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Diurnal birds in the Bungawalbin Creek catchment, northern New South Wales, with a focus on spatial and temporal changes in reporting rates of declining woodland birds

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Birds at 41 sites in grassy dry open sclerophyll (eucalypt) forests and woodlands in eight State Forests in the Bungawalbin Creek catchment, Richmond River District, northern New South Wales, were surveyed across all seasons from February 2004 to July 2006. One hundred and eight diurnal species were detected, including 11 state-listed threatened species and a further 17 temperate woodland species considered to be of conservation concern. No introduced species were found. Results suggest that the bird assemblages of the Bungawalbin Creek middle catchment dry forests have remained largely intact over the 25 years following a previous study (1977–80), and confirm the persistence of populations of a range of threatened taxa and other species identified as declining or subject to local extinction on the adjoining tablelands and slopes of northern New South Wales. The study area is a stronghold for declining temperate woodland species such as Painted Button-quail *Turnix varius,* Little Lorikeet *Glossopsitta pusilla*, Brown Treecreeper *Climacteris picumnus* and Black-chinned Honeyeater *Melithreptus gularis*. Evidence for lower recent reporting rates was found, however, in Peaceful Dove *Geopelia striata*, Buff-rumped Thornbill *Acanthiza reguloides*, Varied Sittella *Daphoenositta chrysoptera,* Rufous Whistler *Pachycephala rufiventris*, Jacky Winter *Microeca fascinans* and Double-barred Finch *Taeniopygia bichenovii*.

INTRODUCTION

Temperate eucalypt woodlands were once widespread in south-eastern Australia, occurring mainly along and inland of the Great Dividing Range from southern Queensland through to South Australia. These woodlands have been cleared and degraded to such an extent that they now comprise some of the most heavily-modified landscapes in Australia (Lindenmayer *et al.* 2005; Rayner *et al.* 2014). Many temperate woodland birds are regarded as having undergone substantial, and ongoing, population declines at regional to national scales, largely as a consequence of the extensive loss and modification of their eucalypt woodland habitat (Recher 1999; Reid 1999; Ford *et al.* 2001; Olsen *et al.* 2005; Barrett *et al.* 2007; Montague-Drake *et al.* 2009). Although the status of woodland birds has been widely discussed in the published literature, there have been relatively few robust studies measuring population changes in specific locations over time (Rayner *et al.* 2014).

Bungawalbin Creek, a tributary of the Richmond River, drains the lower rainfall south-western sector of the Richmond Valley, on the North Coast of New South Wales (NSW). Although now a mosaic of cleared and forested land, the catchment retains in its middle reaches tracts of grassy woodland and dry open eucalypt forest, mostly within some eight State Forests (SFs) ranging in size between 610 and 11 000 hectares. These vegetation formations include near-coastal outliers of the temperate woodlands of south-eastern Australia (Keith 2004).

Gosper (1992) compiled a comprehensive bird species inventory using monthly surveys at two sites in the Bungawalbin Creek catchment, one each in Myrtle and Royal Camp SFs. The sites were chosen as representative samples of the major vegetation formations in the middle catchment. That study, carried out in 1977–80, and subsequent casual surveys (Gosper and Holmes 2002), identified the presence of coastal populations of a suite of woodland species identified as declining or at risk in south-eastern Australia, including, notably, the adjacent New England Tableland and North-West Slopes regions of NSW (Barrett *et al.* 1994; Reid 1999; Watson *et al.* 2003; Courtney and Debus 2006; Debus *et al.* 2006a; Ford *et al.* 2009).

The aim of the present study (foreshadowed by Gosper and Holmes 2002), in which multiple sites across eight SFs were surveyed, was to provide more recent information on the composition of the bird communities of the Bungawalbin Creek middle catchment, and to compare this with data collected 25 years earlier. There was a focus on assessing the distribution and persistence of species of conservation concern, including, but not limited to, those species currently listed under the NSW *Threatened Species Conservation Act 1995*.

STUDY SITES

Forty-one survey sites were located in eight SFs in the Bungawalbin Creek catchment in north-east NSW (Figure 1; see Appendix 1 for a list of SFs, their areas and locations of sites). The study area lies between 15 and 55 kilometres south of Casino and between 25 and 55 kilometres from the coastline. Topography is relatively flat, with elevation 20 to 130 m asl. Watercourses flow intermittently and semi-permanent waterholes and small dams are few. The area lies in the subtropical climate zone, is characterized by a wet summer and a dry late winter-spring, with a mean annual rainfall (Casino) of 1046 mm (see Gosper 1986 for a more detailed overview).

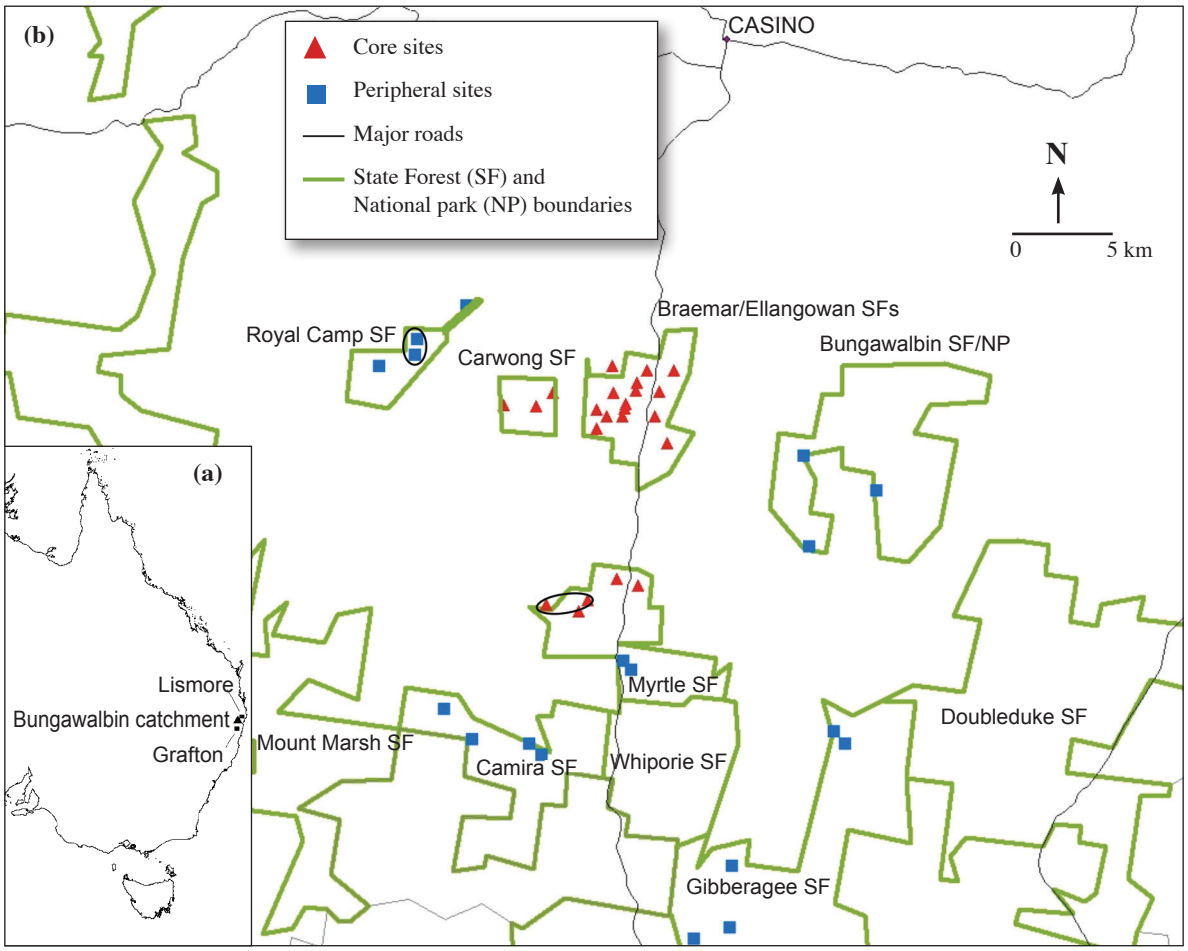

Figure 1. *Location of the: (a) Bungawalbin Creek catchment in Australia; and (b) sample sites within the catchment. The two encircled pairs of 2004–6 sites comprise those areas also surveyed in 1977–80. See Methods for the rationale underpinning the division of sites into core and peripheral.*

Vegetation formations are grassy dry open eucalypt forests and woodlands, with Clarence Valley Dry Sclerophyll Forest and Coastal Valley Grassy Woodlands the dominant classes. For floristic and structural descriptions see Binns (1995) and Keith (2004); also Gosper (1992) and Totterman (2012) for details of some specific sites. Canopy dominant trees included spotted gums (*Corymbia henryi* and *C. variegata*), ironbarks (*Eucalyptus siderophloia* and *E. crebra*), Grey Box (*Eucalyptus moluccana*), Grey Gum (*E. propinqua*), Forest Red Gum (*E. tereticornis*) and Pink Bloodwood (*C. intermedia*). The structure and biotas of these formations in the Bungawalbin and nearby Clarence catchments have stronger affinities with woodlands of the New England Tablelands and Western Slopes, and with the dry forests of subtropical south-east Queensland, than with other vegetation formations of the NSW North Coast and adjoining escarpment (Gosper 1992; Keith 2004).

Braemar, Myrtle (part), Carwong and Ellangowan SFs (25 sites in total) comprised the core study area, supplemented by a further 16 sites (termed 'peripheral') in the closest sections of surrounding SFs (Myrtle (part), Royal Camp, Camira, Bungawalbin and Gibberagee) (Figure 1). Peripheral sites tended to be moister forests with more understorey shrubbery (including invasive lantana *Lantana camara*) compared with the more open forests/woodland of the core area. This is associated with closer proximity to the catchment rim (i.e. Richmond Range; except Bungawalbin) to the south and west; and therefore slightly increasing elevation, hilliness of the terrain and precipitation, and local drainage factors, such as sites with riparian vegetation (single sites in Royal Camp and Gibberagee) or bordering swamp sclerophyll forest and associated seasonal inundation in parts (Bungawalbin SF). Sites were selected to provide a coverage of fine-scale habitat features including ridge lines, north and south facing slopes, low-lying areas, proximity to edges (access tracks, adjoining cleared areas and pine plantations, fence lines, log dump clearings, powerline corridors), watercourses, semi-permanent waterholes, and localized plant assemblages (e.g. banksia, paperbark, teatree) which occurred as isolated pockets. The two sites surveyed in 1977–80 were included in the 2004–06 study.

METHODS

Each of the 41 sites was surveyed four times, once in each season (41 x 4 = 164 surveys in total) over a 30-month period between February 2004 and July 2006. Surveys were made in

Table 1

Survey programs 1977–1980 and 2004–2006.

Period	Sites	Duration (months)	Frequency	Search time (minutes)	Surveys (total)	Survey effort (total hours)
Aug 1977-Jan 1980	2	30	monthly	150-180	58	165
Feb 2004-July 2006	41	30	1/season (4)	60	164	164

each calendar month except August 2005 and May 2006. A fixed route, determined by a 60 minute trial survey at each site, was used. Each 1977–80 site was divided and treated as two sites to fit the 2004–06 survey configuration. Actual completion times varied slightly, depending on the abundance of birds, and the need to deviate to identify birds detected from the route proper. Surveys were conducted in the mornings, by walking the route slowly, with frequent pauses. All species seen and heard were logged, although occasional records of waterbirds are not included here. On many days several sites were surveyed consecutively. All surveys in both 1977–80 and 2004–06 were conducted by DGG.

Survey programs used here, and by Gosper (1992), are summarized in Table 1. The 2004–06 survey program, which used multiple sites (i.e. 41 versus 2), was designed to provide a much broader coverage of the middle catchment forests in terms of geographical area and number of SFs sampled, and associated habitat features. Overall survey effort (time) was similar between 2004–06 and 1977–80 surveys (164 v 165 hours) but individual site survey search effort (60 minutes v 150 – 180 minutes), and as a consequence, survey patch size, was much reduced in 2004–6. Species presence only was recorded (i.e. numbers of individuals not tallied). Scientific names of bird species are shown in Table 2.

For each bird species per site, reporting rate was determined by the percentage of all visits in which that species was recorded. In statistical analyses, bird species recorded at less than five percent of total visits across all sites (1977–80 and 2004–06) were omitted, leaving 82 species. Non-metric multi-dimensional scaling ordination of sites by reporting rates of bird species was completed using PRIMER software (Version 6.1.11, PRIMER-E, Plymouth, UK), using the Bray-Curtis dissimilarity metric. Separate ordinations were conducted on all bird species and those previously identified as woodland decliners (see Table 3). PERMANOVA and PERMDISP were used to test whether there were differences in community composition of the whole bird community and woodland decliners between core and peripheral sites. SIMPER was used to identify which bird species contributed most to dissimilarity between core and peripheral sites.

RESULTS

A composite inventory encompassing all seasons and including species not detected in the current study but which were recorded in the 1977–80 study, and/or during incidental visits to some sites in the years between the two studies, produced 124 species (Table 2). One hundred and eight diurnal species were recorded in 2004–06, 12 of which were not recorded in the earlier study. Of the 104 species recorded in 1977–80, nine were not detected in the 2004–06 surveys. An additional seven species were recorded during incidental visits. No introduced species were found. Eleven state-listed threatened species (under NSW legislation) were present, together with a further 17 species (Table 3) considered to be declining or at risk in woodlands in NSW.

Across the survey area as a whole, no regularly-recorded species appears to have been lost. Most species reported in one study only had low levels of occurrence (reporting rates of <3.0 %) and/or were found at few sites (2004–06), suggesting such species are irregular visitors, although often relatively common and/or widespread in adjoining habitats. Species present in 1977–80 but not detected in 2004–06 probably continue to occur in low numbers or periodically. White-winged Chough *Corcorax melanorhamphos* was recorded in Carwong SF in 2010 (Totterman 2012). Regent Honeyeater *Anthochaera phrygia* was recorded at three locations between the studies (Gosper and Holmes 2002). Forest Kingfisher *Todiramphus macleayii*, a species whose local distribution in the southern limits of its range appears to fluctuate (Higgins 1999), was recorded from the edges of the 1977–80 sites, both of which were in close proximity to semi-permanent waterholes. It probably continues to periodically occupy such sites when conditions are suitable.

However, we have identified that a number of species may have declined between the sample periods on the basis of sharply lower reporting rates overall in 2004–06 compared to 1977–80, and also in at least one of the two re-sampled locations (Table 3). During 2004–06 Buff-rumped Thornbills *Acanthiza reguloides* were detected only twice, and were not found at either of the Myrtle and Royal Camp SF sites where they were present in 1977–80 (at reporting rates of 72% and 14% respectively; Table 3). Rufous Whistlers *Pachycephala rufiventris* had an overall reporting rate 35–40 percent lower in 2004–6 than at 1977–80 sites, and similar magnitudes of differences occurred in comparisons between the individual sites that were re-sampled. Overall 2004–6 reporting rates of Peaceful Dove *Geopelia striata*, Varied Sittella *Daphoenositta chrysoptera*, Jacky Winter *Microeca fascinans* and Double-barred Finch *Taeniopygia bichenovii* were much lower than in 1977–80, although among the two individual re-sampled sites the 2004–6 reporting rate was only substantially lower at one. Further, in the case of Varied Sittellas, they were recorded in all 10' squares covering the Bungawalbin Creek catchment between 1973 and 1983 (Gosper 1986), but only at four sites in 2004–6. Species not widely regarded as declining woodland birds but which showed similar patterns of substantially lower reporting

Table 2

Composite bird species list and reporting rates, by season, for 41 sites in State Forests of the Bungawalbin Creek middle catchment in 2004–06. ** = recorded in 2004–06 study but not 1977–80 study; (P) = recorded 1977–80 but not in 2004–06; # = additional species recorded at site(s) between the studies. Nocturnal species are listed for completeness only and were not included in statistical analyses.

Species	Summer n=41	Autumn n=41	Winter n=41	Spring n=41	Total (reporting rate %) n=164	Sites recorded n=41
Brown Quail *Coturnix ypsilophora***	0	0	2	0	2 (1.2)	2
Brown Cuckoo-Dove *Macropygia amboinensis*						(P)
Common Bronzewing *Phaps chalcoptera*	6	5	4	8	23 (14.0)	13
Peaceful Dove *Geopelia striata*	31	26	13	25	95 (57.9)	37
Bar-shouldered Dove *Geopelia humeralis***	2	7	5	6	20 (12.2)	14
Wonga Pigeon *Leucosarcia picata***	10	3	3	8	24 (14.6)	16
Tawny Frogmouth *Podargus strigoides*	0	1	0	0	–	
White-throated Nightjar *Eurostopodus mystacalis*	1	0	0	0	–	
Australian Owlet-nightjar *Aegotheles cristatus*	3	4	2	2	–	
White-throated Needletail *Hirundapus caudacutus*	3	0	0	2	5 (3.0)	5
Square-tailed Kite *Lophoictinia isura*						#
Pacific Baza *Aviceda subcristata*						(P)
White-bellied Sea-Eagle *Haliaeetus leucogaster***	0	0	1	0	1 (0.6)	1
Whistling Kite *Haliastur sphenurus*	1	0	0	1	2 (1.2)	2
Brown Goshawk *Accipiter fasciatus*	0	0	0	1	1 (0.6)	1
Collared Sparrowhawk *Accipiter cirrocephalus*	3	0	1	0	4 (2.4)	4
Wedge-tailed Eagle *Aquila audax*	0	3	0	1	4 (2.4)	4
Little Eagle *Hieraaetus morphnoides*	1	0	0	0	1 (0.6)	1
Peregrine Falcon *Falco peregrinus*						(P)
Painted Button-quail *Turnix varius*	9	14	19	16	58 (35.4)	31
Glossy Black-Cockatoo *Calyptorhynchus lathami*	1	3	0	2	6 (3.7)	3
Yellow-tailed Black-Cockatoo *Calyptorhynchus funereus*	1	5	3	1	10 (6.1)	8
Rainbow Lorikeet *Trichoglossus haematodus*	34	36	36	32	138 (84.1)	41
Scaly-breasted Lorikeet *Trichoglossus chlorolepidotus*	34	28	27	28	117 (71.3)	41
Musk Lorikeet *Glossopsitta concinna***	0	3	1	0	4 (2.4)	4
Little Lorikeet *Glossopsitta pusilla*	27	33	39	37	136 (82.9)	41
Australian King-Parrot *Alisterus scapularis*	17	6	5	12	40 (24.4)	28
Crimson Rosella *Platycercus elegans***	0	0	1	0	1 (0.6)	1
Eastern Rosella *Platycercus eximius*	7	13	8	18	46 (28.0)	26
Turquoise Parrot *Neophema pulchella***	0	1	1	0	2 (1.2)	2
Eastern Koel *Eudynamys orientalis*	7	0	0	2	9 (5.5)	9
Channel-billed Cuckoo *Scythrops novaehollandiae*	6	0	0	4	10 (6.1)	9
Shining Bronze-Cuckoo *Chalcites lucidus*	4	10	2	4	20 (13.7)	16
Little Bronze-Cuckoo *Chalcites minutillus*	0	0	1	1	2 (1.2)	1
Pallid Cuckoo *Cacomantis pallidus*						(P)
Fan-tailed Cuckoo *Cacomantis flabelliformis*	0	11	8	3	22 (13.4)	17
Brush Cuckoo *Cacomantis variolosus*	20	6	0	4	30 (18.3)	22
Barking Owl *Ninox connivens*						#
Southern Boobook *Ninox novaeseelandiae*	0	0	2	0	–	
Laughing Kookaburra *Dacelo novaeguineae*	31	17	12	20	80 (48.8)	37
Forest Kingfisher *Todiramphus macleayii*						(P)
Sacred Kingfisher *Todiramphus sanctus*	11	0	0	17	28 (17.1)	23
Rainbow Bee-eater *Merops ornatus*	21	24	22	13	80 (48.8)	35
Dollarbird *Eurystomus orientalis*	3	0	0	3	6 (3.7)	6
White-throated Treecreeper *Cormobates leucophaea*	10	7	10	10	37 (22.6)	16
Brown Treecreeper *Climacteris picumnus*	27	26	28	31	112 (68.3)	36
Superb Fairy-wren *Malurus cyaneus*	27	24	29	34	114 (69.5)	37
Red-backed Fairy-wren *Malurus melanocephalus*	18	18	18	16	70 (42.7)	25
Variegated Fairy-wren *Malurus lamberti*	19	19	18	19	75 (45.7)	29
White-browed Scrubwren *Sericornis frontalis*	5	2	1	2	10 (6.1)	8
Large-billed Scrubwren *Sericornis magnirostra*	1	0	0	1	2 (1.2)	2
Speckled Warbler *Chthonicola sagittata*	2	3	3	3	11 (6.7)	8
Weebill *Smicrornis brevirostris*	0	3	3	3	9 (5.4)	5
Brown Gerygone *Gerygone mouki*	2	2	2	2	8 (4.9)	3
White-throated Gerygone *Gerygone albogularis*	1	1	0	5	7 (4.3)	6
Striated Thornbill *Acanthiza lineata*	6	5	6	6	23 (14.0)	12
Yellow Thornbill *Acanthiza nana***	0	0	1	2	3 (1.8)	2
Buff-rumped Thornbill *Acanthiza reguloides*	0	0	1	1	2 (1.2)	1
Brown Thornbill *Acanthiza pusilla*	8	5	9	8	30 (18.3)	14
Spotted Pardalote *Pardalotus punctatus*	1	25	24	4	54 (32.9)	31
Striated Pardalote *Pardalotus striatus*	21	28	17	14	80 (48.8)	38
Eastern Spinebill *Acanthorhynchus tenuirostris*	0	1	6	0	7 (4.3)	7

Table 2 (continued)

Species (continued)	Summer n=41	Autumn n=41	Winter n=41	Spring n=41	Total (reporting rate %) n=164	Sites recorded n=41
Lewin's Honeyeater *Meliphaga lewinii*	6	7	6	6	25 (15.2)	9
Yellow-faced Honeyeater *Lichenostomus chrysops*	11	22	18	15	66 (40.2)	29
Fuscous Honeyeater *Lichenostomus fuscus*	40	41	40	41	162 (98.8)	41
Noisy Miner *Manorina melanocephala*	5	7	6	7	25 (15.2)	14
Little Wattlebird *Anthochaera chrysoptera*	6	13	7	17	43 (26.3)	21
Regent Honeyeater *Anthochaera phrygia*						(P)
Red Wattlebird *Anthochaera carunculata***	0	0	1	0	1 (0.6)	1
Scarlet Honeyeater *Myzomela sanguinolenta*	4	31	22	23	80 (48.8)	36
Brown Honeyeater *Lichmera indistincta*	2	6	1	4	13 (7.9)	8
White-cheeked Honeyeater *Phylidonyris niger*	2	3	5	4	14 (8.5)	10
Black-chinned Honeyeater *Melithreptus gularis*	23	20	25	23	91 (55.5)	40
White-throated Honeyeater *Melithreptus albogularis*	5	9	4	8	26 (15.9)	11
White-naped Honeyeater *Melithreptus lunatus*						#
Blue-faced Honeyeater *Entomyzon cyanotis*	8	9	7	13	37 (22.6)	19
Noisy Friarbird *Philemon corniculatus*	33	36	35	41	145 (88.4)	41
Little Friarbird *Philemon citreogularis*	13	12	10	17	52 (31.7)	32
Striped Honeyeater *Plectorhyncha lanceolata***	0	0	3	0	3 (1.8)	3
Grey-crowned Babbler *Pomatostomus temporalis*	5	5	10	9	29 (17.7)	14
Spotted Quail-thrush *Cinclosoma punctatum*	1	1	4	2	8 (4.9)	7
Eastern Whipbird *Psophodes olivaceus*	6	7	7	3	23 (14.0)	11
Varied Sittella *Daphoenositta chrysoptera*	2	0	2	0	4 (2.4)	4
Black-faced Cuckoo-shrike *Coracina novaehollandiae*	32	14	4	26	76 (46.3)	40
White-bellied Cuckoo-shrike *Coracina papuensis*	28	19	26	36	109 (66.5)	40
Cicadabird *Coracina tenuirostris*	17	3	0	2	22 (13.4)	19
White-winged Triller *Lalage sueurii*						(P)
Varied Triller *Lalage leucomela*	1	0	0	1	2 (1.2)	1
Crested Shrike-tit *Falcunculus frontatus*	18	9	11	20	58 (35.4)	30
Golden Whistler *Pachycephala pectoralis*	2	20	15	3	40 (24.4)	26
Rufous Whistler *Pachycephala rufiventris*	35	14	2	29	80 (48.8)	37
Little Shrike-thrush *Colluricincla megarhyncha*	0	0	0	1	1 (0.6)	1
Grey Shrike-thrush *Colluricincla harmonica*	37	37	38	39	151 (92.1)	41
Australasian Figbird *Sphecotheres vieilloti***	1	0	0	2	3 (1.8)	2
Olive-backed Oriole *Oriolus sagittatus*	30	17	10	28	85 (51.8)	40
Masked Woodswallow *Artamus personatus*						#
White-browed Woodswallow *Artamus superciliosus*						#
Dusky Woodswallow *Artamus cyanopterus*	18	20	16	21	75 (45.7)	35
Grey Butcherbird *Cracticus torquatus*	11	8	5	14	38 (23.2)	17
Pied Butcherbird *Cracticus nigrogularis*	4	5	3	3	15 (9.1)	9
Australian Magpie *Cracticus tibicen*	12	11	12	4	39 (23.8)	23
Pied Currawong *Strepera graculina*	4	6	4	4	18 (11.0)	12
Spangled Drongo *Dicrurus bracteatus*	9	3	0	1	13 (7.9)	12
Rufous Fantail *Rhipidura rufifrons*	3	2	0	0	5 (3.0)	5
Grey Fantail *Rhipidura albiscapa*	17	24	14	19	74 (45.1)	28
Willie Wagtail *Rhipidura leucophrys*	32	38	30	38	138 (84.1)	39
Australian Raven *Corvus coronoides***	0	0	2	3	5 (3.0)	5
Torresian Crow *Corvus orru*	16	21	25	34	96 (58.5)	39
Leaden Flycatcher *Myiagra rubecula*	18	6	0	14	38 (23.2)	24
Restless Flycatcher *Myiagra inquieta*	15	18	15	18	66 (40.2)	30
Black-faced Monarch *Monarcha melanopsis*	1	1	0	0	2 (1.2)	2
Spectacled Monarch *Symposiarchus trivirgatus*						(P)
Magpie-lark *Grallina cyanoleuca*	0	1	1	1	3 (1.8)	3
White-winged Chough *Corcorax melanorhamphos*						(P)
Jacky Winter *Microeca fascinans*	13	18	16	19	66 (40.2)	29
Scarlet Robin *Petroica boodang*						#
Rose Robin *Petroica rosea*	0	8	9	0	17 (10.4)	13
Hooded Robin *Melanodryas cucullata*	5	5	5	6	21 (12.8)	13
Eastern Yellow Robin *Eopsaltria australis*	29	26	19	26	100 (61.0)	39
Tawny Grassbird *Megalurus timoriensis***	0	0	0	1	1 (0.6)	1
Rufous Songlark *Cincloramphus mathewsi*						#
Silvereye *Zosterops lateralis*	8	17	16	5	46 (28.0)	24
Welcome Swallow *Hirundo neoxena*	3	3	3	2	11 (6.7)	8
Tree Martin *Petrochelidon nigricans*	5	8	3	0	16 (9.8)	15
Mistletoebird *Dicaeum hirundinaceum*	41	21	19	40	121 (73.8)	41
Double-barred Finch *Taeniopygia bichenovii*	3	2	2	1	8 (4.9)	7
Red-browed Finch *Neochmia temporalis*	20	25	30	24	99 (60.4)	37
Diamond Firetail *Stagonopleura guttata*	3	4	4	8	19 (11.6)	12
Chestnut-breasted Mannikin *Lonchura castaneothorax*						#
Species Total:	83	83	86	93	108	

Table 3

Occurrence by State Forest/survey site of diurnal land-birds considered threatened, declining or at risk in NSW woodlands (after Barrett et al. 1994; Reid 1999; Watson et al. 2003; Debus et al. 2006a), in the Bungawalbin Creek middle catchment. *Threatened species as listed under NSW legislation.

State Forest	Braemar (n=11)	Bungawalbin (n=3)	Camira (n=4)	Carwong (n=3)	Ellangowan (n=4)	Gibberagee (n=5)	Myrtle (n=7)	Royal Camp (n=4)	All	Myrtle	Royal Camp
Species									Reporting rate (%) 2004-6	1977-80	1977-80
Peaceful Dove	11	2	4	3	4	4	6	3	57.9	89.7	93.1
Whistling Kite					1			1	1.2	13.8	6.9
Little Eagle*							1		0.6	3.4	0
Painted Button-quail	9	1	2	3	4	2	6	4	35.4	44.8	10.3
Glossy Black-Cockatoo*						2		1	3.7	10.3	3.4
Musk Lorikeet				1	3				2.4	0	0
Little Lorikeet*	11	3	4	3	4	5	7	4	82.9	93.1	82.8
Turquoise Parrot*			1	1					1.2	0	0
Brown Treecreeper*	11	2	4	3	4	4	5	3	68.3	79.3	62.1
Speckled Warbler*	1			1	1		4	1	6.7	0	48.3
Weebill					1	2	1	1	5.4	44.8	6.9
Buff-rumped Thornbill								1	1.2	72.4	13.8
Brown Thornbill	1	1	1		2	2	4	3	18.3	31	100
Spotted Pardalote	5	3	4	3	3	4	5	4	32.9	37.9	48.3
Black-chinned Honeyeater*	11	3	4	3	4	5	6	4	55.5	41.4	48.3
Grey-crowned Babbler*	1	1	3	2		1	5	1	17.7	69	0
Varied Sittella*							3	1	2.4	20.7	10.3
White-bellied Cuckoo-shrike	11	3	4	3	4	5	6	4	66.5	86.2	79.3
Crested Shrike-tit	7	3	4	1	3	4	5	3	35.4	34.5	24.1
Rufous Whistler	7	3	4	3	4	5	7	4	48.8	89.7	86.2
Grey Shrike-thrush	11	3	4	3	4	5	7	4	92.1	93.1	96.6
Dusky Woodswallow	10	2	4	3	4	4	5	3	45.7	86.2	34.5
Restless Flycatcher	8	1	4	3	1	4	6	3	40.2	69	37.9
Jacky Winter	9	1	3	3	3	3	4	3	40.2	69	96.6
Hooded Robin*	7			2	1	1	2		12.8	51.7	0
Eastern Yellow Robin	10	3	4	2	4	5	7	4	61	55.2	96.6
Double-barred Finch		1		1	2		1	2	4.9	13.8	79.3
Diamond Firetail*	7		1	3	1				11.6	17.2	0

rates overall and at re-sampled sites in 2004–6 were Black-faced Cuckoo-shrike *Coracina novaehollandiae* and White-throated Gerygone *Gerygone albogularis*. Other species with markedly lower reporting rates across all sites in 2004–6 than at either of the 1977–80 sites (Table 3) had similar reporting rates in the two periods at the re-sampled sites, indicating that the overall differences may be a result of spatial variability, rather than a temporal change in reporting rate.

Wonga Pigeon *Leucosarcia picata* and Bar-shouldered Dove *Geopelia humeralis* were found at greater than 30 percent of the 2004–06 sites, and had reporting rates of greater than 12 percent, but were not recorded in the earlier study. The Wonga Pigeon in particular has become more plentiful in the Richmond River district during the last 30 years (Gosper and Holmes 2002) and may be an 'increaser', while the increase in Bar-shouldered Doves is consistent with state-wide trends (Barrett *et al*. 2007). Musk Lorikeets *Glossopsitta concinna*, also not recorded in 1977–80, irrupt into the district in autumn-winter at irregular intervals, and can be present in large numbers in the Bungawalbin Creek SFs at such times (unpub. data). Olive-backed Orioles *Oriolus sagitattus* had consistently higher reporting rates overall and at the re-sampled sites in 2004–6 compared to 1977–80. Influxes of White-browed and Masked Woodswallows (*Artamus superciliosus* and *A. personatus*), species not detected during either survey, were recorded in the study area, including at a number of survey sites, at irregular intervals outside the survey periods.

Table 4

Differences in the bird community between core and peripheral sites in the Bungawalbin Creek catchment based on reporting rates of all bird species or declining woodland bird species (see Table 3). Non-significant PERMDISP tests indicate no difference in dispersion between core and peripheral sites. *** P = 0.001; ** P < 0.01.

Birds included	df	PERMANOVA Pseudo-F	PERMDISP F
All species	1,39	6.26***	2.04
Woodland decliners	1,39	4.59**	0.03

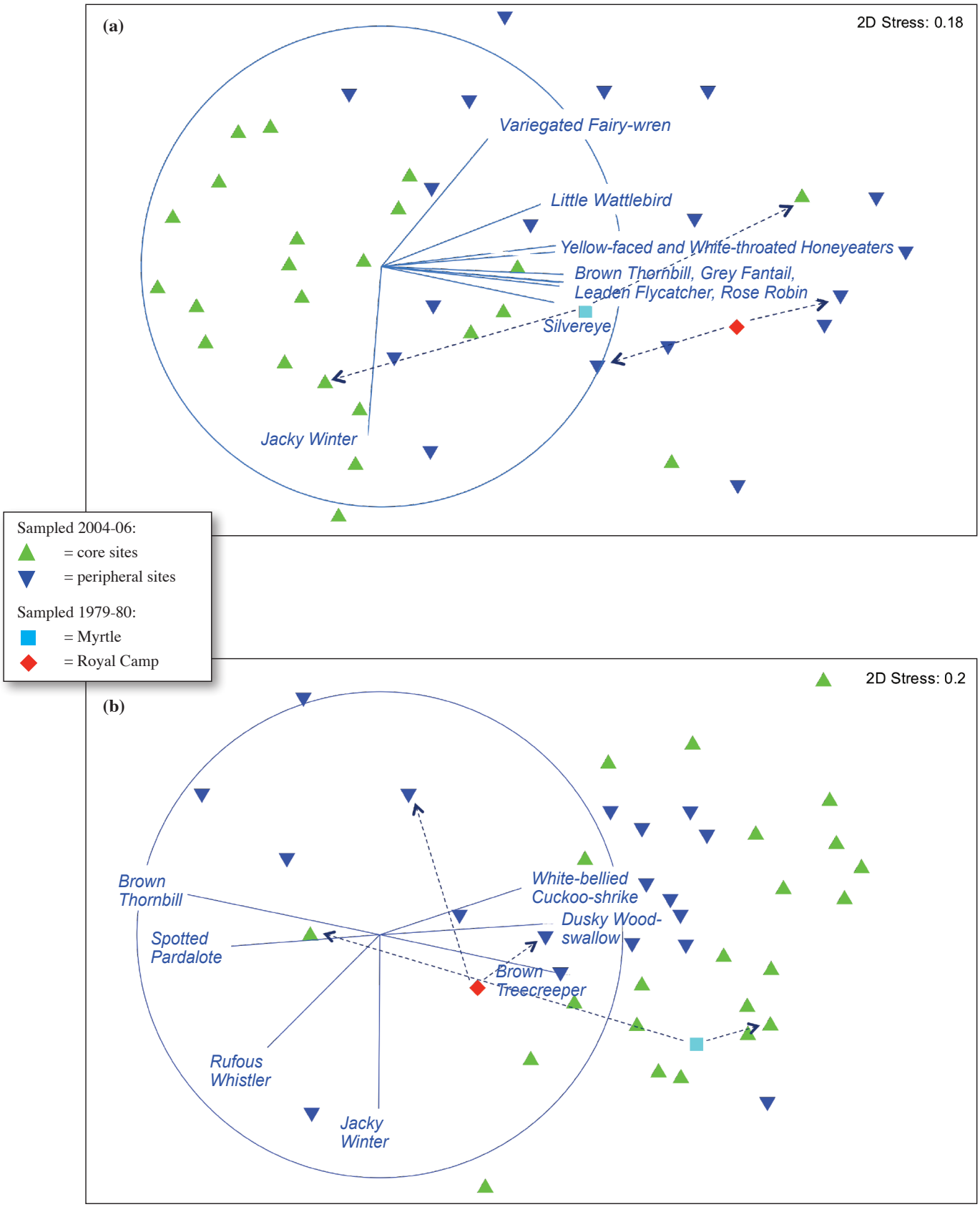

Figure 2. *Non-metric multi-dimensional scaling of survey sites in the Bungawalbin Creek catchment by reporting rates of* ***(a)*** *all bird species; and* ***(b)*** *declining woodland bird species (see Table 3). Vectors show the direction of association of bird species with Pearson's correlation coefficients* ***(a)*** *> 0.7; and* ***(b)*** *> 0.6. The dashed lines show the placement in ordination space of the two components of the sites surveyed in 1979–80 sampled again but separately in 2004–06.*

Figure 3. *Spatial patterns of reporting rates for selected threatened or declining woodland birds in the Bungawalbin Creek catchment:* ***(a)*** *Painted Button-quail;* ***(b)*** *Brown Treecreeper;* ***(c)*** *Hooded Robin; and* ***(d)*** *Diamond Firetail. See Figure 1 for the context of sample sites. Reporting rate:* + = 0; △ = 0.25; ▲ = 0.5; ▲ = 0.75; ▲ = 1.0.

Table 5

The species contributing most to differences between (dissimilarity) core and peripheral sites in the Bungawalbin Creek catchment, ordered by decreasing dissimilarity. Declining woodland bird species are indicated by bold font.

Species	Mean reporting rate		Dissimilarity (% contribution)	Cumulative dissimilarity (% contribution)
	Core	Peripheral		
Red-backed Fairy-wren	0.66	0.13	2.96	2.96
Grey Fantail	0.3	0.64	2.53	5.49
Variegated Fairy-wren	0.29	0.67	2.49	7.98
Little Wattlebird	0.07	0.51	2.33	10.31
Yellow-faced Honeyeater	0.26	0.58	2.29	12.61
Jacky Winter	0.5	0.28	2.05	14.65
White-throated Treecreeper	0.08	0.42	1.94	16.59
Eastern Yellow Robin	0.47	0.79	1.86	18.46
Red-browed Finch	0.57	0.65	1.86	20.32
Brown Treecreeper	0.72	0.64	1.77	22.09
Painted Button-quail	0.47	0.21	1.77	23.86

The ordinations indicate that there is little evidence for substantial change in the overall bird community having occurred between 1977–80 and 2004–06 based on reporting rates. In the all species ordination (Figure 2a), at the two locations surveyed in both periods the placement in ordination space of the 1977–80 sites was between that of the two corresponding 2004–06 sites, with the pairs of 2004–06 sites being separated along the mesic/shrubby-xeric/open divide characterising the overall ordination. While the ordination by declining woodland birds also shows the location of the 1977–80 sites between the corresponding 2004–06 sites on the mesic/shrubby-xeric/open axis, there is also a consistent shift in ordination space on the other axis (Figure 2b). This shift was associated with higher reporting rates of Jacky Winter and Rufous Whistler in 1977–80.

There was little overlap in ordination space between core and peripheral sites on the basis of reporting rates of all regularly-recorded bird species or solely on declining woodland birds (Figure 2). In the all-species ordination, a set of bird species typically associated with mesic and/or shrubbier habitats was strongly correlated with the distribution of sites in ordination space. These species, such as Rose Robin *Petroica rosea*, Leaden Flycatcher *Myiagra rubecula*, Silvereye *Zosterops lateralis* and Brown Thornbill *Acanthiza pusilla* were associated with peripheral sites. Among woodland decliners, reporting rates of mesic/shrubby-associated species (Brown Thornbill, Spotted Pardalote *Pardalotus punctatus*) were orientated in ordination space in the opposite direction to Brown Treecreeper *Climacteris picumnus*, White-bellied Cuckoo-shrike *Coracina papuensis* and Dusky Woodswallow *Artamus cyanopterus*. The latter set of species was associated with core sites and with open woodland.

Differences in the all-species and woodland decliner bird communities between core and peripheral sites were confirmed by the significant PERMOVA tests (Table 4). Of the species contributing greatest dissimilarity between core and peripheral sites (Table 5), those with higher reporting rates in peripheral sites were either more typically associated with mesic and/or shrubby habitats (Grey Fantail *Rhipidura albiscapa*, Variegated Fairy-wren *Malurus lamberti*, Yellow-faced Honeyeater *Lichenostomus chrysops*, White-throated Treecreeper *Cormobates leucophaea*, Eastern Yellow Robin *Eopsaltria australis*), or coastal areas (Little Wattlebird *Anthochaera chrysoptera*). Species contributing high dissimilarity with substantially higher reporting rates in core sites are mostly strongly associated with dry forests and woodlands and are also vulnerable to decline in fragmented landscapes (Jacky Winter, Brown Treecreeper, Painted Button-quail *Turnix varius*).

DISCUSSION

Our results highlight the on-going value of the Bungawalbin Creek grassy dry sclerophyll forests and woodlands for an array of species that are vulnerable to the effects of habitat fragmentation and degradation, and that have declined in south-eastern Australia. The middle catchment SFs and core sites in particular are a stronghold for Painted Button-quail (Figure 3a), Little Lorikeet *Glossopsitta pusilla*, Brown Treecreeper (Figure 3b), Black-chinned Honeyeater *Melithreptus gularis*, Hooded Robin *Melanodryas cucullata* (Figure 3c) and Diamond Firetail *Stagonopleura guttata* (Figure 3d) (Table 3). This is in stark contrast to the dramatic population reductions and local extinctions of these and/or other species, during the period discussed here, in the adjoining New England Tablelands and North-West Slopes regions of NSW (Courtney and Debus 2006; Debus *et al.* 2006a, 2006b; NSW Scientific Committee 2008, 2011a, 2011b; Ford *et al.* 2009). The strongest evidence of declines in reporting rates in the Bungawalbin catchment between 1977–80 and 2004–6 was found in the Buff-rumped Thornbill, Rufous Whistler, Peaceful Dove, Jacky Winter, Double-barred Finch and Varied Sittella. Unfortunately, the experimental design of this study does not allow the causal factors driving these results to be identified, as any shifts in reporting rates may also be influenced by different survey methods, variability in climate between survey periods (Barrett *et al.* 2007) and/or other factors.

The relatively high consistency of the bird assemblages of the Bungawalbin Creek SFs between 1977–80 and 2004–06 is further demonstrated by the absence of introduced species, and of open country birds such as Crested Pigeon *Ocyphaps lophotes* and Galah *Eolophus rosiecapillus*, which are widespread in

the district (Gosper 1986; Gosper and Homes 2002). Noisy Miners *Manorina melanocephala*, an aggressive species known to negatively impact on the diversity and abundance of small passerines in habitats where fragmentation and degradation have occurred (e.g. Maron 2008), and Pied Currawongs *Strepera graculina* and Grey Butcherbirds *Cracticus torquatus*, both known nest predators of small passerines (Higgins *et al.* 2006; Debus *et al.* 2006a; pers. obs.), have remained patchily distributed across the study area.

The SFs of the Bungawalbin Creek catchment form part of the Casino Management Area (CMA) of the Forestry Corporation of NSW. Most of the threatened species identified in this study were not listed under the NSW *Threatened Species Conservation Act 1995* at the time of preparation of the CMA Environmental Impact Statement (EIS), which considered proposed forestry management and operations for the period 1996 to 2005. As such they were not recognized in the EIS, and therefore were not considered when mitigation measures for the amelioration of proposed forestry activities were devised (State Forests of NSW 1995). The continued persistence of most species at similar reporting rates suggests that forest management practices (at least up until 2006) had not caused a substantial decline in habitat quality. It is also likely that the large size of the habitat units involved (all SFs >600 ha), and the presence of linking vegetation on adjoining private lands and their low intensity land use (mainly grazing), were also important. On the other hand, one threatened and five non-threatened but generally declining woodland bird species appear to have declined in the Bungawalbin Creek catchment, and none of the core sites which are particularly important in supporting the assemblage of declining woodland birds most strongly associated with dry forests and woodlands is in a conservation reserve.

Summary of status of Threatened Species in the Bungawalbin Creek middle catchment 1977 –2006.

Species status is shown in parentheses, with status under the NSW *Threatened Species Conservation Act 1995* listed first, followed by that in *The Action Plan for Australian Birds 2010* (Garnett *et al.* 2011).

Little Eagle *Hieraaetus morphnoides* (Vulnerable/Least Concern): scarce; singles recorded irregularly and infrequently across the catchment in 2004–06 and 1977–80, also between studies.

Glossy Black-Cockatoo (south-eastern subspecies *C. lathami lathami*) (Vulnerable/Near Threatened): widely distributed across catchment (Gosper 1986); low numbers, mostly pairs, trios; in 2004–06 recorded from three sites in two SFs, reporting rate <4%; in 1977–80 present at both Myrtle and Royal Camp SF sites with reporting rates 10% and 3% respectively; also records between studies (Table 3).

Little Lorikeet (Vulnerable/Least Concern): widespread in catchment (Gosper 1986); abundant; in 2004–06 present at all 41 sites; high reporting rate (>80%) with little seasonal variation in both 1977–80 sites and across all sites in 2004–6 (Table 3).

Turquoise Parrot *Neophema pulchella* (Vulnerable/Least Concern): irregular visitor in small numbers to the Bungawalbin Creek catchment (Gosper and Holmes 2002); in 2004–06 singles/ pairs at sites in Carwong and Camira SFs; also Carwong SF between studies; drought refugees or scarce non-breeding visitors (records were in autumn and winter)?

Brown Treecreeper (eastern subspecies *C. picumnus victoriae*) (Vulnerable/Near Threatened): widespread in catchment (Gosper 1986; Figure 3b); moderately abundant; in 2004–06 present at 34 sites (83%), reporting rate 68%; in 1977–80 reporting rates of 79% and 62% respectively at Myrtle and Royal Camp SF sites.

Speckled Warbler *Chthonicola sagittata* (Vulnerable/Least Concern): widespread in catchment (Gosper 1986) but patchily distributed; low densities; in 2004–06 found at eight (20%) sites across five SFs, reporting rate 7%; in 1977–80 found at one of two sites (Royal Camp) where reporting rate 48%; records between the studies from various locations in catchment, including survey sites.

Regent Honeyeater *Anthochaera phrygia* (Critically Endangered/Critically Endangered): recorded Myrtle SF in 1977–80 study; recorded between studies at Gibberagee, Ellangowan and Myrtle SFs (Gosper and Holmes 2002); not recorded 2004–06.

Black-chinned Honeyeater (south-eastern subspecies *M. gularis gularis*) (Vulnerable/Near Threatened): widespread in catchment (Gosper 1986); moderately abundant; in 2004–06 found at 40 sites (>97%), reporting rate 56%; in 1977–80 reporting rates of 41% and 48% respectively at Myrtle and Royal Camp SF sites.

Grey-crowned Babbler (eastern subspecies *P. temporalis temporalis*) (Vulnerable/Least Concern)*:* widespread in catchment but not evenly distributed (Gosper 1986); moderately common; in 2004–06 found at 14 sites (34%) across seven SFs, reporting rate 18%; in 1977–80 found at one of two sites (Myrtle SF) where reporting rate 69%.

Varied Sittella (Vulnerable/Least Concern): widespread in catchment (Gosper 1986); low densities; has probably declined over the last few decades in the catchment (see Results).

Hooded Robin (south-eastern subspecies *M. cucullata cucullata*) (Vulnerable/Near Threatened): fairly widespread in core sites, but rare in peripheral sites (Figure 3c); in 2004–06 recorded from 12 sites (29%) across five SFs, reporting rate 13%; in 1977–80 recorded from one of two sites (Myrtle SF) where reporting rate 52%; recorded Camira, Carwong, Braemar, Gibberagee and Myrtle SFs between the studies.

Diamond Firetail (Vulnerable/Least Concern): limited distribution in middle catchment being largely confined to core sites in Braemar, Ellangowan and Carwong SFs (Figure 3d); present at low densities; in 2004–06 recorded from 11 sites (27%) across four SFs, reporting rate 12%; in 1977–80 recorded from one of two sites (Myrtle SF) where reporting rate 17%; recorded Carwong, Braemar, Ellangowan and Myrtle SFs between studies.

Square-tailed Kite *Lophoictinia isura* (Vulnerable/Least Concern), Swift Parrot (Endangered/Endangered), Scarlet Robin (Vulnerable/Least Concern) and Flame Robin (Vulnerable/Near Threatened) were recorded from the study area between the studies (Gosper and Holmes 2002).

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Appendix 1

Survey sites in the Bungawalbin Creek middle catchment 2004 –2006.

State Forest (area) Site code	Elevation (metres asl)	Location
Braemar SF (2016 ha)		
BR1	50	29º01'57.8" S / 153º00'19.4" E
BR2	55	29º02'21.6" S / 152º59'59.2" E
BR3	65	29º02'36.3" S / 152º59'57.8" E
BR4	110	29º03'10.8" S / 152º59'36.5" E
BR5	75	29º03'02.8" S / 152º59'38.5" E
BR6	60	29º02'40.7" E / 152º59'13.8" E
BR7	85	29º03'24.6" E / 152º59'30.9" E
BR8	80	29º03'48.2" E / 152º58'43.4" E
BR9	65	29º03'24.8" E / 152º59'02.4" E
BR10	60	29º03'12.5" E / 152º58'43.0" E
BR11	45	29º01'50.3" S / 152º59'12.9" E
Bungawalbin SF / National Park (1199 ha + 3722 ha)		
BW1	25	29º07'32.5" S / 153º05'27.8" E
BW2 (now NP)	30	29º05'45.8" S / 153º07'36.1" E
BW3	50	29º04'41.3" S / 153º05'17.8" E
Camira SF (4999 ha)		
CM1	100	29º14'10.6" S / 152º56'57.6" E
CM2	80	29º13'48.2" S / 152º56'34.6" E
CM3	100	29º13'39.1" S / 152º54'47 1" E
CM4	105	29º12'43.0" S / 152º53'53.0" E
Carwong SF (610 ha)		
CW1	70	29º02'41.6" S / 152º57'18.9" E
CW2	85	29º03'06.2" S / 152º56'48.5" E
CW3	75	29º03'03.6" S / 152º55'46.1" E
Ellangowan SF (1175 ha)		
EG1	40	29º01'57.3" S / 153º01'10.1" E
EG2	60	29º02'39.3" S / 153º00'41.3" E
EG3	90	29º03'25.8" S / 153º00'32.8" E
EG4	90	29º04'17.1" S / 153º00'58.0" E
Gibberagee SF (11332 ha)		
GG1	20	29º13'26.1" S / 153º06'15.2" E
GG2	35	29º13'49.5" S / 153º06'36 6" E
GG3	50	29º17'42 0" S / 153º03'01 0" E
GG4	75	29º19'58.8" S / 153º01'48.7" E
GG5	100	29º19'37 6" S / 153º02'55.8" E
Myrtle SF (5711 ha)		
M1	60	29º08'35.6" S / 152º59'20.7" E
M2	45	29º08'48.8" S / 153º00'01.2" E
M3##	50	29º09'15.0" S / 152º58'25.7" E
M4##	50	29º09'24.5" S / 152º57'06.9" E
M5	40	29º09'36.1" S / 152º58'07.9" E
M6	40	29º11'27.8" S / 152º59'49.3" E
M7	35	29º11'10.9" S / 152º59'34.0" E
Royal Camp SF (2193 ha)		
RC1	70	28º59'54.3" S / 152º54'35.8" E
RC2##	80	29º00'57.8" S / 152º53'02.4" E
RC3##	80	29º01'28.5" S / 152º52'57.7" E
RC4	130	29º01'49.2" S / 152º51'48.4" E

Source: DECCW (2009)

##1977-80 study sites