

special issue:
Advances in tools for bird population
monitoring in New Zealand



Using five-minute bird counts to study magpie (*Gymnorhina tibicen*) impacts on other birds in New Zealand

John Innes^{1*}, Eric B. Spurr², Greg C. Arnold³ 1944-2009, Dai Morgan⁴, Joseph R. Waas⁴ and Corinne Watts¹

¹Landcare Research, Private Bag 3127, Waikato Mail Centre, Hamilton 3240, New Zealand

²Landcare Research, PO Box 40, Lincoln 7640, New Zealand

³Landcare Research, Private Bag 11052, Manawatu Mail Centre, Palmerston North 4442, New Zealand

⁴Department of Biological Sciences, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand

*Author for correspondence (Email: innesj@landcareresearch.co.nz)

Published on-line: 30 July 2012

Abstract: We used five-minute bird counts to investigate whether introduced Australian magpies (*Gymnorhina tibicen*) influence the abundance of other birds in rural New Zealand. Over 3 years, magpies were removed from five c. 900-ha study blocks, one in each of Northland, Waikato, Bay of Plenty, Wellington and Southland. Birds were counted in both the treatment blocks and paired non-treatment blocks for the 3 years of removal and also 1 year before. To minimise problems raised elsewhere with index counts we (1) selected treatment blocks and count stations using randomisation procedures, (2) used trained observers who spent equal time in paired treatment and non-treatment blocks, and (3) counted all blocks at the same time of year and only in good weather. On average, 548 magpies were removed from each treatment block each year, with magpie counts reduced by 76% relative to non-treatment blocks. Our results suggest magpies may restrict the movements of some birds (including kererū and tūī) in rural areas, but are less important than pest mammals at limiting population abundance at a landscape scale. We submit that five-minute bird counts were appropriate for our objectives, but that more research to examine their relationship to absolute densities is needed.

Keywords: abundance indices; Australian magpie; impacts

Introduction

Here we present an example of the use of five-minute bird counts (5MBCs) to determine the outcomes of a management treatment. Specifically, we investigate whether intensive, large-scale control of Australian magpies (*Gymnorhina tibicen*) benefits other birds. We discuss behavioural interactions between magpies and other birds, strengths and weaknesses of the 5MBC method, and circumstances in which such index counts are (and are not) appropriate.

Magpies

Australian magpies were introduced to New Zealand in the 19th century to control pasture invertebrate pests and have now spread throughout both main islands (Higgins et al. 2006). They are most abundant in pasture areas that have tall trees nearby for roosting and nesting, and feed mainly on ground-dwelling invertebrates with vertebrates and seeds also occasionally taken (Higgins et al. 2006). They have a complex social system in which individuals may occur in non-territorial flocks or territorial groups or pairs; obtaining and defending a territory is central to magpie social behaviour,

and is required for successful breeding (Carrick 1963; Veltman 1989). Magpies communally defend territories by singing, aggressive posturing and fighting, with aggressive behaviour also frequently targeted at other species including people (Morgan et al. 2005).

In Australia and New Zealand, magpies attack and occasionally kill other birds, including both threatening (predatory) and benign species (Cilento & Jones 1999; Morgan et al. 2005). In a South Island, New Zealand, survey of how magpies are perceived, 52% of the 120 people surveyed described incidents of magpie harassment of other birds, and 6% claimed to have witnessed birds being killed (McKay 1997). However, the impact of these attacks on target bird populations has received little study. In New South Wales, Australia, magpies actively excluded white-winged choughs (*Corcorax melanorhamphos*) from preferred grassland habitat by persistent attack (Cox & Bauer 1997). In New Zealand there is anecdotal evidence that native bird populations increased after magpie numbers were controlled (Morgan et al. 2005). While interactions between magpies and other birds have been investigated by Morgan et al. (2005, 2006a, b, 2007), the responses of other bird populations to magpie control have never received serious investigation in New Zealand.

This special issue reviews the advances in tools for bird population monitoring in New Zealand. This issue is available at www.newzealandecology.org/nzje/.

New Zealand Journal of Ecology (2012) 36(3): 0-0 © New Zealand Ecological Society.

Regional councils have statutory authority under the Biosecurity Act 1993 to manage pests on private land in New Zealand, but in the absence of research all regional councils share the same uncertainty about the best strategy to use for any particular pest species. In this project, nine regional councils agreed to combine their resources to undertake research to clarify whether and on what basis magpies should be included in regional pest management strategies. We here describe an experiment in which native bird populations were indexed in treatment and non-treatment blocks before and after magpie control.

Five-minute bird counts

Five-minute bird counts were designed by Dawson and Bull (1975, p. 102) who ‘...sought simply an efficient index of bird numbers, to measure bird populations accurately enough to detect major differences in abundance’. Since then 5MBCs have been widely used in New Zealand, resulting in more than 200 000 individual counts across more than 260 studies (Hartley 2012).

Index counts are quick and efficient, but assume that the counted sample represents a constant but unknown proportion of the actual population (Bull 1981). Critics of them argue that observer, environmental, and target species behaviour effects can all change this relationship in unknowable ways, undermining the reliability of resultant inferences (Barraclough 2000; Anderson 2001, 2003; Buckland et al. 2008). For example, Anderson (2003, p. 290) wrote: ‘Without estimates of detection probabilities, the use of index values is without a scientific or logical basis.’ However, supporters respond that such observer and conspicuousness effects, if present, would also bias other wildlife data collection procedures (Engeman 2003; Johnson 2008). Rather, it is emphasised that count techniques should primarily be valid for the particular question being asked, which may not actually require estimates of absolute density or abundance. For example, in most New Zealand studies, 5MBCs have been used either to assess the effects of a treatment such as pest control (Spurr 1991; Miller & Anderson 1992; Baber et al. 2009) or to compare bird abundances in different habitats and/or over time (Spurr et al. 1992; Smith & Westbrooke 2004; Fitzgerald & Innes 2009). In these situations, the key outcome is the difference between two populations rather than their absolute abundances.

Methods

Study areas

Five study areas were selected between Northland and Southland (Fig. 1; Appendix 1). Each study area consisted of paired treatment (magpie removal) and non-treatment blocks. Each block was c. 900 ha (3×3 km), with treatment and non-treatment blocks at least 15 km apart; treatment versus non-treatment designation was decided by coin toss. Pasture represented 50–88% of each block, but the vegetation cover making up the remaining 12–50% varied greatly (Appendix 1).

Magpie control

Three years of magpie control started in the second year of the study, allowing one pre-treatment session of bird counts (see below). Control was undertaken by regional councils, using their own staff, contractors, or landowners. There were no proven or best practice control regimes available

for magpies in New Zealand when this research started, so each council developed its own approach. All the councils used traps lured with food or call birds as their main control technique, supplemented to varying degrees by shooting and poisoning with alpha-chloralose (Appendix 2), with control usually undertaken in winter and spring. In the Bay of Plenty and Southland, magpies were also controlled on some farms adjacent to the main study areas; we refer to these as ‘buffer areas’ in Appendix 2.

Some control of mammal pests, particularly possums (*Trichosurus vulpecula*), occurred in or adjacent to all study blocks (Appendix 3); such control varied from low key and sporadic to intensive and sustained, but with paired blocks treated the same.

Bird counts

Bird populations in all 10 blocks were counted using point 5MBCs (Dawson & Bull 1975; Dawson 1981), which do not enumerate populations absolutely but provide indices of bird abundance that can be compared between treatments. Thirty-six count stations per block were randomly selected from 81 possible locations on a 9×9 grid (200 m between locations) in the centre of each 900-ha block.

Two trained observers from each regional council counted all magpies observed from count stations, and counted other species observed within 100 m of the count stations. The two observers counted on the same day, one at all stations in the treatment block and one at all stations in the non-treatment block. The next day, the observers swapped to count the other

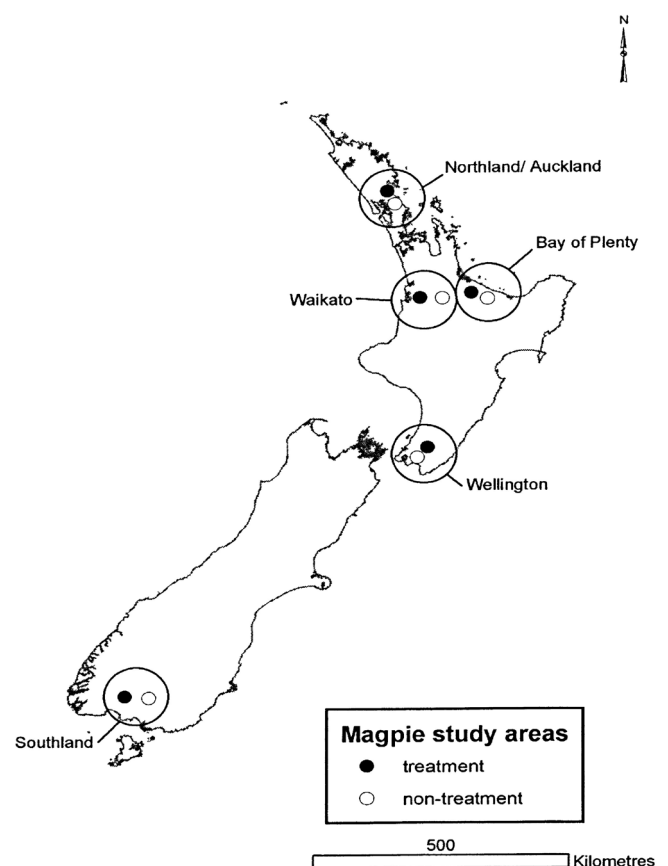


Figure 1. Locations of paired magpie study blocks in New Zealand, where five-minute bird counts were undertaken in November and January 1999/2000–2002/03.

block. Pre-treatment counts occurred between November 1999 and January 2000, and post-treatment counts in the same months for the following three years. Each observer counted each block three times per season, giving a total of 216 counts per block per season. Observers avoided strong wind and rain conditions that would impede counting birds, and counts occurred between about 0900 and 1600 hours (New Zealand Standard Time); biases potentially arising from observer, weather, and seasonal effects were thus minimised.

Statistical analysis

The effect of treatment was analysed separately for each species, modelling each species' counts in the three years post-treatment using a generalised linear model with a log link function and a Poisson distribution (McCullagh & Nelder 1989). Significance was assessed using *F*-ratios to allow for counts being clustered rather than purely random. The null model comprised categorical variables for every combination of year and region, and a variable for sites within each study area. This allowed for differences in bird counts between regions and years, in addition to differences between each pair of sites within each study region. The null model had 15 residual degrees of freedom from 5 study areas times 3 years. The treatment effect was added to this base model as a (0,1) variable indicating the magpie-controlled sites for Years 2–4. Pre-treatment numbers were included as a covariate.

To investigate the relationship between the counts of other bird species with those of magpies, the treatment indicator variable in the above model was replaced by log (magpie counts). This was to show whether there was any

linear correlation in the log of the ratio of the treatment to non-treatment block counts of magpies and the other species, calculated by taking the exponential of model coefficients. S-Plus 6.1 for Windows, 2001 (Insightful Corporation, Seattle, WA) was used for all analyses.

Results

Response of magpie counts to magpie control

Magpie counts varied greatly between areas. In Wellington, where magpies were most abundant (averaging 3.06 and 2.40 per count in treatment and non-treatment blocks respectively in Year 1), counts in the treatment block in the year immediately *after* magpie control (0.63 per count) were greater than in Southland *before* magpie control (0.57 per count).

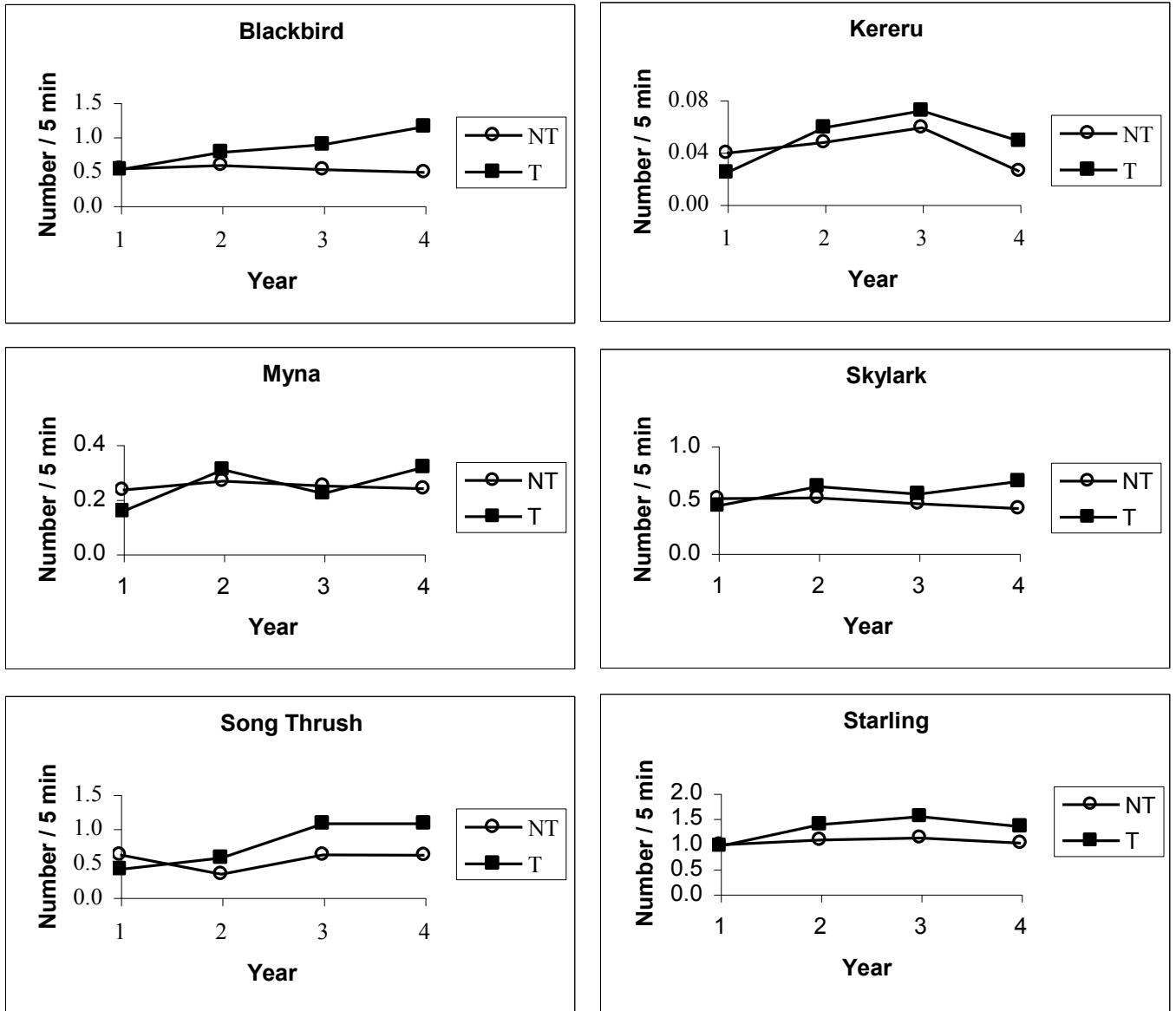
Using Year 1 as a baseline to correct for differences between paired blocks, the average reduction in magpie counts in the treatment blocks in Years 2–4 was 76% (Table 1; Fig. 2). Reductions in individual regions varied from 85% in Wellington to 22% in Southland. The smaller reduction in Southland was due to an increase in the number of magpies counted in the treatment block and a decline in the non-treatment block in Year 2.

In the absence of banding, we did not know what percentage of birds counted on treatment blocks after control in any year were survivors and what percentage were immigrants. We also did not know the social status (territorial pair, territorial group, non-territorial flock) of any magpies present either before or after control.

Table 1. Test for change in ratio of bird counts in treatment (T) blocks over non-treatment (NT) blocks post-treatment in relation to pre-treatment (for some species, excluding data from ¹Southland, ²Wellington, ³both Southland and Wellington). See Appendix 4 for scientific names.

Bird species	Change in T/NT ratio post-treatment			Trend
	% change	<i>F</i> value	<i>P</i> value	
Australasian harrier	+19	0.385	0.547	
Blackbird	+75	19.700	0.001	Increase
Chaffinch	–22	3.796	0.075	
Eastern rosella ¹	–36	2.191	0.173	
Fantail	–26	5.537	0.037	Decrease
Goldfinch	+9	0.397	0.541	
Greenfinch	–14	1.792	0.205	
Grey warbler	+17	0.768	0.398	
House sparrow ²	–6	0.219	0.651	
Kererū	+130	12.464	0.004	Increase
Kingfisher ¹	–21	1.453	0.259	
Magpie	–76	35.790	<0.001	Decrease
Mallard duck	–4	0.007	0.936	
Myna ³	+77	15.634	0.003	Increase
Paradise shelduck	–23	0.446	0.517	
Pheasant ³	–16	0.094	0.767	
Silvereye	–13	1.194	0.296	
Skylark	+39	7.743	0.017	Increase
Song thrush	+147	84.530	<0.001	Increase
Spur-winged plover	+52	1.166	0.302	
Starling	+74	5.798	0.033	Increase
Tūi ¹	+122	2.622	0.140	
Welcome swallow	–23	1.705	0.216	
Yellowhammer	+4	0.135	0.720	

SPECIES THAT INCREASED IN ABUNDANCE



SPECIES THAT DECREASED IN ABUNDANCE

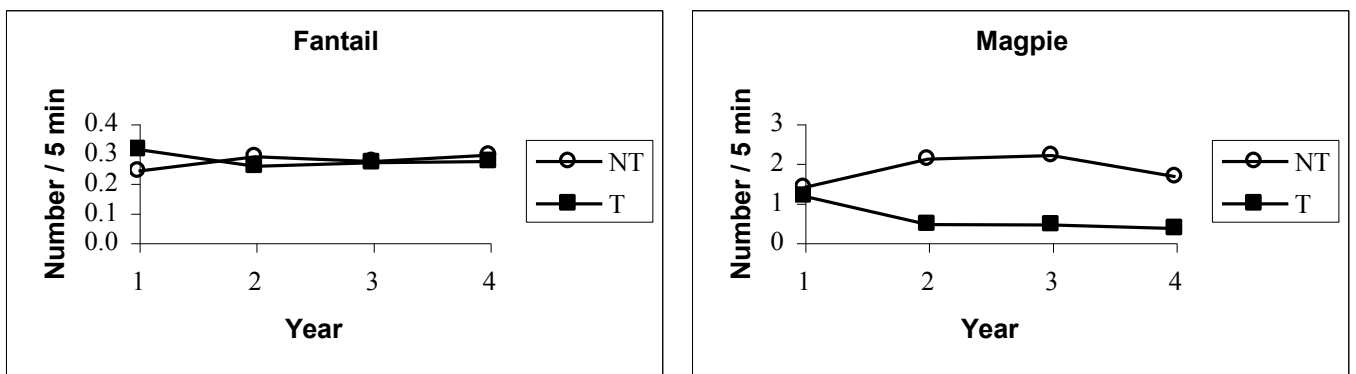


Figure 2. Mean numbers of birds (counted per five-minute count per annum for all blocks) whose counts increased or decreased significantly after magpie control.

Responses of other birds to magpie control

There were 53 bird species other than magpies detected in the treatment and/or non-treatment blocks (Appendix 4; names follow Gill et al. 2010). Thirty of the 53 species that were seldom counted (averaging < 0.04 per 5MBC), or were confined to just one or two study areas, are not considered further here. Of the 23 remaining species, one (fantail) decreased significantly, and six (blackbird, kererū, myna, skylark, song thrush, and starling) increased significantly over time in treatment blocks cf. non-treatments (Table 1; Fig. 2; scientific names of all species are in Appendix 4). Tūi counts more than doubled overall, but the increase was not statistically significant, probably because of the high variability between regions (Table 2); by Year 4 they had increased 30-fold in the Waikato, but only 2–3-fold in Northland and Wellington, and to a lesser extent in the Bay of Plenty. Very few tūi were counted in Southland; this area was excluded from further analysis of this species.

Changes in the counts of all species that increased significantly in treatment blocks, except for kererū, were significantly inversely related to changes in magpie counts (Table 3). Although kererū counts more than doubled, and magpie counts more than halved, in the treatment blocks relative to the non-treatment blocks during Years 2–4, the relationship was only near significant because the actual number of times kererū were counted was relatively small (Table 4).

Discussion

Responses of other birds to magpie control

Magpie control resulted in significant increases in counts of five introduced bird species (ordered from highest to lowest increase: song thrush, myna, starling, blackbird, skylark) and the native kererū, and a near significant increase for the native tūi (Table 1, Fig. 2). Fantails declined, for reasons we cannot explain. Three of the five introduced species that increased significantly (blackbird, song thrush, and skylark) were among the eight species (of 45) most attacked by magpies according to the literature and public reports (Morgan et al. 2005), while starlings were equal 13th, and the less widely distributed myna was equal 30th. Kererū and tūi were equal 4th and equal 9th most reported as being attacked.

The generally weak responses of other birds to regional council magpie control are consistent with research that shows that magpies chase other birds short distances but very rarely kill them (Morgan et al. 2006a). Excluding predatory harriers that may threaten magpies or their nests, only 8% of birds observed flying within 50 m of territorial breeding magpies near Hamilton (New Zealand) were chased, and none were actually struck or killed. This suggests that published accounts of magpie attacks (reviewed by Morgan et al. 2005) are biased towards sensational events that are in fact rare.

Table 2. Numbers of tūi (*Prothemadera novaeseelandiae*) counted at 216 count stations in each of the treatment (T) and non-treatment (NT) blocks.

Year	Northland		Waikato		Bay of Plenty		Wellington		Southland	
	NT	T	NT	T	NT	T	NT	T	NT	T
1999	16	32	8	6	6	17	18	5	2	2
2000	9	17	12	21	9	58	25	7	0	0
2001	10	41	12	53	8	46	36	15	0	0
2002	5	32	5	112	17	40	25	14	2	0

Table 3. Test for proportional relationship between counts of magpies and counts of bird species that increased after magpie control. See Appendix 4 for scientific names.

Bird species	F value	P value	Relationship
Blackbird	20.353	0.001	Inverse
Kererū	4.024	0.066	Inverse
Myna	16.386	0.002	Inverse
Skylark	5.855	0.031	Inverse
Song thrush	21.010	0.001	Inverse
Starling	8.007	0.014	Inverse

Table 4. Numbers of kererū (*Hemiphaga novaeseelandiae*) counted at 216 count stations in each of the treatment (T) and non-treatment (NT) blocks.

Year	Northland		Waikato		Bay of Plenty		Wellington		Southland	
	NT	T	NT	T	NT	T	NT	T	NT	T
1999	13	13	6	6	5	4	9	2	9	1
2000	8	14	18	26	8	8	5	3	12	12
2001	7	13	9	30	18	17	22	14	7	3
2002	2	5	8	30	11	9	3	4	2	5

Magpies are also very infrequent predators at bird nests in rural New Zealand compared with ship rats (*Rattus rattus*), harriers and cats (*Felis catus*) (Morgan et al. 2006b). If nest predation and contact attacks by magpies on other species are rare, the cost of magpie aggression for other pasture-feeding species is either disturbance (involving movements of birds for short distances) or exclusion from preferred feeding areas. This could contribute to the death of birds if they consequently succumbed to predation because of inadequate or risky feeding, perhaps in combination with season, weather and other factors. Also, the beneficial effects of magpie control for some species may be offset by deleterious effects of other increasing species. Disentangling such complex interactions is difficult, and there are no current conservation concerns for any of the introduced passerines that are most frequently attacked by magpies. Most public concern about magpie attacks in New Zealand is for native birds, especially tūī and kererū, which may be declining and may have to move many kilometres to the next nearest safe habitat (see below). Using distance counts on South Island farms, Green et al. (2005) found no evidence that abundance of magpies correlated negatively with abundance of other species.

The absence of a likely mechanism by which magpies may influence bird abundance, plus observations that birds avoid foraging and sometimes flying near magpies (Morgan et al. 2006a), suggest that the count changes of passerines detected in this research were due more to changes in behaviour (and hence conspicuousness to observers) than abundance. Green et al. (2005) found that skylark, song thrush and starling use of open pastures declined where more magpies were present.

Magpie impacts on kererū and tūī

In our research, counts of both kererū and tūī more than doubled on average in magpie treatment blocks compared with non-treatment blocks, although there was considerable variation between study blocks (Tables 2 & 4; Fig. 2). Kererū and tūī are both frequently reported to be attacked by magpies despite being uncommon now in most rural areas (Morgan et al. 2005). Tūī feed mainly on nectar and fruit, and kererū on fruit and leaves, in both native forests and exotic gardens. Both species are known to move many kilometres to seasonal food sources, including across pasture in fragmented landscapes. Neither species forages commonly on pasture on the New Zealand mainland, and it is unclear why magpies attack such apparently harmless species. Anecdotes that magpies can exclude these species from some preferred feeding areas are common (Morgan et al. 2005). In a fragmented rural landscape with isolated native forest remnants, the nearest escape cover or safe feeding site for chased tūī and kererū may be several kilometres away.

Cox and Bauer (1997) described such an exclusion process for white-winged choughs in Australia. Magpies repeatedly attacked feeding chough groups until the choughs moved towards suitable cover. No choughs were killed, but eventually chough territories were predominantly located in forest that held significantly less invertebrate biomass than the preferred grassland, whereas magpie territories were mostly in grassland. Fragmentation of the forests apparently increased the conflict between magpies (prefer grassland) and choughs (prefer forest), as is probably true for magpies and tūī and kererū in New Zealand.

It is feasible that tūī and kererū are chased from particular food sources (e.g. a farmhouse garden) on farms, but not from whole farms if other food sources are present. Our bird counts

were undertaken at a moderate (whole-farm, 256 ha) scale, and our conclusions are whole-farm conclusions. Understanding this may reconcile anecdotal comments such as ‘[magpies] have displaced the tuis which previously frequented the garden’ (McCaskill 1945, p. 98) with the results of our study. Anecdotes from landowners about this interaction are widespread, and it deserves further research. We suggest introduced mammals preying on nests in native forests are primarily likely to limit tūī and kererū numbers in the wider landscape (Innes et al. 2004, 2005), but magpies may block access to key, perhaps seasonal, resources for these birds at particular sites. Research to see whether removal of territorial magpies from particular sites where tūī and kererū prefer to feed benefits the latter species is reported by Morgan et al. (2012).

Control of magpies, non-targets and other pests

There is possibly a minimum threshold residual abundance of magpies that may result in large increases of other birds, which regional councils did not meet. Removing territorial magpies may reduce magpie attacks on other birds, but removing flock magpies is unlikely to do so. Furthermore, magpie aggression against other birds may be highly variable between individuals for other reasons, as Cilento and Jones (1999) and Warne and Jones (2003) found with urban Australian magpies that attacked humans. Reducing magpie numbers further than achieved by most councils in this project is unlikely to be economically sustainable in practice. Two councils spent on average \$30 per hectare controlling magpies (inclusive of monitoring costs), about the average per hectare cost of various possum control programmes.

Magpies as ‘disturbers of other birds’ are conspicuous to human observers because they are diurnal, black and white, aerial and noisy, whereas pest mammals in New Zealand are secretive, cryptic, nocturnal and arboreal. We suggest that regional councils do not attempt to recover native bird populations by controlling magpies in pastoral land at landscape scales because it is expensive, and the benefits to both native birds and other indigenous biodiversity are likely to be smaller than when pest mammals are controlled in native vegetation remnants (e.g. Gillies et al. 2003; Innes et al. 2004). However, magpies should be retained in regional pest management strategies and controlled experimentally at particular sites if aggressive territorial magpies exclude native birds such as tūī and kererū from key resources such as seasonal food. Maximum enhancement of tūī and kererū populations in rural areas in the future may involve a combination of pest mammal control in forest remnants to protect nesting attempts and maximise food (flowers, fruit and invertebrates), planting of marginal pastoral land to increase food supply away from native forests, and magpie control at particular local sites to maintain bird access to this food.

Appropriateness of the count technique in this study

Anderson (2001) criticised index counts in general because the probability of detection – and therefore the index count value – is affected by variables associated with the observer, the environment, the study animal’s behaviour, and time itself operating via factors such as habitat change. He also queried the reliability of data taken subjectively along roads and tracks or near camp, and suggested that such ‘convenience sampling’ was worth little and prevented inference applying to larger, more general environments. We understand these potential shortfalls, but suggest that they can often be overcome by

good design so that index counts can be appropriately used to address certain questions. That is, studies can be designed so that detectability can reasonably be assumed to be constant between treatment and non-treatment blocks, or more specifically that the contribution of detectability change to count changes is much smaller than that of abundance change (Johnson 2008). The advantages of indices are that they are time-efficient both in the field and during data analysis, and they simultaneously sample many species.

In our study, general inference is reasonable because: (1) the treatment blocks were selected from study block pairs by coin toss; (2) the 36 point-count locations in each block were selected randomly from 81 possible sites; and (3) we counted in five replicate pairs of blocks to raise the power of the experiment (Weller 2011). Having replicates was clearly beneficial because some birds (e.g. tūī in the Waikato) apparently responded strongly to magpie control in ways that did not occur in other regions. Analysis of magpie impacts was determined using the first pre-treatment year to derive abundance ratios between blocks that were then subjected to perturbation, a BACI design. Observer, weather, season, and habitat effects were overcome primarily by using trained observers in reasonable weather at the same time of year in all blocks and counting identically in paired blocks with very similar habitats. At all five sites, observers counted an equal number of times in both blocks overall, and counts were undertaken in the two blocks on the same days, so that if there was variation due to observers or weather, it would apply equally to both blocks. Our counts also applied standard (Dawson & Bull 1975) measures to minimise repeat counts of the same individuals, with stations at 200-m intervals and a 100-m cutoff for inclusion of individuals in the count (Dawson and Bull used a 200-m cut-off).

Limitations of the 5MBC method for this study were that we do not know the absolute densities of any of the study birds either before or after magpie control, nor the relative magnitudes of abundance changes between species. Also, we cannot separate abundance changes from conspicuousness changes by our count data alone, but use other research about the mechanisms of interactions with magpies to infer that abundance change is less likely. Barraclough (2000) thought that a distance-sampling snapshot count could be included at the end of a 5MBC, but we could not see how to achieve this in our study in practice. Distance sampling required that birds vacating the count site itself be noted, and that birds flying over be excluded, whereas we included only those birds that were detected in the 5MBC period, and included birds flying over if they were within 100 m. In this study we recorded the distances to all birds noted, but since these were taken over 5 min rather than a snapshot in time, we never analysed these data. However, Johnson (2008) suggested that variability in detectability would influence all bird count techniques including distance sampling, and that all should be treated as indices anyway.

Questions and situations for which five-minute bird counts are appropriate

Dawson (1981) suggests that frequency-of-occurrence counts such as 5MBC cannot be used to compare species with each other because indices measure each species on a different scale, but they can reasonably be used to compare between years, treatments and also habitats provided that habitats are similar. Critics of index counts point out that conspicuousness can vary greatly between habitats, but little evidence documents this in situations where habitats are not clearly different. Blackbirds

were observed more frequently in subalpine scrub than valley forest in a Tararua study, but based on near:far ratios as a measure of sampling area were more abundant in the forest (Moffat & Minot 1994). Seen:heard ratios—possible measures of conspicuousness—varied between sheep and beef farms and kiwifruit orchards (Blackwell et al. 2005). These compared habitats are very different indeed, and conspicuousness differences are to be expected. However, Blackwell et al. (2005) also noted ratio differences between some clusters of sheep and beef farms with smaller habitat differences.

Five-minute bird counts have often provided coherent outcomes in relation to management perturbations, which encourages further careful use. That is, when reasonable samples are taken and observers are trained, index counts are not characterised by fluctuating values or counter-intuitive results that are difficult to interpret. For example, counts of endemic birds are higher on pest-free islands compared with sites where some or many mammal pest species remain (Miskelly & Robertson 2002; Spurr & Anderson 2004; Harper 2009). Many endemic and native birds also increase during mainland pest control, but grey warblers frequently decline (Innes et al. 2004; Smith & Westbrooke 2004; Baber et al. 2009). Counts collated between different study areas can also enable general statements to be made about management treatments, bird groups or habitats (e.g. Blackwell et al. 2005; Innes et al. 2010). Recently, 5MBCs made at the same sites over many years have suggested dramatic declines in previously common native birds (Smith & Westbrooke 2004; Elliott et al. 2010). The low cost of index counts has valuably facilitated such projects, and will hopefully prompt more detailed analyses of the trends and mechanisms involved. We suggest that 5MBCs are appropriate to compare between years, treatments, and similar habitats provided that: (1) skilled, trained observers are used; (2) each observer counts an equal number of times in each one of paired treatment and non-treatment blocks, if there is a treatment; (3) habitats in the blocks are similar in terms of bird conspicuousness; and (4) an appropriate number of counts are undertaken in relation to the magnitude of difference required to answer the question at hand.

It is unfortunate that despite the frequent criticism of 5MBCs, so few opportunities have been taken to quantify their perceived shortfalls, such as by comparing their results with those of other techniques at the same time and place. Gill (1980, p. 242) compared mean annual 5MBC data for grey warbler and South Island robins with estimates of density determined by banding and territory mapping in two habitats, and found that ‘... for both species the indices vary in proportion to the densities in each habitat’. Further testing of the accuracy and precision of 5MBCs was recommended also by Blackwell et al. (2005), while Johnson (2008) asked for broader research into the relative importance of all sources of variation to bird population estimates, the costs of all methods, and their required sample sizes. Until such research is completed, we support the ongoing careful use of 5MBCs with particular design settings and objectives.

Acknowledgements

David Moore (Bay of Plenty Regional Council) and Diederik Meenken (Wellington Regional Council) initiated enquiries in 1997 that led to this research. We thank the nine participating regional councils who funded this research (Northland, Auckland, Waikato, Bay of Plenty, Hawke’s Bay, Wellington,

Marlborough, Canterbury, and Southland) and their staff, especially Ray Clarey, Peter Russell, and Richard Bowman. Other regional council staff who helped were Dave Byers, Carl Cooper, Greg Corbett, Clyde Edmiston, Dave Galloway, Sharyn Garner, Rachel Helson, Steve Henderson, James Lambie, Nicky Palmer, Harvey Phillips, Steve Playle, and Nick Rosewarne, and the many council contractors who counted the birds. Thanks to Aaron McGlinchy who undertook much preliminary sorting and curation of the bird count data, Anne Austin for editing, Stephen Ferriss and David Hunter for draughting, Neil Cox (AgResearch) for stats advice, and Catriona MacLeod, John McLennan and Dan Tompkins (all Landcare Research), and Paul Bellamy, for helpful comment on the manuscript. The Foundation for Research, Science and Technology funded writing under contract CO9X0503. Finally, thanks to Dan Tompkins and Catriona MacLeod for conceiving of and compiling this journal issue.

References

- Anderson DR 2001. The need to get the basics right in wildlife field studies. *Wildlife Society Bulletin* 29: 1294–1297.
- Anderson DR 2003. Response to Engeman: Index values rarely constitute reliable information. *Wildlife Society Bulletin* 31: 288–291.
- Baber M, Brejaart R, Babbitt K, Lovegrove T, Ussher G 2009. Response of non-target native birds to mammalian pest control for kokako (*Callaeas cinerea*) in the Hunua Ranges, New Zealand. *Notornis* 56: 176–182.
- Barracough RK 2000. Distance sampling. A discussion document produced for the Department of Conservation. Science & Research Internal Report 175. Wellington, Department of Conservation. 26 p.
- Blackwell G, O'Neill E, Buzzi F, Clarke D, Dearlove T, Green M, Moller H, Rate S, Wright J 2005. Bird community composition and relative abundance in production and natural habitats of New Zealand. ARGOS Research Report 05/06. Dunedin, University of Otago. 59 p.
- Buckland ST, Marsden SJ, Green RE 2008. Estimating bird abundance: making methods work. *Bird Conservation International* 18: 91–108.
- Bull EL 1981. Indirect estimates of abundance of birds. In: Ralph CJ, Scott JM eds. Estimating numbers of terrestrial birds. *Studies in Avian Biology* 6. Kansas, USA, Cooper Ornithological Society. Pp. 76–80.
- Carrick R 1963. Ecological significance of territory in the Australian magpie, *Gymnorhina tibicen*. *Proceedings of the International Ornithological Congress* 13: 740–753.
- Cilento NJ, Jones DN 1999. Aggression by Australian magpies *Gymnorhina tibicen* toward human intruders. *Emu* 99: 85–90.
- Cox SJ, Bauer JJ 1997. Species interactions between white-winged chough and Australian magpie in a fragmented landscape. *Pacific Conservation Biology* 3: 289–294.
- Dawson DG 1981. Experimental design when counting birds. In: Ralph CJ, Scott JM eds. Estimating numbers of terrestrial birds. *Studies in Avian Biology* 6. Kansas, USA, Cooper Ornithological Society. Pp. 392–398.
- Dawson DG, Bull PC 1975. Counting birds in New Zealand forests. *Notornis* 22: 101–109.
- Elliott GP, Wilson PR, Taylor RH, Beggs JR 2010. Declines in common, widespread native birds in a mature temperate forest. *Biological Conservation* 143: 2119–2126.
- Engeman RM 2003. More on the need to get the basics right: population indices. *Wildlife Society Bulletin* 31: 286–287.
- Fitzgerald N, Innes J 2009. Hamilton City biennial bird counts: 2004–2008. Landcare Research Contract Report LC0910/099. Hamilton, Landcare Research. 17 p.
- Gill BJ 1980. Abundance, feeding, and morphology of passerine birds at Kowhai Bush, Kaikoura, New Zealand. *New Zealand Journal of Zoology* 7: 235–246.
- Gill BJ, Bell BD, Chambers GK, Medway DG, Palma RL, Scofield RP, Tennyson AJD, Worthy TH 2010. Checklist of the birds of New Zealand, Norfolk and Macquarie Islands, and the Ross Dependency, Antarctica. 4th edn. Wellington, Te Papa Press and Ornithological Society of New Zealand. 500 p.
- Gillies CA, Leach MR, Coad NB, Theobald SW, Campbell J, Herbert T, Graham PJ, Pierce RJ 2003. Six years of intensive pest mammal control at Trounson Kauri Park, a Department of Conservation “mainland island”, June 1996–July 2002. *New Zealand Journal of Zoology* 30: 399–420.
- Green M, O'Neill E, Wright J, Blackwell G, Moller H 2005. Interspecific interaction and habitat use by Australian magpies (*Gymnorhina tibicen*) on sheep and beef farms, South Island, New Zealand. ARGOS Research Report 05/07. Dunedin, University of Otago. 44 p.
- Harper GA 2009. The native forest birds of Stewart Island/Rakiura: patterns of recent declines and extinctions. *Notornis* 56: 63–81.
- Hartley LJ 2012. Five-minute bird counts in New Zealand. *New Zealand Journal of Ecology* 36: 268–278.
- Higgins PJ, Peter JM, Cowling SJ eds 2006. Handbook of Australian, New Zealand and Antarctic birds, Vol. 7, Boatbill to Starlings. Melbourne, Oxford University Press.
- Innes J, Nugent G, Prime K, Spurr EB 2004. Responses of kukupa (*Hemiphaga novaeseelandiae*) and other birds to mammal pest control at Motatau, Northland. *New Zealand Journal of Ecology* 28: 73–81.
- Innes J, Fitzgerald N, Watts C, Thornburrow D, Blackwell H, Lancaster E, Burns B 2005. Distribution, movements and nesting success of Waikato tui. *Notornis* 52: 173.
- Innes J, Kelly D, Overton JMcC, Gillies C 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology* 34: 86–114.
- Johnson DH 2008. In defense of indices: the case of bird surveys. *Journal of Wildlife Management* 72: 857–868.
- McCaskill LW 1945. Preliminary report on the present position of the Australian magpies (*Gymnorhina hypoleuca* and *G. tibicen*) in New Zealand. *New Zealand Bird Notes* 1: 86–104.
- McCullagh P, Nelder JA 1989. Generalized linear models. 2nd edn. London, Chapman & Hall. 511 p.
- McKay DH 1997. Quardle ardle oodle: perceived value and appropriate controls of the Australian bell magpie (*Gymnorhina* spp.) in South Island, New Zealand. Unpublished thesis for SOCI 601 Social Science Research Methods (Quantitative). Lincoln University, Lincoln, New Zealand. 29 p.
- Miller CJ, Anderson S 1992. Impacts of aerial 1080 poisoning on the birds of Rangitoto Island, Hauraki Gulf, New Zealand. *New Zealand Journal of Ecology* 16: 103–107.
- Miskelly C, Robertson H 2002. Response of forest birds to rat eradication on Kapiti Island, New Zealand. In: Veitch CR, Clout MN eds. Turning the tide: The eradication of invasive species. Occasional publication of the IUCN Species

- Survival Commission 27. Auckland, New Zealand. P. 410 (abstract only).
- Moffat M, Minot EO 1994. Distribution and abundance of forest birds in the Ruamahanga Ecological Area, North Island, New Zealand. *New Zealand Journal of Zoology* 21: 135–150.
- Morgan D, Waas JR, Innes J 2005. Magpie interactions with other birds in New Zealand: results from a literature review and public survey. *Notornis* 52: 61–74.
- Morgan D, Waas JR, Innes J 2006a. Do territorial and non-breeding Australian magpies influence the local movements of rural birds in New Zealand? *Ibis* 148: 330–342.
- Morgan D, Waas JR, Innes J 2006b. The relative importance of Australian magpies (*Gymnorhina tibicen*) as nest predators of rural birds in New Zealand. *New Zealand Journal of Zoology* 33: 17–29.
- Morgan D, Waas JR, Innes J 2007. Can redirected aggression explain interspecific attacks by Australian magpies on other birds? *Behaviour* 144: 767–786.
- Morgan DKJ, Waas JR, Innes J, Arnold G 2012. Native bird abundance after Australian Magpie (*Gymnorhina tibicen*) removal from localised areas of high resource availability. *New Zealand Journal of Ecology* 36: 333–339.
- Smith ANH, Westbrooke IM 2004. Changes in bird conspicuousness at Pureora Forest. *Notornis* 51: 21–25.
- Spurr EB 1991. Effects of brushtail possum control operations on non-target bird populations. *Acta Congressus Internationalis Ornithologici XX*: 2534–2545.
- Spurr EB, Anderson SH 2004. Bird species diversity and abundance before and after eradication of possums and wallabies on Rangitoto Island, Hauraki Gulf, New Zealand. *New Zealand Journal of Ecology* 28: 143–149.
- Spurr EB, Warburton B, Drew KW 1992. Bird abundance in different-aged stands of rimu (*Dacrydium cupressinum*) – implications for coupe-logging. *New Zealand Journal of Ecology* 16: 109–118.
- Veltman CJ 1989. Flock, pair and group living lifestyles without cooperative breeding by Australian magpies *Gymnorhina tibicen*. *Ibis* 131: 601–608.
- Warburton B 1996. Trap-catch for monitoring possum populations. Landcare Research Contract Report LC9596/060. Lincoln, Landcare Research.
- Warne RM, Jones DN 2003. Evidence of target specificity in attacks by Australian magpies on humans. *Wildlife Research* 30: 265–267.
- Weller F 2011. Testing the power of an experiment to measure predator control and habitat complexity impacts on farmland bird abundance. *New Zealand Journal of Ecology* 35: 44–51.