Ecography

E6094
Driscoll, D. A. and Lindenmayer, D. B. 2010.Assembly rules are rare in SE Australian bird communities, but sometimes apply in fragmented agricultural landscapes. – Ecography 33: 854–865.

Supplementary material

Appendix S1

Habitat variables from each region used in GLM analyses

Data from all sites except those in Victoria included stand height, foliage depth, fallen log count, tree hollow count, and percentage cover of logs, under-storey, mid-storey, over-storey and leaf litter. At Jervis Bay, we used topographic slope and percentage cover of forbs, grasses, bracken fern (*Pteridium esculentum*, a native weedy species), bitou bush (*Chrysanthemoides monilifera*, an invasive weed), grasses, and bare earth. We also used two categorical variables at Jervis Bay which distinguished sites burned or not burned in a bushfire in 2003, and classified sites according to broad vegetation classes (forest, heathland, shrubland, sedgeland, woodland, rainforest, garden (one site only)). At Nanangroe we used grass height and percentage cover of weeds, blackberry (*Rubus* spp. an invasive weed), grasses, shrubs, regrowth *Eucalyptus*, and mistletoe (*Amyema* spp.). On the SW-Slopes, we used percentage cover of native tussock grass, exotic tussock grass, annual grass, broadleaf weeds, forbs, bryophytes and bare ground. At Tumut we used topographic slope and percentage cover of bark, blackberry, grass, bracken fern and shrubs. Characteristics used to describe the Victorian sites were: number of standing dead trees, basal area measured using a basal area wedge, age category of dominant trees (1939 regrowth, pre 1939), forest type (*E. regnans*, *E. delegatensis*, *E. nitens*), *Acacia* species indices (prevalence in the community on a scale of 1–5) for *A. dealbata*, *A. frigisens*, *A. melanoxylon*, *A. obliquinerva*), presence/absence of eight species: *Nothofagus cunninghamii*; *Atherosperma moschatum*; *Olearia argophylla*; *Pomaderris aspera*; *Bedfordia arborescens*; *Cassinia aculeata*; *Prostanthera lasianthos*; *Zieria* spp. and Total Wilderness Quality. Total Wilderness Quality was derived by summing standardized values of the four following measures. 1) Distance from settlement; 2) distance from access roads; 3) the degree to which the landscape is free from permanent human structures; 4) the degree to which the landscape is free from disturbance caused by modern land use activities (Lindenmayer et al. 2002a). For further details on habitat variables at Tumut see (Lindenmayer et al. 1999, 2002b), at Nanangroe, see (Lindenmayer et al. 2001), at SW Slopes, see (Cunningham et al. 2007), at Jervis Bay, see (Lindenmayer et al. 2008) and at Victoria, see (Lindenmayer et al. 1990).

References

Cunningham, R. B. et al. 2007. Reptile and arboreal marsupial response to replanted vegetation in agricultural landscapes. – Ecol. Appl. 17: 609–619.

Lindenmayer, D. B. et al. 1990. The conservation of arboreal marsupials in the Montane Ash Forests of the Central Highlands of Victoria, southeast Australia. 1. Factors influencing the occupancy of trees with hollows. – Biol. Conserv. 54: 111–131.

Lindenmayer, D. B. et al. 1999. The response of arboreal marsupials to landscape context: a large-scale fragmentation study. – Ecol. Appl. 9: 594–611.

Lindenmayer, D. B. et al. 2001. A prospective longitudinal study of landscape matrix effects on fauna in woodland remnants: experimental design and baseline data. – Biol. Conserv. 101: 157–169.

Lindenmayer, D. B. et al. 2002a. On the use of landscape surrogates as ecological indicators in fragmented forests. – For. Ecol. Manage. 159: 203–216.

Lindenmayer, D. B. et al. 2002b. Effects of forest fragmentation on bird assemblages in a novel landscape context. – Ecol. Monogr. 72: 1–18.

Lindenmayer, D. B. et al. 2008. How predictable are reptile responses to wildfire? – Oikos 117: 1086–1097.

Appendix S2

Description of the automated step-wise analysis used to fit habitat variables to species abundance

The explanatory variables (with the exception of two categorical variables at Jervis Bay) were converted to principal components. The first eight or ten (Victoria only) components explained at least 80% of the original variation in our data. We fitted the first eight or ten components in a binomial step-wise regression, using BIC as the criteria for variable inclusion (model 1) (McCullagh and Nelder 1989, Venables and Ripley 2002). Cook's statistics were calculated for each site, and the most influential 5% of the data were excluded to test for the influence of outliers. The step-wise modelling was repeated (model 2), then we tested the results against three criteria:

1. If no new explanatory variables appeared in model 2, and all of the variables in model 1 were in model 2, then model 1 was taken as the final model.

2. If no new variables appeared in model 2 but variables from model 1 were not in model 2, then those variables were only included due to the influence of 5% of the data, and they do not represent the majority of the data points. Therefore, we removed those variables from the list of variables entering the step-wise procedure. The step-wise procedure was repeated to generate a new model 1, and the above process was repeated (calculate Cook's statistic, exclude 5% most influential points, generate model 2, test result against the three criteria). This procedure was repeated until criterion 1 was met.

3. If new explanatory variables appeared in model 2, these variables were only excluded from the model by 5% of the data (outliers). The presumed outliers were removed from the data set. Cook's statistics were calculated for each site and the step-wise model repeated (model 3). Model 3 was compared against model 2 using criteria 1 and 2 above. If new variables appeared in model 3, they were ignored so that no additional data points were removed. Outliers could be represented in 5% of sites, but we think it is not reasonable to regard a higher percentage as outliers. Therefore, if the most influential 5% of data were removed, the final model was based on 95% of the data. Explanatory variables were those that did not drop out when a further 5% of influential data points were removed.

References

McCullagh, P. and Nelder, J. A. 1989. Generalized linear models 2nd ed. – Chapman and Hall.

Venables, W. N. and Ripley, B. D. 2002. Modern applied statistics with S, 4th ed. – Springer.

Appendix S3

Summary of the number species for which environmental variables were fitted successfully using the automated stepwise generalised linear model and the proportion of variation explained.

Location and year	No. species for which no environmental parameters fitted	No. species with environmental parameters fitted	Average proportion variation explained (SD)
JB04	5	27	0.3 (0.15)
JB06	4	27	0.2 (0.12)
Nan98	16	25	0.21 (0.17)
Nan99	10	29	0.18 (0.15)
SWS02	13	23	0.15 (0.07)
SWS04	10	20	0.16 (0.08)
Tum96	8	41	0.16 (0.12)
Tum97	11	34	0.17 (0.11)
Vvic04	14	21	0.15 (0.12)
Vic05	10	23	0.19 (0.12)

Appendix S4

A comma-delimited file for importing to a spreadsheet, listing all species-pairs with a q cut-off ≤ 0.3, plus location/year, proportion of variation explained, P, q, direction of relationship, guild affiliation and number of predators (one or both).

(This appendix is provided as a separate comma-delimited text file.)

Appendix S5

Predatory and aggressive bird species

Species from our study regions that are potential nest predators or aggressively defend territories. Sourced from unpublished bird observations and published research (Stone 1996, Zanette and Jenkins 2000, Boulton and Clarke 2003, Clarke et al. 2003, McFarland 2003, Piper and Catterall 2003, 2006, French et al. 2005, Debus 2006, Parsons et al. 2006

Common name	Scientific name
Australian magpie	*Gymnorhina tibicen*
Australian raven	*Corvus coronoides*
bell miner	*Manorina melanophrys*
black faced cuckoo shrike	*Coracina novaehollandiae*
common myna	*Acridotheres tristis*
common starling	*Sturnus vulgaris*
eastern whipbird	*Psophodes olivaceus*
grey butcherbird	*Cracticus torquatus*
grey currawong	*Strepera versicolor*
grey shrike thrush	*Colluricincla harmonica*
laughing kookaburra	*Dacelo novaeguineae*
little friarbird	*Philemon citreogularis*
little raven	*Corvus mellori*
little wattlebird	*Anthochaera chrysoptera*
noisy friarbird	*Philemon corniculatus*
noisy miner	*Manorina melanocephala*
pied butcherbird	*Cracticus nigrogularis*
pied currawong	*Strepera graculina*
red backed kingfisher	*Todiramphus pyrrhopygia*
red wattlebird	*Anthochaera carunculata*
sacred kingfisher	*Todiramphus sanctus*
white-plumed honeyeater	*Lichenostomus penicillatus*
willie wagtail	*Rhipidura leucophrys*
yellow-faced honeyeater	*Lichenostomus chrysops*

References

Boulton, R. L. and Clarke, M. F. 2003. Do yellow-faced honeyeater (*Lichenostomus chrysops*) nests experience higher predation at forest edges? – Wildl. Res. 30: 119–125.

Clarke, M. F. et al. 2003. The social organization and breeding behaviour of the yellow-faced honeyeater *Lichenostomus chrysops* – a migratory passerine from the southern Hemisphere. – Ibis 145: 611–623.

Debus, S. J. S. 2006. Breeding and population parameters of robins in a woodland remnant in northern New South Wales, Australia. – Emu 106: 147–156.

French, K. et al. 2005. Use of native and exotic garden plants by suburban nectarivorous birds. – Biol. Conserv. 121: 545–559.

McFarland, D. C. 2003. Protection behaviours of breeding white-plumed honeyeaters *Lichenostomus penicillatus*. – Emu 84: 42–43.

Parsons, H. et al. 2006. Species interactions and habitat associations of birds inhabiting urban areas of Sydney, Australia. – Aust. Ecol. 31: 217–227.

Piper, S. D. and Catterall, C. P. 2003. A particular case and a general pattern: hyperaggressive behaviour by one species may mediate avifaunal decreases in fragmented Australian forests. – Oikos 101: 602–614.

Piper, S. D. and Catterall, C. P. 2006. Impacts of picnic areas on bird assemblages and nest predation activity within Australian eucalypt forests. – Landscape Urban Plann. 78: 251–262.

Stone, C. 1996. The role of psyllids (Hemiptera: Psyllidae) and bell miners (*Manorina melanophrys*) in canopy dieback of Sydney blue gum (*Eucalyptus saligna* Sm). – Aust. J. Ecol. 21: 450–458.

Zanette, L. and Jenkins, B. 2000. Nesting success and nest predators in forest fragments: a study using real and artificial nests. – Auk 117: 445–454.

Appendix S6

The number of bird species used in pair-wise comparisons and the number of pair-wise comparisons (no. comps) are shown for each of five regions (JB (Jervis Bay), Nan (Nanangroe), SWS (South west slopes), Tum (Tumut), Vic (central highlands, Victoria) surveyed in two years (numbers after region code). Total rainfall in each year provides an indication of relative resource availability. For three different q-value cut-offs (q ≤ 0.1, 0.2 and 0.3), the number of negative pair-wise relationships (no. neg, with number of bird species involved in those pair-wise relationships in parenthesis), mean proportion of variation explained by fitting species 2 for negative relationships (standard deviation in parenthesis), number of positive relationships (no. pos), the proportion of total pair-wise comparisons that were negative (prop-comps), the proportion of pair-wise comparisons that were positive (prop+comps), the maximum p value from permutations with the given q value (max p value).

q		JB04	JB06	Nan98	Nan99	SWS02	SWS04	Tum96	Tum97	Vic04	Vic05
	no species	32	31	41	39	36	30	49	45	54	31
	no. comps.	496	465	820	741	630	435	1176	990	1431	465
	rain (mm)	993	1175	921	1147	487	586	1110	577	1181	1048
q ≤ 0.1	no. neg	1 (2)	2 (4)	32 (24)	82 (34)	37 (22)	45 (24)	4 (7)	12 (17)	0	0
q ≤ 0.1	mean proportion expl (SD)	0.062 (–)	0.079 (0.015)	0.093 (0.04)	0.078 (0.036)	0.139 (0.071)	0.113 (0.056)	0.072 (0.009)	0.094 (0.037)	–	–
q ≤ 0.1	no. pos	23	15	99	114	91	55	28	84	4	8
q ≤ 0.1	prop-comps	0.002	0.004	0.039	0.111	0.059	0.103	0.003	0.012	0.000	0.000
q ≤ 0.1	prop+comps	0.046	0.032	0.121	0.154	0.144	0.126	0.024	0.085	0.003	0.017
q ≤ 0.1	max p value	0.004	0.002	0.019	0.036	0.02	0.025	0.001	0.009	0	0.001
q ≤ 0.2	no. neg	5 (7)	3 (6)	84 (36)	136 (38)	55 (32)	73 (29)	6 (11)	31 (31)	2 (4)	1 (2)
q ≤ 0.2	mean proportion expl (SD)	0.061 (0.008)	0.069 (0.019)	0.058 (0.029)	0.055 (0.031)	0.107 (0.068)	0.093 (0.051)	0.085 (0.035)	0.058 (0.028)	0.209 (0.036)	0.195 (–)
q ≤ 0.2	no. pos	52	31	171	183	145	72	52	157	13	16
q ≤ 0.2	prop-comps	0.010	0.006	0.102	0.184	0.087	0.168	0.005	0.031	0.001	0.002
q ≤ 0.2	prop+comps	0.105	0.067	0.209	0.247	0.230	0.166	0.044	0.159	0.009	0.034
q ≤ 0.2	max p value	0.019	0.012	0.075	0.122	0.063	0.076	0.006	0.036	0.003	0.005
q ≤ 0.3	no. neg	9 (12)	13 (17)	139 (39)	190 (39)	85 (35)	110 (30)	10 (17)	53 (37)	9 (9)	12 (13)
q ≤ 0.3	mean proportion expl (SD)	0.053 (0.017)	0.069 (0.05)	0.042 (0.026)	0.042 (0.029)	0.086 (0.061)	0.075 (0.049)	0.084 (0.042)	0.055 (0.025)	0.131 (0.043)	0.158 (0.079)
q ≤ 0.3	no. pos	94	72	245	263	184	93	99	224	33	52
q ≤ 0.3	prop-comps	0.018	0.028	0.170	0.256	0.135	0.253	0.009	0.054	0.006	0.026
q ≤ 0.3	prop+comps	0.190	0.155	0.299	0.355	0.292	0.214	0.084	0.226	0.023	0.112
q ≤ 0.3	max p value	0.055	0.046	0.182	0.268	0.129	0.161	0.019	0.082	0.012	0.028

Appendix S7

A comma-delimited text file reporting results of Fisher's exact tests of abundance of species pairs in either two years (prediction 2) or in high and low species richness sites (prediction 5). Pair-wise comparisons of species that were negative in the first year, or in high species richness sites are shown.

(This appendix is provided as a separate comma-delimited text file.)

Appendix S8

A comma-delimited text file reporting results of binomial GLM testing the difference in abundance between either two years (prediction 2) or between high and low species richness sites (prediction 5). Species examined include those that were involved in negative pair-wise interactions with another species in the first year, or in high species richness sites.

(This appendix is provided as a separate comma-delimited text file.)

Appendix S9

Species accounting for half of the negative relationships (q ≤ 0.1) at Nanangroe and SW-Slopes. Numbers indicate how many negative relationships each species was involved in. HE = honeyeater.

Species	Nan98	Species	Nan99	Species	SWS02	Species	SWS04
White-plumed HE *Lichenostomus penicillatus*	12	White-plumed HE *Lichenostomus penicillatus*	13	Noisy miner *Manorina melanocephala*	14	Noisy miner *Manorina melanocephala*	10
Willie wagtail *Rhipidura leucophrys*	6	Red-rumped parrot *Psephotus haematonotus*	10	Eastern rosella *Platycercus eximius*	9	Striated pardalote *Pardalotus striatus*	9
Crested shrike tit *Falcunculus frontatus*	4	Rufous songlark *Cincloramphus mathewsi*	9	Striated pardalote *Pardalotus striatus*	7	Eastern rosella *Platycercus eximius*	8
Grey fantail *Rhipidura fuliginosa*	4	Brown thornbill *Acanthiza pusilla*	8	Grey shrike thrush *Colluricincla harmonica*	5	White-plumed HE *Lichenostomus penicillatus*	7
Red-rumped parrot *Psephotus haematonotus*	4	Grey fantail *Rhipidura fuliginosa*	8	White-plumed HE *Lichenostomus penicillatus*	4	Galah *Cacatua roseicapilla*	6
White-throated gerygone *Gerygone olivacea*	3	Willie wagtail *Rhipidura leucophrys*	8			Grey shrike thrush *Colluricincla harmonica*	6
		Yellow-faced HE *Lichenostomus chrysops*	8				
		Magpie lark *Grallina cyanoleuca*	7				
		Spotted pardalote *Pardalotus punctatus*	7				
		Dusky woodswallow *Artamus cyanopterus*	6				

Appendix S10

The species that declined in low species richness sites at Nan98 and SWS02 for species involved in significant ($q \leq 0.1$) negative pair-wise relationships at high species richness sites. Dash indicates the species was not involved in negative relationships at high species-richness sites at that region. Red-rumped parrot scored y/n because it had lower abundance but occurred at more sites among the low species richness sites. * species commonly found in open habitat and farmland (Morcombe 2003).

Species	Scientific name	declined Nan98	declined SWS02
Willie wagtail	*Rhipidura leucophrys*	n	y
White-plumed honeyeater	*Lichenostomus penicillatus*	n	y
Eastern rosella*	*Platycercus eximius*	n	n
Common starling*	*Sturnus vulgaris*	n	–
Crested shrike tit	*Falcunculus frontatus*	n	–
Brown thornbill	*Acanthiza pusilla*	y	–
Crimson rosella*	*Platycercus elegans*	y	–
Grey fantail	*Rhipidura fuliginosa*	y	–
Leaden flycatcher	*Myiagra rubecula*	y	–
Red-rumped parrot*	*Psephotus haematonotus*	y/n	–
Rufous whistler	*Pachycephala rufiventris*	y	–
Silvereye	*Zosterops lateralis*	y	–
White browed scrubwren	*Sericornis frontalis*	y	–
White-throated gerygone	*Gerygone olivacea*	y	–
White-throated treecreeper	*Cormobates leucophaeus*	y	–
Yellow-faced honeyeater	*Lichenostomus chrysops*	y	–
Cockatiel	*Nymphicus hollandicus*	–	n
Crested pigeon*	*Ocyphaps lophotes*	–	n
Noisy miner*	*Manorina melanocephala*	–	n
Pied butcherbird	*Cracticus nigrogularis*	–	n
Striated pardalote*	*Pardalotus striatus*	–	n
Yellow-rumped thornbill*	*Acanthiza chrysorrhoa*	–	n
Brown treecreeper	*Climacteris picumnus*	–	y
Dusky woodswallow*	*Artamus cyanopterus*	–	y
Grey shrike thrush	*Colluricincla harmonica*	–	y
Laughing kookaburra*	*Dacelo novaeguinea*	–	y
Peaceful dove	*Geopelia striata*	–	y

References

Morcombe, M. 2003. Field guide to Australian birds. – Steve Parish Publ.