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Five-minute bird counts in New Zealand

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Abstract: The five-minute bird count (5MBC) method was developed in New Zealand in the early 1970s by the DSIR for monitoring forest birds. The method has been undertaken consistently for nearly 40 years leading to a large resource of counts (over 200 000). These counts are valuable as they often provide our only historical baseline measure of multi-species bird populations in New Zealand forests. Over 120 000 counts are held in the 5MBC database. The method was used between 1973 and 1992 by the DSIR, NZ Wildlife Service and NZ Forest Service to investigate important ecological questions such as which forests are important for which bird species, and whether pest control operations affect bird populations. The method played a role in persuading the government to cease all logging of native forests on public land in New Zealand in 2002. Reviewing 5MBC studies suggests a number of features of the method that should be considered when designing a study including that (1) it is an index not a census method, (2) observer, species behaviour, weather and season can all affect the number of birds detected, (3) counts are habitat- species- and probably year- specific preventing inter-species comparisons, and comparisons of species numbers at different sites if the counts were undertaken in different years. The method is suitable for investigating long term trends but there is likely to be considerable annual variability and a pilot study should be undertaken to investigate the number of counts needed to detect the difference of interest (i.e. power). The Department of Conservation website includes pages that provide resources for counters including standard data recording sheets. At present counters cannot enter their data into the 5MBC database and there is a risk that data from counts will continue to be lost.

Keywords: database; forest; index method; indices of abundance; monitoring; point count

Introduction

The five-minute bird count (5MBC) method, as described in Dawson & Bull (1975), has been the standard method for counting forest birds in New Zealand since the early 1970s. The method involves an observer, who is stationary at a single point, counting every bird of every species that they see or hear over a period of exactly 5 min. The method was developed and fully described by the then Ecology Division of the Department of Scientific and Industrial Research (DSIR) to provide an efficient index of numbers of birds in New Zealand forests, 'accurate enough to detect major differences in abundance' (Dawson & Bull 1975). It has now been used for nearly 40 years, and over 200 000 counts have been made across more than 260 studies. Here I describe both the development of the method and its history of use up until 1992, including use by three government agencies: the DSIR, the New Zealand Forest Service, and the New Zealand Wildlife Service (initially known as the Wildlife Branch) of the Department of Internal Affairs. I also describe the Five-Minute Bird Count Database (5MBC Database), recently developed by the New Zealand Department of Conservation (DOC) to preserve these datasets.

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The 5MBC method allowed quantitative information to be collected on multi-species bird populations consistently for the first time in forest. These datasets are, therefore, historically and nationally important as they are often the only baseline measures we have of bird numbers and the only data available for investigating long-term trends (e.g. Smith & Westbrooke 2004).

The 5MBC method has been the subject of much unpublished debate in New Zealand and this account is, therefore, restricted to a description of studies that took place, the rationale for developing and using the method at the time, and a discussion on what has been learnt. The material for this paper was obtained by reviewing the published literature, unpublished reports, and count data from the 5MBC Database. There were also discussions with Dave Dawson, Eric Spurr and Malcolm Harrison who were previously employed by the DSIR, Forest Service and Wildlife Service respectively. Studies after 1992, the year by which all three organisations had been disbanded, are not included in this account as information about these studies (many of which are unpublished) is very scattered.

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Origins of the five-minute bird count method

In 1971, the New Zealand Government announced the 'South Island Beech Utilisation Project' (New Zealand Forest Service 1971). The project proposed large-scale milling of lowland beech and beech-podocarp forests in Nelson, Southland and the West Coast and the setting up of biological reserves that would remain unlogged (15% of the proposed 400 000 ha). To advise on the best locations for these reserves, both the DSIR and the Wildlife Service identified the need for a method to count native birds in forest to investigate (1) which forests and forest-types were richest in bird species and preferred by key species, (2) whether birds' use of forests changed seasonally, and (3) the size and nature of forest areas needed to provide an adequate network of reserves. There was no obvious nationally, or internationally, recognised method that was suitable. International literature at the time referred to bird 'census' techniques, using the term to refer to any quantitative study of bird numbers (Dawson pers. comm.). There was a large number of plot- and transect-based methods, including a new distance sampling method (Emlen 1971), but few standards and little agreement (Dawson & Bull 1975). Dawson and Bull (1975) reviewed early quantitative work in New Zealand, which started with Turbott's (1940) study on Taranga Island, finding that 'three basic counting techniques have been used though the details of each have varied. Breeding pairs have been counted on plots of known size; transect counts have been made while walking; and birds have been recorded in terms of their frequency of occurrence during some stated interval'. The latter included a five-minute stationary count (Dawson 1964). Dawson and Bull recognised the distinction between methods that 'by mapping territories and nest sites, sought to establish the actual numbers of breeding birds' and methods that 'by some sampling procedure, sought merely an index of numbers'.

Method development and use at the DSIR

Dawson and Bull describe their reasons for favouring an index method, and the DSIR trialled three methods in February 1973 (Dawson & Bull 1975): (1) walking counts at about 0.8 km per hour, recording every bird seen and heard – sub-totalled every 15 min (approx. 200 m), (2) five-minute stationary counts at points 200 m apart (the 5MBC method), and (3) ten-minute stationary counts at points 200 m apart. In the analysis conducted, all three methods agreed closely with each other and the variances did not differ significantly. The counters preferred stationary counts as they could pay undivided attention to the birds, while 5 min allowed more forest to be sampled in a given time than 10 min and had less chance of erroneously recording the same individual bird twice. The authors concluded that five-minute stationary counts were the most practical and efficient method trialled. The resulting paper described the method in sufficient detail for it to be repeated, provided sample data-recording forms, and listed factors that could affect the number of birds recorded including observer ability, bird activity, topography and density of vegetation.

The first application of the 5MBC method to a practical question was in 1974–1975, when it was used to document the broad habitat preferences and seasonal distribution of bird species in four different forests representing different proposed levels of logging under the Beech Utilisation Project (Dawson et al. 1978). The study design also allowed examination of the various factors influencing the numbers counted. Counts (480 in total) were made in each of the study areas at 2-month

intervals, and the authors concluded this was sufficient to identify differences in counts in different habitats for 19 of the most widespread species. Most species were more prevalent in the forest type that was most actively targeted for logging and a proportion of the population of many species moved seasonally between forest types (both conclusions had implications for reserve design). Observer bias was identified, particularly for tomtit (*Petroica macrocephala*), chaffinch (*Fringilla coelebs*) and song thrush (*Turdus philomelos*), for which differences between observers were found to be greater than differences between areas.

The second DSIR application of the 5MBC method was in a long-term study initiated in 1974 at Mount Misery (Nelson Lakes, New Zealand), to better understand beech forest ecosystems (Elliott et al. 2010). Counting stations were placed along a transect spanning the full range of altitudes up to the treeline. This study became one of the longest running 5MBC datasets in New Zealand with 5355 counts conducted between 1974 and 1984. The same stations were adopted by DOC from 2002 onwards as the non-treatment area for the Rotoiti Nature Recovery Project (1229 counts as at January 2011). These two datasets have been reanalysed recently (Elliott et al. 2010). The authors considered confounding factors such as differences in observers between the two periods and potential differences in habitat structure, but concluded the changes in bird numbers observed reflect actual population changes.

A third application of the 5MBC method by the DSIR was a 3-year study initiated in 1975 looking at the importance of lowland forest in the Beech Utilisation Area for birds and, in particular, whether the forest had essential resources that were needed seasonally (Wilson et al. 1988). The results again suggested that many species move seasonally and reserve design needed to consider the welfare of wide-ranging species such as tūi (*Prosthemadera novaeseelandiae*), bellbird (*Anthornis melanura*), New Zealand pigeon (kererū, *Hemiphaga novaeseelandiae*) and kākā (*Nestor meridionalis*), as well as resident species.

The 5MBC method was also employed by the DSIR to investigate the impact of introduced predators on native bird populations (Wilson 1988; Efford & Morrison 1991). Efford and Morrison (1991) counted at intervals of 2–3 weeks over three years (1977–1979) in sites with and without stoat (*Mustela erminea*) trapping, finding higher counts of several species in the trapped areas. The authors concluded, however, that careful study design is needed in order to rule out observed differences in counts being due to unrelated factors such as habitat difference between sites or irregular fluctuations in bird populations. The data were also analysed for monthly correlations with a concurrent study by a University of Canterbury student at Kowhai Bush, Kaikoura (Gill 1980), but low (or even negative) correlations were found with 8 of the 10 species examined. These comparisons, and the year-to-year variation observed by Efford and Morrison, showed that it is not possible to apply simple adjustments to allow comparison of 5MBCs made in different months as had been proposed by Dawson et al. (1978). Abrupt changes in numbers were found to occur within 1- to 2-month periods, suggesting that counts at longer intervals may not adequately describe seasonal patterns. Wilson (1988), also looking at the effect of stoat control (this time on islands), undertook counts quarterly for a year (960 in total) at trapped and untrapped locations. The counts of one species (bellbird) increased but the counts of four species unexpectedly decreased. The author did not differentiate between the possibility that (1) bird numbers

Organisation and study location	Number of Counts	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Private cont.																					
Little Wanganui, Karamaea	81										■										
Tuku Reserve, Chathams	150											■									
North Okarito	2300														■						
Auckland Domain	195															■					
Rowallan, Southland	100																■				
Korokoro, Wellington	175																	■	■		
Ornithological Society																					
Kapiti Island	600			■	■	■	■					■	■	■							
Banks Peninsula	29				■																
Tiritiri Matangi	500																				
Mana Island	3936																				
Botanic Gardens, Wellington	506																				
DOC																					
Matemateonga District	40																				
Hawdon, Arthur's Pass	484																				
Chathams	446																				
Windbag Valley, Westland	615																				
Boundary Stream	320																				
Pohangina, Ruahines	500																				
Eglinton, Fiordland	560																				
Lands and Survey																					
Secretary Island, Fiordland	70																				
Egmont	2000																				

Method development and use at the New Zealand Wildlife Service

After the 1971 Beech Utilisation Project announcement the Wildlife Service was asked to investigate the suitability of the proposed reserves in the Beach Project Area, specifically whether the proposed locations would allow representative populations of the existing birdlife to survive. The service already had considerable experience with studying specific native species and had experimented with a stationary-count method lasting 5 minutes to investigate general forest birds in 1971 (Moynihan et al. 1979). It trialled Dawson and Bull's about-to-be-published method with initial practice counts carried out on Little Barrier Island (Crook & Best 1973), Kapiti Island and Rotoehu Forest in the North Island. The data and survey sheets from the Kapiti Island trial have survived, making this the first 5MBC using the Dawson & Bull (1975) method for which the raw data still exist.

A set of systematic surveys was then undertaken between 1974 and 1976 in the Beech Utilisation Area starting with 'pilot surveys' in 11 blocks in mainly unlogged forests, in five main regions around Westport and Reefton (Crook & Best 1974). Counts were made at stations at 500-yard (475 m) intervals on a grid pattern based on the 1000-yard squares of the then-standard NZMS 1 topographic maps, allowing multiple points to be counted within each forest while ensuring systematic coverage. The intention was to detect major differences in counts between forests (Crook et al. 1977). The Wildlife Service then used this design to survey the lowland forests in the West Coast Beech Utilisation area over 3 years visiting new forests each year (Crook & Best 1975; Best & Harrison 1976; Crook et al. 1977). These surveys revealed that beech forests, contrary to their popular image as rather uniform and relatively lifeless, were a 'rich mosaic'

of distinctly different habitats with bird species distributed unevenly. The forests were richer in birds than was previously believed and Crook and Best (1974) expressed concern that some of the areas already committed to utilisation, such as Hochstetter State Forest, had higher counts than the reserves of Little Barrier and Kapiti Islands. Counts were undertaken yearly for all 3 years in one forest and the relative abundance of species appeared to change between years (Crook et al. 1977), indicating that it is not possible to reliably compare sites with counts undertaken in different years.

In 1976 the Wildlife Service started surveys in the Western Southland forests, which were also part of Beech Utilisation proposals (Best & Ogle 1979). Large differences in counts were found between the eight blocks examined and these differences were greater than between the Southland forests and those on the West Coast. In 1979–1980 the Wildlife Service returned to eastern Southland and Otago to carry out counts in all large areas of forest (>1500 ha) as part of a detailed wildlife and habitat survey (Coker 1980). Surveys were also undertaken in South Westland in 1977–1978 (Coker & Imboden 1980) and again in 1983 (O'Donnell & Dilks 1986), with the latter counts suggesting good populations of several threatened species.

While the North Island state forests were not part of the Beech Utilisation Project, many were either being logged or designated for logging. Hence the Wildlife Service undertook 17 surveys (11193 counts) using 5MBC methodology in these areas between 1974 and 1980. Recommendations from these surveys resulted in the setting aside of protected areas (e.g. the 1225-ha Mokaihaha Ecological area). The largest North Island study (during the period reviewed) was from 1978 to 1981 (6367 counts), but Harrison and Saunders (1981) found little difference between the selectively logged and unlogged areas examined. They did note, however, that the precision achieved

with 5MBCs in this study was greater than expected; while the researchers expected to be able to detect a 30% difference in only three or four species, in reality they were able to detect a 30% difference for at least 11 of the 15 species analysed, and a considerably smaller difference (<10%) for several species. As with previous studies, analysis also showed there were differences between the main observer and the occasional observer, and Harrison and Saunders (1981) suggested that tūi, bellbirds and rifleman *Acanthisitta chloris* could all be problematic for counters. Temperature and the Dawson & Bull (1975) category 'other noise' (i.e. noise other than that associated with wind and rain) were found to have a small effect, with noise varying from species to species and the direction of the temperature effect differing between species. This dataset was reanalysed by Smith and Westbrooke (2004) comparing the counts from 1978–1981 with a set from 1997–1998 at a comparable, but not the same, site. The counts of four out of five native insectivorous species decreased significantly with bellbirds also showing a large significant decrease. The authors were concerned by the apparent drop in numbers and suggested further study was needed to clarify whether the differences observed were actual differences and if the same declines had happened elsewhere. They suggest it is better to revisit the original count stations when repeating counts from earlier time periods to obtain more consistent data and allow more powerful analysis.

The Wildlife Service undertook many other 5MBC studies throughout New Zealand up to 1987 when it was disbanded. A total of 19007 counts are recorded across 35 studies (Table 1). This was the first time any organisation had systematically attempted to study multi-species bird populations over large areas in New Zealand and it has not been attempted since. The Service used 5MBC data to report on broad patterns of relative abundance of birds in forests and its conclusions and recommendations contributed to the intense public debate at the time over whether logging of native forests should continue. The Service believed a systematic and consistent approach using the 5MBC method meant its conclusions were reliable and defensible (M. Harrison pers. comm.). The reports contributed to the establishment of new reserves such as wildlife corridors in North Westland (New Zealand Wildlife Service 1986) and influenced government policy (e.g. Joint Campaign on Native Forests 1986). The Wildlife Service's studies, using the 5MBC method, contributed to the process that, ultimately, resulted in all logging on public land in New Zealand being stopped in March 2002.

Method development and use at the New Zealand Forest Service

The Forest Service first used the 5MBC method in a small study in 1975, investigating bird populations relative to vegetation features (Wilkinson & Guest 1977). Then, in 1976 and 1977, large numbers of a wide range of birds, including native species, were found dead after several aerial 1080-poisoning operations and research trials for brushtail possum (*Trichosurus vulpecula*) control in the central North Island (Spurr 1981, 1991, 1994). This led to the implementation of the 5MBC method in a BACI (Before-After Control-Impact) study design to assess the impacts of 1080-poisoning on bird populations, i.e. counts were made before and after 1080-poisoning in both poison and non-poison areas. In order to overcome diurnal, seasonal, and climatic biases, counts were made in the paired areas (poison and non-poison) at the same time on the same days (using two or more observers), and to overcome observer

bias, observers were switched between areas on subsequent days so that they counted an equal number of times in each area (Spurr 1981). Using this approach to monitor a series of 1080-poisoning operations and trials between 1977 and 1986, researchers concluded that there was no evidence of deleterious long-term impacts on populations of any non-target bird species from 1080-poisoning for possum control that was adequately monitored (Spurr 1981, 1989, 1991, 1994, 2000; Warren 1984; Calder & Deuss 1985). However, the limited detail in these reports makes it difficult to determine the degree of certainty associated with these results.

The above reports and conclusions were considered, along with other evidence, in two government advisory reviews, both of which concluded that the risks of using 1080 were acceptable in relation to the benefits (Parliamentary Commissioner for the Environment 1994; Environmental Risk Management Authority 2007).

Between 1978 and 1985 the 5MBC method was employed by the Forest Service in several studies investigating seasonal and annual changes in bird populations. One of these studies, at Craigieburn Forest from April 1978 to December 1982, is New Zealand's largest 5MBC study in terms of the number of counts (9547). However, as with many Forest Service 5MBC studies, it has yet to be written up. A second study, in the Blue Mountains, counting in four seasons for 2 years (1983–1985), is the largest study in terms of counts (5282) undertaken by a single observer (Foord 1987). The 5MBC method was also used in a BACI design during 1979–1982, to monitor impacts of other pest control methods on bird populations. One, on Stewart Island from 1979 to 1982, assessed the non-target impacts of 1080-gel used for control of white-tailed deer (*Odocoileus virginianus*) (New Zealand Forest Service 1982, 1983). In addition to daytime counts, counts were also made at night for nocturnal species (Stewart Island kiwi *Apteryx australis lawryi* and morepork *Ninox novaeseelandiae*); this is the only known example of five-minute counts being made at night.

Other notable uses of the 5MBC method by the Forest Service, between 1981 and 1987, included assessing the impacts on bird populations of coupe-logging where the forest was logged in blocks and allowed to regenerate naturally on a 120-year rotation (Spurr 1987). Spurr reported that the populations of some species (yellow-crowned parakeet *Cyanoramphus auricaps*, New Zealand pigeon, kākā, rifleman, and yellowhead *Mohoua ochrocephala*) were substantially adversely affected by the logging, with considerably lower counts in the forest logged 1 year previously than in unlogged forest, fewer still in the forest logged 5 years previously, and fewer again in the forest logged 15 and 25 years previously (Spurr 1987). Only silvereye (*Zosterops lateralis*) and seven introduced species had higher counts in the logged areas. Two species, bellbird and tūi, had similar counts in all logged stands regardless of age, and Spurr (1987) concluded this lack of differentiation was probably a consequence of not applying the 200-m cut-off rule prescribed in Dawson & Bull (1975); calls of these two species carry a long way and calls from surrounding unlogged forest could have been recorded as coming from within logged forest. Similarly, Spurr et al. (1992) used the method to assess the seasonal abundance of birds in small podocarp forest patches undergoing logging, but noted that the 5MBC method was not useful in estimating bird abundance in such patches because birds that were heard, and not seen, could not be accurately allocated to small units of forest.

The Forest Service, through its research branch the Forest Research Institute, was the most prolific bird-counting organisation in the country to date, undertaking 30 studies

between 1977 and 1992 amounting to over 70708 counts (Table 1). The Service was disbanded in 1992.

Method development and use at other organisations

Universities, private individuals, the Ornithological Society of New Zealand, and others undertook studies using the 5MBC method between 1975 and 1992. University researchers adopted the Dawson & Bull (1975) method shortly after it was published, using it to investigate bird diversity in relation to habitat structure (e.g. Dodgshun 1976), recolonisation of regenerated beech forest by birds (e.g. Willoughby 1976) and the seasonal use of different forest habitats (e.g. Gill 1980). Other notable studies included a large study (2865 counts) on the Mamaku Plateau (Taylor 1985), and Moffat and Minot's (1994) 3-year study looking at the relationships between forest structure and avian communities. Moffat and Minot used a variant on the 5MBC method introducing a 'near/far' split to permit binomial distance sampling (Buckland 1987), which they used to derive indices of relative abundance. They concluded the near/far ratio was very useful in assessing the distribution of common bird species but was inadequate for rarer species.

Developing the 5MBC Database

Developing and populating the 5MBC Database cost over \$200,000 and took more than 3 years, with one full-time and numerous part-time DOC staff. As the first step, a list of New

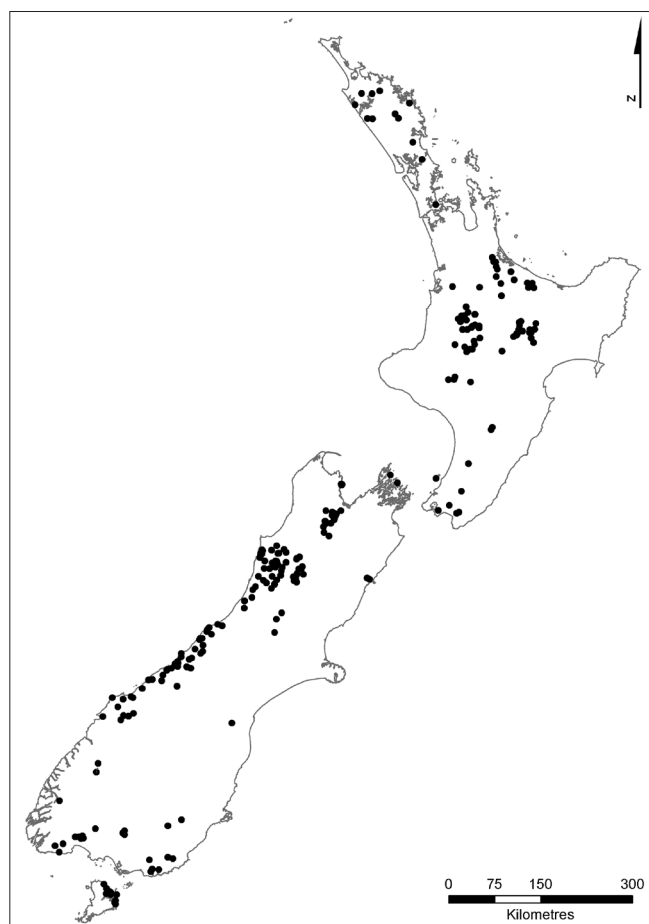


Figure 1. Map of New Zealand showing the locations of the 5MBC studies held in the 5MBC Database.

Zealand studies that followed the Dawson & Bull (1975) 5MBC method was collated. Metadata including the names of researchers, details of the study and the location and form of the data were collated for 266 studies amounting to over 200400 counts. A database was then developed, and priority given to securing and entering the older (pre-1987) and larger 5MBC datasets. These sets had become inaccessible and vulnerable to loss, due to changes in both government organisations and storage technologies over time.

The 5MBC Database currently holds over 120000 counts from 75 studies (Figure 1; Department of Conservation 2011). This equates to over 14 years of full-time bird counting (assuming 15 min per count, 8 h per day, 5 days a week and 52 weeks per year). At least another 19 studies (representing a minimum of 86504 counts) are known to exist but are not in the database. Approximately 33% of the 266 identified studies were found to be published or otherwise accessible, another 27% were written up in internal reports of variable quality and accessibility, while the remainder were either not written up or difficult to find. The raw data from 84% of the studies are still stored somewhere but the rest are either lost (11%; > 18 500 counts) or their status is unknown (5%; Table 2). Irreplaceable, older data are particularly vulnerable, and more datasets would have continued to be lost over time if the database had not been developed. For poorly-documented studies, important metadata could not be found, including information about the exact method used in the field, the locations of the stations, and the reason for the study.

The 5MBC Database, designed in Microsoft Access, stores three levels of information about each study: (1) level one is metadata about the study including where and why it was undertaken and by whom; (2) level two has information about the specific locations of each count, i.e. station details such as height above sea level and grid reference; and (3) level three contains the data recorded during each count including the observer identity, the time and date, the number of birds, their species, whether they were seen or heard, and auxiliary information about the weather during the count. Not all information is known for all studies. As slightly different auxiliary information was collected by different researchers historically, the database does not restrict the form in which this data can be entered (e.g. numbers or letters) but allows the units or scale (and any associated category definitions) to be specified in level one. Weather, for example, was often recorded using a numerical scale (from 1 to 5) or codes (such as *r* for rain, *s* for snow, etc.) and this information can be recorded for each study.

All researchers who were approached were willing to have their datasets entered and stored in the database. However, some were reluctant to make their data publicly available until their studies are written up and permission is required from the owners of these sets before they can be released. I suggest the

Table 2. Percentage of 5MBC studies for which the raw datasets are lost, not lost, or of unknown status (1964–2006).

Years	Lost (%)	Not lost (%)	Unknown (%)
1964–1976	22	68	10
1977–1986	24	72	4
1987–1996	4	88	8
1997–2006	1	98	1

status of such access restricted datasets is reviewed regularly as these data were collected with public money, some over 20 years ago, and are nationally important.

Discussion

Proposed changes to the method

Five-minute bird counters have remained remarkably faithful to the original Dawson & Bull (1975) 5MBC method. However, one change that was made almost immediately was the abandonment of the recommended 200-m cut-off beyond which birds are not recorded; counters found it difficult to estimate 200 m in forest and it became routine to include all birds regardless of distance from the observer. Ninety percent of the known datasets are of this form (i.e. unbounded). Removing the cut-off, however, introduced other problems for species that can be heard at great distances such as bellbird and tūī (e.g. Spurr 1987; Spurr et al. 1992). Researchers have subsequently, and independently, made up their own rules on whether and how they record very distant birds.

There is considerable interest in replacing Dawson and Bull's (1975) categories of seen and heard by a near/far split at a chosen break point. Both Dave Dawson (pers. comm.) and the author support this change as seen/heard has rarely been analysed, the task of determining and recording two distance categories seems comparable to the seen/heard category that is being replaced, and two categories would enhance the options for analysis (e.g. Moffat & Minot 1994) while preserving comparability with the large body of historical data. DOC is currently trialling a new 5-minute bird count method for the national Tier 1 Inventory and Monitoring programme which has three distance categories <25 m, ≤100 m and >100 m (MacLeod et al. 2012). The rationale is that the >100 m category replaces the original 200 m cut off and allows distant birds to be removed during the analysis, and the 25 m break replaces the original seen/heard split. It remains to be seen whether this new method is practical and whether it results in the same number of birds being recorded as the Dawson and Bull method; there is a risk that counters, preoccupied with the distance categories, fail to record some birds. As discussed, it is essential that any new method results in data comparable with historical data.

Designing a five-minute bird count study

Over the years, several things have been learnt, or confirmed, about the 5MBC method and these should be considered when designing a study. First, 5MBCs are an index, not a census method. One of the remaining unresolved questions is the nature of the relationship between the numbers of birds counted and the real populations. The often-unstated assumption is that the relationship is positive and linear (i.e. the more birds there are, the more a counter records). While changes in the numbers counted do appear to reflect real changes in some studies (e.g. Pierce et al. 1993; Murphy & Kelly 2001; Elliott et al. 2010), this has rarely been tested and there are situations where this relationship could plausibly break down in a way that cannot be covered by study design. Possible failures include if birds call more vigorously following a drop in numbers as they search for new mates (Dawson 1981), if male-biased populations are more conspicuous (Smith & Westbrooke 2004), and if counters reach a saturation point as the numbers of a given species increase or if changes in one species 'drown out' the calls of another. Greene & Pryde (2012) may be the only New Zealand study that has investigated this relationship as few researchers are

in a position to know the true number of individuals present in a study area. More work is needed and researchers should always consider the possibility that any changes (or lack of changes) observed might not be real.

Second, a balanced study design is very important for 5MBC studies as there are sources of variability that can be confounded with the abundance of a species, including observer effects, weather and hourly and monthly changes in detectability. Researchers should spend time on observer training and testing to minimise observer differences and use matched non-treatment areas to control for weather and season effects. Experience has shown that there are severe limitations on the ability of statistical models to deal with lack of balance in design.

Third, the apparent relative abundance of species can differ from year to year at a site for reasons that are not understood, and the covariates recommended for recording by Dawson and Bull (1975) may explain little of the variation. It is not valid therefore to compare two areas that were counted in different years (Crooke et al. 1977; Efford & Morrison 1991), even for the same season, unless an appropriate study design has been used. Seasonal changes in counts can be sudden and comparisons between years could be compromised if annual counts happened to take place on differing sides of such changes from year to year (Efford & Morrison 1991). The observed seasonal changes may be due to real changes, e.g. birds moving into an area or changes in the conspicuousness of a resident population. For example kākā and New Zealand pigeon are known to move seasonally to food sources (e.g. Robertson & Hackwell 1995). Blackbirds (*Turdus merula*) and other bird species are known to be less conspicuous in winter (Dawson 1981; Harrison & Saunders 1981).

Fourth, although 5MBCs can be suitable for investigating long-term changes (as they require few resources and can be repeated seasonally and annually); many years of counting may be required to detect a trend underlying the annual 'noise'. Unfortunately there are few long-term datasets; however, sets from two distinct time periods have been successfully analysed (e.g. Pierce et al. 1993; Smith & Westbrooke 2004; Elliott et al. 2010). Revisiting exactly the same stations in the two time periods is recommended if a study is being repeated.

Fifth, using the method to compare the same species in different areas may be misleading due to differences in habitat. For example, Moffat and Minot (1994), using a modified 5MBC, found that inconspicuous species varied little in their mean radius of detection between habitats but the detection of conspicuous species varied markedly with changes of habitat. Likewise, as each species is measured on its own index scale there are serious questions over the validity of totalling counts across species or calculating species 'diversities' (Johnson 2008). Other bird-counting methods are becoming available, such as distance-sampling techniques, where species-specific detection functions are constructed and the use of these should be considered where appropriate (e.g. Broekema & Overdyck 2012; Spurr et al. 2012). One approach to analysis is to treat 5MBC data as detection/non-detection data rather than counts.

Sixth, the power of a 5MBC study to detect differences is critical, and preliminary pilot studies are recommended to determine whether the proposed regime of counts will have sufficient power to answer the question of interest. Reports (including for studies that did not detect a change in numbers) should provide estimates for the change or other parameters of interest together with confidence intervals.

Finally, flocking species such as silvereyes are problematic as the assumption of independence between the individuals

counted is violated. The 5MBC method is usually restricted to diurnal birds although it has been used, on at least one occasion, for nocturnal birds.

Database information and recommendations for five-minute bird counters

Advice and resources are now available online for people planning 5MBC studies (Department of Conservation 2011). Information about the 5MBC method is also available internally within DOC's Inventory and Monitoring Toolbox, which should be publicly available on the Department's website in the near future. DOC also runs 5MBC training courses for staff and the public (Department of Conservation 2011).

To encourage good data management it is recommended that five-minute bird counters ensure that they:

- (1) Print the methods on every field sheet (see standardised examples provided online; Department of Conservation 2011). This will ensure that both observers and future researchers have ready access to the method description and do not deviate from the method over time.
- (2) Enter metadata about the study at the same time as the data and store the two together (e.g. on separate worksheets within the same spreadsheet). There is a standard Excel spreadsheet in a suitable format available online (Department of Conservation 2011). All raw data (i.e. the counts at each station) should be stored, not just derived data such as averages.
- (3) Record the grid references using GPS for each counting station, with this information entered on the same spreadsheet as the raw data and the metadata, ensuring that the GPS grid system used is specified.
- (4) Ensure that electronic datasets are stored where they are safe and can be found in the future, and updated as electronic storage formats change.
- (5) Analyse and write up the data collected.

Future improvements to the 5MBC Database

Unlike the National Vegetation Survey Database (which stores data collected using the Recce sampling protocol; Hurst & Allen 2007), there is currently no single national repository for 5MBC data in New Zealand. The 5MBC Database is only accessible by the database administrators (Department of Conservation 2011), so neither members of the public nor DOC staff can access the data directly. Ideally the 5MBC Database should be further developed to make it accessible online for internal and external parties to enter and store 5MBC data efficiently and securely. Systems also need to be developed for checking and validating the data in the database as well as any new data added to it. Priority to date has been given to data entry rather than validation, relying on data users to inform the database administrator of any errors they identify. The integrity and value of the database remains compromised until data validation is completed.

Conclusions

The consistent use of the 5MBC method in New Zealand since the 1970s has facilitated several major advances in our understanding of bird ecology, allowing (1) comparisons of bird populations in different forests and in different seasons, (2) comparisons of forest areas and an understanding of

the species composition of each area, (3) understanding of which particular forests were important for which species and groups of species, and (4) investigation into whether and how birds move between forests seasonally and attitudinally. The information gained allowed organisations to make scientifically-based and justifiable recommendations on the optimal location and attributes of reserves. The method also allowed bird populations to be monitored through 1080 operations for the first time (providing evidence that 1080 had no detectable adverse effect on bird populations), and the identification of the adverse effects of logging and conversion of native forest to conifers. Additionally, the method was employed in many informative specific studies, for example demonstrating that coupe-logging is detrimental in the short, medium and long term to native birds, and allowing the first research into the effect of stoats on birds at a population level.

Over 200 000 5MBCs have been undertaken since the method was developed in 1975. These data are often the only available measure of historical bird numbers in New Zealand forests and therefore our only way of determining population trends over time. These data present opportunities for (1) reanalysis using recently developed statistical techniques, (2) repeating earlier studies to investigate changes over time, (3) adding information to historical presence/absence distributions, and (4) investigating changes in areas where there has been on-going conservation work relative to other areas. The large body of data also presents an opportunity to investigate which variables such as observer, noise, weather, etc., have substantial effects on the counts.

The 5MBC Database is a valuable resource as it contains over 120 000 counts. More work is needed before the database can be accessed directly so contemporary data can be added by interested parties. It is fortunate that many of the historical 5MBCs were undertaken by well-trained counters for government agencies and that there was a clear description of the method right from the start. These methodological consistencies meant large quantities of data could be added to the database relatively easily. However, post-1987 the number of different formats in which 5MBCs were collected and stored increased dramatically, making the collating and entering of these data a daunting task. People conducting 5MBCs are encouraged to follow the standard method and enter their data into the standard spreadsheet provided on the DOC website until such time as a publically accessible database is available.

Together with the National Vegetation Survey Database, the 5MBC data are one of the very few indexes of biodiversity in New Zealand forest that was collected using a consistent methodology. As the data span decades they provide a unique data source for assessing long-term trends for birds in New Zealand forests. Five-minute bird counts have a place in the history of ecological research in New Zealand and the data from them have made a difference for conservation in New Zealand.

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