Introduction to bird monitoring

Version 1.0

This introduction was prepared by John Dowding in 2012.

Contents

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Introduction

Many endemic New Zealand birds display the typical life-history characteristics of island-endemic species; they are commonly long-lived, show delayed maturation, and have low annual reproductive output. They are often highly susceptible to predation, having evolved in the absence of the terrestrial mammals that have been introduced in the past 1000 years. Largely because of this susceptibility to mammalian predators, New Zealand has a high proportion of threatened bird species—in 2008, there were 206 extant taxa resident and breeding, of which 77 (37%) were classified as Threatened, and 93 (45%) were At Risk (Miskelly et al. 2008). Inventory and monitoring programmes are vital tools in the conservation of these species.

Earlier sections of this Toolbox outline the general principles that should be considered when designing any inventory or monitoring study (see 'A guideline to monitoring populations'—docdm-870579). This section is designed to provide additional material specific to the inventory and monitoring of bird populations in New Zealand. In particular, it identifies some of the difficulties that may be encountered in counting birds, outlines the issues that need to be considered when choosing a bird-counting method, and provides a decision tree and tables to assist with selection of appropriate methods for different species or groups of birds. It also considers some of the issues that need to be considered in the detailed planning of a project, after a method has been selected.

Inventory and monitoring

The fundamental difference between inventory and monitoring is described below.

Inventory is a one-off survey or stock-take, normally undertaken over a relatively short period. When such a survey is undertaken, there is no intention to repeat it.

Monitoring requires the collection of information at two or more points in time (and sometimes in different places), with the specific intention of detecting change. It may also seek to assess the reasons for change, and it often measures the rate of change. Monitoring may seek to measure natural changes in bird populations, or to measure a response to management actions or other perturbations. Monitoring may take place over a wide range of time scales; where long-lived species are involved, trends may need to be monitored over many years (or even decades).

Note that a project may start as inventory (with no intention to repeat it) but become a monitoring project if it is repeated in a comparable way later. Both inventory and monitoring may be carried out at widely differing scales, ranging from counts of a single, localised population of one taxon to ecosystem-level counts of many taxa. Both inventory and monitoring will often involve the collection of covariate data that may be required to assist with analysis and explanation. Typically, such data might include observer name, date and time, weather, habitat type, state of tide, altitude, etc.

Potential issues in inventory and monitoring of birds

There is a general perception that birds are easier to survey and monitor than many other taxonomic groups (e.g. Bibby et al. 2000) because they are generally well-known, and many are relatively large and conspicuous animals. For a variety of reasons, however, some species or groups of birds present particular challenges:

- For some groups or species there are obvious issues of detectability. Kiwi and owls are largely nocturnal, some species may be diurnal but cryptic (e.g. wrybills in braided rivers), and some are secretive and normally remain under cover (e.g. crakes in wetlands). These issues are considered in more detail below.
- Some species are rare or occur at low density (e.g. New Zealand falcon), and encounter rates within a study area of workable size may be so low that accurate estimation of abundance may be impossible. In other situations, however, a species may be rare at a national scale but occur at high density (e.g. many island-endemic taxa), and encounter rates will be high.
- Many birds are highly mobile and can move quickly over a wide range of spatial and temporal scales. At a local level, birds may flee from observers or move towards them, and some species (e.g. nectivorous and frugivorous birds) may move considerable distances in response to food availability. Some species migrate and are found in different parts of their ranges at different times of year.
- Some species occur in remote locations (such as islands) that present logistical difficulties. This may not affect the accuracy of counts, but it may reduce their frequency and thereby increase the time required to establish trends.

Even when birds are relatively conspicuous, there may be less obvious issues, such as differences in movement patterns, detectability, catchability, or identification of different age classes or genders within a species. For example, differences in appearance and vocal behaviour mean that male tomtits are normally detected more frequently than females; juvenile birds of many species are more naïve than adults (and may approach an observer more often); juvenile birds are often easier to trap than adults, which can introduce bias to techniques based on standardised capture rates.

Demographic and numeric measures

There are two types of measures used in monitoring: demographic and numeric.

In the case of birds, demographic measures usually involve estimation of survival rates (normally of different age classes and/or genders) and productivity. Demographic studies tend to be labour-intensive, as they nearly always involve capturing and marking birds and repeated re-sighting or re-capture. They also normally involve a relatively small sample of the total population, and are often restricted spatially. Monitoring of the response of bird populations to management actions often involves measurement of demographic parameters, most commonly productivity and adult survival. These data normally have an immediate purpose (i.e. demonstrating an effect of management), but may also be used (sometimes in combination with data from different seasons and/or locations) to model population trends. The Toolbox currently contains no bird monitoring methods based on modelling of demographic data, but these are under development.

Numeric measures involve census counts, indices, and estimations of density and abundance, and are often undertaken at larger scales than demographic studies. Demographic and numeric measures can be used independently, but the desirability and advantages of combining them during monitoring are highlighted in the section 'Measures used in monitoring' in 'A guideline to monitoring populations' (docdm-870579).

Why inventory and monitor birds?

For conservation purposes in New Zealand, birds are counted for three main reasons.

1. Inventory of one or more bird species in an area is used to determine presence/absence or obtain one-off counts.

The *Atlas of bird distribution in New Zealand 1999–2004* (Robertson et al. 2007) is an example of presence/absence surveying for terrestrial and coastal birds undertaken at a national scale. Inventory is more commonly used at smaller scales, to collect information on bird species and numbers within a defined area for specific purposes. Single counts may be used to assess the significance of an area for a taxon (e.g. the regular presence of 1% or more of a species of waterbird makes an area one of international significance in terms of the Ramsar Convention). Such information is often used to assess the potential for impacts, particularly on threatened birds, when resource consent applications are being considered.

2. Monitoring is used to detect trends in local, regional or national populations of birds.

For taxa ranked as Threatened or At Risk, monitoring may be used to decide whether management intervention is appropriate and/or successful. Trends may be determined by numeric and/or demographic measures.

Both surveillance and monitoring are essential in the assessment of the threat status of New Zealand birds. Threat status is determined by one or more of the criteria listed in the New Zealand Threat Classification System manual (Townsend et al. 2008):

- Total number of mature individuals
- Population trend
- Number of populations
- Number of mature individuals in the largest population
- Area of occupancy of the total population

The accurate application of any of these criteria requires data from either surveillance or monitoring studies.

3. Bird counts are used to monitor responses to management actions.

Such monitoring must usually distinguish between background (natural) fluctuations in populations and changes caused by the management action. This will normally involve pre- and post-treatment comparisons and/or the use of treatment and non-treatment (control) areas. In New Zealand, these

methods are commonly used to assess the response of a threatened bird population to predator control, for example. Again, responses to management actions may be measured numerically or demographically.

Birds may also be counted for other purposes. For example, surveillance may be used for biosecurity purposes (to detect arrival of unwanted bird species in New Zealand) or monitoring may be used to check for range expansion of established exotic species that may have an impact on native species (e.g. on islands). Overseas, counts of birds are often used to assess a range of measures of environmental health, such as water quality. In New Zealand, bird counts have rarely been used in this way to date. Many of the methods in this Toolbox could be used to count birds for such purposes, but care is needed to establish a cause-and-effect relationship so there is certainty that changes in bird numbers actually reflect changes in environmental quality at a site.

Issues to consider when selecting a method

Introduction

Birds inhabit a remarkably wide range of habitats and also display a very wide range of behaviours. Conspicuousness can vary hugely between habitats and species, and this has resulted in an enormous variety of counting methods and methods of data analysis. All these methods provide opportunities, but they also contain pitfalls. Clearly, no single method will ever be suitable for all species. Some species, however, may be counted by different methods, depending on the particular aims of the project. For example, if a total population estimate is required for a migratory shorebird, it might be achieved by complete counts of flocks on its wintering grounds; if the impact of management on the same species at a breeding site is being assessed, however, demographic measures or changes in a measure of relative abundance locally may be appropriate.

As a result, there is not necessarily a single method that will always be the 'correct' one for a given species. In practice there are species that are very difficult to count, and in some cases it is possible that only one viable method is available. In principle, the choice of method should primarily be governed by the objectives of the project, but in reality it may be subject to practical constraints imposed by a range of factors (species behaviour, habitat type, and resources). Any compromises that are made to accuracy and precision of results because of such constraints *must* be considered and understood.

Selecting a method

A detailed framework for designing and implementing a project is provided in 'A guideline to monitoring populations' (docdm-870579). It is also advisable to talk to technical experts, particularly someone familiar with the ecology and behaviour of the target species, and to a statistician for advice on sampling, power, and analysis. Consult the literature, which may contain reports of previous studies that addressed similar questions.

This section provides further guidelines and tools to allow selection of an appropriate counting method for birds. Method selection is aided by a decision tree (Fig. 1) which leads to different types of counting techniques or groups of techniques. Where detectability is high, complete counts may be possible, either of a whole population or a defined subset. Where it is unlikely that all individuals will be detected, incomplete counts are undertaken; depending on the method used, these can provide estimates of absolute density or indices of relative abundance. Further information is provided in Tables 1–6. Each table considers the suitability of various methods for a 'functional group' of birds; these groups consist of species that share common behaviours and/or habitat types that are likely to result in common counting methods.

When selecting a bird-counting method, a number of basic issues must be considered.

1. What is the fundamental question to be answered?

It is first essential to define why counts are being undertaken, so that it is clear whether any particular method will answer the question within practical constraints. Ideally, the question should dictate the method, not vice-versa. These issues are discussed in detail in the section 'Designing and implementing a monitoring plan' in 'A guideline to monitoring populations' (docdm-870579).

2. What features of the target species may affect method selection?

Features of the behaviour and/or habitats of different species or functional groups of birds will have a major effect on the suitability of various counting methods.

- **Nocturnal or secretive birds**
  There are obvious difficulties when birds are nocturnal or secretive, and indirect survey and monitoring methods are normally necessary. Call counts are often used to index nocturnal and secretive wetland birds. Because not all birds will call (or respond to taped calls), call counts will almost always under-estimate numbers. They will provide a minimum number alive (MNA) and may provide an index that can be used to detect change. Many factors affect calling rates, and precision may not be high. Other indirect methods that may be suitable include quantification of tracks or scats, counts of burrows, using a trained dog to detect individuals, and territory mapping with birds carrying transmitters.

- **Aquatic birds**
  These can also be difficult to survey, particularly at sea, on large lakes or around the vegetated margins of water bodies. If the sample area is small, a complete census or count may be possible; otherwise, some form of index or measure of distribution may be the only viable option, depending on objectives. In some circumstances, mark/recapture methods may be suitable.

- **Colonial surface and subsurface nesting birds**
  Detectability is often high, and these species can be counted using a greater selection of methods. These range from total counts of roosts or colonies (particularly those that are traditional) from the ground or from the air, to maps of distribution and estimates of density for the birds themselves or (indirectly) from counts of burrows or nests.

- **Non-colonial surface and subsurface nesting birds**
  These can sometimes be counted using similar methods to colonial nesting birds, but some

species in the group can be particularly challenging. Nesting may occur at low density, and in some species nesting birds may be shy, cryptic or difficult to observe (e.g. cliff-nesters). Indirect counts or indirect evidence of presence are either impossible or extremely difficult when the target species is thinly spread over a wide area.

- **Open country birds**
  These are often easy to see or hear, although some species (e.g. game birds) habitually seek cover. A range of methods can be applied. These are often index-based counts (and care must be taken with assumptions), but it is also possible to obtain estimates of absolute density and abundance by using methods such as distance sampling and mark-recapture. As with other functional groups, some open country birds may occur at low densities, and high levels of counting effort may be required to achieve sufficient detections.

- **Forest and shrubland birds**
  These can usually be counted using the same or similar methods to those used for open country birds, providing adjustments are made to cope with more heavily vegetated environments. Index methods have been specifically designed to count forest birds in New Zealand (e.g. five-minute bird counts) but care is needed with study design and interpretation of results. Although more robust methods are available, their application may be hampered by vegetation density, a reliance on detection and identification of calls, species behaviour (e.g. fleeing or approaching an observer), cost, and counting efficiency.

3. What other methodological issues and potential sources of bias exist that will affect method selection?

Are sufficient sites available, and are encounter rates likely to be high enough at these sites to provide data of sufficient quality? Will sufficient resources be available to allow the preferred method to be undertaken? Availability of skilled observers may be a limiting factor in large-scale projects.

Sources of bias in bird counting have been considered in a number of texts, including Bibby et al. (2000), Sutherland et al. (2004) and Morrison et al. (2001). These all contain many references to papers dealing with the limitations of different methods.

Method selection

Methods decision tree

Once the objectives of the study are defined, and practical constraints (e.g. detectability, sample sizes, resources) have been considered, use the methods decision tree (Fig. 1). This should lead to a single method (or a related group of methods) likely to meet the objectives of the project.

Figure 1. Bird methods decision tree.

Functional group tables

The decision tree provides a guide to a method or a group of related methods. Tables 1–6 provide additional information. Because most studies will be focused on a species (or group of species sharing a particular habitat), these tables consider birds in functional groups and identifies methods that are likely to be useful for each group in most circumstances. The tables serve three important purposes:

1. They provide a rapid assessment of the likely precision of a method (for both inventory and monitoring purposes) for that group of birds.
2. They give an indication of the resources and skill levels that will be required for each method.
3. They provide an important check that the method chosen via the decision tree is appropriate for the species or group of species being counted.

Note that for a variety of reasons some species may be included in different functional groups when different methods are appropriate (e.g. at different times of year).

The six functional groups considered in the tables are as follows:

Table 1   **Nocturnal and/or secretive birds**

   includes kiwi, owls, snipe, bittern, some rails, some waterfowl

Table 2   **Aquatic (feeding/roosting) birds**

   includes some waterfowl, grebes, some seabirds, shorebirds, wading birds

Table 3   **Colonial surface and subsurface nesting birds**

   includes some penguins, albatrosses, gannets, gulls, terns, shags, some herons and egrets, noddies, shearwaters, petrels

Table 4   **Non-colonial surface and subsurface nesting birds**

   includes some penguins, albatrosses, boobies

Table 5   **Open country birds**

   includes introduced passerines, rock wren, pipit, kingfisher, pūkeko, game birds, raptors

Table 6   **Forest and shrubland birds**

   includes warblers, silvereye, fernbirds, *Mohua* spp., fantails, flycatchers, honeyeaters, wattlebirds, parrots, pigeons, cuckoos

Table 1. Recommended techniques for the inventory and monitoring of **nocturnal and/or secretive** birds in New Zealand (includes kiwi, owls, snipe, bittern, rails (some rails diurnal) and some water fowl). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; – Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Nocturnal and/or secretive birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	–				–	–	–			
Total mapping—marked birds	✗	H	H	M/H	✗	✓	✓	H	H	M/H
Plot sampling (e.g. quadrats)	✗	H	H	M/H	✓	✓	✓	H	H	M/H
Complete and simple aerial photo counts										
Ground-based photo counts (e.g. seabirds)	–				–	–	–			
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)										
Site occupancy										
Complete and simple aerial photo counts										
Simple counts—terrestrial (visual, dogs, flushing, etc.)										
Simple counts—dispersed or flocking water birds										
[‡]Simple counts—roosts										
[‡]Apparently occupied nests and burrows	✗	L	H	H	✗	✓	✓	L	H	H
[‡]Surveys for sign—encounter rates for tracks, nests, etc.										

Nocturnal and/or secretive birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✓✓	L	M	M	✗	✗	✗	L	H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✓	H	M	M	✗	✓	✓	H	M	M
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping—unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling—terrestrial (transects & points)	✗	M/H	H	M/H	✗	✓	✓	M/H	H	M/H
Distance sampling—aerial (transects)	–				–	–	–			
Distance sampling—boat (transects)	–				–	–	–			
Distance sampling—nests, burrows, etc.	✗	L	H	H	✗	✗	✗	L	H	H
Mark-recapture, resight, removal	✗	M/H	H	H	✗	✓✓✓	✓✓✓	M/H	H	H

[*] Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships?

What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

[†] Monitoring assesses change or trend over time and requires re-measurement of parameters at some pre-determined frequency. Typical monitoring objectives include:

[1] What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?

[2] What is the population abundance or density of a species or community? Is this stable over time? What are the population trends? Does this relate to habitat use?

[3] Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

[‡] Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Table 2. Recommended techniques for the inventory and monitoring of **aquatic (feeding/roosting)** birds in New Zealand (includes waterfowl, grebes, dabchick, seabirds, shorebirds and waders). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; − Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Aquatic (feeding/roosting) birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	✓	L	H	M	✗	✓✓✓	✓✓✓	L	H	M
Total mapping—marked birds	✗	M/H	H	M/H	✗	✓	✓	M/H	H	M/H
Plot sampling (e.g. quadrats)	−				−	−	−			
Complete and simple aerial photo counts	███	███	███	███	███	███	███	███	███	███
Ground-based photo counts (e.g. seabirds)	✗	M	M	L	✗	✗	✗	M	H	L
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)	███	███	███	███	███	███	███	███	███	███
Site occupancy	███	███	███	███	███	███	███	███	███	███
Complete and simple aerial photo counts	███	███	███	███	███	███	███	███	███	███
Simple counts—terrestrial (visual, dogs, flushing, etc.)	███	███	███	███	███	███	███	███	███	███
Simple counts—dispersed or flocking water birds	███	███	███	███	███	███	███	███	███	███
[‡]Simple counts—roosts	███	███	███	███	███	███	███	███	███	███
[‡]Apparently occupied nests and burrows	−				−	−	−			
[‡]Surveys for sign—encounter rates for tracks, nests, etc.	███	███	███	███	███	███	███	███	███	███

Aquatic (feeding/roosting) birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✗	L	M	M	✗	✓	✓	L	H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✗	M/H	M	M	✗	✓	✓	M/H	H	M
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping— unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling— terrestrial (transects & points)	✗	M	M	H	✗	✗	✗	M	H	H
Distance sampling— aerial (transects)	✗	H	M	H	✗	✗	✗	H	H	H
Distance sampling— boat (transects)	✗	H	M	H	✗	✗	✗	H	H	H
Distance sampling— nests, burrows, etc.	✗	M	H	H	✗	✗	✗	M	H	H
Mark-recapture, resight, removal	✗	H	H	H	✗	✓✓✓	✓✓✓	H	H	H

[*] Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships?

What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

[†] Monitoring assesses change or trend over time and requires re-measurement of parameters at some pre-determined frequency. Typical monitoring objectives include:

[1] What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?

[2] What is the population abundance or density of a species or community? Is this stable over time? What are the population trends? Does this relate to habitat use?

[3] Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

[‡] Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Table 3. Recommended techniques for the inventory and monitoring of **colonial surface and subsurface nesting** birds in New Zealand (includes penguins, albatrosses, gannets, gulls, terns, shags, herons, egrets, noddies, shearwaters and petrels). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; – Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Colonial surface and subsurface nesting birds	Inventory objectives [*]	Resources			Monitoring objectives [†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance [1]	Status & trend [2]	Management [3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	✗	L	H	M	✗	✓✓✓	✓✓✓	L	H	M
Total mapping—marked birds	✗	M	H	M	✗	✓✓✓	✓✓✓	M	H	M
Plot sampling (e.g. quadrats)	✗	L	M	M	✓	✓✓	✓✓	L	H	M
Complete and simple aerial photo counts										
Ground-based photo counts (e.g. seabirds)	✓	M	L	M	✗	✓✓	✓✓	M	M	M
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)										
Site occupancy										
Complete and simple aerial photo counts										
Simple counts—terrestrial (visual, dogs, flushing, etc.)										
Simple counts—dispersed or flocking water birds										
[‡]Simple counts—roosts										
[‡]Apparently occupied nests and burrows	✗	M	M	M	✗	✓	✓	M	H	M

Colonial surface and subsurface nesting birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
[‡]Surveys for sign—encounter rates for tracks, nests, etc.										
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✓✓	L	M	M	✓	✓	✓	L	H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✓	M	M	M	✓	✓	✓	M	H	M
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping—unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling—terrestrial (transects & points)	✗	M	H	H	✗	✓✓	✓✓	M	H	H
Distance sampling—aerial (transects)	–				–	–	–			
Distance sampling—boat (transects)	–				–	–	–			
Distance sampling—nests, burrows, etc.	✗	M	H	H	✗	✓✓	✓✓	M	H	H
Mark-recapture, resight, removal	✗	M/H	H	H	✗	✓✓✓	✓✓✓	M/H	H	H

Inventory and monitoring toolbox: birds

* Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships? What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

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1. What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?

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3. Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

‡ Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Table 4. Recommended techniques for the inventory and monitoring of **non-colonial surface and subsurface nesting** birds in New Zealand (includes some penguins, albatrosses, boobies). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; – Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Non-colonial surface and subsurface nesting birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	✗	L/M	H	M	✗	✓✓✓	✓✓✓	L/M	H	M
Total mapping—marked birds	✗	M/H	H	H	✗	✓✓	✓✓	M/H	H	H
Plot sampling (e.g. quadrats)	✗	M	H	M/H	✗	✓✓	✓✓	M	H	M/H
Complete and simple aerial photo counts	■	■	■	■	■	■	■	■	■	■
Ground-based photo counts (e.g. seabirds)	–				–	–	–			
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)	■	■	■	■	■	■	■	■	■	■
Site occupancy	■	■	■	■	■	■	■	■	■	■
Complete and simple aerial photo counts	■	■	■	■	■	■	■	■	■	■
Simple counts—terrestrial (visual, dogs, flushing, etc.)	■	■	■	■	■	■	■	■	■	■
Simple counts—dispersed or flocking water birds	■	■	■	■	■	■	■	■	■	■
[‡]Simple counts—roosts	■	■	■	■	■	■	■	■	■	■
[‡]Apparently occupied nests and burrows	✓✓	M	H	M	✗	✓✓	✓✓	M	H	M

Non-colonial surface and subsurface nesting birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
[‡]Surveys for sign—encounter rates for tracks, nests, etc.										
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✓✓	L	M	M	✗	✗	✗	L	H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✓	M	M	M	✗	✓	✓	M	M	M
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping—unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling—terrestrial (transects & points)	✗	M	H	H	✗	✓✓	✓✓	M	H	H
Distance sampling—aerial (transects)	✗	H	H	H	✗	✓✓	✓✓	H	H	H
Distance sampling—boat (transects)	–				–	–	–			
Distance sampling—nests, burrows, etc.	✗	M	H	H	✗	✓✓	✓✓	M	H	H
Mark-recapture, resight, removal	✗	H	H	H	✗	✓✓✓	✓✓✓	H	H	H

* Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships? What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

† Monitoring assesses change or trend over time and requires re-measurement of parameters at some pre-determined frequency. Typical monitoring objectives include:

1. What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?
2. What is the population abundance or density of a species or community? Is this stable over time? What are the population trends? Does this relate to habitat use?
3. Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

‡ Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Table 5. Recommended techniques for the inventory and monitoring of **open country** birds in New Zealand (includes introduced passerines, rock wren, pipit, kingfisher, pūkeko, pheasants, quail, partridge, raptors). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; ‒ Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Open country birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	✗	L/M	H	M	✗	✓✓	✓✓	L/M	H	M
Total mapping—marked birds	✗	M	H	H	✗	✓✓	✓✓	M	H	H
Plot sampling (e.g. quadrats)	✗	M	H	H	✗	✗	✗	M	H	H
Complete and simple aerial photo counts										
Ground-based photo counts (e.g. seabirds)	‒				‒	‒	‒			
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)										
Site occupancy										
Complete and simple aerial photo counts										
Simple counts— terrestrial (visual, dogs, flushing, etc.)										
Simple counts— dispersed or flocking water birds										
‡Simple counts—roosts										
‡Apparently occupied nests and burrows	✗	L	H	M/H	✗	✓	✓	L	H	M/H
‡Surveys for sign— encounter rates for tracks, nests, etc.										

Open country birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✓✓	L/M	M	M	✓✓	✓	✓	L/M	H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✗	M	M	M/H	✗	✓	✓	M	M	M/H
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping—unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling—terrestrial (transects & points)	✗	M/H	H	H	✗	✓✓✓	✓✓	M/H	H	H
Distance sampling—aerial (transects)	–				–	–	–			
Distance sampling—boat (transects)	–				–	–	–			
Distance sampling—nests, burrows, etc.	✗	M/H	H	H	✗	✗	✗	M/H	H	H
Mark-recapture, resight, removal	✗	H	H	H	✗	✓✓✓	✓✓✓	H	H	H

[*] Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships?

What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

[†] Monitoring assesses change or trend over time and requires re-measurement of parameters at some pre-determined frequency. Typical monitoring objectives include:

[1] What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?

[2] What is the population abundance or density of a species or community? Is this stable over time? What are the population trends? Does this relate to habitat use?

[3] Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

[‡] Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Table 6. Recommended techniques for the inventory and monitoring of **forest and shrubland birds** in New Zealand (includes warblers, silveryes, fernbirds, *Mohoua* spp., fantails, flycatchers, honeyeaters, wattlebirds, parrots, pigeons cuckoos). **Method precision** (relative to objectives): ✓✓✓ Good; ✓✓ Medium; ✓ Poor; ✗ Not Recommended; – Not Applicable. **Resources:** L = Low; M = Medium; H = High. Methods that are blacked out are under development.

Forest and shrubland birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Complete counts										
Complete counts (true census)	✗	L/M	H	H	✗	✓✓	✓✓	L/M	H	H
Total mapping—marked birds	✗	M/H	H	H	✗	✓✓	✓✓	M/H	H	H
Plot sampling (e.g. quadrats)	✗	M	H	H	✗	✗	✗	M	H	H
Complete and simple aerial photo counts										
Ground-based photo counts (e.g. seabirds)	–				–	–	–			
Incomplete counts										
Presence/absence indices (e.g. 5MBC, plot searches, transects, etc.)										
Site occupancy										
Complete and simple aerial photo counts										
Simple counts— terrestrial (visual, dogs, flushing, etc.)										
Simple counts— dispersed or flocking water birds										
[‡]Simple counts—roosts										
[‡]Apparently occupied nests and burrows	✗	L/M	H	M/H	✗	✓	✓	L/M	H	M/H
[‡]Surveys for sign— encounter rates for tracks, nests, etc.										

Forest and shrubland birds	Inventory objectives[*]	Resources			Monitoring objectives[†]			Resources		
Method	Suitability for inventory	Equipment costs	Personnel costs	Skills required	Surveillance[1]	Status & trend[2]	Management[3]	Equipment costs	Personnel costs	Skills required
Indices of relative abundance										
Indices of relative abundance/density (e.g. 5MBC, line transects)	✓✓✓	L	M/H	M	✓✓✓	✓✓	✓✓	L	M/H	M
[‡]Display counts										
Call counts										
Call playback										
Trapping indices (e.g. standardised mist netting)	✓	M/H	H	H	✗	✓	✓	M/H	H	H
[‡]Flushing counts										
[‡]Spotlight counts										
Territory mapping—unmarked birds										
Estimates of absolute density & abundance										
Double sampling—index & absolute measures										
Distance sampling—terrestrial (transects & points)	✗	M	H	H	✗	✓✓✓	✓✓✓	M	H	H
Distance sampling—aerial (transects)	–				–	–	–			
Distance sampling—boat (transects)	–				–	–	–			
Distance sampling—nests, burrows, etc.	–				–	–	–			
Mark-recapture, resight, removal	✗	H	H	H	✗	✓✓✓	✓✓	H	H	H

[*] Inventory is a one-off survey or assessment with no intention to re-measure. If inventory of a site is repeated in the future this can be considered monitoring. Typical inventory objectives include: What species are present at a site and how are they distributed over a landscape? What are the species habitat relationships?

What is the wildlife value/significance of an area (SSWI, etc.)? Is this a baseline survey? Interpretation of results must be based on the understanding that these are single surveys.

† Monitoring assesses change or trend over time and requires re-measurement of parameters at some pre-determined frequency. Typical monitoring objectives include:

1. What species have moved into an area? Have range extensions occurred for a species of interest (e.g. monitoring for biosecurity risk—illegal introductions and cage bird releases)?
2. What is the population abundance or density of a species or community? Is this stable over time? What are the population trends? Does this relate to habitat use?
3. Do population estimates of density and abundance change as a result of management action? Over what time-scale does this occur? Has a species translocation succeeded? Has management been effective? Has species composition altered as a result of management? What are the visitor impacts?

‡ Please note that some methods described in the comparative tables (particularly within the incomplete count sections) are not expanded as full method specifications, but are provided as common examples of a wide range of index methods that are available.

Method specifications

Once a method has been selected, and the functional group table has confirmed its suitability, consult the method specification. The methods provide detailed information on each technique, including the assumptions required, advantages and disadvantages, suitability for inventory and monitoring, the skills and resources required, and recommendations on data storage and analysis. There are also one or more case studies showing how each method has been applied in New Zealand.

Approved methods for inventory and monitoring of birds

Complete counts

- [Birds: complete counts—true census (docdm-577914)](#)
- [Birds: complete counts—plot sampling (complete counts of a portion of a study area) (docdm-580509)](#)
- [Birds: complete counts—ground-based photo counts for seabirds (docdm-578675)](#)
- [Birds: complete counts—aerial photo counts (docdm-308974)](#)

Incomplete counts

- [Birds: incomplete counts—line transect counts (docdm-580459)](#)
- [Birds: incomplete counts—five-minute bird counts (docdm-534972)](#)
- [Birds: incomplete counts—standardised mist netting (docdm-538395)](#)

Estimates of absolute density and abundance

- [Birds: estimates of absolute density and abundance—mark-resight for closed populations (docdm-580154)](#)
- [Birds: estimates of absolute density and abundance—distance sampling (docdm-534993)](#)

Other methods

Many other methods are currently being developed for inclusion in the Toolbox. Alternative counting methods may be used if circumstances suggest that they (or variations of existing methods) will answer a particular question. However, new methods (or variations) must be scientifically robust and should be subject to particularly high levels of scrutiny before being used. When a new method is introduced, there should be a period of overlap with an established method to establish comparability.

Planning the study

Once a method has been selected, and the method specification confirms that it is suitable, complete a 'Standard inventory and monitoring project plan' (docdm-146272).

In compiling a plan, a number of issues will need to be considered that do not affect method selection itself, but will affect the execution and interpretation of the project. Overall, the primary aim at this stage should be to maximise consistency, both through careful planning and through careful attention during data collection. This will minimise variation between and within surveys, and result in maximum robustness.

Observers

Depending on the method chosen, consider observer skill levels and the possible need for training. Observers may have very different levels of experience identifying a species (or gender and age class within a species) by sight or sound, different acuity of eyesight or hearing, different abilities to estimate distance, and differing ability to cope with field conditions. Depending on the method and habitat type, these differences can have major impacts on the quality of data collected. For example in forest, where visibility is often limited, many birds will be detected by sound, and hearing acuity, distance estimation and call-recognition are particularly important.

The effects of differences in observer ability can be reduced in various ways. Training (and testing) of observers may be required to bring observers to a minimum standard. Whenever possible, especially on short-lived projects, the same observers should be used for all sessions of field-work. Where changes in observers are unavoidable, joint fieldwork to provide overlap between old and new observers is advisable. Observer name should be recorded against all data collected.

Observers differ in the length of time they can remained focused, and results collected later in the day may reflect this. Emlen & DeJong (1981) considered that 3–5 hours of full attentiveness during surveying was close to the maximum for most observers.

Timing of observations and weather

Choosing an appropriate time of year for counts is often important. Some species migrate and are found in different parts of their ranges in different seasons (e.g. cuckoos, some shorebirds, some passerines). Some species breed colonially and then disperse (e.g. some penguins, gulls and terns), while others breed as solitary pairs and then join post-breeding groups (e.g. oystercatchers and plovers). Other species call more frequently at certain times of the year (high call rates pre-breeding and low rates during the moult period). Many factors can affect the timing of these events; windows of study can therefore be complex and may require considerable knowledge of the species. Choosing an appropriate time of day may also be important. For example, periods of vocal activity often vary (e.g. forest birds sing most early in the morning), and this will affect detectability. The state of the tide may be crucial when counting coastal birds, as many species disperse to feed over the low tide period, then congregate at high-tide roosts.

Whenever possible, counts should not be undertaken during unusually adverse weather or following severe weather events, as these are likely to affect consistency of results. For example, high levels of wind noise in vegetation will affect detectability of birds in forest, and wind strength and direction will affect choice of high-tide roost sites by coastal birds. Recent weather events (such as floods in rivers or storm surges on the coast) may mean that birds are temporarily absent from their normal ranges.

Observer disturbance

Observer disturbance should be considered when the target species is highly threatened, or is particularly sensitive to disturbance. It is probably the case that most survey and monitoring activities cause some level of disturbance, but the value of the information gathered is usually assumed to outweigh the impacts. It may be appropriate to consider (and if necessary test) that assumption, especially for new counting techniques or very rare species. Consideration of the potential impacts of observers is particularly important at bird breeding sites, where

- Repeated monitoring and observer presence may cause disturbance that results in nest desertion and the death of eggs (or chicks) through thermal stress or exposure
- Disturbance may increase predation rates (observers may leave tracks or scent trails that lead predators to nests, or may keep adults away from chicks)
- Observers may crush cryptic eggs or chicks, or collapse burrows

Data recording

Consider how the results will be recorded. It may be necessary or useful to design data sheets; these may be particularly useful as a prompt to observers when covariate data are being recorded. Consider what other information (if any) needs to be recorded. In bird counting, it is likely to include observer, date, time, and weather, as a minimum. Think carefully about the need for other covariate data. Consider also how the data will be backed up and stored.

Tests and pilot studies

Consider whether tests or a pilot study would be useful. The use of these is discussed in the section 'Finalise design and sampling programme' in 'A guideline to monitoring populations' (docdm-870579). Tests or pilot studies allow testing of an untried method (or an established method on a new species or in a new habitat), to determine whether practical issues such as access arrangements, travel time, survey time, suitability of equipment, etc., have been adequately addressed. They also allow testing of data collection sheets, data storage, and analytical methods using a real dataset. They may identify unexpected sources of bias or failure of critical assumptions, and allow for adjustments to the methodology before implementation.

Longer-term projects

Some additional issues are specific to longer-term projects, and may need to be taken into account during initial planning.

Objectives must be reviewed regularly to ensure that the questions being asked are still relevant. The experimental design of the project should also be reviewed regularly; it should be maintained if still appropriate and robust, but new techniques of data collection or analysis or new technologies that become available should also be considered. In particular, objectives and methodology should be reviewed when an old project is inherited.

The human and financial resources required to continue the project must be maintained to ensure data integrity but it should be acknowledged that this can be extremely difficult. Staff and volunteer turnover is more likely to occur in long-term projects, and overlap between previous and new observers will help to reduce variability. It is essential that all descriptions, maps, and other details of the method are written (and detailed enough), so that future surveyors can repeat exactly what previous surveyors did. Where observers do undertake a project for many years, care may be required with complacency and development of bad habits.

For long-running projects, it is advisable to undertake interim analyses of data to look for problems; it is obviously important to discover and correct these as early as possible. One problem specific to mark/resight or mark/recapture methods in long-term bird studies is that birds may lose marks, particularly colour bands, or become trap shy.

Sources of further information

There is an extensive literature on bird-count methodology. Useful introductory texts include:

- Bibby et al. (2000), which deals exclusively with bird surveying and monitoring
- Thompson et al. (1998), which deals with methods for monitoring vertebrate populations, including bird populations
- Sutherland (2006), which covers ecological census techniques, with a substantial section on bird counting techniques
- Sutherland et al. (2004), which describes techniques for the study of bird ecology and conservation.

These sources all contain a large number of references to papers dealing with a wide range of methods used to enumerate birds. There is also online information, such as the monitoring manual on the web pages of the Patuxent Wildlife Research Center (2009).[1]

References and further reading

Bibby, C.J.; Burgess, N.D.; Hill, D.A.; Mustoe, S. 2000: Bird census techniques. 2nd edition. Academic Press, London.

Emlen, J.T.; DeJong, M.J. 1981: The application of song detection threshold distance to census operations. Pp. 346–352 in Ralph, C.J.; Scott, J.M. (Eds): Estimating numbers of terrestrial birds. *Studies in Avian Biology No. 6.* Cooper Ornithological Society, Allan Press, Kansas.

Miskelly, C.M.; Dowding, J.E.; Hitchmough, R.A.; Elliott, G.P.; Powlesland, R.G.; Robertson, H.A.; Sagar, P.M.; Scofield, R.P.; Taylor, G.A. 2008: Conservation status of New Zealand birds, 2008. *Notornis 55*: 117–135.

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[1] http://www.pwrc.usgs.gov/monmanual/

Morrison, M.L.; Block, W.M.; Strickland, M.D.; Kendall, W.L. 2001: Wildlife study design. Springer-Verlag, New York. 210 p.

Nichols, J.D.; Williams, B.K. 2006: Monitoring for conservation. *Trends in Ecology and Evolution 21*: 668–673.

Patuxent Wildlife Research Center. 2009: Managers' monitoring manual. USGS website: http://www.pwrc.usgs.gov/monmanual/

Robertson, C.J.R.; Hyvönen, P.; Fraser, M.J.; Pickard, R. 2007: Atlas of bird distribution in New Zealand. Ornithological Society of New Zealand, Wellington. 533 p.

Sutherland, W.J. (Ed.) 2006: Ecological census techniques. 2nd edition. Cambridge University Press, Cambridge.

Sutherland, W.J.; Newton, I.; Green, R.E. 2004: Bird ecology and conservation: A handbook of techniques. Oxford University Press, Oxford.

Thompson, W.L.; White, G.C.; Gowan, C. 1998: Monitoring vertebrate populations. Academic Press, San Diego.

Townsend, A.J.; de Lange, P.J.; Duffy, C.A.J.; Miskelly, C.M.; Molloy, J.; Norton, D. 2008: New Zealand Threat Classification System manual. Department of Conservation, Wellington.

Appendix A

The following Department of Conservation documents are referred to in this introduction:

docdm-308974   Birds: complete counts—aerial photo counts

docdm-578675   Birds: complete counts—ground-based photo counts for seabirds

docdm-580509   Birds: complete counts—plot sampling (complete counts of a portion of a study area)

docdm-577914   Birds: complete counts—true census

docdm-534993   Birds: estimates of absolute density and abundance—distance sampling

docdm-580154   Birds: estimates of absolute density and abundance—mark-resight for closed populations

docdm-534972   Birds: incomplete counts—five-minute bird counts

docdm-580459   Birds: incomplete counts—line transect counts

docdm-538395   Birds: incomplete counts—standardised mist netting

docdm-870579   A guideline to monitoring populations

New Zealand Government