A SURVEY OF THE NATIVE BIRD FAUNA OF FORESTS IN THE PROPOSED BEECH PROJECT AREA OF NORTH WESTLAND

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SUMMARY: Surveys of bird life in forests below about 600m a.s.l. in the West Coast Beech Project Area have shown wide differences from place to place in the abundance of 13 more common native birds. Some variation can be attributed to the range of different types of forest represented in the area. The results are consistent with the diversity of bird habitats in the West Coast Beech Project Area and provide a basis for its representation in a network of conservation areas. The wildlife values of the Area are as much a function of the large expanse of continuous, relatively undisturbed forests as the diversity of habitats itself. Alternative strategies for management of the production forests are examined in relation to the maintenance of this continuity, and recommendations are put forward.

INTRODUCTION

Surveys of native birdlife in lowland* forest of the West Coast Beech Project Area, North Westland (New Zealand Forest Service 1971) were made in the period January to March of 1974 and 1975 with the following objectives:

1. To compare the avifauna of West Coast forests with that of other areas.
2. To assess the range of diversity of the native bird fauna and the abundance of individual species in the unmilled forest habitats represented in the Area.
3. To compare the bird fauna of unmilled and cut-over beech/podocarp forests in the Area.

The first of these objectives was met in the first (1974) series of surveys (Crook and Best, 1974). These showed firstly that levels of bird abundance recorded in the Project Area were comparable to and sometimes exceeded those of places traditionally considered to be richly endowed with birds (such as offshore island sanctuaries). The assumption that bird faunas of beech-dominated forests are poor in diversity and density, based largely on extrapolations from studies in South Westland and Fiordland (reviewed by McLay, 1974), are not borne out in fact.

This report examines the range of variation in the bird fanua of the Project Area and assesses the likely impact of any large scale timber utilisation scheme on wildlife values.

*In this context "lowland" refers generally to areas below 600 m a.s.l.

THE FORESTS SURVEYED

Approximately 24 000 ha of forests were surveyed in the two seasons (Table 1, Fig. 1). In 1974 examples of the whole range of unmilled, lowland forests represented in the Project Area were examined. In the second season (1975) five blocks of the one National Forest Survey type of beech/podocarp forest (PB5*) scattered through the project area, three blocks of pure beech forest and two areas of recently cut-over forest were covered. The survey blocks for the two seasons may be grouped in five regions, as follows:

1. *Western Paparoa*

Four blocks, all in Charleston State Forest, were surveyed, being in the catchments of *Aranui Creek* (1975), *Sirdar Creek*, *Tiropahi River* and *Fox River* (1974), respectively. These last two lie within the proposed Paparoa Ecological Reserve and, with *Sirdar Creek*, were chosen to represent the sequence of forest types found at lower altitudes on the western side of the Paparoa Range (Nicholls, 1974).

The *Aranui Creek* block is the westernmost of the

* PB5 is a National Forest Survey forest type described as rimu, rata, kamahi, *Quintinia*, hard beech, local red and silver beech forest. It occurs on sharply dissected gravel country where fingers of PB1 forest, which contains denser stands of podocarps, extend up narrow valleys. The steep sides of these valleys are covered with poor hard beech and rimu forest of decreasing quality as the ridges are approached.

five blocks of PB5 forest surveyed in 1975 and the only one on the western fall of the Paparoa Range. It extends from 60 to 360 m a.s.l. between the Awakari River and Atbara Creek on terrain characterised by gently sloping main ridges flanked by steep gullies and bluffs.

2. *Inangahua*

Two blocks in the vicinity of Rotokohu were surveyed—one on the western side *(Fletcher Creek)* and the other on the eastern side of the Inangahua Valley *(Winding Creek).*

The *Fletcher Creek* block (1974) intrudes into the southern end of the proposed Blackwater Ecological Reserve. It consists of logged and unlogged beech/podocarp and pure beech forests on flood plains and gravel terraces, limestone terrain and dissected gravels between about 120 and 520 m a.s.l. which characterise the western side of the Inangahua Valley in this area.

Winding Creek is the northernmost of the blocks of PB5 forest surveyed in the Inangahua—Grey Valley system. It consists of lowland hill country between 120 and 270 m a.s.l. and is part of the proposed Coal Creek Ecological Reserve, being bounded by Coal Creek itself to the north and Landing Creek to the south.

3. *Reefton Hill Country and mid-Grey Valley*

Two blocks in the northern part of Tawhai State Forest *(Slab Hut Creek* and *Merrijigs)* were surveyed in 1974 as representative of the mainly unmilled beech/podocarp forests occurring on the Reefton Hill Country and the Inangahua—Grey Divide. *Slab Hut Creek* lies immediately south of Highway 7 (Reefton-Greymouth Road) between Devils Creek and Slab Hut Creek, and *Merrijigs* is on the western side of the Inangahua River between it and Merrijigs township.

The *Maimai, Antonios Creek* and *Granville* blocks (1975) were set up as replicate areas of PB5 forest in the mid-part of the Grey Valley, lying between about 200 and 400 m a.s.l. in the hill country south of Reefton and (mainly) on the eastern side of the Grey and Mawheraiti Rivers between Reefton and Totara Flat.

4. *Upper Grey and Maruia Valleys*

Three blocks in the vicinity of Springs Junction surveyed in 1975 *(Woolley River, Alfred River* and *Palmer Rd.)* represent the undisturbed red/silver beech forest which characterises the undulating flats of the Maruia, Alfred and Upper Grey River Valleys respectively.

5. *Lower Grey Valley*

Three blocks *(Nelson Creek, Hochstetter* and *Flagstaff)* representing the wide variety of beech/podocarp and pure beech forests in the 100-300 m altitude range in the lower Grey Valley were surveyed in 1974. The *Flagstaff* block was re-surveyed in 1975 and 1976.

The two blocks of cut-over forest surveyed in 1975 were also in this region. *Brown Creek* is mainly beech/podocarp forest cut-over for podocarps 10-16 years ago, and it lies on gently undulating outwash gravels on the northern bank of the Grey River opposite Bald Hill. *Kopara* consists of contiguous areas of unmilled beech/podocarp forest, forest cut-over for podocarps less than six years ago, and areas cut-over more than 10 years ago. It also lies on outwash gravels and a granite-based ridge to the north of Lake Ahaura. It was selected for comparison both with *Brown Creek* and *Flagstaff,* which lies immediately to its north.

METHODS

1. *Data collection*

The data consist of records of bird occurrence and abundance collected at a number of stations in each block surveyed. The stations were arranged in a regular square pattern at 500 yard intervals within the framework of the National Yard Grid* (four stations to each thousand-yard grid square). Where possible blocks were large enough to contain over 50 stations, though the area of the type of forest represented in some was too small to do so. The number of stations in each block is given with other data in Table 1.

Information describing bird abundance was based on a five-minute count of all birds seen or heard at each station. The "five-minute count" system of

* Regular and consistent placement of stations in relation to the National Grid, an example of square grid systematic sampling, has several advantages for this kind of survey. Firstly it facilitates systematic coverage and assures that stations are placed randomly in relation to all features of a habitat which may influence distribution and numbers of birds. Secondly, distribution maps based on the National Grid may be produced directly from the data; and thirdly the system simplifies repetition of surveys. Stations are located on the ground using N.Z.M.S. 1 topographic maps, a magnetic compass and a reasonable amount of skill in dead-reckoning navigation in forested terrain. Stations can therefore be located and re-located with equal facility on any number of occasions without need to mark reference points.

TABLE 1. *The survey blocks.*

Name	Period of Survey	Stations	Area (ha)	Altitude Range (m a.s. l)
Tiropahi River	19, 27–28/2, 5/3/1974	40	830	150–330
Fox River	27–28/2/1974	30	620	60–330
Sirdar Creek	21/2/1974	16	330	100–210
Aranui Creek	15/1–1/2/1975	55	1,140	60–360
Fletcher Creek	6–17/2/1974	92	1,900	120–540
Winding Creek	17–21/1/1975	65	1,340	120–270
Slab Hut Creek	22–27/1/1974	53	1,100	240–560
Merrijigs	28/1–1/2/1974	65	1,340	300–750*
Maimai	22–24/1/1975	60	1,240	200–440
Antonios Creek	24–30/1/1975	60	1,240	150–390
Granville	26–27/2/1975	54	1,120	200–420
Woolley River	9–12/1/1975	55	1,270	360–570
Alfred River	14–18/1/1975	55	1,140	470–690*
Palmer Road	13–16/1/1975	63	1,300	450–600
Nelson Creek	13–16/3/1974	61	1,260	100–300
Lake Hockstetter	12–19/3/1974	57	1,180	150–300
Flagstaff	8–10/3/1974	97	2,020	140–300
	11–19/3/1975	97		
	23, 24, 26/2/1976	97		
Brown Creek	3, 20, 23, 25/2/1975	66	1,360	240–480
Kopara	2–10/3/1975	111	2,290	150–580

* *Merrijigs* includes 16 and *Alfred River* 9 stations above 600 m a.s. 1.

recording bird abundance was similar to that described by Dawson and Bull (1975) except that no distinction was made between numbers of birds "seen" and "heard". Aural and visual records were assumed to be equally reliable. However, as Dawson and Bull observe, as well as providing an index of numbers of each species, bird counts may also reflect factors such as:

1. The abilities of different observers to detect and identify birds and to judge the numbers present.
2. Differences in the conspicuousness of different species.
3. Diurnal, seasonal and weather-related changes in conspicuousness.

In the absence of data to show the extent of bias from these sources, the surveys were designed to reduce it to a minimum, and the analyses adapted to allow for it.

To reduce observer differences all field officers involved in a particular season of surveys took part in the survey of every block surveyed that season. Error associated with observer performance was therefore similar in each block compared. In addition the performance of each observer was checked at intervals by comparison with his fellows. In this way large discrepancies could be recognised and rectified.

Variation in conspicuousness of birds was more difficult to allow for completely as time of year and day, weather, extraneous environmental factors such as noise, and the way these (particularly the last two) interact with observer performance, may all have been involved.

Diurnal variations were reduced by spreading observations as evenly as possible between 0800 and 1700 hours NZST each day in all areas. Seasonal changes were similarly reduced by limiting length of the survey season.

The survey season began on 22 January and 9 January in 1974 and 1975 respectively and ended on 19 March in both years. Further precautions against seasonal bias were taken by surveying blocks likely to be compared as near as possible to the same time.

The possible effects of weather on conspicuousness were reduced by limiting the range of weather conditions during which bird counts were attempted. Counts were not made in winds estimated as being Beaufort Scale 5 or greater or in steady rain.

These measures may not have totally eliminated

bias in the five-minute bird counts, but having so reduced its effects a number of replication trials were designed which are described below to assses what may have remained.

2. *Data analysis*

For the purposes of this report bird counts and stations were grouped for analysis according to the survey block to which they belong. Variables derived from the bird counts include:

1. Number of individuals of each of 14* species of native, forest-dwelling birds recorded at each station, namely: tui *(Prosthemadera novaeseelandiae)*, bellbird *(Anthornis melanura)*, kaka *(Nestor meridionalis)* red- and yellow-crowned parakeets *(Cyanoramphus novaezelandiae* and *C. auriceps)***, western weka *(Gallirallus australis)* yellow-breasted tit *(Petroica australis)*, rifleman *(Acanthisitta chloris)*, brown creeper *(Finschia novaeseelandiae)*, fantail *(Rhipidura fuliginosa)*, New Zealand pigeon *(Hemiphaga novaeseelandiae)*, grey warbler *(Gerygone igata)* and silvereye *(Zosterops lateralis)*.
2. Total number of native, forest-dwelling birds of all the above species the basis of an index of overall bird abundance.
3. Number of native, forest-dwelling bird species recorded at each station—the basis of a similar index of bird "diversity".

Casual comparisons of different blocks were made with average values for each of these variables. However, non-parametric methods were used for closer examination, and contingency tables comparing the number of stations in different blocks which have the same attribute (e.g. absence, presence or number of individuals of a particular species) were the basis of the analysis reported here. Values for chi square computed from these tables have been used to assign probabilities of similarity or difference between blocks in the variables derived from the bird counts.

* Frequency of occurrence of several other native species (kea—*Nestor notabilis*—, rock wren—*Xenicus gilviventris*—, fernbird—*Bowdleria punctata*—, long-tailed cuckoo—*Eudynamis taitensis*—and kingfisher—*Halcyon sancta*—) and the introduced birds, was too low to be used in the analysis.

** The two parakeets are often difficult to differentiate in the field, and counts were made only of parakeets as a single "species".

REPLICATION OF SURVEYS

Any comparison of surveys of different areas, necessarily done at different times, brings to question the repeatability of the results obtained from the survey method. Two sets of replication trials were therefore made as part of the West Coast study, the first involving comparison of blocks of forest chosen for their *similarity* rather than their differences. The second set of trials compared surveys of the same block made in different years.

1. *Comparison of similar habitats surveyed in the one season*

Blocks of the same forest types, according to National Forest Survey type maps, and similar physical features (determined from N.Z.M.S. 1 topographic maps) were selected for comparison in three separate replication trials.

Two trials were done in beech/podocarp forest in the hill country south of Reefton. In the first (1974) two nearly adjacent blocks were compared *(Slab Hut Creek* and *Merrijigs)*. The second trial was done in 1975 and compared three more widely separated blocks of the one National Forest Survey type (PB5) in the same general area *(Maimai, Antonios Creek* and *Granville)*.

In the third trial, also done in 1975, three blocks of beech forest *(Woolley River, Alfred River* and *Palmer Rd.)* were compared.

THE BEECH/PODOCARP FOREST COMPARISONS

Average values for total bird and species counts were similar in both trials (Table 2), but there were some differences in counts of individual species. In the 1974 *(Slab Hut Creek—Merrijigs)* trial counts of yellow-breasted tits and grey warblers differed to an extent that could be considered statistically significant as did counts of tuis, kakas and robins in the 1975 *Maimai—Antonios Creek—Granville* trial.

Of these latter differences numbers of tuis and kakas were similar in two of the three areas compared *(Maimai* and *Antonios Creek* for kakas and *Maimai* and *Granville* for tuis). On the other hand, counts of robins were significantly different in each of the three blocks.

THE PURE BEECH FOREST COMPARISONS

Wide variation in robin counts was also a feature of the beech forest trial (Table 3) and differences in number of species per station, and bellbird and rifleman counts were also encountered. These latter three differences were contributed by the *Alfred River* block, *Woolley River* and *Palmer Rd*, being similar in all respects except for number of robins.

TABLE 2. *The beech/podocarp forest replication trials.*

	1974			1975			
	Slab Hut Creek	Merrijigs	Probability	Maimai	Antonios Creek	Granville	Probability
Total Birds/station	7.58	7.72	n.s.	9.05	9.03	8.87	n.s.
Species/station	4.13	4.31	n.s.	4.65	4.50	4.15	n.s.
Individual Species Counts (no./station):							
Tui	0.26	0.15	n.s.	0.13	0.43	0.19	<0.005
Bellbird	2.89	2.55	n.s.	2.67	3.02	3.02	n.s.
Kaka	0.23	0.32	n.s.	0.20	0.17	0.02	<0.025
Parakeets	0.11	0.02	n.s.	0.03	0.03	0.00	n.s.
Weka	0.06	0.00	n.s.	0.20	0.02	0.07	n.s.
Yellow-Breasted Tit	0.89	1.40	<0.01	1.12	1.07	1.19	n.s.
Robin	0.09	0.25	n.s.	0.55	0.25	0.06	<0.005
Rifleman	0.02	0.25	n.s.	0.10	0.00	0.07	n.s.
Brown Creeper	0.06	0.25	n.s.	0.10	0.00	0.06	n.s.
Fantail	0.70	0.42	n.s.	0.97	0.98	1.33	n.s.
Pigeon	0.11	0.05	n.s.	0.42	0.28	0.24	n.s.
Grey Warbler	0.62	0.88	<0.05	0.83	0.82	0.94	n.s.
Silvereye	1.55	1.20	n.s.	1.73	1.97	1.69	n.s.
Number of Stations	53	65		60	60	54	

2. *Comparison of the same block in different years —the* Flagstaff *surveys.*

The *Flagstaff* block is made up of a wide variety of forest types including areas of several beech/podocarp associations (some with high densities of rimu compared with other blocks surveyed), red/silver beech forest and pole stands of mainly hard beech and mountain beech to about 20 m height. The 1974 surveys showed the block to support densities of birds as high as any area previously surveyed, native pigeons and silvereyes being particularly abundant compared with other forests in the Project Area. Some species, particularly the less common, were not themselves notably abundant. *Flagstaff* ranked fifth among the areas surveyed in 1974 for abundance of parakeets, brown creeper and rifleman, seventh for robin and eighth for kaka (Crook and Best, 1974). On the other hand density of honeyeaters was high and the large numbers of these and other more generally common species resulted in the high total counts of birds recorded.

Counts of only four species (bellbird, weka, fantail and robin) remained reasonably steady over the three annual surveys (Table 4). Statistically significant changes ($p < 0.05$) in counts of all others were noted

TABLE 3. *The beech forest replication trial.*

	Woolley River	Palmer Road	Alfred River	Probability
Total Birds/station	7.51	8.57	10.16	n.s.
Species/station	4.27	4.32	5.25	<0.001
Individual Species Counts (nos./station):				
Tui	0.05	0.08	0.02	n.s.
Bellbird	1.20	1.65	1.82	<0.05
Kaka	0.04	0.11	0.09	n.s.
Parakeets	0.13	0.51	0.42	n.s.
Weka	0.00	0.02	0.00	n.s.
Yellow-Breasted Tit	1.60	1.62	2.00	n.s.
Robin	1.93	1.32	2.00	<0.001
Rifleman	0.60	0.78	1.42	<0.01
Brown Creeper	0.09	0.16	0.15	n.s.
Fantail	0.44	0.62	0.75	n.s.
Pigeon	0.05	0.02	0.02	n.s.
Grey Warbler	1.16	1.14	1.24	n.s.
Silvereye	0.22	0.56	0.25	n.s.
Number of Stations	55	63	55	

TABLE 4. *The* Flagstaff *Surveys. (Ninety-seven stations were surveyed in* Flagstaff *on each occasion.)*

	1974	1975	1976	Probabilities 1974 vs. 1975	1974 + 1975 vs. 1976
Total Birds/station	10.30	10.27	8.47	n.s.	<0.01
Species/station	4.99	4.33	4.45	<0.025	n.s.
Individual Species Counts (nos./station):					
Tui	0.77	0.34	0.46	<0.005	n.s.
Bellbird	3.15	2.69	2.87	n.s.	n.s.
Kaka	0.07	0.01	0.29	n.s.	<0.001
Parakeets	0.35	0.05	0.30	<0.005	n.s.
Weka	0.12	0.19	0.12	n.s.	n.s.
Yellow-Breasted Tit	1.22	1.50	0.99	n.s.	<0.05
Robin	0.10	0.02	0.07	n.s.	n.s.
Rifleman	0.06	0.05	0.24	n.s.	<0.001
Brown Creeper	0.20	0.00	0.20	<0.001	n.s.
Fantail	0.87	1.22	0.85	n.s.	n.s.
Pigeon	0.40	0.45	0.24	n.s.	<0.025
Grey Warbler	0.87	0.65	1.20	n.s.	<0.001
Silvereye	2.11	3.11	0.66	n.s.	<0.001

TABLE 5. *Station counts of birds in* Flagstaff *compared with all other areas surveyed.*

	1974		1975		1976	
	All other areas surveyed	Flagstaff	All other areas surveyed	Flagstaff	All other areas surveyed	Flagstaff
Tui	0.36	0.77	0.26	0.34	0.30	0.46
Bellbird	2.36	3.15	2.51	2.70	2.12	2.87
Kaka	0.15	0.07	0.10	0.01	0.13	0.29
Parakeets	0.16	0.35	0.15	0.05	0.15	0.30
Weka	0.05	0.12	0.07	0.19	0.08	0.12
Yellow Breasted Tit	1.27	1.22	1.22	1.49	0.94	0.99
Robin	0.29	0.10	0.53	0.02	0.28	0.07
Rifleman	0.13	0.06	0.26	0.05	0.40	0.24
Brown Creeper	0.17	0.20	0.05	0.00	0.27	0.20
Fantail	0.80	0.87	0.92	1.22	0.68	0.85
Pigeon	0.21	0.40	0.26	0.44	0.21	0.24
Grey Warbler	1.02	0.87	0.83	0.65	1.03	1.20
Silvereye	1.42	2.11	1.38	3.11	0.58	0.66
Number of Stations	414	97	644	97	370	97

between 1974 and 1975 or when the combined results of these surveys were compared with the one done in 1976.

Changes in counts of individual species tended to cancel one another out between 1974 and 1975, and total bird numbers remained reasonably steady. However, the number of different species counted at each station tended to be lower in 1975 than in the previous year.

In 1976, total bird counts were substantially lower than in the two preceding surveys, and some of the species for which *Flagstaff* had earlier been notable, such as the native pigeon and silvereye, had apparently declined in numbers. Other counts, including those of grey warblers, riflemen and kakas, were higher in 1976.

Changes such as these were probably not confined to *Flagstaff*. Although no other block was surveyed more than once changes in bird counts occurred from year to year, and average counts for all other areas surveyed often followed trends encountered in *Flagstaff* (Table 5).

Of the species particularly common in *Flagstaff*, bellbird numbers changed little over the three years, but tui, fantail and grey warbler counts showed similar trends from year to year in all areas. Silvereye numbers were also one half to two thirds less in 1976 than 1974 both in *Flagstaff* and in all other areas combined. However, pigeon numbers which were remarkably high in *Flagstaff* in 1974 and 1975, but were 50 percent lower in 1976, remained fairly stable in other areas over the three years. Thus *Flagstaff* retained its position relative to other areas surveyed in the high numbers of tuis, bellbirds, fantails, grey warblers and silvereyes recorded there, but lost its position as a prime area for native pigeons.

The low count of pigeons in 1976 may have been an isolated occurrence, like the low counts of parakeets and brown creepers recorded in 1975 which returned to their earlier levels the following year. The first of the changes was not paralleled in other areas, the second was.

Counts of species less common in *Flagstaff* also showed trends generally similar to those in other areas. For example, counts of wekas and robins were relatively steady while rifleman counts trended upward in all areas over the three years and those of the yellow-breasted tit were lower in 1976 than 1974. The only other major inconsistency between

TABLE 6. *Summary of differences.*

	Slab Hut Creek Merrijigs	Maimai, Antonios Creek, Granville	Woolley River, Palmer Rd. Alfred River	Flagstaff 1974–1975	Flagstaff 1974 + 1975–1976
Tui		<0.005		<0.025	
Bellbird			<0.05		
Kaka		<0.025			<0.001
Parakeets				<0.005	
Weka					
Yellow-Breasted Tit	<0.01				<0.05
Robin		<0.005	<0.001		
Rifleman			<0.01		<0.001
Brown Creeper				<0.001	
Fantail					
Pigeon					<0.025
Grey Warbler	<0.05				<0.001
Silvereye					<0.001

Flagstaff and other areas occurred in counts of kakas which were substantially higher in *Flagstaff* in 1976 than previously but remained reasonably steady elsewhere. Whether this was also an isolated occurrence remains to be seen.

3. *Discussion*

REPLICATION IN THE SAME SEASON

The three within-season, between-block replication trials permitted 39 comparisons of counts of individual species. Differences which are statistically significant at a probability of 0.05 or less were seen in eight (21%—Table 6).

Two of these involve particularly mobile species, birds which move from place to place in search of food (tui and bellbird). In three more (two comparisons of the robin and one of rifleman) the species are more sedentary but have distinct habitat preferences which are reflected in their discontinuous distributions. One other (kaka) combines both these characteristics. Day to day or seasonal movements of birds are a potential source of error in the survey method, variation associated with habitat requirements is not. There is therefore some value in trying to isolate the cause of particular variations encountered in these trials.

Because of its loud and easily recognised song and its tendency to come down and investiagte human visitors, the South Island robin is one of the most evenly conspicuous birds encountered in the West Coast surveys. However, significant differences in robin counts were noted between all the blocks surveyed in the 1975 replication trials. Considering its conspicuousness on the one hand and its discriminating habitat requirements on the other (together with the comparatively less discriminating criteria for selecting blocks for comparison) variations in habitat between blocks unaccounted for in block selection is a more likely explanation for the differences than error in the survey method.

Other differences in the trials in pure beech forests (between rifleman and bellbird counts) may have been the result of differences of habitat between the *Alfred River* block and the other two. *Alfred River* covers the whole lower catchment of the narrow Alfred River valley and the area around Lake Daniells whereas *Woolley River* and *Palmer Rd.*, though similar in altitude range, topography and the type of forest they support, are situated on the more open slopes of the wider Maruia and Upper Grey river valleys.

Habitat factors may also have contributed to some of the differences seen in the beech/podocarp forest blocks. Kakas, for example, were generally more

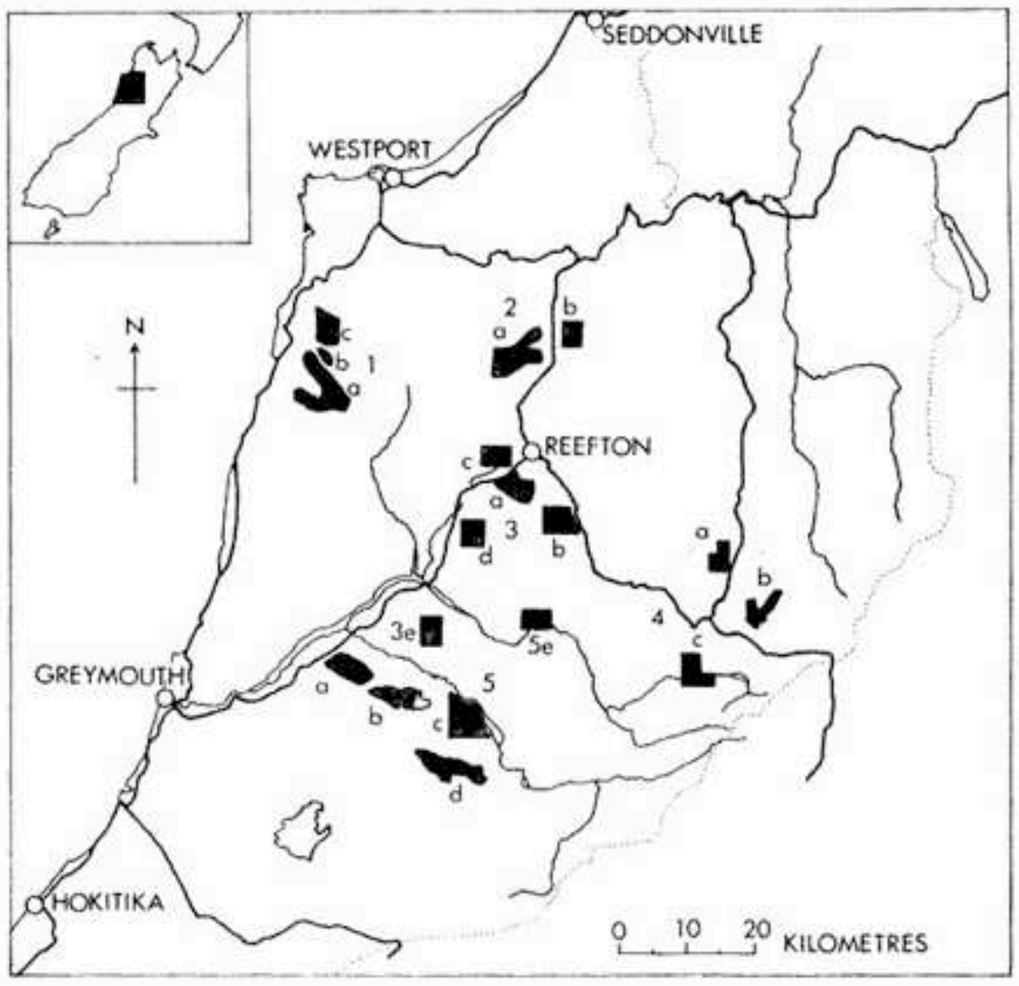

FIGURE 1. *The areas surveyed.* 1: PAPAROA REGION. (*a* Tiropahi and Fox River, (*b.* Sirdar Creek, *c.* Aranui Creek) 2: INANGAHUA REGION (*a.* Fletcher Creek *b.* Winding Creek) 3: REEFTON HILL COUNTRY (*a.* Slab Hut Creek, *b.* Merrijigs, *c.* Maimai, *d.* Antonios Creek, *e.* Granville) 4: UPPER GREY, MARUIA AND ALFRED RIVER VALLEYS: (*a.* Woolley River, *b.* Palmer Rd, *c.* Alfred River) 5: LOWER GREY VALLEY: (*a.* Nelson Creek, *b.* Lake Hochstetter, *c.* Flagstaff, *d.* Kopara, *e.* Brown Creek).

common in the Reefton hill country than in the lower Grey Valley blocks immediately to the south. The only statistically significant difference in counts of kakas in these trials occurred in *Granville*, the southernmost (and therefore nearest to the lower Grey Valley) of the three PB5 replicate blocks (Fig. 1). However, shortcomings in the survey method cannot be completely ruled out as a cause of these and other differences in both the beech and beech/podocarp forest trials.

Thus, if statistical significance is ascribed at a probability level of 0.05 or less, shortcomings in the survey method could have resulted in erroneously "significant" differences in six (15%) to eight (21%) comparisons of individual species. The lower rate excludes variations in robin counts, which are most likely to have resulted from habitat differences. The higher rate includes them as errors. At a probability of less than 0.05 one of the six comparisons of abundance and diversity indexes was also significant.

However, if the level at which statistical significance is ascribed is lowered to 0.01, the rate of possible errors (which includes random variation) in comparisons of counts of individual species drops to a lower level of three (8%) and a higher level of five (13%) depending on whether, or not, differences in robin counts are included. The one difference in abundance and diversity indexes also remains (17%). Consequently, using these methods, comparisons between blocks and within years are considered "significant" only at probabilities less than 0.01 and "highly significant" at probabilities less than 0.005.

REPEATABILITY BETWEEN YEARS

The number of statistically significant differences in bird counts in the three *Flagstaff* surveys (in which 26 single species comparisons gave 10 significant differences at probabilities of 0.05 or less (38%) and 8 at 0.01 or less (31%) was substantially higher than in replication trials done in the same year (Table 6). These differences may have been the result of changes in bird populations, variations in observer proficiency or some combination of both factors.

Many of the changes observed in *Flagstaff* from year to year, but not all of them, are paralleled by similar changes in other areas. The 1975 counts of parakeets and the 1976 counts of kakas and native pigeons, showed large changes in *Flagstaff* which did not occur in other areas. The 1975 counts of bellbirds, robins, riflemen and silvereyes showed smaller, non-significant changes in *Flagstaff* and changes in the opposite direction elsewhere. In all other comparisons (Table 5) trends in other areas were similar to those in *Flagstaff*. However, changes from year to year, whether restricted to one block or apparent over the whole Area, are too frequent to permit any close comparison of blocks surveyed in different years. Such comparisons have not been made in this report.

DIVERSITY OF THE BIRD FAUNA IN THE PROJECT AREA

Three tests were made to determine whether the bird fauna may vary in different places and different types of forest in the Project Area to a greater extent than in the replication trials. The first test compared representative examples of the range of principally beech/podocarp forest types in the Area. The second compared blocks with similar physical features and the one National Forest Survey forest type in different parts of the Area and the third compared the two major classes of forest present: beech/podocarp

TABLE 7. *Range of variation in the bird fauna of beech/podocarp forests: the* 1974 *surveys.* (*Significance levels are shown only for comparisons between adjacent areas and the two extremes:* * = $p < 0.01$, ** = $p < 0.005$, *** = $p < 0.001$).

	Paparoa	Significance	Inangahua	Significance	Reefton Hill Country	Significance	Lower Grey Valley	Significance	Paparoa
Total Birds/station	6.88		7.72		7.66	***	9.83	***	6.89
Species/station	4.29		4.39		4.23		4.81		4.28
Individual Species Counts (nos./station):									
Tui	0.42	**	0.12		0.20		0.57		0.42
Bellbird	1.38	***	2.04	**	2.70		2.99	***	1.38
Kaka	0.08		0.22		0.28	***	0.08		0.08
Parakeets	0.19		0.10		0.06		0.25		0.19
Weka	0.12	*	0.01		0.03		0.06		0.12
Yellow-Breasted Tit	1.20		1.25		1.17		1.13		1.20
Robin	0.55		0.46	***	0.18	***	0.06	***	0.55
Rifleman	0.01		0.04		0.14		0.07		0.01
Brown Creeper	0.17		0.08		0.16		0.19		0.17
Fantail	0.66		0.87		0.54	**	1.04		0.66
Pigeon	0.16		0.16		0.08	***	0.40	**	0.16
Grey Warbler	1.00		1.10		0.76	***	1.07		1.00
Silvereye	0.94		1.27		1.36		1.92	***	0.94
No. of stations	86		92		118		215		86

and pure beech forests.

1. *Range of variation in the bird fauna of beech/podocarp forests*

Surveys to cover the range of beech/podocarp forests, which were done in 1974, showed a wide variation in counts of the various bird species (Crook and Best, 1974). The extent of this variation is shown in Table 7, in which blocks have been grouped according to region.

The comparison shows firstly that there was little difference in numbers of species per station and secondly that the major difference in total bird counts occurred between blocks in the lower Grey Valley and the other three regions. However, each area was notable for high counts of one or more species. Robins, for example, were particularly abundant in Paparoa and Inangahua and tuis were most common in Paparoa and the lower Grey Valley. The Reefton hill forests had the highest counts of kakas. Bellbirds, pigeons, grey warblers and fantails reached their highest level in the lower Grey Valley. Overall, 78 comparisons of single species are possible between any two regions and 20 (26%) showed significant differences at probability levels of 0.01 or less—two to three times the rate ascribed to "error" in the replication trials. Only the parakeets, tit, rifleman, brown creeper and silvereye showed no significant variation between any pair of regions.

Considerable local differences between blocks representing the range of forest types within regions, were also detected, the most notable being in the three blocks in the lower Grey Valley (*Nelson Creek, Hochstetter* and *Flagstaff*—Table 8). Significant differences occurred here in total bird numbers and counts of five species: the two honeyeaters, parakeets, brown creeper and grey warbler. The variation in parakeet counts was particularly remarkable as the lowest and highest counts in all the 1974 surveys were made in the two nearly adjacent blocks of *Nelson Creek and Hochstetter.*

2. *Variation associated with region*

The possibility that factors other than forest types may have contributed to the regional differences seen

TABLE 8. *Variation in the bird fauna of the lower Grey Valley region: the* 1974 *surveys.* (*Significance levels:* * = $p < 0.01$, ** = $p < 0.005$, *** = $p < 0.001$).

	Nelson Creek	Flagstaff 1974	Hochstetter	Significance
Total Birds/station	10.54	8.26	10.30	**
Species/station	4.97	4.32	4.99	
Individual Species Counts (nos./station):				
Tui	0.48	0.35	0.77	**
Bellbird	3.31	2.35	3.15	**
Kaka	0.02	0.16	0.07	
Parakeets	0.02	0.35	0.35	**
Weka	0.02	0.00	0.12	*
Yellow-Breasted Tit	1.21	0.88	1.22	
Robin	0.00	0.04	0.10	
Rifleman	0.05	0.11	0.06	
Brown Creeper	0.34	0.00	0.20	***
Fantail	1.33	1.04	0.87	
Pigeon	0.43	0.37	0.40	
Grey Warbler	1.36	1.11	0.87	***
Silvereye	1.98	1.53	2.11	
Number of Stations	61	57	97	

TABLE 9. *Variation in the bird fauna of similar forests in different regions: the* 1975 *surveys.* (*Significance levels*: * = $p < 0.01$, ** = $p < 0.005$, *** = $p < 0.001$).

	Paparoa	Significance	Inangahua	Significance	Reefton Hill Country	Significance	Paparoa
Total Birds/station	7.15		8.22		8.99	***	7.15
Species/station	3.76		4.35		4.44	***	3.76
Individual Species Counts (nos./station):							
Tui	0.80		0.42		0.25	***	0.80
Bellbird	2.24	***	2.95		2.90	***	2.24
Kaka	0.00	***	0.37	***	0.13		0.00
Parakeets	0.13		0.18	***	0.02		0.13
Weka	0.04		0.00		0.10		0.04
Yellow-Breasted Tit	1.11		0.88		1.12		1.11
Robin	0.05	***	0.52		0.29	*	0.05
Rifleman	0.05		0.11		0.06		0.05
Brown Creeper	0.05		0.00		0.05		0.05
Fantail	0.65		0.83		1.09		0.65
Pigeon	0.35		0.28		0.32		0.35
Grey Warbler	0.49		0.82		0.86		0.49
Silvereye	1.18		0.86	***	1.80		1.18
Number of Stations	55		65		174		55

in 1974 was examined the following year in a survey of five blocks of the one forest type (PB5) in the Paparoa, Inangahua and Reefton hill country regions. All blocks were on hilly terrain between 60 and 440 m a.s.l., three of them being the replicate blocks *Maimai, Antonios Creek* and *Granville* discussed earlier and considered as one block for this comparison.

The results (Table 9) were in many respects similar to those seen in the 1974 survey. The total bird and species counts were lower in the Paparoa region than the Reefton hill country and total bird counts reached an intermediate level in Inangahua. Six of the thirteen species counts made significant contributions to differences between the three regions, four of which also showed significant variations in the earlier survey (tui, bellbird, kaka and robin). The kaka, particularly, had a similar pattern of abundance in both years, being more common in the Inangahua and Reefton hill country than on the western side of the Paparoa Range.

Tui and bellbird counts also varied in similar ways in both years, tuis being more common in the Paparoa and bellbirds in the Inangahua and Reefton regions. In contrast the high counts of robins in Paparoa in 1974 were not repeated, and no variation in fantail, pigeon and grey warbler counts occurred in the 1975 surveys. In total, there were two to three times the number of significant differences in counts between the three regions than in the three blocks of the same forest type within the one region (i.e. in the *Maimai, Antonios Creek, Granville* replication trial).

3. *Variation between beech and beech/podocarp forests.*

Comparison of the PB5 blocks in the Reefton hill country and Inangahua regions with the three areas of pure beech forest surveyed reveals wide differences in their bird faunas (Table 10). Although total bird and species counts are similar all counts of individual species, with the exception of the brown creeper, are significantly different. The tendency is for principally frugivorous and honey-eating species

such as the tui, bellbird, pigeon and silvereye to be less common and for predominantly insectivorous species (yellow-breasted tit, robin, rifleman and grey warbler) to be more common in the pure beech forests. However, the fantail and kaka were more common in beech/podocarp forests and parakeets were found in large numbers in the pure beech.

DISCUSSION

The surveys have shown significant differences in the bird faunas of:

(a) different classes of forest,
(b) different types of beech/podocarp forest, and
(c) different parts of the Project Area in blocks of similar forest type and physical features.

In each case the number of variables showing significant change was two or three times greater than in blocks of the one type of forest in the same general area (i.e. in the replication trials).

By New Zealand standards the West Coast Beech Project Area has a rich bird fauna (Crook and Best, 1974). In addition, the surveys reported here show the quantitative composition of the bird fauna to be particularly diverse, varying with types of forest and from region to region throughout the Project Area.

Tne repeated surveys in *Flagstaff* suggest that some of the differences encountered between areas could themselves change from time to time. If so, a single survey may not be sufficient to delineate key areas that should be set aside to represent the diversity. However, the possibility that temporal changes may occur also emphasises the importance of the continuity of the forest habitat. Continuity facilitates movements which can quickly compensate for local fluctuations in bird numbers.

This *combination* of largeness, diversity and continuity in the West Coast Beech Project Area, both of the avifauna and the framework of habitats on which it depends, is not found in most other forest areas considered to be of high wildlife value. These usually have one or more species which are rare or do not occur in other places; and they are often isolated, being either oceanic islands or terrestrial ones where the surrounding habitat has been sufficiently modified to exclude the species of interest (e.g. habitats of the North Island kokako—*Callaeas cinerea*).

The first two of these features (largeness and continuity) are in no sense unique to the Project Area. Large expanses of forest occur in National and Forest Parks in the South Island; but even superficial comparison of these areas (e.g. N.Z. Forest Service 1974) shows that the large area of low altitude beech/podocarp forest, particularly from the Inangahua to the lower Grey Valley and including the hill country between, has no parallel elsewhere. The great diversity of recogisably different habitats in these forests is not as well represented in other areas. The forests of the Project Area are as unique, and as important to wildlife, as any of the small reserves for relatively uncommon species which have been established in various parts of the country.

TABLE 10. *Comparison of the bird fauna of pure beech and beech/podocarp forests: the* 1975 *surveys.* (*Significance levels:* * = $p < 0.01$, ** = $p < 0.005$, *** = $p < 0.001$).

	Inangahua and Reefton Hill Country PB5 Blocks	Upper Grey Valley Beech Forests	Significance
Total Birds/station	8.78	8.74	
Species/station	4.42	4.60	
Individual Species Counts (nos./station):			
Tui	0.30	0.05	***
Bellbird	2.91	1.56	***
Kaka	0.20	0.08	***
Parakeets	0.07	0.36	***
Weka	0.07	0.01	**
Yellow-Breasted Tit	1.05	1.73	***
Robin	0.36	1.73	***
Rifleman	0.07	0.92	***
Brown Creeper	0.04	0.13	
Fantail	1.02	0.60	***
Pigeon	0.31	0.03	***
Grey Warbler	0.85	1.18	**
Silvereye	1.54	0.35	***
Number of Stations	239	173	

CONSERVATION OF WILDLIFE VALUES OF THE PROJECT AREA

The higher altitude forests of the Area, those above about 750 m a.s.l., will generally not be logged (N.Z. Forest Service 1971). Their exclusion from the surveys rests on the assumption that their value to wildlife can be satisfactorily conserved by maintaining the continuity of the existing altitudinal sequence of forests. Consideration of alternative management

strategies and their impact on the avifauna is here restricted to the zone which would be directly affected by timber utilisation.

1. *Conservation of the diversity of bird habitats*

The beech utilisation scheme proposes reservation of representative assemblages of vegetation and fauna in a network of Ecological Reserves in the Project Area. Best and Harrison (1976) made draft proposals for modification and enlargement of specific reserves in the light of our present knowledge of variation in composition of the avifauna. These modifications would increase the value of the reserve network as a series of core areas representing the known diversity of the bird fauna and its habitats.

2. *Conservation of the continuity of habitats*

The proposed Ecological Reserves may become more or less isolated from one another if large areas are clear-felled for conversion to exotics or regeneration in beech. The effect of inducing this kind of isolation on a bird fauna is not clear. Completely isolated habitats such as offshore islands tend to support fewer species of animals than areas of the same size which are not isolated (Hooper, 1971). How isolation would affect finer, quantitative differences between parts of a large area, like the Project Area itself, is not known. The isolation caused by replacing one kind of forest with another is not as complete as the geographic isolation of an offshore island. It may not even be as great as separating forested areas with urban or agricultural land; and the extent to which bird populations of isolated woodlands come to resemble those of geographic islands has not been established (Moore and Hooper, 1975, Helliwell, 1976).

However, there is no doubt that continuity of habitats stands to be reduced in any large-scale timber utilisation scheme. We therefore compared the effects which different options for management of production forests might have on this continuity, to show how disruption may be minimised.

CONTINUITY OF THE FOREST HABITAT AND OPTIONS FOR MANAGEMENT OF PRODUCTION FORESTS

Some combination of three broadly different types of production forest management is possible in the Project Area:

1. Selective logging of podocarp and some beech for sawn timber and veneers leaving the structure of the original forest intact.
2. Clear-felling and conversion to forests of exotic conifers.
3. Removal of all canopy trees except a scattering of beech seed trees and regeneration in pure beech or mixtures of beech and exotic species.

The last two options would largely replace the first in any beech utilisation scheme (N.Z. Forest Service, 1971, Kirkland, 1975) and they involve total destruction of the original habitat. The initial disruption of continuity would be considerable but could be varied with the rate and pattern of cutting. The extent to which the original continuity would re-establish as the new forests develop depends upon their capacity to support the original fauna.

Some indication of the possible ultimate effects can be obtained by comparing the bird fauna of the existing forests with those of the end products of each management option—i.e. forest cut-over for podocarps, pine forest and even-aged stands of pure beech forest respectively.

1. *The bird fauna of cut-over and unmilled beech/podocarp forests*

Two areas of cut-over beech/podocarp forest in the lower Grey Valley were surveyed as part of the 1975 series of surveys— *Brown Creek,* which was logged between 10 and 16 years ago, and *Kopara.* The *Kopara* block consists of contiguous areas of cut-over and unmilled beech/podocarp types.

Comparison, firstly, of cut-over and unmilled areas within the *Kopara* block (Table 11) revealed no significant differences. The cut-over areas had marginally lower bird and species counts, and kakas were not recorded there. However, kaka populations appeared to be low in the region as a whole in 1974 and 1975. Failure to record them in the cut-over area could be the result of chance.

Kakas were present in *Brown Creek*, however, and comparison with *Kopara* shows somewhat larger differences between the two than were found between the cut-over and uncut areas in *Kopara* itself. (Table 11).

A further indication of the apparently minor differences between unmilled and cut-over forests of similar type was obtained by comparing counts from the cut-over part of *Kopara* and *Brown Creek* with those from *Flagstaff* (unmilled). The only statistically significant differences in this comparison were in counts of robins and bellbirds, which were higher in *Brown Creek* than *Flagstaff*. There were no significant differences between the cut-over part of *Kopara* and *Flagstaff*. The rate of variation between cut-over and uncut blocks was not higher than between two cut-over or two unmilled blocks of similar type.

2. *The bird fauna of exotic conifer forests*

No surveys have been done in forests of exotic conifers in the Project Area, but a picture of the bird fauna such forests would support can be gleaned from the literature. Gibb (1961) found that 26-28

TABLE 11. *Comparisons of the bird fauna of unmilled and cut-over forests in the lower Grey Valley* (*Significance levels:* * = $p < 0.01$, ** = $p < 0.005$, *** = $p < 0.001$).

	Kopara Unmilled	Significance	Kopara Milled	Significance	Flagstaff 1975	Significance	Brown Creek	Significance	Kopara Milled
Total Birds/station	9.31		8.75		10.27		10.21		8.75
Species/station	4.52		4.31		4.33		4.36		4.31
Individual Species Counts (nos./station):									
Tui	0.21		0.30		0.34		0.27		0.30
Bellbird	2.83		2.90		2.69	***	4.35		2.90
Kaka	0.14		0.02		0.01		0.20		0.02
Parakeets	0.10		0.16		0.05		0.26		0.16
Weka	0.10		0.06		0.19		0.05		0.06
Yellow-Breasted Tit	1.10		1.04		1.49		1.26		1.04
Robin	0.03		0.02		0.02	***	0.39	***	0.02
Rifleman	0.07		0.25		0.05		0.00		0.25
Brown Creeper	0.00		0.00		0.00		0.05		0.00
Fantail	1.59		1.09		1.22		1.38		1.09
Pigeon	0.31		0.36		0.44		0.24		0.36
Grey Warbler	1.03		0.89		0.65		0.61		0.89
Silvereye	1.79		1.67		3.11		1.17		1.67
Number of Stations	33		78		97		66		78

year-old radiata pine forest in the North Island supported dense populations of birds (approaching 500 individuals per 100 acres). This figure compares well with others obtained for beech forest (Kikkawa, 1960a), regenerating mixed forest on Kapiti Island (Kikkawa, 1960b) and the various forest types represented on Little Barrier Island (Gravitt, 1969).

A substantial proportion of the birds counted by Gibb were introduced passerines such as chaffinch *(Fringilla coelebs)* and redpoll *(Carduelis flammea)* (about 160 individuals per 100 acres or about 30%); but several native species were also found, indicating their ability to adapt to the exotic forest situation. These included silvereye, shining cuckoo *(Chalcites lucidus)*, fantail, pied tit, robin, whitehead *(Mohoua albicilla)* and grey warbler. A broader, qualitative survey and review (Jackson, 1971) added the rifleman to this list and the brown creeper occurs in radiata pine forests in the South Island.

To this extent the forest of *Pinus radiata* acts as a habitat for birds, but its suitability extends to only one section of the native fauna. The principally insectivorous passerines generally appear to adapt to the new habitat, sometimes in numbers rivalling those found in indigenous vegetation. The mainly fruit- and honey-eating birds and the native parrots do not. Although some of these have been reported in stands of pines their occurrence is apparently on a part-time basis (Jackson, 1971) and possible at all only because of the presence of pockets of native forest and scrub in the near vicinity.

3. *The bird fauna of regenerated beech forests*

Pure stands of mature, even-aged red and silver beech, forests of similar composition to those that may result from beech management, support the same species as the beech podocarp types but in distinctly different proportions (Table 10).

4. *Discussion*

Of the three management options available in beech/podocarp forest the first, careful logging for podocarp and some beech, would clearly best maintain continuity of habitats and bird fauna between Ecological Reserves. The original forest structure is retained, no catastrophic change is involved and the modified habitat is capable of supporting all species of native birds in closely similar proportions to those found in unexploited forests.

The beech management option entails an initial period of complete disruption, but the developing forests would probably re-establish continuity for all species.

Exotic conversion also entails an initial change of major proportions, but in this case the new forest would not provide a suitable habitat for an important part of the avifauna. The degree of isolation of Ecological Reserves would be substantially greater if they were separated by plantations of exotic pines than if the indigenous vegetation cover was maintained.

A STRATEGY FOR CONSERVATION OF WILDLIFE VALUES

The information collected during these surveys provides an *instantaneous* picture of the bird fauna which is adequate to do little more than point to some of the gross effects of any scheme of large scale utilisation of forests in the Project Area. The surveys provide no information, for example, on the extent to which forests above the line of utilisation may act as corridors and maintain continuity between Ecological Reserves. Nor do they indicate the importance or extent of the changes that may occur seasonally or from year to year in the fauna of any one area. The results reported here also give little information on the particular factors which may be responsible for the variations which occur from place to place. In order to elucidate the dynamics of bird populations and their habitat relationships, together with the effects of man induced changes, more intense, longer term studies would be required.

However, in the meantime, a system of Ecological Reserves, core areas of unaltered forest, can be established to represent the obvious pattern of differences detected through the Project Area. These areas should, in turn, be buffered and linked by protection forest or substantial zones of "light exploitation" in which utilisation is limited to careful extraction of podocarps. The interstices of the resulting continuous matrix of relatively undisturbed forest could then be used for more radical forms of exploitation: Exotic conversion and beech management in beech/podocarp forests and beech management in pure beech forests.

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REFERENCES

BEST, H. A.; HARRISON, M. 1976. An assessment of the proposed biological reserves in the West Coast Beech Project Area with respect to the avifauna of the region. Unpublished report. July 1976.

CROOK, I. G.; BEST, H. A. 1974. Diversity and numbers of bush birds in some forests of the West Coast Beech Project Area. Fauna Survey Unit Report Series: 2. New Zealand Wildlife Service. (Reprinted in *Beech Research News* (1) 1974. Scientific Co-ordinating Committee for Beech Research).

DAWSON, D. G.; BULL, P. C. 1975. Counting birds in New Zealand forests. *Notornis* 22: 101-109.

GIBB, J. A. 1961. Ecology of birds in Kaingaroa Forest. *Proceedings of the New Zealand Ecological Society* 8: 29-38.

GRAVATT, D. 1969. The feeding ecology of honeyeaters on Little Barrier Island. M.Sc. Thesis, University of Auckland.

HELLIWELL, D. 1976. The extent and location of nature conservation areas. *Environmental Conservation* 3: 255-258.

HOOPER, M. D. 1971. The size and surrounding of nature reserves, in DUFFEY, E. D. and WATT, A. S. (Eds) *The Scientific management of animal and plant communities for conservation* pp. 555-561. Blackwell, Oxford.

JACKSON, R. 1971. Birds in exotic forests in New Zealand. *New Zealand Journal of Forestry* 16: 61-68.

KIKKAWA, J. 1960a. The seasonal change of bird populations in a modified South Island habitat. *Proceedings of the New Zealand Ecological Society* 7: 11-13.

KIKKAWA, J. 1960b. A bird census of Kapiti Island. *Records of the Dominion Museum, New Zealand* 3: 307-320.

KIRKLAND, A. 1973. *Beech Forests.* New Zealand Forest Service, Wellington.

MCLAY, C. L. 1974. The species diversity of New Zealand forest birds; some possible consequences of the modification of beech forests. *New Zealand Journal of Zoology* 1: 179-196.

MOORE, N. W.; HOOPER, M. D. 1975. On the number of bird species in British woods. *Biological Conservation* 8: 239-250.

NEW ZEALAND FOREST SERVICE 1971. *Report by the Director-General of Forests on Utilisation of South Island Beech Forests.* A. R. Shearer, Government Printer, Wellington.

NEW ZEALAND FOREST SERVICE 1974. *New Zealand Indigenous Forests—South Island.* Forest Service Mapping Series No. 15. A. R. Shearer, Government Printer, Wellington.

NICHOLLS, J. L. 1974. Biological reserves in the West Coast and Southland beech forest management regions. *Proceedings of the New Zealand Ecological Society* 21: 5-10.