Bats: exit counts at bat roosts—simple visual counts

Version 1.0

This specification was prepared by Jane Sedgeley in 2012.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

Long-tailed bats start to leave roosts while it is still light and can be counted directly without the aid of cameras or video equipment. Observers outside a roost are best placed in positions where any flying long-tailed bats will be back-lit against the sky. Bat detectors can be used to alert observers to the presence of bats. Counts should begin before sunset and finish either when there is no further activity, activity has ceased for 15 minutes, or when it is too dark to see bats exiting clearly. Occasionally bats can loop around in the entrance of the roost (particularly at cave roosts) or exit and enter simultaneously. Therefore, it is frequently necessary to tally bats both exiting and entering roosts and record the net number exiting to obtain the most accurate estimate of the number of bats using the roost (Thomas & LaVal 1988; O'Donnell & Sedgeley 1999; Walsh et al. 2001; O'Donnell 2002).

Accuracy of counts will improve if several people watch the roost. It is useful to have more than one person watching a new roost site if precise exit holes are unknown and when a roost is known to have multiple exits. If large numbers of bats exit a roost, it is helpful to have one person observing the bats and the other recording the data. Alternatively, tally counters or electronic recording devices can be used as recording aids.

In some situations, such as at tree roosts, direct visual counts may be a little less accurate than counts derived from infrared cameras and video recorders. When O'Donnell & Sedgeley (1999) compared simultaneous counts of long-tailed bats derived from video cameras with direct counts made by observers, they found the observers underestimated numbers of bats by 4%. The observers most likely underestimated bat numbers because visibility from the ground was limited and bats continued to emerge after it was too dark to see them with the naked eye.

Under optimal conditions (warm temperatures, fine weather), watching roosts at dusk to see whether long-tailed bats emerge can be used as a technique for determining simple presence/absence and roost occupancy over time. Counting the number of long-tailed bats exiting a roost can also give a relatively accurate assessment of the total number of bats exiting a particular roost on a particular night. However, some bats may not leave the roost, so unless those remaining inside can be counted, the use of exit counts alone will always underestimate the total number of bats using a roost. It is seldom possible to count bats inside a tree roost, but there are techniques for counting bats roosting inside caves and buildings. See O'Donnell (2002) and 'Bats: counting inside roosts' (docdm-590915) for more details.

Roost counts are generally of limited value for obtaining accurate one-off estimates of population size or for monitoring population trends over time. Members of long-tailed bat colonies are usually spread among several communal roosts and many solitary roosts on any one night. Therefore, unless all roosts are known and are counted simultaneously, roost counts will always underestimate the total population by an indeterminate, and usually considerable, amount. Numbers of roosting bats are influenced by a range of factors such as temperature and other environmental conditions, and stage of the breeding season. Therefore, roost counts are of limited use for monitoring trends, unless factors influencing this variability are recorded and accounted for in any analyses. A few studies outside New Zealand have managed to use roost exit counts for monitoring purposes, but such approaches were statistically challenging and similar analyses have not been useful for long-tailed bats. It is very easy to misinterpret roost-count data.

It is not possible to use observers to make direct counts of lesser short-tailed bats exiting their roosts because this species does not emerge until after dark. The only method currently available for obtaining accurate roost exit counts for lesser short-tailed bats is to use infrared cameras and recorders.

Assumptions

- Bats will leave roosts.
- All bats leave the roost.
- All exit holes have been accounted for.
- All individuals are visible.

Advantages

- This counting method is simple and requires no extra time at the roost to set up complex equipment.
- Because it is comparatively low in technology and resources, it is a relatively cheap method to use.
- Using observers to count and record the number of bats exiting roosts means no extra time is required to collate data (i.e. to review videotapes, cassette tapes or download data).

Disadvantages

- This method is only suitable for long-tailed bats and cannot be used for lesser short-tailed bats.
- Sometimes it is not possible to see roost exit holes from available viewing positions.
- If environmental conditions are unsuitable (e.g. cold or wet), bats may not exit roosts.
- At tree roosts, direct visual counts may be less accurate than counts derived from infrared cameras and recorders.
- Direct counts can only be used while it is still light enough to see bats. If information is required on activity at roost sites throughout the whole night, it is necessary to use other methods such as ‘Bats: roost occupancy and indices of bat activity—infrared beam counters’ (docdm-131260).

Suitability for inventory

- Provided environmental conditions are suitable for emergence, this method can be used to determine simple presence/absence at roost sites.
- With an unobscured view of roost entrances, this method can provide an accurate count of bats exiting a particular roost on a particular night, although for tree roosts, this method is possibly not

quite as accurate as counts derived using infrared cameras. Cameras may be less efficient when trying to cover large roost exit holes such a cave entrances.

- Exit counts at tree roosts will usually be poor estimators of the number of bats using a roost because it is seldom possible to count bats remaining inside. It may sometimes be possible to count bats inside caves and buildings to achieve a more accurate count of the total number of bats using a roost (e.g. O'Donnell 2002; 'Bats: counting inside roosts'—docdm-590915).
- Roost counts are usually poor estimators of total population size. Members of a bat colony or population are usually spread among several communal roosts and a large number of solitary roosts on any one night. For example, long-tailed bats in Eglinton Valley, Fiordland, occupied communal roosts for an average of 1–2 nights, and each colony circulated around > 150 trees. They occupied on average > 7 communal roosts each night and an unknown number of solitary roosts (O'Donnell & Sedgeley 2006). These behaviours make it almost impossible to locate all long-tailed bat roost sites, and impractical to count at all known roost sites. Therefore, minimum population estimates derived from roost counts will always be directly correlated to sampling effort and the number of roosts found during the sampling period.

Suitability for monitoring

Roost counts can give a reasonably accurate assessment of the total number of bats exiting a particular roost on a particular night. In some situations, exit counts can be used to monitor trends in roost use of a particular roost over time (i.e. for how many years the roost is occupied, and by how many bats). For example, long-tailed bats have been counted intermittently at Grand Canyon Cave near Piopio for over 50 years. This includes a period when the cave was monitored more intensively over 8 consecutive years (O'Donnell 2002). However, collecting adequate roost-count data for monitoring purposes will generally be impractical and expensive in terms of time and human resources, and resulting data are difficult to interpret, due to the following factors:

- The majority of long-tailed bat roosts are in tree cavities. Long-tailed bats seldom occupy tree roosts for more than 1–2 days.
- Members of a bat colony or population are always spread among several communal roosts and a large number of solitary roosts on any one day.
- These behaviours make it almost impossible to locate all long-tailed bat roost sites, and impractical to count at all known roost sites. Therefore, minimum population estimates derived from roost counts will always be directly correlated to sampling effort and the number of roosts found during the sampling period. Trying to interpret data when sampling effort varies from year to year is problematic.
- Numbers of roosting bats are influenced by a range of factors such as temperature and other environmental conditions, and stage of the breeding season. Therefore, roost counts are of limited use for monitoring trends, unless factors influencing this variability are recorded and accounted for in any analyses.
- It is difficult to interpret simple counts from roosts. Such counts are generally highly variable, often fluctuating from night to night, seasonally, and from year to year, thus making statistical interpretation of raw count data problematic (Walsh et al. 2001).

Studies have also shown that roost counts are poor estimators for monitoring population trends in long-tailed bats over time because changes in average roost counts do not always reflect changes in population (see 'Case study A'; Pryde et al. 2005).

Skills

Unless inventory and monitoring are to be undertaken at known roosts, workers will need skills to locate new roosts, in addition to the skills necessary for conducting and interpreting the roost counts.

Skills required for finding roosts

Workers must be able to:

- Demonstrate a basic level of bushcraft and be comfortable working at night.
- Identify areas of bat activity by using bat detectors to survey for bat calls. See 'Bats: counting away from roosts—bat detectors on line transects' (docdm-590701), and 'Bats: counting away from roosts—automatic bat detectors' (docdm-590733) for more information.
- Set up harp traps or construct mist net rigs in areas of bat activity. The section on 'Catching bats' in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465) contains information on trap construction and how to place traps to optimise capture rates.
- Handle bats competently and humanely.
- Be able to identify species of bat; age, sex, and measure bats.
- Meet minimum standards—anyone wishing to catch and handle bats must receive appropriate training and must meet the minimum requirements for catching, handling, examining, measuring, and releasing bats described in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465).
- Attach radio transmitters and use radio-tracking to follow tagged bats and locate their communal roosts (see 'Bats: trapping at roosts—estimating survival and productivity'—docdm-590867).

Skills required for conducting roost counts

With minimal training, anyone can conduct direct visual counts of long-tailed bats exiting roosts. Workers need to:

- Have reasonable observational skills.
- Be able to visually identify flying long-tailed bats.
- Be able to operate a bat detector and identify bat calls.
- Be comfortable working at night in the dark, and at times alone.

Resources

At known roost sites, this counting method is comparatively low in technology and resources. Requirements are simple: one or two observers, notebooks, a watch, torches and bat detectors.

Minimum attributes

Consistent measurement and recording of these attributes is critical for the implementation of the method. Other attributes may be optional depending on your objective. For more information refer to 'Full details of technique and best practice'.

DOC staff must complete a 'Standard inventory and monitoring project plan' (docdm-146272).

The minimum attributes to record will depend on the aims of the study. If the aim is simply to document how many bats leave a roost, observers only need to record the total numbers exiting and entering, then calculate net emergence (number exiting minus number entering). If the study aims to investigate timing and patterns of emergence, it will be necessary to record exact times that bats exit and enter. It is important to record temperature and weather variables because these can influence patterns of emergence (and even whether the bats will emerge at all). Recording time of first emergence is useful for planning further counts, to ensure observers arrive at the roost in time to count all the bats.

Minimum attributes to record:

- Observer's name and contact details
- Location (place name, GPS coordinates)
- Roost type (tree cavity, under bark, cave, building, etc.) and any roost identification (roost number, cave name, etc.)
- A sketch of the roost showing location of exit holes
- Start time, finish time
- Start temperature, finish temperature
- Weather conditions (cloud cover, wind, rain)
- Time of first bat activity, i.e. the time the first bat exited or entered

Depending on aims of study, record one or more of the following:

- Total number of bats exiting and entering
- The time each bat entered or exited the roost
- Tally of the number of bats entering and exiting for defined intervals (e.g. time periods of 5 or 10 minutes)
- Net number of bats exiting the roost (number exiting minus number entering)
- Time of last bat activity, i.e. the time the last bat exited or entered

Minimum attributes can be recorded in the field on a standardised recording sheet—see 'Blank field sheet: roost counts' (docdm-131425). The blank reverse side of the form can be used to sketch the roost and provide information on the location of the exit holes and the best places to stand to observe the bats.

Data storage

Forward copies of completed survey sheets to the survey administrator, or enter data into an appropriate spreadsheet as soon as possible. Collate, consolidate and store survey information securely, also as soon as possible, and preferably immediately on return from the field. The key steps here are data entry, storage and maintenance for later analysis, followed by copying and data backup for security.

Summarise the results in a spreadsheet or equivalent. Arrange data as 'column variables', i.e. arrange data from each field on the data sheet (date, time, location, plot designation, number seen, identity, etc.) in columns, with each row representing the occasion on which a given survey plot was sampled.

If data storage is designed well at the outset, it will make the job of analysis and interpretation much easier. Before storing data, check for missing information and errors, and ensure metadata are recorded.

Storage tools can be either manual or electronic systems (or both, preferably). They will usually be summary sheets, other physical filing systems, or electronic spreadsheets and databases. Use appropriate file formats such as .xls, .txt, .dbf or specific analysis software formats. Copy and/or backup all data, whether electronic, data sheets, metadata or site access descriptions, preferably offline if the primary storage location is part of a networked system. Store the copy at a separate location for security purposes.

Roost count results are best summarised in a spreadsheet (e.g. Microsoft Excel). Columns in the spreadsheet should include all data recorded on the original field sheet because the influences of factors such as location, observer, weather, etc. need to be accounted for in future analyses. At the time of writing, there are no standardised spreadsheets or databases maintained by the DOC to store bat roost-count data.

However, counts could be recorded in the DOC bat database. Each DOC conservancy should have a separate Excel spreadsheet for this purpose, with access rights held by the conservancy bat contact (see 'Bat Recovery Group contacts'—docdm-132033). If a conservancy has not set up its own spreadsheet, one can be created using the 'National bat database template' (docdm-213136). See the 'Canterbury Conservancy bat database' (docdm-213179) for an example of a spreadsheet containing data. Many of the data entry fields will not be relevant, but there are fields for location, GPS coordinates and for comments that could be used to describe count results (Fig. 1).

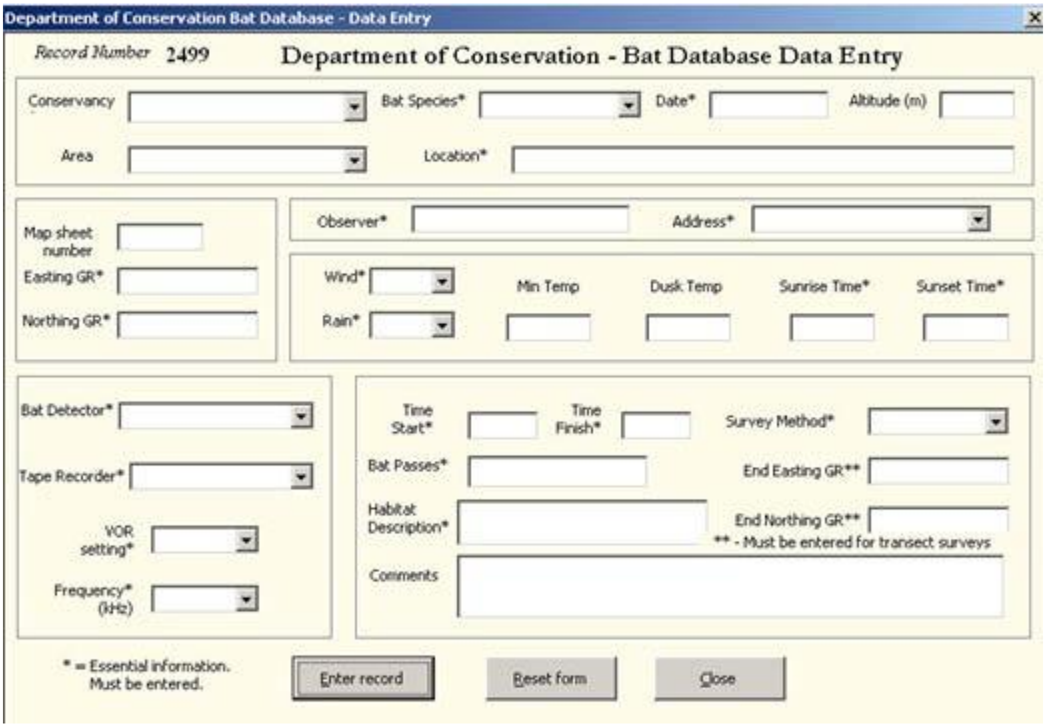

Figure 1. Data entry page from the DOC bat database.

Analysis, interpretation and reporting

Seek statistical advice from a biometrician or suitably experienced person prior to undertaking any analysis.

This method measures:

- Simple presence/absence
- Presence/absence over time (roost occupancy)
- Total number of bats exiting a particular roost on a particular night
- Changes in number of bats exiting roosts over time

Results can be presented in a number of ways. Simple statistics for comparison can be calculated, such as maximum count (either the highest number of bats exiting any roost during the sampling period, e.g. Fig. 2), or the sum of the number of bats using simultaneously occupied roosts. Alternatively, average counts per night or per year can be calculated. Raw data can be graphed and used to show daily patterns at single roosts or averaged to show seasonal patterns at several roosts (e.g. Fig. 2.) Simple interpretations include statements like: 'There were 37 long-tailed bats occupying roost number 165 in the Eglinton Valley on 10/10/03', or 'An average of 34 ± 2 SE long-tailed bats emerged from roosts in the Eglinton Valley in summer 2004'. Also see the results section in O'Donnell & Sedgeley (1999).

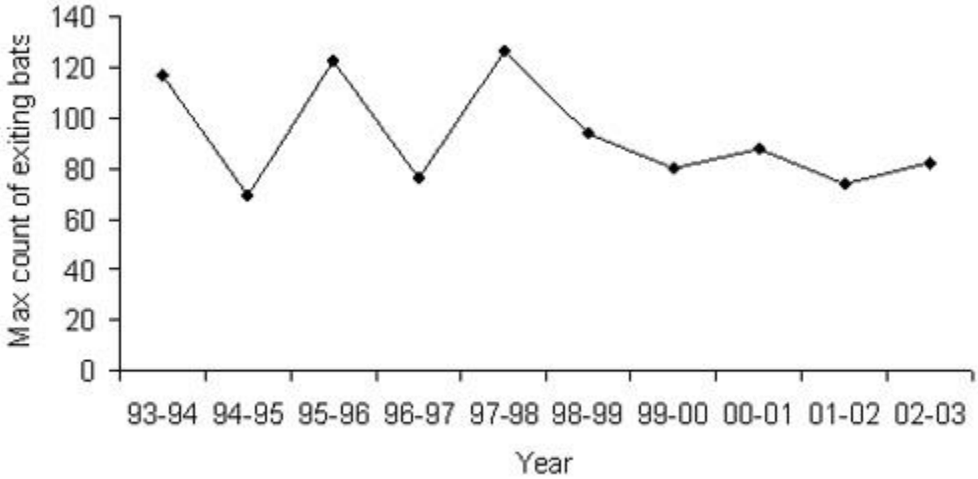

Figure 2. Graph showing highest roost count per season over a 10-year period in the Eglinton Valley, Fiordland. The number of roosts sampled varied from 14–40 roosts per season.

However, simple descriptive statistics are of limited use for inferring anything about population size and trend. Nowhere has it been demonstrated that there is a consistent correlation between numbers of long-tailed bats exiting roosts and population size. For example, studies at Grand Canyon Cave near Piopio; Eglinton Valley, Fiordland; and near Geraldine, South Canterbury show that in comparison with known numbers of banded bats, maximum roost counts for a season underestimate total population size up to 40%. The maximum count of bats using Grand Canyon Cave was 250 bats roosting inside and 338 exiting, but total number of bats banded at the cave is 1874 bats. In the Eglinton Valley study, long-tailed bats occupied several tree roosts on any given day, but it was not possible to conduct counts simultaneously. The maximum number of bats observed exiting an individual roost was 126 bats, far less than the total number of > 300 banded bats in the study area. This was also the case for roost counts made in South Canterbury where the maximum number of bats exiting individual tree roosts was 32 bats, but there were > 150 banded bats present in the study population.

Case studies A and B provide examples of how difficult it can be to interpret trends from the raw data of simple roost exit counts. Case study A shows that exit counts from roost trees occupied during summer months in the Eglinton Valley did not reflect the population declines that were evident from a mark-recapture study (Pryde et al. 2005). Case study B shows that data from roost counts undertaken as part of the National Bat Monitoring Programme in the UK were being misinterpreted. In some cases, the initial interpretation of simple counts resulted in researchers suggesting populations were declining, whereas the correct statistical analysis indicated the opposite trend (Walsh et al. 2001).

Case study A

Case study A: visual counts of long-tailed bats exiting roosts in the Eglinton Valley as a method for monitoring changes in population size

Synopsis

Long-tailed bats are classified as an endangered species and at the beginning of this study (1993) there was a perception that the species was declining. At the time, there were no techniques available to assess whether populations were decreasing, stable or increasing. Undertaking exit counts at tree roosts was one of the methods used to assess trends in a population of long-tailed bats in the Eglinton Valley, Fiordland.

Objectives

The aim of this case study is to assess whether changes in roost exit counts reflected changes in the bat population, by comparing roost counts with results from a concurrent mark-recapture study.

Sampling design and methods

Roosts were located by following radio-tagged bats (caught on their foraging grounds) to tree cavities each day during summer field trips. The bat population was spread over many roosts on any one night and it was usually impossible to count more than one roost on any given night because of logistical and practical constraints. Roost exit counts began 30 minutes before sunset and finished when it was too dark to see.

Roost counts were compared with population estimates derived from a mark-recapture study (Pryde et al. 2005). In that study, bats were caught and recaptured annually in a random sample (< 10%) of roosts using harp traps (Sedgeley & O'Donnell 1996) during January and February, when young of the year began flying. Bats were marked with 2.9 mm flanged bat bands (from The Mammal Society, UK).

Results

Overall, 357 roost exit counts were made. The count data is graphed in Fig. 3. Average counts showed little fluctuation from year to year and maximum counts were highly variable, showing no particular trend or pattern.

In the mark-recapture study, bats were caught in a consistent manner over the 10-year study period, and 5286 captures, representing 1026 individuals, were made. Three methods of population estimation were used to analyse the bat capture data (program MARK, minimum number alive (MNA), and population viability analysis (PVA)). In contrast with the count data, all three population estimates derived from capture data showed a clear trend of decline, driven largely by population crashes in 1996 and between 1999 and 2001 (Fig. 4). See Pryde et al. (2005) for more details.

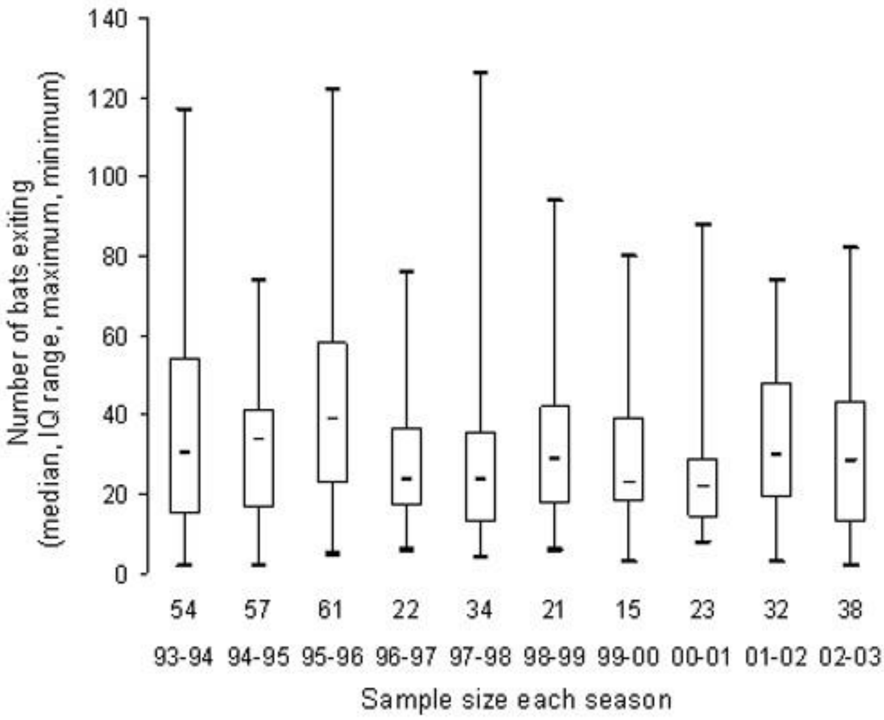

Figure 3. Graph showing mean number of long-tailed bats (median, inter-quartile (IQ) range, maximum, minimum) exiting roosts over a 10-year period between 1993 and 2003. Sample sizes (number of roosts) for each year are shown on the *x*-axis.

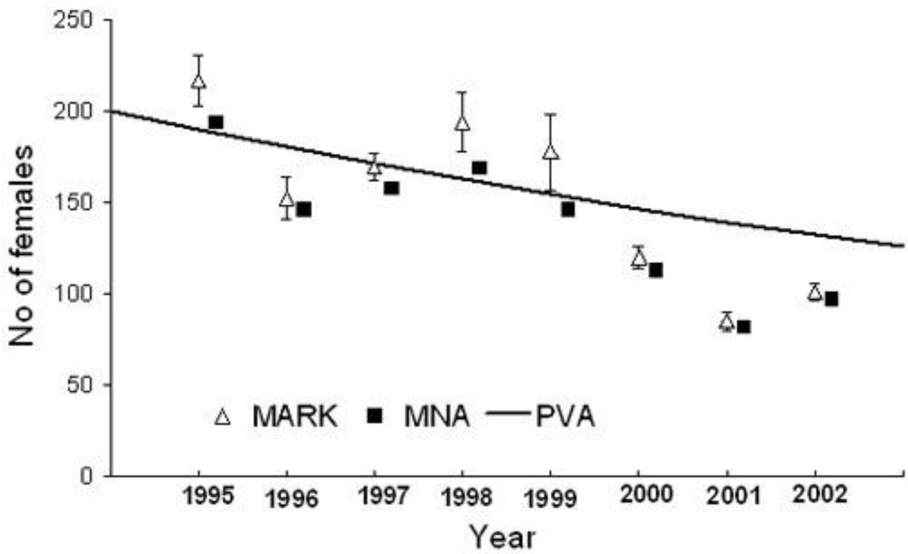

Figure 4. Graph showing three methods of population estimation of adult female long-tailed bats in the Eglinton Valley, Fiordland, from 1995 to 2002. Data points labelled MARK use the recapture rates from program MARK, MNA indicates the minimum number alive per year, and PVA uses the survival rates from MARK combined with productivity rates in a matrix model. All methods combine the data for three sub-populations. In contrast with roost-count data (Fig. 3), declines were identified in 1996 and 1999–2001 (after Pryde et al. 2005).

Limitations and points to consider

These results suggest that for long-tailed bats, exit counts at roosts may not be sufficient to pick up changes in numbers of bats at the population level.

Interpreting long-tailed bat roost-count data is extremely problematic. Banding data showed that the minimum number of banded bats alive in the Eglinton Valley study area was around 300 bats. However, the maximum roost count in the study was 126 bats. Therefore, the entire population probably never roosted together in the same tree during the 10-year study period. Average roost counts were around 34 bats, which is presumably the optimal roosting group size in Eglinton Valley. This means colony members are usually spread among several communal roosts and a large number of solitary roosts on any one day. Bats also changed roost sites almost every day and banding data showed composition of individuals using roosts also changed on a regular basis.

An examination of the banding data revealed why roost counts did not reflect changes in the population. The bat population was split into three sub-colonies or roosting groups. Each group had a distinct roosting area and individuals belonging to one group seldom roosted with individuals from another group. The population declines in 1996 and 2001 were associated with increases in numbers of introduced predators. Although only one of the three roosting groups was affected, all but eight of its members disappeared, presumably by being preyed upon. However, because members of the three sub-colonies seldom mixed, the average roost count did not change, despite loss of one third of the population.

Population estimates from roost counts can be improved by locating as many roosts as possible in an area and conducting exit counts simultaneously (e.g. as occurred in the lesser short-tailed bat monitoring programme in Rangataua Forest, see Specht 2002) and summing maximum counts. However, this approach is likely to be prohibitively expensive for long-tailed bats because such a study would require a large number of radio-transmitters, radio-tracking equipment, and personnel to locate roosts, and it would be virtually impossible to locate all long-tailed bat roost sites in an area.

Results from this case study suggest that mark-recapture methods to estimate long-tailed bat population size and survival are more appropriate methods for monitoring population trends. See 'Bats: trapping at roosts—estimating population size' (docdm-590819) and 'Bats: trapping at roosts—estimating survival and productivity' (docdm-590867) for further information.

References for case study A

Pryde, M.A.; O'Donnell, C.F.J.; Barker, R.J. 2005: Factors influencing survival and long-term population viability of New Zealand long-tailed bats (*Chalinolobus tuberculatus*): implications for conservation*. Biological Conservation 126*: 175–185.

Sedgeley, J.A.; O'Donnell, C.F.J. 1996: Harp-trapping bats at tree roosts in tall forest and an assessment of the potential for disturbance. *Bat Research News 37*: 110–114.

Specht, P. 2002: Short-tailed bat population census 2002. Report to the Department of Conservation, Ōhakune Field Centre, Ōhakune (unpublished).

Case study B

Case study B: using appropriate analysis tools for monitoring population change: the example of lesser horseshoe bats in the UK

Synopsis

Effective bat conservation relies on gathering information to identify changes in populations that are of conservation concern. Like conservation managers in New Zealand, bat researchers in the UK have been investigating ways of treating roost counts as indices of relative abundance in an effort to monitor population trends in threatened bats (National Bat Monitoring Programme (NBMP), Walsh et al. 2001). The NBMP uses field and waterway surveys on foraging grounds, and counts at summer maternity colonies and hibernation sites to survey and monitor 17 species of bats. While developing this programme, the UK researchers identified and demonstrated the need for more detailed and specialised statistical analysis of roost count data to examine population trends. Early single-species case studies showed that simple counts were being misinterpreted; in some cases initial interpretation of simple counts resulted in researchers suggesting populations were declining, whereas the correct statistical analysis indicated the opposite trend (Walsh et al. 2001).

Objectives

The primary aim of the NBMP is to produce statistically-defensible population trend data for all resident UK bat species. The objective of this case study is to describe some of the lessons learnt from analysis of counts of lesser horseshoe bats (*Rhinolophus hipposideros*) at roost sites—particularly the need for correct statistical analysis so that potential trends in counts are not misinterpreted.

Sampling design and methods

Lesser horseshoe bat colony counts are undertaken between 29 May and 17 June annually. Surveyors are asked to count numbers of bats emerging from roosts at sunset on two evenings during the survey period. Surveyors choose their own roosts. In 2005, c. 40 volunteers counted at 99 sites across the known range of the species in the south-western UK (Bat Conservation Trust 2005).

Results

There are now many complex statistical modelling techniques widely available to assist with analysing bat counts. For example, a wide range of Generalized Linear Modelling techniques (McCullagh & Nelder 1989) are now much more accessible, and are included in most statistical software packages. Non-linear modelling is also more achievable using the larger statistical packages (e.g. SPLUS and R).

These techniques have been applied to counts of lesser horseshoe bats in an effort to elucidate population trends.

Several interpretations of the lesser horseshoe bat survey data have been published. The interpretations varied because (a) analyses were conducted at different stages of the monitoring programme, and (b) data were analysed using different statistical techniques. A decrease in average counts of bats from UK roosts in the first 3 years of the programme (1993–1995) raised early concerns about an apparent decline in this species (A. Walsh, pers. comm.) (Fig. 5). However, a different picture emerged when a formal analysis of count data from roosts in Wales was conducted. Warren & Witter (2002) analysed 5 years of count data along with environmental variables, and showed there was no statistically significant change in the number of bats counted during the monitoring period (1993–1997). These results suggested the lesser horseshoe bat population in Wales was stable (Fig. 6). After 7 years, however, data were re-analysed using two different models (restricted maximum likelihood (REML) and a generalized linear model; Fig. 5). Each method demonstrated slightly different mean counts of bats, though both indicated increases in the population rather than a decline or a stable population as reported earlier (Walsh et al. 2001).

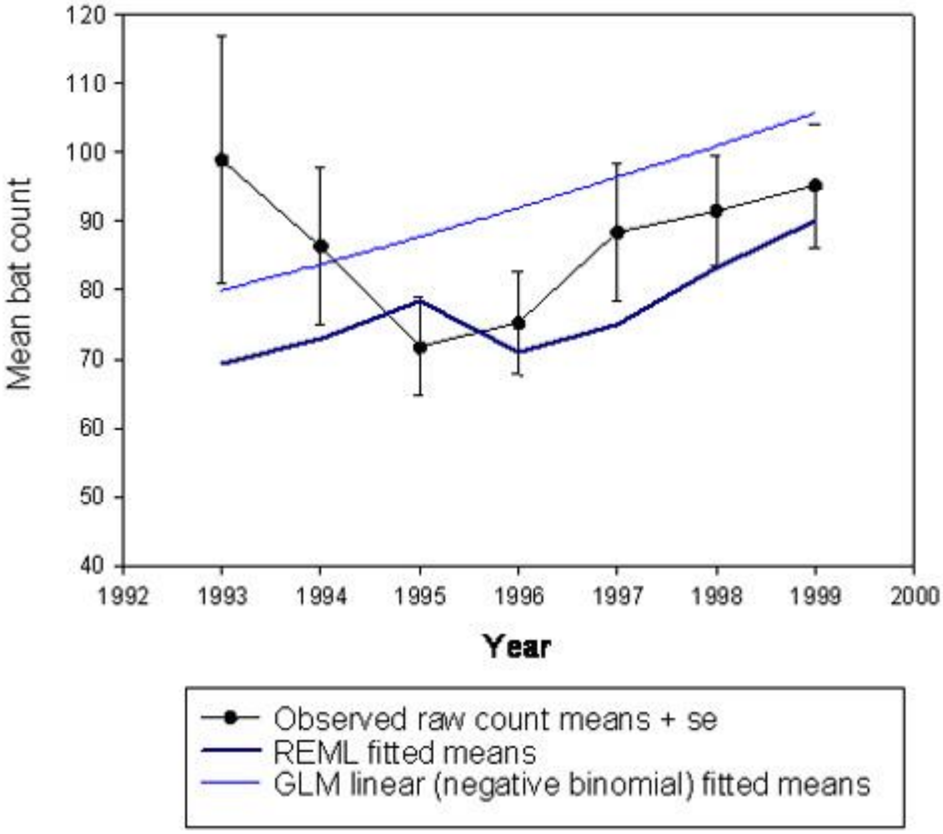

Figure 5. Comparison between raw counts and modelled counts (fitted means) for lesser horseshoe bats at breeding colonies throughout the UK (after Walsh et al. 2001).

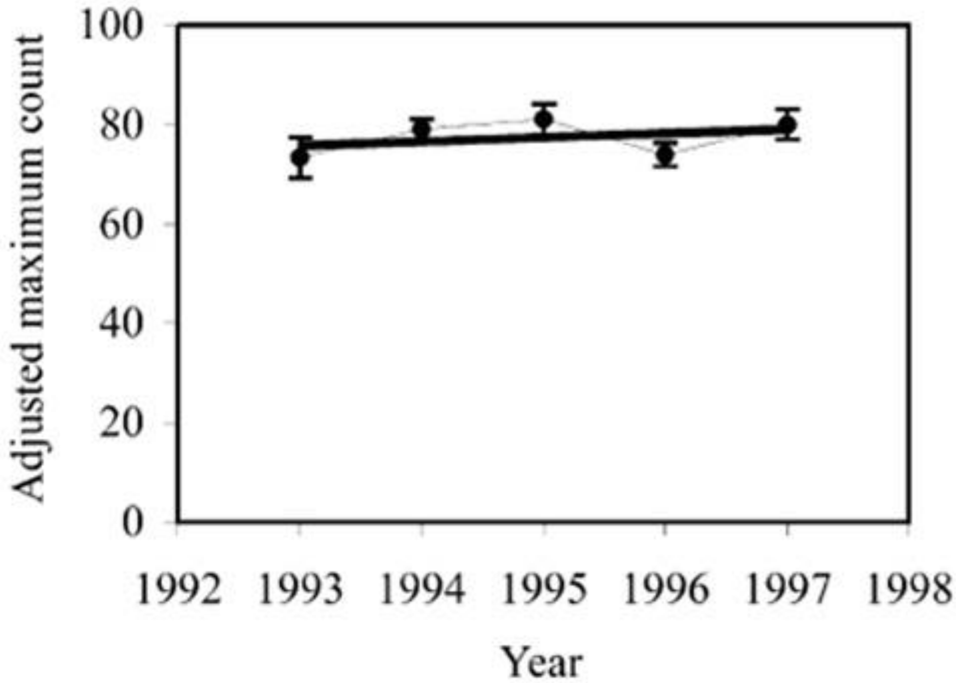

Figure 6. Maximum counts of lesser horseshoe bats at breeding colonies in Wales observed at each site within each year, controlling for significant terms of the final statistical model in relation to Year ($y = 0.82x–1558.4$, $R2$ = 0.135) (after Warren & Witter, 2002).

Limitations and points to consider

One reason why the fitted mean counts are different when using different analysis methods is that the statistical modelling procedures attempt to account for variation in counts that results from changes in environmental factors (e.g. temperature), which raw counts cannot. These environmental factors can have a profound effect on conspicuousness of bats. Unfavourable conditions can just as easily account for a low raw count as an actual change in population size.

Computer processing speeds now enable better access to General Additive Models (GAMs), which are a non-parametric approach to modelling, useful for zero-inflated data and data that combine both categorical and continuous variables (Barry & Welsh 2002; Borchers et al. 2002). The lesser horseshoe bat counts are now being analysed using GAMs, which provide a more accurate trend. Rather than vindicating earlier fears about population declines, these new data indicate a steady, statistically significant trend, and the average annual increase in colony size is now estimated to be 5.6% (Fig. 7) (Bat Conservation Trust 2005).

There are still some significant limitations to just using colony counts to monitor trends. Colony counts in the NBMP are restricted to areas where the species of interest is known to occur: no potential sites are monitored (i.e. sites where a colony is not present but could be in the future). Colony counts are likely to be effective for monitoring population change only if it is rare for new colonies to be established. Sampling only known roosts means there is no measure of the rate that new colonies are established or their effect on population trends. Little is known about the extent of new colony establishment so it is difficult to assess the magnitude of the issue. Species such as the lesser horseshoe bat are assumed to form new roosts only occasionally (because they have very specific roost requirements), and the chances of possible erroneous trends derived from colony counts may not be as high as for other species with less stringent roost requirements.

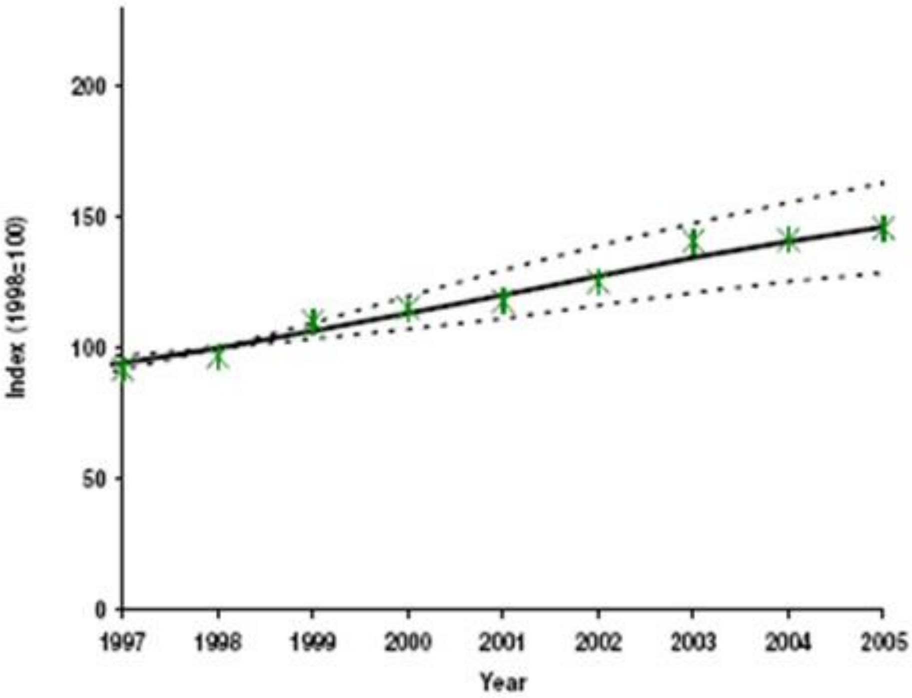

Figure 7. Index of population change for lesser horseshoe bats at breeding colonies using General Additive Models to analyse counts (Bat Conservation Trust 2005).

References for case study B

Barry, S.C.; Welsh, A.H. 2002: Generalized additive modelling and zero inflated count data. *Ecological Modelling 157*: 179–188.

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Walsh, A.; Catto, C.; Hutson, A.M.; Racey, P.A.; Richardson, P.; Langton, S. 2001: The UK's National Bat Monitoring Programme. Department of Environment, Transport and the Regions Contract Report No. CR018. The Bat Conservation Trust, London.

Warren, R.D.; Witter, M.S. 2002: Monitoring trends in bat populations through roost surveys: methods and data from *Rhinolophus hipposideros. Biological Conservation 105*: 255–261.

Full details of technique and best practice

How to conduct a count

Long-tailed bats start to leave roosts at dusk while it is still light. They can simply be counted by observers, without the aid of cameras or video equipment. One or more observers are placed in positions where any flying long-tailed bats will be seen back-lit against the sky. Bat detectors can be used to alert observers to the approach of bats. Long-tailed bats frequently roost high up in trees and are seldom disturbed by observers talking quietly. However, bats using low roosts may be disturbed by noises close to the entrance and emergence may be affected. Noise must be minimised within 20 m of a roost.

In some situations, it is useful to have more than one observer. Depending on the location of the exit holes, or position relative to the forest canopy, it may be difficult to find an observation point where exiting bats will be back-lit. Sometimes the exact exit hole is unknown. In these situations it is good practice to have two or more observers placed in different positions to undertake independent counts. This is useful for validating counts if there are large numbers of bats present. It may be easier to have one person observing the bats and one person recording. Alternatively, a simple tally counter or electronic recording device (e.g. tape recorder, MP3 recorder or mobile phone) can be used as a recording aid.

It is important to tally bats both exiting and entering roosts. Sometimes during early emergence, bats will loop in and out of the entrance, a behaviour known as light-sampling. This doesn't happen very often at tree roosts, but is a common occurrence at caves. Occasionally, individual bats return to the roost after short foraging flights while other bats are still exiting. Without keeping a strict tally of 'ins' and 'outs' the same bats could be counted at least twice, resulting in an overestimate of the total number of bats exiting. The difference between numbers flying in and out gives the net number exiting.

If a roost contains a large number of bats (such as at Grand Canyon Cave), it is helpful to have two people counting at the same exit, either one tallying bats flying out and the other tallying bats flying in, or one person calling out both in and out observations with the other person recording. A third system involves one person keeping the tally by using two mechanical tally counters—one in each hand. Bats seldom emerge in a single stream; they often emerge in bursts with gaps between. If observers are interested in timing and patterns of emergence, bats can be counted at intervals. This approach can also be useful when dealing with large numbers of emerging bats. A previously prepared standardised recording sheet with clearly separated columns to tally 'ins' and 'outs' is also very useful (see 'Blank field sheet: roost counts'—docdm-131425). Alternatively, electronic recording devices can be used in the field and the information can be transcribed into datasheets and databases at a later date.

Colonies of long-tailed bats roosting in trees are generally relatively small, with < 100 bats present at one time. If numbers are low, it is often possible to record emergence time for almost every individual.

Timing

In the Eglinton Valley, long-tailed bats can emerge up to 1 hour before sunset, but most start emerging between 20 minutes before and 20 minutes after sunset. Therefore, roost counts must begin at least 30 minutes before sunset. Because bats often emerge in bursts with gaps between, and juveniles emerge significantly later than adults, it is difficult to know precisely when to end a count. To ensure as complete a count as possible, the count must continue until it is too dark to see. Unfortunately, newly-fledged bats frequently do not emerge until after all the adults have left, and then it is too dark to see them with the naked eye.

What to record

A standardised recording sheet should be used (see 'Blank field sheet: roost counts'—docdm-131425). Date, location and a basic description of the roost and its exit holes are essential to help with future counts. Long-tailed bats use a large number of roosts and only occupy them for 1–2 days, but they return to the same roosts every season (O'Donnell & Sedgeley 2006).

To help assess how accurate a count is, the start time, end time, and time of first bat emergence should also be recorded. A range of variables including time of year, temperature and weather can affect bat activity. It is important to collect data on a range of environmental variables as this may help interpretation of results. If observers are interested in timing and patterns of emergence, exit times can be recorded for individual bats or 'bursts' of bats.

Best practice for counting long-tailed bats exiting roosts

- It is helpful to mark a trail into roost sites in the forest using coloured and/or reflective tags so that it is easy to find the route back out in the dark.
- Counts must begin at least 30 minutes before sunset.
- There should be a minimum of two observers for new roost sites.
- Bat detectors should be used to aid counts.
- Number of bats flying in and flying out should be tallied, with the net result used to estimate total bats exiting.
- Counts should finish when it has become too dark to see exiting bats.
- Start and end time of counts should be recorded, as well as time of first and last bat emergence.
- Environmental variables, including temperature and weather conditions, must be recorded in order to interpret results.

References and further reading

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Appendix A

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

docdm-132033	Bat Recovery Group contacts
docdm-590733	Bats: counting away from roosts—automatic bat detectors
docdm-590701	Bats: counting away from roosts—bat detectors on line transects
docdm-590915	Bats: counting inside roosts
docdm-131260	Bats: roost occupancy and indices of bat activity—infrared beam counters
docdm-590819	Bats: trapping at roosts—estimating population size
docdm-590867	Bats: trapping at roosts—estimating survival and productivity
docdm-131425	Blank field sheet: roost counts
docdm-213179	Canterbury Conservancy bat database
docdm-131465	DOC best practice manual of conservation techniques for bats
docdm-213136	National bat database template
docdm-146272	Standard inventory and monitoring project plan