Chapter 6
Avian surveys and monitoring

A more complete understanding of the role that wild birds play in the ecology of wildlife diseases require baseline studies of those species likely to host, transmit or spread pathogens. Baseline studies of wild bird populations will generally fall into three categories: inventory and monitoring, movement patterns and behavioural studies. Initial studies will likely focus on inventory and monitoring with specific objectives that include: 1) an inventory of all the bird species in an area of interest; 2) determining the abundance or density of the species present; and 3) monitoring seasonal changes in species composition and numbers. When applied to understanding the emergence of infectious diseases such as H5N1 AI, these techniques serve to provide an early warning system for detection of higher than expected mortality rates in wild bird populations.

Species inventories and population monitoring are common tasks of biologists, and a variety of avian survey and monitoring techniques are available. While each technique has its advantages, the most appropriate technique will depend on the specific objectives of the study, the size of the study area, characteristics of the species and habitat of interest, and the logistic and financial feasibility of implementing the study. This Manual provides a brief review of some the practical techniques used to survey and monitor avian populations, with special emphasis on those techniques applicable to waterbirds, shorebirds and other species known or suspected of hosting, transmitting or spreading the H5N1 virus.

Various approaches can be employed to assess wild bird species composition and abundance over an area of interest, from total counts of all animals present (a complete census) to sampling strategies that provide population estimates that can be extrapolated over the entire study area. One important precept applies regardless of the technique employed: it is essential that all techniques are properly described and surveys are conducted by qualified personnel using standard methods that are consistent over time. Observers will undoubtedly encounter a variety of species, conditions and habitats during surveys, but counts are of little use if the species identification is dubious and the survey methodology varies from one day to the next or among sites. Thus, observers should be able to identify most, if not all, of the species likely to be encountered during a survey, including closely-related species that may be nearly identical, and different sexes and age groups within a species.

COMPLETE CENSUSES

The goal of a complete census is to conduct a total count of all the animals present over a specified area to obtain an unbiased estimate of abundance without statistical inferences or underlying assumptions. A reliable census is conditional on the assumption that all individuals present in an area can be recorded; therefore, censuses are most useful for conspicuous species occupying discrete and well-defined habitats. Some situations in which a reliable census may be possible include complete counts of herons and cormorants nesting in trees

FIGURE 6.1
Bird survey with a telescope

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along a wetland margin, waterbirds frequenting small open wetlands, or shorebirds at high tide roost sites in estuaries.

However, in many situations, such as where waterbirds are very numerous or tightly grouped or where time is limited, it may be necessary to estimate the number of individuals rather than to count every individual. Experienced counters can accurately estimate 10, 20, 50, 100 or more birds almost instantaneously, and scan through flocks counting in these units with a tally counter. It is preferable to estimate in small units (10 is probably the most commonly used unit); units of 100 or more are generally used for birds in flight or on nests (for colonial nesting species), and when time is limited.

A complete census is more practical when targeted at large and conspicuous species such as swans or geese and is the preferred method especially where there are active networks of participants to undertake the work. This kind of approach is promoted for periodic special census of swans by organisations such as Wetlands International/IUCN/SSC Swan Specialist Group at the regional level (*see for* e.g. Worden *et al.* 2006). For large-scale coordinated census of waterbirds, such as under the annual International Waterbird Census coordinated by Wetlands International (Delany 2005a, 2005b), all the birds of a selection of appropriate species, at a selection of suitable sites are covered, in a series of "look-see surveys" (*sensu* Bibby *et al*. 1998).

Achieving the ambitious goals of a conventional census count will often involve considerable logistic preparations. A large census area will usually need to be divided into smaller units that can be conveniently surveyed over time or by multiple field personnel at the same time. In the latter case, the survey team requires proper training in census techniques, species identification, accurate number counting or estimation, and use of field equipment (e.g. spotting scopes, Global Positioning System - GPS). In either case, the survey period should also be considered. Observers need enough time to thoroughly examine each survey unit, but not so much time that individuals of the target species move between survey units and are counted more than once.

The census area also needs to be accurately mapped and the entire area completely surveyed. Individual survey units should be easily discernable in the field because poorly defined unit boundaries may result in missing or double counting individuals. All habitats in the survey area which are suitable to the target species must be searched. Incomplete coverage (e.g. neglecting areas considered less suitable to the target species) may miss some individuals and introduce biases in the survey data.

Photographic or video images provide an efficient census technique that has been used increasingly in recent years. This involves producing a set of photograph or video images covering the entire area of interest (and all the animals within) which can be counted at a later time. Photographic and video surveys are usually conducted from aircraft, but any platform which provides unobstructed views of the survey area is suitable for conducting a census.

Photographic surveys must be conducted at a distance (or altitude) that produces images with sufficient resolution to permit species identification and distinguish individual birds in sometimes dense flocks or colonies, but not so close that the spatial relationship among images is lost. Concurrent ground- or boat-based surveys are advisable when conducting aerial photographic or video surveys to verify species identification and examine other potential biases.

SAMPLE PLOTS

In many studies, the time and effort required to conduct a complete and accurate census is prohibitive, usually because the area of interest is too large to adequately survey in a reasonable amount of time. In such cases, sample plots can provide data indicating species diversity and the abundance of each species within the study area. Sample plots are most amenable to ground-based observers because time is less of a limiting factor than in boat-based or aerial surveys, allowing for greater search effort dedicated to ensuring accurate counts and proper species identification.

Sample plots need not be limited to counts of actual birds and cannot be used for that purpose where birds move between sample plots during counts. Sample plots are most useful when the target species (or objects) are relatively immobile over the survey period, for example wading birds attending discrete roost sites. Specific applications of sample plots to AI-related wildlife investigations may include estimating waterbird nest densities or the number of carcasses at an H5N1 outbreak site.

The selection of sample plots should be carefully considered when designing a study because plot location can have a strong influence on population estimates. Consideration must be given to factors such as bird behaviour and heterogeneous habitats which may result in non-random animal distributions that require stratified sampling techniques. Details of more sophisticated sample plot design and analysis techniques are beyond the scope of this Manual, but Bibby *et al*. (1998, 2000) provide useful references[9].

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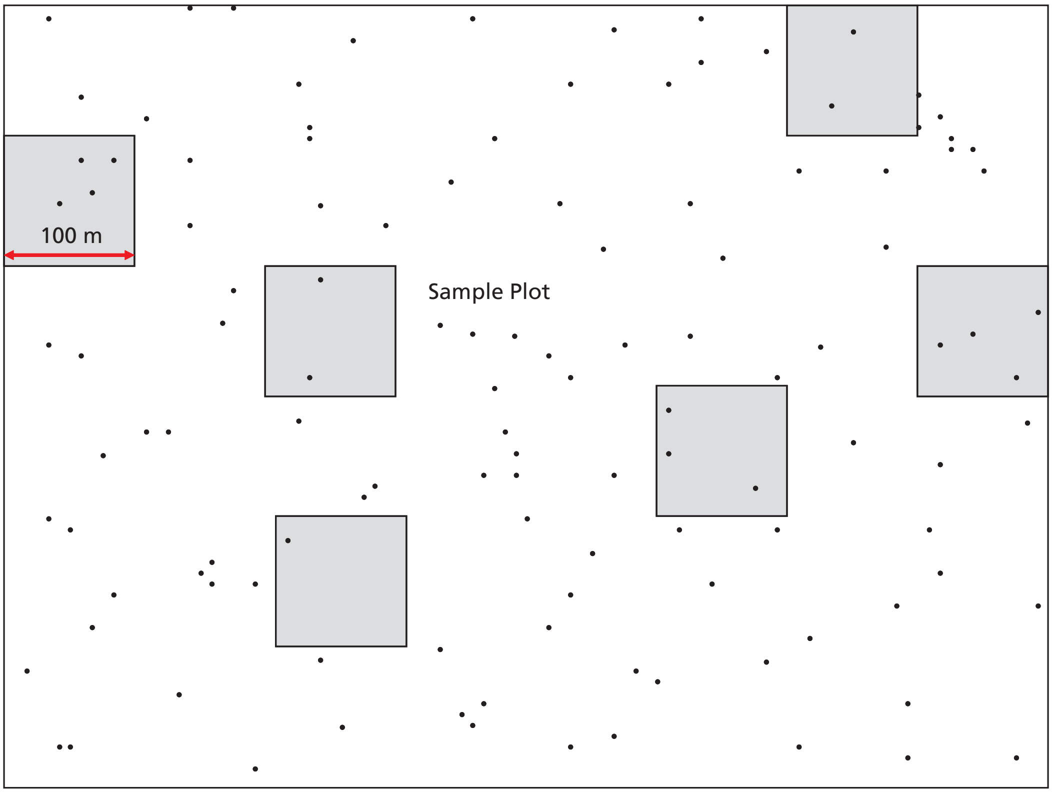
9 A free download is available at http://conservation.bp.com/advice/field.asp#fsm.

FIGURE 6.2
Use of sample plots for estimating avian density and abundance



Note: Dots represent individual birds.

In the simplest applications, complete counts of all animals *(n)* in sample plots of known size *(a)* are conducted and the plot density is calculated as $d = n / a$. The average density *(D)* from all the plots can be calculated and extrapolated over the entire study area *(A)* to provide an estimate of total animal abundance *($N = D / A$)*, although more sophisticated means of determining average density by examining variability in sample plots may be desirable.

Figure 6.2 illustrates a simplified example of the use of sample plots to determine waterbird nest density and abundance.

Actual density in this hypothetical population of 120 nests distributed over 0.48 km^2 is 250 nests km^{-2}. A total of 16 nests are detected in the six randomly chosen 100 m^2 plots for an average density of 267 nests km^{-2} (16 nests / 0.06 km^2) and an abundance estimate of 128 nests (267 nests km^{-2} x 0.48 km^2) over the entire study area.

The accuracy of density estimates will increase as survey effort (the number or size of the plots) increases. In the above example, sampling a single 100 m^2 plot could result in densities ranging from 0 to 800 nests km^{-2}. The size and number of sample plots will depend on the effort required to detect individuals of the target species. Intuitively, more or larger plots can be established for species that are easier to detect and require less search time per individual, thus moving closer to the conditions of a complete census.

Sample plots need not be square (quadrats), although regularly shaped plots (e.g. square or circular) are usually easier to demarcate and search. If plots are to be repeatedly surveyed, boundaries should be marked and coordinates recorded with a GPS unit.

STRIP TRANSECTS

Strip transects are one of the most commonly used survey techniques for determining avian species composition and density. Essentially, strip transects are modified versions of a sample plot in which the observer performs counts while traveling along a fixed transect line instead of searching over an entire plot.

Transects are randomly located, often within stratified sub-areas of the total study area, to obtain representative samples of the species and numbers of each species present. If density estimates are desired, the counts are limited to objects within a fixed distance of the transect line. In such cases, the sampled plot becomes a rectangular strip extending a specified distance on either side of the transect line.

Strip transects have been adapted for a variety of species and habitats that have direct applications to AI-related studies. Aerial and boat-based strip transect methodologies have been specifically developed for conspicuous aquatic species and these techniques have become the preferred survey method in large open water habitats. Aerial strip transects can be established to assess the distribution and abundance of waterfowl over broad geographic areas where waterfowl habitat overlaps with poultry production, agricultural fields and other potential H5N1 outbreak zones. Over smaller scales, ground-based strip transects established along the interface between waterbird habitats and poultry operations can identify particular species likely to bridge these habitats.

As for sample plots, the density from a strip transect plot can be extrapolated over the study area to obtain an abundance estimate. Figure 6.3 illustrates a simplified example of a 50 m strip transect (extending 50 m on each side of the line).

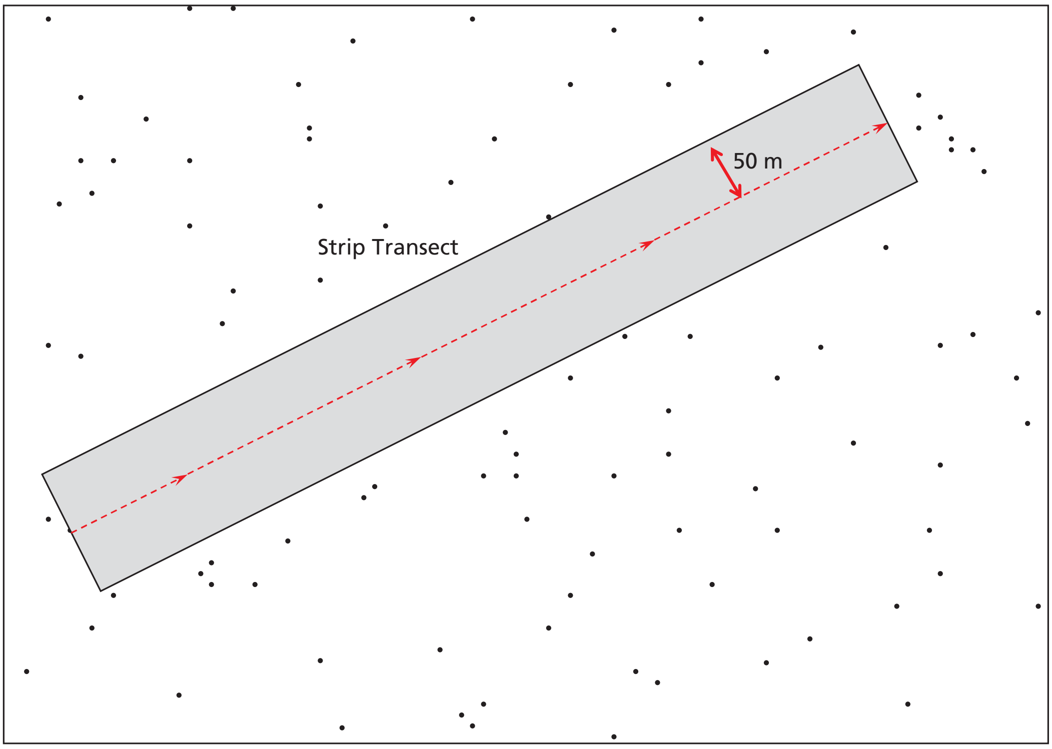
As in the previous example, actual density is 250 animals km^{-2}. A total of 17 animals are detected within the 700 m long by 100 m wide transect for a density of 243 animals km^{-2} (17 animals / 0.07 km^2) and an abundance estimate of 117 animals (243 animals km^{-2} x 0.48 km^2) over the entire study area.

In practice, strip transect methodology is rarely as simple as the above example suggests, and several factors must be considered before surveys can be conducted. If density estimates are desirable, choice of the appropriate strip transect width is a compromise between maximising detection probability for the target species and surveying as large an area as possible. Intuitively, detection probability (and strip transect width) increases for large, conspicuous species in more open habitats. Obviously, it is senseless to establish a 400 m wide strip transect to count tiny sandpipers foraging in a vegetated wetland, just as it is inefficient to use a 50 m strip transect to survey large and conspicuous swans on a lake.

Like sample plots, density estimates from strip transect surveys operate on the assumption that all animals within the plot are detected, thus surveys are best conducted in open habitats where visibility is unobstructed. However, unlike sample plots, the observer does not usually leave the transect line to search the plot, thus complete detection of all animals in the plot may be difficult to achieve. Binoculars (image-stabilised models are best) are commonly used during ground- and boat-based strip transect surveys to aid visual detection and species identification, but visual aids are of little use during aerial surveys.

The ability to make quick and accurate assessments of bird locations in relation to survey boundaries is imperative for reliable density estimates. Errors in estimating bird location

FIGURE 6.3
Use of strip transects for estimating avian density and abundance



Note: Dots represent individual birds.

relative to the transect line can have a considerable effect on density estimates. In the illustrated example (Figure 6.2), counting three individuals located just outside the boundary results in a density of 287 animals km^{-2}, while excluding three just inside the boundary yields 200 animals km^{-2}.

Consistent assessments of bird location in relation to the boundary require that aerial surveys be conducted at the same altitude and boat-based observers are stationed at similar heights above the water (and these parameters are accurately recorded). Aids to distance estimation, such as range finders or markings on airplane windows or wing struts, are helpful for calibrating the observer's eye during the training period, but reliance on these aids often distracts from the primary task of identifying and counting birds.

Strip transects can be conducted by observers on the ground, in boats or in aircraft. Aerial surveys offer far greater spatial coverage (and incur much higher costs) compared to ground- and boat-based surveys, although the extended range sometimes comes at the expense of accuracy, as the speed of the aircraft limits observation time and may make accurate counts and species identification more challenging. In fact, performing a good aerial survey requires specific training and experience.

If biases among survey platforms are suspected, concurrent counts using different survey methods are advisable (triangulation of the data and information). For example, observers on aerial surveys may be more likely to miss single birds or birds of a particular species. Ground-based surveys ("ground truthing") conducted concurrently with aerial surveys can often detect these biases and, if biases are consistent over a number of replicates, a "correction factor" based on the average ratio of counts between the survey types can be determined to account for birds likely missed by aerial observers.

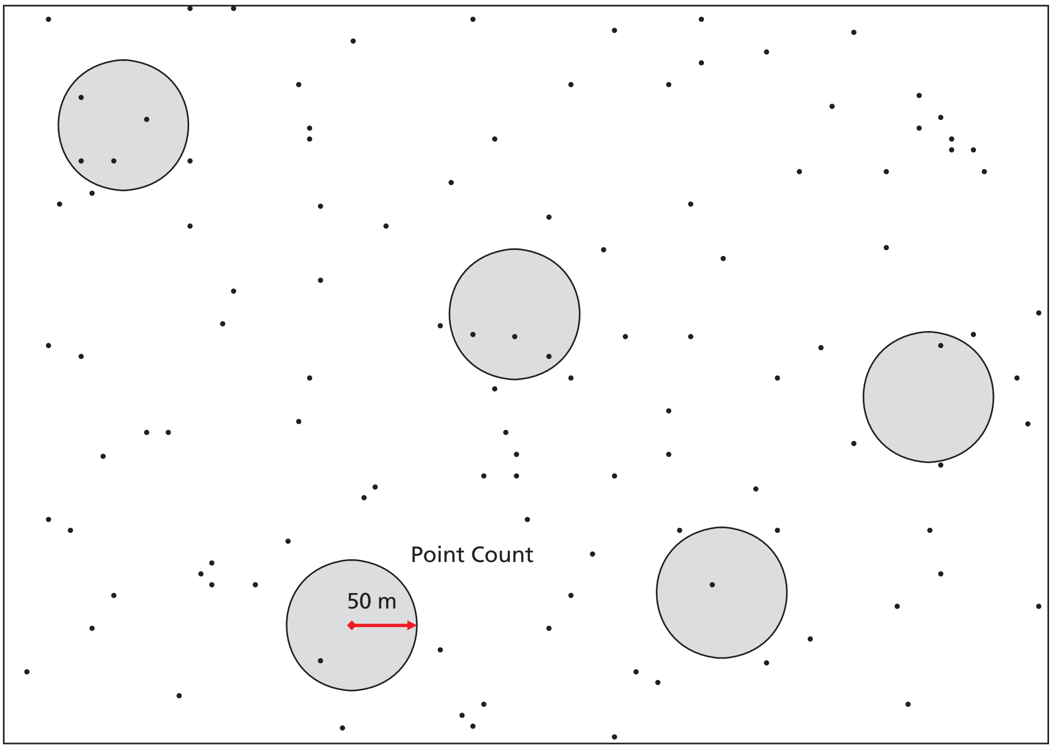
POINT COUNTS

Point counts are another of the most commonly used survey techniques for determining avian species composition and abundance. Point counts are essentially strip transects of zero length in which the observer performs the count in a 360° arc around a fixed survey station. Survey stations are randomly located throughout the study area to obtain representative samples of the species and numbers of each species present. If density estimates are desired from point counts, the counts are limited to objects within a fixed radius from the survey point. In such cases, the sampled plot becomes a circular plot of specified radius from the survey point (Figure 6.4).

As related survey techniques, many of the issues discussed for strip transects also apply to point counts. However, some important differences should be noted. Unlike strip transect surveys, point counts are usually conducted for a pre-determined and fixed period time, usually after allowing for the avian population to come to "rest" before the survey begins. Point counts are limited to ground- and boat-based surveys because observers must remain at the fixed count station.

Point count surveys have been developed for a variety of species and habitats which may not be effectively surveyed with other survey techniques. Point counts are especially useful in difficult terrain where it is not be possible to establish practical transects or per-

FIGURE 6.4
Use of point counts for estimating avian density and abundance



Note: Dots represent individual birds.

form counts while travelling along the transect line; for example ground-based surveys of wetland birds in shallow marshy habitat with soft substrates, or surveys in steep terraced agricultural fields.

Because point count observers are sedentary, they may be more likely to detect shy species that would otherwise hide and escape detection when mobile and conspicuous strip transect observers approach. Thus, point counts can be used to inventory shy and retiring "bridge" species in the immediate vicinity of poultry farms and disease outbreak sites.

Point counts based on vocal cues have been developed for situations where visual cues are limited, such as nocturnal surveys or heavily vegetated habitats. For some species, vocal cues may be the only reliable means of detection; for example, most counts of secretive rails in heavily vegetated marshes have relied on vocal cues for determining their presence and abundance. However, distances from the point count station are often difficult to determine from vocal cues, making density estimates problematic.

DISTANCE SAMPLING

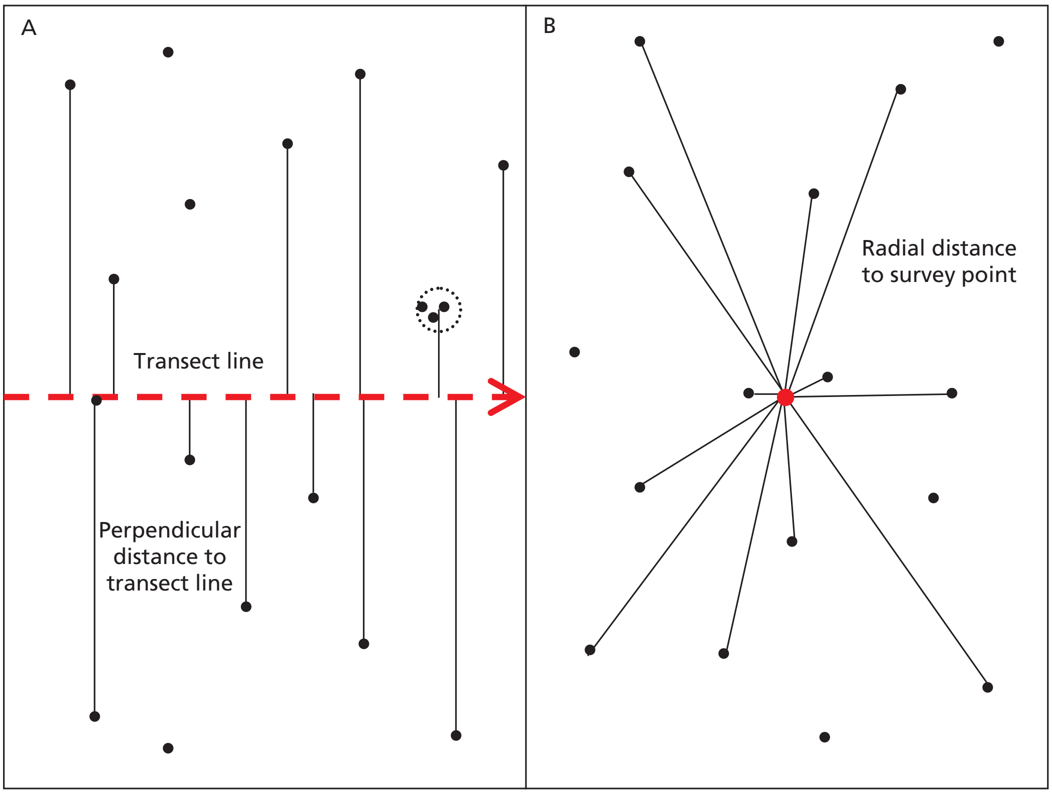
Several studies have demonstrated that a significant proportion of animals within a defined plot are overlooked during strip transect and point counts, particularly those located at distance from the transect line or survey point. Distance sampling offers an alternative to these techniques that takes into account the decreasing probability of detecting animals as distance from the observer increases. In theory, distance sampling provides more reliable density estimates and should be considered when reliable absolute density or abundance estimates (as opposed to relative measures) are important objectives of the study.

Distance sampling survey techniques are similar to strip transect and point counts, with one major exception; distance data (recorded as perpendicular distances from the transect line or radial distances from point count station) are recorded for each animal (or group of animals) observed (Figure 6.5).

Unlike strip transect or point counts, distance sampling does not assume that all individuals within a defined area are detected, but three assumptions need to be satisfied before distance sampling methodology can be used: 1) all objects on the line or point must be detected; 2) objects must be detected at their initial location, prior to any movement in response to the observer; and 3) distances must be measured accurately. In addition, a sufficient sample of observations is needed to model the detection function adequately. However, if the above assumptions and sample requirements can be met, then it is likely that distance sampling will yield more reliable population estimates than analogous estimates from strip transects and point counts.

The computer software program DISTANCE (Thomas *et al.* 1998) uses distance data to generate a detection function that models the decreasing probability of detecting an object as distance increases. DISTANCE is a very user-friendly program and offers a variety of input and analysis options, although a detailed review of distance sampling methodology is beyond the scope of this Manual. An excellent introduction to distance sampling by Buckland *et al.* (2001) provides background information and discussion of relevant issues such as model selection, data grouping and truncation, counting groups versus individuals and much more.

FIGURE 6.5
Use of distance sampling for estimating avian density and abundance



Note: Dots represent individual birds

CAPTURE-MARK-RECAPTURE

Capture-mark-recapture (CMR) studies have a long history of use for estimating population abundance, and a considerable body of literature has been dedicated to the use of CMR models. The basic theory underlying CMR modelling, in its simplest form, can be summarised as follows. Within a closed population of animals *(N)*, two samples (*n1* and *n2*), are captured, marked and released at times 1 and 2, such that the number of marked animals recaptured at time 2 (*m2*) can be accurately determined. Intuitively, the proportion of marked animals recaptured in the second sample (*m2 / n2*) should equal the proportion of the total animals captured at time 1 in the total population (*n1 / N*), or alternatively *N = n1 n2 / m2* , where *N* equals the total population size.

This basic model, the Lincoln-Petersen model, makes several assumptions that very few natural populations can meet. However, a number of modifications on this basic theme have been developed to permit CMR analyses even when the basic assumptions above are violated.

An in-depth discussion of all the different models is beyond the scope of this Manual, but references to several useful reviews are included at the end of the chapter for those seeking further information on CMR modelling. The computer program CAPTURE (Rexstad and Burnham, 1991) includes modifications of the Lincoln-Petersen model that provide population estimates with CMR data which account for unequal capture probabilities. The Jolly-Seber model is the basic CMR model for population estimates of open populations.

Programs which provide Jolly-Seber population estimates from CMR data include POPAN (Arnason and Schwartz, 1999), JOLLY (Pollock *et al*. 1990) and MARK (White and Burnham, 1999).

REFERENCES AND INFORMATION SOURCES

Arnason, A.N. & Schwartz, C.J. 1999. Using POPAN-5 to analyse banding data. *Bird Study*, 46: S157-168.

Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. 2000. *Bird Census Techniques.* 2nd edition. Academic Press, London.

Bibby, C., Jones, M. & Marsden, S. 1998. *Expedition Field Techniques: Bird Surveys.* Royal Geographical Society, London.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. & Thomas, L. 2001. *Introduction to distance sampling, estimating abundance of biological populations.* Oxford University Press, London.

Delany, S. 2005a. *Guidelines for participants in the International Waterbird Census (IWC).* Wetlands International, Wageningen, The Netherlands. (available at http://www.wetlands.org).

Delany, S. 2005b. *Guidelines for National Coordinators of the International Waterbird Census (IWC).* Wetlands International, Wageningen, The Netherlands. (available at http://www.wetlands.org).

Javed, S & Kaul, R. 2002. *Field Methods for Bird Surveys.* Bombay Natural History Society, Mumbai, India.

Lancia, R.A., Kendall, W.L., Pollock, K.H. & Nichols, J.D. 2005. Estimating the number of animals in wildlife populations. *In* C.E. Braun, ed. *Techniques for wildlife investigations and management*, pp. 106-153. The Wildlife Society, Bethesda, USA.

Pollock, K.H., Nichols, J.D., Brownie, C. & Hines, J.E. 1990. *Statistical inference for capture-recapture experiments.* Wildlife Monographs No. 107. The Wildlife Society, Bethesda, USA.

Rexstad, E. & Burnham, K.P. 1991. *User's guide for interactive program CAPTURE.* Colorado Cooperative Fish and Wildlife Research Unit, Colorado State University, Fort Collins, USA.

Thomas, L., Laake, J.L., Derry, J.F., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Strindberg, S., Hedley, S.L., Burt, M.L., Marques, F., Pollard, J.H. & Fewster, R.M. 1998. *Distance 3.5.* Research Unit for Wildlife Population Assessment, University of St. Andrews, St Andrews, UK.

White, G.C. & Burnham, K.P. 1999. Program MARK: survival rate estimation from both live and dead encounters. *Bird Study*, 46:S120-139.

Worden, J., Cranswick, P.A, Crowe, O., Mcelwaine, G. & Rees, E.C. 2006. Numbers and distribution of Bewick's Swan *Cygnus columbianus bewickii* wintering in Britain and Ireland: results of international censuses, January 1995, 2000 and 2005. Wildfowl . 56: 3-22 (also available at www.wwt.org.uk/research/pdf/worden_et_al_2006.pdf).