Surveillance and Monitoring Methods for European Bats

Guidelines produced by the

Agreement on the Conservation of Populations of European Bats (EUROBATS)

- FINAL DRAFT -

1 Surveillance and Monitoring of bats across Europe

1.1 The importance of surveillance and monitoring

European bats are a species-rich group widely distributed through the range of agricultural and non-agricultural landscapes and habitats that form the wider countryside. The landscape of Europe has been and continues to be affected by intensive and varied human influences that have had widespread and sometimes devastating effects on bat populations. These include: loss of roost sites through fragmentation and loss of woodland areas, destruction and development of old buildings often used by bats, and disturbance and loss of structures used as hibernacula; loss of foraging areas and reduction in insect prey through habitat destruction and fragmentation and increased use of pesticides; and poisoning by timber treatment chemicals when old buildings are renovated (Jefferies, 1972; Clark, 1981; Leeuwangh & Voûte, 1985; Racey & Swift, 1986). In addition, there is continued misunderstanding and prejudice arising from ignorance about bats and their lives and habits.

As a result of these effects many species are considered endangered, some have even become extinct in certain countries, and all are considered sufficiently threatened to be protected by legislation (Hutson *et al.,* 2001). The threatened status of bats in Europe means that information on changes in the distribution and abundance of bat species over time is urgently required. Monitoring and surveillance programmes are needed across Europe at varying levels; country, region and Europe wide. The information collected will assist government and non-government organisations in Europe to:

- **Detect changes in distribution, range and abundance and provide long-term population trends** in order to have an informed understanding of what is happening to European bat populations. Many bat species travel long distances at certain times of the year, to maternity roost sites, mating sites or hibernation sites and in doing so often cross country boundaries. Data collected in European monitoring programmes will facilitate effective targeting of conservation action (including the selection of species of conservation concern, key sites and priority habitats) by a wide range of organisations and individuals.

- **Influence national and international policy/setting of conservation priorities**. National governments and the European Community as a whole require good quality information on the status and changing fortunes of different elements of biodiversity in order to produce effective conservation and wildlife management policy. Bats are important elements of that biodiversity and the reliance of bats on insect prey and their specialised feeding behaviour and habitat requirements suggest that bats are potentially valuable indicators of the general health of the environment.

- **Assess the effects of conservation and other types of wildlife management**. There is a great deal of habitat and species management in operation and being recommended across the European Union for conservation and sustainable use. It is extremely important to know whether such management is achieving the intended goals and the main ways of assessing this are through monitoring changes in habitat structure and species abundance and distribution.

- **Educate people about conserving and managing mammal populations**. Education is an important part of any conservation or wildlife management initiative. Informing the general public about issues affecting wildlife in urban environments and in the wider countryside and obtaining public support and involvement in these areas are the keys to success. In some countries monitoring schemes have been initiated, using volunteers to collect the data and indeed they are an extremely important part of many surveillance schemes. Many volunteers attend training courses to improve their survey and identification skills and receive newsletters about the results of the work they have done and thereby improve their knowledge and understanding. It is also important to inform and engage the general public more widely through mass participation surveys, easy to access websites, and annual reports and newsletters and surveillance and monitoring schemes are ideal for achieving these interactions and information dissemination process.

1.2 International monitoring obligations

The threats to bats have been recognized in a number of International Conventions, Agreements under those Conventions and European Directives.

- **The Convention on the Conservation of Migratory Species of Wild Animals, Bonn Convention** (CMS, www.wcmc.org.uk/cms/), which recognises that endangered migratory-species can be properly protected only if activities are carried out over the entire migratory range of the species. All European bat species are listed on Appendix II. Under Article IV of the Convention, Range States for Appendix II species are required to conclude legally binding Agreements for their conservation.

- **The Agreement on the Conservation of Populations of European Bats** (EUROBATS, www.eurobats.org/) came into force in 1994. It is one of the Agreements under Article IV of the Bonn Convention and the first international Agreement devoted to the conservation of bats. There are 48 Range States and more than thirty European States are Parties to the Agreement.

  The Bat Agreement aims to protect all European bat species, through legislation, education, conservation measures and international co-operation with Agreement members and with those who have not yet joined. In 1995, the First Session of the Meeting of Parties to the Agreement formed an Action Plan, which was to be translated into international action. An Advisory Committee was established to carry forward this Plan between the Meetings of Parties.

  The most significant items for the Advisory Committee are monitoring and international activities. International protection measures for bats have, above all, to concentrate on those species that migrate the furthest across Europe, in order to identify and address possible dangers caused by conservation risks encountered along their migratory routes. The results of these studies are intended to lead to a comprehensive international programme for the conservation of the most endangered bat-species in Europe.

- **The Convention on the Conservation of European Wildlife and Natural Habitats, Bern Convention** (**www.ecnc.nl/doc/europe/legislat/bernconv.html**), is another important international treaty. It imposes a legal obligation on Parties to protect all breeding and resting sites of the strictly protected species on Appendix II, including all

European bat species apart from *Pipistrellus pipistrellus* and *Pipistrellus pygmaeus*, which are listed on Appendix III.

- **The Convention on Biological Diversity** (CBD, www.biodiv.org) also has relevance to European bat populations. Two of the main objectives are the conservation of biological diversity and the sustainable use of its components. Article 7 of the Convention requires that contracting parties should 'monitor, through sampling and other techniques, the components of biological diversity, paying particular attention to those requiring urgent conservation measures and those with the greatest potential for sustainable use.' It notes that regard should be given to species that are threatened, of social, scientific or cultural importance, indicator species and alien species.

- **The European Community's Directive 92/43/EEC, on the Conservation of Natural and Semi-natural Habitats and of Wild Flora and Fauna** (The Habitats Directive, www.ecnc.nl/doc/europe/legislat/habidire.html) was notified with the fundamental purpose of establishing a network of protected areas (Natura 2000) throughout the European Community, designed to maintain the distribution and abundance of threatened species and habitats. Several European bat species are listed in Annex II and all are listed in Annex IV of the Directive, requiring Member States to maintain and restore 'favourable conservation status' of the species. Article 11 of the Directive states that 'Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species.'

Finally, a new Red List for European mammals has been completed through the European Mammal Assessment (IUCN, 2007). Monitoring mechanisms to provide data on bat populations are required to continue measurement of conservation status in the future.

1.3 Surveillance and monitoring of bats at a European level

The EUROBATS Agreement aims to assist in setting-up pan-European surveillance programmes to identify population trends and then to facilitate the timely introduction of measures to address any problems highlighted by the results of the programmes.

The purpose of this manual is to recommend best practice in surveillance and monitoring methods so that consistent methods can be developed within and between Range States, allowing comparison of results obtained and eventually the production of European trends for bat populations.

2 Developing surveillance and monitoring schemes

2.1 *Introduction*

There are many factors to consider when designing long-term surveillance and/or monitoring programmes. The terms 'surveillance' and 'monitoring' have been used somewhat interchangeably in the past, but in fact a distinction can be drawn between the two activities and this is quite important when considering the level of information required.

Surveillance, in the context of measuring populations, consists of repeated and standardised observations of abundance over time, using methods that enable changes in numbers to be detected (Hellawell, 1991). Surveillance is a means of assessing what is happening to populations of a particular species over time.

Monitoring requires that targets are set, management recommendations made and carried out, the effectiveness of the management assessed and changes made to improve the process. Monitoring therefore, involves surveillance, not only of the species in question but, so far as possible, of the other factors likely to affect populations of that species.

The guidelines concentrate on standardised surveillance methods required to produce indices of population change. However, it is important to note that the recommended surveillance methods can be used in conjunction with the collection of other information, such as roost site condition, habitat extent and quality, climate, food availability, disturbance and other variables, to monitor possible causal factors of changes in bat populations. Some of this additional information will be particularly valuable in making assessments of conservation status for species listed in the Annexes of the European Habitats and Species Directive.

An example of using surveillance data in conjunction with other data is provided by the UK, where research funded by the Environment Agency (EA) and carried out by the National Bat Monitoring Programme (NBMP) has demonstrated a significant, positive relationship between foraging activity of *Myotis daubentonii* and insect biodiversity, itself an indicator of water quality (Catto *et al.,* 2003). This research showed that the status of waterway bat populations could also be an important indicator of waterway 'health' and could contribute to wider conservation issues.

The main factors to consider when setting up a surveillance programme are listed below.

2.2 *What is being measured?*

2.2.1 Species occurrence

There are several steps to assessing changes in populations over time. If very little information is known about the occurrence of a particular species then the first step is to assess the presence or distribution of the species in certain areas e.g. habitat types, administrative units or geographical grid squares. The methods used should focus on having a high probability of detecting and recognizing all bat species occurring in a distinct area (Limpens & Roschen, 1996; 2002).

The results of such surveys are usually displayed as simple distribution maps showing where species are known to occur and can be repeated at regular (say 5 or 10 yearly) intervals to provide some indication of change in species distribution.

2.2.2 Species abundance

A more rigorous approach involves making some assessment of species abundance in a given area and assessing trends in abundance over time. This could involve carrying out a full census of all individuals and then repeating the census at regular intervals. However, a full census of a population is likely to be time consuming, costly and to have very wide confidence limits.

Sampling a subset of the population to provide an estimate of relative abundance and to use this as an index of the true population is an easier and probably more reliable approach. With repeated, standardised surveys, changes in the index can be assessed over time, providing population trends. If total population size has been estimated at any point in time, then the index trend can be used to reassess the population estimate at regular intervals. The collection of standardised time-series data in this way provides an opportunity to apply a variety of sophisticated analyses or develop models.

2.3 Survey frequency and standardisation

Surveillance schemes should collect data at frequent and regular intervals. For the majority of purposes data should be collected at least annually, because population trends (up or down) will be detected more quickly and with greater certainty. However, for some species less frequent surveillance may be effective.

The value of surveillance data increases with the length of time over which they have been collected. Surveillance projects should be long-term, i.e. for decades, which will require long-term commitment. It is only through the collection of data over long periods of time that real declines or increases in bat populations can be detected separately from the natural fluctuations that are often observed from year to year.

When the survey method has been selected, it is important to ensure that the application of the method is standardised as much as possible, so that it is repeatable between sites within one survey year and between years, to allow comparisons to be made across years and over long periods of time. Creating standard survey forms with clear instructions is one very effective way of standardising the methods and effort used for data collection.

2.4 Area coverage, stratification and sample sizes

When setting up a surveillance scheme it is important to consider the size of area to be surveyed and the sample size required to generate statistically significant trend information. Generally, the finest scale at which information is required will be the scale that determines the overall sample size. It may be that information on population trends is required at a country level, but that it is also desirable to have trend information for regions within the country or for particular habitat or environmental areas. The number of sample sites required to provide trend information at a country level will also be required at each of the regional levels, so it is important to consider this when initially planning the surveillance effort. For example, a sample of 40 sites, surveyed each year for a number of years, might be considered sufficient to deliver country-level trends. However, if there are five regions in the country and trends are required for each of those regions, then 40 sites will need to be surveyed in each region, giving a total of 200 sites overall. The situation becomes more complex as additional stratifications are included.

Selection of survey sites should be completely random or randomly selected within a designed stratification, although it is possible to stratify the sample at the data analysis stage. Randomly selected sites provide more statistically robust results and are also more likely to be representative of the total population than survey sites that have been specifically chosen. This may mean including sites in the survey sample where bats are seldom or never seen.

2.5 Species coverage

It is best, if possible, to carry out multi-species surveillance, because it is easier to manage and is more cost effective. Multi-species bat detector surveys are possible even where species echolocate at very different frequencies, especially with the use of frequency-division or time-expansion detectors. If resources are limited and only a selected proportion of species occurring in a particular area can be surveyed, then consideration of priorities at country, regional and European level may help in deciding which species to include in the survey. Another consideration is the ease with which the species can be surveyed, because good data on slightly lower priority species may be more informative than poor quality data on high priority but less tractable species.

2.6 Assessing the surveillance scheme- the pilot phase

Establishing a long-term surveillance scheme involves piloting the design of the scheme to test ability to deliver the required level of information. The pilot phase of a survey is usually a test of survey power and survey bias.

2.6.2 Survey sensitivity and power

The benchmark for monitoring sensitivity needs to be set when setting up the scheme. One measure used for UK birds in that sufficient sites are monitored to detect a population change of 50% over 25 years, equivalent to the Red Alert declines for UK birds, (Gregory *et al*., 2002) and hopefully the more sensitive measure of 25% over 25 years, equivalent to the Amber Alert decline for UK birds.

The power of a surveillance scheme is the ability of the scheme to correctly identify an ongoing population trend and is expressed as the percentage chance that a particular survey design will detect a trend of the specified magnitude. Power is influenced by many factors, including the magnitude of population change over time, between year population variation, the number of years of data, frequency of surveillance, the number of sites surveyed, proportion of samples with the species present and sampling error.

The power of surveillance schemes should be analysed in the pilot phase to assess the level of information and degree of certainty that a scheme can deliver. Sample sizes and, therefore, the level of certainty of the results may vary for different species in the same surveillance scheme (because of differences in detectability). The power of a scheme will be increased if the design includes repeating data collection at sample sites within and across years, and this should be a priority.

2.6.3 Survey bias

Bats are difficult to count, and even using the best available sampling methods, there will be uncertainties inherent in population estimates and estimates of trend. In trend estimation, however, repeatable counts do not have to be accurate in the sense that the population estimate is close to the actual population figure. If the counts are consistently wrong for any reason the changes from year to year can still be measured accurately using repeatable methods to achieve high precision.

Thus the ability to count bats with the same detectability each year remains an essential attribute of a successful bat population monitoring scheme. However, the effects of small sources of bias are often over-emphasised in comparison with a lack of precision (Toms *et al.*, 1999). For this reason, it is important to measure or justifiably estimate the magnitude of bias and to take this into consideration when balancing bias and precision in monitoring schemes.

There are a number of factors that influence the encounter rate of bats on field surveys or numbers of bats counted from summer roosts. These can be divided into two categories:

1. Factors that influence bat encounters and are likely to change over time resulting in potentially erroneous trends
2. Factors that influence bat encounters but are likely to remain stable over time

Detailed analyses of the potential biases in the data can be conducted using a Residual Maximum Likelihood (REML) model to explore the effects of covariates, in order to allow for the complex structure of the data. Factors evaluated can include the influence of bat detector model, survey duration and temperature (BCT, 2005).

2.7 Data collection, management and validation

Managing surveillance data is probably one of the most difficult and time consuming aspects of running a surveillance scheme. It is essential to have a database of survey results that can be easily accessed and analysed. If volunteers have collected the data then it is also important to have a database for the volunteers, including names and addresses, which survey they are participating in, which site they are surveying etc. The nature of the database should be decided before commencing the project so that resources, both in time and money, are used most efficiently. Some of the main issues to consider are listed below.

2.7.1 Database requirements

What will be the present and future requirements of the database? What information will need to be stored and in what format? The format may be determined by the type of analysis that will be carried out on the data and so these factors need to be considered when designing the database. As a minimum, the information collected should include: species, number of specimens, method (survey technique and bat habitat type), site and spatial reference (*e.g.* grid reference at 1 km^2 level or more detailed if possible), date, a measure of survey effort and the recorder’s name.

2.7.2 Database compatibility

It may be that exchange of data with others is not a consideration. However, it is likely that pan-European information exchange and sharing of data will have much greater conservation potential than keeping datasets in isolation. Building a database that allows for easy information exchange i.e. is compatible and compliant with databases held by other organisations, will save time and money in the long run.

2.7.3 Quality control of data

There may be some concerns over the accuracy of raw data provided and a process of data validation should be put in place when entering the data electronically, so that the accuracy can be checked. Surveillance data can be collected by inexperienced surveyors, including volunteers, because the data collection process can be fairly simple. However, it is important to have some way of verifying the data they provide. As a minimum, the information collected should include: species (sightings or signs), spatial reference (*e.g.* grid reference at 1 km^2 level or more detailed if possible), date, a measure of survey effort and the recorders name. It is also important that schemes include some form of training and feedback of results to surveyors.

2.7.4 Data entry and storage

A decision should be taken on how to enter the data. There are several options, including manual entry by the survey organiser, scanning information using Optical Mark Recognition (OMR), paying for professional data entry or asking the volunteers to enter the data through a website. All the methods have their advantages and disadvantages in terms of cost, time required, and accuracy.

In the UK, the National Biodiversity Network Trust has devoted a great deal of time and thought to all the issues to do with data management. All the information can be found on their website www.nbn.org.uk.

Data should be stored in a format that is accessible and can be maintained in perpetuity and made available to as wide an audience as possible. Long-term (i.e. over decades) organisational, financial, data archiving and data supply structures should be put in place. In particular procedures should exist to safeguard the forgoing irrespective of changes in personnel.

2.7.5 Data analysis

The purpose of analysis is to draw correct conclusions on population trends occurring in species of interest. Many factors can influence the appearance of trends (apart from true changes in population size) and the magnitude of their effect should be estimated and methods for reducing their influence put into place to reduce the possibility of data misinterpretation.

The models used for analysis of species trends are usually General Additive Models (GAM) or General Linear Models (GLM) with Poisson error distribution (appropriate for count data). Annual means can be calculated from survey data using GLMs, which will show the variations between years. For easier interpretation the means can then be converted to an Index that starts at 100 for the first reliable year of data.

General Additive Models (GAM) calculate individual trends over time for each site surveyed. They then amalgamate trends from all sites to produce an overall estimation of trend direction with confidence limits. GAMs can be used to fit a smooth line to each dataset (ter Braak et al., 1994; Fewster *et al.*, 2000) in order to produce a clear picture of the long-term trend for individual species. These smoothed curves are quite robust against random variation between years.

GAM models can include covariates for factors that could influence the means (e.g. bat detector make, temperature). Generalised Linear Mixed Models (GLMMs) can be used to investigate these factors, and any variables that are statistically significant and that have a biologically plausible relationship can be included in subsequent GAMs.

It is not uncommon for the first year's results in a survey to be atypical because:

- the methodology is not yet well established (teething problems);
- observers are learning the ropes;
- fieldwork may start late because of the difficulties in getting funding and recruitment sorted out in time.

To counteract this problem, it is best not to use the first year of a survey as the baseline year, where the index equals 100. The first year's results can be discarded and this is often done in analyses once a scheme is well established. Another possibility is to keep the first year's data, but use the second or even the third year as the "base year" on which to base the 100 index against which all other estimates are shown (BCT, 2007).

2.8 Recruiting surveyors

2.8.1 Volunteers or professionals?

When designing a monitoring scheme it is important to decide whether it will be better to use professional surveyors or recruit volunteers to collect the data. There are some major advantages to using volunteers. A large network of volunteers will be able to cover a large number of sites over a short period of time and give a level of coverage that would be prohibitively expensive if professional surveyors were employed. Volunteers also tend to be highly motivated and often have local knowledge of the area they are surveying and have contact with local land owners and naturalists. Generally it is very cost effective to ask volunteers to collect data rather than pay professionals to do the job. This means that organisations are able to run surveys that would otherwise not be possible and to ensure effective use of available funds.

There are, however, some potential disadvantages to engaging volunteers. Levels of uncertainty increase, because there is no control over whether volunteers return data or not. Volunteers expect more information and more feedback than professionals and, because of time constraints and level of expertise, they may have more problems in carrying out surveys. The level of knowledge of some volunteers can be extremely high, but the majority of volunteers will have lower field craft abilities than professionals. This can be rectified somewhat through good training courses. Volunteers are also likely to have more constraints on their time, if they are giving it freely and not being paid to do the work. If volunteers are asked to survey randomly selected poor quality sites where they seldom see anything, they can become disillusioned about the survey work.

Many European countries do not have a culture of using volunteers to collect natural history information and so do not have a source of volunteer surveyors to call on. An alternative is to have a combination of volunteer and professional surveyors or only professionals to carry out the work.

2.8.2 Health and Safety issues for surveyors

In the UK the Tracking Mammals Partnership (TMP) and the National Biodiversity Network Trust (NBN) have produced a manual on engaging volunteers in survey work and managing volunteer networks (TMP & NBN, 2004) and this could provide useful information for organizations considering using volunteer surveyors.

2.9 Resource issues

When setting-up a surveillance scheme the long-term viability of the scheme is one of the most important factors to consider. Bat fieldwork is normally labour intensive, requiring highly trained surveyors with often one person-night fieldwork generating one data point. Bat detector surveys are mainly restricted to the summer months and in most cases the three hour period post sunset on each survey evening. Thus, to generate 100 independent data points requires 100 nights of fieldwork and a large number of surveyors. Therefore, availability of personnel and finances, accessibility of terrain, transport issues, habitat features and other aspects all have to be taken into account and their importance weighed against the preferred survey methods.

For example, bat detector surveys covering transects in the wider countryside is the recommended method for many species, but if surveyors are in short supply or the terrain makes such surveys difficult or dangerous then another option might have to be considered. A relatively new method involving attaching ultrasonic detectors and recording equipment to moving vehicles is one option, where fewer people may be required.

3. Surveillance methods

3.1 Introduction

The surveillance methods listed here are based on those agreed at the Second Meeting of Parties of the EUROBATS Agreement and outlined in Resolution 2.2 (Doc.EUROBATS.MOP2.5.AnnexBfin Resolution No. 2), but include other methods that have been developed in recent years.

The surveillance method or methods selected for a particular species or scheme will depend on the life-style of the bat species concerned, local circumstances and seasonal changes in bat occurrence. A surveillance scheme should always aim to obtain high quality data, which will be appropriate for robust forms of data analyses. However, the methods used should be as simple as possible, allowing surveyors with minimum skills and training to participate, thus increasing the possibility of obtaining a sufficiently large sample over the long-term. They should also cause the minimum disturbance possible to the bats, because of the long-term, repeated nature of the activity.

Surveillance of bat populations can generally be carried out in two main ways.

- Bat detector transects of foraging bats. This could be walked transects in the open countryside or along waterways or transects along roads using moving vehicles.

- Records of roosting bats. This could be at maternity roosts or other summer roosts, at hibernation sites and at mating roosts.

3.2 Walked bat detector transects of foraging bats in the open countryside

Ultrasonic-detector surveys using pre-defined sampling methods provide the most statistically-robust and repeatable surveillance, although they provide an index of abundance rather than absolute density. Standardisation of bat detector surveys is possible using line-transects and point-counts. Line-transect surveys require the observer to follow a pre-determined path of known length; point-counts require the observer to listen at a fixed point for a known time. The two methods can be combined to give estimates of relative abundance of species being surveyed. (ref BCT bat detector guide?, Rombout de Wijs in proceedings bat detector workshop in Luxembourg).

Some bat species forage preferentially or even exclusively over waterbodies such as rivers and lakes and the standard field survey methods can be adapted for use at waterways to collect data on population trends for those species.

Remote automatic recording of bats can replace surveyors in certain circumstances, to record bat presence in a particular habitat.

3.2.1 Species suitability

Counts away from roosts using bat detectors are most suitable for any species which has a loud and distinctive echolocation call.

3.2.2 Sampling

Sampling areas may be chosen in a variety of ways, provided these do not violate the need for a repeatable sampling method and a random, or stratified-random, selection of areas. Sampling should cover a wide range of habitat types (these may be the strata) rather than just selecting the habitats most likely to contain bats. For a survey of waterways, data are collected in a simple, repeatable fashion at a random selection of waterbodies.

Suitable sampling may be based on selecting squares from the national mapping system (non-stratified) or selecting areas from a national land-classification scheme (stratified). Within these areas, line-transects, point-counts or a combination of both can then be set up according to a standard methodology. Suitable line-transects may involve a walk across or around the square, or a random 1km stretch of waterbody. (Walsh & Harris, 1996a; 1996b)

3.2.3 Timing

Sampling effort should be well-defined, either by setting the length of transect to be followed (at a constant speed) or by pre-defining the time to be spent at each sampling point. Similarly, the time of day when sampling is to be carried out should be standardised. Sampling should commence shortly before sunset and continue for at least one hour and up to three hours. The timing of survey of a given transect will depend on whether early or late flying species are being detected.

Surveying waterways should be carried out during the months of peak bat activity (May-August).

3.2.4 Number of counts

Surveyors should make a day visit to each site to secure landowner permission and to assess the site for safety.

The number of counts that should be carried out during the active season will depend on resources available. Generally, the more counts that are completed at each sampling point the lower the associated sampling variation. However, it is statistically preferable to sample more areas (use more replicates) than to sample areas more intensively (repeated measures at fewer sites). Two to three counts per area is probably a good number, but if bat activity in a certain area has to be evaluated carefully, up to five surveys per year could be made.

For surveying waterways, surveyors should mark out 10 points, approximately 100m apart, along a 1km stretch. On two evenings during the survey months, surveyors should stand at each of the 10 points for four minutes, recording bat activity with a heterodyne detector. A torch should be used to confirm the bat is flying close to the water surface, a behavioural characteristic of *Myotis daubentonii* (dry ultrasounds with maximum at 45 kHz, flight 5-15 cm above water surface) and *Myotis dasycneme* (dry or wet ultrasounds at 60-25 kHz with maximum at 35 kHz, flight 15-60 cm above water surface).

3.2.5 Data management and analysis

All separate bat-passes (A “bat pass” can be defined as a sequence of two or more echolocation calls registered as bat passes within the range of a microphone. (Fenton, 1988; 2001) should be recorded on a map (for transects) or associated with a sampling point (for point-counts). For analysis, the classification of habitat along a transect or around each point should be completed during a daytime visit.

3.2.6 Example: Bat detector surveys in Germany (Dietz & Simon, 2006)

In Germany a proposal was made for standardising bat detector surveys, in order to fulfil the EC Habitats Directive reporting requirements. Recommendations were as follows:

- In each survey area at least one line-transect should be allocated per 500 ha. Line-transects should include several habitat types.
- Each line-transect should be 1.5 to 2 km long with surveyors taking about 8 minutes to walk each 100 m section.
- Line-transects should be surveyed five times per year, between the end of April and mid-September. All surveys should be carried out under good weather conditions.
- If particular species need to be recorded (e.g. *Myotis myotis*) additional 100m line-transects could be selected in the most promising habitats. These specific transects should be surveyed five times per year, taking 15 minutes to walk the transect.

3.3 Bat detector transects along roads using moving vehicles

At a minimum, vehicle-based projects deliver high quality distributional data for common species and will identify distributional changes in common species with good sensitivity. Through annual monitoring, they will also provide statistically robust conclusions on population trends of common species along roadsides.

Annual vehicle-based surveillance should have high year to year precision, provided the following factors are recorded: 1) start time; 2) survey date; 3) route taken; 4) roadside habitats noted; 5) same bat detector system is used. Roads are easy features to follow and normally well identified on maps.

3.3.1 Species suitability

This method is generally restricted to open/edge species such as *Pipistrellus spp, Nyctalus spp, Eptesicus spp* and *Vespertilio murinus* as they are loud echolocators that are found foraging in open habitats along roadsides. *Miniopterus schreibersii* might be suitable, because although it forages in closed habitats, or high in the air, it is also found at street lamps. In Sweden good results have been obtained with *Myotis mystacinus/M. brandtii* over forest roads.

3.3.2 Sampling

The protocol should be designed to minimise variation between repeat visits. Any detector system could be used, but once a system has been selected then the same system should be used on each survey.

Survey transects should be representative of landscape types (not forgetting the inherent bias in following roads). The landscape to be surveyed can be divided into 30 km blocks and a selection of these blocks chosen at random. This provides a structure and target number of blocks to be surveyed.

3.3.3 Timing

Ideally surveillance should coincide with the pre-parturition period (May/June) to avoid annual 'noise' from numbers of volant young and does not have to coincide with the highest period of activity. The annual survey date, start time and starting point should be consistent between years and repeat surveys should take place under similar environmental conditions.

3.3.4 Number of counts

Surveyors drive each route twice, with each survey transect driven at 25km/h. The route should be driven at least twice annually within a 4 week period. More transects can be driven if resources allow, to increase survey sensitivity. As surveillance is likely to be long-term, costs should be minimised.

3.3.5 Count method

Surveyors can design a route within each 30km block that is roughly circular and of approximately 100 km length, which can be driven within a 4 hour period.

The route can be divided into transects of e.g. 1.6 km length, 3.2 km apart. Each transect can then be defined as an independent sampling unit. Thus for each route driven, 20 independent sampling units are surveyed, providing a large sample size from a few nights of survey. The distance between each survey transect, combined with the driving speed, makes it highly unlikely that the same bat could be recorded on more than one survey transect.

Driving speed alters recorded peak frequencies due to Doppler Shift and this can result in misidentification of species. For this reason vehicles should be driven at a constant 25km/h.

3.3.6 Data management and analysis

The main advantage of the vehicle based survey is that few surveyors are required to deliver a large number of sites. For example, based on power analysis, a single surveyor could collect sufficient data with 10 nights of fieldwork to provide a statistically defensible surveillance project.

Roadside habitats are unlikely to be in proportion to habitats available in the wider countryside and this introduces biased habitat sampling. There is potential for streetlights to attract certain species and give an over estimate of species abundance along roads in relation to actual abundance in the wider countryside. There is also potential for roads to be developed at a different rate and in a different way to the general countryside, introducing other biases in data collection. It is important, therefore to note bat encounter rates at streetlights and any changes in type and number of lights over time, and any road development activity.

With these biases in mind, great care must be exercised if attempting to extrapolate bat encounter rates from vehicle-based surveys to the wider countryside, because they could lead to erroneous conclusions. If this is to be attempted then, at the very least, roadside habitat assessments should be made. For example, preliminary results from vehicle-based surveys in the UK suggest that pipistrelle bats are more likely to be encountered along roads with boundary features than featureless roads. Thus we assume that the vehicle-based survey is monitoring pipistrelle bats at boundary features (not the roads themselves) and if further research confirms this, then encounter rates of bats along roads with boundaries can be extrapolated to include boundary features away from roads.

3.3.7 Example – Republic of Ireland car survey (Roche *et al.*, 2005)

A pilot survey using this method was carried out in the Republic of Ireland in 2004. The Table shows the results of power analyses, indicating the number of years of surveying required to achieve 90% power to detect Amber (25% decline in 25 years) and Red (50% decline over 25 years) Alerts for each species. All results using two repeat surveys of each square per year (each square with 20, 1.609km transects).

Table 3.1. Results of the Republic of Ireland Car Survey power analysis

	Pipistrellus pipistrellus		***Pipistrellus pygmaeus***		***Nyctalus leisleri***	
Squares	**Amber**	**Red**	**Amber**	**Red**	**Amber**	**Red**
10	>25	11	>25	11	>25	12
15	19	10	24	10	>25	11
20	16	9	20	9	24	10
25	15	7	17	8	19	9

3.4 Counts at maternity roosts

Counts of bats at maternity roosts are a traditional method for monitoring the status of roosts. Information can be used to make an assessment of the importance of the roost at local, regional, national and international levels through collation and analysis of data. Counts of bats in, or emerging from, maternity roosts have also often been used as a way of monitoring the status of a species.

External counts of bats emerging from roosts are preferred to counts inside roosts to minimise disturbance, but may not always be possible. In some cases it is better to carry out counts inside the roost, usually when colonies are very large, or where bats roost in mixed species groups and identification with a bat detector on emergence is very difficult.

Internal counting is the method most widely used in Central and Eastern Europe where buildings, such as churches and castles, have very large attic spaces, allowing surveyors to go in and survey without disturbing the bats. Colonies are usually highly philopatric and faithful to their roosts throughout the breeding season. In southern countries and in Central Europe, maternity colonies of some species e.g. *M. schreibersii, R, euryale, M. myotis, M. capaccini* are often found in mixed groups in warmer mines and caves throughout the summer and internal counts are required to estimate numbers of the separate species.

3.4.1 Species suitability

The most suitable species for colony counts are those where:
- the bats appear to be relatively faithful to their maternity roosts, and return predictably to the same site each year
- the establishment of a new colony is a rare event
- the species tends to form large colonies
- the bats can easily be distinguished from other species which may be present.

Examples of such species include *Rhinolophus euryale, Rhinolophus ferrumequinum, Rhinolophus hipposideros, Myotis capaccinii, Myotis dasycneme, Myotis emarginatus, Myotis myotis, Myotis schreibersii*. Internal counts are appropriate for free hanging species such as *R. euryale, R. ferrumequinum, R. hipposideros, M. myotis, Barbastella leucomelas, Plecotus austriacus*.

Colony counts are less appropriate for species that often use a network of roosts and where individuals frequently change between roosts. Internal counts are also not appropriate for crevice dwelling species, where only a proportion of the bats may be seen at any time. Such species include *Pipistrellus pipistrellus, Eptesicus serotinus* and *Barbastella barbastellus.*

Species such as *M. myotis* and *M. dasycneme,* and to some extent *Rhinolophus spp*., also use networks, and the numbers in the central roost might fluctuate. However, these species have a tendency toward the model of a “central important roost’’ with “satellites’’, so this surveillance method is considered appropriate.

3.4.2 Sampling

In countries or regions where the species is widespread, a sample of sites should be counted on a regular basis, with roosts selected to give a range of roost sizes (number of bats), geographic locations and land-use types. Stratified random sampling of roosts, with strata selected for roost size and/or land-use type probably provides the most statistically robust methodology. Where the species is rare, it may be possible to count all known sites.

3.4.3 Timing

Counts need to be timed to take account of the breeding season, which will vary with climate. Local research may be required to determine this before setting up a monitoring project. Counts should generally be timed to occur between the time when bats arrive in the maternity roost and the time that the earliest births occur, usually between 20^{th} May and 20^{th} July. This will give an indication of the number of adult females in the population associated with the maternity site.

3.4.4 Number of counts

At least one count should be carried out annually, covering the period between the arrival of bats and the first possible date for parturition. The preferred method involves two counts during this period, but the logistics and cost of organising counts may mean that only one is possible. If data on reproductive success are required, another count should be carried out prior to colony dispersal. Statistical advice suggests that it is better to increase the sample of roosts than to increase the number of counts at each roost. However, it is also important that the agreed number of counts is carried out at each roost and that the same time period is used each year.

3.4.5 Count methods

Counts of emerging bats

- Observers should be stationed outside each entrance to the roost, but not so close as to disturb the bats or obstruct their flight lines.
- The number of bats emerging in each five minute period should be recorded.
- Recording should begin when the first bat emerges and end when it is too dark to continue counting, or no bat has emerged for ten minutes.
- The roost entrances should not be illuminated with white light. It is recommended that no torch is used, though one fitted with a dark-red filter may be acceptable.
- Ultrasonic detectors can be used to give warning of the approach of a bat. They should be tuned to an appropriate frequency and used with headphones.
- Counts should not be made in bad weather-conditions, or on nights with previous bad weather, as this is known to inhibit bats from emerging. Bad weather-conditions include low temperature, rain or strong winds.

- In some cases, for instance when colonies are very large but it is not possible to do internal counts (see below), filming of bats emerging from the roosts using infrared videos connected to bat detectors is desirable.

Counts inside the roost

- In regions where mixed species groups occur in caves, a photographic method of counting bats inside the roost may be appropriate. The main avantage of this method is minimising the time spent with the colony and therefore minimising disturbance, which is especially important for some shy (sensitive) species such as *R. ferrumequinum* and *R. hipposideros* etc.
- This type of count should be carried out by two people, one taking photographs, the other holding the light, and should be completed as quickly as possible. It is best to take photos of separate groups of bats, but if groups are too large, then 2-3 photos of a group can be taken, shifting the focus of the camera each time. One of the main limitations of this method is the distance from counter to colony.
- One or two counts during the season should be sufficient. Surveyors should have some knowledge of identifying attic dwelling species and all crevices and beams should be checked using a torch. Droppings located underneath beams are a good indication of presence.
- Counts can be carried out in any kind of weather conditions, but colonies are less active and easier to count when temperatures are cooler.

Measuring colony productivity

Measuring the productivity of a maternity colony may be possible in some circumstances with some species. For some cave-dwelling bats and species that preferentially roost in buildings it may be possible to enter the roost after the adult evening emergence and to count the non-volant young. In cases where the adults remain with the young after the young are able to fly, such as some *Myotis* species, a recorded increase in the colony size post-weaning may indicate the number of young weaned. However, in some species such as *E. serotinus* and *P. pipistrellus*, the adult femailes depart as soon as the young are capable of fending for themselves and the spread of weaning dates means that there may be no marked increase in the colony size, or any such increase may not reflect the full productivity of the colony.

3.4.6 Example: measuring colony productivity of *Rhinolophus ferrumequinum*

To measure the productivity of *R. ferrumequinum* colonies three annual counts can be done:

1. emergence count of females in the 2nd or 3rd week of June (A = number females);
2. emergence count of females in the first 2 weeks of July with a count in the colony when females have left (control of A; B = number of juveniles)
3. emergence count in the last week of July or 1st week of August (control of A and B; C = number of dead juveniles in the colony).

3.4.6 Data management and analysis

Counting roosting or swarming bats usually involves non-random selection of survey sites. The sites tend to be ones that are known about, often because they are large, visible sites with large numbers of bats. If the sample size of roosts is sufficiently large then any biases in the dataset introduced as a result of being non-random are probably not important, but it is factor to consider.

Colony counts are not the most statistically robust method for assessing population trends, because of the non-random sampling method. However, for some species that predominantly dwell in buildings and are highly philopatric, it is a robust method for assessing population trends if the majority of potential buildings are surveyed.

The relationship between trends in species' colony size and population trends has not been established, but comparison of different survey methods over time may help to provide the required information.

3.4.7 Example: Estimating population size of *Nyctalus noctula* in housing estates in Hungary and other central European countries

In Hungary *N. noctula* is a very common species in the housing estates of large towns, where it roosts in the crevices of prefabricated panels of tall 10 storeyed houses. *N. noctula* is very active before sunset, and can be heard squeaking very loudly. A monitoring method has been used in 19 towns and 3 housing estates in Budapest to estimate population size for the species.

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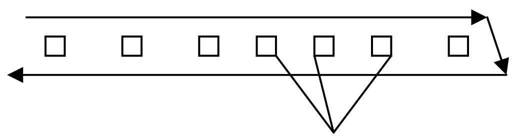
Method:

In the housing estates a transect is chosen which touches 40 houses. Surveyors walk the transect twice, first along one side and then on the other side of the houses, listening for the sound of bats. The aim is to locate the position of bat roosts and mark the location on a map.



Two counts are carried out, at least seven days apart, the first count between 1-15 September, and the second count between 16-30 September. Counts are carried out on calm, clear days with no rain, starting half an hour before sunset. The number of colonies along a transect and the number of buildings on each housing estate are counted to provide an estimate of the number of colonies in a town.

3.4.8 Colony counts in bat boxes

Counts of colonies using bat boxes has been suggested as a surveillance method. However, bat boxes only occasionally hold an entire colony and counts are unlikely to be representative of the general population or to produce a comparative national or even regional picture, because breeding success in boxes is likely to be different from natural sites. There are additional issues of potential disruption to bat communities through placing large numbers of bat boxes in semi-natural woodland and disturbance to bats because boxes might need to be invasively checked for occupancy and numbers. Therefore, the effect of introducing bat boxes to woodlands needs to be thoroughly investigated before bat box occupancy can be considered as a surveillance strategy.

Counts in bat boxes may, however, be the only suitable method for some mobile woodland species, or in locations where species cannot easily be surveyed using other methods. This may be where closely related species (*Myotis* spp.) overlap in distribution, making field surveys difficult, or where species seldom use buildings as roosts. In this case the sampling unit is the area of woodland rather than the individual bat-box (Warren et al., 2002 – check paper). Other European examples??.

3.5 *Locating new colonies*

Locating new or previously unknown colonies is an important part of improving the robustness of colony count data. Previously unknown overground maternity roosts may be located by looking for bats swarming around the entrance to a roost before sunrise. On returning to their roosts many bat species make repeated circular, swooping flights around and up to the roost entrance before going in. For rare species, capture and radio-tracking of females is a more certain method.

3.5.1 Timing

The best time of year to survey for dawn swarming activity is when colony sizes are greatest and this will vary depending on latitude. In northern Europe this tends to be mid-July to mid-August.

3.5.2 Count Method

Surveys should start one hour before sunrise and may take the form of a static survey outside a structure (e.g. building, tree, bridge) thought to house bats, or a moving survey along a transect of up to one kilometer in length. Surveyors should look for groups of bats circling in front of potential roost sites and watch to identify the roost entry point.

3.6 *Counts at hibernation sites*

Some bat species aggregate at hibernation sites during the winter months and it is possible to make annual counts of the number of bats encountered. Hibernation counts are particularly useful in assessing the importance of a site for conservation purposes and site data collected by monitoring programmes can be used to inform decisions when considering site protection under national and international designations.

One advantage of hibernation site monitoring is that multiple species can be encountered at the same site. It is also possible for surveyors to survey multiple sites in a day and fewer surveyors are required than on field projects to collect the same data quantity.

One problem with hibernation site surveys is that the relationship between the number of bats *seen* and the number of bats *present* is not always clear. In complex sites bats can hide away in cracks and crevices and it is not always possible for surveyors to see all of them. As an example: Bad Segeberg cave in northern Germany is a cave with lots of fissures. About 300 individual bats are visible upon normal visual inspection. About 15,000 (mostly *M. nattereri* and *M. daubentonii*) are present when counted with infrared detection. For complex sites like this an assumption for population trend analysis is that the proportion of bats seen to the number of bats actually present remains constant over time.

In roost sites with large spaces species identification can be problematic, because of poor visibility or low light and because the bats could be a long distance away from the surveyor. In such cases the reliability of collected data must be evaluated in order to avoid biases.

Bats are vulnerable to disturbance when hibernating and strict protocols should be observed before and during hibernation site surveys. Some species can be hard to identify unless they are handled, but handling is not recommended as it is considered too disturbing and could affect the survival of the bat.

3.6.1 Species suitability

Counts of bats in hibernation sites are most suitable for species where:
- the species is faithful to the site
- the species can be identified accurately without disturbance
- the species hibernates in large numbers at one site
- a high proportion of the population regularly hibernates underground

3.6.2 Sampling

In countries or regions where the species is widespread, a sample of underground sites should be counted on a regular basis, with sites selected to give a range of sizes (number of bats), geographic conditions and land-use types. Stratified-random sampling, with strata selected for roost size and/or land-use type probably provides the most statistically-robust methodology, though the accessibility of sites is likely to influence the sampling methods. Where the species is rare, it may be possible to count all known sites.

Areas where only small numbers of individuals are found, spread across many sites, present great difficulties for hibernation-site monitoring and it is probably better to attempt to find maternity sites.

3.6.3 Timing

The extent to which bats occupy hibernation sites depends on the local climate and in some parts of Europe bats may be active throughout most of the year. This makes the method more reliable in the northern part of species' ranges, where the bats will remain in hibernation sites for longer periods. Counts are probably best done in January or February, but local research may be required to check this before setting up a monitoring project.

3.6.4 Number of counts

The logistics and cost of organising counts and the danger of disturbance to bats means that the number of counts at each site should be limited to two per winter, carried out at least two weeks apart. To reduce disturbance to a minimum and following statistical advice, it is better to organise counts at more sites than to increase the number of counts at each site. However, it is also important that the agreed number of counts is carried out at each roost and that the same time-period is used each year.

3.6.4 Count method

When large colonies are present, it may be better to estimate the area the bats cover through the use of photography or video camera. Notes should be kept annually for each site indicating which areas were searched and the main areas in which bats were found. This provides useful information for future surveyors.

It is preferable to adopt the same counting method each year, so that valid comparisons can be drawn. If the count method is changed, any differences should be recorded. Ideally, the extension of counting to new parts of a site should be recorded separately. Data should be recorded separately for each site, or each sub-site, particularly if parts of the site are liable to flooding or other climatic factors that may make it impossible to count all parts of the site each year.

3.7 Surveys of mating roosts

Tree roosts, including bat boxes, are often occupied by advertising males displaying territorial behaviour. Such roosts can be found by following the advertising calls, which can be heard without technical aid in some species. It is most efficient to survey along edges of forests and water, especially near larger rivers and lakes, because such places are preferred by males of some species.

3.7.1 Species suitability

This method is most suitable for species where the males display territorial mating behaviour and generally have loud display behaviour, notably *Nyctalus noctula*, *N. leisleri* and *Pipistrellus nathusii (in trees and houses)*, but also *Myotis dasycneme* (found in mating roosts, but without loud display behaviour). *P. pygmaeus* and *P. pipistrellus* do not advertising from a stationary site but in a territory. As with breeding birds this behaviour can be used to assess territories and numbers of advertising males.

3.7.2 Sampling

Surveys of mating roosts in tree holes or bat boxes follows the same procedures as surveys of maternity colonies at such places, counting the number of emerging bats.

However, one could also use the advertisement calls of the species and take the number of advertising males as the parameter for monitoring. The whole area can be surveyed and a cluster analysis performed, or transect and relative numbers from year to year can be used.

3.7.2 Timing

The best time to survey mating roosts is during peak migration in the region, and this will vary across Europe. For e.g. *Nyctalus noctula* and *Pipistrellus nathusii* the peak in advertisement behaviour seems to coincide with the peak in migrating females passing by.

In the Region of Bonn, Germany, some bat boxes are occupied by *P. nathusii* from August to September and then by *N. noctula* throughout the winter.

3.7.3 Number of counts

During migration the number of females in the mating roost of a territorial male changes from day to day. For this reason roost surveys should be carried out every week until there are no longer any bats present.

3.8 Surveys at underground swarming sites

In late summer and autumn some species begin to migrate to underground sites where mating and/or hibernation take place. During this period, large numbers of bats can be encountered at some underground sites, swarming inside and outside the site. This is primarily a mating event, since it occurs long before hibernation, but probably also serves to check hibernation sites and guide inexperienced juveniles to them (Rivers et al., 2006).

Swarming sites attract very large populations of bats (thousands) from large catchment areas (~ 100 km radius or more), with many hundreds visiting a site each night at the peak of the season. The number of species present varies from five in the north of England to 10 or more in parts of Europe. Two hundred or more individuals may be caught per night at the 'best' sites, representing an estimated 5-20% of the bats present each night. Individual bats are faithful to one or a small number of sites. Every late summer/autumn a very high proportion of these bats will visit their swarming site(s) on one or more occasions. Surveillance of swarming sites can therefore provides a useful index of the status of a number of species over a very large area.

Swarming populations are dominated by males (60-90%), but it is not known if this is a real sex bias or an artifact of differences in behaviour that make them easier to catch.

3.8.1 Species suitability

The method is suited for those species that appear to use a mating strategy that involves extensive chasing flights of large bat assemblages (hence the term swarming), these include *M. bechsteinii, M. dasycneme, M. daubentonii, M. nattereri, M. brandtii, M. mystacinus,* almost certainly other *Myotis* species, *Plecotus auritus* and *P. austriacus* and possibly other species. Some of these bats cannot be surveyed easily using other methods.

3.8.2 Sampling

One possible surveillance method would be to place automatic loggers at the entrance to swarming sites to log bat passes/min for a period of at least a week, ideally several, in early September. Although species ID would be difficult or impossible, it would give an index of the bats visiting the site to mate (and perhaps later hibernate) from the large catchment. It could be repeated with ease each year.

It should be noted that species composition can vary considerably through August and September, so some initial investigation is needed to determine patterns of activity of different species. Harp trapping/mist netting can be used to determine the species present and their relative abundance. Following the initial assessment of species numbers, catching bats at intervals (e.g. 5 years) can be used to keep track of species present and their relative abundance.

Because of the often large numbers of bats, harp traps are preferred to mist nets and should be used whenever possible. The number of traps and/or nets used will depend on the size and number of entrances to the site. However, the numbers and positions should be identical each year. Traps and nets should not prevent bats from entering or leaving the site, to minimize disturbance.

3.8.3 Timing

Catching should be carried out on dry nights with little wind. Do not catch on more than three consecutive nights: although there is considerable turnover of individuals each night, some bats will learn the position of traps and nets. Swarming activity peaks between mid-August and mid-September, but may vary depending on latitude. Peak activity is 4-5 hours after sunset in the UK, but again may vary across Europe.

3.9 Remote automatic recording

This method can be used to record bats where it is not possible to use surveyors. Recent developments in technology allow a range of bat species to be recorded and their calls identified with sonogram analysis. Remote automatic recording using a heterodyne detector connected to a tape recorder and a timer is one of the cheapest methods. Heterodyne detectors have to be set to a chosen frequency and the voice activated tape recorder will only register sounds at that frequency. Thus the method is restricted to single species surveys e.g. surveying *M. daubentonii* over a waterbody or at potential sites for wind turbine construction.

3.9.1 Sampling

Sampling can be done at different sites and for different purposes. Placed at the entrance of roosts e.g. of caves, it can give an indication of the onset of activities either in spring at a hibernation site, or in summer for the timing of emergence activities. Due to possible swarming activities at such sites, numbers of emerging bats cannot be counted reliably.

Other possible positions to use automatic recorders may be along linear landscape features, such as waterways, hedgerows, forest edges, to monitor the use of flightpaths by a species.

3.9.2 Timing and number of counts

The device has to be used in accordance with the needed monitoring data. Surveys for wind turbine installations should start early in the season, shortly after hibernation, to identify possible migration routes e.g. of *N. noctula* through an area. Surveys at cave entrances to monitor post-hibernation activities should be done at least twice during the six-week early spring period e.g. after the last nights of severe frost.

Recordings during the main bat activity period should include at least two settings of the recording device, with the detector placed at the same spot each time and tuned to the same frequency.

3.9.3 Data management

All separate bat passes have to be identified clearly. Care should be taken to identify other bat species using similar echolocation frequencies to the chosen one. Misidentification could occur due to the skewed tonal quality of the registered calls.

3.10 Catching bats

Invasive methods involving catching and handling of bats, including the use of bat attractors, harp traps and mist nets, are not recommended for the purposes of surveillance because of the potentially high levels of disturbance to bats. However, they are extremely useful for initial research prior to setting up surveillance schemes and also for periodic assessments of bat abundance.

Catching can be used to identify bat species that cannot be recognized with a bat detector, to prove the sex and the reproductive status of abundant bats, or to obtain specimens for radio tagging, or in the case of swarming sites, periodically to assess changes in species relative abundance (as described in 3.8.2).

Catching requires a license in most countries. Rigorous training is required in both putting up nets correctly and in removing bats from them to minimize distress to the bats. Harp traps are preferred to mist nets since they are more efficient (bats are less able to detect them), cause less distress and require minimal training in use. However, their small catching area means they are only useful at roost entrances or where the bats are moving along natural fly-ways, such as woodland paths or small streams. They are also heavy and expensive. Mist nets are more versatile (available in 2.6 to >18 m lengths), light and easy to carry. However, it is possible to be overwhelmed by bats if care is not taken. Mist nets should never be left unattended for more than a few minutes. Harp traps can be left for longer, depending upon capture rate, prevailing weather conditions and the physiological status of the bats at that time.

3.10.1 Sampling

Bats are capable of detecting and avoiding both harp traps and mist nets, but careful positioning and the element of surprise allows both to be used with considerable success. Capture success declines rapidly if the bats are given time to learn the positions of nets and traps, so it is best to move them every night if catching is to be carried out on consecutive nights (with some exceptions, e.g. at swarming sites). The finest mist nets designed for catching birds, or those specifically designed for bats, are equally successful, but their efficiency declines rapidly under even moderately windy conditions, since bats are better able to detect moving objects. Harp traps can be used very successfully in conjunction with nets, the latter turning the more alert bats towards a trap.

Netting is especially successful in forests and across rivers. At a netting site mist nets with a length of at least 60 m should be set, the optimum for efficient and standardized surveys is a total net lengh of 90-100 m.

3.10.2 Example: Netting study in Germany (Dietz & Simon 2006)

A study in Germany showed that the optimum number of netting sites is related to the area being surveyed:

area size	number of netting sites
< 30 ha	1
30-250 ha	2
251-500 ha	3
501-1,000 ha	4
> 10 km^2	6
> 100 km^2	8

Netting should start shortly before sunset and last for 6-8 hours. Most efficient is the period from May to August.

3.11 Ringing

Ringing of bats is not recommended as a surveillance method. Ringing can be used for research projects, often those that extend over many years, and can provide very useful information on population structure and migration behaviour. However, ringing bats to assess population trends is inappropriate because of the invasive nature of the method and because it is unlikely to provide any useful information for surveillance purposes. Ringing requires a license in most countries and best practice guidance on ringing and catching bats has been produced by the EUROBATS Scientific Advisory Committee (Ref).

3.12 Best practice to be adopted when carrying out bat surveys

Surveillance of bats and their roosts is a long-term activity, over many years if robust population trends are to be derived. The methods generally involve repeated counts and visits to the same sites at least annually, but sometimes more frequently and may involve entry into the roost site or catching and tracking of bats. It is therefore very important to follow a strict code of practice to ensure that all the surveillance activity does not have detrimental effects on the populations of bats that we are endeavouring to conserve. The recommendations listed below address the main factors to consider when surveying bats and their roosts and follow the best practice guidance on ringing and catching bats that has been produced by the EUROBATS Scientific Advisory Committee (Ref).

3.12.1 Surveys of winter and summer bat shelters

- Any survey should be carried out with the approval of the owner or administrator of the shelter (excluding shelters both located on public land and with open access).
- During hibernation, counting and identification of bats should be done without waking or catching them, except to read the number on a ring where a bat has one.
- Only electrical light should be used during counting. Use of light sources with a flame (torches, candles) is unacceptable. Using modern conventional or LED-based lighting systems, specifically designed for use in caves, it is possible to survey even the longest and most technically difficult caves.
- The survey (counting) duration, as well as the identification of each animal, should be kept to the minimum necessary.
- During surveys of summer colonies, counting and identification of bats in the roost should be done without catching them if at all possible. Single individuals may be caught only if there is no other way to identify the species, but this should not be done while non-flying young are in the colony.
- It is important to be as quiet as possible when carrying out the survey, so as not to disturb the bats. The number of people in a counting group (summer and winter) should also be kept to a minimum.
- Survey of shelters at any time of year should not be carried out more than twice a year with at least one month between visits, and in the event that research on season number dynamics is justified, not more than once every two weeks.
- Any damage to the bat roost structures is unacceptable (e.g. making holes in walls, removing rubble blocking corridors, draining water, removal of parts of the roof or bark sheets) even where these activities would increase the effectiveness of the survey.

3.12.2 Catching bats

- Catching of bats around breeding colonies when non-flying young are present should only be carried out in the event that there is no other way to identify the species reliably using less invasive methods (e.g. daytime surveys, ultrasound detection). If catching bats is necessary then the number of individuals caught should be kept to a minimum.

- No catching should be carried out during the expected time of parturition.
- Where nets and other traps are used, they should be checked at least every 15 minutes.
- When removing bats from the net, check first if the web's thread is caught in the bat's teeth, and if so, it should be removed very carefully (this particularly concerns small species). Disentanglement should proceed as quickly as possible. The animal should be held softly with one hand and the other hand used to take the bat out the same way it entered the net.
- When the bat is disentangled it should be placed in a dark fabric bag to minimize stress for the animal.
- The time the individual is captured must be kept to the minimum necessary – ideally not exceeding 10 minutes. Visibly pregnant females should be released immediately after removal from the net. If many bats are captured at the same time then additional catches should be stopped until all animals have been disentangled.
- In the event that a large number of bats are caught at the same time each individual of a medium or large sized species should be placed in a separate fabric bag and nursing females should be dealt with first.
- After examination, bats should be released immediately. If a bat does not fly from the hand it should be placed on a tree trunk or a branch. Captured bats may lower their body temperature for energetic purposes and then need some time to heat up before departure. For this reason bats must not be thrown in the air during release.

4 Species accounts

EUROBATS Resolution 2.2 originally recommended methods for a selected group of species that could be surveyed in many countries, to represent the range of bat behaviour and habitat patterns found in European bat species, including: *Rhinolophus hipposideros*, *Myotis myotis/M. blythii*, *Myotis bechsteinii*, *Myotis capaccinii*, *Eptesicus serotinus/E. nilssonii*, *Nyctalus noctula*, *Miniopterus schreibersii*. However, recommendations are provided here for all European species, taking into account the variety of factors affecting species in individual countries. Methods are listed for each species in order of preference.

4.1 Pteropodidae

4.1.1 Rousettus aegyptiacus (Geoffroy, 1810)

Recommended methods

1. Colony counts inside roosts in the breeding season if access is possible (March – May).

Other information

Colonies can be hard to find and access depends on circumstances e.g. by sea canoe for remote colonies. The species emerges very late and flies very low so emergence counts may not be applicable. However, they are faithful to sites.

This species is considered a pest by local fruit farmers and is often persecuted. These bats can be conspicuous in car headlights as they fly low across roads from tree to tree. It may be possible to carry out car headlight surveys, but at present this method requires testing and development of a protocol.

4.2 Emballonuridae

4.2.1 *Taphozous nudiventris* Cretzschmar, 1830

Recommended methods

1. Colony counts, internal.

Other information

There is only one recorded site in the EUROBATS Agreement area (in eastern Turkey). The species needs further survey and status assessment before any monitoring can be entertained (using mist nets and bat detectors). The known site is a bit remote, but should be checked as and when possible (e.g. counting in the roost).

4.3 Rhinolophidae

4.3.1 *Rhinolophus blasii* Peters, 1866

Recommended methods

1. Colony counts at maternity roots.

2. Counts at hibernation sites.

Other information

The species has a relatively quiet and highly directional echolocation call, and the use of ultrasonic detectors is therefore inappropriate. It is considered to be an exclusively cave-dwelling species, natural or man-made and appears to be faithful to its underground roosts.

The general problem for surveillance of all "middle" sized horseshoe bats – *R. euryale*, *R. mehelyi* and *R. blasii,* is that they often form mixed colonies in which the visual separation of each species is impossible. Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site. This could be repeated at five yearly intervals to assess any changes in relative proportions of each species.

4.3.2 Rhinolophus euryale Blasius, 1853

Recommended methods

1. Counts at hibernation sites.
2. Colony counts, internal or emergence, if colonies are known to be faithful to their roost sites.

Other information

The species has quiet and highly directional echolocation calls, and the use of ultrasonic detectors is therefore inappropriate. The species is particularly faithful to its hibernation roosts, while some maternity colonies move between roosts.

The species is susceptible to disturbance. Roost fidelity can be increased through protection of the site. The general problem for surveillance of all "middle" sized horseshoe bats – *R. euryale*, *R. mehelyi* and *R. blasii* in the Balkans, is that they often form mixed colonies in which the visual separation of each species is impossible. Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site.

4.3.3 Rhinolophus ferrumequinum **(Schreber, 1774)**

Recommended methods

1. Colony counts, emergence, in early and mid July (if not mixed with other species and colony size < 400 individuals).
2. Counts in hibernation sites by visual determination with one winter census between 15th December and 15th March. (when not mixed with other Rhinolophid species).

Other information

Echolocation calls are intense, but highly directional and observer held detectors rarely pick up bats unless they are detected moving along commuting routes. However, static detector systems can be successfully used to confirm suspected commuting routes and foraging areas within suitable foraging habitats near linear features.

Small samples of droppings collected from beneath the maternity colony at known intervals (weekly, fortnightly or monthly) may be dried and stored in small, labelled canisters. If surveillance highlights population declines, samples can be analysed for diet content and contaminants. *R. ferrumequinum* is often living during summer and winter in mixed nursing colonies together with other Rhinolophid species or with *Myotis emarginatus*. This makes monitoring sometimes difficult.

To assess number of young and reproductive success, internal counts of young present can be carried out once the adults have emerged.

Literature: Pir *et al.*, 2004

4.3.4 Rhinolophus hipposideros **(Bechstein, 1800)**

Recommended methods

1. Colony counts, emergence or internal.
2. Counts in hibernation sites.

Other information

The species has a quiet and highly directional echolocation call, and the use of ultrasonic detectors is therefore inappropriate. It appears to be faithful to its maternity roosts and depends completely on underground sites for hibernation.

The species can be counted in roosts using DNA analysis of droppings. Summer emergence counts are favoured over hibernation counts because populations are more aggregated during the breeding season than during hibernation. There is also more potential for disturbance during hibernation.

4.3.5 Rhinolophus mehelyi Matschie, 1901

Recommended methods

1. Colony counts, emergence or internal.
2. Counts at hibernation sites.

Other information

The species has a relatively quiet and highly directional echolocation call, and the use of ultrasonic detectors is therefore inappropriate. It appears to be faithful to its underground roosts.

General problem for the monitoring of all "middle" sized horseshoe bats – *R. euryale*, *R. mehelyi* and *R. blasii* in the Balkans, is that they often form mixed colonies in which the visual separation of each species is impossible. Preliminary research involving catching of bats for species identification and justification of the proportion of each species is required for each site, which can be repeated at five yearly intervals.

4.4 Vespertilionidae

***4.4.1 Barbastella barbastellus* (Schreber, 1774)**

Recommended methods

1. Bat detector surveys in selected woodlands.
2. Colony counts, emergence. Accurate population estimates for each colony will rely on the invasive techniques of a radio-tracked individual coupled with infra red camcorder roost exit counts. This procedure is best undertaken during early August when the colonies are at their largest and most stable. Although invasive, radio tracking is the only method consistently reliable enough at revealing roost locations to ensure at least partly accurate emergence counts.

Other information

It now seems possible to identify *B. barbastellus* from echolocation calls with reasonable confidence and this opens possibilities for carrying out field surveys. The species tends to be scarce in the landscape so difficult to encounter, but commutes long distances along regular flight-lines to foraging areas, which aids detection. Colony counts are difficult because colonies constantly divide and move locations.

Occasionally individuals will utilise open buildings or barns in very cold weather, but normally they are active in all milder spells throughout the winter. In the more continental climate of central Europe *B. barbastellus* widely hibernates in colder underground sites. In these areas the species has similar requirements to *Pipistrellus pipistrellus* with consequent possibilities for winter surveillance.

Long term colony surveillance and monitoring should cover both an estimate of the number of breeding females in a colony and the quality of the habitat. Foraging habitat quality is well assessed by species richness, particularly botanical and insect diversity.

4.4.2 Barbastella leucomelas (Cretzschmar, 1826)

Recommended methods

There is no information for this species.

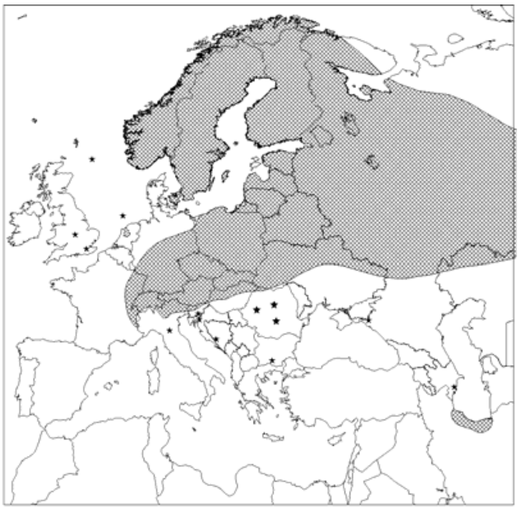
4.4.3 Eptesicus bottae (Peters, 1869)

Recommended surveillance methods

1. Bat detector surveys.

Other information
This species has a distinctive echolocation call (Holderied *et al.*, 2005).

4.4.4 Eptesicus nilssonii (Keyserling & Blasius, 1839)



Recommended surveillance methods
Recommended surveillance methods include:
1 Bat detector surveys, including car surveys.
2. Counts at underground hibernation sites in parts of Central and Eastern Europe and higher altitudes in the southern part of its distribution.
3. Colony counts, emergence, at summer roosts (but may not be philopatric in some places).

Other information
The species has loud calls which are distinctive from all other species.

4.4.5 Eptesicus serotinus (Schreber, 1774)

Recommended methods

1. Bat detector surveys, including car surveys.
2. Colony counts, emergence, from summer roosts.
3. Remote automatic recording.

Other information

The species has loud echolocation calls which are distinctive from all other species. Hibernation sites for the species are not generally known.

The species is synanthropic throughout most of its range. It is therefore highly dependent on conservation measures and the attitude of private house owners. For roof-inhabiting serotines, at least 2 counts are recommended: one in mid-May after the establishment of colonies, and one in mid/end-June, before young become volant. Crevice-inhabiting colonies differ almost daily in numbers and all known roosts of the colony have to be followed to get accurate numbers. Radio transmitters should be fitted to individuals caught at drinking/foraging sites to follow them to roosts; e.g. in Greece where there are no known roosts.

4.4.6 *Hypsugo savii* (Bonaparte, 1837)

Recommended methods

1. Bat detector surveys, possibly using balloons with remote recording equipment attached.

Other information

The roosts of *H. savii* are hazardous to find. The species has calls which are distinctive from all other species, but it is important to take account of the vertical distribution of this species when foraging, as it is often found flying at relatively high altitudes compared with other species, above the tree canopy. *H. savii*, like several other species, seems to roam widely to different foraging areas to feed on swarming insects, so counts could vary a lot within a short period and should rbe repeated many times during summer (Russo & Jones, 2002).

May overlap with *P. kuhlii*; roosts can be located by fitting transmitters on individuals caught at foraging/drinking sites.

4.4.7 *Myotis alcathoe* von Helversen & Heller, 2001

Recommended methods

There are no methods known for this species

Other information

The echolocation calls of this species cannot be separated for identification purposes from those of other *Myotis* species. The only known option is to mist-net and identify in the hand.

4.4.8 *Myotis aurascens* Kuzyakin, 1935

Recommended methods

No information exists for this species.

4.4.9 *Myotis bechsteinii* (Kuhl, 1817)

Recommended surveillance methods

1. Use artificially produced social calls to attract species into mist nets and follow up with radio tracking to locate roosts and infra red camcorders to do emergence counts.

Other information

This species has a close association with semi-natural woodland. The bats habitually forage in tree crowns at some distance from the ground. This behaviour makes it particularly difficult to monitor their quiet echolocation calls with ultrasonic detectors.

The constant shifting and dividing of maternity colonies makes accurate counts difficult and the species rarely hibernates where it can be counted.

Bechstein's bat is caught in sufficient numbers at mating 'swarming' sites in late summer and this could offer a potential for surveillance. These swarming animals are, however, predominantly male and too little is currently known about male /female birth proportions and survival rates to make population predictions based on male numbers alone. Counting juvenile bats at swarming sites may hold possibilities, but the bats need to be caught and handled to identify them. Swarming sites are not known across wide areas so how relevant the data would be from the few currently known swarming sites is unknown.

Echolocation calls are very quiet and often difficult to separate from *Myotis mystacinus.* For long-term population monitoring the numbers of breeding females in a selected number of colonies should be assessed and estimated every five years. A habitat assessment should form part of this exercise.

4.4.10 *Myotis blythii* (Tomes, 1857)

Recommended methods

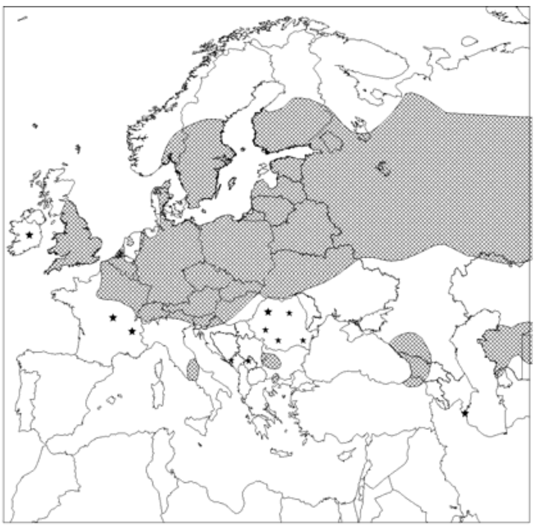
1. Counts at hibernation sites.
2. Colony counts, internal, in mixed colonies. For separate colonies (particularly in the north), emergence counts are possible.

Other information

Identification of the difference between the two species is difficult with ultrasonic detectors and also in mixed colonies. *M. blythii* has a distinctive white patch on the back of its head, making it distinguishable from *M. myotis* while roosting, although identification can be difficult in some roosts, particularly in attic spaces. These species are faithful to their summer and winter roosts.

Preliminary research, involving catching bats for species identification and assessment of the proportion of each species, is required for each site. This could be repeated at five yearly intervals to assess any changes in relative proportions of each species. Counts may be possible using DNA analysis of droppings.

4.4.11 *Myotis brandtii* (Eversmann, 1845)



Recommended surveillance methods

1. Counts at hibernation sites with mass occurrence of the species
2. Surveying at swarming sites.
3. Netting over water bodies or in forest clearings could be useful in transient parts of the season.

Other information

Ultrasonic detectors are ineffective with this species, because of the current impossibility of distinguishing from other closely related *Myotis* species.

The species can be confused with *M. alcathoe* and *M. mystacinus,* which are very similar. Punch samples of wing membrane can be gathered, under licence, for possible later confirmation of identification. Droppings can also be gathered for DNA analysis.

4.4.12 *Myotis capaccinii* (Bonaparte, 1837)

Recommended methods

1. Counts at hibernation sites (south eastern Europe)
2. Colony counts, internal, at maternity roosts (south western and south eastern Europe) using photos.

Other information

Ultrasonic detectors are ineffective with this species, because of the current impossibility of distinguishing from *M. daubentonii*.

The species may form mixed colonies with *M. myotis/M. blythii/Miniopterus schreibersii*. The species tends to emerge later than other species with which it shares the roost (in particular *M. schreibersii*), but emergence times overlap and so counting the bats emerging from the roost when other species have departed is not really an option. It is possible in some roosts to count the young after the adults have departed, which could give a measure of colony productivity.

4.4.13 *Myotis dasycneme* (Boie, 1825)

Recommended surveillance methods

1. Bat detector surveys, using point count method around waterbodies.
2. Colony counts, emergence, at maternity roosts.
3. Hibernation site counts.
4. Surveys at swarming sites.

Other information

It is possible to distinguish this species from other trawling bats acoustically and visually.
Literature: Britton *et al*., 1997

4.4.14 *Myotis daubentonii* (Kuhl, 1817)

Recommended surveillance methods

1. Bat detector transects, using point count method, around water bodies using a torch to confirm identity from flight style.

2. Counts at hibernation sites, although the species can be hard to identify because it uses crevices during hibernation.
3. Surveys at swarming sites.
4. Remote automatic recording under bridges, because this species often roosts in such locations.

Other information

The foraging style means that the species can easily be identified foraging over water bodies. The species can be confused with *M. capaccinii* and *M. dasycneme*.

4.4.15 *Myotis emarginatus* (Geoffroy, 1806)

Recommended methods

1. Counts at hibernation sites. *M. emarginatus* can easily be counted in underground habitats, with one winter census between 15th December and 15th March. However, only a small percentage of existing populations is seen.
2. Colony counts, internal, at maternity roosts, preferably one count but with a maximum of two to avoid disturbance.. This is the preferred method in southern Europe.
3. Surveys at swarming sites.

Other information

The species uses several roosts and the number of individuals in maternity roosts changes from one year to another or even from the beginning to the end of the breeding season, which makes surveillance using colony counts difficult. There is no evidence that bat detector transects are effective for this species.
Literature: Pir, 2004

4.4.16 *Myotis hajastanicus* Argyropulo, 1939

Recommended methods

There is no information for this species.

Other information

There is only one colony known, in Armenia, with about 30 specimens.

4.4.17 *Myotis myotis* (Borkhausen, 1797)

Recommended methods

1. Colony counts, internal, inside caves in mixed colonies. Emergence counts are possible for separate colonies (particularly in the north). However, the species often has many exit points so care needs to be taken when organising the count.
2. Hibernation site counts, possibly using digital photography.
3. Colony counts, internal, in large attic roosts or caves, again using photographic methods.

Other information

Identification is difficult between *M. myotis* and *M. blythii.* These species are faithful to their summer and winter roosts.

4.4.18 *Myotis mystacinus* (Kuhl, 1817)

Recommended methods

4. Counts at hibernation sites with mass occurrence of the species
5. Surveying at swarming sites.
6. Netting over water bodies or in forest clearings could be useful in transient parts of the season.

Other information

Ultrasonic detectors are ineffective with this species, because of the current impossibility of distinguishing from other closely related *Myotis* species.

The species can be confused with *M. alcathoe* and *M. brandtii,* which are very similar. Punch samples of wing membrane can be gathered, under license, for possible later confirmation of identification. Droppings can also be gathered for DNA analysis.

4.4.19 *Myotis nattereri* (Kuhl, 1817)

Recommended methods

1. Counts at hibernation sites. The species is often found in underground sites and is easy to identify.
2. Colony counts, internal, at maternity roosts.
3. Surveying at swarming sites, although not appropriate at smaller hibernation sites.
4. If no other alternative is possible then mist-netting in forests provides some information.

Other information

Surveillance using ultrasonic detectors is not recommended because of the quiet calls of M. nattereri and confusion with other foraging Myotis species. Emergence counts at maternity roosts are also not very reliable because of the unpredictable behaviour of emerging bats, frequently returning to the roost and emerging again, causing confusion in the counts.

4.4.20 *Myotis nipalensis* (Dobson, 1871)

Recommended surveillance methods

1. Counts at hibernation sites with mass occurrence of the species
2. Surveying at swarming sites.

3. Netting over water bodies or in forest clearings could be useful in transient parts of the season.

Other information

Ultrasonic detectors are ineffective with this species, because of the current impossibility of distinguishing from other closely related *Myotis* species.

The species can be confused with *M. alcathoe* and *M. brandtii,* which are very similar. Punch samples of wing membrane can be gathered, under licence, for possible later confirmation of identification. Droppings can also be gathered for DNA analysis.

4.4.21 *Myotis punicus* Felten, 1977

Recommended surveillance methods

1. Colony counts, internal, at maternity roosts. Emergence counts are also possible, but the large size of colonies can make counting quite difficult.

4.4.22 *Myotis schaubi* Kormos, 1934

Recommended surveillance methods
No colonies are known, but the methods would be the same as for *M. nattereri*.

4.4.23 *Nyctalus lasiopterus* (Schreber, 1780)

Recommended methods
1. Bat detector line transects.

Other information
N. lasiopterus is a large heavy bat with less maneuverable flight than other smaller bats. It is also highly connected to water bodies, as it seems it needs a regular water supply (possibly connected with its rapid flight).- so the specimens visit drinking places regularly. This means that mist-netting can be a good method for surveying.

Mist-nets placed on the banks of small ponds or brooks with calm surfaces where the species comes to drink can be used to provide information on sex ratio and reproductive condition. It is important to use the same locations for the mist–net each time and mist-nets must be of similar quality (mesh; denier parameters). In Hungary mist-netting at such localities has been very successful. The use of accoustic lures may be effective. The species can be confused with *N. noctula*.

4.4.24 *Nyctalus leisleri* (Kuhl, 1817)

Recommended methods

1. Bat detector line transects, including car surveys.
2. Colony counts, emergence, where species roosts in buildings.
3. Counts at mating roosts. The mating calls of the species can be easily identified using time expansion detectors and may also be useful for the purposes of monitoring during August to early October.

Other information

The species echolocation call is intermediate between *N. noctula* and *E. serotinus*, the exact type of call dependent on the environment where it is found, although there is overlap between species. Identification with reasonable confidence requires surveyors who have some previous experience of this species.

Absolute separation accoustically from *N. noctula* may not be possible except in very open habitats.

4.4.25 *Nyctalus noctula* (Schreber, 1774)

Recommended methods

1. Bat detector line transects, including car surveys.
2. Counts at mating roosts, of calling males during the mating season.

Other information

Counts at maternity and hibernation sites probably do not give a reliable index of *N. noctula* population density. However, the species can be easily identified with a bat detector. It is possible to hear this species in tree roosts during the day time.

4.4.25 *Otonycteris hemprichii* Peters, 1859

Recommended methods

The species needs further survey and status assessment before any monitoring can be entertained.

4.4.27 *Pipistrellus kuhlii* (Kuhl, 1817)

Recommended methods

1. Bat detector line transect surveys. Need to be aware of overlap between calls of *P. kuhlii* and *P. nathusii*.
2. Colony counts at maternity roosts.

Other information

(see Russo & Jones 2002 for *P. kuhlii* frequencies).

4.4.28 *Pipistrellus nathusii* (Keyserling & Blasius, 1839)

Recommended methods

1. Bat detector transects. Broadband detectors can be used on field surveys with post-survey species identification through sonogram analysis. But beware overlap with *P. kuhlii*.
2. Counts at mating roosts.
3. Colony counts, emergence, at maternity roosts

Other information

A highly migratory species.
Literature: Barlow & Jones, 1996

4.4.29 *Pipistrellus pipistrellus* (Schreber, 1774)

Recommended methods

1. Bat detector surveys, including car surveys.
2. Colony counts of emerging bats in summer.
3. Surveys of mating roosts.

Other information

The species has very distinctive and loud echolocation calls at 45 kHz and can readily be identified using a bat detector. The use of buildings as maternity roosts by this species means that colony counts during the summer are also an appropriate method. However, it should be noted that this is a very mobile species, with colonies moving location within and between years. Colonies may also grow and shrink in size during the breeding season, making colony counts of questionable reliability.

4.4.30 *Pipistrellus pygmaeus* (Leach, 1825)

Recommended methods

1. Line transects using ultrasonic detectors, including car surveys. Beware of overlap of calls from *P. pygmaeus* with those of *M. schreibersii* where the two species are sympatric (Russo & Jones, 2002). There is little overlap in dominant frequencies of *P. pygmaeus* and *P. pipistrellus* (< 5% overlap at maternity roosts).
2. Counts of emerging bats at maternity roosts.
3. Social calls of the two species are usually (but not always) straightforward to separate, so surveys of mating roosts might be useful.

Other information

The species has very distinctive and loud echolocation calls at 55 kHz and can readily be identified using a bat detector. The use of buildings as maternity roosts by this species means that colony counts during the summer may be a good monitoring method. Colonies of *P. pygmaeus* are larger and more stable than those of *P. pipistrellus*, perhaps rendering them more suitable to this type of monitoring.
Literature Barlow & Jones, 1997, Russo & Jones, 2002

4.4.31 *Plecotus macrobullaris* Kuzyakin, 1965

Recommended methods

1. Colony counts at summer roosts should give reliable population density information.

Other information

Bat-detector surveillance is almost impossible and is not recommended. Preliminary mist-netting surveys may be required to determine true range and distribution.

4.4.32 *Plecotus auritus* (Linnaeus, 1758)

Recommended methods

1. Counts of emerging bats at summer roosts.
2. Hibernation site counts.
3. Surveys at swarming sites.

Other information

The species is predominantly a woodland species and has very quiet echolocation calls. It is not usually encountered in the open countryside, so it is not suitable for bat detector surveys. It forms fairly stable colonies and tends to be philopatric, especially when roosting in buildings.

This species tends to emerge late in the evening and have a pattern of emerging in groups of two or three with a few minutes between groups. The species can, therfore, take a long time to emerge from roosts, so visibility of bats may be an issue, particularly for larger colonies where the last bats will be emerging quite late.

4.4.33 *Plecotus austriacus* (Fischer, 1829)

Recommended methods

1. Colony counts, both internal and emergence.
2. Hibernation site counts, but only in some parts of the species range.

4.4.34 *Plecotus kolombatovici* Dulic, 1980

Recommended methods

1. Counts at maternity sites would probably give a reliable index of *P. kolombatovici* population density. Possible problem could be identification of this species in areas of sympatry with other *Plecotus* species.

2. Locating new colonies using bat detectors during early morning swarming in front of summer shelters.

4.4.35 *Plecotus sardus* Mucedda, Kiefer, Pidinchedda & Veith, 2002

Recommended methods

No information exists for this species. Surveys are required to assess roost locations.

4.4.36 *Vespertilio murinus* Linnaeus, 1758

Recommended methods

1. Colony counts, emergence, at maternity roosts.
2. Bat detector line transect surveys.
3. Counts at mating roosts.

Other information

The species has distinctive echolocation calls. Long distance migrant in eastern and central Europe.

4.4.37 *Miniopterus schreibersii* (Kuhl, 1817)

Recommended methods

1. Hibernation site counts. A visual count should be undertaken as quickly as possible inside the cave or mine, assessing the size of the colony by estimating, through photography (stereoscopic if the roof is sloping) the square metre area which it covers (1 square metre corresponding to about 2,000 specimens).
2. Colony counts, internal, using above method.
3. Bat detector line transects, where species not sympatric with *P. pygmaeus*.

Other information

Beware of overlap of calls from *P. pygmaeus* with those of *M. schreibersii* where the two species are sympatric

Literature: Russo & Jones, 2002.

4.5 Molossidae

4.5.1 *Tadarida teniotis* (Rafinesque, 1814)

Recommended methods

1. Bat detector line transects in foraging habitats. Echolocation calls are distinctive and can be heard at long range (see Russo & Jones 2002).
2. Colony counts, emergence, are possible, mainly for colonies roosting in buildings.

Other information

T. teniotis emits loud and audible echolocation calls, so sound surveys (possibly with bat detectors) in summer are recommended for surveillance of the species. It may even be possible to survey this species acoustically without bat detectors, as calls are audible to humans.

Literature: Russo & Jones, 2002.

4.6 Summary table of species and methods

Species	Methods										
	Bat detector survey			Hibernation survey	Colony counts		Remote recording	Mating roosts	Locating roosts	Swarming sites	Catching bats
	Field	Car	Water		Internal	External					
Pteropodidae											
Rousettus aegyptiacus					1						
Emballonuridae											
Taphozous nudiventris					1						
Rhinolophidae											
Rhinolophus blasii				2	1	1					
Rhinolophus euryale				1	2	2					
Rhinolophus ferrumequinum				2		1					
Rhinolophus hipposideros				2	1	1					
Rhinolophus mehelyi				2	1	1					
Vespertilionidae											
Barbastella barbastellus	1					1					
Barbastella leucomelas											
Eptesicus bottae	1										
Eptesicus nilssonii	1	1		2		1					
Eptesicus serotinus	1	1				1	1				
Hypsugo savii	1										
Myotis alcathoe											1
Myotis aurascens											
Myotis bechsteinii											1
Myotis blythii				1	2	2					
Myotis brandtii				1						2	3
Myotis capaccinii				1	2						
Myotis dasycneme			1	3		2				4	
Myotis daubentonii			1	2			4			3	
Myotis emarginatus				1	2					3	
Myotis hajastanicus											
Myotis myotis				1	1	1					
Myotis mystacinus				1						2	3
Myotis nattereri				1	2					3	
Myotis nipalensis				1						2	3
Myotis punicus					1	1					
Myotis schaubi				1	2					3	
Nyctalus lasiopterus	1										
Nyctalus leisleri	1	1				2		3			
Nyctalus noctula	1	1						2			
Otonycteris hemprichii											
Pipistrellus kuhlii	1					1					
Pipistrellus nathusii	1					3		2			
Pipistrellus pipistrellus	1	1				2		3			
Pipistrellus pygmaeus	1	1				2		3			
Plecotus macrobullaris						1					
Plecotus auritus				2		1				3	
Plecotus austriacus				2	1	1					
Plecotus kolombatovici						1			2		
Plecotus sardus											
Vespertilio murinus	2				1	1		3			
Miniopterus schreibersii	3			1	2						
Molossidae											
Tadarida teniotis	1					2					

5. National bat monitoring programmes

Some examples of bat monitoring programmes in European countries are provided here to show how the guidelines on survey methods can be applied in practice for a range of species.

5.1 Belgium

Bat Monitoring in Wallonia started in the 1940s, set up by Jacques Fairon (National Royal Institute for Natural Sciences, Brussels). Since 1990 it has been part of the regional surveillance programme. Monitoring methods have been established for winter and summer surveys.

5.1.1 Surveying hibernacula

A number of representative underground sites per natural region of Wallonia have been selected (from 712 underground sites, 95 have been chosen). Timing and number of visits and use of equipment have been standardised (no carbid lamps!). Emphasis is on respect of conservation issues (no touching bats, avoidance of disturbance of hibernating animals).

5.1.2 Surveying summer roosts

Estimating colony size and change in size is carried out through counts of droppings. Maternity roosts are located and species identified. Roosting places within the site are identified and plastic foil of standardized size is put under the main roosting places of the colony. The plastic sheeting is checked at regular time intervals, and the presence and size of the colony can be estimated according to the number (classified) of droppings. This method is especially useful if monitoring a large number of roosts and external counts are not possible. It minimises the disturbance caused by internal counting.

These long term standardized surveys show country level population trends of all species and in relation to the natural regions where they occur.

5.2 France

5.2.1 Introduction

Bat surveillance has been ongoing in France for several decades, and has provided information on the dramatic decline of many bat species, particularly horseshoe bats (Brosset, 1978; Brosset *et al.*, 1988). However, surveys were restricted to a few main roosts and often carried out at a regional level (e.g. Faugier, 1983; Ariagno & Salaün, 1991; Faugier & Issartel, 1993; Noël, 2002).

In the 1990s a long term surveillance programme for Annex II Habitats Directive species was initiated during the National Bat Meeting in Bourges. This surveillance was planned on an annual basis for wintering *Rhinolophus ferrumequinum* and was partly possible because of the dramatic increase in the number of bat workers. Later on, during the period 1999-2003, a 5-year Action Plan for bats was implemented by the French mammal society (S.F.E.P.M). One aim of this first Action Plan was to annually survey some priority species and to test new methods.

Finally, in order to fill the gaps of the two previous surveys, regional surveillance was carried out mainly by counting rhinolophids in hibernacula and mapping the distribution of all species. All work has been carried out on a voluntary basis.

5.3.2 Long term winter and summer surveys

In 1995 the first national survey attempted to estimate the populations of the 12 Annex II Habitat's Directive species (Roué *et al*., 1997). The number of bats was recorded for both hibernation sites and nursery roosts selected by surveyors. In winter, bats were counted inside the roosts by volunteers. Disturbance of bats was kept to a minimum, with one visit only, no handling (excluding some identification, and bats deeply hidden in cracks), a small number of counters, and limiting time spent in the hibernacula to an absolute minimum. Sites were surveyed preferably on the same day each year, more usually from mid-January to mid-February. In summer, colony counts were traditionally carried out from late May to mid-July depending on the species. Counts were either inside the roost for a very short visit or during emergence with or without a bat detector.

This investigation highlighted a great disparity between regions, as the majority of the surveys were conducted in the northern half of the country and only localised information came from the southern part. A report was produced in 1995 to make the national and local authorities aware of the necessity to conserve these mammals and it gave the ministry in charge of the environment the incentive to start an Action Plan.

In 2004, a new assessment (Fauvel *et al.,* 2004) of bat populations was made nearly 10 years after the 1995 report. This assessment showed that the disparity between regions previously reported, still exists although systematic inventories have started in some regions, explaining the increase in numbers of sites and bats. However, some large areas of the country still need to be investigated.

Table 5.1: Seasonal counting of French bat roosts at a nine-year interval, after Roué *et al.,* 1997, Fauvel *et al.,* 2004 (*Rhinolophus ferrumequinum* was also surveyed in 1999 [Ros, 2002]; *Myotis myotis* and *Myotis blythii* are sympatric in the south of France and even form mixed maternity colonies; as they cannot always be identified separately, three different tables have been presented).

Species	Year	Winter		Summer	
		Bats	Sites	Bats	Sites
Rhinolophus ferrumequinum	*1995*	*21 268*	*810*	*6 430*	*270*
	1999	*28 422*	*1433*	*10 572*	*210*
	2004	42 043	1823	19 171	291
Rhinolophus hipposideros	*1995*	*5 930*	*909*	*10 644*	*578*
	2004	15 268	2 199	31 212	1 496
Rhinolophus euryale	*1995*	*2 899*	*51*	*3 616*	*49*
	2004	9 367	117	6 524	48
Rhinolophus meheylii	*1995*	*5*	*1*	*0*	*0*
	2004	1	1	0	0
Myotis myotis	*1995*	*13 035*	*681*	*37 126*	*252*
	2004	15 520	1 363	52 449	311
Myotis blythii	*1995*	*1 116*	*9*	*8 685*	*32*
	2004	2 537	118	21 362	97

Myotis myotis/blythii	*1995*	*14 151*	*690*	*45 011*	*284*
	2004	18 057	1 481	73 811	408
Myotis capaccinii	*1995*	*541*	*35*	*1 525*	*21*
	2004	720	78	3 803	14
Myotis dasycneme	*1995*	*18*	*5*		
	2004	23	6	0	0
Myotis emarginatus	*1995*	*9 670*	*345*	*7 681*	*123*
	2004	18 240	751	35 251	198
Myotis bechsteinii	*1995*	*732*	*239*	*191*	*30*
	2004	823	528	135	8
Barbastella barbastellus	*1995*	*1 983*	*239*	*1 155*	*51*
	2004	4 886	528	3 141	200
Miniopterus schreibersii	*1995*	*211 109*	*45*	*114 056*	*95*
	2004	74 786	52	57 515	50

As data from some areas or for some species had not been communicated at the time of the compilation, a full analysis could not be carried out. But some comment can be made for *Miniopterus schreibersii*.

After the exceptional mortality that affected *Miniopterus schreibersii* in France, Portugal and Spain in 2002, population decline on a national scale has been observed, but is still difficult to evaluate in the absence of national monitoring of all hibernation and maternity roosts. For this species, the absolute protection of its roosts seems to be the prerequisite that will allow its population to recover, in peace and quiet.

5.2.3 Five-year surveillance program 1999-2003

The first national action plan for bats (S.F.E.P.M. 1999), included a programme of roost surveys of 8 Habitats Directive Annex II species in winter and/or summer (Arthur *et al*., 2000).

Due to the large number of roosts for 6 species, only the two most important ones for each region and for each study season were selected (table 5.2). During the 5-year period the surveillance of some roosts was abandoned due to the disappearance of the colony or of the roost itself or because there was no volunteer to continue the survey. Survey protocols for each species were similar (see long term surveillance) except for *Myotis capaccinii* (often found in mixed colonies, appendix 1) and *Miniopterus schreibersii* (species that gathers in very large colonies, appendix 2).

The information collected included site characteristics (location, type of roost, protection and disturbance), the date of survey, the number of bats as well as some other data (isolated individuals, swarm, cadavers, etc.). The winter survey was scheduled between 15/01 and 10/02, and the summer survey between 01/06 and 15/07, before the young start flying, in order to count them at night once the adults have left to forage.

Table 5.2: Extent of the five-year surveillance program in France

Species	**Winter**		**Summer**		**Method**	**Regions**	**Total sites**
	North	South	North	South			
Rhinolophus ferrumequinum	√		√		general	10	20

Rhinolophus hipposideros	√		√		general	10	20
Rhinolophus euryale *	√	√			general	12	28
Myotis capaccinii *				√	specific	3	14
Myotis emarginatus	√		√		general	11	22
Myotis myotis			√		general	8	16
Barbastella barbastellus **	√				general	6	6
Miniopterus schreibersii *	√	√			specific	10	22

* (if possible all sites); ** (only roosts > 100 individuals)

5.3.4 Regional surveys

Regional surveillance mainly involves rhinolophids that are easy to count in hibernacula, and was initiated some decades ago in some localities (Ariagno & Salaün, 1991; Lustrat, 1994; Barataud & Jourde, 1999; Lustrat, 2001; Ariagno *et al.*, 2002; Auboin, 2002; Noël, 2002; Lustrat & Jullien, 2003; Boireau, 2006). For example, in the Ardèche departement (south-eastern France), winter and summer roosts (mainly caves), have been surveyed annually since 1953 (Faugier, 1983; Faugier & Issartel, 1993). This long-term surveillance deals with seven cave-dwelling species (*Rhinolophus ferrumequinum, R. hipposideros, R. euryale, Myotis myotis, M. blythii, M. emarginatus* and *Miniopterus schreibersii*) in a total of 238 sites. The data are particularly good for a comparison betweens decades 1953-1963 and 1981-1991 because there was similar recording effort in the field.

Results of various field surveys (roost counts, mistnetting, bat detector records) are usually stored on a regional basis. These databases are then used to map the distribution of the species and possibly identify trends in the evolution of their range. For example in the region Midi-Pyrénées, all bat contacts are recorded by volunteers, either on field sheets or stored directly in a local Access database. Once a year the local datasets are collected into a regional database for analysis and mapping. For each species, bat workers must give information on the site: name of the locality, map number (IGN 1/50,000) and quadrant (8 quadrants per map) or preferably geographic coordinates (altitude included), date, number of bats, type of contact (seen alive, cadaver, droppings), bat activity (breeding, hibernating, transit, etc.), age and breeding status, habitat. Standardised field sheets with codings are provided to bat workers. Maps of bat presence/absence are then easily obtained on any kind of information: breeding colonies, hibernating sites, mating roosts, etc. Maps can also provide information on gaps in survey effort in order to plan future work.

5.3.5 Surveyors and volunteer training

In France the majority of bat surveys rely on volunteers because universities are not interested in bat research at present. Volunteers are members of the local bat groups, they do not require any licence for counting bats, including inside roosts. However they must have undergone training and/or be accompanied by a licensed bat worker. On average over 300 volunteers take part every year. Volunteer training is organised by local bat groups across the country during field surveys conducted by licensed bat workers.

5.3.6 Databases

Data are stored in regional databases and population trend information is made available through reports and sometimes publications. Data for national reports are then extracted and centralised by the programme coordinators of S.F.E.P.M. No national database is available.

Appendix 1

RECOMMENDED SURVEILLANCE METHOD FOR *MINIOPTERUS SCHREIBERSII*

This survey concerned 10 regions for a total of 25 hibernation sites which were visited between January 15th and Jan. 25th for the most important ones and if necessary until February 10th for the others.

Protocol

The aim is to evaluate the size of the colony by counting on a photograph (with an aliquot area of 400 cm²) the number of individuals and the surface covered by the colony. Two surveyors are necessary for this work.

General remark

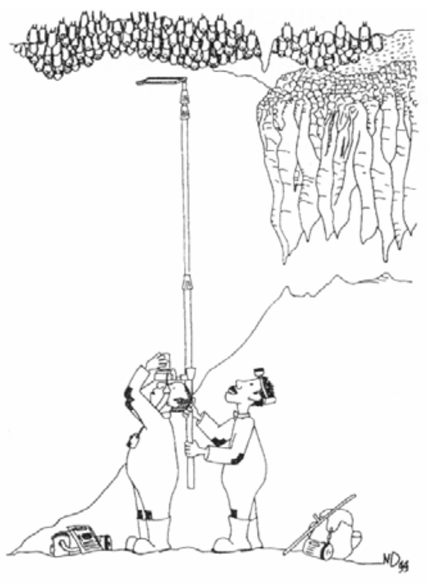
In a cave the roof and the walls are rarely flat and their relief is more or less strongly marked. As the photograph does not take the third dimension into account, it is necessary to establish relief classes which correspond to a percentage of added surface according to the slope.

Index 0 = 0% (nonexistent or insignificant relief: slope from the horizontal < 20°)
Index 1 = + 10% (slope around 30°)
Index 2 = + 25% (slope around 50°)
Index 3 = + 35% (slope around 60°)
Index 4 = + 55% (slope around 70°)
Index 5 = + 75% (slope around 80°)

On a sketch showing the form of the swarm the according index will be noted for the different relief areas.

In the field

a) Height of the colony < 8 m



- Use a light colour wooden square frame (internal size 20 cm x 20 cm) on top of a telescopic pole (3 m x 2). The camera will be a 24 x 36 reflex with changeable lens. You need to be able to change the focal length from 28 to 200 mm, so a zoom lens is useful. It is also essential to use a film for slides and a powerful flash gun (recommended guide number 45).

- With the frame as close as possible under the colony take a picture. If the density of the swarm is not uniform or if spaces of a few cm² appear in between the bats, take one picture of each of the different zones.
- Attach a light colour wooden ruler (1 m long) at right angles to the end of the pole and place as close as possible to the colony. Take a picture focusing on the ruler (its light colour will help doing it even in low light). If you cannot get the whole colony on the same shot, take a picture of the different parts, noting the characteristic rocky features which surround the colony. Never use a focal length less than 28 mm, because picture distortions will affect the results.

b) Height of the colony > 8 m

If the colony is out of reach of the pole, the margin of error will vary and it will be necessary to mention the method used for the estimation. The most efficient way is the following:

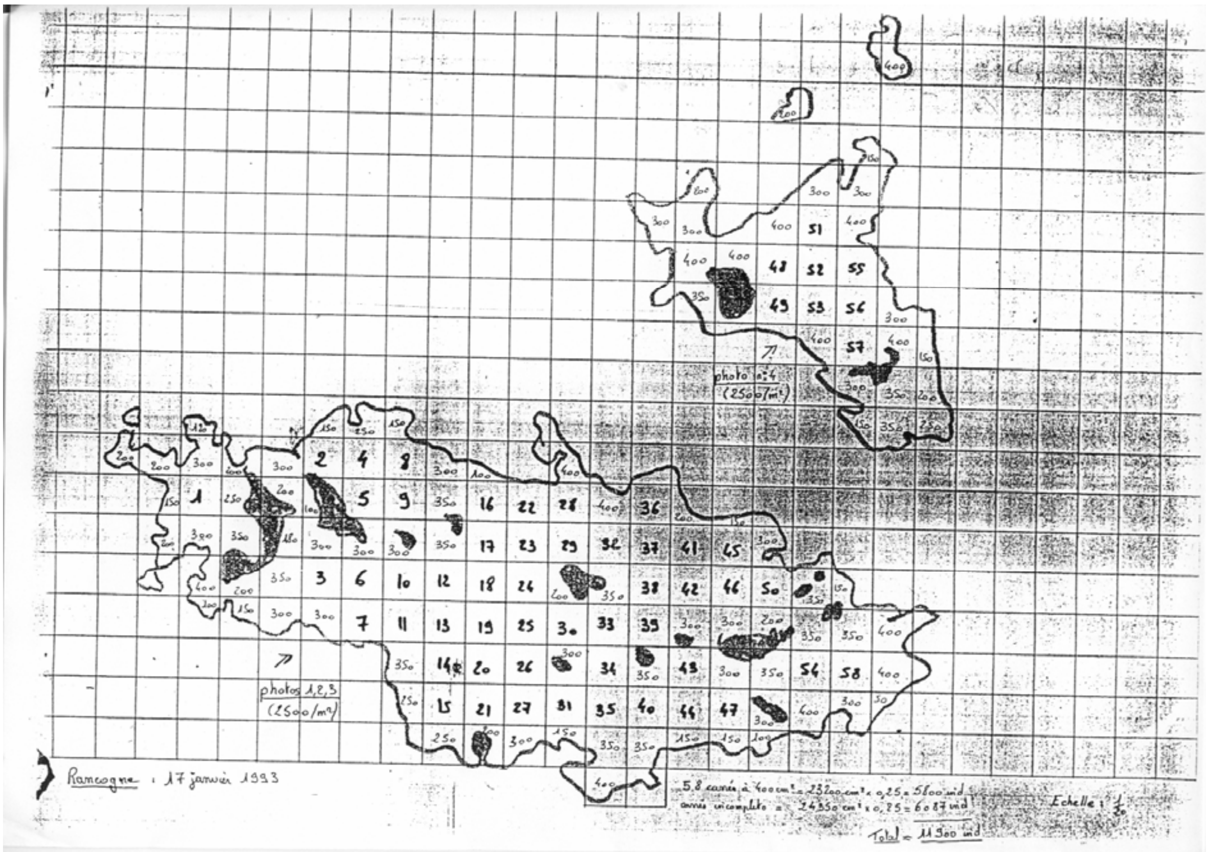
- Using a torch with a narrow beam, first calculate the beam diameter at different distances (e.g. every meter from 8 to 25 m).
- Taking landmarks, evaluate as precisely as possible the distance observer-colony. Then measure approximately the size of the colony, using the projected beam of the torch, draw the form of the swarm and if necessary of the areas with different densities.
- With binoculars estimate the different densities of the colony and copy them out on the drawing.

Processing the data

a) from photographs

- On a white sheet of paper show the slide of the 400cm² frame. Count the number of individuals in the square ticking every counted nose with a felt-tip pen. Multiply the number by 25 to get the density of one m² or divide it by 400 for a density of one cm².
- On a vertical support, put a sheet of paper with a 1/10 grid (2 cm squares) or preferably 1/20 grid (1 cm squares) – or several sheets according to the size of the colony.
- Place the projector so that its beam is perpendicular to the sheet of paper and adjust the distance in order that on the projected slide the ruler in front of the colony measures 10 cm (1/10) or 5 cm (1/20). Each square on the sheet represents the aliquot[1] area of 400 cm² .
- Then draw on the sheet the outlines of the colony, showing if necessary the areas with a different density and from the field sketches the roof areas with a relief.
- Count the full squares and multiply their true area (400 cm²) by the density per cm² that they can have.
- Every incomplete square will be measured (according to the used scale) to determine the surface covered by the bats, this surface being simplified to show a triangle or a quadrilateral. The obtained surfaces will be multiplied by the corresponding densities and their total added to the full squares.
- All the information regarding the colony should appear in the caption (densities of individuals/m² and relief index for each zone), give each group a number that will appear on the annual count form.

[1] An aliquot part is contained in another and dividing it without a remainder, e.g. 2 is an aliquot part of 6 (Oxford English dictionary)



Example of count sketch with the area covered by the different groups of *Miniopterus schreibersii* (in black the areas without bats). The numbers in bold show the full squares with the same density as the reference frame on photos 1, 2, 3, 4. The figures in the incomplete squares correspond to the calculated number of individuals (Source M. Barataud).

b) from evaluation with torch beam

- With reference to the field sketch, draw the outlines of the colony on a squared sheet of paper, using the measures estimated with the torch beam to determine the scale.
- You might have to outline the areas of different densities or relief that have been observed in the field.
- Proceed as above to calculate the surface and the number of individuals.

Appendix 2

RECOMMENDED SURVEILLANCE METHOD FOR *MYOTIS CAPACCINII*

As part of the Action Plan for bats (Objective 3) 12 maternity colonies of *Myotis capaccinii* were surveyed for 5 years (1999-2003) in 3 regions. They were the most important roosts of the species.
The period of survey was preferably 30 May -10 June, i.e. starting about 10 days after the first births (around May 20th).

Survey method

a) Count of emerging bats

- At least 2 observers are necessary for the count. They have to sit in front of the cave entrance(s) before the emergence of the bats and note the time when the first and the last individual leaves the roost.

- As *Myotis capaccinii* forms mixed maternity colonies with *Miniopterus schreibersii* or/and *Myotis myotis/blythii* it is necessary to count the emerging bats with a bat detector (Bat Box III or Petterson D200) set up on 35 kHz (peak frequency for *M. capaccinii*).
- If *Miniopterus schreibersii* is also present in the site there should be no problem as the peak frequency of its calls is on 50 kHz and no overlap of the 2 species is to be expected. The count of *M. capaccinii* will be fairly reliable (it is corroborated by the second surveyor).
- But difficulties arise in presence of *M. myotis* or *M. blythii* (peak frequency 30 kHz and it is then necessary to separate visually *M. capaccinii* from the group *M. myotis/blythii*. In that case a subdued light will be used (a paraffin oil lamp or a soft head-lamp) to see which bat is which.
- This count will give the number of individuals in the cave during the parturition period.

b) Count of the young
A quick count of newborns can be tried only if the presence of people in the cave does not disturb them, and once the adults have left the roost.
Some characteristics of *M. capaccinii* ecology allow this method, which had been previously tested without any mortality:

- Parturition starts very early, generally from May 20th to the end of the month in most cases.
- The young of *M. capaccinii* are present before the young of other species which do not give birth before the end of May or the beginning of June.
- Although we have little knowledge of female behaviour during the first nights after giving birth, it seems that the females leave the young in nursery when they are a few days old, under the supervision of one adult or more. However, the females go back and forth inside the cave network or even outside. But there is great variability in their behaviour which can be affected by the prevailing weather and some nights they do not even fly out. So caution is necessary.

This count is therefore performed at night, once the adults have left the cave. The counting can start only when most of the colony has departed. A maximum of 2 observers should be allowed in the cave to compare their numbers and to shorten their stay, as much as possible, as lactating females return rapidly to feed the young.

The counting method is the following:

- Count the young as precisely as possible using binoculars (8x23) or a spotting scope or using the projected area of the torch beam (use a powerful torch with a focalised beam which should project a clear ring on a wall – if possible ring diameter of 1 m at 10 m distance).
- Observers should minimise the time spent in the roost.

This second count will reveal the number of births for the year and then the breeding success (but not the flight success).

This survey method might possibly allow establishing a ratio between the number of emerging adults and the number of counted newborns. This ratio would give an estimate of newborn *M. capaccinii* (in normal parturition conditions) in sites with inaccessible spaces or where the swarm of newborns is not visible.
It shows that for regular parturition roosts of the species it is possible to perform precise counts of the maternity colony.

In Languedoc-Roussillon adults of both sexes gather at the end of winter (February) and are grouped together in the same resting places without mixing with other species. A survey of these swarming sites could be done from February 20th to March 10th and would cast a new light on the annual cycle of *M. capaccinii*.

5.3 Germany

The first steps towards a nationwide monitoring programme occurred in 1996: A questionnaire was sent to all federal Länder, asking for all known summer and winter roosts of *Myotis myotis* (including their accurate geographical coordinates, numbers of individuals). The result was the first map of national distribution with colony size classes. Problems encountered included missing accuracy of data files and not all data being available to administrations because they are held by NGOs and cooperation is sometimes lacking.

The next step was cooperation between the Federal Agency of Nature Conservation and NGOs using criteria agreed upon at a conference in Vilm in 2002. This was the beginning of a national monitoring programme of *M. myotis*. The monitoring methods were identified and tested in 2003 with good results (Biedermann & Geiger, 2005).

5.4 Netherlands

5.4.1 Introduction

Biodiversity in the Netherlands is monitored through the Network Ecological Monitoring (NEM) programme, which is funded by the Dutch Government. Partners in this programme are, amongst others, the NGOs who gather the data and CBS (Statistics Netherlands) who calculates indices and trends, and checks the quality of the data. Analyses are done using TRIM, a loglinear GLM adapted and implemented for ecological time series (Van Strien *et al*., 2004; freely downloadable from www.cbs.nl).

For bats, there is one long-running scheme, hibernacula counts, and two summer schemes that have recently been started: car-monitoring and counts of colonies in attics. There are also a number of other initiatives underway including a new Dutch mammal atlas project, which will involve training and facilitating volunteers and gathering and validation of bat distribution data.

5.4.2 Hibernacula counts

Hibernacula counts in the Netherlands have been performed since the 1940s. In the early years, they were almost only done in the chalk mines in the south. In 1986, these counts were formed into a monitoring scheme, which is now coordinated by Zoogdiervereniging VZZ, and the number of counted objects increased. Mines are still counted, but now volunteers also visit bunkers, fortresses, ice cellars, old brick ovens, castle cellars and even bridge pillars. Currently about 1100 sites are counted yearly.

Method

In October, the monitoring coordinator of VZZ sends site lists, forms, and a permit to visit the hibernacula to all volunteers. Volunteers visit their site once between 15th December and the 15th of January, counting all bats visible using LED torches. Forms are filled in, and sent to the provincial coordinator. He or she checks the forms for errors, and then sends them to the monitoring coordinator at VZZ. Here, data are entered into a database, a number of additional error checks are performed, and the data are send to Statistics Netherlands (CBS).

Indices are calculated, and placed on the CBS website www.statline.cbs.nl (in Dutch), and presented to the Dutch government. VZZ gives feedback of the results to volunteers. Volunteers are actively stimulated to keep visiting “disappointing” sites. Training is organized by VZZ, which involves training of new volunteers during counts and provision of identification workshops by a number of workgroups.

5.4.3 Attic colony counts

For a number of years, bat workers have counted bats in attics of churches and abbeys. In 2007 a pilot study was carried out by VZZ and CBS to see if these counts could be combined and standardized to form a new monitoring scheme. The pilot was successful: the data already gathered were of good quality, and the volunteers were willing to add the data already gathered in past years to the scheme. 2008 is the first “official” counting year. A handbook and identification guide have been printed, forms and a database have been designed. A course on the method and on species identification has been developed and is given to new volunteers.

The scheme focuses on *Plecotus austriacus* and *Myotis emarginatus*. Of the latter, all breeding females (i.e. both breeding colonies) known are counted. For this reason, the scheme now focuses on the counties of Zeeland, Noord-Brabant and Limburg, where these species occur. In the next three years, the scheme will be expanded to include the whole of the Netherlands, so that data on other species living in attics can be gathered.

5.4.4 Car transect monitoring

In 2007 a car transect monitoring scheme was piloted (Dekker *et al*., 2007). This pilot consisted of driving 10 transects, testing the method and technique and finding the detection frequencies of target species. The pilot is being repeated in 2008 with aims to increase the number of transects, test a number of improvements in the setup used in 2007, and calculate inter-transect variation in number of bats encountered.

Method

Transect are driven at 20-30 km $hour^{-1}$ with an Anabat detector on the roof of the car, and with a hand held computer (PDA) with a Global Positioning System (GPS) logging the route. Sounds are analysed by a professional of VZZ. As Anabat timestamps the recordings, the record of bats and position of the car can be pin pointed to create maps. The resulting database of information is sent to CBS for analysis.

5.4.5 Species coverage

The three schemes aim to cover all Dutch bat species (see Table 5.2). *Myotis mystacinus* and *M. brandtii* can only be distinguished in the hand, and VZZ considers it unethical to disturb animals during hibernation, so these species are included together. However, a study in which a number of animals were identified in the hand during mistnet counts, and examination of dead or awake animals in hibernacula showed that *M. brandtii* is rare: only 1.7% of the *M. mystacinus/brandtii* that were checked were in fact *M. brandtii* (Mosterd *et al.,* 2005).
The car transects and attic counts will be planned so that they also provide summer distribution maps, on a 10x10 km grid precision.

Table 5.2. Coverage of the NEM bat monitoring schemes.

Species	*Hibernacula*	*Car transects*	*Attics*
Plecotus auritus	X		
P. austriacus			X
Myotis mystacinus/brandtii	X		
M. natterii	X		
M. emarginatus	X		X
M. dasycneme	(X)[1]	X	?
M. myotis	X		
M. daubentonii	(X)	X	
M. bechsteinii	(X)[2]		
Nyctalus noctula		X	
Eptesicus serotinus		X	
Pipistrellus nathusii		X	
P. pipistrellus		X	

[1] Only 350 individuals counted, population estimated to be ~10.000 individuals.
[2] Only a few individuals counted.

A newsletter is published twice a year for all VZZ volunteers on the results of the monitoring programme.

5.4.6 Other initiatives

Apart from these schemes, there are a number of initiatives that are not (yet) part of the NEM programme: a study focused on *Myotis dasycneme*, counts of bats in bat boxes, and swarming studies.

A large study on *Myotis dasycneme* is underway to provide detailed information on roost counts, capture-mark-recapture/resight of pond bats in summer, spring and autumn and resighting the marked animals in winter.

Annual counts of bats in bat boxes have been carried out, in some cases over long time periods. This yields mostly information on *P. nathusii*. No trend analyses have been performed with these data so far.

There has been much swarming research in the past few years. In 2001 a first workshop was held to train people in mistnetting (Spoelstra, 2006), as there was little experience with mistnetting in the Netherlands. In 2006 and 2007, again workshops were given, resulting in a pool of experienced volunteers (Dekker & Limpens, 2007). At these workshops, a number of species, such as *Myotis bechsteinii* and *Myotis brandtii* were caught at numbers higher than are found at hibernacula-counts.

Following these surveys, a monitoring study has been set up under the umbrella of VZZ, with the support of a large pool of volunteers. In this study, swarming animals are identified by mistnetting one night at 6 selected chalk mines every 3 weeks. The aim is to learn more about the temporal and spatial dynamics in the number of individuals and species that are swarming at these sites. These data will be compared with counts of hibernating species at these sites.

5.6 Romania

The National Bat Monitoring Programme in Romania commenced in 2002. This Programme is modelled on the UK's National Bat Monitoring Programme. Two principal methods have been applied in Romania: observations at summer maternity roost sites and winter hibernation sites in underground habitats: surveys occur twice in the hibernation period (December-February) and twice in the summer period (May-July). The data are collated in standard datasheet.

Selected key species and categories for monitoring include:
Cave dwelling bats: *Rhinolophus ferrumequinum, Rhinolophus hipposideros, Myotis myotis/blythii, Miniopterus schreibersii*
Non cave dwelling bats: *Myotis daubentonii, Eptesicus serotinus, Pipistrellus pipistrellus/pygmaeus, Nyctalus noctula*
Species, which have priority for further observations and research: *Pipistrellus nathusii, Barbastella barbastellus, Myotis dasycneme*

Monitoring is carried out throughout Romania: 35 underground habitats (Eastern Carpathians 3 caves, Western Carpathians 15 caves, Dobrogea, Southern Carpathians 17 caves).

To implement the NBMP it has been necessary to develop and maintain a network of volunteers covering all regions of Romania. Volunteers have been recruited through talks to University students, speleological clubs, Environmental Protection Agencies, Environmental NGOs and National Parks. Bat identification skills have been increased through training and workshops and field work participation.

5.7 United Kingdom

5.7.1 Introduction

The UK National Bat Monitoring Programme (NBMP) is designed to collect population trend information for bat species resident in the UK. It is run by the Bat Conservation Trust (BCT) a non-governmental organization (NGO), in partnership with the Joint Nature Conservation Committee. The NBMP was established in 1996 as a pilot programme to test the methods being used and continued as a pilot until 2000, when it became an established long-term surveillance programme.

A sampling approach is used on all surveys with the assumption that trends occurring in sample sites reflect trends occurring in the general population. Theoretically, this assumption is strongest when sample sites are chosen at random and random surveys are considered to be more robust and representative of the total population than surveys using self-selected samples.

The NBMP datasets offer a unique opportunity to examine the quality of data collected in different surveys, because some species are surveyed using more than one method. However, at present there are no long term datasets (20 years +) that allow a comparison of population trends between different surveillance methods for the same bat species and longer time-series are required before robust analyses can be initiated.

Based on the theoretical grounds discussed above, where species are covered in more than one survey, priority is given to population trend results in the following order:

1. Waterways Survey and Field Survey
2. Hibernation Survey
3. Colony Counts

5.7.2 Waterway Survey

The Waterway Survey began in 1997 with a successful pilot and surveys have continued annually. It focuses on *Myotis daubentonii* along water courses (such as rivers and streams, but excluding lakes and ponds) as this species has a high dependence on waterbodies for foraging and the ease of identifying this species fits in well with mass participation surveys.

The Environment Agency (EA), through its River Habitat Survey (RHS), has surveyed over 10,000 random stretches of waterway for a variety of habitat features including flow rate and bankside vegetation. The BCT has worked closely with the EA since 1998 and, where possible, surveyed existing RHS sites for *M. daubentonii*. This approach adds value to the dataset because it enables cross analysis of both datasets.

Method

Data are collected in a simple, repeatable fashion at a random selection of courses throughout the UK. Where possible, surveyors are assigned a random 1km stretch of waterbody that lies on an existing RHS site and that is within 10km of the surveyor's home address.

Surveyors make a day visit to secure landowner permission and to assess the site for safety. They mark out 10 points along the 1km stretch, approximately 100m apart. On two evenings in August they stand at each of the 10 points for four minutes, recording *M. daubentonii* activity with a heterodyne detector, using a torch to confirm the bat is flying close to the water surface (behaviour characteristic of *M. daubentonii*).

5.7.3 Field survey

This survey began in 1998 and provides data on four species – *Pipistrellus pipistrellus, Pipistrellus pygmaeus, Nyctalus noctula and Eptesicus serotinus*.

Method

Data are collected in a simple, repeatable fashion in 1km squares, drawn from a pool of 5000 randomly generated 1km² distributed throughout the UK using National Grid References. Volunteers are assigned a square at random within 10km of their home address. Within each square a triangular 'ideal' transect containing 12 marked stopping points is overlaid. Surveyors make a day visit to secure landowner permission and assess the site for safety. On two evenings in July they walk the transect with heterodyne ultrasonic detectors. At each of the 12 stopping points they listen for *P. pipistrellus* and *P. pygmaeus* for two minutes then re-tune their detector and listen for *N. noctula* and *E. serotinus* bats whilst walking to the next stopping point. The survey starts at twenty minutes post sunset.

Trends derived from field surveys are considered to provide the most robust trend data. Volunteers are assigned random sites across the UK and the random selection process includes sites where the species of interest may not occur at present but has the potential to do so in the future. This provides a means of assessing change in distribution as a result of population expansion as well as change in relative abundance. There are potential problems with volunteers using different types of electronic equipment over time, volunteer turnover and volunteer experience, but these can be included as covariates in the data analysis to assess effects on the results.

5.7.4 Hibernation survey

A range of bat species aggregate at a variety of hibernation sites during the winter months and it is possible to make annual counts of the number of bats encountered. Bats are vulnerable to disturbance when hibernating and surveyors require training and a licence from the relevant UK Statutory Nature Conservation Organisations (SNCO) before entering sites. However, unlicensed surveyors can accompany licensed surveyors into sites.

Hibernation counts are particularly useful in assessing the importance of a site for conservation purposes and site data collected by the monitoring programme are used by SNCOs when considering protected sites. However, the relationship between the number of bats seen and the number of bats present is not always clear. In complex sites bats can hide away in cracks and crevices and it is not always possible for surveyors to see all of them. For complex sites, population trends assume that the proportion of bats seen to bats actually present remains constant.

One advantage of the hibernation project is that multiple species can be encountered at the same site and thus the survey cost per species is low. It is also possible for surveyors to survey multiple sites in a day and fewer surveyors are required than on field projects to collect the same data quantity.

Method

Sites are self-selected by volunteers who make two counts, one in January and one in February. Counts are made of all species encountered and site details are also recorded.

Unlike colony counts, the hibernation survey monitors potential sites as species can move into almost any existing site where they have never been recorded previously. One problem is the unknown relationship between the numbers of bats observed in sites and the actual numbers of bats present. Bats can hide away in cracks and crevices and there is evidence that large numbers of bats can be present in sites, but few actually observed. However, if the proportion of bats seen/not seen remains constant over time then it shouldn’t affect population trend conclusions.

5.7.5 Colony counts

Colony counts are a traditional method for monitoring the status of roosts. For each species, information can be used to make an assessment of the importance of the roost at the national, regional and local level through collation and analysis of data.

The relationship between trends in species’ colony size and population trends has not been established but, over time, comparison of field and colony trends may provide an answer. For the present, where trend direction conflicts between field and colony counts for the same species, the trend derived from field surveys will be considered most robust.

Method

Survey protocols for each species are similar although there are some minor inter-species differences (related to differences in emergence times of species). Roosts are self-selected by volunteers who make two counts of bats emerging from the roost between late May and the end of June. A summary of species surveyed on the project is shown in Table 5.3.

Colony counts are restricted to 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 future). Colony counts are likely to be effective for monitoring population change only if it is rare for new colonies to be established. This is because sampling only known roosts and not all potential 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.

One way of assessing the potential importance of new colony formation or colony mobility in general on species population trends would be to look at roost site age. For example, if a species is recorded using new buildings (new roosts) then this would provide evidence of colonies (or parts of colonies) switching from existing roosts. If new sites are often used by a species then it could indicate that interpreting population trends from counts at existing roosts only is not robust. Species such as *R. hipposideros* 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 other species with less stringent roost requirements such as *Pipistrellus* species.

5.7.6 Survey coverage

The total site network for the NBMP was 3,906 sites in 2006 and continues to grow annually. Statistical analysis of past survey data has shown that a sample size of at least 40 sites with presence of bats is required to provide robust population trends for the UK (BCT, 2001). Where species have been encountered on less than 40 sites trend analysis confidence is reduced due to low precision associated with small samples. For 11 of the 16 UK resident species there is sufficient coverage to carry out robust statistical analysis and this is shown below in Table 5.3.

The difficulty in differentiating the two closely related *Myotis* species, *M. mystacinus* and *M. brandtii*, means that the data for these two species has been pooled for trend analysis and the trends assumed to be the same for both species.

Table 5.3 Coverage of UK bat species with each monitoring method

Species	**Colony Count**	**Field & Waterway Survey**	**Hibernation Survey**
Rhinolophus ferrumequinum			**A**
Rhinolophus hipposideros	**A**		**A**
Myotis daubentonii		**A**	**A**
Myotis brandtii			**B**

Myotis mystacinus			**B**
M. brandtii/mystacinus			**A**
Myotis nattereri	**A**		**A**
Myotis bechsteinii			**C**
Pipistrellus pipistrellus	**A**	**A**	
Pipistrellus pygmaeus	**A**	**A**	
Pipistrellus nathusii			
Eptesicus serotinus	**A**	**A**	
Nyctalus noctula		**A**	
Nyctalus leisleri			
Barbastella barbastellus			**C**
Plecotus auritus	**A**		
Plecitus austriacus			

Key:
A = encountered on more than 40 sites
B = encountered on between 10 and 40 sites
C = encountered on less than 10 sites

5.7.7 The surveyors

One of the most important aspects of the NBMP is the participation of the general public as volunteer surveyors. Volunteers are the bedrock of the NBMP and come from a variety of backgrounds. Many colony counters are householders who happen to play host to 'their' colony. Participation requires little previous bat experience and the project enables them to learn more about, and value, 'their' colony.

Field volunteers tend to be more experienced local Bat Group members as some skill with a bat detector is required. For the Hibernation Survey volunteers require a licence from the relevant UK Statutory Nature Conservation Organisation before they can survey sites and undergo extensive training before being awarded such a licence. Unlicensed volunteers can enter hibernation sites if accompanied by a licensed bat worker.

Volunteers invest a tremendous amount of time and effort in the NBMP. Over 2000 volunteers have surveyed over 3000 roost and field sites since the programme began. On average over 730 volunteers take part every year with over 1400 sites being surveyed. Data are stored in a centralised database and population trend data and information about the monitoring programme are made available through the NBMP annual reports, published on the BCT website.

5.7.8 Volunteer training

Volunteer training has always been a key feature of the NBMP and each year a series of detector workshops is organised across the UK.

At workshops volunteers learn about the basic elements of bat sounds, how to use their own hearing in order to discriminate between the various species and how to use bat detectors as tools to help identify bat sounds in the field. The workshops also teach volunteers how to take part in various surveys with an opportunity to go on a field session to polish up existing or practice new found skills. They also ensure there is standardisation for field surveys and recruit new volunteers to the programme. On average 15 workshops are held annually across the UK with over 300 participants receiving training.

5.7.9 Data analysis

The purpose of analysis is to draw correct conclusions on trends occurring in populations of interest. There are many factors that can influence trends (outside the population trends themselves) and the magnitude of their effect should be estimated and methods for reducing their influence put into place.

Annual means for each project are calculated from a log-linear generalised model. The model includes terms for factors that could influence the means e.g. bat detector make, temperature etc., so their effect can be measured. For easier interpretation the means are then converted to an Index that starts at 100 for the first reliable year of data.

General Additive Models (GAM) calculate individual trends over time for each site surveyed. They then amalgamate trends from all sites to produce an overall estimation of trend direction with confidence limits. On the graphs in each survey description, crosses represent the calculated means (converted to Index) and the line represents the estimated trend from the GAM. Dotted lines represent confidence limits. The actual trend occurring can be described from either the GAM (line) or the log-linear generalised model (crosses) although in many cases the interpretation is similar.

The annual percentage change assumes the annual trend direction is constant. It is estimated by calculating the annual percentage change that would take the population from 100 in the base year to the index value in 2003.

The benchmark for monitoring sensitivity is that sufficient sites are monitored to detect as a minimum population change of 50% over 25 years, equivalent to the Red Alert declines for UK birds (Gregory *et al.,* 2002) and hopefully the more sensitive measure of 25% over 25 years, equivalent to the Amber Alert decline for UK birds.

Power analyses carried out in 2002 showed that if a minimum of 20 sites is monitored annually (in the pattern of returned data from previous years i.e. a mixture of new sites and sites surveyed in previous years) then monitoring sensitivity is sufficient to identify UK declines of Red Alert magnitude for all surveys and Amber alert declines for the hibernation survey. A minimum of just under 100 sites would be sufficient to identify UK declines of Amber Alert magnitude for the field surveys. Power analysis has not been carried out on the Colony Counts.

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7. List of contributors

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