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EFFECTS OF EUCALYPT DIEBACK ON BIRD SPECIES DIVERSITY IN REMNANTS OF NATIVE WOODLAND

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Data on bird species diversity, bird density, species diversity of various foraging groups and of honeyeaters were analysed in relation to mean dieback scores of woodland remnants in the Australian Capital Territory. Bird species diversity and bird density were found to be significantly reduced as dieback increased. The reduction in bird species diversity can be accounted for by the declines in subcanopy bird species diversity and insectivorous bird species diversity, the latter being restricted most to the foliage insectivores, ground insectivores and bark insectivores. Honeyeaters were also shown to decline significantly with an increase in dieback. Reasons for the decline in bird species diversity with increased dieback, the dieback-insects-birds cycle and the implications of dieback for the conservation of bird species are discussed in relation to these observations.

INTRODUCTION

Where eucalypt woodlands once dominated large areas of the northern and southern tablelands in south-eastern Australia, they occur today largely as remnant stands on pastoral land. Many of these woodland remnants are severely affected by eucalypt dieback, a symptom of ecosystem dysfunction. It is characterised by the progressive and often protracted dying back of tips or branches in the crown of the tree, leading eventually to death. While the causes of eucalypt dieback are not fully understood, it is becoming clear that it may be the result of a complex web of interactions involving biological and non-biological agents (Old *et al.* 1981; Heatwole and Lowman 1986; Wylie and Landsberg 1990; Landsberg and Gillieson 1995; Landsberg *et al.* 1990).

One of many such interactions is the role of birds in preventing defoliating insect populations from reaching outbreak levels, thereby contributing to eucalypt dieback. Ford (1985) estimated that birds eat in the order of 55–70 per cent of foliage insects produced each year and concluded that they have the potential to influence insect populations, thereby minimising the occurrence of eucalypt dieback. A similar conclusion was also reached by Loyn (1987) who showed that the absence of forest birds in small heavily grazed forest remnants resulted in such sites having a higher degree of eucalypt dieback due to insect defoliation. More interestingly, Loyn *et al.* (1983) and Loyn (1985, 1987) provided evidence that in some of these forest remnants, the presence of Bell Miners *Manorina melanophrys* and Noisy Miners *Manorina melanocephala* excluded other foliage insectivorous bird species through indiscriminate interspecific aggression, thereby contributing to higher defoliating insect populations and increased levels of eucalypt dieback.

While there have been several studies on the role of birds in controlling insect populations that contribute to eucalypt dieback, only one study has documented the effects of eucalypt dieback on birds. Working in the northern tablelands, Ford and Bell (1981) found that bird density declined from over 20 individuals per ha in healthy woodland to 10 individuals per ha in woodland with moderate dieback and finally, to only two individuals per ha where dieback was severe. The number of bird species was also noted to decrease dramatically.

The reductions in the number of bird species and abundance of individuals in areas affected by eucalypt dieback may further accelerate the dieback, as some of these birds are insectivorous and may play a part in controlling defoliating insects. It is therefore important to understand the response of different bird species to eucalypt dieback. In view of this, a study was conducted to provide additional observations on the effects of eucalypt dieback on the woodland bird community, focusing primarily on bird species diversity, bird density and diversity of various foraging groups.

STUDY AREA AND METHODS

The study area was in Yellow Box *Eucalyptus melliodora*-Blakely's Red Gum *E. blakelyi* woodland which once covered large areas of the Australian Capital Territory below 750 m (Banks and Paton 1993). Large areas of the woodland have since been cleared for pastoralism, urbanization and plantation forestry. Remnants of woodland have been retained on pastoral land as well as in nature reserves fringing the city of Canberra. Much of this woodland has been degraded by grazing, fire and the removal of trees for timber and firewood (Frawley 1991). Eucalypt dieback as a result of repeated defoliation by insects over many years is also common in many of these woodland remnants, with the larvae of the Chrysomelid Beetle *Paropsis atomaria*, Christmas Beetles *Anoplognathus* spp. and psyllids (Psyllidae) being the chief defoliators (Hogg 1983a, b; Landsberg *et al.* 1990; M. Tanton, pers. comm.; K. Er, pers. obs.).

Nine woodland remnants and an arboretum (planted in the 1930s) dominated by Yellow Box and Blakely's Red Gum were randomly selected as study sites. Ranging from 2 ha to 600 ha, they differed in tree stand density, shrub cover and were affected to varying degrees by eucalypt dieback (Table 1). Further details of the study sites have been described by Er (1995).

Birds were sampled by the method described in Er *et al.* (1995). A total of 28 fixed-width transects (200 m by 60 m) were systematically located across all 10 study sites (Table 1). A single observer traversed the centre line of each transect at a steady rate of 50 m per 10 minutes. Bird species and numbers within the transect strip were recorded only when birds were seen. Bird calls were used to locate birds and to aid identification. Birds seen flying overhead were also recorded only when they appeared to be hunting (e.g. raptors) or foraging in the air space above the vegetation (e.g. swallows).

The study was conducted from March 1994 to December 1994 inclusive. Each transect was sampled four times, once in each season, autumn (March to May), winter (June to August), spring (September to November) and summer (December).

Bird records from all transects in each study site were pooled together for each season, excluding the waterbird species. Overall bird species diversity for each study site in each season was represented by the Shannon-Wiener species diversity index[1], while bird abundance was represented by bird density (i.e. birds ha^{-1}). Averages for these indices were then calculated across all four seasons for each study site.

The bird species were also grouped according to their foraging height, diet and substrate, based on Frith (1969), Gilmore (1985), Recher *et al.* (1985), Ford *et al.* (1986) and Schodde and Tidemann (1993). The foraging groups were canopy (> 10 m above ground); subcanopy (4–10 m); shrub (0.2–4 m); ground (0–0.2 m); granivores; insectivores; foliage insectivores; ground insectivores; aerial insectivores; and bark insectivores (see Appendix for species in each group). There were too few birds in the other foraging groups (e.g. nectarivores and frugivores) to permit any meaningful analysis. Honeyeaters (Meliphagidae) were also pooled together to enable further analysis. The Shannon-Wiener species diversity index was derived for each of these foraging groups and for honeyeaters in each study site in each season. These were also averaged across all seasons for each study site.

Each transect was divided equally into four strata (lengthwise). A 20 m by 20 m quadrat plot was randomly chosen within each strata (i.e. 112 quadrat plots in the 10 sites) (York *et al.* 1991). Trees (> 4 m in height) within each quadrat plot were assessed for dieback and given a score of 1 to 5. The scoring system followed the different stages of dieback described by Heatwole and Lowman (1986). A score of 5 depicted a stage with no live foliage, while a score of 1 represented a healthy tree. A mean dieback score was obtained for each study site.

[1]The Shannon-Wiener species diversity index was calculated as

$$H = -\sum_{i=1}^{s} P_i (\log_2 P_i)$$

where P_i is the relative abundance of each species recorded in all transects within the study site (Krebs 1989).

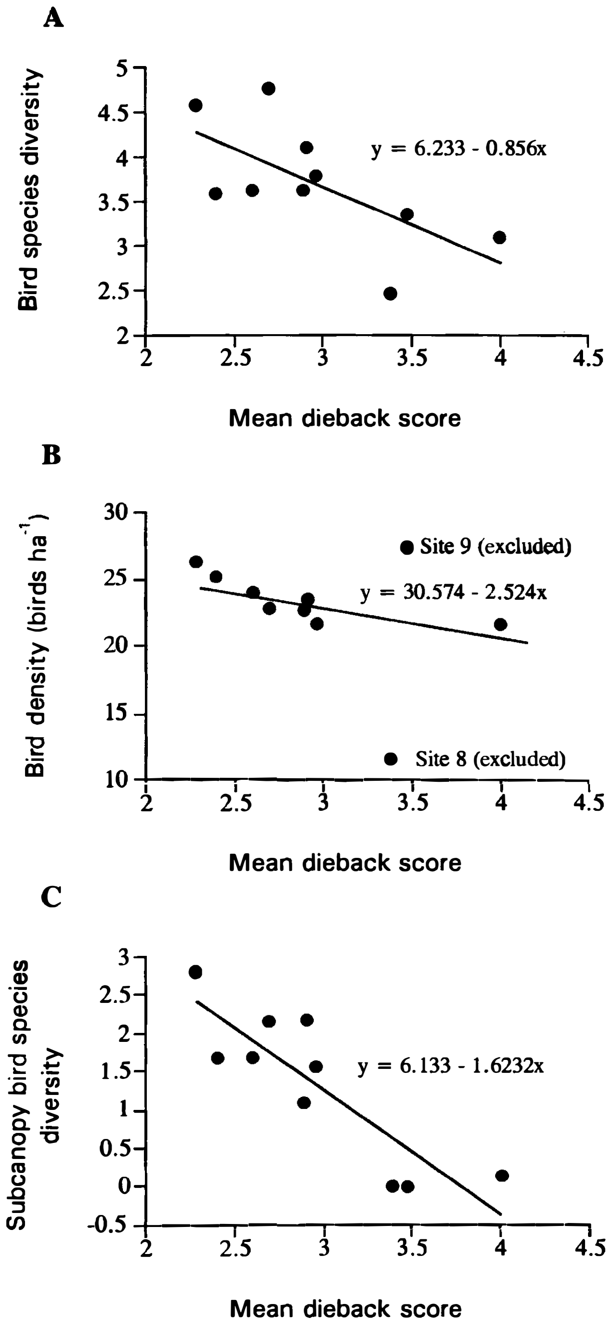

Figure 1. *Effect of eucalypt dieback on: A. bird species diversity; B. bird density; C. subcanopy bird species diversity in Yellow Box-Blakely's Red Gum woodland remnants in the ACT.*

Simple linear regression analysis was used to examine the relationships between bird species diversity and dieback; bird density and dieback; mean species diversity of each foraging group and dieback; and honeyeater species diversity and dieback. Normality and residual plots confirmed that the data conformed to the assumptions of normality and constant variance (Zar 1984). Cook's D-statistic was used to identify influential points. They were excluded and the regression line replotted. Changes were noted and the influential points were examined in detail.

RESULTS

The overall bird species diversity, bird density and the species diversity of the various foraging groups and honeyeaters in each study site are summarised in Table 2, while the mean dieback score for each site is summarised in Table 1.

Simple linear regression analysis revealed that bird species diversity was significantly reduced as dieback increased ($r^2 = 0.377$, d.f. = 9, $p = 0.0349$) (Fig. 1A). As with bird species diversity, bird density also showed a general trend of decline with the increase in dieback. However, this relationship was found to be statistically significant only upon the exclusion of two influential points, Site 8 and Site 9 ($r^2 = 0.545$, d.f. = 7, $p = 0.0221$). Bird density remained high in Site 9 (27.3 birds ha^{-1}) despite a relatively high mean dieback score of 3.47, but was extremely low in Site 8 (11.5 birds ha^{-1}) despite it having a mean dieback score almost similar to that of Site 9 (i.e. 3.39) (Tables 1 and 2, Fig. 1B).

Focusing on the species diversity of the four foraging height groups, it was found that only subcanopy bird species diversity appeared to be significantly reduced by an increase in dieback ($r^2 = 0.707$, d.f. = 9, $p = 0.0014$) (Fig. 1C). No significant responses were found with canopy bird species diversity ($r^2 = 0.321$, d.f. = 9, $p = 0.0509$), shrub bird species diversity ($r^2 = -0.066$, d.f. = 9, $p = 0.5234$) and ground bird species diversity ($r^2 = 0.299$, d.f. = 9, $p = 0.0592$).

In terms of the diet groups, granivorous bird species diversity appeared least affected by an increase in dieback ($r^2 = 0.166$, d.f. = 9, $p = 0.1335$), while insectivorous bird species diversity was significantly reduced ($r^2 = 0.514$, d.f. = 9, $p = 0.0118$) (Fig. 2A). Further investigation of the insectivorous species revealed that the response to dieback was dependent on the substrate used. It seemed that the species diversity of foliage insectivores ($r^2 = 0.537$,

TABLE 1

Characteristics of study sites, including location, number of transects per site, density of trees (stems ha^{-1}), percentage shrub cover and mean dieback score.

Site	Location	No. of transects	Stand tree density (stems ha^{-1})	Shrub cover (%)	Mean dieback score
1. Ainslie Nature Reserve	35°17′00″S, 149°09′00″E	6	149	35.0	2.28
2. Hall	35°10′17″S, 149°04′08″E	2	47	40.0	2.40
3. Kowen	35°18′42″S, 149°14′28″E	2	31	15.0	2.60
4. Callum Brae	35°21′50″S, 149°07′40″E	6	135	36.7	2.69
5. Lambrigg	35°27′40″S, 149°02′50″E	2	72	85.0	2.89
6. Mulligan's Flat Nature Reserve	35°09′47″S, 149°10′24″E	4	173	25.0	2.91
7. Bulgar Creek	35°21′30″S, 149°00′10″E	3	42	43.3	2.96
8. Cotter Arboretum	35°20′18″S, 149°59′05″E	1	500	0	3.39
9. Stirling Park	35°18′30″S, 149°06′00″E	1	206	60.0	3.47
10. Urambi Hills Nature Reserve	35°24′13″S, 149°03′13″E	1	19	40.0	4.00

d.f. = 9, p = 0.0096) (Fig. 2B), ground insectivores (r^2 = 0.583, d.f. = 9, p = 0.0062) and bark insectivores (r^2 = 0.428, d.f. = 9, p = 0.0238) were most significantly reduced by an increase in dieback. The species diversity of aerial insectivores did not show any significant response to the increased dieback (r^2 = 0.083, d.f. = 9, p = 0.2143). Honeyeaters, as a group, also showed a signifieduction in species diversity as dieback increased (r^2 = 0.419, d.f. = 9, p = 0.0256) (Fig. 2C).

DISCUSSION

Reasons for the decline in bird species diversity

The observed decline in both bird species diversity and bird density are consistent with those observed by Ford and Bell (1981) in wood

TABLE 2

Summary of bird density, bird species diversity, species diversity of the various foraging groups and honeyeaters recorded in each study site. 1 = Ainslie Nature Reserve; 2 = Hall; 3 = Kowen; 4 = Callum Brae; 5 = Lambrigg; 6 = Mulligan's Flat Nature Reserve; 7 = Bulgar Creek; 8 = Cotter Arboretum; 9 = Stirling Park; 10 = Urambi Hills Nature Reserve. [a]Bird density is calculated as birds ha^{-1}. [b]Species diversity is calculated as the Shannon-Wiener diversity index[c].

Bird variables	Study sites 1	2	3	4	5	6	7	8	9	10
[a]Bird Density	26.4	25.1	23.9	22.8	22.6	23.4	21.5	11.5	27.3	21.5
[b]Bird species diversity	4.58	3.59	3.64	4.75	3.63	4.12	3.79	2.46	3.36	3.09
[b]Canopy bird species diversity	2.33	1.40	1.36	2.73	1.87	2.21	1.76	0.66	0.85	1.02
[b]Subcanopy bird species diversity	2.81	1.69	1.69	2.15	1.09	2.18	1.57	0	0	0.13
[b]Shrub bird species diversity	1.02	0	0	0.58	0.77	0.14	0	0	0.56	0.20
[b]Ground bird species diversity	3.48	2.77	2.87	3.89	2.36	2.88	3.07	1.76	2.58	2.35
[b]Granivorous bird species diversity	1.78	1.41	1.58	2.41	0.75	1.39	2.15	0.63	1.06	1.07
[b]Insectivorous bird species diversity	4.26	3.09	2.96	4.18	3.26	3.72	2.95	1.90	2.68	2.12
[b]Foliage insectivorous bird species diversity	3.19	2.05	1.85	2.70	1.94	2.56	1.55	0.25	1.19	1.02
[b]Aerial insectivorous bird species diversity	1.58	0.63	0.25	1.88	1.07	1.47	0.98	0.15	0.48	0.62
[b]Bark insectivorous bird species diversity	1.38	0.23	0.69	0.71	0.34	1.06	0.5	0	0	0
[b]Ground bird species diversity	2.58	1.88	1.72	2.80	1.73	2.06	1.80	1.06	1.63	0.78
[b]Honeyeater species diversity	2.25	0.45	1.15	1.40	0.45	0.97	0.18	0	0	0.23

[c]The Shannon-Wiener species diversity index was calculated as

$$H = -\sum_{i=1}^{S} P_i (\log_2 P_i)$$

where P_i is the relative abundance of each species recorded in all transects within the study site (Krebs 1989).

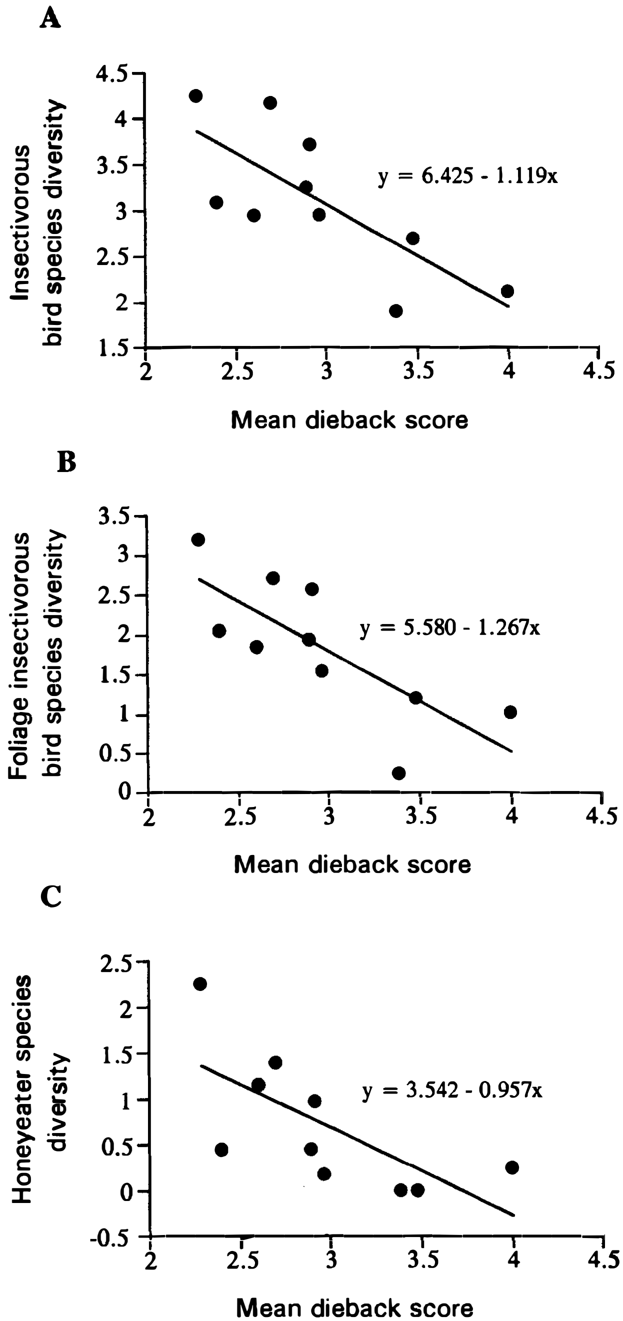

Figure 2. *Effect of eucalypt dieback on: A. insectivorous bird species diversity; B. foliage insectivorous bird species diversity; C. honeyeater species diversity in Yellow Box-Blakely's Red Gum woodland remnants in the ACT.*

lands affected to varying degree by eucalypt dieback (Fig. 1A and 1B). There could be several reasons as to why bird species diversity and density were reduced as dieback increased. They may include (1) reduction of foraging substrate, i.e. tree foliage; (2) the reduction of tree cover against predators and environmental factors, such as strong wind, cold and heat; (3) absence of a shrub layer; (4) indiscriminate exclusion of insectivorous species by Noisy Miners. These reasons are discussed in greater detail with reference to observations made in this study, where possible.

FORAGING SUBSTRATE

The loss of tree foliage is apparent as eucalypt dieback progresses and will result in the loss of an important foraging substrate. While this may seem a logical explanation for the observed reductions in subcanopy bird species diversity and foliage insectivorous bird species diversity (Fig. 1C and 2B), its effect is probably most strongly manifested in the later stages of dieback where virtually all tree foliage is lost. Indeed, it is often observed that in trees suffering from dieback due to insect defoliation, insect populations remain high even in trees with poor crown condition (i.e. sparse foliage) (Ford 1986; Landsberg *et al.* 1990; K. Er, pers. obs.). Moreover, most of the defoliating insects known to induce dieback are taken by a great number of native insectivorous bird species (Ford 1985, 1986). Furthermore the selection of tree foliage as a substrate by Australian birds is correlated with the abundances of suitable invertebrates found on the foliage (Bell 1985; Woinarski 1985; Recher 1989; Recher and Majer 1994). The increase in dieback due to insect defoliation should therefore result in an increase in subcanopy bird species diversity or foliage insectivorous bird species diversity.

TREE COVER

Ford (1986) reasoned that the loss of tree cover against predators may outweigh the benefits of high insect populations in areas where dieback was caused by insect defoliation. Although there is no direct evidence of this, there is evidence to suggest that the lack of cover against predators and also against strong wind, extreme cold and heat will not only reduce foraging efficiency in birds (Grubb 1975, 1978; Lima 1985; Miller *et al.* 1991; Weiss and Murphy 1993; Larsson and Hemborg 1995), but also bring about nest failure (Ricklefs 1969; Woinarski 1989; Ford 1989; Bridges 1994). In view of this argument, it may be postulated that the reductions in subcanopy bird species diversity and foliage insectivorous bird species diversity were brought about largely by the loss of tree cover against predators and environmental effects, with the loss of tree foliage as a foraging substrate becoming additive towards the later stages of dieback (Fig. 1C and 2B). On the other hand, the observed reductions in ground insectivorous bird species diversity and bark insectivorous bird species diversity with increased dieback may be wholly attributed to the loss of tree cover against predators and environmental effects, especially since both substrates do not appear to be affected by dieback.

Although overall bird species diversity was reduced by dieback, it must be noted that not all species would be similarly affected. Ford and Bell (1981) observed that larger birds (mass greater than 100 g), such as the Eastern Rosella *Platycercus eximius*, Australian Magpie *Gymnorhina tibicen* and Grey Butcherbird *Cracticus torquatus*, appeared to be least affected by dieback. It is probable that such species are less vulnerable to predation and environmental factors under reduced tree cover. The higher tolerance of larger bird species may explain why granivorous bird species diversity and overall ground bird species diversity were not significantly affected by dieback. The presence of a high number of large granivorous birds (mass greater than 100 g) (e.g. rosellas) would have masked the effects of dieback on the smaller granivorous birds (e.g. firetails), thereby rendering the effect on granivorous bird species diversity insignificant. Similarly, as a small number of large birds are strictly insectivorous (i.e. Australian Magpie, White-winged Chough *Corcorax melanorhamphos*, Magpielark *Grallina cyanoleuca*, Blackbird *Turdus merula*), the higher tolerance of large birds to dieback became negligible in the analysis involving ground insectivorous bird species diversity. This was however manifested when overall ground bird species diversity was analysed due to the greater number of large birds (i.e. including those not strictly insectivorous, such as the Pied Currawong *Strepera graculina* and Australian Raven *Corvus coronoides*).

SHRUB LAYER

The analysis of bird density in this study revealed that the reduction in bird density due to dieback *per se* may be confounded by the presence or absence of a shrub layer. The presence of dense shrub cover (60%) in Site 9 may have compensated for the loss of tree cover due to eucalypt dieback by providing additional cover against predators and environmental factors, thereby creating suitable foraging and nesting sites for small insectivorous birds (Table 1 and Fig. 1B). Some support for this comes from the observation that the site had relatively high densities of Silvereyes *Zosterops lateralis* and Superb Fairywrens *Malurus cyaneus*, species known to prefer nesting in dense shrubs (Kikkawa and Wilson 1983; Nias 1986). Hence, high densities of small ground insectivores and foliage insectivores may continue to persist, contributing to a high overall bird density in Site 9. This is in contrast to Site 8 where the absence of a shrub layer would have aggravated the loss of species due to dieback (Table 1 and Fig. 1B). The maintenance of a shrub layer in sites adversely affected by dieback may be even more critical during periods of extreme weather conditions (e.g. winter or periodic droughts) where large numbers of small insectivorous birds, such as thornbills, tend to move into woodland remnants from adjacent farmland to forage and obtain shelter (Recher *et al.* 1983; Arnold *et al.* 1987; Er and Tidemann 1996). Notwithstanding the importance of maintaining a shrub layer, too dense a shrub layer may be counter-productive. This is because it can become a hindrance to foraging manoeuvres and the presence of too many nectar-bearing or berry-bearing shrubs could encourage aggressive species (e.g. Red Wattlebird *Anthochaera carunculata*, Noisy Friarbird *Philemon corniculatus* and Noisy Miner) and nest predators (e.g. Pied Currawong) (Ford 1986; Holmes and Recher 1986). Perhaps Site 5 with relatively high dieback and shrub cover of 85 per cent is a case in point.

NOISY MINERS

It was not possible to conclude in this study whether aggressive bird species, such as Noisy Miners, had any effect on dieback by excluding other insectivorous species. There were insufficient data on Noisy Miner abundance to do a statistical analysis. It is however noteworthy that Noisy Miners were observed on several occasions exhibiting aggression towards other foliage foragers, including honeyeaters (e.g. White-plumed Honeyeater *Lichenostomus penicillatus*, Fuscous Honeyeater *Lichenostomus fuscus* and Brown-headed Honeyeater *Melithreptus brevirostris*). Aggression of such nature can become detrimental to tree health, as demonstrated by Loyn (1985, 1987), Loyn *et al.* (1983).

Dieback and conservation — case of the honeyeaters

The discussion so far has centred upon the possible reasons for the reduction of bird species diversity with increased dieback due to insect defoliation. As highlighted earlier, the significance of such knowledge stems from the fact that the interaction between dieback, insects and birds is a vicious cycle. Increased insect populations result in increased dieback, thereby bringing about a decrease in bird species diversity. This will then lead to further increase in insect populations and hence, worsening of dieback. When unchecked, this cycle may bring about serious implications for the conservation of native birds. This concept is discussed with reference to the effects of dieback on the honeyeaters.

The species diversity of honeyeaters was significantly reduced in sites showing higher degrees of dieback (Fig. 2C). This could be due to: the majority of honeyeaters being foliage foragers (i.e. Yellow-faced Honeyeater *Lichenostomus chrysops*, White-naped Honeyeater *Melithreptus lunatus*, Brown-headed Honeyeater, Fuscous Honeyeater and White-plumed Honeyeater); a lack of shrub cover resulting in low numbers of nectarivorous honeyeaters (i.e. Eastern Spinebill *Acanthorhynchus tenuirostris*, Red Wattlebird and Noisy Friarbird); and to a lesser extent, exclusion by Noisy Miners through indiscriminate interspecific aggression.

Although largely migratory, the honeyeaters form a major component of the woodland bird community in the Australian Capital Territory (Er and Tidemann 1996). As they are mainly generalized insectivores and have higher energy demands than the smaller insectivores (e.g. thornbills) (given that energy demands are closely related to body weights, Ford 1985), the decline of these species in sites with high dieback would probably result in a worsening of the dieback due to uncontrolled insect defoliation. As more sites become adversely affected by dieback, complications can arise due to the "modified" habitat favouring one species over another. An example is the decline of the rare Helmeted Honeyeater *Lichenostomus melanops cassidix* in Victorian woodlands due to indiscriminate exclusion by Bell Miners which appeared to be favoured as trees became chronically infested by psyllids (Wykes 1985). More importantly, the result appeared to suggest that honeyeaters tend to favour healthy sites. If left unchecked, eucalypt dieback can have serious implications on the population of over-wintering honeyeaters in the woodland remnants and the survival of northward bound migrating honeyeaters.

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APPENDIX

List of bird species recorded in the study.

Foraging Height Group: Ground (0–0.2 m); Shrub (0.2–4.0 m); Subcanopy (4.0–10.0 m); Canopy (>10 m). Foraging Guild: **AI** — Aerial Insectivores; **BI** — Bark Insectivores; FI — Foliage Insectivores; **GI** — Ground Insectivores; **G** — Granivores; **F** — Frugivores; **N** — Nectarivores; **O** — Omnivores; **C** — Carnivores.

Species		Foraging guild	No. of sites observed*
Canopy Foragers			
Dollarbird	*Eurystomus orientalis*	AI	3
Masked Woodswallow	*Artamua personatus*	AI	1
White-browed Woodswallow	*Artamus superciliosus*	AI	2
Dusky Woodswallow	*Artamus cyanopterus*	AI	5
Welcome Swallow	*Hirundo neoxena*	AI	6
Tree Martin	*Hirundo nigricans*	AI	6
Fairy Martin	*Hirundo ariel*	AI	1
Pallid Cuckoo	*Cuculus pallidus*	FI	2
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	FI	2
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*	FI	2
Striated Pardalote	*Pardalotus striatus*	FI	7
Weebill	*Smicrornis brevirostris*	FI	9
Western Gerygone	*Gerygone fusca*	FI	5
White-throated Gerygone	*Gerygone olivacea*	FI	7
Striated Thornbill	*Acanthiza lineata*	FI	7
Fuscous Honeyeater	*Lichenostomus fuscus*	FI	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	FI	1
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	FI	7
Mistletoebird	*Dicaeum hirundinaceum*	F	2
Gang-gang Cockatoo	*Callocephalon fimbriatum*	G	1
Australian King-Parrot	*Alisterus scapularis*	G	3
Crimson Rosella	*Platycercus elegans*	G	10
Little Lorikeet	*Glossopsitta pusilla*	N	1
Noisy Friarbird	*Philemon corniculatus*	N	4
Olive-backed Oriole	*Oriolus sagittatus*	O	3
Subcanopy Foragers			
Leaden Flycatcher	*Myiagra rubecula*	AI	3
Grey Fantail	*Rhipidura fuliginosa*	AI	10
White-throated Treecreeper	*Cormobates leucophaeus*	BI	8
White-eared Honeyeater	*Lichenostomus leucotis*	BI	5
Varied Sittella	*Daphoenositta chrysoptera*	BI	2
Crested Shrike-tit	*Falcunculus frontatus*	BI	1
Spotted Pardalote	*Pardalotus punctatus*	FI	4
Yellow Thornbill	*Acanthiza nana*	FI	3
Noisy Miner	*Manorina melanocephala*	FI	6
Yellow-faced Honeyeater	*Lichenostomus chrysops*	FI	6
White-plumed Honeyeater	*Lichenostomus penicillatus*	FI	5
White-naped Honeyeater	*Melithreptus lunatus*	FI	4
Rufous Whistler	*Pachycephala rufiventris*	FI	7
Shrub Foragers			
Rufous Fantail	*Rhipidura rufifrons*	AI	1
Brown Thornbill	*Acanthiza pusilla*	FI	6
Golden Whistler	*Pachycephala pectoralis*	FI	7
Silvereye	*Zosterops lateralis*	FI	6
Red Wattlebird	*Anthochaera carunculata*	N	1
Eastern Spinebill	*Acanthorhynchus tenuirostris*	N	1

*Detailed breakdown of individual abundance of bird species in each site is presented in Er (1995).

Appendix — *continued*

Species		Foraging guild	No. of sites observed*
Ground Foragers			
Restless Flycatcher	*Myiagra inquieta*	AI	1
Willie Wagtail	*Rhipidura leucophrys*	AI	10
Brown Treecreeper	*Climacteris picumnus*	BI	3
Grey Shrike-thrush	*Colluricincla harmonica*	BI	8
Superb Fairy-wren	*Malurus cyaneus*	GI	8
White-browed Scrubwren	*Sericornis frontalis*	GI	5
Speckled Warbler	*Chthonicola sagittata*	GI	4
Buff-rumped Thornbill	*Acanthiza reguloides*	GI	7
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	GI	10
Jacky Winter	*Microeca leucophaea*	GI	3
Scarlet Robin	*Petroica multicolor*	GI	7
Red-capped Robin	*Petroica goodenovii*	GI	1
Flame Robin	*Petroica phoenicea*	GI	2
Hooded Robin	*Melanodryas cucullata*	GI	1
Magpie-lark	*Grallina cyanoleuca*	GI	6
White-winged Triller	*Lalage sueurii*	GI	3
Australian Magpie	*Gymnorhina tibicen*	GI	9
White-winged Chough	*Corcorax melanorhamphos*	GI	7
Richard's Pipit	*Anthus novaeseelandiae*	GI	1
Blackbird	*Turdus merula*	GI	2
Fan-tailed Cuckoo	*Cacomantis flabelliformis*	GI	5
Black-shouldered Kite	*Elanus axillaris*	C	1
Whistling Kite	*Haliastur sphenurus*	C	1
Brown Goshawk	*Accipiter fasciatus*	C	1
Wedge-tailed Eagle	*Aquila audax*	C	3
Nankeen Kestrel	*Falco cenchroides*	C	2
Laughing Kookaburra	*Dacelo novaeguineae*	C	7
Crested Pigeon	*Ocyphaps lophotes*	G	3
Galah	*Cacatua roseicapilla*	G	9
Sulphur-crested Cockatoo	*Cacatua galerita*	G	8
Eastern Rosella	*Platycercus eximius*	G	8
Red-rumped Parrot	*Psephotus haematonotus*	G	4
Double-barred Finch	*Taeniopygia bichenovii*	G	2
Red-browed Firetail	*Neochmia temporalis*	G	6
Diamond Firetail	*Stagonopleura guttata*	G	2
European Goldfinch	*Carduelis carduelis*	G	2
Brown Quail	*Coturnix ypsilophora*	O	1
Southern Whiteface	*Aphelocephala leucopsis*	O	1
Pied Currawong	*Strepera graculina*	O	6
Grey Currawong	*Strepera versicolor*	O	3
Australian Raven	*Corvus coronoides*	O	8
Skylark	*Alauda arvensis*	O	1
House Sparrow	*Passer domesticus*	O	1
Common Starling	*Sturnus vulgaria*	O	8
Common Myna	*Acridotheres tristis*	O	4

*Detailed breakdown of individual abundance of bird species in each site is presented in Er (1995).

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BOOK REVIEW

Oystercatchers and their estuarine food supplies *Ardea* 84A: 1–538, 1996

Anne-Marie Blomert, Bruno J. Ens, John D. Goss-Custard, Jan B. Hulscher and Leo Zwarts (eds)

The Netherlands Ornithologist's Union has published a special edition of their journal *Ardea* presenting 34 papers covering all aspects of recent European research on Oystercatchers *Haematopus ostralegus.* It is concluded in the forword to this publication that the Oystercatcher is now one of the best studied species of bird but it would be wrong to conclude that we now know all about it.

The text is well edited with clear easy-to-read diagrams and tables with black and white photographs of Oystercatchers and habitats interspersed at the end of papers. All papers are published in English with a Dutch summary at the end of the paper.

Subjects covered in the papers include;

- **Methodology;** ageing, sexing, weight, statistical analysis and food intake.
- **Detailed studies on foraging behaviour;** prey choice and search speed, differences between male and female feeding, search behaviour and diet, seasonal changes in diet, intake rates, energy consumption, daily energy requirements and time and energy budgets.
- **Adaptation:** conflicting demands; seasonal and annual variation in body weight, sex ratio, population structures and temporal variation in social rank.
- **Numbers in relation to food supply;** predicting seasonal and annual fluctuations, effect of Oystercatchers on shellfish populations and winter mortality: the effect of severe weather.
- **Experimental manipulations of the available food supply;** effect of created mussel beds, feeding behaviour during tidal manipulation and distribution of Oystercatchers in relation to main prey species.

I found all the papers interesting and easy to read, and I would recommend this publication to all serious wader workers in Australasia. It will serve as a model for future broad scope studies on wader species.

A copy of this publication is available in the ABSA Library held by Birds Australia, Southern New South Wales and Australian Capital Territory Group, Sydney Office. Copies can be purchased from the IBN. To this end, advance payment should be made by giro transfer of the price of 55 Dutch guilders to post account 948540 of the DLO Institute for Forestry and Nature Research, P.O. Box 23, 6700 AA Wageningen, The Netherlands. Specify Oystercatcher *Ardea.*

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