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Changes in passerine populations during ongoing predator control at a community-based conservation project: a case study to evaluate presence-absence surveys

BRYCE M. MASUDA
MORGAN MCLEAN
Department of Zoology, University of Otago, PO Box 56, Dunedin 9054, New Zealand

PETER GAZE*
48 Brooklands Road, Atawhai, Nelson 7010, New Zealand

Abstract The monitoring of endemic birds during the control of introduced mammalian predators is a common practice at community-based conservation projects in New Zealand. We describe long-term trends of endemic passerines monitored using the presence-absence technique during the control of stoats (*Mustela erminea*) and brushtail possums (*Trichosurus vulpecula*) in the Flora Valley, near Nelson, New Zealand. Data collected over an 8 year period by Friends of Flora, a community-based organisation, suggests that bellbirds (*Anthornis melanura*) significantly increased, while South Island robin (*Petroica australis*), tomtit (*P. macrocephala*) and rifleman (*Acanthisitta chloris*) populations showed little or no change, and grey warblers (*Gerygone igata*) significantly decreased. All species showed a greater increase during the first 4 years of the survey compared to the second 4 years, which suggests that meso-predator release of rats may have occurred from ~4 years after the start of the surveys. The presence-absence technique is simpler to conduct than the more commonly used 5-minute bird count method, and thus may be better suited for use by the community sector in similar situations.

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INTRODUCTION

It is widely acknowledged that island avifaunas are particularly susceptible to introduced mammalian predators (Blackburn *et al.* 2004; Duncan & Blackburn 2004). In New Zealand, introduced predators were largely responsible for the extinction of over 40% of endemic bird species since the arrival of humans (Holdaway *et al.* 2001), as well as the ongoing decline of extant populations (Elliott *et al.* 2010; Innes *et al.* 2010). As a result, efforts to control and eradicate introduced predators are now widespread at ecosystem restoration projects (Parkes & Murphy 2003; Towns *et al.* 2006).

The positive impacts of controlling introduced predators on endemic New Zealand bird species has been well documented, particularly for large birds that nest in cavities, or on or close to the ground (Basse *et al.* 1999; Moorhouse *et al.* 2003; Whitehead *et al.* 2008). Additional studies have also

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*Correspondence: *peterdgaze@gmail.com*

examined the response of cup nesting passerines to predator control or eradication, particularly when some (but not all) predator species are controlled or eradicated (*e.g.* Innes *et al.* 1999; Innes *et al.* 2004; Spurr & Anderson 2004). Ongoing predator control is associated with lower nest predation rates in New Zealand passerines, and is thus expected to result in a direct increase in abundance (Starling-Windhof *et al.* 2011; Remeš *et al.* 2012). Alternatively, the control of selected predator species could result in an indirect decline in passerine abundance due to meso-predator release, whereby the control of a top-level predator (*e.g.*, stoats *Mustela erminea*) results in an increase in a lower-level predator (*e.g.*, rats *Rattus* spp.) and a subsequent increase in predation on passerines (King & Moody 1982; Tompkins & Veltman 2006; Ritchie & Johnson 2009).

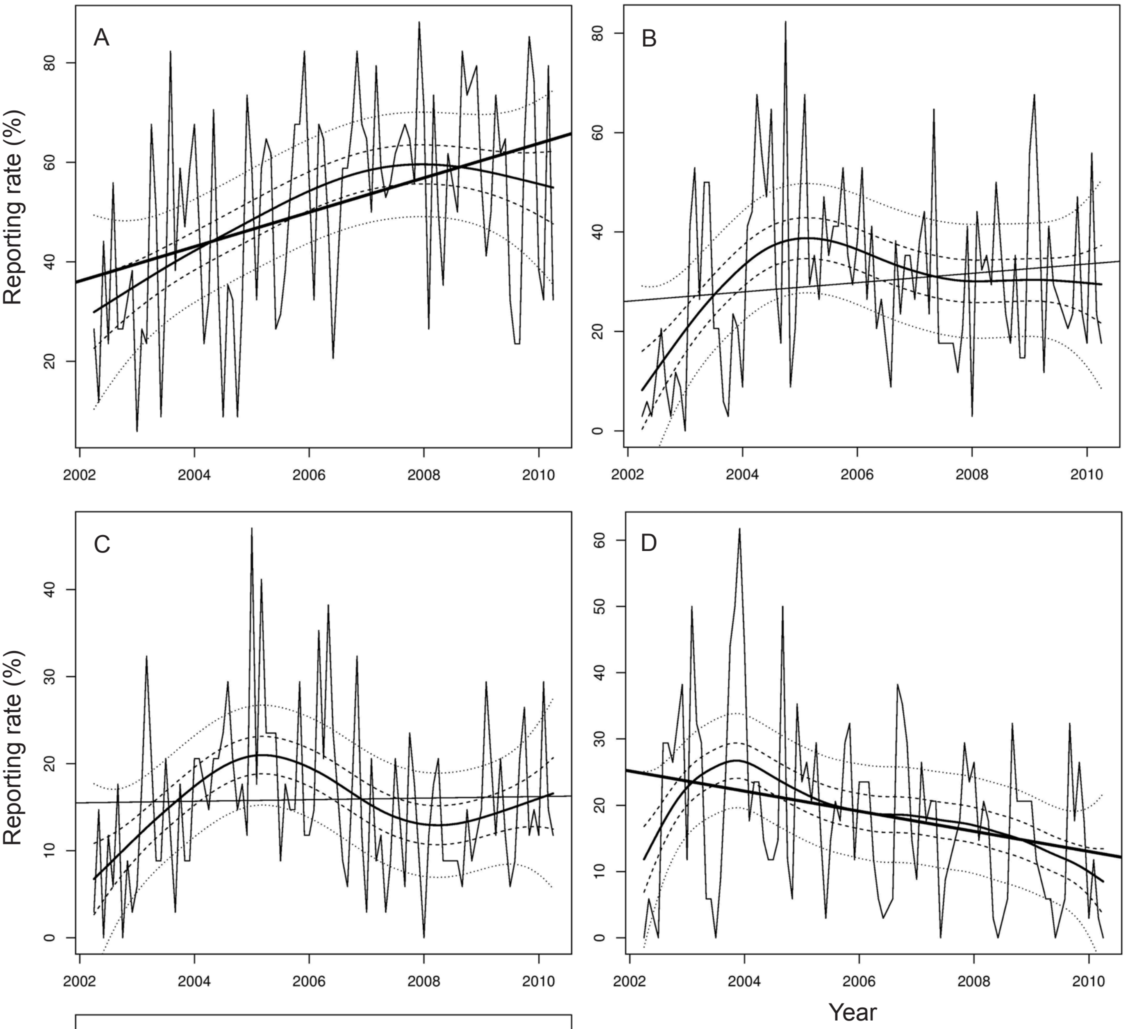
At restoration projects, bird surveys are frequently conducted in conjunction with ongoing predator control to determine the effect on endemic birds (Baber *et al.* 2009; O'Donnell & Hoare 2012). Although bird surveys were traditionally conducted by professional fieldworkers, there has been a recent increase in participation by the community, or citizen, sector in conservation management (Dearden *et al.* 2005; Silvertown 2009). This community-based conservation movement generally involves ecosystem protection and restoration by, for and with the local community, with the aim of achieving conservation goals, as well as social, spiritual and economic benefits for the wider community (Western & Wright 1994; Campbell & Vainio-Mattila 2003; Clewell & Aronson 2006; Campbell-Hunt *et al.* 2010; Roche & Rolley 2011). The community sector has initiated and managed a growing number of restoration projects over the past 20 years in New Zealand and worldwide (Agrawal & Gibson 1999; Forgie *et al.* 2001; Campbell-Hunt *et al.* 2010; Shukla & Sinclair 2010). Although the community sector is a valuable resource in restoration projects, they may lack experience conducting some management activities which could be problematic. For example, bird survey data collected by first-time observers can be biased for some techniques (Kendall *et al.* 1996) and therefore such techniques may need to be tailored to the community sector (Cohn 2008).

In this study, we describe long-term population trends of 5 endemic passerines during ongoing predator control by Friends of Flora, a community-based conservation group based near Nelson, New Zealand. Stoats and brushtail possums (*Trichosurus vulpecula*), but not rats, were the primary target of predator control, and we were interested in the effect of predator control specifically on endemic passerines which were monitored from 2002 to 2010 using the presence-absence survey technique. We discuss the merits and limitations of this technique particularly in comparison to the commonly used 5-minute bird count (5MBC) method in New Zealand. We also discuss the benefits of using presence-absence surveys to monitor endemic forest passerines at mainland sanctuaries where a large proportion of observers are from the community sector.

METHODS

The Flora Valley (41° 10′ 26″ S, 172° 45′ 50″ E; 800 m a.s.l.) is a tributary of the Takaka River on the eastern boundary of Kahurangi National Park, ~40 km east of Nelson, New Zealand. Friends of Flora was established in 2001 as a charitable trust working in collaboration with the Department of Conservation (DOC) to enhance the birdlife in this catchment. The predominant canopy species in this area is silver beech (*Lophozonia menziesii*), with small scattered areas of red beech (*Fuscospora fusca*) and mountain beech (*Fuscospora cliffortioides*), as well as pockets of southern rata (*Metrosideros umbellata*) in the limestone bluff areas. One of the conservation management actions conducted by Friends of Flora has been the trapping of stoats and possums, which was initiated in 2002 to protect blue duck (whio; *Hymenolaimus malacorhynchos*), but expanded to cover 5500 ha of forest habitat by 2012 in order to restore the native terrestrial birdlife. Predators were controlled using DOC 200 traps, in addition to a limited number of DOC 150 traps (Warburton *et al.* 2008).

The bird monitoring described in this study was conducted at each predator trapping station, between trap checks, by volunteers of Friends of Flora. These bird surveys started within 6 months of predator trapping and involved recording the presence or absence of forest bird species during a 5 minute period. Potential bias due to the relative inexperience of volunteers was in part accounted for because only the presence or absence, not abundance, of relatively few species was recorded. These presence-absence surveys were conducted at each of 34 predator traps, which were spaced 100 m apart starting from the Flora Hut and continuing down the main valley track along the predator trapline, for a total survey transect length of 3400 m. Surveys along the transect were always conducted in the same order starting from the Flora Hut, and only conducted during favourable weather conditions with light wind and no heavy rainfall. Trap checks and surveys along the transect were conducted between 0900 and 1600 hours, and took ~4 hours to complete. The terrain was easy to traverse along the entire transect, and thus all species had an equal chance of being detected. The beech forest habitat was found along the entire length of the survey transect and this habitat is appropriate for all 5 species surveyed. As a result,



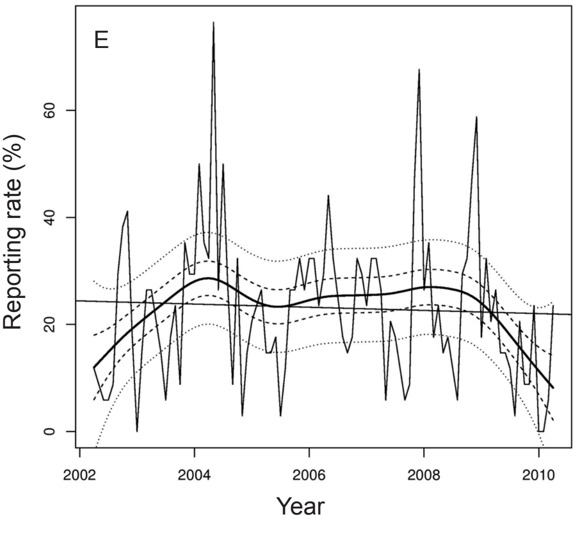


Fig. 1. Reporting rate of (a) bellbird (*Anthornis melanura*), (b) rifleman (*Acanthisitta chloris*), (c) South Island robin (*Petroica australis*), (d) grey warbler (*Gerygone igata*), and (e) tomtit (*P. macrocephala*) surveyed in the Flora Valley using the presence-absence technique. Lines represent seasonal average reporting rates (irregular line), a linear fit (straight line), smooth fit obtained using a regression spline (curved, bold line), 95% confidence intervals (dashed lines) and Bonferroni bounds (dotted lines). The linear fit is represented as a bold line when the slope is significantly different from zero, and as a plain line otherwise. Seasons were grouped by December to February (summer), March to May (autumn), June to August (winter) and September to November (spring).

for this current study, an increase in distribution can be interpreted as an increase in the abundance of a species even though the presence-absence technique measures a species distribution. Because the presence-absence surveys were conducted in conjunction with trap checks, survey data was collected each month for 8 years, since March 2002. We report monitoring results until March 2010 from 5 passerine species: bellbird (*Anthornis melanura*), grey warbler (*Gerygone igata*), rifleman (*Acanthisitta chloris*), South Island robin (*Petroica australis*) and tomtit (*P. macrocephala*).

Data analysis
All statistical analyses were carried out in R statistical software, version 2.15.3 (R Development Core Team 2013). Prior to analysis, data from each species were grouped by year and season, and the observed reporting rates (expressed as a percentage) were calculated for each season for each species. Seasons were grouped by December to February (summer), March to May (autumn), June to August (winter) and September to November (spring). These reporting rates showed high levels of variation from season to season (see Fig. 1a-e), so regression splines were employed to smooth this variation, and allow long term trends to be evaluated (Cunningham & Olsen 2009). The R package *fields* was used for the analysis (Fields Development Team 2006). Regression splines are very flexible, and the amount of smoothing that can be employed for any particular analysis can be specified. In this case, a high level of smoothing was used, in order to eliminate any seasonal variation, or other short term trends, and to highlight any long term trends (see Cunningham & Olsen 2009 for an in depth description of the use of regression splines for estimating species abundances). In addition, 95% confidence limits were calculated for the trend curves, along with the more conservative simultaneous Bonferroni bounds (Fields Develop-ment Team 2006), to indicate the precision of the trends observed. Next, a linear model was fitted to the data using the *MASS* statistical package (Venables & Ripley 2002), and the slope and standard deviation of reporting rates for each species was calculated. The initial regression splines indicated an apparent increase, then subsequent decrease in rifleman and robin reporting rates. As a result, we also fit a linear model to the data after dividing the dataset into 2 halves using the median date (*i.e.*, March 2002 to March 2006, April 2006 to March 2010). Although linear trends may give an indication of any long term changes in abundance of some bird species, due to the non-linear nature of the changes in abundance of many species, linear trends must be interpreted with caution.

RESULTS

From 2002 to 2010, the bellbird was the only species that showed strong evidence of increase (Fig. 1a; Table 1), while rifleman, South Island robin, and tomtit populations were stable (Fig. 1b & 1c; Table 1). In contrast, grey warblers showed a significant linear decrease in reporting rate (Fig. 1d & 1e; Table 1).

When we divided the study into 2 four-year periods (*i.e.*, the first 4 years from 2002, and the second 4 years from 2006), 4 of 5 species exhibited a greater increase in reporting rate during the first 4 years than the second 4 years of monitoring. Increases in 3 species (bellbird, rifleman, robin) during the first 4 years were significant and were followed by a stable reporting rate during the second 4 years (Table 1). In contrast, tomtits were stable during the first 4 years, then significantly decreased during the second 4 years (Table 1).

DISCUSSION

Response of endemic passerines to predator control in the Flora Valley
Of the 5 endemic passerines monitored in this study, only bellbirds showed strong evidence of increase during the control of stoats and possums over the entire study period, while the remaining passerines showed either weak evidence of change (robin, tomtit, rifleman) or strong evidence of decrease (grey warbler). Our results thus suggest that trapping of stoats and possums did not appear to successfully restore 4 of 5 endemic forest bird species over a period of 8 years. However, because predator trapping data over this period was inconsistently collected and thus not suitable for analysis, our results alone do not prove that observed change (or lack of change) in reporting rate of the 5 passerines were due to predator control. Nevertheless, we infer that predator control was a driver of our observed reporting rates introduced predators are the primary cause of bird declines in large tracks of forests in New Zealand (Elliott *et al.* 2010; Innes *et al.* 2010).

The initial increase we observed in all 5 bird species during the first 4 years of monitoring may have been the direct result of the control of stoats and possums. Native passerines in New Zealand are preyed on by stoats and compete with (and to a lesser extent are preyed on by) possums, and thus the removal of stoats and possums could have resulted in a direct, positive impact on bird populations (Moors 1983; Harper 2009). Similar to our results, Kelly *et al.* (2005) also described a significant increase in bellbird numbers during stoat trapping over 2 summers, due to a decrease in nest predation by stoats.

On the other hand, the relative decrease we observed in all 5 species during the latter 4 years of the survey could have been due to an indirect

Table 1. Estimates of linear slope based on reporting rates of 5 passerines between March 2002 and March 2010 at Flora Valley. A significant change in reporting rate ("Trend") refers to $P < 0.05$.

Species	Entire study period (2002-2010)			First 4 years (2002-2006)			Second 4 years (2006-2010)		
	Slope	*se*	Trend	Slope	*se*	Trend	Slope	*se*	Trend
Bellbird	0.00242	0.00077	Increase	0.00616	0.0021	Increase	-0.00166	0.0021	No change
Grey warbler	-0.00164	0.00051	Decrease	0.00046	0.00156	No change	-0.00207	0.0012	No change
Rifleman	0.00085	0.0067	No change	0.00704	0.0018	Increase	0.00065	0.00171	No change
Robin	0.0001	0.00035	No change	0.00319	0.00089	Increase	-0.00003	0.00096	No change
Tomtit	-0.00024	0.00055	No change	0.00175	0.00142	No change	-0.0036	0.00162	Decrease

increase in rat abundance following the removal of stoats and possums. Meso-predator release of rats has previously been observed following the control of stoats or possums in New Zealand (Sweetapple & Nugent 2007), and it is possible that meso-predator release occurred at Flora Valley as well, although robust predator abundance data was not available to confirm this hypothesis. Empirical and modelling studies at other sites in New Zealand suggest that rat populations begin to increase 2 to 3 years following stoat and/or possum control (Tompkins & Veltman 2006; Ruscoe *et al.* 2011), and thus the decline (or lesser increase) we observed in bird populations from 4 years after stoat and possum control at Flora Valley may have been due to an increase in rat populations and subsequent increase in nest predation. The impact of meso-predator release may have been slower to develop in the Flora Valley (from 4 years, compared to 2 to 3 years) due to the relatively low density of rats that naturally occurs in higher altitude forests (Christie *et al.* 2009). For example, Kelly *et al.* (2005) also did not observe meso-predator release of rats in beech forest habitat at a similar altitude (900 m a.s.l.) during the first 2 years of stoat control.

Alternative causes of the relative decreases we observed in all 5 species during the latter 4 years of the study may include disease or changes in climate, although these factors would likely have been secondary to predation. Avian malaria parasites have been detected in bellbirds in Kaikoura, ~150 km from our study site, although only 3% of individuals were infected (Baillie & Brunton 2011). Environmental stochasticity due to variation in mean winter temperature can also affect population dynamics of small songbirds (Sæther *et al.* 2000), but this is unlikely to be the case in New Zealand where the climate has not changed drastically over the past 50 to 100 years (Withers *et al.* 2009).

Considerations when selecting a bird survey technique

When considering methods for conducting bird surveys, it is important to initially define the objective of the study (Greenwood 2007). Initially, the primary objective for monitoring endemic birds in the Flora Valley was to determine whether predator control was having a beneficial effect on forest birds, particularly blue duck. Although it was initially believed that the presence-absence methodology would be suitable for all forest bird species, only passerines, not blue duck or other large bird species, were observed frequently enough to be analysed using the regression spline technique in our study (see Methods).

A secondary objective of bird monitoring at community-based projects is often to achieve social goals via the involvement of the community sector (Campbell-Hunt *et al.* 2010; Roche & Rolley 2011). Bird monitoring at restoration projects combines bird watching and contributions toward conservation, both of which are popular recreational activities and thus significant recruiting tools at community-based projects (Greenwood 2007; U. S. Deparment of the Interior *et al.* 2012). Bird monitoring also achieves social goals by inspiring and educating participants through the direct contact with endemic species (Innes *et al.* 2012). Furthermore, reporting trends in endemic bird populations will allow stakeholders to have tangible feedback of their contribution toward ecosystem restoration which increases the likelihood that observers will continue to participate in activities, as well as encourage advocacy and business partnership opportunities (Greenwood 2007; Campbell-Hunt *et al.* 2010).

The presence-absence survey technique was chosen to be used at Friends of Flora. Additional techniques used to monitor endemic bird populations in New Zealand that were also considered include the 5MBC (*e.g.*, Hartley 2012), as well as fixed-width strip transect counts(*e.g.* Westbrooke & Powlesland 2005) and line- and point- transect distance-sampling (*e.g.*, Cassey *et al.* 2007). For the remainder of this paper, we will compare the presence-absence method with the 5MBC method, which is the most commonly used bird survey technique in New Zealand (Hartley 2012).

Comparison between the presence-absence and 5MBC techniques

The 5MBC method was first described nearly 40 years ago by Dawson & Bull (1975) and has since been used in more than 260 different studies (Hartley 2012), including the examination of long-term population trends (*e.g.*, Smith & Westbrooke 2004; Elliott *et al.* 2010). This method has been shown to detect changes following management activities (*e.g.*, Spurr & Anderson 2004; Baber *et al.* 2009), and is the suggested technique for bird monitoring at community-based conservation projects in New Zealand (see www.sanctuariesnz.org).

The 5MBC and presence-absence techniques both require observers to monitor birds from pre-determined locations (Dawson & Bull 1975; see Methods), and are thus both susceptible to bias such as that between observers (Dawson *et al.* 1978). However, observer bias is less likely to occur during presence-absence surveys because no estimate of abundance is required. During presence-absence surveys, observers are only required to record the detection (or non-detection) of a species, in contrast to 5MBC during which the number of individuals observed is recorded (Hartley 2012; MacLeod *et al.* 2012). While the collection of these data provides additional robust measures of abundance, they may also result in observational errors because observers may be preoccupied with simultaneously collecting multiple types of data. Bias and errors can be reduced during training, but it may be difficult for each observer to undergo extensive training at community-based conservation projects where many different observers may participate.

Survey techniques that are straightforward are attractive to the community sector because they can be easily and quickly taught to inexperienced observers. Furthermore, many volunteers prefer simpler methods such as compiling lists of species, rather than recording the number of individuals recorded at each station (Bart & Klosiewski 1989), likely because volunteers could find recording more complex data to be tiresome (Greenwood 2007). At the Flora Valley, observers were principally involved with checking the predator traps and the bird monitoring was an additional task, and thus in this case, the use of a relatively simple bird monitoring technique could be more attractive to volunteers and ultimately result in a more sustainable initiative (Danielsen *et al.* 2003). As such, survey techniques used at community-based conservation projects are inherently different from those conducted by professional fieldworkers during ecological studies, which typically involve the collection of larger amounts of data which could be perceived as logistically and technically more difficult to collect.

Statistical considerations of the presence-absence technique

Although the presence-absence technique obtains fewer data and thus has less statistical power than the 5MBC method (Field *et al.* 2005), it is believed to be a good indicator of long-term changes in population size (Gaston 1994; Cunningham & Olsen 2009). The use of regression splines is an effective method to analyse long-term trends using presence-absence data (Cunningham & Olsen 2009). This technique accounts for intermediate time periods, compared to a linear regression which may over over-simplify the rate of change. However, the regression spline technique is limited by requiring an overall reporting rate of at least 3% for each species (Cunningham & Olsen 2009), and therefore large bird species (kākā [*Nestor meridionalis*], kākāriki [*Cyanoramphus*ssp.], weka [*Gallirallus australis*], falcon [*Falco novaeseelandiae*] and blue duck) were not analysed in this study. As a result, species-specific monitoring techniques (*e.g.*, river surveys for blue duck) may be necessary to monitor large bird species.

Overcoming potential shortfalls of the presence-absence technique

Sampling methods such as the presence-absence technique are often criticised because they assume equal detectability between datasets (Wilson & Bart 1985). For example, if the number of observations of a species differs between seasons, this variation could be assumed to be due to seasonality. However, other factors can affect detection probability such time of day (Farnsworth *et al.* 2002), habitat (Schieck 1997), conspecific density (Penteriani *et al.* 2002) and observer skill (Sauer *et al.* 1994).

To resolve potential biases, detection probability can be estimated using different techniques. For example, 2 observers can simultaneously collect data during each survey, and the probability that a bird is recorded given that it could be detected by at least 1 observer is modelled (Nichols *et al.* 2000). However, this technique requires an additional observer for each survey.

Another technique that could be used is to compare the observed indices with the true number of individuals in the study area, but this is often too costly and logistically unfeasible. We are aware of only 2 studies in New Zealand that compared indices to the true density of resident adults. Gill (1980) compared the true numbers of grey warblers and robins in Kowhai Bush to observed indices, and Greene & Pryde (2012) also did this for robins in Fiordland.

Ultimately, it is important to note that biases can also be accounted for by collecting data in a systematic and comprehensive manner regardless of the technique used. For example, the sequence of visiting sample points, or systematic switching of the sequence, as well as weather conditions and time of year during which the surveys are conducted can all be standardised. By ensuring that observers collect data using proper field techniques in a consistent manner, the resulting data collected is more likely to be valuable for determining population trends.

CONCLUSION

The use of the presence-absence technique to monitor changes in wildlife populations has recently increased (Marsh & Trenham 2008). Given its attractiveness and accessibility to the community sector, we believe this technique could be useful for determining long-term trends of passerine populations at community-based conservation projects, except in cases where managers want an overall quantitative assessment of the birdlife. We also acknowledge the importance of realising the benefits of the continued use of the 5MBC method in New Zealand, particularly when 5MBC monitoring schemes are already in place at the study site. When considering survey techniques to monitor bird populations, the comprehensiveness of the 5MBC method must be considered compared to the simplicity of the presence-absence method. Ultimately, consultation between key stakeholders, including conferring with on-the-ground observers who conduct pilot studies, is necessary when choosing a bird survey technique at community-based conservation projects.

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LITERATURE CITED

Agrawal, A.; Gibson, C.C. 1999. Enchantment and disenchantment: the role of community in natural resource conservation. *World Development 27*: 629-649.

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.

Baillie, S.M.; Brunton, D.H. 2011. Diversity, distribution and biogeographical origins of *Plasmodium* parasites from the New Zealand bellbird (*Anthornis melanura*). *Parasitology 138*: 1843-1851.

Bart, J.; Klosiewski, S.P. 1989. Use of presence-absence to measure changes in avian density. *Journal of Wildlife Management 53*: 847-852.

Basse, B.; McLennan, J.A.; Wake, G.C. 1999. Analysis of the impact of stoats, *Mustela erminea*, on northern brown kiwi, *Apteryx mantelli*, in New Zealand. *Wildlife Research 26*: 227-237.

Blackburn, T.M.; Cassey, P.; Duncan, R.P.; Evans, K.L.; Gaston, K.J. 2004. Avian extinction and mammalian introductions on oceanic islands. *Science 305*: 1955-1958.

Campbell-Hunt, D.M.; Freeman, C.; Dickinson, K.J.M. 2010. Community-based entrepreneurship and wildlife sanctuaries: case studies from New Zealand. *International Journal of Innovation and Regional Development 2*: 4-21.

Campbell, L.M.; Vainio-Mattila, A. 2003. Participatory development and community-based conservation: opportunities missed for lessons learned? *Human Ecology 31*: 417-437.

Cassey, P.; Craig, J.L.; McArdle, B.H.; Barraclough, R.K. 2007. Distance sampling techniques compared for a New Zealand endemic passerine (*Philesturnus carunculatus rufusater*). *New Zealand Journal of Ecology 31*: 223-231.

Christie, J.E.; Brown, D.J.; Westbrooke, I.; Murphy, E.C. 2009. Environmental predictors of stoat (*Mustela erminea*) and ship rat (*Rattus rattus*) capture success. *DOC Research & Development Series 305*: Wellington: Department of Conservation. 27 p.

Clewell, A.F.; Aronson, J. 2006. Motivations for the restoration of ecosystems. *Conservation Biology 20*: 420-428.

Cohn, J.P. 2008. Citizen science: can volunteers do real research? *BioScience 58*: 192-197.

Cunningham, R.; Olsen, P. 2009. A statistical methodology for tracking long-term change in reporting rates of birds from volunteer-collected presence–absence data. *Biodiversity and Conservation 18*: 1305-1327.

Danielsen, F.; Mendoza, M.M.; Alviola, P.; Balete, D.S.; Enghoff, M.; Poulsen, M.K.; Jensen, A.E. 2003. Biodiversity monitoring in developing countries: what are we trying to achieve? *Oryx 37*: 407-409.

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

Dawson, D.G.; Dilks, P.J.; Gaze, P.D.; McBurney, J.G.R.; Wilson, P.R. 1978. Seasonal differences in bird counts in forests near Reefton, South Island, New Zealand. *Notornis 25*: 257-278.

Dearden, P.; Bennett, M.; Johnston, J. 2005. Trends in global protected area governance, 1992–2002. *Environmental Management 36*: 89-100.

Duncan, R.P.; Blackburn, T.M. 2004. Extinction and endemism in the New Zealand avifauna. *Global Ecology and Biogeography 13*: 509-517.

Elliott, G.P.; Wilson, P.R.; Taylor, R.H.; Beggs, J.R. 2010. Declines in common, widespread native birds in a mature temperate forest. *Biological Conservation 143*: 2119-2126.

Farnsworth, G.L.; Pollock, K.H.; Nichols, J.D.; Simons, T.R.; Hines, J.E.; Sauer, J.R. 2002. A removal model for estimating detection probabilities from point-count surveys. *Auk 119*: 414-425.

Field, S.A.; Tyre, A.J.; Possingham, H.P. 2005. Optimizing allocation of monitoring effort under economic and observational constraints. *Journal of Wildlife Management 69*: 473-482.

Fields Development Team 2006. Tools for spatial data. Boulder, CO: National Center for Atmospheric Research.

Forgie, V.; Horsley, P.; Johnston, J. 2001. Facilitating community-based conservation initiatives. *Science for Conservation 169*: Department of Conservation, Wellington.

Gaston, K.J. 1994. *Rarity*. London, Chapman & Hall.

Gill, B.J. 1980. Abundance, feeding, and morphology of passerine birds at Kowhai Bush, Kaikoura, New Zealand. *New Zealand Journal of Zoology 7*: 235-246.

Greene, T.C.; Pryde, M.A. 2012. Three population estimation methods compared for a known South Island robin population in Fiordland, New Zealand. *New Zealand Journal of Ecology 36*: 340-352.

Greenwood, J.J.D. 2007. Citizens, science and bird conservation. *Journal of Ornithology 148*: 77-124.

Harper, G.A. 2009. The native forest birds of Stewart Island/Rakiura: patterns of recent declines and extinctions. *Notornis 56*: 63-81.

Hartley, L.J. 2012. Five-minute bird counts in New Zealand. *New Zealand Journal of Ecology 36*: 268-278.

Holdaway, R.N.; Worthy, T.H.; Tennyson, A.J.D. 2001. A working list of breeding bird species of the New Zealand region at first human contact. *New Zealand Journal of Zoology 28*: 119-187.

Innes, J.; Nugent, G.; Prime, K.; Spurr, E.B. 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.; Kelly, D.; Overton, J.M.; Gillies, C. 2010. Predation and other factors currently limiting New Zealand forest birds. *New Zealand Journal of Ecology 34*: 86-114.

Innes, J.; Hay, R.; Flux, I.; Bradfield, P.; Speed, H.; Jansen, P. 1999. Successful recovery of North Island kokako *Callaeas cinerea wilsoni* populations, by adaptive management. *Biological Conservation 87*: 201-214.

Innes, J.; Lee, W.G.; Burns, B.; Campbell-Hunt, C.; Watts, C.; Phipps, H.; Stephens, T. 2012. Role of predator-proof fences in restoring New Zealand's biodiversity: a response to Scofield *et al*. (2011). *New Zealand Journal of Ecology 36*: 232-238.

Kelly, D.; Brindle, C.; Ladley, J.J.; Robertson, A.J.; Maddigan, F.W.; Butler, J.; Ward-Smith, T.; Murphy, D.J.; Sessions, L.A. 2005. Can stoat (*Mustela erminea*) trapping increase bellbird (*Anthornis melanura*) populations and benefit mistletoe (*Peraxilla tetrapetala*) pollination? *New Zealand Journal of Ecology 29*: 69-82.

Kendall, W.L.; Peterjohn, B.G.; Sauer, J.R. 1996. First-time observer effects in the North American Breeding Bird Survey. *Auk 113*: 823-829.

King, C.M.; Moody, J.E. 1982. The biology of the stoat (*Mustela erminea*) in the National Parks of New Zealand II. Food habits. *New Zealand Journal of Zoology 9*: 57-80.

MacLeod, C.J.; Greene, T.C.; MacKenzie, D.I.; Allen, R.B. 2012. Monitoring widespread and common bird species on New Zealand's conservation lands: a pilot study. *New Zealand Journal of Ecology 36*: 300-311.

Marsh, D.M.; Trenham, P.C. 2008. Current trends in plant and animal population monitoring. *Conservation Biology 22*: 647-655.

Moorhouse, R.; Greene, T.; Dilks, P.; Powlesland, R.; Moran, L.; Taylor, G.; Jones, A.; Knegtmans, J.; Wills, D.; Pryde, M.; Fraser, I.; August, A.; August, C. 2003. Control of introduced mammalian predators improves kaka *Nestor meridionalis* breeding success: reversing the decline of a threatened New Zealand parrot. *Biological Conservation 110*: 33-44.

Moors, P.J. 1983. Predation by mustelids and rodents on the eggs and chicks of native and introduced birds in Kowhai Bush, New Zealand. *Ibis 125*: 137-154.

Nichols, J.D.; Hines, J.E.; Sauer, J.R.; Fallon, F.W.; Fallon, J.E.; Heglund, P.J. 2000. A double-observer approach for estimating detection probability and abundance from point counts. *Auk 117*: 393-408.

O'Donnell, C.F.J.; Hoare, J.M. 2012. Quantifying the benefits of long-term integrated pest control for forest bird populations in a New Zealand temperate rainforest. *New Zealand Journal of Ecology 36*: 131-140.

Parkes, J.; Murphy, E. 2003. Management of introduced mammals in New Zealand. *New Zealand Journal of Zoology 30*: 335-359.

Penteriani, V.; Gallardo, M.; Cazassus, H. 2002. Conspecific density biases passive auditory surveys. *Journal of Field Ornithology 73*: 387-391.

R Development Core Team 2013. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.

Remeš, V.; Matysioková, B.; Cockburn, A. 2012. Nest predation in New Zealand songbirds: exotic predators, introduced prey and long-term changes in predation risk. *Biological Conservation 148*: 54-60.

Ritchie, E.G.; Johnson, C.N. 2009. Predator interactions, mesopredator release and biodiversity conservation. *Ecology Letters 12*: 982-998.

Roche, M.; Rolley, C. 2011. Workplace wellbeing on Maungataturi Mountain: the connection between ecological restoration and workplace happiness. *Journal of Applied Business Research 27*: 115-126.

Ruscoe, W.A.; Ramsey, D.S.L.; Pech, R.P.; Sweetapple, P.J.; Yockney, I.; Barron, M.C.; Perry, M.; Nugent, G.; Carran, R.; Warne, R.; Brausch, C.; Duncan, R.P. 2011. Unexpected consequences of control: competitive vs. predator release in a four-species assemblage of invasive mammals. *Ecology Letters 14*: 1035-1042.

Sæther, B.E.; Tufto, J.; Engen, S.; Jerstad, K.; Røstad, O.W.; Skåtan, J.E. 2000. Population dynamical consequences of climate change for a small temperate songbird. *Science 287*: 854-856.

Sauer, J.R.; Peterjohn, B.G.; Link, W.A. 1994. Observer differences in the North American Breeding Bird Survey. *Auk 111*: 50-62.

Schieck, J. 1997. Biased detection of bird vocalizations affects comparisons of bird abundance among forested habitats. *Condor 99*: 179-190.

Shukla, S.R.; Sinclair, A.J. 2010. Strategies for self-organization: learning from a village-level community-based conservation initiative in India. *Human Ecology 38*: 205-215.

Silvertown, J. 2009. A new dawn for citizen science. *Trends in Ecology & Evolution 24*: 467-471.

Smith, A.N.H.; Westbrooke, I.M. 2004. Changes in bird conspicuousness at Pureora Forest. *Notornis 51*: 21-25.

Spurr, E.B.; Anderson, S.H. 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.

Starling-Windhof, A.; Massaro, M.; Briskie, J.V. 2011. Differential effects of exotic predator-control on nest success of native and introduced birds in New Zealand. *Biological Invasions 13*: 1021-1028.

Sweetapple, P.J.; Nugent, D.S.L. 2007. Ship rat demography and diet following possum control in a mixed podocarp–hardwood forest. *New Zealand Journal of Experimental Agriculture 31*: 186-201.

Tompkins, D.M.; Veltman, C.J. 2006. Unexpected consequences of vertebrate pest control: predictions from a four-species community model. *Ecological Applications 16*: 1050-1061.

Towns, D.R.; Atkinson, I.A.E.; Daugherty, C.H. 2006. Have the harmful effects of introduced rats on islands been exaggerated? *Biological Invasions 8*: 863-891.

U. S. Deparment of the Interior; U. S. Fish and Wildlife Service; U. S. Department of Commerce; U. S. Census Bureau 2012. 2011 National survey of fishing, hunting, and wildlife-associated recreation.

Venables, W.N.; Ripley, B.D. 2002. *Modern Applied Statistics with S*. 4th ed. New York: Springer.

Warburton, B.; Poutu, N.; Peters, D.; Waddington, P. 2008. Traps for killing stoats (*Mustela erminea*): improving welfare performance. *Animal Welfare 17*: 111-116.

Westbrooke, I.M.; Powlesland, R.G. 2005. Comparison of impact between carrot and cereal 1080 baits on tomtits (*Petroica macrocephala*). *New Zealand Journal of Ecology 29*: 143-147.

Western, D.; Wright, R.M. 1994. The background to community-based conservation. pp. 1-12. *In:* Western, D.; Wright, R.M. (*ed.*) *Natural connections: perspectives in community-based conservation*. Washington, D.C.: Island Press.

Whitehead, A.L.; Edge, K.-A.; Smart, A.F.; Hill, G.S.; Willans, M.J. 2008. Large scale predator control improves the productivity of a rare New Zealand riverine duck. *Biological Conservation 141*: 2784-2794.

Wilson, D.M.; Bart, J. 1985. Reliability of singing bird surveys: effects of song phenology during the breeding season. *Condor 87*: 69-73.

Withers, C.S.; Krouse, D.P.; Pearson, C.P.; Nadarajah, S. 2009. Modelling temperature trends in New Zealand. *Environmental Modeling & Assessment 14*: 231-249.