

# **Surveillance and Monitoring Methods for European Bats**

**Guidelines produced by the  
Agreement on the Conservation of Populations of European Bats  
(EUROBATS)**

**- FINAL DRAFT -**

## Table of Contents

.....	1
Surveillance and Monitoring Methods for European Bats .....	1
Guidelines produced by the .....	1
Agreement on the Conservation of Populations of European Bats (EUROBATS).....	1
Table of Contents.....	2
Foreword.....	6
1 Surveillance and Monitoring of bats across Europe .....	6
1.1 The importance of surveillance and monitoring .....	6
1.2 International monitoring obligations .....	7
1.3 Surveillance and monitoring of bats at a European level .....	8
2 Developing surveillance and monitoring schemes.....	9
2.1 Introduction.....	9
2.2 What is being measured?.....	9
2.2.1 Species occurrence .....	9
2.2.2 Species abundance .....	10
2.3 Survey frequency and standardisation.....	10
2.4 Area coverage, stratification and sample sizes .....	10
2.5 Species coverage .....	11
2.6 Assessing the surveillance scheme- the pilot phase.....	11
2.6.1 Survey sensitivity and power.....	11
2.6.2 Survey bias.....	12
2.7 Data collection, management and validation.....	12
2.7.1 Database requirements .....	12
2.7.2 Database compatibility .....	12
2.7.3 Quality control of data.....	13
2.7.4 Data entry and storage.....	13
2.7.5 Data analysis .....	13
2.8 Recruiting surveyors .....	14
2.8.1 Volunteers or professionals?.....	14
2.8.2 Health and Safety issues for surveyors.....	15
2.9 Resource issues .....	15
3. Surveillance methods .....	16
3.1 Introduction.....	16
3.2 Site Species Richness .....	16
3.2.1 Species suitability.....	16
3.2.2 Technical requirements .....	17
3.2.3 Sampling .....	17
3.2.4 Timing .....	17
3.2.5 Number of counts.....	17
3.2.6 Skills.....	18
3.2.7 Data management, analysis and quality control .....	18
3.2.8. Example from the Danish bat surveillance programme 2005-2010 within NOVANA.....	18
3.3 Walked bat detector transects of foraging bats in the open countryside .....	19
3.3.1 Species suitability.....	19
3.3.2 Sampling .....	20
3.3.3 Timing .....	20
3.3.4 Number of counts.....	20
3.3.5 Data management and analysis.....	20

## FINAL DRAFT

3.3.6	Example: Bat detector surveys in Germany .....	21
3.4	Bat detector transects along roads using moving vehicles .....	21
3.4.1	Species suitability.....	21
3.4.2	Sampling.....	21
3.4.3	Timing .....	21
3.4.4	Number of counts.....	22
3.4.5	Count method.....	22
3.4.6	Data management and analysis .....	22
3.4.7	Example – Republic of Ireland car survey .....	22
3.5	Counts at maternity roosts .....	23
3.5.1	Species suitability.....	23
3.5.2	Sampling .....	24
3.5.3	Timing .....	24
3.5.4	Number of counts.....	24
3.5.5	Count methods .....	24
3.5.6	Example: measuring colony productivity of <i>Rhinolophus ferrumequinum</i> in the UK.....	25
3.5.7	Data management and analysis.....	26
3.5.8	Example: Estimating population size of <i>Nyctalus noctula</i> in housing estates in Hungary and other central European countries.....	26
3.5.9	Colony counts in bat boxes.....	26
3.6	Locating new colonies.....	27
3.6.1	Timing .....	27
3.6.2	Count Method .....	27
3.7	Counts at hibernation sites.....	27
3.7.1	Species suitability.....	28
3.7.2	Sampling.....	28
3.7.3	Timing .....	28
3.7.4	Number of counts.....	28
3.7.5	Count method.....	28
3.8	Surveys of mating roosts .....	29
3.8.1	Species suitability.....	29
3.8.2	Sampling.....	29
3.8.3	Timing .....	29
3.8.4	Number of counts.....	29
3.9	Surveys at underground swarming sites .....	29
3.9.1	Species suitability.....	30
3.9.2	Sampling.....	30
3.9.3	Timing .....	30
3.10	Remote automatic recording.....	31
3.10.1	Sampling.....	31
3.10.2	Timing and number of counts.....	31
3.10.3	Data management.....	31
3.11	Catching bats.....	31
3.11.1	Sampling.....	32
3.11.2	Example: Netting study in Germany.....	32
3.12	Ringing .....	32
3.13	Best practice to be adopted when carrying out bat surveys.....	33
3.13.1	Surveys of winter and summer bat shelters .....	33
3.13.2	Catching bats.....	33
4.	Species accounts .....	34

FINAL DRAFT

4.1	Pteropodidae .....	35
4.1.1	<i>Rousettus aegyptiacus</i> (Geoffroy, 1810) .....	35
4.2	Emballonuridae .....	35
4.2.1	<i>Taphozous nudiventris</i> Cretzschmar, 1830.....	35
4.3	Rhinolophidae .....	36
4.3.1	<i>Rhinolophus blasii</i> Peters, 1866.....	36
4.3.2	<i>Rhinolophus euryale</i> Blasius, 1853.....	37
4.3.3	<i>Rhinolophus ferrumequinum</i> (Schreber, 1774).....	37
4.3.4	<i>Rhinolophus hipposideros</i> (Bechstein, 1800) .....	38
4.3.5	<i>Rhinolophus mehelyi</i> Matschie, 1901.....	39
4.4	Vespertilionidae .....	39
4.4.1	<i>Barbastella barbastellus</i> (Schreber, 1774).....	39
4.4.2	<i>Barbastella leucomelas</i> (Cretzschmar, 1826).....	40
4.4.3	<i>Eptesicus bottae</i> (Peters, 1869).....	41
4.4.4	<i>Eptesicus nilssonii</i> (Keyserling & Blasius, 1839).....	41
4.4.5	<i>Eptesicus serotinus</i> (Schreber, 1774).....	42
4.4.6	<i>Hypsugo savii</i> (Bonaparte, 1837).....	42
4.4.7	<i>Myotis alcathoe</i> von Helversen & Heller, 2001.....	43
4.4.8	<i>Myotis aurascens</i> Kuzyakin, 1935 .....	44
4.4.9	<i>Myotis bechsteinii</i> (Kuhl, 1817).....	44
4.4.10	<i>Myotis blythii</i> (Tomes, 1857).....	45
4.4.11	<i>Myotis brandtii</i> (Eversmann, 1845) .....	46
4.4.12	<i>Myotis capaccinii</i> (Bonaparte, 1837) .....	46
4.4.13	<i>Myotis dasycneme</i> (Boie, 1825).....	47
4.4.14	<i>Myotis daubentonii</i> (Kuhl, 1817).....	48
4.4.15	<i>Myotis emarginatus</i> (Geoffroy, 1806).....	48
4.4.16	<i>Myotis hajastanicus</i> Argyropulo, 1939 .....	49
4.4.17	<i>Myotis myotis</i> (Borkhausen, 1797).....	49
4.4.18	<i>Myotis mystacinus</i> (Kuhl, 1817) .....	50
4.4.19	<i>Myotis nattereri</i> (Kuhl, 1817).....	51
4.4.20	<i>Myotis nipalensis</i> (Dobson, 1871) .....	51
4.4.21	<i>Myotis punicus</i> Felten, 1977 .....	52
4.4.22	<i>Myotis schaubi</i> Kormos, 1934 .....	52
4.4.23	<i>Nyctalus lasiopterus</i> (Schreber, 1780) .....	53
4.4.24	<i>Nyctalus leisleri</i> (Kuhl, 1817).....	53
4.4.25	<i>Nyctalus noctula</i> (Schreber, 1774).....	54
4.4.25	<i>Otonycteris hemprichii</i> Peters, 1859 .....	55
4.4.27	<i>Pipistrellus kuhlii</i> (Kuhl, 1817) .....	55
4.4.28	<i>Pipistrellus nathusii</i> (Keyserling & Blasius, 1839) .....	56
4.4.29	<i>Pipistrellus pipistrellus</i> (Schreber, 1774).....	56
4.4.30	<i>Pipistrellus pygmaeus</i> (Leach, 1825).....	57
4.4.31	<i>Plecotus macrobullaris</i> Kuzyakin, 1965 .....	58
4.4.32	<i>Plecotus auritus</i> (Linnaeus, 1758) .....	58
4.4.33	<i>Plecotus austriacus</i> (Fischer, 1829).....	59
4.4.34	<i>Plecotus kolombatovici</i> Dulic, 1980.....	59
4.4.35	<i>Plecotus sardus</i> Mucedda, Kiefer, Pidinchedda & Veith, 2002 .....	60
4.4.36	<i>Vespertilio murinus</i> Linnaeus, 1758.....	60
4.4.37	<i>Miniopterus schreibersii</i> (Kuhl, 1817).....	61
4.5	Molossidae .....	61
4.5.1	<i>Tadarida teniotis</i> (Rafinesque, 1814).....	61
4.6	Summary table of species and methods .....	63

FINAL DRAFT

5.	National bat monitoring programmes .....	64
5.1	Belgium .....	64
5.1.1	Introduction.....	64
5.1.2	Surveying hibernacula .....	64
5.1.3	Surveying summer roosts .....	64
5.2	France .....	64
5.2.1	Introduction.....	64
5.2.2	Long term winter and summer surveys .....	65
5.2.3	Five-year surveillance programme 1999-2003 .....	66
5.2.4	Regional surveys .....	67
5.2.5	Surveyors and volunteer training .....	67
5.2.6	Databases .....	67
5.2.7	Recommended surveillance methods for <i>Miniopterus schreibersii</i> .....	67
5.2.8	Recommended surveillance method for <i>Myotis capaccinii</i> .....	70
5.3	Germany.....	71
5.3.1	Introduction .....	71
5.3.2	Regional bat monitoring programmes .....	72
5.3.3	Surveillance of Greater mouse-eared bats .....	72
5.3.4	German federal surveillance and monitoring of bats under the Habitats Directive	73
Region.....		77
5.4	Netherlands .....	77
5.4.1	Introduction.....	77
5.4.2	Hibernacula counts.....	77
5.4.3	Attic colony counts .....	78
5.4.4	Car transect monitoring .....	78
5.4.5	Species coverage .....	78
5.4.6	Other initiatives.....	79
5.5	Portugal.....	80
5.5.1	Introduction.....	80
5.5.2	Surveying hibernacula .....	80
5.5.3	Surveying summer roosts .....	80
5.6	Romania.....	81
5.7.	Slovenia .....	81
5.8	United Kingdom.....	82
5.8.1	Introduction.....	82
5.8.2	Waterway Survey .....	82
5.8.3	Field survey .....	83
5.8.4	Hibernation survey .....	83
5.8.5	Colony counts .....	84
5.8.6	Survey coverage.....	84
5.8.7	The surveyors.....	85
5.8.8	Volunteer training .....	86
5.8.9	Data analysis .....	86
6.	References.....	87
7.	List of contributors.....	91

## Foreword

This document provides guidance on methods for surveillance and monitoring of European bat species. It is recognized that methods may need to be amended to take account of regional variations and in the light of new information.

Some examples of monitoring schemes used in different countries are provided for illustrative purposes only. These are not intended to be proscriptive for every species or every region. Distribution maps are shown with the species accounts.

Case studies of national monitoring schemes are provided for illustrative purposes only. It is important to note that the document is evolving and it will be necessary to update it at intervals.

## 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/](http://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/](http://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](http://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](http://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](http://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 (Temple *et al.*, 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.

It is recognized that methods may need to be amended to take account of regional variations and in the light of new information.

## **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; Flaquer et al., 2007).

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***

### **2.6.1 *Survey sensitivity and power***

Establishing a long-term surveillance scheme involves piloting the design of the scheme to test ability to deliver the required level of information. 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.

### 2.6.2 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 model (REML) 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<sup>2</sup> 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<sup>2</sup> level or more detailed if possible), date, a measure of survey effort and the recorder's 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](http://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).

If data analysis by computer is intended in order to extract trends and statistic indices from a series of survey results the application of the Dutch PC-programme TRIM is recommended. It is available free of charge and widely used by European ornithologists from many countries as well as international institutions for bird research (e.g. EBCC).

## ***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 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**

Fieldwork on bats is always accompanied by special risks for the surveyor, but all people and institutions being involved in a bat monitoring programme should take the utmost care to minimize these risks. For this reason survey work has to be planned carefully and all appropriate measures for safety reasons of the surveyors should be taken. Institutions which are involved in the coordination and implementation of surveillance schemes are urged to inform surveyors about health and safety issues and offer appropriate education and training for them.

Surveys at night should be preceded by an inspection of the sites during daylight in order to be aware of rough or even dangerous areas. If a special place will be occupied for a longer period at night, e.g. to observe emerging bats at a roost or to attend a mist net, it should be cleared before from obstacles like branches or large stones, so the risk of being hurt or stumbling in the dark is low. Surveyors must have enough lights with them to detect at any time during their fieldwork all features which might be of danger, e.g. ditches, borrows in the ground, wire fences, or inconvenient animals such as cattle or wild boar. Reserve light equipment is recommended.

Bats may be hosts of diseases which can also infect humans. In particular viruses (rabies and others) may be a risk for human health if bats are caught and handled or dust with bat faeces from a roost site is inhaled. When access to a bat roost or catching bats is necessary a safe approach is important to minimize disease and accident risks. Secure measures and special training is of greatest importance if underground sites or roosts in higher trees are inspected. At any stage of their fieldwork bat surveyors must take effective measures to protect their personal health conditions.

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 organisations 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. It is recognized that methods may need to be amended to take account of regional variations and in the light of new information.

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 Site Species Richness**

Measurement of Site Species Richness can be used whenever it is considered necessary to register all bat species in an area, including rare or only locally occurring species. Some European bat species are difficult to identify and often need a period of observation to secure a safe species identification. In such cases the bat researcher has to remain at the spot of first encounter for a variable amount of time to secure a good recording of the species, or to move around to find the species again.

Methods that are based on line transects or listening points generally do not include prolonged stops at a given point. This means the occurrence of rare species is often underestimated or missed altogether and samples of rarer species will often be insufficient for statistical analyses.

It is not possible to actually count number of bats using this method. However, repeated surveys over the years, in the same selected areas and using a standardised method will reveal changes in species occurrence and distribution and gives the earliest indications of disappearance as well as expansion to new sites. High species richness can be an indicator of habitat quality so this method could be useful for general monitoring of the environment.

##### **3.2.1 Species suitability**

Potentially all European species can be detected using this method.

### 3.2.2 Technical requirements

The method requires the use of high quality bat detectors (heterodyne combined with time expansion or high speed recording) and good quality recordings of long sequences of bat calls. For some species visual clues about behaviour and appearance are also needed, sometimes with a strong handheld lamp (Ahlén & Baagøe, 1999). In some cases field work also involves the use of other methods such as searches indoors, netting and automatic registration.

Automatic registration, or "autoboxes" can also be used. These act as a complement to detectors, especially in species rich sites. The boxes collect time-expansion or high speed recordings of high technical quality and most species can be identified. The efficiency of finding all species is likely to be improved by adding this method. Instructions should be given on the best positions for the boxes and appropriate use of netting or visual observations.

### 3.2.3 Sampling

Specific geographical units are selected for survey, e.g. 10 x 10 km square grid or small administrative units. Within each select one or more main sites known (from atlases or inventories) to have the highest possible bat species richness for the region (i.e. by drawing a polygon with coordinates on the map) are selected. If necessary, smaller satellite sites with supplementary biotopes to secure registration of bat species missing in the main site(s) are included. Main sites are usually between 1-10 hectares depending on diversity and configuration of biotopes. Satellite sites are often smaller.

Sites are surveyed on foot, with detectors, under optimal weather conditions, during "prime time", i.e. the first 4 hours after sunset. The different habitats and localities within the site are visited several times during this period to cover differences between species in time of emergence, commuting and foraging. This may include visits inside large barns or other buildings (e.g. for *Plecotus*). Satellite sites can be visited later the same night, but still within the "prime time".

Autoboxes can be used especially in areas with high species richness, or in one or more of the satellite sites. If any species remain unidentified, the same site, or a satellite site, is visited the following night, employing netting or other supplementary activities.

### 3.2.4 Timing

Most often surveys are carried out during one night in the breeding season in the first four hours after sunset, when females remain in an area and generally forage short distances from maternity roosts. Roosts are often found during the surveys with bat detectors.

There are also time periods between hibernation and breeding, both in spring and autumn, when bats use insect rich habitats which are restricted to small areas. These key habitats are necessary to find and protect because the bats may depend on them for their survival at certain times of year.

### 3.2.5 Number of counts

Surveys can be repeated at regular intervals, i.e. every six years (to coincide with frequency of Habitats Directive reporting). Repeated survey in each of the selected areas reveals changes in presence or absence of the species. The number of encounters or number of bats hunting together or swarming can give a rough estimate of bat abundance.

### 3.2.6 Skills

Bat detector researchers need high quality training to attain the capability necessary for finding all species and for recording and analysing bat sounds. Those with a good ear quickly learn to distinguish the easy bat species by sound, and over time they can build up great skill in distinguishing also small differences in sound quality, rhythm and frequency. Most people have initial difficulties and need a couple of seasons of intensive field experience to build up enough skill to be able to work professionally with detector based surveys or monitoring.

Individual human beings have quite different abilities to learn to use sound, and there is no doubt that some people will never learn to use this technique, in spite of great effort, especially because their sound memory is not good enough. This is a problem, especially since this lack of "ear" cannot be fully compensated by recording the sounds and visualizing them on the computer screen. But it should not prevent those who can, from using the technique.

### 3.2.7 Data management, analysis and quality control

Quantification and analysis is based on presence/absence data at a number of sites in each surveyed region. Sound recordings must be stored and made available. Subsequent control is sometimes useful for verification when dealing with species records in new areas and in difficult identification cases.

### 3.2.8. Example from the Danish bat surveillance programme 2005-2010 within NOVANA

This surveillance method has been commonly used with great success for many years in Sweden and Denmark (Ahlén & Baagøe, 1999). The current programme has been running for four years. Main sites and satellite sites in 26 selected 10km UTM squares are surveyed each year during the breeding season. Results are entered into a database.

Figure 3.1. "Standard Bat" All Danish 10km UTM squares visited at least one night with high quality bat detectors under optimal conditions 1981-2004.

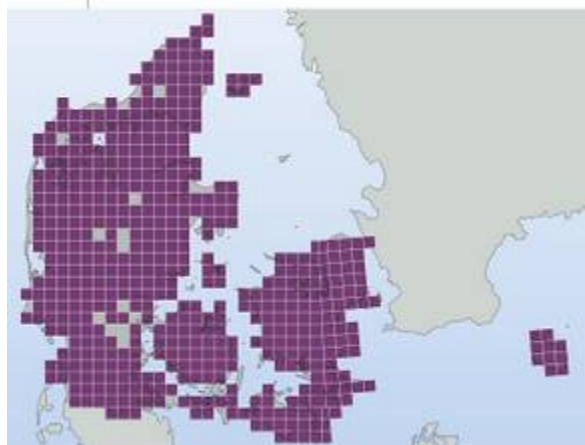


Figure 3. 2. Based on knowledge about bat species occurrence in each of the squares in Fig 3.1, 157 squares of special interest were selected (red squares). In these squares main sites and sometimes satellite sites were selected for surveillance for bat species richness.

Red rasters: satellite sites in neighbouring squares.

Blue rasters: surveillance in well known winter roosts.

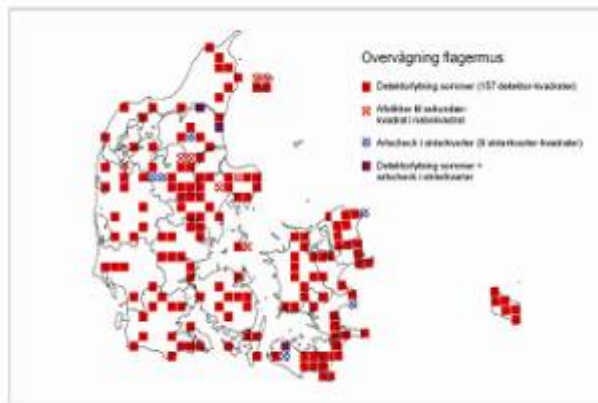
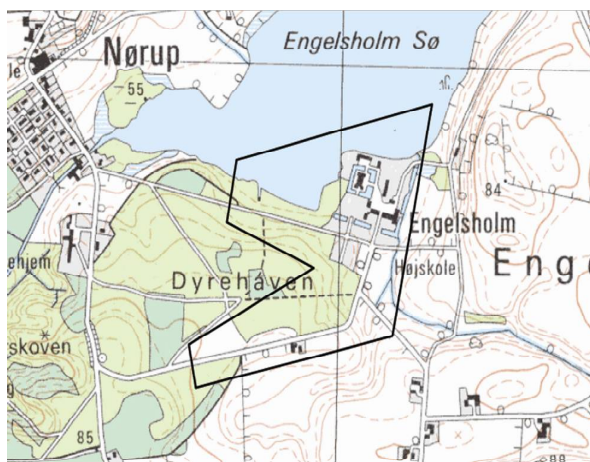


Figure 3. 3 Polygon showing one of the surveillance sites in one of the selected squares.



### 3.3 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.

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.

#### 3.3.1 Species suitability

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

### 3.3.2 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)

### 3.3.3 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).

### 3.3.4 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. If it is difficult to estimate height then flying speed can be used).

### 3.3.5 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.

### 3.3.6 Example: Bat detector surveys in Germany

In Germany a proposal was made for standardising bat detector surveys, in order to fulfil the EC Habitats Directive reporting requirements (Dietz & Simon, 2005). 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.

### 3.4 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.

#### 3.4.1 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.

#### 3.4.2 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.

#### 3.4.3 Timing

Ideally surveillance should coincide with the pre-parturition period (April to June depending on latitude) 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.

#### 3.4.4 Number of counts

Surveyors drive each route, with each survey transect driven no faster than 25km/h. The route should be driven (preferably 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.

#### 3.4.5 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.

Adding stopping points or sections alongside rivers, canals or at other water bodies means that *Myotis duabentonii* and *M. dasycneme* could also be detected using this method.

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 slow speed where possible (no more than 25km/h).

#### 3.4.6 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.

#### 3.4.7 Example – Republic of Ireland car survey

A pilot survey using this method was carried out in the Republic of Ireland in 2004 (Roche et al., 2005). 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**

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

### 3.5 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.

Non invasive counting can also be performed using DNA analyses of bat droppings using specific markers (Puechmaille & Petit, 2007, Petit *et al.*, 2007). 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.

#### 3.5.1 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 blythii*, *Myotis capaccinii*, *Myotis dasycneme*, *Myotis emarginatus*, *Myotis myotis*, *Myotis schreibersii*, *Plecotus auritus*, *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 generally 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* (Simon *et al.*, 2004). However, in the case of *Eptesicus* certain sites are suitable for internal counts (several cases in Slovenia and Serbia).

Species such as *M. myotis* and *M. dasycneme*, and to some extent *Rhinolophus spp.*, also use networks of sites in some regions, 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.

### 3.5.2 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.

### 3.5.3 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 late April and mid July depending on latitude. This will give an indication of the number of adult females in the population associated with the maternity site.

### 3.5.4 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.

### 3.5.5 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 advantage 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*. The least invasive methods involve the use of infrared camera techniques used in combination with a reflector with IR filter. For large colonies a stick of known length can be used to calibrate the subsequent estimation of surface area covered by individuals.
- 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 species and all crevices and beams should be checked using a torch. Droppings located underneath beams are a good indication of presence.
- Bats are less disturbed with red light; a red filter can be applied to the torches. Counts should be carried out in the morning and early afternoon because bats start to fly around in middle afternoon. Strong torches are needed for high ceilings.
- 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 females 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.

#### **3.5.6 Example: measuring colony productivity of *Rhinolophus ferrumequinum* in the UK**

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).

### 3.5.7 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 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 a 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.

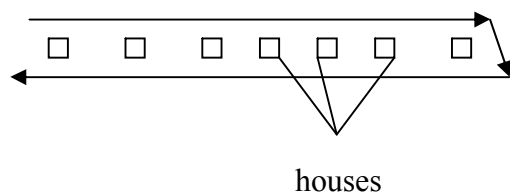
### 3.5.8 Example: Estimating population size of *Nyctalus noctula* in housing estates in Hungary and other central European countries

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.

#### 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.

Figure 3.4



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.

### 3.5.9 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.

### ***3.6 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.

#### **3.6.1 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.

#### **3.6.2 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.

### ***3.7 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.

### **3.7.1 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

### **3.7.2 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.

### **3.7.3 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.

### **3.7.4 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 a maximum two per winter (preferably one count), 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.

### **3.7.5 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. Strong torches are needed for high ceilings. In some cases binoculars are very helpful. 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.

### ***3.8 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.

#### **3.8.1 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 advertise 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.

#### **3.8.2 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.

#### **3.8.3 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.

#### **3.8.4 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.

### ***3.9 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.

### **3.9.1 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.

### **3.9.2 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 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.

### **3.9.3 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.