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BIRD ABUNDANCE IN DIFFERENT-AGED STANDS OF RIMU *(DACRYDIUM CUPRESSINUM)* - IMPLICATIONS FOR COUPE-LOGGING

Summary: The abundance of birds in three different-aged stands (young, mature, and old) was examined at North Okarito, a lowland rimu *(Dacrydium cupressinum)* forest in Westland, using 5-minute counts, transect counts, and mist-netting. Most of New Zealand's common forest bird species were present in the study area, with relatively high numbers of brown creeper *(Mohoua novaeseelandiae)* and New Zealand robin *(Petroica australis),* and low numbers of kaka *(Nestor meridionalis)* and yellow-crowned parakeet *(Cyanoramphus auriceps)*. Most insectivorous species were more abundant than expected (from sampling effort) in young and mature stands, the frugivorous New Zealand pigeon *(Hemiphaga novaeseelandiae)* was more abundant than expected in mature and old stands, and most omnivorous species, *viz.,* bellbird *(Anthornis melanura),* silvereye *(Zosterops lateralis),* and tui *(Prosthemadera novaeseelandiae),* were more abundant than expected in young and old stands. North Okarito Forest provided an important source of seasonal foods (nectar, fruit, and seeds) for frugivorous, omnivorous, and introduced granivorous species, which tended to have greater changes in their seasonal abundance than did insectivorous species. Coupe-logging of old stands will affect all bird species because it will reduce the overall area of standing forest, but it will have a greater impact on the pigeon, bellbird, silvereye, robin, and tui because of their preference for old stands.

Keywords: Westland; podocarp forest; rimu; *Dacrydium cupressinum;* logging; birds; forest management.

Introduction

North Okarito is a lowland podocarp forest dominated by rimu *(Dacrydium cupressinum* Lamb.). Together with neighbouring Saltwater Forest it was recommended for sustained-yield logging of rimu in 1981 (New Zealand Forest Service, 1981). Management of these forests could involve coupe-logging or selective-logging (James, 1987). Coupe-logging recognises that the forest comprises a natural mosaic of even-aged stands of rimu, and involves clear-felling some of the old stands, which are then left to regenerate. Selective-logging involves removal of a proportion of the mature and old rimu trees from the forest, with as little disturbance as possible to the other tree species and forest structure. The effects of either logging method on bird populations in these forests are unknown. Presumably coupe-logging would have a greater impact on those bird species that favour old stands, while selective-logging would have a greater impact on those bird species that prefer the particular tree species targeted for removal. The objective of this paper is to predict the likely effects of coupe-logging on birds by examining their abundance in different-aged stands. A subsequent paper (Warburton *et al.,* 1992) predicts the likely effects of selective-logging on birds by examining bird use of specific tree species.

Study Area

The study area covered 100 ha within a larger area of unlogged forest situated between Oroko and Okutua creeks, on the west side of Oroko Road in North Okarito Forest, Westland (8760 ha) (Fig. 1). Apart from rimu, other less frequent merchantable species included miro *(Prumnopitys ferruginea* (D. Don) Laubenf.), Hall's totara *(Podocarpus hallii* Kirk), and silver pine *(Lagarostrobos colensoi* (Hook.) Quinn) (James, 1987; Spurr and Warburton, 1991). The dominant hardwoods were kamahi *(Weinmannia racemosa* Linn. f.) and quintinia *(Quintinia acutifolia* Kirk).

Methods

Stand typing

Stand types were mapped by forest management staff using aerial photographs to outline the stand boundaries. The map was then ground-truthed by traversing the area and verifying that stands were correctly allocated to an age-class and the boundaries were correctly delineated. Three stand types of relatively even-aged rimu were recognised; young, mature, and old, based on their vertical structure and

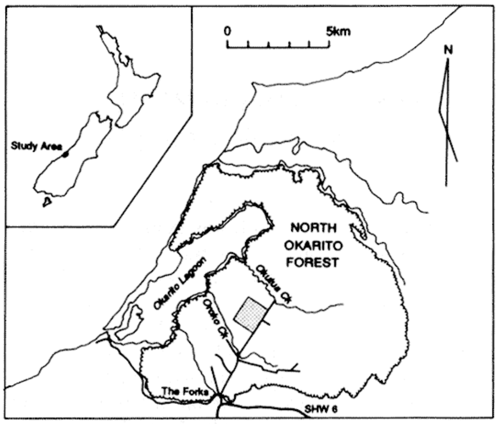

Figure 1: *Study area (shaded) in North Okarito Forest. West/and.*

species composition (James, 1987). Young stands consisted of relatively dense, small-diameter, immature pole rimu with an even canopy of vertically elongated crowns. Mature stands consisted of well spaced, large-diameter, mature rimu with rounded crowns and a well formed subcanopy of kamahi and quintinia. Old stands had a few tall, large-diameter, old (senescent) rimu with broken crowns and an often dense understorey of regenerating sapling rimu and shrub hardwood species. Old stands are those targeted for rimu extraction. Six Dijkstra, Mead and James (1985) recognised intermediate stages between these stand types in Saltwater Forest, but to enable birds to be consistently allocated to the correct stand type the number of stand types recognised in this study was kept to these three.

Indices of bird abundance

Three methods were used to determine which bird species were present in the forest, and two of these methods were used to estimate bird abundance in different-aged stands.

Five-minute counts

The 5-minute count technique (Dawson and Bull, 1975; Dawson, 1981) provided seasonal abundance indices for birds in the forest as a whole. It could not be used for estimating bird abundance in small units of forest, such as individual stands, because most birds were heard (not seen), and could not be accurately allocated to a stand type.

Thirty count-stations were located at 200 m intervals on transects 200 m apart, and 5-minute counts were made at each station on four days every second month from April 1984 to February 1986. Birds heard and/or seen within the forest were recorded. Two observers each counted on two days. Counts were restricted to days without excessive rain or wind.

For each species, the bimonthly counts were grouped into seasons (Spring = October; Summer = December and February; Autumn = April; and Winter = June and August). The mean counts from each station within each season for each year were used to test season, year, and season X year interaction effects using a two-way ANOVA. This was followed by Fisher's Protected Least Significant Difference tests to compare specific season-year means with a significance level of 0.05 (Snedecor and Cochran, 1980).

Transect counts

Counts of birds seen were made along five transects 600 m long and 100 m apart from dawn to dusk on six days every second month for two years while recording which plant species the birds were using (Warburton *et al.,* 1992). Because all birds were seen, they could be allocated to a stand type. The bimonthly counts were grouped into seasons (as above) and the two years' data were combined to increase sample sizes. The number of birds of each species seen in each stand type and season was then compared with the number expected to be seen (based on the number of hours spent searching) using a chi-square goodness of fit test with a significance level of 0.05 (Sokal and Rohlf, 1969).

Mist-net captures

Mist-nets were used to capture birds in each stand type to provide an alternative index of abundance not influenced by behavioural changes in observability of birds. Lures (e.g., tape recorders or baits) were not used, so capture rates represent unmodified rates of net interception (Karr, 1981). All birds captured were banded to enable recaptures to be identified.

Standard mist-nets (2.7 m high x 12.2 m long = 32.9 m^2; 38-mm mesh size) were used at 32 sites, 150-300 m apart, for sampling birds in the understorey; nine in young stands, 13 in mature stands, and 10 in old stands. Half the sites were sampled on the first two days and half on the next two days every second month from April 1984 to February 1986. Nets were operated for approximately seven to eight hours between 0800 and 1700 hours. Sampling was restricted to fine days or days with light rain only to minimise bird mortality. Monthly sample sizes were small for most species, so the two years' data were grouped into four seasons (as above). The number of birds of each species caught in each stand-type and season was compared with the number expected to be caught (derived from the number of hours nets were operated) using a chi-square goodness of fit test with a significance level of 0.05.

High mist-nets (18.2 m high x 18.3 m long = 333.1 m^2; 38-mm mesh size) were established at four sites in the forest (one in young, one in mature, and two in old stands) to determine if birds used different height tiers and/or changed their height use between stand types. Each high mist-net consisted of six 3.04 m x 18.3 m nets arranged above each other, similar to the design of Whitaker (1972). These were run concurrently for three days every second month from April 1984 to February 1986. Netted birds were assigned to one of the six nets, but to increase sample sizes the nets were grouped in pairs; "lower" (0-6 m), "middle" (6-12 m), and "upper" (12-18 m). However, even with pairing, the data were still insufficient to allow for satisfactory statistical analysis, so interpretation was limited to describing broad trends.

Results

Bird abundance and seasonal changes

Twenty-six bird species were recorded in the study area; 19 native and seven introduced (Table 1). Most (22) were detected from 5-minute counts; fewer (16) from transect counts and mist-netting. Three species observed incidentally were not detected by any of the three methods. One species (kea; see Table 1 for scientific names of birds) was caught only in high mist-nets. For convenience of presenting results, species were classified into four groups based on their predominant food type (Table 1).

The most frequent birds recorded on 5-minute counts were bellbirds (26% of birds counted), silvereyes (15%), and grey warblers (13%). Counts varied from overall high counts of bellbirds and grey warblers, through seasonally high counts of silvereyes,

Table 1: *Common and scientific names of the bird species (nomenclature follows Turbott. 1990) recorded* in *North Okarito Forest. Five-minute count values are mean counts/station/day; transect and mist-net values are counts and captures per 100 hours. * = species observed incidentally. ** = species caught* in *high mist-nets.*

Common name	Scientific name	5-minute counts	Transect counts	Mist-net captures
Insectivorous species				
Brown creeper	*Mohoua novaeseelandiae*	0.56	53.9	1.2
Fernbird	*Bowdleria punctata*	*	-	-
Grey warbler	*Gerygone igata*	1.44	102.6	1.2
Hedge sparrow	*Prunella modularis*	*	-	-
New Zealand fantail	*Rhipidura fuliginosa*	0.57	84.7	1.4
New Zealand robin	*Petroica australis*	0.52	41.7	1.1
New Zealand tomtit	*Petroica macrocephala*	1.02	61.7	2.7
Rifleman	*Acanthisitta chloris*	0.32	11.9	0.4
Shining cuckoo	*Chrysococcyx lucidus*	0.002	-	-
Carnivorous species				
Long-tailed cuckoo	*Eudynamys taitensis*	0.04	-	-
Morepork	*Ninox novaeseelandiae*	0.001	-	0.02
New Zealand falcon	*Falco novaeseelandiae*	*		
New Zealand kingfisher	*Halcyon sancta*	0.003	-	0.02
Frugivorous/omnivorous species				
Bellbird	*Anthornis melanura*	2.88	103.8	3.4
Blackbird	*Turdus merula*	0.29	4.6	1.0
Kaka	*Nestor meridionalis*	0.004	0.2	-
Kea	*Nestor notabilis*	-	-	**
New Zealand pigeon	*Hemiphaga novaeseelandiae*	0.37	20.3	-
Silvereye	*Zosterops lateralis*	1.68	43.7	6.9
Song thrush	*Turdus philomelos*	0.01		0.04
Tui	*Prosthemadera novaeseelandiae*	0.29	17.9	0.1
Yellow-crowned parakeet	*Cyanoramphus auriceps*	0.08	1.2	-
Granivorous species				
Chaffinch	*Fringilla coelebs*	0.46	3.5	1.8
Goldfinch	*Carduelis carduelis*	0.09	-	-
Greenfinch	*Carduelis chloris*	0.06	0.9	0.1
Redpoll	*Carduelis flammea*	0.41	3.1	0.2

chaffinches, and redpolls (Fig. 2), to the very low counts of species that visited the forest infrequently, such as kaka, long-tailed cuckoo, morepork, New Zealand kingfisher, shining cuckoo, and yellow-crowned parakeet (Table 1). Only 16 species had a sufficient number of counts to allow for season and year comparisons.

Insectivorous species generally showed less seasonal amplitude in their counts than frugivorous, omnivorous, and granivorous species (Fig. 2). Nevertheless, except for riflemen, the seasonal differences in their counts were significant, being high in autumn and/or in spring and summer. Except for grey warblers, the seasonal patterns were similar in both years (i.e., there was no season X year interaction). However, counts were significantly different between years for some species (Fig. 2).

The counts of most frugivorous and omnivorous species differed markedly between seasons (Fig. 2). Tui and blackbirds had high counts in summer, New Zealand pigeons and silvereyes in autumn, bellbirds in autumn and winter, and yellow-crowned parakeets in winter. However, the omnivorous bellbird, which fed on insects more than the tui, showed only small seasonal changes in counts, similar to insectivorous species. The frugivorous and omnivorous species, unlike the insectivorous ones, had significant differences in the seasonal pattern of counts between years (i.e., significant season X year interactions).

The introduced granivorous species had changes in their seasonal counts which were even more marked than those of frugivorous and omnivorous species, with large increases in their winter counts, particularly in the first year (Fig. 2). Their counts in the second year were significantly lower than in the first year, except for redpolls which had similar counts in both years. Goldfinches and greenfinches were absent from the forest in autumn and summer but chaffinches and redpolls were still present in very low numbers.

The birds seen most frequently on transect counts were bellbirds (19% of birds counted), grey warblers (18%), New Zealand fantails (15%), New Zealand tomtits (11%), and brown creepers (10%) (Table 1). Silvereyes, the second most commonly detected species on 5-minute counts, were ranked only sixth on transect counts. Overall, transect counts were highest in autumn (Table 2). However, brown creeper counts were highest in autumn and winter, and tui counts were highest in summer. Grey warbler, rifleman, and blackbird counts were similar in all seasons.

Standard mist-nets caught 0.655 birds m^{-2} 100 net-hours^{-1}, whereas high mist-nets caught only 0.216 birds m^{-2} 100 net-hours" (Table 3). The most commonly caught species were silvereyes (32% of captures in standard mist-nets and 51% in high mist-nets), bellbirds (16% and 15%), and tomtits (12% and 6%) (Table 3).

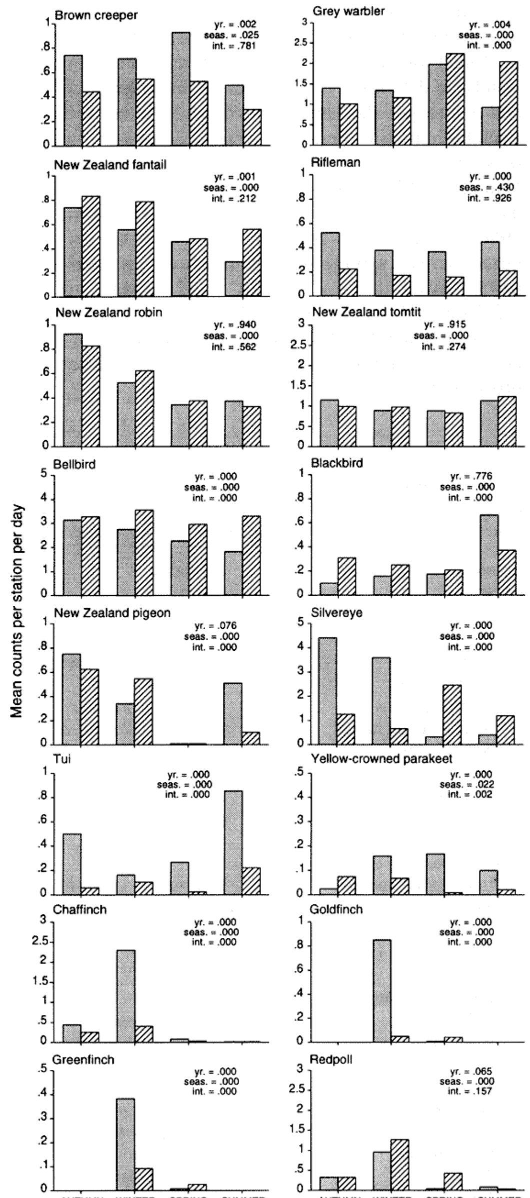

Figure 2: *Five-minute counts by year and season for birds* in *North Okarito Forest. Year I stippled, year* 2 *cross-hatched. Probabilities given for year (yr), season (seas), and interaction (int) effects. Note different scales on* y *axis.*

Table 2: *Seasonal transect counts of birds* in *North Okarito Forest*.
* = *a significant difference between seasons, NS = not significant, - = not tested.*

	Number encountered per 100 hours				
	Autumn	Winter	Spring	Summer	
Insectivorous species					
Brown creeper	73	84	45	30	*
Grey warbler	99	110	118	91	NS
New Zealand fantail	136	91	57	75	*
New Zealand robin	58	43	25	44	*
New Zealand tomtit	99	50	45	64	*
Rifleman	11	10	15	12	NS
Frugivorous/omnivorous species					
Bellbird	134	112	110	84	*
Blackbird	4	3	5	6	NS
Kaka	0	0	I	0.5	-
New Zealand pigeon	38	19	0	24	*
Silvereye	73	39	36	40	*
Tui	3	8	18	31	*
Yellow-crowned parakeet	2	1	2	0.5	-
Granivorous species					
Chaffinch	0	12	0	0.5	-
Greenfinch	0	2	2	0	-
Redpoll	0	9	3	0	-
Total	730	593	482	502	*
Observation hours	94	181	126	256	

Of the more frequently caught species, recapture rates in standard mist-nets varied from 38% for New Zealand robins to 0.5% for silvereyes; recapture rates in high mist-nets were also greatest for robins (33%) and lowest for silvereyes (3%). As with transect counts, most birds were caught in autumn (Table 4).

Bird abundance in different-aged stands

Transect counts showed that of the insectivorous species, brown creeper, grey warbler, fantail, and rifleman were seen more often in young and mature stands than in old stands, tomtits were seen an equal number of times in all stand types, and robins were seen most often in old and mature stands (Table 5). The frugivorous pigeon was observed most often in old and mature stands, whereas the omnivorous bellbird, silvereye, and tui were observed more often in old and young stands than in mature stands (i.e., in old stands like the frugivorous pigeon, and in young stands like most insectivorous species). In total, more birds were seen in young stands than in mature and old stands.

Mist-netting generally supported transect counts but gave significant results for fewer species because fewer birds were caught than seen (Table 6). The discrepancy between where most brown creepers were seen (young stands) and where most were caught (old stands) appears to be a result of standard mist-nets being limited to the understorey, whereas transect counts sampled all tiers of the forest. In high mist-nets, more brown creepers were caught in young stands than in mature or old stands. Total captures per 100 net-hours in standard mist-nets were highest in old stands, although 48% of these were silvereyes. With silvereyes excluded, captures in the three stand-types were similar (13.3, 15.1, and 15.5 captures per 100 net-hours for young, mature, and old stands, respectively).

Vertical distribution of birds in different-aged stands

Of the 759 birds caught in high mist-nets, only 364 were assigned to a height. The remainder were in large mixed-species flocks (mainly silvereyes), and all effort was made to release these birds before dark at the expense of recording capture location.

Most species were caught consistently at the same heights in all stands (Table 7). Bellbird, silvereye, and chaffinch were caught mostly in the upper nets, but fantail, robin, and tomtit were caught more often in the lower nets. However, brown creepers were caught mostly in the upper nets in young and mature stands, but in the middle and lower nets in old stands.

Table 3: *Mist-net captures and recaptures of birds in North Okarito Forest.*

	Standard nets (32.9 m^2)		High nets (333.1 m^2)	
	Total number caught	Percent recaptures	Total number caught	Percent recaptures
Insectivorous species				
Brown creeper	63	12.5	33	15.2
Grey warbler	64	4.9	37	8.1
New Zealand fantail	72	9.1	28	7.1
New Zealand robin	58	38.1	18	33.3
New Zealand tomtit	138	12.2	43	20.9
Rifleman	20	15.0	3	0.0
Carnivorous species				
Long-tailed cuckoo	0	-	2	0.0
Morepork	1	0.0	1	0.0
New Zealand kingfisher	1	0.0	3	0.0
Frugivorous/omnivorous species				
Bellbird	176	23.1	116	18.9
Blackbird	51	13.3	19	5.3
Kea	0	-	1	0.0
New Zealand pigeon	0	-	3	0.0
Silvereye	359	0.5	387	3.1
Song thrush	2	0.0	1	0.0
Tui	5	40.0	6	0.0
Yellow-crowned parakeet	0		4	0.0
Granivorous species				
Chaffinch	94	3.3	45	6.7
Goldfmch	0	-	1	0.0
Greenfinch	4	0.0	-	
Redpoll	8	0.0	8	0.0
Total	1116		759	
Net-hours	5180		1055	

Discussion

Most of New Zealand's common forest bird species were recorded in North Okarito Forest, but noticeable features of the avifauna were the scarcity of kaka and parakeet species, and the relatively high numbers of robin and brown creeper (c.f. Crook, Best and Harrison, 1977; Dawson *et al*. 1978; Coker and Imboden 1980; Onley, 1980; Morse, 1981; O'Donnell and Dilks, 1986). Coker and Imboden (1980) also found brown creeper to be in significantly higher numbers in Okarito Forest than in several neighbouring forests such as Saltwater, Ohinemaka, Mataketake, and Waiatoto. Kaka and parakeets were once common in Okarito Forest (J.Y. Morris, *pers. comm.)* and reasons for their present scarcity are not readily apparent, but could include habitat destruction, predation, and competition. Both species are highly mobile and seasonally use high-country forest (Dawson *et al.,* 1978; O'Donnell and Dilks, 1986). A decline in the condition of mid-high-altitude rata-kamahi forest caused by brushtail possum *(Trichosurus vulpecula* Kerr) browsing (Rose, Pekelharing and Platt, 1992) may have resulted in an overall decline in kaka numbers, for example, which would be reflected in other habitats such as North Okarito Forest that are used seasonally.

Seasonal changes in 5-minute counts could be attributed either to changes in conspicuousness of birds (e.g., greater frequency of singing in spring and summer) or to changes in numbers of birds (e.g., movements of birds in response to food availability, or recruitment of juveniles in summer and autumn), or to both. For example, seasonal changes in grey warbler counts, which were similar to those found by Gill (1980), closely followed the pattern of song intensity recorded by Cunningham (1955). Fantail counts were significantly higher in winter than in summer, a pattern similar to that recorded by Onley (1980) in lowland coastal forest in North Westland but opposite to that recorded by Dawson *et al*. (1978) in higher altitude forest near Reef ton. Presumably, the different patterns of abundance result from movement of fantails to lower

Table 4: *Seasonal capture rates of birds in standard mist-nets in North Okarito Forest. * = a significant difference between seasons, NS = not significant, - = not tested.*

	Number caught per 100 net-hours				
	Autumn	Winter	Spring	Summer	
Insectivorous species					
Brown creeper	2.3	0.9	1.3	1.0	*
Grey warbler	2.7	1.8	0.8	0.1	*
New Zealand fantail	4.3	0.7	1.2	0.6	*
New Zealand robin	2.3	1.0	0.8	0.9	*
New Zealand tomtit	7.1	2.5	1.0	1.5	*
Rifleman	0.0	0.7	0.6	0.2	*
Carnivorous species					
Morepork	0.0	0.1	0.0	0.0	-
New Zealand kingfisher	0.1	0.0	0.0	0.0	-
Frugivorous/omnivorous species					
Bellbird	6.9	3.4	2.1	2.2	*
Blackbird	0.5	1.3	1.5	0.7	*
Silvereye	27.9	3.4	4.3	0.9	*
Song thrush	0.0	0.1	0.0	0.0	-
Tui	0.0	0.0	0.0	0.3	-
Granivorous species					
Chaffinch	0.0	5.4	0.0	0.0	*
Greenfinch	0.0	0.0	0.4	0.0	-
Redpoll	0.2	0.2	0.3	0.0	-
Total	54.3	21.5	14.3	8.4	*
Net-hours	879	1754	916	1631	

altitudes such as North Okarito Forest in winter.

The numbers of most frugivorous, omnivorous, and granivorous species appeared to change in response to food availability. For example, high counts of pigeons coincided with the seasonal availability of new foliage and fruits. Pigeons are known to move considerable distances to seasonal foods (Clout *et al.,* 1986), and in this study the rapid changes in counts from one month to the next indicated such movements. Pigeons were seldom recorded in North Okarito in late winter and spring, but many were seen feeding on fuchsia *(Fuchsia excorticata* (J.R. et G. Forst.) Linn. f.) and kowhai *(Sophora microphylla* Ait.) in the neighbouring coastal forest (E.B. Spurr, B. Warburton and K.W. Drew*, pers. obs.)*. Over the summer, they became more abundant in North Okarito Forest, feeding on new growth and then extensively on miro and rimu fruit in autumn and early winter. Tui also had marked seasonal changes in abundance, increasing coincidentally with the onset of rata flowering in summer and remaining high during autumn when rimu were fruiting. Tui are known to move long distances and have marked seasonal changes in numbers (Gravatt, 1970). High numbers of silvereyes and finches also coincided with rimu fruiting. Bellbirds, although feeding on nectar like the tui, did not have large seasonal fluctuations in abundance, probably because of their greater use of invertebrates as a food source (Gravatt, 1970).

Increased transect counts and mist-net captures of birds in autumn presumably reflect an increase in the number of birds present as a result of the recruitment of juveniles to the population. Because transect counts were counts of birds seen rather than heard, they were not so influenced by changes in conspicuousness (e.g., singing) as were 5-minute counts.

We have accepted differences in indices of bird abundance in the three different-aged stands as reflecting real differences in numbers, rather than differences in observability or catchability of birds. Although many factors affect counts (Dawson, 1981) and mist-net captures (Lovejoy, 1975), most invalidate comparisons between species, not comparisons of one species between habitats. Our acceptance appears justified because the higher abundance of most insectivorous birds in young and mature stands correlates with a higher density of invertebrates on tree trunks in these stands *(unpubl. data)*. Likewise, the greater than expected abundance of most frugivorous and omnivorous birds in old stands presumably reflects the greater abundance of rimu fruit in old stands. The

Table 5: *Transect counts of birds in young. mature, and old stands in North Okarito Forest. * = a significant difference between stands, NS = not significant. - = not tested.*

	Number encountered per 100 hr			
	Young stands	Mature stands	Old stands	
Insectivorous species				
Brown creeper	77	47	43	*
Grey warbler	128	107	77	*
New Zealand fantail	91	101	62	*
New Zealand robin	29	42	52	*
New Zealand tomtit	66	66	54	NS
Rifleman	16	16	4	*
Frugivorous/omnivorous species				
Bellbird	101	90	122	NS
Blackbird	3	4	6	-
Kaka	0	0	0.5	-
New Zealand pigeon	11	25	23	*
Silvereye	48	26	60	*
Tui 1	8	12	24	*
Yellow-crowned parakeet	0.5	0.5	3	-
Granivorous species				
Chaffinch	4	2	4	-
Greenfinch	1	0.5	1.5	-
Redpoll	0.5	1	7.5	-
Total	594	540	543	*
Observation hours	184	246	226	

Table 6: *Capture rates of birds caught in mist-nets in different aged stands of rimu in North Okarito Forest. * = a significant difference between stands, NS = not significant, - = not tested.*

	Number caught per 100 net-hours			
	Young stands	Mature stands	Old stands	
Insectivorous species				
Brown creeper	0.6	0.8	2.3	*
Grey warbler	1.2	1.6	0.8	NS
New Zealand fantail	1.5	1.7	0.9	NS
New Zealand robin	0.7	1.3	1.3	NS
New Zealand tomtit	2.6	2.8	2.6	NS
Rifleman	0.8	0.4	0.1	*
Carnivorous species				
Morepork	0.1	0.0	0.0	-
New Zealand kingfisher	0.1	0.0	0.0	-
Frugivorous/omnivorous species				
Bellbird	2.9	2.9	4.5	*
Blackbird	1.2	1.1	0.7	NS
Silvereye	4.7	2.7	14.4	*
Song thrush	0.0	0.1	0.1	-
Tui	0.1	0.1	0.1	-
Granivorous species				
Chaffinch	1.5	2.2	1.5	NS
Greenfinch	0.0	0.1	0.1	-
Redpoll	0.0	0.0	0.5	-
Total	18.0	17.8	29.9	*
Net-hours	1449	2097	1635	

ground-feeding robin, unlike other insectivorous species, was most abundant in old stands, suggesting perhaps a greater availability of ground-dwelling invertebrates in these stands.

A potential problem with standard mist-nets sampling only those species utilising the lower tiers of the forest, is that they may not provide comparative density data if a species changes its tier use between stand types. Most species were caught more frequently in a particular height tier, as found by Fitzgerald, Robertson and Whitaker (1989), and patterns of capture were consistent between different-aged stands. However, high mist-net captures of brown creepers indicated a shift in tier use between stands. Thus, the standard mist-net data that suggest brown creepers favour old stands are probably misleading. High mist-net data substantiate this because in total more brown creepers were caught in young stands than in mature and old stands. Also, higher numbers of brown creepers were recorded on transect counts in young and mature stands than in old stands. The change in tier use between stand types may reflect brown creepers' preference for dense vegetation, as in the canopy of young stands and in the lower tiers of old stands.

Because the native frugivorous and omnivorous birds (pigeon, bellbird, silvereye, and tui) and the insectivorous robin were found in old stands more than expected, they are the species most likely to be detrimentally affected by coupe-logging. Other insectivorous birds are likely to be less detrimentally affected by coupe-logging than robins because they preferred either young or mature stands or had no stand-type preferences. The granivorous species (all introduced) are less likely to be detrimentally affected by coupe-logging than frugivorous and omnivorous species. They visited North Okarito Forest mainly in winter to feed on rimu fruit and seeds, and although coupe-logging will decrease the availability of this food source, this may be partly compensated for by the seeds of weeds invading the logged areas. Elsewhere in New Zealand, introduced granivorous birds have increased in abundance when forest has been modified (Diamond and Veitch, 1981; McCallum, 1982; Spurr, 1985; Forest Research Institute, 1987). Because some granivorous species also feed on fruit, they may compete for the food resources of indigenous frugivorous and omnivorous species, adding further to the adverse effects of logging on these birds.

This study has identified which bird species are most abundant in old stands and therefore those which

Table 7: *High mist-net capture rates of birds showing association of stand-type and net height.*

	Stand type	Number caught per 100 net-hours <6m	6-12m	12-18m
Insectivorous species				
Brown creeper	Young	0.4	0.8	1.9
	Mature	0.0	0.4	0.8
	Old	0.6	0.6	0.2
Grey warbler	Young	0.0	0.4	0.8
	Mature	2.6	1.1	1.5
	Old	0.8	1.3	0.8
New Zealand fantail	Young	0.4	0.0	0.0
	Mature	1.1	1.9	0.8
	Old	1.9	0.4	0.0
New Zealand robin	Young	1.1	0.4	1.1
	Mature	1.1	0.8	0.0
	Old	0.4	0.0	0.0
New Zealand tomtit	Young	1.5	0.0	0.4
	Mature	2.6	1.9	1.1
	Old	1.3	0.6	0.2
Frugivorous/omnivorous species				
Bellbird	Young	1.1	1.1	4.2
	Mature	2.6	4.1	5.7
	Old	0.2	3.0	3.9
Blackbird	Young	0.4	0.4	0.8
	Mature	0.8	1.9	0.4
	Old	0.2	0.2	0.4
Silvereye	Young	1.1	1.5	3.8
	Mature	0.4	3.4	6.0
	Old	1.5	2.7	1.9
Granivorous species				
Chaffinch	Young	0.8	0.8	0.8
	Mature	1.1	1.9	3.4
	Old	1.1	0.6	2.3
Net hours	Young	262.4		
	Mature	265.4		
	Old	526.9		

are most likely to be detrimentally affected by coupe-logging. Apart from the robin, these sPecies are the same ones likely to be detrimentally affected by selective-logging of old rimu (Warburton *et al.,* 1992). This is not surprising because old stands contain a greater proportion of the tree species preferred by these birds, *viz.,* old rimu, than do younger stands. However, it cannot be assumed that a greater abundance of a particular bird species in one stand-type implies that that stand-type is critical for the survival of the bird species. Future study, therefore, should use experimental coupe-logging to elucidate which habitat features are critical for the survival of bird species, particularly those such as kaka, parakeets, and robins which are now rare or have specialised niche requirements.

Acknowledgements

We thank I. James for typing the stands in the study area; D. Lewitt and S. Kingsford for assistance in the field and with collation of the data; D. Hilliard for logistic support; B. Fredric and C. Frampton for statistical and computer assistance; and J. Parkes and J. Orwin for commenting on drafts of the manuscript.

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