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Counting terrestrial bird species in mixed habitats: an assessment of relative conspicuousness

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Abstract Conspicuousness of terrestrial birds from a distribution study using 100 ha squares based on the New Zealand map grid was investigated. Logistic regression was used to determine the amount of time observers should spend in each square to have a 50% chance of detecting any given bird species if it was present. The analysis was conducted for 3 habitats. For 14 species of native and introduced birds, the length of time necessary to determine presence was 1 - 631 min. To ensure that most species are accounted for in future distribution studies using similar grids, it is recommended that observers spend 1 h in each square.

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INTRODUCTION

In assessing the conservation importance of any given habitat or ranges of habitat, the distribution and assemblage of birds species is often used as a measure of many aspects of biological importance (Bibby *et al.* 1992). In undertaking a distribution study of birds possible outcomes from an individual sample are: the species is recorded; it is not present; and; the species is present but not recorded. The first of these is relatively easy to establish. There has been considerable debate, however, about how to establish with any certainty the absence of any given species at any given site or count station (Scott & Ramsey 1981; Udvardy 1981). To interpret results of a bird survey, there must be confidence in statements of both presence and absence. For example, if a large-scale survey is to be undertaken, then comparing the differences in distribution of any species between samples requires some confidence that absences recorded in each survey are a correct record. Inaccurate methods waste time and money.

In 1999, the Ornithological Society of New Zealand launched a distribution survey for the period 1999-2005 (Robertson & Taylor 1999). As the atlas approach is the only long-term national monitoring method used in New Zealand for birds, it is important that there is some assessment of the effectiveness of similar survey methods.

Many factors influence the accurate recording of the presence of any given species. This paper investigates the influence of relative conspicuousness. Conspicuousness is defined as the probability of recording a species if it is present in any given area for a given length of observation time. Some species are naturally more conspicuous than others. Relative conspicuousness has implications for the amount of time an observer must spend at a particular site to ensure that all the birds present there have been recorded.

The number of species observed in a grid square increases, asymptotically, with observation time and the size of squares being surveyed (Bibby *et al.* 1992). The problem is to determine the time that must be spent in a grid square or other sampling unit to be confident that the resultant bird list is complete.

The aims of this study were to investigate the assumption that, in each of a mixed set of habitats, increased effort leads to an increase in detection of bird species, and to identify the length of time required to have a 50% chance of detecting any species.

STUDY AREA AND METHODS

Study area

The Otago branch of the Ornithological Society of New Zealand undertook a bird atlas study of the Dunedin

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urban area and the Otago Peninsula in 1985-87 (McKinlay 1995). A full description of the landscapes and habitats of the study site is given in Peat & Patrick (1995). The area includes a diverse set of topographic features ranging from mid-altitude mixed podocarp forest to extensive coastal areas of both enclosed wetland and open coast. Land uses ranged from suburban housing and farming to land managed for the conservation of indigenous flora and fauna.

Methods

The study used grid squares (100 ha; 1000 × 1000 m) based on the New Zealand map grid. Observers were encouraged to visit each of the 214 squares (Table 1) to complete a bird list. Their instructions were to spend a minimum of 30 min in each square; the time actually spent in individual squares was 5 min - 5 h. Observers either sat in the square at 1 site or walked through parts of it on tracks or along streets, listening and sighting birds as they went. Surveys shorter than the specified 30 min (n = 78, 15.2% of total) were either spot records or short trips into a square from an adjacent square.

In all, 512 individual surveys were made, in 3 habitats (Table 1). Squares were assigned to a habitat class based on the topographic map for Dunedin (Terralink 1997). "Urban" squares were those dominated by areas of housing, open park space, commercial, and industrial buildings. "Bush" squares were dominated by manuka/kanuka (*Leptospermum scoparium/Kunzea ericoides*) shrubland, totara (*Podocarpus totara*) forest, and associated tall forest communities, while "open" squares were those with habitats dominated by areas of farmland, including paddocks, wetlands, buildings, tree lanes, open coast, and hedgerows, as well as exotic scrub (Table 1).

Full details on methods and the total bird list for the survey are given in McKinlay (1995). I chose for analysis 21 terrestrial species known to be widespread throughout the study area. Each of the species included in the analysis was classed as absent, or present. The species were: bellbird (*Anthornis melanura*); black-backed gull (*Larus dominicanus*); blackbird (*Turdus merula*); chaffinch (*Fringilla coelebs*); dunnock (*Prunella modularis*); fantail (*Rhipidura fuliginosa*); goldfinch (*Carduelis carduelis*); greenfinch (*Carduelis chloris*); grey warbler (*Gerygone igata*); Australasian harrier (*Circus approximans*); house sparrow (*Passer domesticus*); magpie (*Gymnorhina tibicen*); New Zealand pigeon (*Hemiphaga novaeseelandiae*); silvereye (*Zosterops lateralis*); skylark (*Alauda arvensis*); song thrush (*Turdus philomelos*); starling (*Sturnus vulgaris*); tui (*Prosthemadera novaeseelandiae*); yellowhammer (*Emberiza citrinella*).

The surveys were analysed by Logistic Regression (SAS Institute 1985). The multiple regression method was chosen because the response variable (presence or absence of species) is binary. The data can be described as binomial because the analysis involves the prediction of the true binomial proportions for all the surveys (Harraway 1995). The results of the regression analysis were tested for a significant relationship between presence of a species and amount of time given to the survey using a χ^2 approximation. Species whose logistic regression was not significant were excluded from further analysis.

Table 1 Summary of number of squares in the survey and the number of surveys by habitat.

Habitat	Number of squares	Number of surveys	Number of surveys square^{-1}
Urban	45	168	3.77
Bush	32	65	2.03
Open	137	279	2.03
	214	512	2.39

Two of the 3 habitat classes were each assigned a dummy variable that specified the habitats to be analysed. In the absence of these variables, the 3rd habitat was analysed.

A logistic regression equation was developed for all species for each of the 3 habitats. Three observed distributions were compared with the regression curve to ensure that the model approximated the observed values. The logistic regression equation takes the following form:

$$p=1/\mathrm{EXP}[-(b_o+b_1x_1+...b_px_p)]+1. \quad (1)$$

From this, the logistic regression equation for any given species in "open" habitats was:

$$p= 1/\mathrm{EXP}[-(\mathrm{INTERCEPT} + \mathrm{COEFF}(1) * T + \mathrm{COEFF}(3))]+1 \quad (2)$$

where T is time in min. The coefficient values are taken from Table 1.

The logistic regression equation for any given species in "urban" habitats was:

$$p= 1/\mathrm{EXP}[-(\mathrm{INTERCEPT} + \mathrm{COEFF}(1) * T + \mathrm{COEFF}(2))]+1 \quad (3)$$

The logistic regression equation for any given species in "bush" habitats was:

$$p= 1/\mathrm{EXP}[-(\mathrm{INTERCEPT} + \mathrm{COEFF}(1) * T)]+1 \quad (4)$$

The probability of detection for bird species, that showed a significant regression, was further analysed for increasing time periods. The intervals used corresponded to the following: 10 min minimum for

Table 2 Results of logistic regression analysis; coefficient values for each term in the equation are presented. Level of significance is χ^2 test of independence. #, non-significant, these species were not considered further in the analysis. Levels of significance: *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

Species	n	Intercept	$SE_{\bar{x}}$	Test for overall model	Effort		Habitat 1 (urban)		Habitat 2 (open)	
					Coeff (1)	P	Coeff (2)	P	Coeff (3)	P
Bellbird	244	0.7294	0.3189	93.732	0.00836	***	-1.9733	***	-1.2729	***
Black-backed gull #	377	70.4267	0.2697	9.916	-0.00112	n.s.	0.883	**	0.7089	n.s.
Blackbird	402	0.2618	0.3334	51.415	0.0134	***	0.0103	n.s.	0.6574	*
Chaffinch	276	-0.6669	0.2840	64.099	0.0114	***	-0.00223	n.s.	-0.1573	n.s.
Dunnock	271	-0.8369	0.2844	61.647	0.0109	***	0.1644	n.s.	0.0552	n.s
Fantail	213	-0.5876	0.2748	65.649	0.0835	***	-0.7598	**	-0.1452	n.s.
Goldfinch	243	-0.4622	0.2748	44.439	0.00842	***	-0.3193	n.s.	-0.4669	n.s.
Greenfinch	138	-2.5867	0.3866	96.143	0.00997	***	0.3379	n.s.	1.2707	*
Grey warbler	260	-0.3192	0.2485	69.243	0.0114	***	-0.5190	n.s.	-0.7916	*
Australasian harrier #	148	-0.5571	0.2829	82.417	-0.0006	n.s.	0.2574	n.s.	-2.2477	***
House Sparrow	327	-0.8082	0.2911	89.413	0.00868	***	0.4369	n.s.	1.8616	***
Magpie #	142	-1.0432	0.2929	35.424	0.00206	n.s.	0.350	n.s.	-1.1521	**
New Zealand pigeon	148	-0.7299	0.2747	96.404	0.00762	***	-1.6314	***	-0.3025	n.s.
Silvereye	329	0.2599	0.3059	67.796	0.0104	***	-0.7323	***	0.0157	n.s.
Skylark #	179	-0.9968	0.2990	50.475	-0.00055	n.s.	0.9551	**	-0.551	n.s.
Song thrush	287	-0.3189	0.2753	35.686	0.0073	***	-0.0904	n.s.	0.1227	n.s.
Starling	351	-0.9758	0.3041	74.386	0.0129	***	0.8696	**	1.3192	***
Tui	53	-1.6104	0.3169	84.954	0.00801	***	-3.4433	***	-0.9589	**
Yellowhammer #	128	-1.4074	0.3211	35.628	0.00148	n.s.	0.6600	*	-0.890	*

Table 3 Time required in minutes to have a 50% chance of detecting a bird species in 3 habitats.

Species	Habitat: Open	Urban	Bush
Bellbird	149	<1	<1
Blackbird	<1	<1	<1
Chaffinch	59	72	58
Dunnock	62	72	77
Fantail	162	88	71
Goldfinch	93	111	55
Greenfinch	226	132	560
Grey warbler	74	98	28
House sparrow	43	<1	94
New Zealand pigeon	310	136	96
Silvereye	46	<1	<1
Song thrush	57	26	44
Starling	9	<1	76
Tui	631	321	202

the New Zealand Atlas Project (Bull *et al.* 1985); 30 min minimum specified by McKinlay (1995); 60 min (O'Donnell & Dilks 1986): and 120 min, as a practical maximum based on observer experience.

RESULTS

Results of the regression analysis are summarised in Table 2, with the coefficient for each factor in the habitat analysis. Habitat 1 values were used in the "urban" analysis whereas habitat 2 values were used for "open" habitat analysis. For "bush" habitats no habitat variables were used (see Methods).

Fig. 1 shows an example of modelled regression curves compared with observed values in open habitats. The 3 observed values at c. 380 min were an average over all time periods from 175 to 600 min; because of the few observations involved (bellbird 3, blackbird 11, and New Zealand pigeon 2), these points have no interpretative value. For New Zealand pigeon and bellbird the model did not provide a good fit with the observed values.

Increasing time in "open" and "bush" habitats led to increased probability of detection (Fig. 2), but there is high variance and sample sizes above 200 min limited the predictive value of the data (Fig.1).

From the regression equation for each species in the 3 habitats, the amount of time in minutes required to reach a 0.5 probability of recording each species if present are calculated. The results of this are presented in Table 3. Clearly species are more or less conspicuous in different habitats. For the greenfinch, there was little difference in conspicuousness between "open" and "bush" habitats and in both these habitats greenfinches were less conspicuous than in "urban" habitat (Fig. 3A). In contrast, New Zealand pigeon were equally conspicuous in "urban" and "open" habitats, but far less conspicuous in "bush" habitats (Fig. 3B). Tui varied widely in conspicuousness among habitats, but were generally inconspicuous.

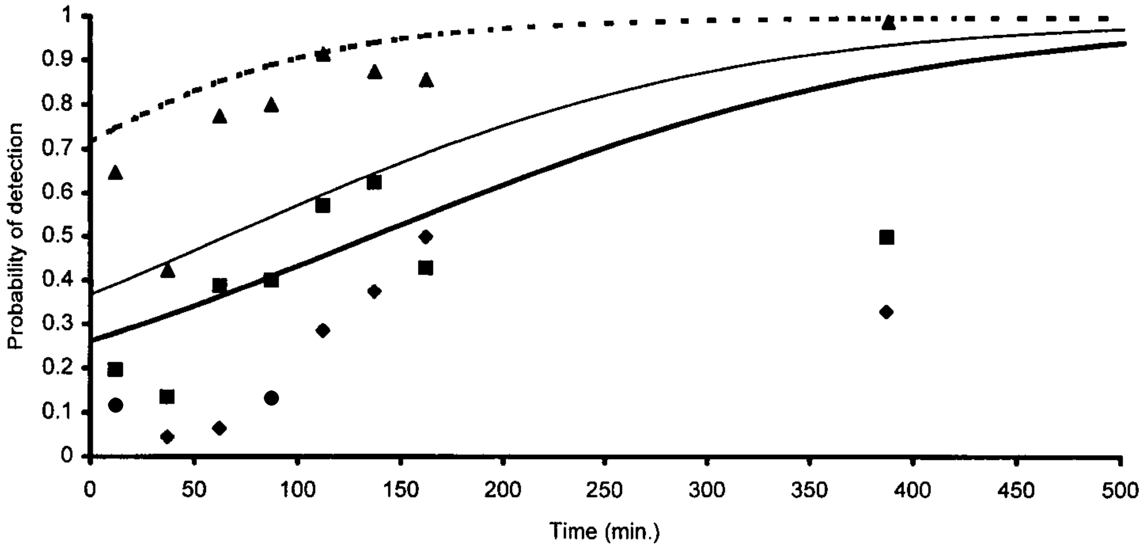

Fig. 1 Predicted and observed probability of detection for 3 species of birds in open habitats in Dunedin. Thin solid line, bellbird predicted; ■ bellbird observed. Broken line, blackbird predicted; ▲ blackbird observed. Heavy solid line, New Zealand pigeon predicted; ◆New Zealand pigeon observed.

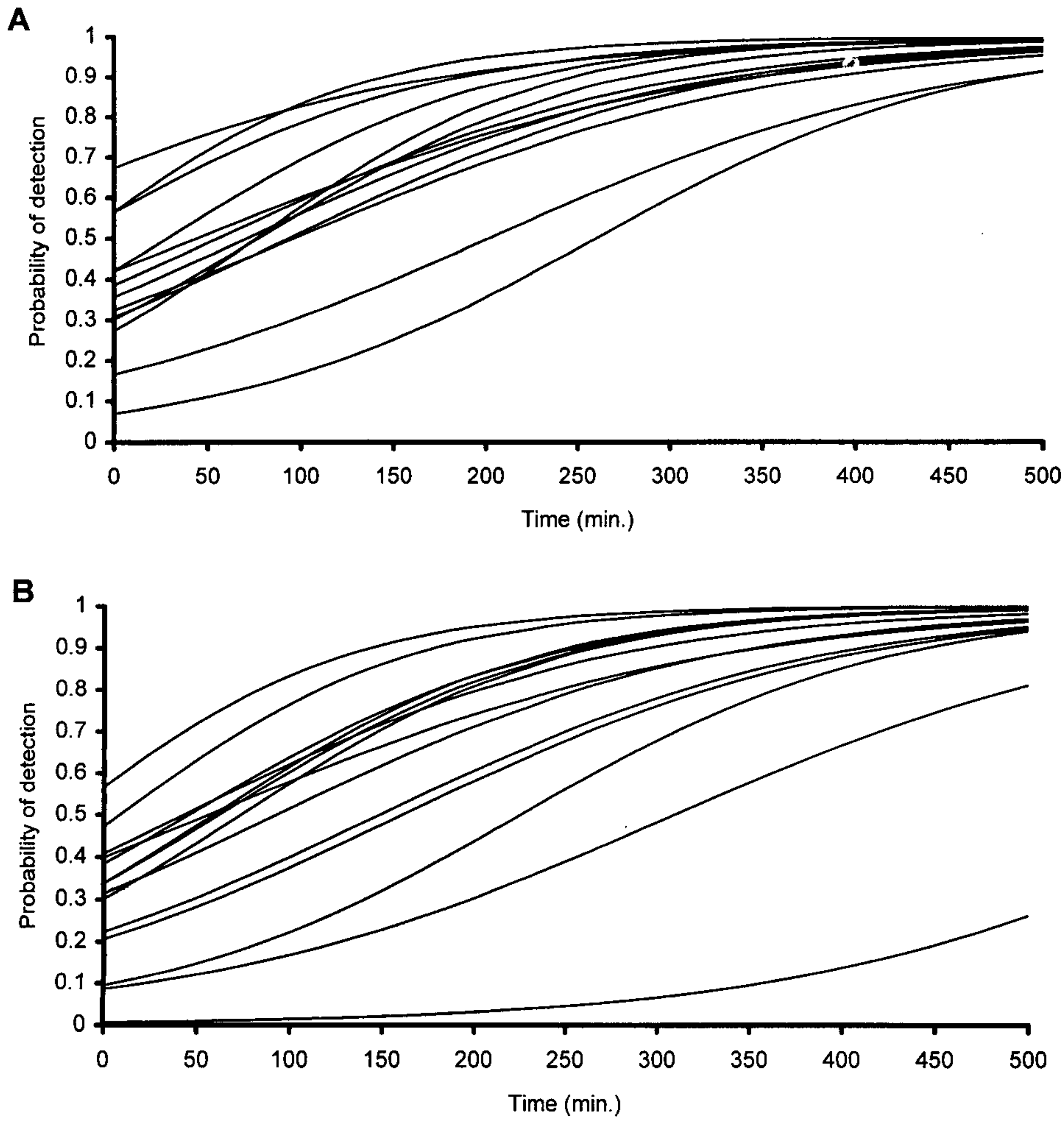

Fig. 2 Probability of detection as a function of time for 14 bird species in habitats in Dunedin; A, bush; B, urban.

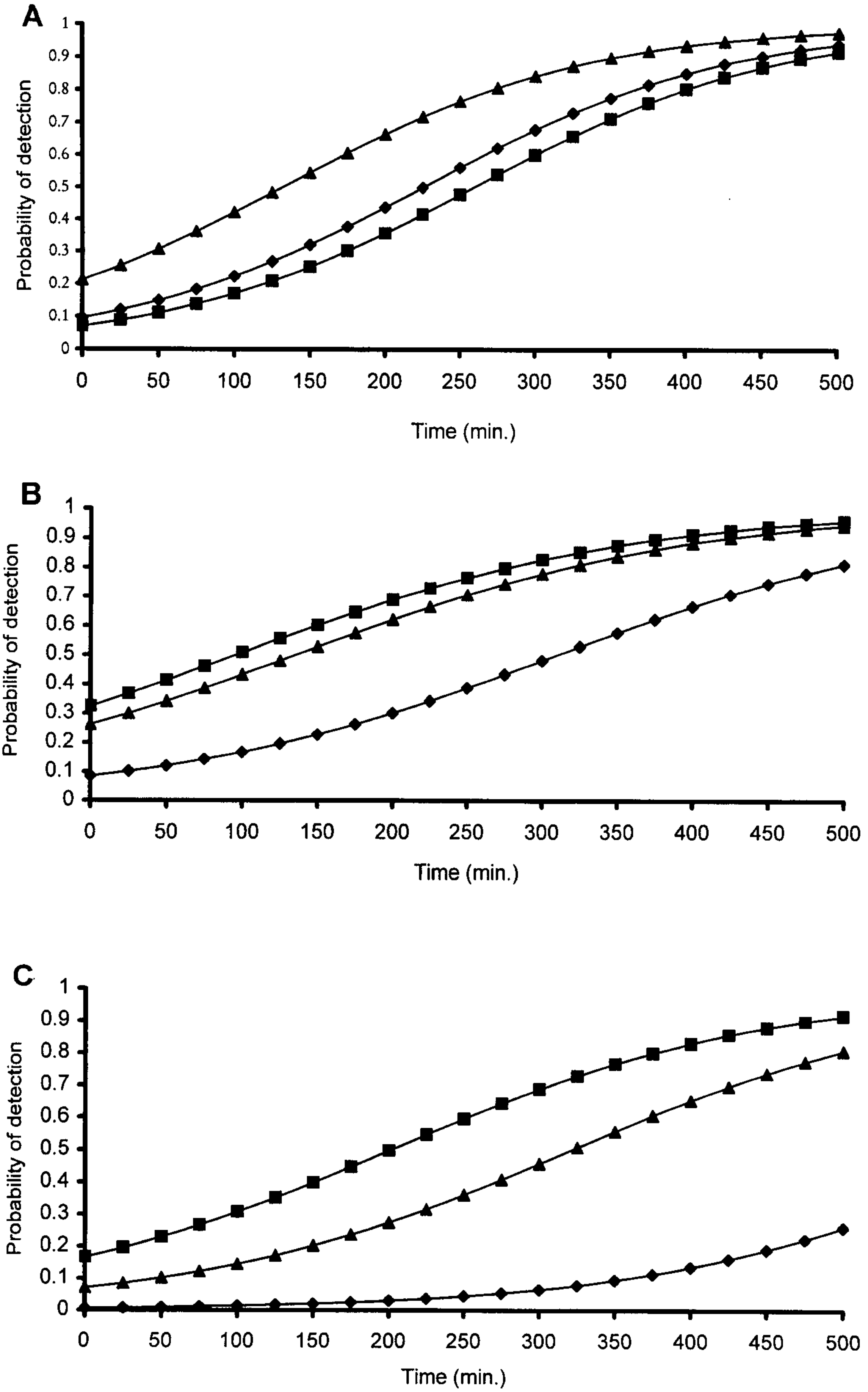

Fig. 3 Probability of detection as a function of time in three habitats in Dunedin: A, greenfinch; B, New Zealand pigeon; C, tui. "Urban" habitats, diamond; "bush" habitats, squares; "open" habitats, triangles.

As the probability of detection for species analysed for 4 time periods (Table 4) shows, current specified minimum times to complete distribution surveys do not allow confidence that all the birds present have been recorded. Repeat samples within the grid square, as in the case of the New Zealand Atlas Project (Bull *et al.* 1985) and the distribution study in Dunedin (McKinlay 1995; Table 1) are clearly necessary to increase total survey time in the square. Even allowing 120 min, in the mix of habitats covered in this study in Dunedin, does not provide confidence that the birds included in the analysis will be recorded if present.

DISCUSSION

Habitats in the study site were varied, and the area was not directly comparable with the tall forested habitats where much developmental work was undertaken to develop bird counting methodologies (Dawson & Bull 1975). It is, however a subset of the country that was covered by the New Zealand Atlas Project (Bull *et al.* 1985). The results from the present study therefore need to be carefully assessed before they are applied in different circumstances. They do, however, highlight the need for workers starting distribution studies to ensure that adequate lengths of time are spent sampling, either as 1 continuous survey or several repeat samples.

My analysis does not take account of seasonal effects on species, relevant life history stage, the effect of time of day, nor the impact of density (either relative or absolute) of the sampled species. For example, although tui (Fig. 3C) are sometimes strikingly loud and obvious members of the Dunedin avifauna they are, overall, inconspicuous, particularly in urban habitats. These factors also need to be taken into account when interpreting the results. Clearly, some birds flock for various purposes, others use song for attracting conspecifics, others for identifying territory (Gibb 2000).

The species used in this analysis were chosen initially because of their prominence in the existing survey results. However, for some species, such as black-backed gull and Australasian harrier, with large numbers of observations there was no significant relationship between probability of being recorded and effort (Table 2). Conversely, other species did not occur in sufficient numbers to satisfy the requirements of regression analysis.

Black-backed gull, Australasian harrier, and magpie are all large, obvious, common species and the non-significant relationship between effort and detectability for them can be explained by their always being present and recorded by observers. That there appeared to be no significant relationship between effort and detectability in some species merits examination. It may be that there is not a significant relationship for these species, but that view is not supported by the relationships found for the other species.

Table 4 Percentage mean of species analysed that had a 50% chance of detection if present at increasing periods of time.

	Time in minutes			
Habitat	10	30	60	120
Urban	28	35	35	78
Open	14	14	42	64
Bush	21	28	50	85

The placing of each survey in a habitat class was arbitrary, using data mainly from base maps. At a survey scale of 100 ha there is considerable variation in vegetation and landform. In any future exercise it would be preferable to collect habitat data at the time the survey is done, as in Bull *et al.* (1985).

An underlying assumption in all bird surveys is that increased observation time will result in a more complete bird list for point count as well as grid square surveys (Bibby *et al.* 1992; Scott & Ramsey 1981). The overall regression analysis confirmed that the assumption is true for a grid square study up to an interval of 200 min. However the times required to be able to have a 50% chance of detecting various species, if they are present, were much longer than observation times recommended at present. For the 14 species examined here (Tables 2, 3), for all habitats, spending 1 h in a 100 ha-square achieved a 0.5 success rate for only 6 species. It seems clear that improved bird census techniques are necessary as a basis for any further large-scale bird surveys.

The effects of density on conspicuousness were investigated by Gibb (1996). He sought to develop correction factors for changes in conspicuousness and concluded that such correction factors would not compensate entirely for variation in conspicuousness. The present study tends to support his conclusions. Some species are highly conspicuous and readily detectable while others take considerable amount of time before an observer can be sure 50% of the time of having detected them if they are present. Such a result reflects the observation that a large bird such as New Zealand pigeon will be able to be seen more readily in non-forested habitat.

Bird counting techniques in New Zealand were developed in the 1970s and 1980s to allow bird conservation to be incorporated into the decision-making process of indigenous forest managers (Dawson & Bull 1975; O'Donnell & Dilks 1986). Since then, bird surveys have become much more species-specific with an increasing emphasis on monitoring threatened species as part of conservation management programmes. Currently there is no national long-term monitoring programme such as the British Common Birds Census (Bibby *et al.* 1992; Dobinson 1976) or the Audubon National Bird Count to detect changes in national populations of all bird species. A base line exists in the work of Bull *et al.* (1985), but the present study raises issues about the utility of the atlas work. The new Bird Distribution Atlas Scheme (Robertson & Taylor 1999) is based on 10 km-grid squares. Although the instructions for this scheme request that total cumulative time be recorded they do not recommend a minimum time to be spent in a square.

As well as further use in endangered species management, monitoring ecosystem health as part of pest management programmes can be expected to increase in the future. To meet the needs of such programmes adequately for all bird species, greatly improved methods of sampling bird abundance are required. Part of the work needed includes developing regression models such as those presented in this study for a range of different habitats and for a larger suite of species.

A case can be made for bringing together all available data, no matter how "spotty" they are, for documenting our state of knowledge and spurring interest in further field surveys (Udvardy 1981). Current methods are inadequate to provide confidence that all birds that are present are being detected, yet the methodology must be cost-effective. The results presented here suggest a minimum of 1 h of observation is necessary before considering that a 100 ha-square has been adequately surveyed in a distribution survey.

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