell, I. D. (Eds), 1995. An Interim Biogeographic Regionalisation for Australia, version 4.0. Australian Nature Conservation Agency, Canberra.

Watson, D. M., 2003a. The "standardized search": An improved way to conduct bird surveys. *Austral Ecol.* **28:** 515–25.

Watson, D. M., 2003b. Long-term consequences of habitat fragmentation—highland birds in Oaxaca, Mexico. *Biol. Cons.* **111:** 283–303.

Watson, D. M., 2004. Comparative evaluation of new approaches to survey birds. *Wildl. Res.* **31:** 1–11.

Watson, J., Watson, A., Paull, D. and Freudenberger, D., 2003. Woodland fragmentation is causing the decline of species and functional groups of birds in southeastern Australia. *Pac. Cons. Biol.* **8:** 262–70.