Bats: counting away from roosts—automatic bat detectors

Version 1.0

This specification was prepared by Jane Sedgeley in 2012.

Contents

Department of Conservation
Te Papa Atawhai

Synopsis

Many bat species use a form of sonar known as echolocation to navigate, orientate and forage. The frequency of bat echolocation calls is generally much higher than humans can hear (ultrasonic). Bat detectors can be used to listen to these calls, and are useful tools to unobtrusively survey, monitor and identify bat species. Bat calls are picked up by the detector's microphone and transformed into lower frequencies that are heard on the detector as series of clicks as a bat flies into and out of range. A series of these audible clicks is defined as a ‘bat pass’. DOC uses the Batbox III bat detector as its standard. These detectors are best tuned to 40 kHz to pick up calls of long-tailed bats and 28 kHz to pick up calls of lesser short-tailed bats. The ‘DOC best practice manual of conservation techniques for bats’ (docdm-131465) provides more information on bat detectors and bat call identification.

Both long-tailed bats and lesser short-tailed bats can be surveyed remotely by using automated systems that record and store ultrasonic bat calls. Several automated detection and recording devices have been developed that use different types of bat detectors and different methods for storing data (e.g. O'Donnell & Sedgeley 1994; automatic bat monitors, Fig. 1). Consequently, relative effectiveness and costs vary. Many systems include timers, delay switches or are activated only when a bat call is detected. This means units can be left in the field for part of a night, a full night or several nights. The DOC Electronics Workshop has developed a device that is in common use (Fig. 1) and is known as an automatic bat monitor (ABM). However, this device is currently being replaced with a smaller and lighter version. There are also two other automatic systems being developed at the time of writing. The Bat Recovery Group leader should be contacted for further information.

There are no strict guidelines describing sampling effort for surveying bats in New Zealand using automatic bat detection and recording devices. Recommendations for the number of sampling nights will vary according to the number of automatic units available, resources, terrain, habitat type and area requiring coverage. If the objective is simply to determine presence of bats, and calls are recorded the first night, units may be moved on to a new site. However, because bat activity is strongly influenced by weather conditions, it is often necessary to leave the units in place for several nights to ensure the sampling period includes nights of fine weather.

An example of a survey approach for inventory is to set out 10–20 ABM units positioned at a minimum distance of 200 m apart (with ad hoc placement). They should be left in place for 1–6 fine-weather nights before moving them on to another site within the study area. A minimum of 2 weeks should be spent in a study area during summer through to autumn/March. On-site sampling conditions should also be standardised as closely as possible (i.e. same number of units, same layout in the same location). Counts derived from stationary automated bat call detection systems are useful for answering inventory questions such as: Are there bats present in an area? What is their distribution in an area? Automated systems are particularly useful for investigating what kind of habitats bats are using. If numerous bat passes are recorded during a night, and from a large number of sites in a study area, it is likely there is a reasonable-sized population of bats present. However, if passes are rare or absent, the results of the survey could equally reflect the inconspicuousness of the bats or unsuitable environmental conditions.

The efficacy of collecting bat calls using automatic detection and recording devices for monitoring of populations has not been formally evaluated. However, counts of calls are likely to have limited value for monitoring because: (a) large numbers of zero counts and highly variable counts make it difficult to detect population trends from raw data; and (b) the number of bat passes recorded does not necessarily relate to the number of bats encountered. Thus, recording the number of bat passes provides an index of activity. This means relative abundance can only be estimated coarsely (e.g. you can conclude that bats are common, uncommon or rare).

Hand-held bat detectors can also be used manually to detect bat calls. For more details on using bat detectors manually, see 'Bats: counting away from roosts: bat detectors on line transects' (docdm-590701). There are several differences to note in relation to use of hand-held detectors compared with automatic systems. Stationary automatic bat detector and recording devices can sample bat activity over many hours and several nights, but they have a limited bat detection range. Multiple units are required to sample larger areas effectively. Therefore, equipment costs are often high, but fewer people are required to conduct the work. In contrast, walking along transects with hand-held detectors means a large area can be covered quickly, but time spent at each location is relatively short. This means equipment costs are far less, but several people are required to cover a large survey area. Line transects are not suitable for surveying lesser short-tailed bats.

Figure 1. The 2007 model of DOC's automatic bat monitor (ABM).

These devices incorporate a voice-activated tape recorder and a timer which enable the unit to be run in the field for several days. Newer units incorporate digital technology. The DOC Electronics Workshop should be contacted to find out further details and recent developments.

Assumptions

- All bats calling within the bat detector range are detected. (For more details, see 'Background to bat detectors' in the 'DOC best practice manual of conservation techniques for bats'—docdm-131465)
- If survey conditions have been standardised, then all individuals are equally detectable.
- Provided survey conditions are optimum and standardised, the level of bat activity (number and frequency of passes) is related to relative abundance (O'Donnell 2000; O'Donnell & Sedgeley 2001).
- High activity = bats are relatively abundant.
- Little or no activity = bats are relatively rare/uncommon.

Advantages

- Bat activity can easily be sampled throughout an entire night, remotely.
- Many systems include timers, delay switches or are activated only when a bat call is detected. This means units can be left in the field for several nights.
- The method does not require numerous trained field assistants.
- Many person-hours of fieldwork can be avoided.
- Standardised units are available from DOC.
- Output from bat detectors is automatically recorded and stored. A permanent record is useful for retrospectively checking species identification.

Disadvantages

- It is not easy to distinguish between calls of long-tailed bats and lesser short-tailed bats without moderate training and experience. Without sound-analysis software some bat calls are ambiguous (usually < 5% of calls), even to trained personnel.
- Extracting and processing bat call data (e.g. listening to recordings, downloading computer files) and interpreting results (e.g. using computer sound analysis packages) can be time consuming. Listening to recordings that contain environmental noise such as rainfall can be particularly problematic. However, some of the newer units have the capacity to switch off when it rains, and systems currently under development may be able to provide more automated methods for classifying species and counting calls.
- Different listeners can introduce observer bias. The use of paired units, different types of bat detector and different methods of data storage can resolve most of these issues, but this may not prove to be cost-effective.
- Individual automatic systems, even those of the same design and from the same manufacturer, often vary in their sensitivity to bats and will therefore require regular calibration.
- Stationary units have a relatively small sampling area. Therefore, to sample effectively, multiple units are required and these can be costly.
- The ABM units most commonly used by DOC at the time of writing have several limitations:
  - — The units are technologically complex. They are made up of several components, which all require regular maintenance.
  - — They are relatively expensive, making it costly to purchase the multiple units needed to provide good survey coverage.
  - — The units are fairly large and heavy, so it is difficult to carry large numbers of units around in the field.

However, the DOC Electronics Workshop is currently field testing new units that are designed to address these limitations.

Suitability for inventory

- Stationary automatic systems are suitable for recording presence of both long-tailed bats and lesser short-tailed bats (but some detectors need to be set on different optimum frequencies to pick up each species; see 'Skills').
- Data can be used to answer inventory questions such as: Are there bats present in an area? What is their distribution in an area? Which species are present?
- Stationary automatic systems are particularly useful for investigating bat habitat use because several units can be placed to sample different habitat types simultaneously.
- Stationary automatic systems are excellent for simultaneous inventory of numerous sites over several consecutive nights.

Suitability for monitoring

- Stationary automatic detection and recording units are particularly useful for investigating what kind of habitats bats are using in an area over time, because several units can be placed to sample different habitat types simultaneously.
- Recording the number of bat passes provides an index of activity. However, the relationship between amount of activity and number of bats in a population has not been determined. This means relative abundance can only be estimated coarsely (e.g. bats are common, uncommon or rare).
- If bats are uncommon or patchily distributed, results can be highly variable; probably more variable than results obtained using the 'Bats: counting away from roosts: bat detectors on line transects' (docdm-590701) method.
- Large numbers of zero counts and highly variable counts make it difficult to detect population trends from raw data.
- Raw statistics can be misleading when trying to detect trends because environmental conditions have a huge influence on activity levels (O'Donnell 2000). These statistics need to be subjected to in-depth statistical modelling to separate variability in environmental or sampling conditions from the actual variation in bat population size. Even if this is done, no one has yet established whether there is a consistent relationship over time between amount of bat activity and trends in population size.

Skills

- In theory, setting up automatic units in the field should be relatively simple. However, many of the ABM units used by DOC at the time of writing are technologically complex, and are often difficult to set up in the field. Moderate training is required to ensure units are functioning correctly, maintained regularly and calibrated properly.
- Workers must be able to identify bat calls from other sounds picked up on bat detectors, and be able to distinguish between long-tailed bats and lesser short-tailed bats calls. See 'Full details of technique and best practice' for more information.

- Automatic detection and recording devices that contain heterodyne bat detectors need to be tuned (e.g. Batbox III detectors which are most commonly used by DOC). The detector dial needs to be set to 40 kHz to pick up calls of long-tailed bats or 28 kHz to pick up lesser short-tailed bats.
- Recorded calls can be sent to more experienced bat workers to obtain assistance with identification. The DOC Bat Recovery Group leader or the DOC conservancy bat contact should be able to provide a list of useful people who can help with identification (see 'Bat Recovery Group contacts'—docdm-132033).
- Workers must be able to identify and quantify 'bat passes'. Passes are defined as a sequence of two or more echolocation clicks and a period of silence separating one bat pass from the next (Furlonger et al. 1987). See 'Full details of technique and best practice' for further information.
- Workers must be comfortable with working at night in the dark, and at times working alone.
- Workers must demonstrate at least a basic level of bushcraft.

Resources

This method is costly in terms of equipment. Multiple units are required to sample effectively, and these can be costly. The ABM devices most commonly used in DOC can be purchased or borrowed from the DOC Electronics Workshop, Wellington. The DOC Electronics Workshop has some capacity to develop new automatic bat detection and recording systems and this group should be contacted to discuss new options.

It is important to allocate adequate time for extracting (e.g. listening to recordings, downloading computer files), processing and interpreting bat call data (e.g. identifying bat species, counting calls and entering them into a spreadsheet and DOC database). This part of the process can be very time consuming. New systems that are under development may be able to provide more automated methods for identifying, counting and storing bat calls.

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).

Minimum attributes to be collected per unit per night:

- Observer's name and contact details
- Location (place name)
- GPS coordinates
- Date
- Dominant vegetation and habitat type (e.g. beech forest edge, podocarp forest interior, riparian willows, cabbage trees)

- Unit identification number and settings
  - Tape recorder model, sensitivity and voice activation level
  - Bat detector model
  - Bat detector frequency
  - Timer settings (e.g. set to turn on at 19:00 hrs, off at 07:00 hrs)
- Weather conditions for each day the detector was left out in the field
- Daily minimum, maximum and dusk temperatures
- Number of bat passes per hour, and a tally of the totals per night

Summary attributes for survey to be collected for several nights of sampling or when multiple units are deployed:

- Survey start date
- Survey finish date
- The total number of units used
- The total number of days each unit is left in the field
- The total number of fine-weather nights sampled
- The total number of bat passes for the entire sampling period per unit

If researchers are interested in indexing foraging activity in different areas or habitats the following attribute will also need to be recorded:

- Number of terminal/feeding buzzes per hour, and a tally of the totals per night. See 'Full details of technique and best practice' for a definition of feeding buzzes.

Minimum attributes can be recorded on standardised automatic detection forms. 'Field sheet for recording bat passes using ABMs' (docdm-133273) includes two forms:

- The first is a field sheet for recording minimum attributes required for each night of sampling (i.e. the first set of bullet points above). One field sheet should be filled in per unit per night sampled.
- The second sheet is a summary sheet for recording information collated from several nights of sampling, either from one unit left in place for several nights, or from multiple units at the same site. (The summary sheet covers the attributes listed in the second set of bullet points above).

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.

All bat sightings should be recorded in the DOC bat database. Each DOC conservancy should have a separate Excel spreadsheet for this purpose (Fig. 2). Access rights are 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.

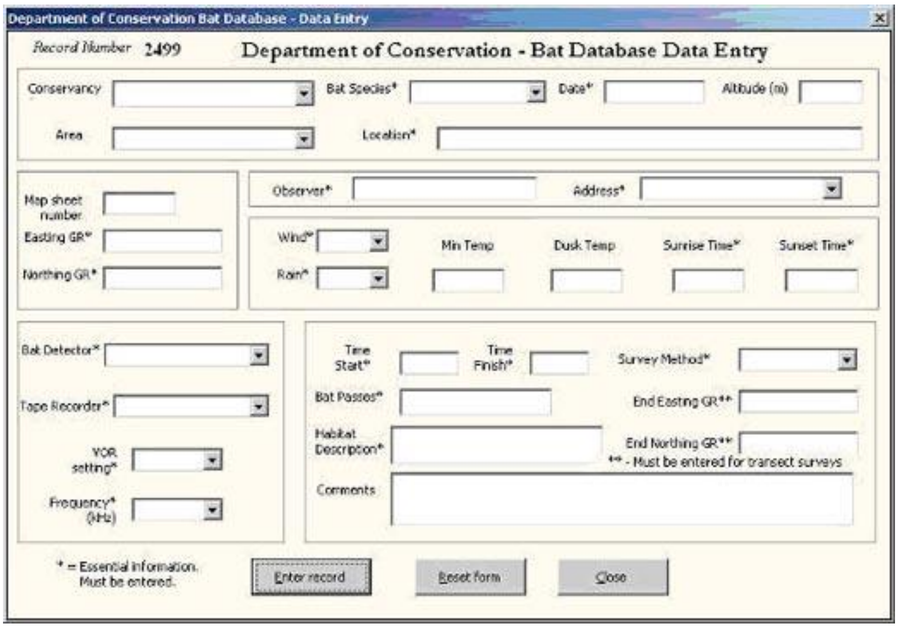

Figure 2. Screenshot illustration of data entry page from the DOC bat database.

Analysis, interpretation and reporting

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

This method measures:

- Presence of bats
- Number of bat passes per point or per hour or per night surveyed
- Index of activity for a specific place and time

- Distribution and habitat relationships (bat passes per habitat type)

Results are best summarised in a spreadsheet (e.g. Excel). Columns in the spreadsheet should include all data recorded on the field sheet, because the influences of factors such as weather conditions, observer, temperature, etc. need to be accounted for in any analysis.

Presenting results

Results can be presented in a number of ways. Distribution maps of where bats were either detected or not detected can be drawn (e.g. Fig. 3), or the frequency of occurrence of bats on each survey, or average number of bat passes per survey graphed. Simple statistics for comparison can be calculated, such as number of bat passes per hour, total bat passes/night or total bat passes per survey effort.

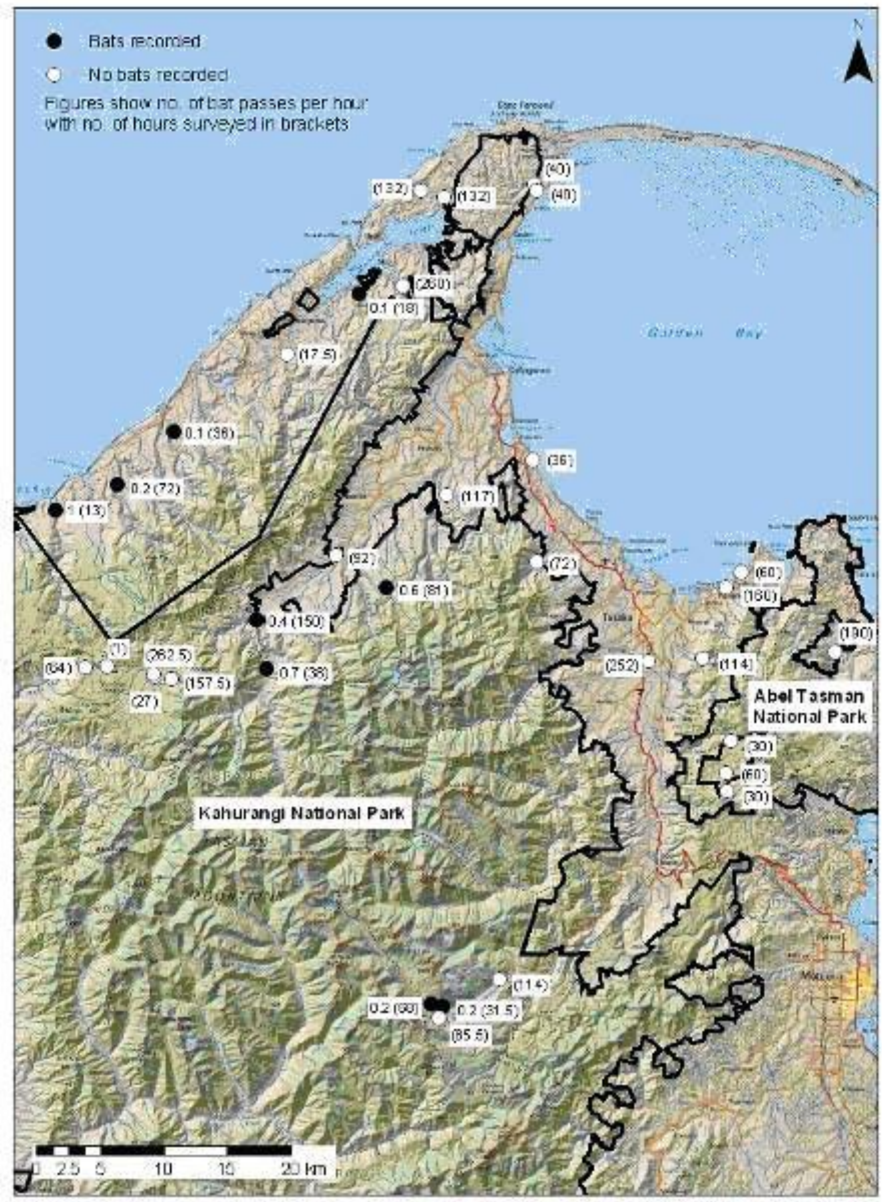

Figure 3. Survey results from a long-tailed bat survey conducted in Golden Bay, 2001–2004.

Thirty-three sites were surveyed and long-tailed bats were found at nine sites (27%). Results are expressed as total number of bat passes per hour, with total number of hours surveyed at each location in brackets. Data were collected by Shirley Hayward and the map was drafted by Geraldine Moore. Further details of the survey can be found in Hayward (2004). A higher resolution map is also available (see 'Bat survey results map'—docdm-574248).

Analysis

Care is needed with more detailed analysis of bat pass rates. Data distributions of bat passes per night are generally non-normal (test with Wilk-Shapiro Statistic W or some other test for normality) and display strongly skewed Poisson-type distributions with a high number of zero counts. Therefore, data cannot usually be transformed adequately to use parametric statistics. Results can be expressed as mean or median number of passes per hour or per night with 95% confidence intervals (CI). Confidence intervals are the best descriptor of central tendency for Poisson-like distributions (Sokal & Rohlf 1981). In a study of habitat use, the simplest analysis would focus on how often bats were detected (present or not recorded) among different habitat types. Fisher's Exact test or a χ^2 test are most appropriate to make these comparisons (e.g. if frequency of occurrence was significantly more in a particular habitat type). To test whether levels of activity (bat pass rates) vary among habitat types or hours of the night, the simple non-parametric Kruskal-Wallis One-way Analysis of Variance (H) (Sokal & Rohlf 1981) can be used. This test would simply tell you whether activity levels varied significantly between habitat types. Non-parametric pairwise comparison of mean ranks (Conover & Iman 1981) can then be used to determine which of the habitat types were significantly different from each other. The Spearman Rank Correlation Coefficient (rs) can test the relationship between nightly bat activity levels and ambient temperature or other co-variates (Fowler et al. 1998).

Alternatively, more rigorous regression models can be used for analysis. For example, Generalized Linear Modelling techniques (McCullagh & Nelder 1989) are now much more accessible and such techniques are included in most statistical software packages. Non-linear modelling is also more achievable using the larger statistical packages (e.g. S-PLUS and R). Fast computer processing speeds now enable better access to, and use of, General Additive Models (GAMs), which are a non-parametric approach to modelling, useful for data with a disproportionate number of zero counts and data that combine both categorical and continuous variables (Barry & Welsh 2002; Borchers et al. 2002). The program GRASP (generalised regression analysis and spatial prediction; Lehmann et al. 2002) concentrates on using GAMs and can be appended to the statistical software S-PLUS and GIS packages. If interested in these more-thorough analysis techniques, it would be wise to consult a statistician first.

Case study A

Case study A: distribution of lesser short-tailed bats in the Ōpārara Basin, West Coast

Synopsis

In the early 1990s, it was thought that lesser short-tailed bats were likely to be extinct in the mainland of the South Island. However, a photograph of a bat was found in an old New Zealand Wildlife Service file note. The bat in the photograph was identified as a lesser short-tailed bat and was said to have come from the Karamea area in the 1950s.

Objectives

The objectives were simple. DOC wanted to:

- Identify whether lesser short-tailed bats could still be present in the Karamea area
- If bats were present, determine how common and widespread they were

Sampling design and methods

From 1996 onwards, automatic detector and recording units (DOC ABMs) were deployed on an ad hoc basis throughout the Karamea area. The ABMs were usually set up in areas of likely forest (usually unlogged forests) when staff were in remote areas doing other tasks. Between 1996 and 2003, around 1400 nights of recording were undertaken throughout the region.

Results

Lesser short-tailed bat calls were recorded in the Ōpārara catchment, North Westland in 1996. The identity of the bats was confirmed by subsequent mist netting in the area. Once lesser short-tailed bats were discovered, there was increased survey effort in the catchment to determine their distribution patterns. Altogether, over 240 nights of survey were conducted between 1996 and 2003, covering about 190 locations. The bats occurred widely throughout the valley (Fig. 4), although there were many sites where no bats were detected (81% of sites). Activity appeared to be concentrated in the mid-valley and on the lower slopes on the true right.

All records were lodged on the 'West Coast Conservancy bat database' (docdm-249920).

Limitations and points to consider

The survey approach indicated the value of following up on the locations of historic records of this endangered species. Using remote ABMs and a follow-up bat-catching expedition, the presence of lesser short-tailed bats was reconfirmed in the South Island. Further concentration of the survey effort in the Ōpārara Basin indicated that lesser short-tailed bats were encountered relatively commonly. However, bat call data derived from ABMs cannot be used to determine actual population size in the area.

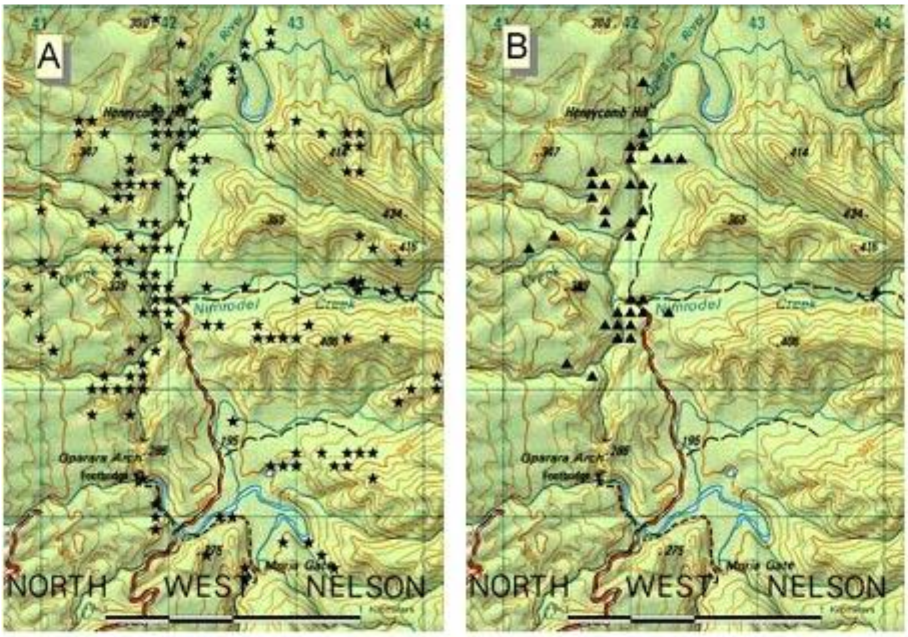

Figure 4. Distribution of lesser short-tailed bats in the Ōpārara Catchment, North Westland, as determined by automatic bat detector units. (A) Locations of ABMs that recorded no bats. (B) Locations of ABMs that recorded bats (source: 'West Coast Conservancy bat database'—docdm-249920).

Case study B

Case study B: habitat use by lesser short-tailed bats in beech forest

Synopsis

The aim of this study was to identify patterns of habitat use and to quantify temporal variation in patterns of activity in lesser short-tailed bats at a population level in beech (*Nothofagus*) forest in Eglinton Valley, Fiordland (O'Donnell et al. 2006). The information could then be used to make recommendations about: (a) which habitat types were best to focus on when surveying for lesser short-tailed bats; and (b) which habitats should be protected for lesser short-tailed bats (for example when designing management areas or reserves, or commenting on logging or other development proposals).

Sampling design and methods

Stratified sample transects were placed at two sites in the valley using a statistically randomised block design (Hayes 1997). The first site was at Knobs Flat near the main lesser short-tailed bat roosting area in the central Eglinton Valley. The second site was at Plato Creek, 12 km to the north, in an area where lesser short-tailed bats were known to forage regularly (O'Donnell et al. 1999). Each site had automatic detector and recording units (DOC ABMs) (O'Donnell & Sedgeley 1994) placed along 10 transects running perpendicular to the Eglinton River at 200 m intervals. Each transect had five stations and each station was in a different habitat type (Fig. 5). Habitats sampled were red beech dominant forest interior (> 200 m from forest edge); silver beech forest interior (~ 100 m from forest edge); road through forest; forest-grassland edge; and open grasslands > 200 m from forest edge (Fig. 5). Automatic detector units were placed on one transect per night. The order in which transects were sampled was random. There were 20 transects in total, so all habitat types were sampled 20 times each, except for silver beech, which was only sampled 10 times because it was absent from the Plato Creek site.

Data were collected between 1 November and 31 December 1997. Units began sampling at sunset and ran for 9 hours each night, except on nights when strong wind and rain made recording impossible. Sunrise (9–10 hrs after sunset) marked the end of the night's recording. If weather conditions deteriorated during the night, the data were discarded and the sample repeated on another night. Ambient temperatures at dusk and overnight minima were recorded at Knobs Flat.

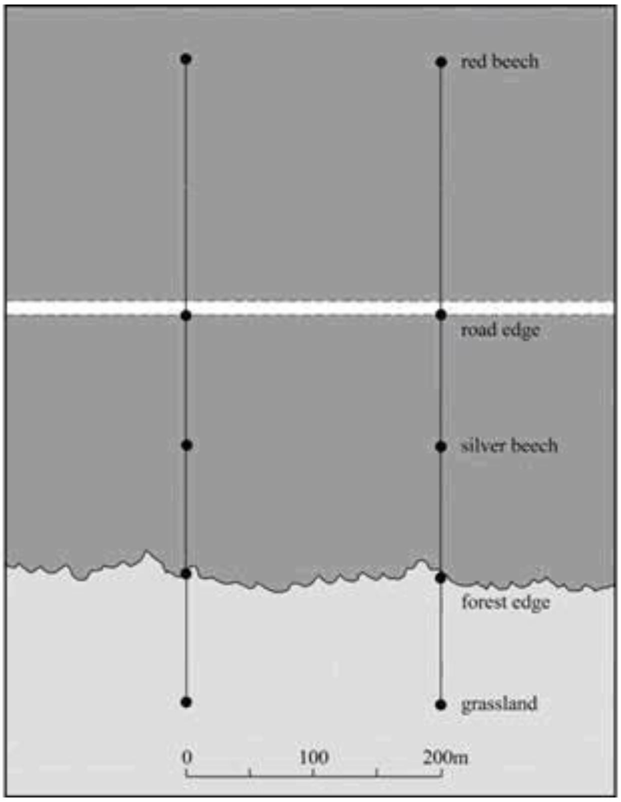

Figure 5. Schematic layout of stratified transects in five habitat types: Red beech forest interior (> 200 m from forest edge); silver beech forest interior (c. 100 m from forest edge; road through forest; forest-grassland edge; open grassland (> 200 m from forest edge). The dark shaded area denotes forest interior and the white line denotes the road.

Results

A total of 668 lesser short-tailed bat passes were recorded from 810 hrs of sampling on 20 transects with 90 stations. The Plato Creek study site was omitted from further analysis because from 360 hrs sampling only 11 bat passes were recorded (5 on the road through forest, 4 in red beech, 2 on forest edge). Activity levels varied significantly among the five habitat types (Fig. 6) and with hour of the night (Fig. 7). Lesser short-tailed bats were active throughout the night, with passes detected from the first hour after sunset to just before sunrise (up to 9 hrs). Of the activity recorded, most passes (82.6%), were in red beech forest > 200 m from forest edge (Fig. 6); with 13.7% of passes in silver beech within 100 m of forest edges, 0.9% on the forest-grassland edge, 0.2% in the open grassland, and 2.6% along roads through forest.

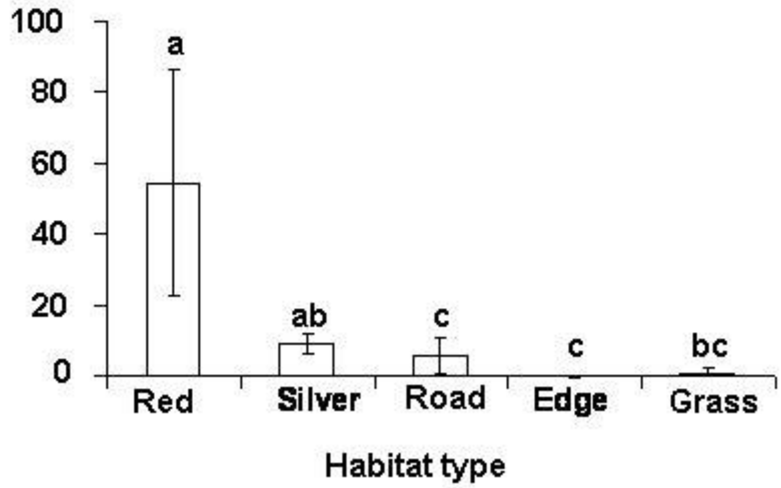

Figure 6. Activity of lesser short-tailed bats in different habitat types in the Eglinton Valley during late spring and early summer. Activity is graphed as mean number of bat passes ± 95% confidence intervals. Habitat types are red beech forest interior (Red); silver beech forest interior (Silver); road through forest (Road); forest-grassland edge (Edge); and open grasslands (Grass). Letters a–c indicate groups of mean ranks that are significantly different from each other (pairwise comparison of means, $p < 0.05$).

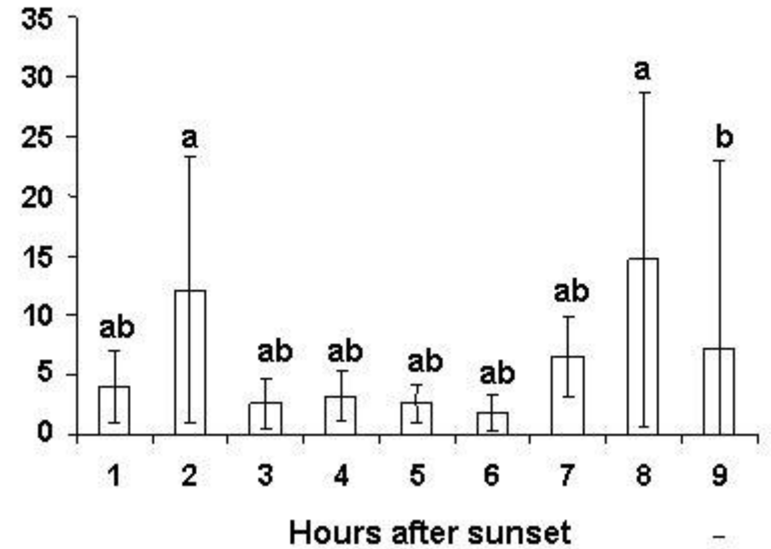

Figure 7. Activity of lesser short-tailed bats in red beech forest interior (mean number of bat passes ± 95% confidence intervals) in different portions of the night at Knobs Flat, Eglinton Valley, Fiordland, during late spring and early summer.

Limitations and points to consider

Results from this study suggest that inventory surveys for lesser short-tailed bats should target forest interiors, at least when surveying in southern beech forests. It seems automatic detector units are best placed more than 200 m inside the forest (away from the forest edge) to maximise the chance of detecting lesser short-tailed bats. The high variability in bat pass rates recorded between nights during this study suggests that ABMs should be set to record throughout the night and over a number of nights in an area to maximise the likelihood of detecting bats. Findings indicate new populations of lesser short-tailed bats could still be very difficult to detect, if pass rates in the Plato Creek area are typical of those away from roosting areas.

Results from this study can be used to predict how changes in habitat might affect lesser short-tailed bat populations. For example, low levels of activity in open and edge habitats suggest lesser short-tailed bats would not adapt to highly fragmented and cleared forest habitats. Logging in private indigenous forests may continue to threaten bat populations in local areas. Protection of lesser short-tailed bat habitat should include areas of mature forest interior in mixed beech forests.

It is not known how applicable these results are to other forest types and other locations in New Zealand.

References for case study B

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Case study C

Case study C: using reports of bats to create a model to predict bat distribution and improve survey success

Synopsis

Models that predict distribution of animals and their preferred habitats are commonly used in the conservation management of threatened species. This case study illustrates how results from earlier bat surveys were used to predict in which habitats there would be a high probability of detecting new bat populations (Greaves 2004; Greaves et al. 2006). These predictions were then tested by surveying the new areas predicted to have bats. Information from this study can be used to improve future bat surveys.

Sampling design and methods

Initially Greaves et al. (2006) sourced data from the 'West Coast Conservancy bat database' (docdm-249920). They used a subset of 1033 presence/absence records derived from a combination of stationary automatic detector and recording units (DOC ABMs) and line transect surveys obtained between 1994 and 2003. The authors used generalised linear modelling to assess relationships among various habitat and environmental variables for locations where bats were either detected or not detected. These models were coupled with the GIS data to develop maps of predicted occurrence of both long-tailed bats and lesser short-tailed bats within the West Coast region study area (e.g. Fig. 8).

The usefulness of maps of predicted distributions was tested by conducting field surveys at sites where the model predicted there was a high probability of finding bats.

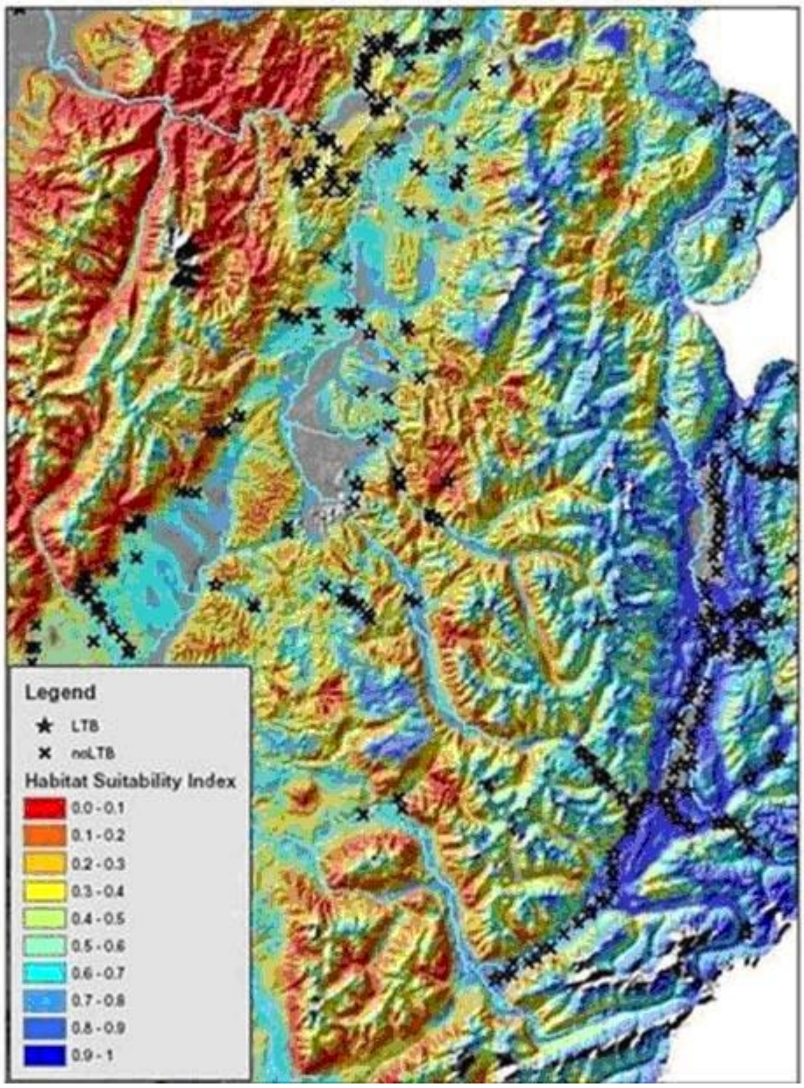

Figure 8. Map showing areas predicted to be suitable for long-tailed bats in the Springs Junction / Maruia area, North Westland. Habitat suitability is described as a probability of detection, where 0–0.1 = low probability of detection (< 10%) and where 0.9–1.0 = high probability of detection (90%–100%). The habitat suitability map was then field-tested by surveying for bats using bat detectors along transects and stationary automatic bat detector and recording units (ABMs). The survey results are plotted: ★ = long-tailed bats recorded, × = no long-tailed bats recorded.

Results

The model for long-tailed bats found that distance to forest boundary, slope, presence of beech forest, general land cover, variability in mean annual solar radiation, and mean ambient winter minimum temperature were significantly associated with the occurrence of this species. The model for lesser short-tailed bats identified several variables in common; including the distance to forest boundary, slope, and mean annual solar radiation, as well as adding forest class, area of forest patch, water balance, and mean June (winter) solar radiation as significant predictors of presence/absence (Greaves 2004).

The usefulness of maps of predicted distributions (e.g. Figure 8) was tested by conducting field surveys over a 10-week period (961 hours of survey) at 152 sites where the model predicted there was a high probability of finding bats. The model showed a moderate ability to predict presence and absence of long-tailed bats, but was poor at predicting the presence of lesser short-tailed bats (Greaves 2004). Of 80 sites predicted as having long-tailed bats present, 36 were confirmed during the survey period, giving an overall success rate of 45% (Greaves et al. 2006).

Limitations and points to consider

Bats surveyors usually make intuitive guesses about habitats in which they might detect bats. Greaves et al. (2006) calculated from the 'West Coast Conservancy bat database' (docdm-249920) that previous surveys for long-tailed bats recorded bats at about 12% of locations surveyed. By focusing on habitats that were predicted to contain long-tailed bats, the success rate of surveys (> 90% probability of recording presence of long-tailed bats) increased to about 45% (Greaves et al. 2006).

References for case study C

Greaves, G. 2004: *Modelling the distribution of New Zealand bats as a function of habitat selection*. MSc thesis, University of Otago, Dunedin.

Greaves, G.; Mathieu, R.; Seddon, P.J. 2006: *Predictive modelling and ground validation of the spatial distribution of the New Zealand long-tailed bat (Chalinolobus tuberculatus).* Biological Conservation 132: 211–221.

Full details of technique and best practice

Types of automatic detecting and recording devices

Several automated bat detection and recording devices have been developed that use different types of bat detector and different methods for storing data. Consequently, relative effectiveness and costs vary. Many systems include timers, delay switches or voice-activated tape recorders that allow units to be left unattended in the field and activated only when a bat call is detected. Data are most frequently stored on cassette tape, but some systems can record onto minidiscs, secure digital (SD) cards or MP3 recorders. For more information, see 'Background to bat detectors' in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465).

DOC has developed several automatic systems. One of the earliest devices in use in New Zealand (O'Donnell & Sedgeley 1994) was relatively simple and cheap, but had several drawbacks. This device was improved upon and became known as an automatic bat monitor (ABM). It is based around a Batbox III heterodyne tuneable detector, a voice-activated tape recorder, an electronic controller (which replaces the mechanical talking clock used in earlier models) and a 12V 7/Ah gel battery. The units can be run in the field for several days and the components are housed inside a robust and fully waterproof container (Fig. 1). Unfortunately, this DOC system has several practical limitations: (1) the units are technologically complex, (2) the separate components all require regular maintenance, (3) the units are relatively expensive to buy making it costly to purchase multiple units for good survey coverage, (4) the units are fairly large and heavy, making it difficult to carry several units around in the field, and (5) the task of extracting bat calls, i.e. listening to cassette tapes, can be very labour intensive.

At the time of writing there are at least three new automatic bat detector and recording systems being developed. The DOC Electronics Workshop is currently field testing units aimed at directly replacing the DOC ABMs. Additionally, two other systems are being developed by other agencies. One of these is also being field trialled. The Bat Recovery Group leader should be contacted for further information. It is intended that these devices will be less costly, lighter and easier to maintain compared with the DOC ABMs. They may also include some kind of automated collation and interpretation of the bat calls.

Standardisation, calibration and maintenance

Automatic detection and recording devices will vary in their sensitivity to bat calls. This may be because they use different types of operating systems, or simply because the settings on individual bat detectors or tape recorders are not standardised. It is important to test bat detectors before use, particularly if using old or second-hand equipment, then calibrate and standardise units as closely as possible before use in the field. Ability to detect bat calls can be tested either with an artificial signal generator or, if possible, against a known bat population.

Sensitivity between Batbox III units can vary (O'Donnell & Sedgeley 1994; Arkins 1999). The most common causes of variability are under-charged batteries, damaged microphones and misaligned frequency dials. The easiest way to check and to calibrate detectors is with the use of a 40 kHz signal generator. If a detector is working adequately, the signal tone should be audible through the detector's speaker, when the generator is at a distance of 40−50 m, provided the detector is pointed directly at the signal generator. The generator can also be used as a guide to re-align the frequency dial (O'Donnell & Sedgeley 1994). The DOC Electronics Workshop should be contacted for advice.

It is recommended that all equipment be regularly serviced, recalibrated and repaired.

Bat passes and examples of calls

Echolocation, also called biosonar, is the biological sonar used by several mammals including dolphins, shrews, most bats, and most whales. The term was coined by Donald Griffin, who was the first to conclusively demonstrate its existence in bats (Griffin 1958). Many bat species use echolocation to navigate, orientate and forage, often in total darkness. Bats generate high frequency sound via the larynx and emit rapid ultrasonic pulses through their mouths or, less commonly, their noses. By comparing pulses with the information contained in the returning signals (echoes), bats are able to locate, range and identify objects including prey. Individual bat species echolocate within specific frequency ranges that suit their environment and prey types. Echolocation calls provide an opportunity to unobtrusively survey, monitor and identify bat species (Catto 1994; deOliveira 1998; Russ 1999).

The frequency of bat echolocation calls is generally much higher than humans can hear (ultrasonic). Ultrasound detectors, or bat detectors as they are commonly called, can be used to listen to bat echolocation calls, and are useful tools studying bats. Bat calls are picked up by the detector's microphone and transformed into lower frequencies that humans can hear. Bat calls are heard on the detector as series of clicks as a bat flies into range. A series of audible clicks is known as a 'bat pass'. Passes are defined as a sequence of two or more echolocation clicks and a period of silence separating one bat pass from the next (Furlonger et al. 1987).

Occasionally, it is possible to hear a very distinctive call on the bat detector that sounds like buzzing, or almost like someone 'blowing a raspberry'. This call is known as a 'terminal buzz' or a 'feeding buzz'. Its purpose is to provide the bat with additional details of the object it is targeting. As the bat gets closer to an insect, for example, the bat will rapidly increase the pulse repetition rate of its call to provide frequent updating of the distance to the target. The pulse repetition rate reaches its peak rate as the bat attempts to grab its prey. Researchers commonly use the number of feeding buzzes recorded as an index of foraging activity (e.g. Vaughan et al. 1996). See 'Background to bat detectors' in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465) for further information.

The following audio files contain examples of bat calls obtained using Batbox III detectors (the standard bat detector used by DOC):

- 'Sequence of long-tailed bat calls' (olddm-574297) contains a total of six long bat passes. The bat sometimes sounds like it is going away and then returning towards the microphone. This recording was made using an automatic system with a bat detector linked to a voice-activated tape recorder. The hissing noise is the sound of the tape recorder switching on and off between events.
- 'Long-tailed bat call' (docdm-284873) was recorded onto an SD card.
- 'Sequence of lesser short-tailed bat calls' (olddm-574301) contains seven bat passes. These are of shorter duration and have a faster pulse repetition rate compared with the long-tailed bat calls.
- 'Lesser short-tailed bat call' (docdm-284879) was recorded onto an SD card.
- 'Terminal or feeding buzzes' (docdm-284881) contains two terminal or feeding buzzes.

Automatic detection and recording devices that contain heterodyne bat detectors (e.g. Batbox III detectors) need to be tuned. The bat detector dial needs to be set to either 40 kHz to pick up calls of long-tailed bats or 28 kHz to pick up lesser short-tailed bats. Newer style units use a different system and it should be possible listen for bats on 40 kHz and 28 kHz at the same time.

See 'Background to bat detectors' in the 'DOC best practice manual of conservation techniques for bats' (docdm-131465) for more information on bat calls and interpretation of sounds heard on the bat detector.

Where to put automatic bat detection and recording units

Inventory work usually focuses on places that contain suitable areas of foraging habitat or places where there are anecdotal reports of bats (e.g. Barrie 1995; Arkins 1998, 1999; Borkin 1999; Hayward 2004). Information on habitats where bats have been found can be used to predict where bats might be found and to focus survey effort (e.g. Greaves 2004; Greaves et al. 2006). Long-tailed bats and lesser short-tailed bats have different foraging strategies and consequently use habitat types in different ways. Long-tailed bats use forest edge habitats more frequently than they do forest interior, and lesser short-tailed bats use forest interior more than open habitats (see O'Donnell 2000; O'Donnell et al. 2006). To maximise chances of recording long-tailed bats, units should be placed in edge habitats (e.g. along bush-grassland edges, on tracks or roads through bush, in bush clearings, alongside riparian vegetation, by ponds). To maximise chances of recording lesser short-tailed bats, effort should focus on terraces and saddles between catchments within old age forest. Lesser short-tailed bats have been recorded in forest edge habitats, but only rarely.

Recommendations for inventory

There are no strict guidelines describing sampling effort requirements when surveying bats in New Zealand using automatic detection and recording devices. The ideal number of sampling nights will vary according to number of automatic units available, resources, terrain, habitat type and area requiring coverage. If the objective is simply to determine presence of bats, and calls are recorded the first night, units may be moved on to a new site. However, because bat activity is strongly influenced by weather conditions, it is usually necessary to leave the units in place for several nights to ensure the sampling period includes nights of fine weather.

The following are two examples of survey effort for inventory:

1. Arkins (1998, 1999):
    - Nine DOC ABM units set approximately 250 m apart in an area of approximately 800 × 800 m. The units were left in place for as long as it took to obtain a minimum of three good-weather nights. After that, they were moved to a new location.
2. B. Lloyd (pers. comm.) recommends the following for inventory of lesser short-tailed bats:
    - Target an area for which there are historic records and spread out 10–20 ABMs in an ad hoc manner but at least 200 m apart.
    - Spend a minimum of 2 weeks in an area during summer through to autumn/March. If the objective is simply to record presence of bats in an area, and this is achieved in less than 2 weeks, observers may wish to move to a new area.
    - Target areas of potential suitable habitat/higher levels of bat activity, e.g. terraces, old-age forest, saddles between catchments.
    - Leave units at a site for 1–6 fine-weather nights and then move to another site within the study area.
    - If the objective is to create an inventory and calls are recorded the first night, units may be moved to a new site.

Problems with monitoring

Bat workers are often interested in whether bat activity changes following management operations, or whether activity changes over time at a long-term monitoring site. Automatic bat detector and recording devices can be useful for determining presence or absence of bats in response to management, but given that no one has established whether there is a relationship between amount of bat activity and number of bats in a population, bat workers should be cautious about attempting to monitor bat populations using this method.

Any attempts at monitoring should be viewed as experiments and the methods and results should be reported to others so the findings can be examined and debated. If monitoring trials using automatic bat detector and recording devices are to be undertaken, the recommendations for inventory listed above are a useful starting point. In addition, on-site sampling conditions should be standardised as closely as possible during repeat counts (i.e. same number of units, same layout in the same location) and every effort should be made to sample at the same time of year and under the same weather conditions.

Practical best practice guidelines for using automatic bat detector and recorder systems

- Batbox III is standard bat detector used by DOC.
- All equipment must be tested and calibrated before use in the field. Ability to detect bat calls can be tested either with an artificial signal generator or, if possible, against a known bat population.
- All users must be familiar with operating systems (setting timers, recording modes, etc.) and attachment systems, before use in the field.
- Always use blank recording media at each new site.
- To maximise encounter rates and standardise counts, recording must begin at least 30 minutes before sunset for long-tailed bats and at sunset for lesser short-tailed bats.
- Allocate sufficient time to review recordings, charge batteries and do repairs.
- All equipment must be serviced and repaired at the end of the season.

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-574248	Bat survey results map
docdm-590701	Bats: counting away from roosts—bat detectors on line transects
docdm-213179	Canterbury Conservancy bat database
docdm-131465	DOC best practice manual of conservation techniques for bats
docdm-133273	Field sheet for recording bat passes using ABMs
docdm-284879	Lesser short-tailed bat call
docdm-284873	Long-tailed bat call
docdm-213136	National bat database template
olddm-574301	Sequence of lesser short-tailed bat calls
olddm-574297	Sequence of long-tailed bat calls
docdm-146272	Standard inventory and monitoring project plan
docdm-284881	Terminal or feeding buzzes
docdm-249920	West Coast Conservancy bat database