Bat Conservation Trust

Bat Surveys for Professional Ecologists

Good Practice Guidelines

4th edition

Reference as: Collins, J. (ed.) (2023) Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition).
The Bat Conservation Trust, London.
ISBN-978-1-7395126-0-6

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Copy edited and proofread by Ruthanne Gregory
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Printed by BCQ Group

CIEEM welcomes the publication of the fourth edition of the Bat Surveys for Professional Ecologists: Good Practice Guidelines. Like all good guidance it avoids being unnecessarily prescriptive in its recommended approaches and recognises the importance of suitably competent professionals applying their professional judgement appropriately and with justification when circumstances dictate that it is necessary to do so. Accordingly CIEEM is pleased to endorse these new Guidelines as good practice guidance for all those undertaking bat surveys.

The printing of this publication has been sponsored by the following organisations:

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Cover photos: Alcathoe bat, barbastelle, Bechstein's bat, brown long-eared bat, common pipistrelle, Daubenton's bat, grey long-eared bat, lesser horseshoe bat, Nathusius' pipistrelle, Natterer's bat, serotine, soprano pipistrelle – ©Daniel Hargreaves/www.bats.org.uk. Brandt's bat, greater horseshoe bat, Leisler's bat, noctule – ©Hugh Clark/www.bats.org.uk. Whiskered bat – ©Steve Parker/www.bats.org.uk.

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Bat Conservation Trust
Editor – Jan Collins

Foreword

Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition) builds on previous editions and acknowledges that the way we carry out bat surveys is changing. Ecologists now need new skills to deploy night-vision aids, increase their use of passive acoustic monitoring (e.g. for swarming and hibernation surveys) and to use bat call auto-identification technology. Additionally, we continue to seek the best methods to survey trees for bats and highlight the need for effective biosecurity.

The guidelines contain a number of key flowcharts (e.g. Figures 2.1, 5.1 & 6.1), tables (e.g. Tables 2.2, 4.1, 4.2, 6.2-6.5, 7.1, 7.2, 8.2, 8.3, A1.1 & A3.1) and figures (e.g. Figure 4.1). Whilst these contain key information they should not be used in isolation without the supporting text, which contains important context and considerations.

This edition is the product of a public consultation and hard work on the part of BCT and the Technical Review Board. You can buy it as a hard copy or download it from **www.bats.org.uk**. We will continue to review the content; any comments should be sent to **surveyguidelines@bats.org.uk**.

Kit Stoner, *Chief Executive Officer*

Acknowledgements

This publication has benefitted greatly from the input of a large number of people. In particular, the Bat Conservation Trust (BCT) would like to extend its thanks to the Technical Review Board, whose names are all listed on the next page. These people gave significant amounts of their time free of charge to either write new material, review draft versions of the document and/or engage in discussions about the content.

BCT would like to thank all those who responded to the public consultation held in 2020 and those who have provided comments to BCT since the publication of the 3rd edition of these guidelines. All comments and suggestions were considered and many were incorporated into this version. Space precludes us from listing everyone here, but their input was invaluable.

Several members of the BCT team have contributed a great deal to this document in a variety of ways, including Claire Boothby, Katherine Boughey, Philip Briggs, Ella Browning, Jo Ferguson, Lia Gilmour, Mark Goulding, Lil McDermaid, Sonia Reveley, Shirley Thompson, Allyson Walsh, Carol Williams and Lisa Worledge, who provided a sounding board, wrote or discussed sections of the text, and reviewed draft versions of the document.

Many thanks to our sponsors for providing funding towards the copy editing, design, indexing, proofreading and printing costs, thereby enabling proceeds from the sale of this document to go towards BCT for bat conservation.

Many others have helped with the production of this publication and it has not been possible to list everyone by name. We would like to thank you all for your time and expertise.

Editor

Jan Collins BSc MSc MCIEEM CEcol (BCT)

Technical Review Board

The role of this Technical Review Board was to either author specific chapters, author smaller sections and/or review drafts of Bat Surveys for Professional Ecologists: Good Practice Guidelines (4th edition). The Technical Review Board provided comments on multiple drafts and contributed further through verbal and written discussions on key areas. All comments and discussions were taken into account in producing the final version of these guidelines but, where consensus could not be reached, BCT took the final editorial decision. Members of the Technical Review Board and their affiliations are listed below.

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Contents

List of abbreviations used in text

ALBST	Advanced Licence Bat Survey Techniques
ALERC	Association of Local Environmental Records Centres
ASSIs	Areas of Special Scientific Interest (Northern Ireland designation)
BCA	British Caving Association
BCT	Bat Conservation Trust
BLICL	Bat Low Impact Class Licence
BLIMP	Bat Low Impact Licence
BMCL	Bat Mitigation Class Licence
BRTT	Bat Roost Tree Tag
BSI	British Standards Institution
BS42020	British Standard 42020:2013 Biodiversity – Code of practice for planning and development
BTHK	Bat Tree Habitat Key
CIEEM	Chartered Institute of Ecology and Environmental Management
CPD	Continuing Professional Development
CSCS	Construction Site Certification Scheme
CSZ	Core Sustenance Zone
CWS	County Wildlife Site
DAERA	Department for Agriculture, Environment and Rural Affairs (Northern Ireland)
DBW	Daytime Bat Walkover
EC Habitats Directive	Council Directive 92/43/EEC 1992 on the conservation of natural habitats and of wild fauna and flora
EcIA	Ecological Impact Assessment
EIA	Environmental Impact Assessment
EPS	European Protected Species
FCS	Favourable Conservation Status
GIS	Geographical Information System
GLTA	Ground Level Tree Assessment
GPS	Global Positioning System
HRA	Habitats Regulations Assessment
HSE	Health and Safety Executive
JNCC	Joint Nature Conservation Committee
LBG	Local Bat Group
LPA	Local Planning Authority
LERC	Local Environmental Records Centre
LWT	Local Wildlife Trust
MAGIC	Multi Agency Geographic Information for the Countryside
MEWP	Mobile Elevating Work Platform
NBMP	National Bat Monitoring Programme
NBN	National Biodiversity Network
NE	Natural England (formerly English Nature)
NERC Act	Natural Environment and Rural Communities Act, 2006
NBW	Night-time Bat Walkover
NGO	Non Governmental Organisation
NPPF	National Planning Policy Framework
NRW	Natural Resources Wales (formerly the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales)
NVA	Night Vision Aid
PBP	Partnership for Biodiversity in Planning
PEA	Preliminary Ecological Appraisal
PIT	Passive Inductor Transponder
PPE	Personal Protective Equipment
PRA	Preliminary Roost Assessment
PRF	Potential Roost Feature
PTS	Personal Track Safety
PWMS	Precautionary Working Method Statement
SAC	Special Area of Conservation
SINC	Site of Importance for Nature Conservation
SNCB	Statutory Nature Conservation Body
SSSI	Site of Special Scientific Interest
TVP	Track Visitor Permit
UK	United Kingdom
WNS	White Nose Syndrome
ZoI	Zone of Influence

Chapter 1

Background

1.1 Introduction

Aim of the guidelines

1.1.1 This publication aims to provide good practice guidelines in relation to designing and undertaking bat surveys in the United Kingdom (UK), analysing the data collected during those surveys and writing survey reports. The guidelines relate to professional bat surveys carried out to assess how proposed activities may impact bats. They aim to raise standards and increase the consistency of this type of work and ultimately lead to a greater understanding of bats and improvements in their protection and conservation.

Intended audience

1.1.2 These guidelines are intended primarily for professional ecologists carrying out bat surveys and writing reports in relation to proposed activities that could impact bats, for example development activities. They may also be useful to:

- developers commissioning bat surveys and reports from ecologists in relation to development; and
- planners, ecologists and policy-makers working for local authorities, licensing authorities and non-governmental organisations (NGOs), who are responsible for reviewing and assessing the implications of professional bat surveys.

Expertise and professional judgement

1.1.3 The guidelines do not aim to either override or replace knowledge and experience.

1.1.4 It is accepted that departures from the guidelines (e.g. either decreasing or increasing the number of surveys carried out or using alternative methods) are often appropriate.

1.1.5 However, in such scenarios an ecologist should provide evidence of (a) their expertise in making this judgement and (b) the ecological rationale behind the judgement.

1.1.6 Equally, it would be inappropriate for someone with no knowledge or experience to read these guidelines and expect to be able to design, carry out, interpret the results of and report on professional surveys, simply by following the guidelines without the ability to apply any professional judgement.

1.1.7 Training and experience is necessary to carry out *all of the surveys* described in these guidelines and interpret the survey results appropriately (see para 2.5.1 onwards).

1.1.8 The Chartered Institute of Ecology and Environmental Management (CIEEM)'s Code of Professional Conduct (2022a) requires members to agree to *'Only undertake work that I have the competence to do and undertake that work to the expected standard and seek appropriate advice, training and assistance if I am involved in topics beyond my competence'*.

1.1.9 British Standard 42020:2013 Biodiversity – Code of practice for planning and development (British Standards Institution (BSI), 2013, hereafter referred to as BS42020) is relevant to the planning process, other consented development and proposals involving the management and use of land. This states that:

- *'any individual dealing with ecological issues at any stage of the planning application process should be able to demonstrate that they have sufficient technical competence and experience to carry out the particular tasks and activities for which they are responsible in the role that they are performing' (BS42020; Clause 4.3.2);*
- *'an explanation, with evidence, of the assessment and decision-making process and the reasons for a particular course of action or piece of advice should be clearly documented and made available where required and/or necessary' (BS42020; Clause 4.4.3); and*
- *'it is especially important to provide evidence of how professional judgement has been applied where ecological work does not follow, in full or in part, the recommendations set out in national good practice guidelines' (BS42020; Note for Clause 4.4.3).*

1.1.10 The guidelines should be interpreted and adapted on a case-by-case basis according to site-specific factors and the professional judgement of an experienced bat ecologist. The question should not be whether the guidelines were followed, but were the defined objectives of the surveys met? Where examples are used in the guidelines, they are descriptive rather than prescriptive.

What the guidelines do not cover

1.1.11 The guidelines do not aim to provide information on carrying out Ecological Impact Assessments (EcIAs). However, the survey work undertaken should be designed to answer questions that the impact assessment process will generate. Frequent reference is therefore made to the potential impacts of a project and associated relevant questions. *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine* (CIEEM, 2022b) and the *Bat Mitigation Guidelines* (Reason & Wray, 2023) provide more information in this respect.

1.1.12 The guidelines do not aim to provide information on designing strategies to avoid, mitigate or compensate for impacts on bats. Sources of information on this include the *Bat Mitigation Guidelines* (Reason & Wray, 2023), the Bat Conservation Trust (BCT)'s Roost website[1], the Conservation Evidence website[2], the 'What Works in Conservation' publications[3] and/or papers in relevant journals (such as *Acta Chiropterologica, Journal of Conservation Evidence* etc.).

1.1.13 In some cases, local guidance, written with local knowledge, is available and may be used in preference to these

1 https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement
2 https://www.conservationevidence.com/
3 https://www.cambridgeconservation.org/resource/what-works-in-conservation-2021/

guidelines. One example is the South Hams Special Area of Conservation (SAC) Greater Horseshoe Bats Habitats Regulations Assessment Guidance (Devon County Council *et al*., 2019). Another example is Bat SAC, Planning Guidance for Wiltshire (Natural England and Wiltshire Council, 2015).

1.1.14 In these guidelines, a survey is defined as a sampling activity in which a range of variables are measured to describe a site or an area. Surveying is distinct from monitoring, which involves repeated sampling, either year-on-year or periodically, usually to quantify changes over time or to assess whether a particular objective or standard has been attained. These guidelines do not include surveys carried out for monitoring purposes. Some information about monitoring the success of avoidance, mitigation and compensation measures is provided in the *UK Bat Mitigation Guidelines* (Reason & Wray, 2023).

1.1.15 Although the survey techniques described are also often used in bat conservation or research, the guidelines have not been written for these purposes and should not be used to design such surveys. Surveys for bat conservation purposes are described in the *Bat Workers' Manual* (Mitchell-Jones and McLeish, 2004) and surveys for research purposes should be bespoke, designed according to the specific questions the research is intended to answer.

1.1.16 Chapter 9, on Advanced Licence Bat Survey Techniques (ALBST), does not cover the use of bat rings/bands used for long-term monitoring programmes or other techniques usually associated with research such as light-tagging or Passive Inductor Transponder tags (PIT), as these are not generally considered appropriate for surveys associated with developments. For further information on these methods, refer to Kunz and Parsons (2009).

1.1.17 This edition does not include any guidance on survey for proposed wind farms as this is provided in Bats and Onshore Wind Turbines – Survey, Assessment and Mitigation (NatureScot *et al*., 2021), EUROBATS Publication Series No. 6 Guidelines for consideration of bats in wind farm projects (Rodrigues *et al*., 2015) and European Commission Guidance (2020) on Wind Energy Developments and EU Nature Legislation.

1.1.18. Although this edition covers bat surveys of trees, more comprehensive detail can be found in Bat Tree Habitat Key (BTHK) (2018, 2020).

1.1.19. Similarly, this edition does cover hibernation surveys of underground sites, but more comprehensive detail on bats in rock can be found in the new Bat Roosts in Rock - A Guide to Identification and Assessment for Climbers, Cavers and Ecology Professionals (Bat Rock Habitat Key, 2021).

1.1.20. Finally, this edition of the guidelines does not include specific advice in relation to road and rail schemes, although the principles of survey design and execution do apply. Berthinussen and Altringham (2015) provide information on pre- and post-construction surveys of linear infrastructure schemes, designed specifically to assess the effectiveness of mitigation for bats crossing them, although it is not clear how widely these have been adopted. New guidance on the consideration of bats in traffic infrastructure projects will soon be available from EUROBATS[4].

1.2 Legislative context for bat survey work

1.2.1. An overview of the legislation relating to bats and bat surveys is provided here. More detailed information is found in the *UK Bat Mitigation Guidelines* (Reason and Wray, 2023). When dealing with individual cases, readers should consult the full texts of the relevant legislation and obtain legal advice if necessary. They should also check regularly for changes to legislation, guidance and case law. At the time of writing, legislation is being reviewed and policy is changing, which may make the foundation of the planning and licensing processes more uncertain.

1.2.2. A summary of the relevant nature conservation legislation (correct at time of press) is given in Table 1.1.

Table 1.1. Summary of the main legislation pertaining to the protection of bats in the UK.

	Habitat Regulations (transposing the European Commission (EC) Habitats Directive)	**Other nature conservation legislation**
England and Wales	The Conservation of Habitats and Species Regulations 2017 (as amended)[5]	Wildlife and Countryside Act 1981 (as amended)[6] Environment Act, 2021[7] The Environmental Damage (Prevention and Remediation) (England) Regulations 2015[8] The Environmental Damage (Prevention and Remediation) (Wales) Regulations 2009[9]
Northern Ireland	The Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended)[10]	Wildlife and Natural Environment Act (Northern Ireland) 2011[11] Environment Act 2021[7] The Environmental Liability (Prevention and Remediation) Regulations (Northern Ireland) 2009[12]
Scotland	The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended)[13]	Wildlife and Natural Environment (Scotland) Act 2011[14] Environment Act 2021[7] The Environmental Liability (Scotland) Regulations 2009[15]

4 https://www.eurobats.org/publications/eurobats_publication_series
5 https://www.legislation.gov.uk/uksi/2017/1012/contents/made
6 https://www.legislation.gov.uk/ukpga/1981/69/contents
7 https://www.legislation.gov.uk/ukpga/2021/30/contents
8 https://www.legislation.gov.uk/uksi/2015/810/contents
9 https://www.legislation.gov.uk/wsi/2009/995/contents
10 https://www.legislation.gov.uk/nisr/1995/380/contents/made
11 https://www.legislation.gov.uk/nia/2011/15/contents
12 https://www.legislation.gov.uk/nisr/2009/252/made
13 https://www.legislation.gov.uk/uksi/1994/2716/contents/made
14 https://www.legislation.gov.uk/asp/2011/6/contents/enacted
15 https://www.legislation.gov.uk/ssi/2009/266/contents/made

The Habitats Directive and respective domestic legislation

1.2.3 Annex II of the Council Directive 92/43/EEC 1992 on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive) lists animal and plant species of Community interest, the conservation of which requires the designation of Special Areas of Conservation (SACs); Annex IV lists animal and plant species of Community interest in need of strict protection. All bat species are listed in Annex IV; some are listed in Annex II.

1.2.4 In the UK[16], the EC Habitats Directive was transposed into national laws and the regulations implementing the objectives of the Directive include the Conservation of Habitats and Species Regulations 2017 (as amended) (England and Wales), the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (Scotland) and the Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1995 (as amended). Commonly the regulations are referred to as the Habitats Regulations[17]. Hereafter, they are referred to as such.

1.2.5 The UK left the European Union on 31st January 2020 and is therefore no longer bound by European legislation. However, the related domestic legislation has been retained and therefore bats receive the same level of protection as prior to our departure and will do so until this is changed by specific legislation. The European Commission (EC) published an updated version of the *'Guidance document on the strict protection of animal species of Community interest under the Habitats Directive'* (EC, 2021) and this remains a relevant source of information for those working with bats, despite Brexit.

Legal framework

1.2.6 Although the precise wording of the legal protection afforded to bats differs between countries in the UK, it all falls within a common framework making unlawful specific actions against bats, but with differing emphasis on the state of mind (intentional, reckless, deliberate) needed to evidence offences. The legislation does not, in the main, mention bats except in annexes and schedules. The Habitats Regulations refer to specimens of European Protected Species (EPS). All species of bats found in the wild in the UK are EPS.

Kill, injure, capture/take bats

1.2.7 It is unlawful to kill, injure, capture or take a wild bat anywhere in the UK. In England, Wales and Northern Ireland the offence requires a deliberate action; in Scotland it requires a deliberate or reckless action. All offences of this nature are identified within the Habitats Regulations.

Disturbing bats

1.2.8 It is unlawful to disturb bats, in particular if the level of disturbance can be shown to impair their ability to survive; to breed or reproduce; to rear or nurture their young; to hibernate or migrate; or to significantly affect local distribution or abundance. In England, Wales and Northern Ireland the offence requires a deliberate action. In Scotland the offence requires a deliberate or reckless action. All offences of this nature are identified within the Habitats Regulations.

1.2.9 In Scotland it is also an offence in the regulations to deliberately or recklessly disturb a bat whilst it is occupying a place of shelter or protection. This offence does not require the level of disturbance to be significant.

1.2.10 In England and Wales it is also an offence under the Wildlife and Countryside Act[18] to intentionally or recklessly disturb a bat, whilst it is occupying a place of shelter or protection.

1.2.11 The Environment Act 2021 (Section 111) introduces a new exception to the Wildlife and Countryside Act offences for any actions taken under the auspices of a Habitats Regulations licence.

1.2.12 Another change to the Wildlife and Countryside Act brought in by Section 111 of the Environment Act, which came into force in September 2022, is that licences can now be issued in England (but not Wales) for reasons of overriding public interest providing there is no other satisfactory solution and the activities granted by the licence will not be detrimental to the survival of any population of the species of animal or plant to which the licence relates. This provision for development activities was not previously available within this legislation.

1.2.13 A householder who disturbs a bat in its place of shelter or protection does not commit an offence if they first seek the advice of Natural England (NE) or Natural Resources Wales (NRW) and allow time for such advice to be provided. If the bat is in the living area of a dwelling house, it is not an offence in any circumstance to disturb it. This provision does not apply to Scotland or to Northern Ireland.

Harassing bats

1.2.14 In Scotland only, it is an offence to deliberately or recklessly harass a bat or a group of bats. No definition of 'harass' is provided within the regulations and therefore this is open to interpretation. With reference to legislation protecting people, harassment includes causing alarm or distress.

Damage or destruction of roosts

1.2.15 Throughout the UK it is illegal to damage or destroy a place used by a bat for breeding or resting. All offences of this nature are identified within the Habitats Regulations. This offence is unique in that it can be committed accidently. This is a strict liability offence; no element of intentional, reckless or deliberate action needs to be evidenced.

Obstructing access to a breeding site or resting place

1.2.16 In Scotland it is an offence under the Habitats Regulations to deliberately or recklessly obstruct access to a breeding site or resting place of a bat or to otherwise deny a bat the use of such a place.

1.2.17 In Northern Ireland it is an offence under the Habitats Regulations to deliberately obstruct access to a breeding site or resting place used by a bat.

1.2.18 In England and Wales, it is an offence under the Wildlife and Countryside Act to intentionally or recklessly obstruct access to any place used by a bat for shelter or protection. As with intentional or reckless disturbance, the Environment Act 2021 (Section 111) introduces a licensing purpose for reasons of overriding public interest and an exception for any actions taken under the auspices of a Habitats Regulations licence.

1.2.19 A householder will not commit an offence if he or she obstructs access to a bat roost in a dwelling house providing they first seek the advice of NE or NRW and allow them time to provide such advice. This defence does not apply in Scotland or to Northern Ireland.

16 The EC Habitats Directive does not apply to the Isle of Man and the Channel Islands, which are part of the British Isles but not part of the UK.

17 In Scotland and Northern Ireland the Habitats Regulations have been amended on a number of occasions, most particularly in 2007.

18 The Wildlife and Countryside Act 1981 has been amended on numerous occasions, in particular by the Countryside and Rights of Way Act 2004 (CROW) and the Natural Environment and Rural Communities Act 2006 (NERC).

Possession and sale of bats

1.2.20 Under the Habitats Regulations, it is an offence to be in possession or control of a EPS of bat alive or dead (or any part of a bat or anything derived from a bat, although bat droppings are generally considered to be acceptable), or to transport a bat, to sell or exchange a bat or to offer to sell or exchange a bat taken from the wild.

1.2.21 It is an offence under the Wildlife and Countryside Act in England and Wales to: offer or expose for sale any bat of a species listed in Schedule 5 and taken from the wild; or to possess any bat or anything derived from a bat for the purposes of sale; or to publish or cause to be published any advertisement offering to buy or sell a bat.

Illegal methods for taking or killing bats

1.2.22 The Habitats Regulations in all parts of the UK contain provisions prohibiting certain methods of taking or killing bats even when the activity itself has been licensed.

Offences relating to licensing

1.2.23 Actions, which would otherwise be illegal, can be made lawful if licensed by the appropriate licensing body[19]. It is an offence anywhere in the UK to make a false statement in order to obtain a bat licence or to fail to comply with the conditions of a bat licence.

Attempts and possession of items to be used to commit offences

1.2.24 It is an offence in all parts of the UK to attempt to commit any criminal offence or to possess items to be used to commit offences identified in any of the legislation referred to above. Legislation throughout the UK is such that it may not be only those who are directly responsible for offences that are liable. In Scotland, those who cause or permit offences are guilty, as are those who aid or abet offences elsewhere.

Defences

1.2.25 It is not illegal anywhere in the UK:

- to take a disabled bat, for the sole purpose of tending it and releasing it when no longer disabled, as long as that person can show that it was not disabled unlawfully by them;
- to kill a bat, as long as that person can show that the bat was so seriously disabled, other than by their own unlawful act, that there was no reasonable chance of it recovering.

1.2.26 These defences, however, only apply in circumstances where there is no reasonable alternative, and when the act will not be detrimental to the maintenance of the species at a Favourable Conservation Status (FCS) in its natural range.

Protected areas

1.2.27 Some species of bat found in the UK (greater and lesser horseshoe, barbastelle, Bechstein's and greater mouse-eared bat) are listed in Annex II of the Habitats Directive. This means that they can be listed as an interest or 'qualifying' feature of a SAC (the reason why the SAC is designated) as part of the Natura 2000 network. Under Article 6 of the Habitats Directive[20], this means they are also a relevant consideration in a Habitats Regulations Assessment (HRA), which provides these species with additional legislative protection. More information on HRAs can be found on the GOV.UK website[21]. Following the departure of the UK from the European Union, UK Natura 2000 sites are now referred to as the 'National Site Network'.

1.2.28 Across the UK, Sites of Special Scientific Interest (SSSIs) [Areas of Special Scientific Interest in Northern Ireland (ASSIs)] have been identified by the Statutory Nature Conservation Bodies (SNCBs). Some such sites have been notified for their bat interest. Legislation relating to such areas identifies criminal offences if bats are disturbed, if roosts are damaged or if certain operations are undertaken without consent in places notified for their bat interest. In England and Wales, the relevant legislation is the Wildlife and Countryside Act 1981, and in Northern Ireland, the Environment (Northern Ireland) Order 2002. In Scotland, the Nature Conservation (Scotland) Act 2004 creates and protects SSSIs although no sites have been designated for bats. More information on SSSIs can be found on the SNCB websites[22, 23, 24, 25].

Police and court powers

1.2.29 A police constable in any part of the UK has the power, where they have reasonable cause to suspect that a person is committing or has committed an offence, to stop and search them, search or examine any relevant item in their possession, and seize it. They can also enter land other than a dwelling house without a warrant, or enter and search a dwelling house with a warrant. Constables are empowered to take with them any person or any equipment needed to exercise their powers. Legislation in England and Wales provides a defence for police officers who commit certain offences during the course of their enquiries, otherwise their acts are authorised by a licence issued by the SNCBs.

1.2.30 Those found guilty of offences relating to bats can be sentenced to six months' imprisonment and fined. Legislation in England and Wales has removed the maximum amount of fine that can be imposed, and courts there now have the power to impose unlimited fines[26].

1.2.31 In Scotland, if found guilty of an offence on summary conviction persons can be imprisoned up to 12 months and/or receive a fine up to £40,000. If found guilty on conviction on indictment, persons can be imprisoned up to 5 years and/or receive an unlimited fine.

1.2.32 In Northern Ireland, maximum fines at present are set at £5,000 but a penalty can be imposed for each animal involved.

1.2.33 Courts have a wide range of other sanctions available to them; for example, they can order forfeiture of anything used to commit offences or proceeds of crime orders can be made that allow for any profit arising from criminal activity to be confiscated.

19 Natural England, Natural Resources Wales, NatureScot or Department for Agriculture, Environment and Rural Affairs (Northern Ireland).

20 Details of a HRA Handbook can be found at https://www.dtapublications.co.uk/handbooks

21 https://www.gov.uk/guidance/habitats-regulations-assessments-protecting-a-european-site

22 https://www.gov.uk/guidance/sites-of-special-scientific-interest-public-body-responsibilities

23 https://naturalresources.wales/guidance-and-advice/environmental-topics/wildlife-and-biodiversity/protected-areas-of-land-and-seas/sites-of-special-scientific-interest-responsibilities-of-public-bodies-and-statutory-undertakers/?lang=en

24 https://www.nature.scot/professional-advice/protected-areas-and-species/protected-areas/national-designations/sites-special-scientific-interest-sssis#:~:text=Scotland%20has%201%2C422%20SSSIs%2C%20covering%20around%201%2C011%2C000%20hectares,SSSI%2C%20which%20extends%20to%20more%20than%2029%2C000%20hectares.

25 https://www.daera-ni.gov.uk/topics/land-and-landscapes/areas-special-scientific-interest

26 http://www.legislation.gov.uk/uksi/2015/664/contents/made

Interpretation of legislation

1.2.34 Legislation throughout the UK commonly uses the words intentional, deliberate or reckless. There is substantial legal opinion as to the meaning of each. The term 'roost' is not used within the legislation itself and 'disturbance' is also not defined. Commonly, questions are posed as to how long bat roosts retain their legal protection when they cease to be used. Some advice is provided in the EC guidance (2021).

Environmental Damage and Environmental Liability Regulations

1.2.35 These regulations aim to prevent damage to the environment, which includes protected species such as bats and natural habitats. This damage must have a significant adverse effect on reaching or maintaining FCS status for the protected species or natural habitat involved.

1.2.36 These regulations require an operator of an activity to take all practicable steps to prevent environmental damage and give enforcing authorities the power to serve notice on such an operator and specify what action is needed to prevent environmental damage. Failure to comply with these requirements is an offence.

1.2.37 Where environmental damage has been done, remediation orders can be imposed under these regulations to repair damage. This can be used alongside a prosecution under the Habitats Regulations to gain better outcomes for bats and their habitats.

1.3 Licensing

1.3.1 The two main types of licence relevant to these guidelines are EPS survey licences (also known as science and education or conservation licences) and EPS mitigation licences (also referred to as derogation, mitigation or development licences). Both types of licence permit activities that could otherwise be an offence. Below is a summary at the time of writing, but it is necessary to check the relevant licensing body websites to ensure the most up-to-date and relevant information is obtained.

Survey licences

1.3.2 Survey licences are issued by the following licensing authorities:

- England: NE
- Wales: NRW
- Scotland: NatureScot
- Northern Ireland: Northern Ireland Environment Agency, Department of Agriculture, Environment and Rural Affairs (DAERA)

1.3.3 Licences issued in one country of the UK cannot be used in a different country; it is necessary to obtain a licence from each of the individual countries you aim to work in.

1.3.4 These licences do not cover the damage or destruction of a roost site for development; see instead EPS, derogation, mitigation or development licences.

1.3.5 Survey licences are issued to ecologists under the Habitats Regulations and Wildlife and Countryside Act to permit them to undertake activities that could otherwise be illegal and lead to an offence, such as entry into a bat roost, temporary disturbance of bats during a survey (including use of a torch and endoscope) and capture and handling of bats. **Different activities are permitted under different survey licences so ecologists should always check what they are actually licensed to do.**

1.3.6 Ecologists go through a period of training and peer review before being signed off for a licence by their trainer and/or referees. The possession of a survey licence is an indication that the surveyor has reached a minimum standard of training and experience, although this does not relate to impact assessment or the design and implementation of avoidance, mitigation, compensation, enhancement and monitoring schemes. It is, however, worth mentioning that there are no set 'national' criteria established for assessing surveyor competence.

1.3.7 Ecologists without a survey licence should not enter known roosts or sites where signs of bat presence (or possible bat presence) have been found. Even where no signs have been found, surveys of potential roost sites should be carried out by ecologists with a survey licence covering the relevant activities. This will ensure that the ecologist knows what to look for and where, in order to subsequently make a judgement on the suitability of a potential roost site for bats. Licensing authorities may reject survey information completed by non-licensed persons.

1.3.8 A suitably qualified ecologist (in other words a competent ecologist) is required by BS42020 to undertake bat surveys. Some Local Planning Authorities (LPAs) will also have specific requirements regarding surveyors being licensed if carrying out bat surveys for planning purposes, so local requirements should always be checked. It is also important to demonstrate competence in survey work for the submission of bat mitigation licences to the relevant licensing authority.

1.3.9 Although a limited amount of trapping (using mist nets, harp traps and lures) is permitted under some survey licences (class licences in England), a relevant project licence will be required for more complex projects and for any projects involving the attachment of radio transmitters. Other marking methods, not covered by these guidelines, also require a licence, such as the fitting of tags or rings. A project licence is granted for specific species and numbers of bats, for specific dates and at a particular location. When applying for a project licence, the applicant needs to demonstrate that the level of disturbance is justified and that he or she has the necessary experience to undertake the work.

Conservation licences

1.3.10 Conservation licences may be issued to allow improvements to a bat roost where the main purpose of the work is for conservation of the species at a specific site. These licences would normally only be issued for a specific proposal at a specific site and only for the duration of the work.

Photography/filming

1.3.11 A licence to photograph (including filming) bats is not required if the photography is an **incidental part of other licensed bat work** and it causes no extra disturbance above that caused by the licensed activities. Such photography includes:

- non-flash photography (i.e. using only natural light or low-level artificial light such as a domestic torch or low-output LED) of roosting bats and of people carrying out licensed work in and around roosts;
- flash photography in roosts and hibernacula only when no bats are present;

- photography of bats caught at traps during survey work;
- flash photography of individual bats during a roost survey for identification purposes or of groups of bats for survey purposes; and
- the use of night vision aids (NVAs, including night vision/infrared/thermal imaging cameras) to record roosting (as part of other licensed work) or emerging bats either without the use of further illumination or using infrared illumination (not a red filter).

1.3.12 These only apply where the licence holder considers that this would cause less disturbance than handling or prolonged illumination of bats. It is recommended that there is only one designated photographer at any one time to reduce disturbance.

1.3.13 Flash photography in occupied bat roosts or hibernacula, or entering bat roosts or hibernacula specifically for the purpose of photography (including filming), must be specifically licensed.

1.3.14 As disturbing bats specifically for the purpose of photography is potentially very disturbing to bats, licences are only likely to be given where the licensing authority agrees there is a clear need for the photographs and only to experienced photographers who can demonstrate their ability to work efficiently with minimal disturbance to the bats.

Class licences for surveying bats in England

1.3.15 In England, a class licensing system has been introduced for survey licences (issued for the purposes of science and education, including research). These licences are for all bat-related activities (both voluntary and professional) outside of the NE volunteer bat roost visitor advice service. This includes:

- bat box checks;
- hibernation surveys;
- general survey work;
- professional survey work;
- limited use of harp traps, mist nets and acoustic lures for development survey purposes.

1.3.16 At present there are four levels of class licence; these are summarised below. The GOV.UK website[27] should be consulted for further details.

- ***Level one – to survey bats by observation only (licence WML-CL17) – Disturbance only***
  Surveying of bats by observation only (including the use of artificial light, in the form of torches but not endoscopes) for scientific, research or educational purposes, including informing development projects. This does not include surveys of hibernating bats.
- ***Level two – to survey bats using artificial light, endoscopes, hand and hand-held static nets (licence WML-CL18) – Disturbance with handling.*** Surveying of bats using artificial light (e.g. torches), endoscopes, hand and static hand-held nets for scientific, research or educational purposes, including informing development projects. This includes surveys of hibernating bats.
- ***Level three – to survey bats using artificial light, endoscopes, hand and hand-held static nets, mist nets and acoustic lures (licence WML-CL19) – Disturbance with handling and mist netting.*** Surveying of bats using artificial light (e.g. torches), endoscopes, hand, static hand-held nets, mist nets and acoustic lures for scientific, research, or educational purposes, including informing development projects.
- ***Level four – to survey bats using artificial light, endoscopes, hand and hand-held static nets, harp traps and acoustic lures (licence WML-CL20) – Disturbance with handling and harp trapping.*** Surveying of bats using artificial light (e.g. torches), endoscopes, hand, static hand-held nets, harp traps and acoustic lures for scientific, research, or educational purposes, including informing development projects.

European Protected Species (EPS) licences (also known as derogation, mitigation or development licences)

1.3.17 EPS licences are issued by the same licensing authorities as survey licences. EPS licences are issued under the Habitats Regulations only after three tests have been satisfied in relation to the proposed action, as follows:

- the proposed action must be for the purpose of preserving public health or public safety or other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment; and for preventing serious damage to property;
- there is no satisfactory alternative to the proposed action; and
- the action authorised will not be detrimental to the maintenance of the species concerned at a FCS in their natural range.

1.3.18 NE published a Technical Information Note on FCS definitions (Hanna, 2021) and FCS is defined in the Habitats Directive as follows (from (EC, 2016):

> *"conservation status will be taken as 'favourable' when: population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."*

1.3.19 The Environment Act 2021 (Section 111) introduced a new exception to the Wildlife and Countryside Act offences for any actions taken under the auspices of a Habitats Regulations licence. Another change is that licences can now be issued in England (but not Wales) for reasons of overriding public interest providing:

- there is no other satisfactory solution; and
- the activities granted by the licence will not be detrimental to the survival of any population of the species of animal or plant to which the licence relates.

1.3.20 This provision for development activities was not previously available under the Wildlife and Countryside Act (1981).

1.3.21 In order for the licensing tests to be correctly applied, it is essential that baseline survey information of a sufficient quantity, quality and standard is supplied. Without this survey information, a licence may not be granted.

1.3.22 Information on when a licence is required, how to apply for a licence, and maintaining the FCS of a species, can be found on the relevant licensing authority websites.

27 https://www.gov.uk/government/collections/bat-licences#bat-survey-licences

1.3.23 In 2014, NE announced the introduction of a Bat Low Impact Class Licence (BLICL) scheme, now titled the Bat Mitigation Class Licence (BMCL). Ecologists can apply to become a Registered Consultant to use this type of licence (following attendance on a specific training course and a subsequent assessment), which is for low conservation status roosts and relates only to specific bat species identified by NE. One of the conditions for using this licence is that a Site Registration form is completed, submitted to and approved by NE.

1.3.24 In 2018, NE announced the introduction of a Bats in Churches Class Licence, recognising that churches often require a more bespoke and flexible approach to works where large populations of bats are roosting and potentially causing high levels of impact. Novel approaches to avoidance, mitigation and compensation can be used under this licence, based on the findings from church-specific research and with strict monitoring regimes in place. The licence works on the same principles as the BMCL, with ecologists attending training and undertaking an assessment of their skills and experience before applying to become a Registered Consultant and benefitting from a more streamlined licensing process.

1.3.25 In 2021, NE began a pilot of the Earned Recognition scheme. Earned Recognition works on the basis of assessing and accrediting a consultant's competence in undertaking survey work and designing effective avoidance, mitigation and compensation so that, by using an accredited consultant, developers can experience a more streamlined licensing process for their scheme or project. A competency framework defines the requirements for different levels of accreditation. Consultants who work on projects that involve higher risks to bats require a higher level of accreditation that involves demonstrating a higher level of competence. At the time of writing, a second pilot phase known as Beta ER is underway.

1.3.26 It is also possible within England to apply for an organisational licence, which licenses organisations (but with very specific conditions) to carry out routine activities that affect one or more protected species[28].

1.3.27 In 2019, Scotland also provided a streamlined approach to bat mitigation licensing with the introduction of the Bat Low Impact Licence (BLIMP). This can be used where the conservation impacts of works are low, providing certain criteria are met. This system also requires an ecologist to register a site before works are carried out.

1.3.28 Although this is correct at the time of writing, the relevant SNCB websites should be checked for any updates or further information on licences.

1.4 Planning policy context

1.4.1 The biodiversity duty is imposed in England through the Environment Act 2021, which amends the Natural Environment and Rural Communities (NERC) Act 2006 by adding the words 'and enhance' alongside 'conserve'. The new Act states that public authorities must consider what action they can take to further the biodiversity objective and must put together policies and objectives for taking action for biodiversity.

1.4.2 In Wales the biodiversity duty is imposed by the Environment (Wales) Act 2016. Section 6 'Biodiversity and resilience of ecosystems duty' of the act states that a public authority must seek to maintain and enhance biodiversity in the exercise of functions in relation to Wales, and in so doing promote the resilience of ecosystems, so far as consistent with the proper exercise of those functions. Section 7 requires biodiversity lists and duty to take steps to maintain and enhance biodiversity.

1.4.3 The Nature Conservation (Scotland) Act 2004 states that 'it is the duty of every public body and office-holder, in exercising any functions, to further the conservation of biodiversity so far as is consistent with the proper exercise of those functions'.

1.4.4 The Wildlife and Natural Environment (NI) Act 2011 states that public bodies should further the conservation of biodiversity in exercising their functions.

1.4.5 Relevant policy documents for the UK relating to planning and biodiversity/nature conservation are referenced in Table 1.2, current at the time of writing.

Table 1.2. Government policy guidance for biodiversity and nature conservation in the UK.

Country	Relevant Planning Policy
England	National Planning Policy Framework (NPPF) (GOV.UK, 2021a) especially Ch. 15 Conserving and enhancing the natural environment Circular 06/05: Biodiversity and Geological Conservation – Statutory Obligations and Their Impact Within the Planning System (GOV.UK, 2005) National Planning Practice Guidance Natural Environment (GOV.UK, 2019) (para 10 – 35)
Northern Ireland	Strategic Planning Policy Statement for Northern Ireland (Department for Infrastructure (Northern Ireland), 2021)
Scotland	Scottish Planning Policy (GOV.SCOT, 2014) National Planning Framework 4
Wales	Planning Policy Wales 11 (Welsh Government, 2021)

28 https://www.gov.uk/government/publications/organisational-licence-for-routine-work-affecting-protected-species

1.4.6 In addition to the national policy guidance outlined above, regional and local planning policies should be consulted and other country-specific guidance, such as NE's Standing Advice to LPAs (GOV.UK, 2022a) may also be relevant.

1.4.7 Government planning policy guidance throughout the UK requires LPAs to take account of the conservation of protected species when considering and determining planning applications.

1.4.8 Planners are required to consider protected species as a material consideration when assessing a development proposal that, if carried out, would be likely to result in harm to the species or its habitat. This requirement has important implications for bat surveys as it means that, where there is a reasonable likelihood of bats being present and being affected by the development, surveys must be carried out and mitigation/compensation planned and agreed before planning permission is considered.

1.4.9 When biodiversity validation requirements are in place, this may include the need for bat surveys to validate a planning application (before it is even considered) where it is reasonably likely that they will be present and affected by the development proposal.

1.4.10 Adequate surveys are therefore required to establish the presence or absence of bats, to enable a prediction of the likely impact of the proposed development on them and their breeding sites or resting places and, if necessary, to design avoidance, mitigation, compensation, enhancement and monitoring measures.

1.4.11 The term 'development' used in these guidelines includes activities and proposals that have the potential to have a negative effect on bats. In planning terms, this includes activities requiring outline or full planning permission but also those that meet the criteria for permitted development, require listed building consent and/or require prior approval to demolish. SSSI consent may also be needed. CIEEM has produced a guide for householders on what to expect from a bat survey.[28] Guidance on permitted development and nature conservation has been produced by CIEEM and ALGE (2017).

1.4.12 Further details on the standard of information required to assess a planning application is detailed in Clauses 6 and 8 of the BS42020 (BSI, 2013). In particular, *'The final report submitted with the application should provide as much certainty as possible and be prepared specifically with the aim of enabling the decision-maker to reach a sound and lawful determination of the application'* (Clause 6.3.1).

1.4.13 In addition:

- Clause 7.3 of BS42020 (BSI, 2013) states that 'where an applicant has been advised during pre-application discussions, or have themselves identified that they need to provide information on biodiversity with their planning application, they should ensure that what is submitted is sufficient to enable the decision-maker to validate and register the application'. Preliminary ecological appraisal (PEA) reports (see Chapter 4) are inadequate to inform the planning process unless no further surveys or mitigation/compensation are required.
- The 'Note' with Clause 7.3 of BS42020 (BSI, 2013) states that 'failure to provide all the information required might mean an application is not 'valid' and is not considered or determined'. Therefore, good practice would be for an LPA to include biodiversity in its list of local validation requirements and not to validate an application if bat surveys are required (i.e. if there is a reasonable likelihood that bats could be impacted) but none have been carried out.

1.4.14 The planning system should also deliver overall net gains for biodiversity (enhancements), as set out within policy documents for each country. Guidance can be found in British Standard 8683:2021 A Process for Designing and Implementing Biodiversity Net Gain (BSI, 2021). The BCT has produced a document outlining how bats can be accounted for when planning Biodiversity Net Gain (BCT, 2020a). Essentially, this document outlines how and which habitats can be provided for different species within their Core Sustenance Zones (CSZ) to be functionally effective and avoid impacting on habitats important to support roosts.

British Standard for Biodiversity – BS42020:2013

1.4.15 The Code of Practice for planning and development set out within BS42020 (BSI, 2013) provides recommendations and guidance for those in the planning, development and land use sectors whose work might affect or have implications for the conservation or enhancement of biodiversity. It aims to:

- promote transparency and consistency in the quality and appropriateness of ecological information submitted with planning applications and applications for other regulatory approvals;
- give planning authorities and other regulatory bodies greater confidence in the information when they consider proposals for development or land management that potentially affects biodiversity;
- encourage proportionality and a good environmental legacy following development.

1.4.16 Further detail is provided by the BSI[29] and a Smart Guide to Biodiversity in Planning and Development is also available[30].

Wildlife Assessment Check

1.4.17 The Partnership for Biodiversity in Planning (PBP) Project, which was funded by the Esmée Fairbairn Foundation, was an alliance of 19 organisations representing the conservation, planning and development sectors working together to simplify, streamline and improve the consideration of biodiversity in the UK planning process. The Partnership produced an online, interactive trigger list called the Wildlife Assessment Check (WAC)[31], which aims to ensure that:

- protected and priority species and statutory designated sites for nature conservation are considered early in the planning process;
- professional ecological input is sought at an early stage of a development project; and
- necessary ecological assessments are carried out and submitted as part of a planning application.

1.4.18 The WAC is a guide for developers and planners early on in the development process, but it is by no means exhaustive, and the professional judgement of an ecologist (along with the application of local knowledge) should be used to assess where bat surveys are, or are not, appropriate.

1.4.19 Other sites, not identified by the WAC, may require a bat survey due to their context, proximity to existing records of bats, the nature of the structure or the proposed activities. Alternative habitats that may initially appear poor for roosting, flight-paths or foraging may be important at particular times of year or in particular situations, for example where other options for bats are limited. In addition, bats can turn up in unusual places!

28 https://cieem.net/resource/what-to-expect-from-a-bat-survey-a-guide-for-uk-homeowners/
29 https://knowledge.bsigroup.com/products/biodiversity-code-of-practice-for-planning-and-development/standard
30 (https://www.bsigroup.com/LocalFiles/en-GB/biodiversity/BS-42020-Smart-Guide.pdf)
31 https://www.biodiversityinplanning.org/wildlife-assessment-check/

Chapter 2

Considerations for bat surveys

2.1 Assessing the need for a bat survey

2.1.1 It is reasonable to request surveys where proposed activities are likely to negatively impact bats and their habitats. However, surveys should always be tailored to the predicted, specific impacts of the proposed activities. Excessive, speculative surveys are expensive and cause reputational damage to the ecological profession and to bat conservation.

2.1.2 Bat surveys may be triggered via a number of routes or stakeholders:

- by a client who wants to purchase land, is in the early stages of designing a project or wants to put in a planning application;
- by an LPA that has been advised by an ecologist or used a trigger list, biodiversity validation checklist or the Wildlife Assessment Checklist to identify the need for one;
- where a HRA is required;
- where an Environmental Impact Assessment (EIA) is required; or
- to inform an EPS licence application or a non-licensable Precautionary Working Method Statement (PWMS).

2.2 Elements that influence survey design

Stage of proposals

2.2.1 It is good practice for clients to engage with an ecologist as early as possible when planning a project so that ecology can be factored into the design, timetable and budget at an early stage. Later engagement can result in late design changes, delays and (often) additional costs, which can lead to inadequate proposals for bat conservation. In some circumstances, delays can result in grants or funding being lost, which could affect the viability of the development or even cause hardship; these impacts are not beneficial to bat conservation but can be easily avoided by early engagement with an ecologist.

2.2.2 In addition to the client engaging with an ecologist, early engagement with the LPA and the relevant licensing authority is also beneficial. These two bodies have different functions and may make different decisions on the same proposal. In addition, the granting of, or lack of need for, planning permission does not negate the need to consider protected species legislation.

2.2.3 It is necessary to know the stage the project has reached in order to design surveys according to the amount of detail that is required. For example, determining which land option to purchase requires less information than an EPS licence submission, and surveys should be tailored accordingly.

2.2.4 Large projects such as road schemes or power stations often commence years before any work is carried out on the ground. Surveys in the early years of the project may only identify features of high conservation value to inform route selection, subsequently collecting more detail to inform scheme layout/project design (see Table 6.5 for an example relating to trees). It may also be necessary to repeat surveys on projects with long lifespans so that survey data remains current, particularly where licence applications are required.

Potential impacts

2.2.5 The purpose of professional surveys is generally to carry out an assessment of the negative impacts likely to arise from proposed activities. An ecologist should be provided with (or request) enough information about a project from the start to identify the likely ecological impacts (or lack of impacts) from an early stage. These should be reviewed throughout the project, particularly on larger projects where the proposals may be subject to change over time.

2.2.6 Some impacts on bats and their habitats that can arise from proposed activities are given in Table 2.1.

Table 2.1. Negative impacts on bats that can arise from proposed activities.

Impacts on…		
…bats	**…roosting habitats**	**…flight-paths and foraging habitats**
• Physical disturbance • Noise or vibration disturbance through, for example, increased human presence or use of noise- or vibration-generating equipment • Lighting disturbance • Injury/mortality (e.g. in roost during destruction or through collision with road/rail traffic)	• Modification of access point to roost either physically or indirectly, for example, lighting or removal of vegetation • Modification of roost either physically, for example by roof removal, or indirectly,, for example, changed temperature, humidity, ventilation or lighting regime • Loss of roost	• Modification of flight-paths or foraging habitats either physically or through disturbance, e.g. light spill/noise • Severance of flight-paths (fragmentation) • Loss of foraging habitats

2.2.7 Different parameters to consider when assessing the different impacts of a project are:

- Is it a positive or a negative impact?
- What is the extent of the impact? What area does it cover?
- What is the magnitude or size of the impact?
- What is the duration of the impact? How long will it last?
- What is the timing and frequency of the impact?
- Is the impact reversible? Will it be temporary or permanent?
- How do the impacts differ throughout the process from pre-construction through construction to operation (and dismantling and restoration for some projects).

2.2.8 More information can be found in CIEEM's EcIA guidelines (CIEEM, 2022b).

2.2.9 **The unique combination of project and site will influence the type and nature of potential impacts that are relevant to different projects. Understanding how these elements work together is the key to good survey design.**

Zone of influence (ZoI) and defining the survey area

2.2.10 A client should provide a plan showing the site boundary (or red-line boundary for planning purposes), which indicates the area within which proposed activities will take place. Predicted impacts within this boundary will influence the spatial design of surveys. Other considerations when defining survey area are given below.

- The ZoI of the proposed activities may be different from the site boundary. The term ZoI is used in formal EIA projects (although the principle can be applied to any project) and is defined by CIEEM (2017b) as 'the areas/resources that may be affected by the biophysical changes caused by activities associated with a project'.
- It is very likely to be necessary to survey outside the immediate area of a project to understand landscape context, how bats use that landscape and whether resources (such as potential roosts) may be limited.
- The client's land ownership (the blue-line boundary for planning purposes) will determine where access for surveys may be more easily obtained.

2.2.11 **All ecologists working on the project should understand how the survey area has been defined** and the definition should be revisited as the project evolves. It is essential for an ecologist to be familiar with up-to-date plans and review the surveys that have been, and will be, carried out accordingly.

Defining aims and objectives

2.2.12 It is important at the start of any survey that the aims and objectives are clearly defined and that the survey report subsequently demonstrates how these have been met.

2.2.13 The aims of surveying at a proposed development site are generally to:

- collect robust data following good practice guidelines to allow an assessment of the potential impacts of the proposed development on bat populations both on and off site;
- facilitate the design of avoidance, mitigation, compensation, enhancement and monitoring strategies for bats;
- provide baseline information with which the results of post-construction monitoring can be compared, where appropriate;
- provide clear information to enable the LPA and relevant licensing authority to reach a robust decision with definitive required outcomes;
- assist clients in meeting their statutory obligations; and
- support the conservation of bat populations.

2.2.14 Early objectives in a project may be to:

- establish what stage the project is at and therefore what action is needed;
- establish if any previous survey work has been undertaken;
- define the likely ZoI and therefore survey area; and
- carry out a PEA (Chapter 4), a preliminary roost assessment (PRA) for structures (Chapter 5) or a ground level tree assessment (GLTA) (Chapter 6) to inform the design of subsequent, more detailed surveys.

2.2.15 Later objectives may be to:

- obtain roost count data during at least one active period; and
- trap bats to identify them to species level and gain information on gender and breeding status.

2.2.16 Aims and objectives should be revisited throughout a project because each stage of surveying informs the next; bat surveys are an iterative process that should not usually be fixed from the outset. The review of data as a project progresses is essential, which means that acoustic data should be analysed after collection and not stored until the end of the season.

Proportionality

2.2.17 When planning surveys it is important to take a proportionate approach. The type of survey (or suite of surveys) undertaken and the amount of effort expended should be proportionate to the predicted impacts of the proposed activities on bats, but it needs to be recognised that robust surveys are fundamental to understanding what those impacts are.

2.2.18 Clause 4.1.2 of BS42020 (BSI, 2013) states that 'professionals should take a proportionate approach to ensure that the provision of information with the (planning) application is appropriate to the environmental risk associated with the development and its location'.

2.2.19 Below are other elements that influence the type of survey and effort expended, the examples given being descriptive rather than prescriptive:

- likelihood of bats being present (e.g. it is often harder and thus may require more survey effort to show that bats are, on the balance of probability, absent from structures rather than present. However, once presence has been established, further surveys may be required to characterise the roost);
- type of proposed activities (e.g. targeted survey effort may be required for project types known to have specific impacts such as a road scheme or wind farm);
- scale of proposed activities;
- size, nature and complexity of the site;
- species concerned (e.g. some species are harder to detect using standard techniques (such as Bechstein's bat) or are of particular conservation importance (e.g. Annex II species). Different survey types and more survey effort may

be necessary if the site is within the range of such species and habitats on site are suitable); and

- numbers of individuals (e.g. sites with larger numbers of individuals (maternity or hibernation roosts or key flight-paths and foraging areas) may require more survey effort to establish numbers or species assemblages).

Considering data analysis

2.2.20 Where large amounts of bat activity data are collected using automated/static bat detectors, or radiotelemetry is used, statistical analysis is important because the meaning is not readily understood just by looking at the data. In particular, trapping and radiotelemetry surveys are highly intrusive and can have implications for bat welfare so a clear plan of why the data are needed, what data are to be collected and how the data will be analysed is essential. If the methods of analysis (see Chapter 10) are chosen at the survey design stage, this ensures that such testing is possible and makes testing much easier. Data analysis should be an integral part of such surveys and, if data collection and analysis are non-standard, then consideration should be given to conducting a pilot to test these.

2.2.21 It is essential that data collected for direct comparison have been collected in the same way, and by the same equipment (e.g. bat detectors and microphones should be the same make and model and subject to regular sensitivity testing and calibration); and in suitable conditions, otherwise these factors can introduce bias – differences detected may relate to these factors rather than to real differences on the ground.

2.2.22 In addition, the term 'bat pass' could have a different definition according to equipment and operator, therefore it is important to be clear on how 'bat pass' will be defined when setting out. See paras 10.2.1 and 10.3.26 for some options. The important point is to be consistent.

2.2.23 It is worth noting that different software packages work differently, so if the software is changed part-way through a long project, it may be necessary to reanalyse the earlier data for consistency.

2.2.24 The main message is that there are various elements that can add bias to survey results and this bias should be minimised as far as is practical.

Mitigation hierarchy

2.2.25 The mitigation hierarchy dictates that impacts should be avoided in the first instance but, where impacts cannot be avoided, then they should be adequately mitigated or, as a last resort, compensated for. Where mitigation is referred to in these guidelines it should be taken to mean all the elements of the mitigation hierarchy, as defined below.

2.2.26 Avoidance refers to choosing options that avoid harm to bats or disturbance of their roost (for example, by retaining a roosting structure through the development design).

2.2.27 Mitigation refers to measures to protect the bat population from damaging activities and to reduce or remove the impact of development (for example, by carrying out works to a summer roost site when bats aren't present in the winter).

2.2.28 Compensation refers to the offsetting of remaining impacts (for example, by building a new roosting site when the original roosting site is lost through demolition of a building).

2.2.29 Enhancement refers to providing net benefits for biodiversity over and above requirements for avoidance, mitigation or compensation .

2.2.30 Following early surveys, it may be possible to identify potential impacts and adjust the design or timing of the project to avoid them. The extent to which impacts can be avoided will influence the design of further surveys. In some circumstances, further surveys may not be needed; in others, it may be necessary to collect baseline information to assess whether impacts have been successfully avoided.

2.2.31 Where negative impacts cannot be avoided through design ('embedded mitigation'), it is reasonable to recommend further bat surveys to facilitate an impact assessment and support the design of a mitigation and monitoring strategy.

Using good practice guidance

2.2.32 BS42020 (BSI, 2013) states, in relation to reports submitted with planning applications (although the same principles apply to reports produced as part of an EPS licence application or for other purposes):

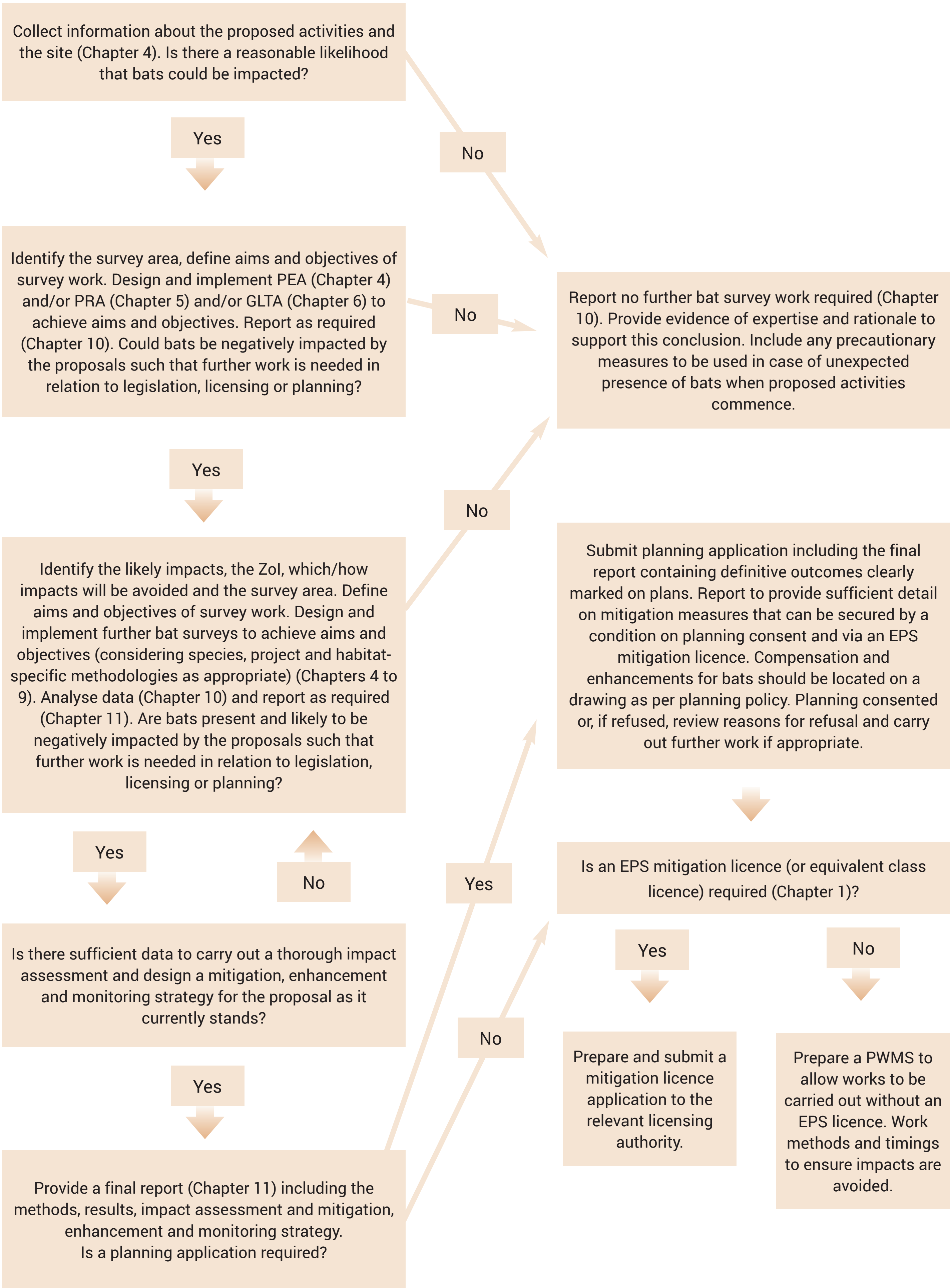
- Methods used to undertake surveys and to prepare information presented in ecological reports should (except in the circumstances described below) follow published good practice guidelines where they exist. Claims of compliance with good practice should be substantiated (Clause 6.3.6).
- A competent ecologist should, as appropriate, modify their approach from that of published good practice or standing advice issued by a statutory body where, for example:
  - it is necessary to adapt to the specific requirements of a case or site;
  - an innovative approach might improve upon published good practice and/or provide a more valuable outcome;
  - it might only be appropriate to follow good practice guidance in part as the guidance offers a range of optional methods (e.g. for surveys), of which only one is appropriate to the study in question; or
  - published good practice is out of date and/or where better techniques have been developed and recognised throughout the profession (Clause 6.3.7).

2.2.33 Deviations from good practice should be fully justified, with the skills and experience of the ecologist clearly stated alongside the rationale for deviation.

2.3 Bat surveys for development

2.3.1 Figure 2.1 illustrates the process that ecologists should go through when carrying out professional bat survey work where activities are proposed that could impact bats.

Figure 2.1. The process of carrying out professional bat surveys for proposed activities that could impact bats.



2.4 Survey timing

2.4.1 Bats use different roosts, flight-paths and foraging areas throughout the year according to their life cycle and the availability of their insect prey, which are both influenced by the ambient conditions (temperature, humidity, rainfall, wind) at the location in question. Multiple surveys are usually needed to investigate temporal or seasonal changes in activity; readers should refer to the individual survey chapters (Chapters 4 to 9) for more information. For landscape-scale or higher-impact projects, it is often appropriate to collect data at least for a year, if not longer. Where critical to such projects, it is essential to consult with the relevant planning and licensing authorities as early as possible to determine whether a single year's worth of survey data will be sufficient.

2.4.2 Table 2.2 provides optimal timings for all types of survey described in these guidelines, although individual survey chapters (Chapters 4 to 9) provide further clarification/caveats with respect to timings.

2.4.3 An experienced surveyor should carry out surveys at a time that gives them the highest chance of establishing whether or not bats are present and how they are using the habitat (including roosts). Actual timings will depend on a number of factors including the surveyor's knowledge and experience of the site and surrounding habitats, existing data records, possible bat species present, geographical location, weather conditions and, of course, the aims and objectives of the survey.

Table 2.2 Recommended UK survey times for survey types described in these guidelines.

Survey type	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Daytime Bat Walkover (DBW)	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal
PRA – structures[a]	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal
Emergence survey for maternity or summer roosts[b]					optimal	optimal	optimal	optimal				
Emergence survey for transitional/ occasional roosts[b]				weather dependent					weather dependent	weather dependent		
Re-entry surveys[c]					sub-optimal	optimal	optimal	sub-optimal				
Emergence survey for mating roosts[b]								optimal	weather dependent	weather dependent		
Hibernation survey – structures[a]	optimal	optimal	weather dependent								weather dependent	optimal
GLTA[d]	optimal	optimal	optimal	sub-optimal	sub-optimal	sub-optimal	sub-optimal	sub-optimal	sub-optimal	sub-optimal	sub-optimal	optimal
PRF inspection survey – trees	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal	optimal
Ground-level bat activity survey – night-time walkover surveys and automated/static				weather dependent	optimal	optimal	optimal	optimal	optimal	weather dependent		
Pre-, during and post-hibernation – automated/static bat activity survey	weather dependent	weather dependent	weather dependent								weather dependent	weather dependent
Swarming survey[e]								weather dependent / optimal	optimal	optimal / weather dependent		
Back-tracking survey				weather dependent	optimal	optimal	optimal	optimal	weather dependent	weather dependent		
Trapping and radio-tagging survey[f]					optimal	not acceptable	not acceptable / optimal	optimal	optimal			

= optimal period = sub-optimal period

= weather or location dependent (i.e. may not be suitable due to spring and autumn conditions in any one year or in more northerly latitudes). Note that October emergence surveys are not acceptable in Scotland.

= it is not acceptable to trap bats when they are heavily pregnant and have dependent pups. Mothers need to optimise foraging due to the physiological demands of pregnancy and lactation, and pups need to be regularly fed. Interrupting these activities could potentially have an impact on breeding success in the year in question. The timing of birth can vary between years – it may be as early as the end of May or as late as the start of August, therefore caution should be exercised and local information gained on birth dates before trapping activities are carried out during the summer months. Any information gained and decisions made should be kept as a record.

a Not including trees.

b Please see Chapter 7 for recommended timings for surveys to give confidence in a negative result. For sites assessed as having low suitability, a survey should be carried out between May and August. For sites with moderate and high suitability, a proportion of the surveys should be carried out between May and August (to detect maternity roosts if present) but some of the surveys may be carried out later in the year in order to detect transitional and mating roosts. The survey season for presence/likely absence surveys is defined as May to September. Roost characterisation surveys may be appropriate in April and/or October depending on the need to characterise transitional/occasional roosts at these times.

c The time that bats return to their roosts is very variable and therefore re-entry surveys are no longer recommended as a standard approach. If they are carried out the constraints should be recognised.

d GLTAs can be sub-optimal in the spring, summer and autumn due to foliage obscuring parts of the tree. If all parts of the tree are visible then the survey can be carried out at any time. If parts of the tree are obscured by foliage then it is not possible to carry out a thorough survey and this limitation should be recognised and the impact on the results acknowledged. Please refer to Chapter 6 for more information.

e Different species show a peak in swarming activity at different times, e.g. Daubenton's bat activity tends to peak in August whilst Natterer's bat activity tends to peak in September (Tomlinson, 2020) and therefore surveying across the swarming season is likely to be important.

f Trapping and tagging in cooler conditions can make release of bats difficult, which should be a consideration if trapping is carried out in spring and autumn. Tagging of bats in April and sometimes early May should be avoided following a poor spring, if bats are in poor condition. Tagging of newly volant pups should be avoided. Tagging of bats should be avoided in October due to the risk that bats will enter hibernation with the tag still attached (bats will groom less often as they enter torpor more frequently). If a tag falls off during hibernation this could leave a bald patch if the fur has been clipped, which could have negative impacts for the hibernating bat. Please refer to Chapter 9 for more information.

2.5 Resources for surveys

Human resources

2.5.1 It is important for those commissioning, scheduling, undertaking and assessing bat survey work to ensure that the ecologists carrying out the work have sufficient training, skills, experience and licences. There is a multitude of bat survey types and the equipment required to carry them out is technical and varied. None of these surveys can be carried out effectively without specific training and some work also requires ecologists to hold licences to carry out the work legally.

2.5.2 There is some concern that developments in technology facilitating automation of survey work (e.g. automated/static detectors, automated sound analysis) will reduce the level of 'fieldcraft' among ecologists. When starting out in bat work it is essential to spend time out in the field observing bats and getting to know their echolocation calls (and how this relates to bat ecology). It is only after spending a considerable amount of time in the field observing and listening to bats that a reasonable level of fieldcraft can be attained.

2.5.3 Alongside survey skills, ecologists planning surveys, leading survey teams, carrying out impact assessments and designing mitigation, enhancement and monitoring schemes require a whole suite of other knowledge and expertise.

2.5.4 It is the responsibility of the ecologist and their employer to ensure that appropriate training, skills, experience and licences are in place before carrying out ecological consultancy work. All training and experience gained should be recorded in a suitable format (also see professional body Continued Professional Development (CPD) requirements below).

2.5.5 Clauses 4.4.1 and 4.3.2 of BS42020 (BSI, 2013) state that 'development proposals that are likely to affect biodiversity should be informed by expert advice' and that ecologists 'should only attempt to offer a bone fide ecological opinion if they have the necessary knowledge, skills and experience to do so, or have secured appropriate competent assistance' respectively.

2.5.6 Clause 4.3.4 of BS42020 (BSI, 2013) states that 'evidence of qualifications, additional training and experience should always be available on request as further evidence of an individual's competence in a particular field of knowledge or area of expertise'.

2.5.7 Training and experience can be gained through mentoring by an experienced and licensed ecologist or attending training courses run by organisations such as BCT, CIEEM or other private providers. Local Bat Groups (LBGs) can also provide training, although this is generally aimed at those carrying out voluntary bat work, for which the aims of surveys are likely to be different. Although skills such as bat handling and identification remain the same for both types of surveys, additional knowledge, skills and experience (such as the ability to design surveys, lead survey teams, assess impacts and design mitigation, enhancement and monitoring strategies) are required to carry out bat surveys professionally.

2.5.8 BCT published an interim 2nd edition of *Professional Training Standards for Ecological Consultants* in 2020 (BCT, 2020b). This describes the knowledge and skills required to competently undertake professional bat work to five experience levels, which are described in Table 2.3 below.

Table 2.3 Different levels of competence to undertake professional bat work.

BCT level	Equivalent CIEEM competency levels	Description
1	Basic	Some knowledge, experience and skills but always works under supervision.
2	Capable	Has knowledge, experience and skills to carry out surveys independently (except for swarming and ALBST), lead and design simple surveys and mitigation and deal with simple planning/mitigation licensing. Assumes a survey licence from the relevant licensing authority for the relevant activities.
3	Accomplished	Has knowledge, experience and skills to carry out and lead complex surveys, design surveys and mitigation and deal with planning/mitigation licensing.
4	Authoritative	Has knowledge, experience and skills to lead the most complex projects such as those involving EIA or HRA.
5	Specialist	Has knowledge, experience and skills in specialist bat survey techniques. Assumes Levels 3 and/or 4 NE licence – mist netting, acoustic lure, harp trapping or equivalent from another country.

2.5.9 The professional training standards document (BCT, 2020b) describes the knowledge and understanding/skill and experience requirements for different topic areas (e.g. Unit 1 Legislation, Licensing and Planning; Unit 2 Considerations for Bat Surveys; Unit 3 Ecological Considerations for Bat Surveys – aligned with the chapters of these guidelines) in relation to the levels described above and provides performance criteria against which these can be assessed.

2.5.10 CIEEM published *Competencies for Species Survey: Bats* in 2013 (CIEEM, 2013) in association with BCT, which also describes knowledge, skills and experience required to carry out professional bat work. Since then, BCT, NE and CIEEM have produced a Competency Framework specifically for the Earned Recognition Pilot Project (although this is England specific).

2.5.11 While membership of a professional body such as CIEEM (or Chartered Ecologist or Environmentalist status) does not provide evidence for a skill level with respect to bats or other species, members are required to conform to a Code of Professional Conduct. CIEEM's Code of Professional Conduct requires members to:

- Maintain their professional knowledge and skills, including undertaking and recording such continuing professional development (CPD) as CIEEM shall require and providing evidence thereof when requested to do so.
- Only undertake work that they have the competence to do and undertake that work to the expected standard and seek appropriate advice, training and assistance if they are involved in topics beyond their competence (CIEEM, 2022a).

2.5.12 The CIEEM website hosts a professional directory[32] of members, which can be searched according to the services provided.

Equipment, documentation and data recording and retention

2.5.13 **The documentation/equipment chosen for a survey should make the survey safer, easier and more efficient, thorough and accurate.** Requirements for documentation/equipment depend on the nature of the survey, the nature of the site and factors such as the client/owner's health and safety requirements. Lists of equipment relevant to different survey types are provided in Appendix 1. A generic list of both documentation and equipment appropriate to all field surveys for bats is provided below:

- any documents that are necessary to allow approved access to the site;
- risk assessment (and biosecurity risk assessment as appropriate);
- any other health and safety documentation;
- copies of relevant licences for the survey activities;
- maps/aerial photographs of the site and surrounding area;
- maps/plans/drawings of site features, clearly illustrating the site boundary;
- any previous survey or background information;
- survey form or digital equipment suitable for recording such as a smartphone, tablet or Global Positioning System (GPS);
- digital camera;
- spare batteries, bulbs and memory cards for all equipment;
- personal protective equipment (PPE); for example, steel toe-capped boots, hard hat, overalls, high visibility jacket, gloves, dust mask);
- first aid kit;
- charged mobile phone (ensure there is network availability at the site in question and ensure back-up such as hand-held radios or buddy system if no signal); and
- biosecurity equipment.

2.5.14 Where it is necessary to use technical measuring devices (e.g. a thermometer) or recording equipment (e.g. a bat detector), it is essential that the equipment is both calibrated and tested in line with the manufacturer's guidance, usually every year, to ensure that when the results are compared this is a like-for-like comparison. Evidence of this should be submitted with reports.

2.5.15 Similarly, it is essential to have a good understanding of the settings of detectors. The settings used will greatly influence the way the detectors capture and record sound.

2.5.16 Finally, different bat detector microphones vary in their properties and, in particular, sensitivity (Adams *et al.*, 2012) and this should be considered. Appendix 2 describes the different types of bat detector available. The sensitivity of microphones declines over time, sometimes quite dramatically, so regular testing is essential.

2.5.17 The equipment used should be suited to the survey purpose, this includes being capable of detecting non-target and target species. Planning and licensing authorities may reject survey data collected using ineffective equipment and/or require additional alternative survey effort.

2.5.18 Data recorded during a survey should be accurate, thorough and consistent across surveys of the same type. Standard survey forms should be used for each survey type to prompt the ecologist to record all the information necessary (and no more) and allow the raw data to be passed on if the need arises, such as in a public inquiry.

2.5.19 When recording survey results, it is obviously important to record positive sightings, but it is also important to make a record where a site or feature has been surveyed but returned a negative survey result (i.e. not suitable for bats or no evidence of bats found). This information can be just as important when justifying subsequent actions undertaken and can also be valuable to Local Environmental Records Centres (LERCs) if submitted.

2.5.20 The benefit of recording bat activity (both using detectors and NVAs) is that there is an auditable record of work carried out; data should be retained for this purpose. It is important that all settings used are similarly documented and retained.

2.5.21 Bat sound data and use of NVAs generate a lot of data and any company doing more than occasional bat work will need to develop (and cost for) a data management policy. This may include returning master copies of data to clients (e.g. on hard drives) after a defined period and/or charging for longer-term storage. Clients should be reminded to store their data securely and create back-ups.

2.5.22 Data should be retained in accordance with the documented company/organisational retention policy but, as a minimum, until post-determination of planning (when there are no bats present) or post-development/monitoring completion (if bats were roosting and there is, or may be, a need for licensing). With these principles in mind, decisions on data

32 https://cieem.net/i-need/finding-a-consultant/

retention could also be made on a case-by-case basis, taking account of additional factors such as an active licence for the site, ongoing monitoring or potential legal, compliance or enforcement action. The relevant licensing authority or an LPA may have specific requirements, e.g. NE specifies, as a mitigation licence condition, that data should be retained for at least 12 months following completion of the licensed activities. As file sizes can be quite large this is likely to require a specific data storage approach/policy.

2.6 Dealing with survey limitations

2.6.1 Clause 6.7.1 of BS42020 (BSI, 2013) states that 'To reduce uncertainty, and to achieve full scientific disclosure, those undertaking surveys and preparing ecological advice and reports should identify all relevant limitations' with respect to methods and site conditions. Clause 6.7.2 of BS42020 (BSI, 2013) states that 'any limitations associated with work should be stated, with an explanation of their significance and any attempt made to overcome them. The consequences of any such limitations on the soundness of the main findings and recommendations in the report should be made clear.'

Environmental conditions

2.6.2 Environmental conditions affect bat activity and therefore surveyors should check weather forecasts prior to surveys for active bats and record those conditions, **including temperature, wind speed and precipitation**. These variables should be recorded at the start and end of each survey and if conditions change during the survey. For longer surveys, (see Reason and Wray, 2023) conditions should be recorded hourly. Equipment used should be accurate (recording temperature using a car or bat detector is unlikely to be acceptable) and the equipment used should be stated in reporting.

2.6.3 When ecologists are not present (for example, during automated/static monitoring surveys) weather conditions should still be recorded. A temperature logger could be used to measure temperature and meteorology data is available online33, although it is important to note how far away from the site the weather data has been collected. A small weather station may be appropriate for more significant projects. These data provide context to the survey results and therefore a plan should be in place to ensure it is recorded/obtained.

2.6.4 The effect of weather conditions on active bats is likely to be different for different species (with different flight capabilities) in different situations (for example, open versus sheltered habitats).

2.6.5 Swift (1980) reported that the time and pattern of common pipistrelle emergence activity between May and September wasn't impacted by ambient temperatures at dusk, with average monthly temperatures ranging from 12.5°C in August to 7°C in September. Smith (2000) reported that from mid-May to mid-June Natterer's bats in a maternity colony didn't emerge to forage when temperatures were lower than 9°C at emergence time, around an hour after sunset. Maier (1992) highlights the importance of temperature impacting common pipistrelle but not wind and rain. Kronwitter (1988) studied the influence of temperature and precipitation on the activity of noctule in Germany, observing no emergence, late emergence and fewer foraging bouts in cooler conditions and later emergence in rainy conditions. Radio-tagged barbastelle bats exhibited the same behaviour in wind speeds of 11m/s as on previous calmer nights in a study by Davidson-Watts (2014a). Slack and Tinsley (2015) looked at bat activity at wind farm sites and found no bat activity at temperatures below 6°C, limited bat activity below 10°C and a reduction in bat activity at wind speeds of 5.4m/s and greater. There are, of course, some conflicting results here.

2.6.6 The expectation is that ecologists avoid weather conditions that are likely to affect/change emergence behaviour and activity surveys carried out during the peak season. The aim should be to carry out such surveys in conditions that are close to optimal (with sunset temperature 10°C or above without heavy rain or strong wind), particularly where low numbers of surveys are planned. Where the temperature drops significantly below this during the survey, the impact on bat activity should be considered and, in many cases, it may be appropriate to stop the survey.

2.6.7 Where multiple surveys are planned, carrying them all out in optimal conditions enables a like-for-like comparison of results, although it is recognised that in spring and autumn, and particularly in more northerly latitudes, these conditions may be rarer and some of the surveys may need to be carried out at lower temperatures or in more windy conditions. This can provide some insight into how the bats respond to conditions that we perceive as 'poorer'. Surveys carried out in what we currently consider to be suboptimal conditions should be justified by the ecologist and the effect on bat behaviour considered.

2.6.8 Trapping surveys are different from emergence and activity surveys in their aims and can be carried out when temperatures are 8°C or above. Below this temperature, bat activity is likely to drop and bats waiting to be processed can become torpid and difficult to release, with welfare implications. See Chapter 9 for more information.

2.6.9 In cooler, wetter and windier conditions bats may not emerge, emerge later, forage for shorter time periods or carry out fewer foraging bouts (Kronwitter, 1988). Wind and rain (with higher temperatures) appear to concentrate bat foraging activity in more sheltered spots (e.g. the leeward side of hedges or in woodland) in contrast to when weather conditions are apparently ideal, when bats are more likely to be dispersed across the landscape. For some surveys, it may be important to find such habitats as they may be crucial to populations at certain times.

2.6.10 The moon phase and the presence of artificial lighting can also impact on bat activity; see Bats and Artificial Lighting in the UK for more information (BCT and ILP, 2023).

2.6.11 Noise may also impact activity although there are examples of bats becoming habituated to noisier conditions, e.g. road bridges.

Restricted access

2.6.12 Clients may impose specific requirements before granting access, such as specific PPE or documentation to prove authorisation, and may insist that surveyors are escorted by site personnel. Some sites may require specialist equipment; for example, gas monitors in a confined space. Site-specific requirements should be established before the site visit and should not be cited as limitations to a survey if they could have been met through advance planning.

2.6.13 Sometimes it is not possible to gain permission to access land. In this situation, a record of access requests and any responses received must be retained as evidence that

33 For example, from https://www.timeanddate.com/ and https://wow.metoffice.gov.uk/

access permission was sought but was not granted as this may be asked for at the licensing stage. Such evidence may be essential to enabling the licensing authority to apply a pragmatic approach in their assessment.

2.6.14 Access to survey may also be restricted for health and safety reasons; for example, a building may be structurally unsound or a tree may not be safe to climb. Documentation may be available from a structural engineer or arborist as evidence and justification should be provided in the bat survey report. It may be necessary to make up for the lack of internal inspection by carrying out more of another type of survey, such as emergence.

2.6.15 The impact of any remaining limitations (relating to access) on the resulting data should be acknowledged in the report.

Age of survey data

2.6.16 Ideally, the survey data should be from the most recent optimal survey season before a planning or licence application is submitted, although often presence/status data (not absence data) older than this can have considerable value, particularly where collected over a number of years using different techniques. The value of older data should be considered when updating surveys as it may not be necessary to start from scratch.

2.6.17 There are a number of considerations involved in deciding whether survey data and the associated report(s) remains valid, which regulators are likely to take into account when making decisions on proposals for planning or licensing:

- Were the original surveys carried out according to good practice guidelines?
- Were the original surveys constrained in any way (in terms of timings, weather conditions, equipment used, number of surveyors, surveyor expertise, etc.)?
- Do the results of the original surveys support the original conclusions and are these still relevant?
- Has the nature of the site or the surrounding area changed since the original surveys (e.g. has a structure deteriorated and become less suitable for a roost or has human occupation ceased and the structure become more suitable for a roost)?
- Are additional surveys likely to provide information that is material to a decision (such as a planning consent), the design of mitigation measures, or specific advice relating to a proposed activity?

2.6.18 CIEEM have issued an Advice Note on the Lifespan of Ecological Reports and Surveys (CIEEM, 2019b), which should be referred to. This suggests that a survey report that is less than 12 months old is likely to be valid in most cases; reports 12-18 months old are likely to be valid with some exceptions; reports 18 months to 3 years old require a site visit plus consideration of repeating the surveys (depending on the circumstances) and reports older than this are likely to require most of the surveys to be repeated.

2.6.19 At the time of writing, the SNCBs positions are as follows.

- The NE EPS mitigation licence application states that surveys must be *'up-to-date and have been completed within the current or most recent optimal season'* and that the applicant should *'Please confirm that a walk over survey/check has been carried out within 3 months prior to application submission by a suitably experienced ecologist to ensure that conditions have not changed since the most recent survey was undertaken.'.*
- The NRW EPS mitigation licence application asks *'is the survey data less than two active seasons old?'* and if not, to *'please provide sound ecological reasoning for why this is acceptable.'.*
- The NatureScot website states that *'The survey information needs to be sufficiently up-to-date when a planning application is submitted. Pre-application bat surveys normally remain valid for two more survey periods, and should be repeated if the application is going to be delayed beyond the start of a third survey period. Unless it is clearly evident that there has been no substantive change in number, distribution or activity of bats since the original survey was undertaken.'.*

2.6.20 BS42020 states that 'all ecological information should be sufficient, i.e. in terms of being sufficiently up to date (e.g. not normally more than two/three years old, or as stipulated in good practice guidance)'.

2.6.21 Because planning, licensing and development can be a long process and each site is unique, a bat survey report should clearly state (preferably in the Executive Summary – see Chapter 11) how long it is likely to be valid for before resurvey will be required.

2.6.22 In some cases, data may be needed from the night before operations are carried out either to confirm that bats have left an identified roost, or as a precautionary measure.

Other potential limitations

2.6.23 The availability of equipment should not be cited as a reason for not using the most appropriate piece of equipment for a bat survey. Professional ecologists should ensure that they consult with the client to establish the nature of the site and scrutinise previous records to ensure they have the right equipment to carry out their work. Equipment with a high value (e.g. thermal imaging or infrared cameras, bat detectors) and maintenance costs (e.g. bat detectors require microphones to be tested regularly and replaced) can be hired out to clients to cover those costs. Hire charges can be calculated by considering the initial purchase cost, lifespan and predicted parts replacements during that lifespan, running costs (batteries), servicing and level of use.

2.6.24 Adding a charge is key to ensuring good equipment that functions properly throughout its life.

2.6.25 Some equipment is inherently constrained but still the most appropriate equipment for the job; for example, bat detectors can only provide a measure of activity rather than absolute numbers of bats and some species are difficult to detect due to their quiet echolocation calls. These constraints should be acknowledged in the report and methods to overcome them described.

2.6.26 Bat surveys are seasonally constrained and this should be factored into project scheduling to ensure that surveys are carried out at the most appropriate time of year. Ideally, timing should not be cited as a limitation to the survey, but, where it is this should be explained and justified by the circumstances and the nature of the impact.

2.7 Health and safety

2.7.1 It is the legal duty of an employer to have a written health and safety policy unless they employ fewer than five employees (although even in this situation it is good practice to have a policy in place). Guidance on safety and risk management can be found on the HSE website[34].

2.7.2 A hazard is something that has the potential to cause harm; it is associated with a degree of danger and is quantifiable in terms of its severity. Risk is the actual likelihood of harm from a particular hazard. If a risk is considered too high, then the proposed action should not be undertaken or measures should be applied to either remove the hazard or avoid/reduce the risk that the hazard poses. It is generally more appropriate for bat surveys to be undertaken in pairs or within a larger team due to the potential risks involved. However, it may be possible to adequately control the risks to a lone worker in certain circumstances.

2.7.3 Bat surveys have some very specific risks arising from particular hazards such as working at height, confined spaces, asbestos and night-time working resulting in fatigue. It is important that these hazards are adequately considered and risks are adequately controlled before surveys are undertaken. The most effective way to ensure this is by carrying out a risk assessment. A targeted risk assessment should be prepared and completed for every site, to ensure that any site-specific risks are considered alongside generic risks. On arrival at a site, for every visit, the risk assessment should be reviewed to establish that all relevant risks have been taken into account. There should be a mechanism in place for items to be added to the risk assessment and for this information to be available for subsequent site visits (particularly important if different staff are deployed each time).

2.7.4 Appendix 3 lists hazards and risks associated with bat field work and measures that can be taken or equipment that can be used to manage them. Sample risk assessments and guidance on completing them can be found on the HSE website[35]. Guidance on carrying out risk assessments for lone working is also available from the Member's Area of the CIEEM website[36]. General guidance on health and safety is also provided in CIEEM's *Good Working Practices* (CIEEM, 2020a).

2.7.5 In some situations, particularly for larger developments, the site owner/developer/client will also have their own risk assessment, a health and safety induction and/or other related procedures. On large sites there may be security protocols to follow and security staff.

2.7.6 Working alongside railways and roads requires specialist training from Network Rail and National Highways. These organisations have very specific safety rules and, on some sites, ecological surveyors will need to be accompanied.

2.7.7 It is reasonable to ask for a structural survey for older or derelict buildings or the asbestos register for non-residential buildings from the client.

2.7.8 All equipment used should be regularly checked and maintained, in line with appropriate legislation (this may require formal inspections by accredited bodies).

2.7.9 The following types of work require advanced knowledge and the use of specialist equipment; information can be gained on the specialist training courses indicated.

- Work in confined spaces (tunnels, culverts, etc.) – confined spaces training course.
- Working at height – working at height training courses provide training on the safe use of ladders and assessment of which equipment is appropriate to the task.
- Work in trees – arboricultural climbing course provides training in the use of specialist equipment and climbing/aerial rescue techniques.
- Work underground (mines, caves, etc.) – confined spaces training course, mine safety course. Basic caver training and advice on safety issues in specific local caves and mines can also be obtained from the British Caving Association (BCA), Regional Caving Councils or local caving clubs.
- Work on a construction site – to get an Ecologist Construction Site Certification Scheme (CSCS) card, you need to apply for the card through the BALI (British Association of Landscape Industries) website[37]. Before you can apply, you need to attend a 1-day ROLO H&S training day and sit the touch screen test.
- Work in buildings which may contain asbestos – asbestos awareness training course. Asbestos may be present in structures built before 2000; some such buildings may have an asbestos risk register that can be requested and scrutinised prior to entry.

2.7.10 Fatigue is often a root cause of major accidents. Many ecologists work unsocial hours and heavy workloads may lead to long working hours. If working arrangements are poorly managed and do not provide sufficient time for rest and recovery, fatigue may result. The legal duty is on employers to manage risks from fatigue. The Management of Health and Safety at Work Regulations 1999 and the Working Time Regulations (WTR; 1998, as amended in 2007) are the main instruments for the assessment and management of fatigue.

2.7.11 The WTR specify that working time should not exceed an average of 48 hours per week averaged over a 17-week period (with a few exceptions for certain industries). Employees can choose to work more than this by voluntarily 'opting out' of the 48-hour week, which should be confirmed in writing. Employers can ask employees to 'opt out' but can't treat employees unfairly if they decide not to do so. However, the impacts of working longer weeks, particularly when those weeks involve night work, should be carefully considered and risk assessed by employers.

2.7.12 The key considerations for managing fatigue risks are described in HSE guidance[38].

2.7.13 Shift-length restrictions are also imposed by safety-critical industries such as Network Rail and National Highways, who usually require 12 hours' uninterrupted rest in each 24-hour period where safety-critical.

2.7.14 Importantly, this imposes restrictions on either side of a particular task. This is easier to monitor/control when booking staff than when using sub-contractors, when it is not always easy to be sure that rest requirements have been met. Sub-contracts should include a requirement to adhere to rest periods.

2.7.15 It is preferable to use personnel close to survey locations, but this is not always possible. Travel time should be accounted for in shift-length calculations. If there will be a drive

34 https://www.hse.gov.uk/simple-health-safety/risk/index.htm
35 https://www.hse.gov.uk/simple-health-safety/risk/risk-assessment-template-and-examples.htm
36 https://cieem.net/
37 https://www.bali.org.uk/lisscscs/
38 https://www.hse.gov.uk/humanfactors/topics/specific2.pdf

of more than 30 minutes for a late-dusk (or roost re-entry survey if this is the proposed approach), accommodation should be considered.

2.7.16 Whether employers provide vehicles or expect employees to drive their own for work purposes, they should have a policy to address working hours, time spent driving and vehicle maintenance. The Health and Safety Executive (HSE) estimates that up to a third of all road traffic accidents involve a driver who is at work at the time. Road accidents are a particular risk for ecologists carrying out nocturnal bat surveys, as the functionality of a driver decreases with increasing sleep deprivation or fatigue. Companies therefore have a duty to develop policies to ensure safe working practices, and driving should be included in working hours in these policies.

2.8 Biosecurity

2.8.1 To effectively manage disease risk and ensure good biosecurity as part of bat-related field work you should consider the risks from your activities in terms of the potential transmission of pathogens:

- from bat to human (e.g. rabies)
- from human to bat (e.g. SARS-CoV-2)
- from bat to bat (e.g. *Pseudogymnoascus destructans*)
- by humans between sites (e.g. *Pseudogymnoascus destructans*).

2.8.2 There are known pathogens of concern in the UK, but good disease risk management should also help prevent the introduction and/or spread of other pathogens. In assessing risk and taking appropriate precautions, consideration should be given firstly to the need to carry out the survey. Other considerations include the proximity ecologists will be in relation to bats (will people be within 2m of bats, will bats be handled?), movement between sites (how many sites and over what timeframe?) and the health of the field team (does anyone have infectious illnesses such as COVID-19?). Biosecurity risks should be included in risk assessments for all bat survey activities.

2.8.3 It is essential to keep up-to-date with the latest information on 'novel diseases' by checking SNCB and Government websites, but also anything relevant from, for example, EUROBATS or the IUCN Species Survival Commission Bat Specialist Group (IUCN SSC BSG).

Precautions when in close proximity to bats or when handling bats

- It is essential to avoid contact with bats when infected or potentially exposed to SARS-CoV-2.
- The time spent in close proximity to bats or in handling them should be minimised, as should the number of people handling bats for processing (IUCN SSC BSG, 2021). Bats should be kept separate from each other; for example, by using one clean holding bag per bat.

2.8.4 For activities that require people to be in close proximity (≤2m, or further if there is poor air flow) to bats, such as hibernation surveys or entering bat roosts, face coverings should be worn. Best practice is to use FFP3 or FFP2 face masks; DO NOT use valved masks, as these do not filter expelled air (IUCN SSC BSG, 2021). It is important that masks are used correctly (e.g. the mask should cover the nose and the mouth and fit comfortably and securely against the side of the face), and good hygiene measures undertaken when putting on and taking off masks (including washing or sanitising hands before their use).

2.8.5 In addition to masks, when handling bats appropriate gloves must be worn (see 'Wearing Gloves When Handling Bats', BCT, 2020c). The gloves serve two purposes: firstly, to assist in protecting you from bat-borne viruses (including European bat lyssaviruses) and pathogens; and secondly, to protect the bat from any pathogens or contaminants on your hands. As per IUCN SSC BSG guidance (2021), field workers should use common sense to evaluate the trade-off between frequency of changing gloves and disinfecting with timely handling and processing of bats. It is important to note that adjusting a face mask, touching your face, coughing and sneezing can all transfer pathogens to your gloves, so it is advisable to then change or disinfect them (IUCN SSC BSG, 2021).

2.8.6 Anyone regularly handling bats should have rabies pre-exposure prophylaxis in accordance with the appropriate guidance (UK Health Security Agency, 2018; Health Protection Scotland[39]), with boosters at appropriate intervals or as informed by antibody testing (UK Health Security Agency, 2022). Useful links are provided on the BCT website[40], including information on organising vaccinations and antibody testing. Even if vaccinated, gloves should still be worn when handling bats and medical attention sought following a bite, nibble, scratch, or lick from a bat (UK Health Security Agency, 2020).

Cleaning and disinfecting

2.8.7 Prior to handling bats, ecologists should ensure that all equipment has been cleaned and disinfected. Wear dedicated clothing when interacting with bats if practical to do so. Cleaning and disinfecting skin, clothes and equipment before and after field work is necessary to minimise exposure of bats and humans to pathogens. Ecologists should use common sense with regards to decontamination procedures if undertaking surveys at multiple sites in one day (e.g. hibernation surveys) to minimise the risk of spreading pathogens (e.g. *Pseudogymnoascus destructans*) (BCT, 2022).

2.8.8 Disinfection agents should be broadly effective, acting against a wide spectrum of microbes, be non-irritant to skin, and be applied/used according to manufacturer's instructions (IUCN SSC BSG, 2021). You should only use products that are safe for mammals for equipment that will come into contact with bats, as direct contact with disinfectant products can be harmful to bats. Any equipment that has been disinfected should be rinsed and dried thoroughly as disinfectant can also damage equipment if it is not rinsed off, especially metal items or surfaces. Please refer to notes in relevant licences where specific products may be required by the issuing SNCB, or in accordance with an order by Defra (relating to an outbreak of a notifiable disease[41]).

2.8.9 Further information on cleaning to minimise risk of pathogen transmission is available from IUCN SSC BSG (2021).

2.8.10 The information and links in this section are correct at the time of publication. Please refer to the latest guidance from the BCT, the relevant SNCB, Animal & Plant Health Agency, relevant public health agency, IUCN SSC BSG and/or other agencies and organisations as appropriate.

39 https://www.hps.scot.nhs.uk/a-to-z-of-topics/rabies/#guidelines
40 https://www.bats.org.uk/about-bats/bats-and-disease/bats-and-disease-in-the-uk/rabies-vaccine
41 https://www.gov.uk/guidance/defra-approved-disinfectant-when-and-how-to-use-it

White-nose syndrome (WNS) in bats in the UK

2.8.11 WNS is a disease caused by the fungus *Pseudogymnoascus destructans*. It affects hibernating bats in North America, where it has caused the death of millions of bats since it was first discovered in 2006. Symptoms of WNS are:

- visible white fungus (*P. destructans*), around the nose, ears, wings and/or tail membrane;
- bats clustered near the entrances of hibernacula, or in areas not normally identified as winter roost sites;
- bats flying outside during the day in temperatures at or below freezing; and
- dead or dying bats in or near hibernation sites.

2.8.12 Whilst the fungus associated with the syndrome has been identified on bats from at least 17 European countries since 2009, these findings have not been linked to mass mortalities and WNS has not been confirmed this side of the Atlantic (the fungus is likely to have evolved in Europe and therefore European bats have a level of immunity that the affected North American species do not).

2.8.13 The fungus has been isolated from several live bats in the UK and from a number of environmental samples but, as with the rest of Europe, there is no evidence of WNS. BCT provides guidance for bat workers undertaking hibernation surveys, including appropriate biosecurity measures to prevent spread of the fungus. Surveyors should continue to remain vigilant and report any suspected cases of either the fungus or WNS to BCT and to observe appropriate decontamination procedures. For more information, refer to the WNS pages on the BCT website[42].

2.9 Insurance

2.9.1 Before undertaking any work for a client, ecologists should have appropriate insurance, including professional indemnity insurance and public liability insurance. For members of CIEEM, adequate insurance cover is a strict requirement of membership.

2.9.2 Professional indemnity insurance can help protect an ecologist if claims are brought against him or her by a client due to a perceived problem with the work undertaken. Professional indemnity insurance is needed if an ecologist provides advice to a client, handles data belonging to a client, is responsible for a client's intellectual property, or provides professional services, or if an ecologist's work could be challenged or questioned. Ecologists may be vulnerable to claims of negligence if professional advice or services fail to meet a client's expectations or are perceived to cause financial loss.

2.9.3 Public liability insurance covers the compensation an ecologist may have to pay a client, contractor or member of the public, due to accidental injury or property damage caused by the ecologist either on the ecologist's premises, during field surveys or at a client's premises.

2.9.4 Other types of insurance may be appropriate depending on the nature of the activities being carried out.

2.10 Summary

2.10.1 Ecologists should be considering the following questions as they carry out their professional survey work:

- Is there a need for survey work to be carried out?
- Is the purpose of this work understood in relation to the current stage of the project?
- Have the aims and objectives of the work been clearly defined and are these fit for the purpose they were intended?
- Will the stated aims and objectives of the survey work be achieved?
- Is the survey work proportionate to the impacts?
- Have the potential impacts, the ZoI and the impacts that could be avoided through design been adequately assessed?
- Is the defined survey area appropriate?
- Are the most appropriate survey types being used?
- Are the surveys being carried out according to good practice? If not, then how will any limitations be accounted for?
- Do the surveys fit in with the planned project schedule? Do the surveys or schedule need to be amended?
- Does the team have the competence and capacity to carry out the survey work?
- Has the right equipment been chosen for the survey work? Does the team have the right equipment? Does the equipment need calibrating, testing or servicing?
- Is all of the appropriate data being recorded? How will it be analysed?
- Are there any specific health and safety requirements that need to be fulfilled and will this impact on the survey results/survey schedule?
- Have biosecurity measures been planned in?
- Is site access available to allow the surveys to be carried out efficiently and effectively within the defined survey area?
- Has the project been altered recently such that the surveys or schedule need to be reviewed?
- Has all the relevant information been requested from the client and communicated back?
- Have clear and definitively stated outcomes been provided to enable the LPA to include conditions in a planning decision?
- Have the client's expectations been realistically managed in terms of meeting good practice and being clear on planning and licensing requirements?

42 https://www.bats.org.uk/about-bats/threats-to-bats/white-nose-syndrome/overview

Chapter 3

Ecological considerations for bat surveys

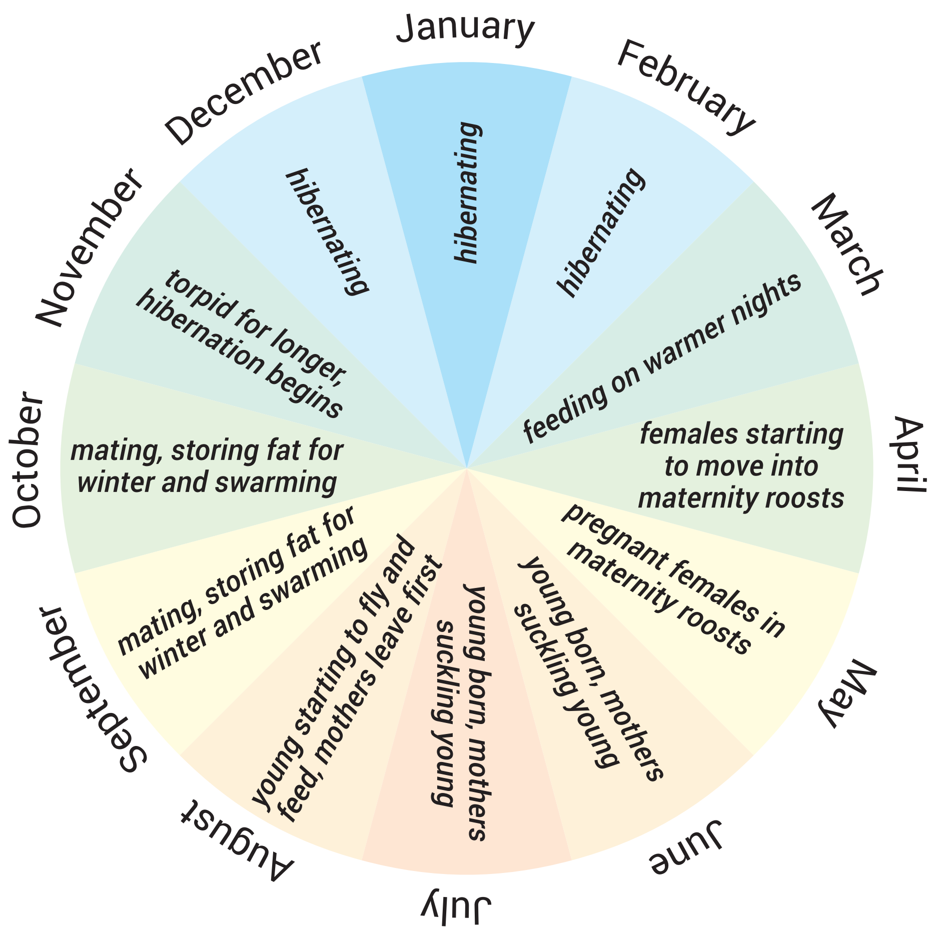
3.1 Introduction

3.1.1 Understanding the ecology of the different species is necessary to determine how bats are likely to use the landscape, so that appropriate survey methods can be chosen. Bats are cryptic, use large geographical areas in three-dimensional space, and have the potential to disperse over large areas, so that they are difficult to survey without an understanding of their ecology.

3.2 Bat life cycle

3.2.1 Figure 3.1 provides a visual representation of the life cycle of a bat; further descriptions are provided in the text below. It should be noted that this is a very general picture of the life cycle; exact timings will vary depending on the species, location and weather conditions in the year in question.

Figure 3.1 Bat life cycle.



3.2.2 Bats can use hibernation torpor during the winter to conserve energy when insect food is less available, although they will emerge to feed, drink and move position within or between hibernacula when conditions are milder. This is very much dependent on the conditions in any one year and different species exhibit different behaviours. See also comments in para 5.3.5.

3.2.3 During the spring, bats feed more and more during the night and the period from April (likely to be slightly later in northerly latitudes) to early June is a time of intense feeding to recover weight lost during the winter. During this time, females gather together at maternity roosts that provide appropriate conditions to rear young. In some species, males are also present in maternity roosts; for others, the males roost elsewhere either individually or in small groups.

3.2.4 Birthing times can be highly variable between locations, years, species and even between individuals of the same species. However, the main period for births is June, then the young begin to fly in July and August, at first still taking milk from their mothers but gradually becoming more independent (Dietz and Pir, 2011). As the young become independent, the females disperse to find mates and gain weight before winter.

3.2.5 During autumn, many species of bats swarm at underground or above-ground sites, a behaviour that may be associated with mating or information exchange between individuals. Males of other species establish mating territories where they may fly or call specifically to attract females; for example, pipistrelles.

3.2.6 As the weather turns colder, bat activity declines and foraging becomes restricted to milder nights. Bats spend progressively more time in torpor and slowly return to their hibernacula.

3.3 Bat roost types

3.3.1 Definitions of different roost types are provided in Table 3.1 below, for the purposes of consistency.

Table 3.1. Bat roost types. (Definitions written by the NE Earned Recognition Project).

Roost type	NE definition
Day roost	A place where individual bats, or small groups, rest or shelter in the day during the summer.
Night roost	A place where bats rest or shelter in the night but are not found in the day. May be used by a single individual on occasion or it could be used regularly by the whole colony.
Feeding roost	A place where individual bats, or a few individuals, rest or feed for short periods during the night but are not present by day.
Transitional roost	A place used by a few individuals or occasionally small groups for generally short periods of time on waking from hibernation or in the period prior to hibernation.
Maternity roost	A place where female bats give birth and raise their young to independence. In some species males may also be present in the maternity roost.
Hibernation roost	A place where bats may be found individually or together during winter. They have a constant cool temperature and high humidity.
Satellite roost	An alternative roost found in close proximity to the main nursery colony used by a few individuals to small groups of breeding females throughout the breeding season.

3.3.2 Other sites used by bats include:

- Swarming site – a place where large numbers of males and females gather, typically during late summer to autumn. These appear to be important mating sites. Roosting may occur alongside the swarming activity and it is the structures used for rest and shelter within the swarming site that are the roost.
- Mating site – a site where mating takes place from late summer and can continue through winter. Mating sites can include those where bats call for mates on the wing; however, these are also associated with a place where the mating actually takes place, which is the mating or harem roost.

3.3.3 Judgements as to what is protected under law should be undertaken on a case-by-case basis (the term ‘roost’ is not used in the legislation). The EC has provided guidance on this point in: Guidance on the strict protection of animal species of Community interest under the Habitats Directive (2021).

3.4 Species roosting preferences

3.4.1 Table 3.2 provides information from studies of the roosting preferences of different bat species. It should be noted that this table is not exhaustive and was not derived from a thorough literature search – species may be found to roost in different locations to those described here.

Table 3.2. Roosting preferences of different species.

Species scientific names	Species common names	Roosting preferences
Rhinolophus ferrumequinum	Greater horseshoe bat	During the summer females use large, old, undisturbed buildings (BCT/BMT Cordah Limited, 2005) including coach houses, stable blocks and barns (Duvergé and Jones, 2003). Also, churches. This species prefers to fly directly into the roost and to their roosting position and bats hang freely (Ransome and Hutson, 2000). Maternity sites are often found in large spaces at least 3-4m high, providing a sufficiently large flight area (BCT/BMT Cordah Limited, 2005). This species generally uses night roosts to rest whilst foraging, which are found in a variety of structures, for example outbuildings, garages, stables, milking sheds, porches and trees (Duvergé and Jones, 1994, 2003; Ransome and Hutson, 2000).

Table 3.2. Roosting preferences of different species. *continued*

Species scientific names	Species common names	Roosting preferences
		Male bats remain solitary through the summer and often use underground sites (BCT/BMT Cordah Limited, 2005). In winter, both male and female bats choose underground sites for hibernation, including tunnels, mines, caves or cold building basements (BCT/BMT Cordah Limited, 2005). Require a range of conditions in a series of suitable hibernacula (Harris and Yalden, 2008). The main hibernation site is usually within 15km of the maternity roost, but some bats may travel up to 60km between such sites (Ransome and Hutson, 2000). Faithful to traditional summer and winter roosts (English Nature, 2003). More information is available in NE's FCS definition for this species (NE, 2023).
Rhinolophus hipposideros	Lesser horseshoe bat	Roost sites include attics, chimneys and boiler rooms of buildings, rural houses and outbuildings in the summer, and cellars, tunnels, disused mines and caves for hibernation (Schofield *et al*., 2002). Also found in industrial buildings and churches. This species prefers to fly directly into roost sites and into their roosting position (BCT/BMT Cordah Limited, 2005). Maternity sites are often found in large roof spaces at least 3-4m high providing a large flight area (BCT/BMT Cordah Limited, 2005). A range of conditions is required throughout the year but this may be found in one building with, for example, an attic for the summer and a cellar for the winter. Summer and winter roost sites are generally no more than 5-10km apart (BCT/BMT Cordah Limited, 2005). The lesser horseshoe bat also uses alternative roost sites during the night and day. Night roosts are important (Downs *et al*., 2016a) for rest and grooming and can be particularly important to pregnant bats, allowing them to forage some distance from the maternity roost (Schofield *et al*., 2002). Occasionally, bats will stay in the night roost during the day and these sites can also be used during the autumn, winter and early spring (Schofield *et al*., 2002). This species has also been found roosting in narrow rock fissures (Schofield *et al*., 2002).
Myotis alcathoe	Alcathoe	Roosts almost exclusively in trees, with only a single building known to be used as a roost. Roosts are typically in cracks, crevices and splits with many roosts similar to those used by barbastelle. Colonies regularly fragment into multiple smaller roosts (5-20 being common), but with high levels of fission/fusion, can come together to form roosts of 100 individuals. It is common for roosts to be more within dense parts of a woodland and high. Only a single bat has been found in hibernation and it is believed that this species predominantly hibernate in trees (Daniel Whitby, *pers. comm*., 2022).
Myotis bechsteinii	Bechstein's bat	Maternity roosts are found in tree holes, generally in trees with dead branches (Altringham, 2003). May be found in woodpecker holes in old oaks and ash (BCT/BMT Cordah Limited, 2005). Recorded switching roosts frequently (Kerth *et al*., 2001; Reckardt and Kerth, 2007)). One study recorded that the main day roosts sites for one colony were in woodpecker holes in English oak, ash and crack-willow (Pimley *et al*., 2018). A study of ten colonies across the Isle of Wight found 90% of maternity roosts in woodpecker holes in ash trees (Davidson-Watts, 2008). Another study found a maternity roost in a woodpecker hole in an oak tree on a golf course (Davidson-Watts, 2014b). Hibernates in trees and sometimes caves or other underground sites (Harris and Yalden, 2008). Chilmark Quarry is an example of Bechstein's bats using an abandoned mine for hibernation[43]. More information is available in NE's FCS definition for this species (NE, 2023).

43 https://sac.jncc.gov.uk/site/UK0016373

Table 3.2. Roosting preferences of different species. *continued*

Species scientific names	Species common names	Roosting preferences
Myotis brandtii/mystacinus	Brandt's / whiskered bat[44]	Both species can roost in trees and a wide range of buildings in the summer (BCT/BMT Cordah Limited, 2005). Buckley *et al*. (2013) recorded whiskered bats roosts ranging from a one-hundred-year-old house with stone walls and a slate roof to a farm shed with concrete walls and a corrugated roof. Mature broadleaved trees including beech and sycamore were also used for roosting and roost switching was observed. Hibernates in caves or other underground sites, where they can be found in the open or in cracks and crevices (Altringham, 2003).
Myotis daubentonii	Daubenton's bat	Roosts are found in hollow trees, bridges or sometimes buildings (Billington and Norman 1997) generally close to water (Racey *et al*., 1998). Nursery roosts are not exclusively female (Angell *et al*., 2013) – males may make up 25% or more of the colony and large male-only colonies have also been recorded. One study recorded roost switching every 1.5 days in non-breeding females and every 5 days in lactating females, although the bats were faithful to the roosting area regardless of whether they were roosting in trees or buildings (Ngamprasertwong *et al*., 2014). Boonman (2000) found that this species selected oaks over beech trees and preferred roosts on the edges of woodlands in a study in the Netherlands. Hibernation sites are usually underground including caves, mines and suitable tunnels where bats are found both in crevices and on open walls (Altringham, 2003). They may also hibernate in tree cavities (BCT/BMT Cordah Limited, 2005).
Myotis nattereri	Natterer's bat	Roost sites include tree holes and different types of buildings but has also been found in bridges (Billington and Norman, 1997; Smith and Racey, 2002). Usually roost in attics between late May and mid-July (Smith and Racey, 2002) and often roosts have enough space for internal flight (Swift, 2009). This species also breeds in bat boxes (Park *et al*., 1998; Bilston, 2014). Timber-framed barns built between the 12th and 19th centuries may be particularly important to this species (Briggs 1995, 2002), with roosts found in mortise joints in both the summer and winter. Churches are also important. A more recent paper (Smith & Racey, 2018) identified that this species exhibits high behavioural flexibility in roost selected. They compared two adjacent maternity colonies and one mostly used trees where the other mainly used buildings; however, roofs appeared to be more important to both during late May to mid-July. The bats showed a preference for tree roosts when temperatures exceeded 29°C. Hibernates in cracks and crevices in caves and mines (Altringham 2003). Other hibernation sites recorded are canal and railway tunnels, ice houses and tree cavities (Smith and Racey 2002).
Nyctalus leisleri	Leisler's bat	Roosts in trees, bat boxes and buildings such as houses; for example, around the gable end of lofts, under tiles, under soffit boards and in disused chimneys (Corbet and Harris, 1991). Often uses a variety of sites in the summer (Waters *et al*., 1999). Hibernates in tree holes, buildings and sometimes underground sites (BCT/BMT Cordah Limited, 2005).

44 Brandt's and whiskered bats were only separated in 1971. Their ecologies are apparently similar although further research is needed.

Table 3.2. Roosting preferences of different species. *continued*

Species scientific names	Species common names	Roosting preferences
Nyctalus noctula	Noctule	Roosts almost exclusively in tree holes, but sometimes found in bat boxes or buildings (Altringham, 2003). One Netherlands study found that woodpecker holes are preferred, in trees close to woodland edge (Boonman, 2000). A study from Poland (Ruczyński, *et al*., 2010) found that this species preferred to roost in deciduous woodland, exceeding 100 years old, with a variety of tree species including oak, hornbeam and lime. In this study, where there was a lack of old deciduous woodland, the bats preferred old wet woodland. A 2020 study (Voigt *et al*.) used GPS loggers to study this species in Berlin, finding that noctules foraged close to artificial lighting when it was adjacent to waterbodies or well-vegetated areas but avoided lit roads. They used dark corridors for commuting. Hibernates in trees but sometimes found in buildings (BCT/BMT Cordah Limited, 2005).
Pipistrellus pipistrellus and P. pygmaeus	Common pipistrelle and soprano pipistrelle	Maternity colonies are found mainly in buildings, usually roosting out of sight in crevices. Colonies may use a number of sites through the summer but are often loyal to the same sites for many years (Thompson, 1992). Maternity colonies are extremely variable in terms of numbers, from 20 to over 1,000 bats (Speakman *et al*., 1999). Barlow and Jones (1999) found that soprano pipistrelle colonies (median of 203) tended to be larger than those of the common pipistrelle (median of 76). Davidson-Watts *et al.* (2006) reported common pipistrelle shifting roosts between pregnancy and lactation. Davidson-Watts (2007) found that roost selection was based on temperature for common pipistrelle and on surrounding habitats (woodland and water) for both species. Males roost singly or in small groups in the summer, in buildings or trees (Lundberg and Gerell, 1986). Churches are used for roosting sites. Bat boxes are used by both males and females, but generally only males use them during the summer (Park *et al*., 1998). These species do not use underground sites for hibernation but are sometimes found in the cracks and crevices of buildings in the winter (BCT/BMT Cordah Limited, 2005). Evidence from the Netherlands shows mass swarming events of common pipistrelle bats in the autumn followed by mass hibernation in a diverse range of building types in urban environments (Korsten *et al*., 2016). Swarming by common pipistrelle has been observed in the UK (Bell, 2022 and Tomlinson, 2020) but this phenomenon requires further research. Ecologists should be aware of the potential for larger numbers of this species to be present during the autumn and winter in large buildings in highly urbanised environments.
Pipistrellus nathusii	Nathusius' pipistrelle	The very few known British nursery roosts are in buildings, with hibernation roosts in hollow trees and crevices in cliffs, walls and caves (Altringham, 2003). One study recorded males roosting under lead flashing and roof tiles (Hargreaves, 2012).
Eptesicus serotinus	Serotine	Roosts in buildings in small cavities or crevices with high access points such as gables but very occasionally also found in trees (BCT/BMT Cordah Limited, 2005). Recorded hibernation sites include cavity walls, disused chimneys and occasionally caves (BCT/BMT Cordah Limited, 2005).

Table 3.2. Roosting preferences of different species. *continued*

Species scientific names	Species common names	Roosting preferences
Barbastella barbastellus	Barbastelle	In summer, breeding females move regularly (Greenaway, 2008) between a large number of different tree roosts (Billington, 2003; Greenaway, 2001; Zeale, 2011). One study found that they preferred dead trees surrounded by holly understorey (Greenaway, 2001) and another found them in tree crevices and cavities, between overlapping limbs and behind ivy (although the ivy was likely concealing another feature), on average 6.9m above ground level (Billington, 2003). Greenaway (2008) found that tree roosts were in relatively undisturbed places and frequently in thick cover, although cracks much higher up in trees were used at the time of birth. Bat boxes are also used (Greenaway, 2008). Davidson-Watts (2008, 2014a) reported almost all roosts found in two studies were behind loose bark and in mixed locations not always surrounded by understorey. Harris (2020) also recorded many roosts behind loose bark. Russo *et al.* (2004) in a study of mostly lactating females in Italy found that trees in unmanaged woodland were favoured. The same study reported that dead beech trees and taller trees were preferred and roost cavities were mainly beneath loose bark, at greater height and facing south. Carr *et al*. (2019) found that woodland thinning negatively affected this species by reducing roosting opportunities. Winter roosts include deep, hollow trees (usually dead and among holly understorey) and sometimes buildings or underground sites (Greenaway, 2001). Other winter roosts recorded are flaking bark and splits less than 2m above the ground (Billington, 2000) and disused railway tunnels, barns, outbuildings, church porches and lime kilns. Chilmark Quarry is an example of barbastelle bats using an abandoned mine for hibernation[45]. One study in Poland recorded barbastelle in a cave from the beginning of October until the end of March – the bats preferred the coldest part of the cave, near the entrance, until temperatures fell below -12°C, at which point the bats moved, potentially to deeper crevices (Hejduk and Radzicki, 2003). Spring and autumn roosts have been recorded behind loose bark (Billington, 2000; Greenaway, 2001), in dead tree stumps (Greenaway, 2001) and in splits in limbs mainly less than 2m above ground level (Billington, 2000).
Plecotus auritus	Brown long-eared bat	Maternity roosts found in trees, in the voids of large, old buildings and bat boxes in woodland (Briggs, 1995; Bilston, 2014). Usually roosts against wooden beams at the roof apex in attics or farm buildings (BCT/BMT Cordah Limited, 2005). Bats often cluster at the highest part of the roof and require enough space for unobstructed, internal flight (Entwistle *et al.*, 1997). Found also in churches. This species can also be found roosting in crevices (Downs & Wells, 2021). Shows high roost fidelity (Entwistle *et al.*, 1997). Commonly uses feeding perches and night roosts in porches or outbuildings separate from the main roost (BCT/BMT Cordah Limited, 2005). Hibernate in underground sites, tree holes and buildings (BCT/BMT Cordah Limited, 2005).
Plecotus austriacus	Grey long-eared bat	Frequently roosts on ridge beam in spaces between rafters. Maternity colonies show high roost fidelity (Razgour *et al*., 2013). Number of males in maternity colony increases through summer. Many males are, however, solitary. More information is available in NE's FCS definition for this species (NE, 2021).

45 https://sac.jncc.gov.uk/site/UK0016373

3.5 Species emergence/return times

3.5.1 Andrews and Pearson (2022) carried out a useful review of papers reporting emergence and return times. Below (in Table 3.3) we have reproduced the emergence times information (mean, median, standard deviation and occasionally actual range from a variety of studies) although Andrews and Pearson (2022) and the original publications referenced by them should be consulted for more detail.

3.5.2 The time of emergence from a roost is likely to depend on the species' ecology, the amount of protective cover around the roost, the reproductive status of the bats in question, and the ambient weather conditions on the night in question and on previous nights. For some species, there is a fine balance between the need to forage and vulnerability to predators. It should be noted that species known to exit roosts later may actually exit the roost itself earlier but remain under cover (within a building or underneath the tree canopy) until it gets dark. The behaviour where bats appear to fly back and forth to 'test' light levels before fully emerging is often termed 'light sampling', but its actual function is unknown.

3.5.3 Return times appear to be far more variable (Andrews & Pearson, 2022) and therefore the efficacy of roost-re-entry surveys before dawn (particularly for presence/absence) is brought into question, particularly as the use of NVAs can vastly improve the quality and accuracy of emergence surveys.

Table 3.3. Summary of emergence times extracted from Andrews & Pearson, 2022 (refer to paper for more detail).

Species common names	Mean or median emergence time in relation to sunset in minutes (m) from a variety of studies (data relates to female bats only)	Standard deviation (range in which 95% of observations occurred in studies) (data relates to female bats only)
Greater horseshoe bat	May/June mean 28m after June median 25m after July mean 26m after	11-45m after No data (but earliest starting 19 m after) 20-32m after
Lesser horseshoe bat	May/June mean 33m after June median 31m after July mean 21m after August mean 37m after	30-36m after No data (but earliest starting 19m after) 14-28m after 16-58m after
Alcathoe	Mean 1.1m before	16.4m before to 14.3m after
Bechstein's bat	Mean 47m after June median 33m after	No data (but actual range 2m before to 92m after) No data (but earliest starting 30m after)
Brandt's	Mean 43.3 minutes after May/June mean 27.3m after July mean 21.4m after August mean 24.9m after	No data 23.7-30.9m after 18-24.8m after 20.8-29m after
Daubenton's bat	May mean 46.1m after June mean 58.1m after July/August mean 43.1m after Lime kiln mean 28m after Trees mean 45m after	No data (but actual range 17-94m after) Lime kiln: 16-40m after Trees: 34-56m after
Natterer's bat	June median 75m after Median 55.9m after July mean 31 minutes after	No data (but earliest starting 31m after) 54.1-57.7m after 22-41.2m after
Whiskered bat	Mean 33.3m after June median 32m after	No data (but earliest starting 28m after)
Leisler's bat	June median 18m after Mean 18.6m after Mean 19m after	No data (but earliest starting 3m after) 8.3-26.9m after No data (but actual range 23m38s before to 77m40s after)
Noctule	May & August median 7.6m after July medium 0.2m before Mean 7m after Mean 11m after	0.1m before to 15.3m after 4.18m before to 4.58m after 16m before to 31m after No data (but actual range 7-26m after)

Table 3.3. Summary of emergence times extracted from Andrews & Pearson, 2022 (refer to paper for more detail).

Species common names	Mean or median emergence time in relation to sunset in minutes (m) from a variety of studies (data relates to female bats only)	Standard deviation (range in which 95% of observations occurred in studies) (data relates to female bats only)
Common pipistrelle	Mean 24.8m after	6.9-42.7m after
Soprano pipistrelle	May/June mean 35m after July mean 27m after August mean 29m after Mean 33.5m after	23-47m after 21-33m after 25-34m after 12-55m after
Nathusius' pipistrelle	Mean 30m after	No data (but actual range 11-50m after)
Serotine	Mean 11.6m after	3.9-19.3m after
Barbastelle	Mean 24m after	17.1-30.9m after
Brown long-eared bat	June median 54m after Mean 61.7m after Mean 61m after	No data (but earliest starting 33m before) 57.4-66m after 28-94m after
Grey long-eared bat	Mean 36m after	20-52m after

3.6 Species foraging habitat preferences

3.6.1 Table 3.4 provides information on the foraging habitat preferences of different bat species. Another source of information is EUROBATS (2019) Guidance on the conservation and management of critical feeding areas and commuting routes for bats. As foraging is likely to be influenced by the availability and quality of habitat around the roost, the time of year (linked to seasonal prey abundance) and the ambient conditions on the night in question, this table should not be considered exhaustive (and was not derived from a thorough literature search). Bats have also been found in open landscapes such as farmland, mires, moorlands and coastal cliffs.

Table 3.4. Foraging habitat preferences and foraging strategies of different UK species.

Species	Foraging habitat preferences (with flight-path preferences added for some species)
Greater horseshoe	Preferred foraging habitats are ancient semi-natural and deciduous woodland and cattle-grazed pastures (Duvergé and Jones, 1994; Ransome, 1997; Duvergé and Jones, 2003). Bats tend to forage on the boundaries of grazed pastures and woodland, tree lines or tall, thick hedgerows (Ransome, 1997). One study showed that bats fly close to field boundaries and reduce their flight height when out in the open (Duvergé and Jones, 2003). A spring study showed grazed pastures and broadleaved woodland were selected over other habitats (Flanders and Jones, 2009). This species can remain active during the hibernation period (Park *et al.*, 1999). More information is available in NE's FCS definition for this species (NE, 2023).
Lesser horseshoe	Preferred foraging habitats include broadleaved woodland well connected by potential flight-paths such as hedges, woodland edge and riparian trees (Bontadina *et al.*, 2002; Schofield *et al.*, 2002). Another study showed riparian broadleaf woodland as the most important foraging area for one colony, although bats also fed along hedgerows and green lanes (also used for flight-routes) and a small number used a conifer plantation for a short period (Schofield *et al.*, 2002). Wet broadleaved woodland was also notable in another study by Downs *et al.*, 2016b. Will cross open spaces immediately after emergence, but will seek to minimise the open distance travelled, and fly low to the ground when doing so (Downs *et al.*, 2016b). Both the length of distance travelled (Downs *et al.*, 2016b) and the height at which this species cross such gaps (Schofield, 2008) increase with decreasing light levels. This species can remain active during the hibernation period (Williams, 2001).

Table 3.4. Foraging habitat preferences and foraging strategies of different UK species.

Species	Foraging habitat preferences (with flight-path preferences added for some species)
Alcathoe	Predominantly found foraging in more ancient denser woodland and woodland edge. They will use smaller copses and wooded corridors and have been found in parkland with high proportions of mature trees, especially oak. In Southern England they are commonly found in the same woodlands as Bechstein's bat particularly where a dense understory is present (Daniel Whitby, *pers. comm.*, 2022).
Bechstein's bat	Predominantly associated with ancient broadleaved woodlands (Greenaway and Hill, 2004), with a strong association with oak and ash (Hill and Greenaway, 2005). Various studies have recorded foraging under a closed canopy (Fitzsimons *et al*., 2002, Harris and Yalden, 2008). More open habitats were least preferred. Davidson-Watts (2014b) also reported use of hedgerows in grazed pasture for flight-paths and patches of coniferous woodland used for the same when these were present as part of a larger broadleaved block. Davidson-Watts (2013) also reported use of tree-lined river margins. A 2018 study (Pimley *et al*.) recorded this species foraging within 1.5km of the day roost and preferring woodland, with tree-lines and tree-lined river corridors being important for connectivity between woodland habitats. In this study woodland habitats with dense regrowth, which are actively coppiced, and cluttered environments with open areas were preferred. More information is available in NE's FCS definition for this species (NE, 2023).
Brandt's / Whiskered bat	Buckley *et al*. (2013) found whiskered bat used mixed woodland, riparian vegetation, arable and rough grassland habitats although selected the first two as core foraging habitats. Berge (2007) found that whiskered bat selected pasture with hedgerows. A German study showed Brandt's bat favours woodland and whiskered bat favours areas near rivers and more open habitats with hedges and coppices (Taake, 1984).
Daubenton's bat	Preferred foraging habitat is over water (Jones and Rayner, 1988): this species favours riverine habitats (Racey and Swift, 1985; Rydell *et al*., 1994) but is also known to forage in woodland.
Natterer's bat	Preferred foraging habitat is semi-natural broadleaved woodland, tree-lined river corridors and ponds, but also uses grassland (Smith and Racey, 2002, 2008). Avoids dense coniferous plantation (Smith and Racey, 2008). An autumn study revealed the species to use woodland and mixed agricultural areas (Parsons and Jones, 2003).
Leisler's bat	Recorded foraging in woodland edge, scrub or woodland-lined roads and over pasture (Waters *et al*., 1999). Also recorded over drainage canals, lakes and coniferous forests (Shiel *et al*., 1999). Recorded as selecting parkland/amenity grassland, deciduous woodland edge and rivers/canals but avoiding improved grassland (Russ and Montgomery, 2002). One road-based study showed this species to be equally active in all habitats available (hedges, tree lines, woodland, grassland, streetlights and arable areas) (Russ *et al*., 2003).
Noctule	Found in a range of habitats, forages out in the open, often over trees and with a strong affinity to water (Altringham, 2003). Reported as selecting broadleaved woodland and pasture (Mackie and Racey, 2007).
Common pipistrelle	Shows a preference for deciduous woodland but a generalist using a wide range of habitats (Davidson-Watts and Jones, 2006; Davidson-Watts *et al*., 2006; Nicholls and Racey, 2006). This includes foraging over cattle (Downs & Sanderson, 2010). In comparison to an open foraging area, a shaded wooded area can extend the time bats spend foraging by approximately half an hour at both dawn and dusk (Downs & Racey, 2006). One study looking at riparian habitat quality found significantly more feeding buzzes were recorded at sites with better quality riparian zones (Scott *et al*., 2010).
Nathusius' pipistrelle	Riparian habitats, broadleaved and mixed woodland and parkland, occasionally found in farmland but always near water (Harris and Yalden, 2008). Found over lakes and rivers (Vaughan *et al*., 1997). One study recorded males feeding over lake edge and managed gardens and fields around a lake (Hargreaves, 2012).
Soprano pipistrelle	Tends to select riparian habitats over other habitat types available (Davidson-Watts and Jones, 2006; Davidson-Watts *et al*., 2006; Nicholls and Racey, 2006). In comparison to an open foraging area, a shaded wooded area can extend the time bats spend foraging by approximately half an hour at both dawn and dusk (Downs & Racey, 2006). As above, more foraging is recorded at sites with better quality riparian zones and also this species is significantly more active at high quality sites than common pipistrelle (Scott *et al*., 2010).

Table 3.4. Foraging habitat preferences and foraging strategies of different UK species.

Species	Foraging habitat preferences (with flight-path preferences added for some species)
Serotine	Catto *et al*. (1996) and Robinson and Stebbings (1997) identified the following habitats as important for foraging: cattle pasture, playing fields, village greens, white streetlights, tree-lined hedgerows and woodland edge. Downs and Sanderson (2010) identified that serotine bats prefer fields with cattle.
Barbastelle	Forages over/in riparian zones, broadleaved woodland, unimproved grassland and field margins (Zeale, 2011; Zeale *et al*., 2012). Foraging has also been recorded at an irrigation reservoir, ponds in woodland, areas of set-aside, flood plain habitats, a sewage farm and a pumping station (Greenaway, 2008). In a Norfolk study, where maternity woodlands were situated in a predominantly arable landscape, foraging bats visited hedges, small woodlands, tree belts, riparian habitats, pasture, country roads and rural villages and farms with gardens and grounds (Harris, 2020). Bats tend to wait for darkness to cross open areas (Greenaway, 2008, Harris, 2020). However, barbastelle avoided wetlands, preferring woodlands and treelines in a study by Davidson-Watts (2014a). Carr *et al*. (2020) found that riparian vegetation and broadleaved woodland were the habitat types most strongly selected by foraging bats and hedgerows within pastoral landscapes were also important linear features in the landscape for this species. These authors identified prey consumed by this species and recommended that conservation should protect and enhance foraging habitats within a 6.5km CSZ, including plant species that support the developmental stages of the barbastelle's preferred moth prey.
Brown long-eared bat	Strongly associated with tree cover (Entwistle *et al*., 1996), prefers woodland with cluttered understorey including native species, particularly deciduous (Murphy *et al*., 2012). Also forages in mixed woodland edge and among conifers. Use of hedgerows increases through the active season (Murphy *et al*., 2012).
Grey long-eared bat	Prefers to forage in more open or edge habitats, including unimproved lowland grassland (meadows and marshes), wooded riparian vegetation and broadleaved woodland (woodland mainly used in low temperatures or heavy rainfall) (Razgour *et al*., 2011, 2013). In agricultural habitats, forages along field margins, hedgerows and scattered trees (Razgour *et al*., 2011). More information is available in NE's FCS definition for this species (NE, 2021).

3.7 Species Core Sustenance Zones (CSZs)

3.7.1 BCT defined CSZs for different bat species through an extensive literature review in 2016[46, 47]. A CSZ refers to the area surrounding a communal bat roost within which habitat availability and quality will have a significant influence on the resilience and conservation status of the colony using the roost.

3.7.2 With reference to development, the CSZ could be used to indicate:

- The area surrounding a communal roost within which development work may impact the flight-paths and foraging habitat of bats using that roost.
- The area within which it may be necessary to ensure no net reduction in the quality and availability of foraging habitat for the colony.

3.7.3 Consideration should be given to the extent of a background data search in relation to the species likely to be present and the impact of the development. CSZs could also be used to interpret the results of background data searches. Table 3.5 over shows CSZs for communal roosts of different species.

46 https://cdn.bats.org.uk/uploads/pdf/Resources/Core_Sustenance_Zones_Explained_04.02.16.pdf?v=1550597495
47 https://cdn.bats.org.uk/uploads/pdf/Resources/Core_Sustenance_Zones_References_04.02.16.pdf?v=1550597496

Table 3.5. CSZs for different UK bat species.

Species	CSZ radius (km)	No. of bats studied	No. of studies	Confidence in zone size[a]
Lesser horseshoe[b]	2	83	4	Good
Greater horseshoe[b]	3	39	4	Moderate
Daubenton's bat	2	7	2	Poor
Whiskered/Brandt's bat	1	24	1	Poor
Natterer's bat	4	53	2	Good
Bechstein's bat[b]	1	70	4	Moderate
Noctule	4	20	1	Poor
Leisler's bat	3	20	2	Moderate
Common pipistrelle	2	23	1	Poor
Soprano pipistrelle	3	91	3	Good
Nathusius' pipistrelle	3	9	2	Poor
Serotine	4	13	1	Poor
Barbastelle[b]	6	69	3	Moderate
Brown long-eared	3	38	1	Poor
Grey long-eared[b]	3	20	1	Moderate

a Confidence is based on the number of bats and number of studies used to inform the calculation of CSZ.
b There may be justification with Annex II and other rare species to increase the CSZ to reflect use of the landscape by all bats in a population. Bechstein's bat and grey long-eared bat both have very specific habitat requirements so CSZs may not work as well for these species and the distances quoted above may need to be increased to reflect this. At the time the CSZs were calculated, insufficient data was available to include Alcathoe.

3.7.4 It is worth noting that this work was carried out using data from communal roosts, generally maternity roosts. However, studies have shown sexual segregation in several UK bat species in response to landscape composition and connectivity (e.g. Senior *et al*., 2005; Angell *et al*., 2013; Filias *et al*., 2022). The optimal habitat is left for the more energetically constrained maternity roost. So the CSZ for females and males is likely to be different, as it is for juvenile bats. It is also likely that the CSZ for a roost will reduce with increasing habitat quality and CSZs are likely to be different at different times of the year, e.g. during swarming or hibernation. These considerations should be borne in mind when using the CSZs in the table above.

3.7.5 The South Hams SAC Greater Horseshoe Bat Habitats Regulation Assessment Guidance (Devon County Council *et al*., 2019) uses proposed sustenance zones of 4km for this species. Where local guidance has been produced based on local knowledge and approaches, it should be used.

3.8 Species population estimates, distribution and status

3.8.1 Data collected on the presence and abundance of bat species should be assessed in the context of any available knowledge about the distribution and rarity of local, county and national bat populations. Without this context, it is not possible to make an assessment about the conservation significance of the survey findings. Potential sources of data on distribution and rarity of bat species are given in Table 3.6.

Table 3.6. Sources of data on distribution and rarity of bat species.

Geographic scale	Sources of data on species distribution and bat population status at relevant scale
Local	• Background data search (see Chapter 4 for different sources of data) • National Biodiversity Network (NBN) Gateway • MAGIC website • Local Biodiversity Action Plans • Local Mammal Atlas • Data from ecological reports submitted with planning applications • LERC • Mammal Society Count Bat app • Ecobat app
County	• County Bat Group • County Wildlife Trust • County Recorder • LERC

Table 3.6. Sources of data on distribution and rarity of bat species.

Geographic scale	Sources of data on species distribution and bat population status at relevant scale
Country	• Article 17 Reporting (e.g. Joint Nature Conservation Committee (JNCC), 2019)[48] • Newson *et al.*, 2017 • FCS definitions available, at the time of writing, for Bechstein's bat, greater horseshoe bat, grey long-eared bat[49]
UK / Great Britain	• Article 17 Reporting • National Bat Monitoring Programme (NBMP) • Harris and Yalden, 2008 • Dietz and Pir *et al.*, 2011 • Mathews *et al.*, 2018 • Crawley *et al.*, 2020

3.9 Species-specific considerations

3.9.1 A few bat species are difficult to detect with bat detectors because they produce quiet (low amplitude) echolocation calls or have very directional echolocation calls. Sometimes bats use their eyes or ears rather than echolocation (especially in familiar surroundings such as close to roosts or when gleaning prey). Longer sampling periods, including the use of automated/static detectors, will increase the likelihood of detecting some species, although not all, acoustically. Other methods include DNA analysis of droppings (where possible) or ALBST (see Chapter 9). Table 3.7 provides information on echolocation call characteristics for species with directional or low-amplitude calls and suggests solutions to overcome this limitation.

Table 3.7. Bat species that are difficult to detect with bat detectors and methods to overcome this limitation.

Species	Echolocation call characteristics which create lower likelihood of detection	Potential solutions to this limitation
Rhinolophus species	Calls are directional, at high frequency and are subject to a marked degree of attenuation that reduces potential detection distance and the likelihood of a bat being detected if echolocation calls are received by the microphone significantly off-axis. Call intensity has yet to be measured in the field for both UK horseshoe bats.	Deploying an automated/static detector within constrained flight corridors such as tunnels and natural corridors through vegetation that are often used by these species and where flights are concentrated will increase the likelihood of recording bats. Also, where possible, directing the microphone towards where the bats are likely to be coming from.
Myotis species	Calls of *Myotis* species for which call intensity has been measured are of fairly low amplitude (Faure *et al.*, 1990) and are generally frequency modulated (FM – where energy is spread across multiple frequencies). When in woodland, Bechstein's bat in particular is likely to spend a proportion of its time high in the tree canopy, making it more difficult to detect.	Where a bat emerges silently/quietly and is observed it may be possible, at least initially, to follow the bat with the bat detector to pick up some echolocation calls. Observing bat behaviour can help to identify the presence of *Myotis* species and separate them, e.g. watching Daubenton's bat trawling the water surface. Other methods such as DNA analysis of droppings and trapping surveys (see Chapter 9) may be more appropriate for these species than acoustic surveys, both of which can also distinguish the species from one another. Even if its calls can be recorded, separating Bechstein's bat from other *Myotis* species can be difficult by acoustic analysis (Parsons and Jones, 2000; Walters *et al.*, 2012). Catching surveys, aided by an acoustic lure, are likely to be required where there is a reasonable potential for Bechstein's to be present (i.e. habitat is suitable and a site is within the known geographic range) if this species may be at risk from a proposal.

48 Member states of the European Union were required to report on the implementation of the Habitats Directive every six years through what is known as Article 17 reporting. Article 17 reports are available for the UK and for England, Wales, Scotland and Northern Ireland separately and include data on population estimates, range, distribution and status of the different bat species, with information taken from a number of sources. The latest reporting at the time of writing was JNCC, 2019 (reporting on the period 2013–2018).

49 https://publications.naturalengland.org.uk/category/5415044475256832

Table 3.7. Bat species that are difficult to detect with bat detectors and methods to overcome this limitation.

Species	Echolocation call characteristics which create lower likelihood of detection	Potential solutions to this limitation
Barbastelle	Very low-intensity echolocation calls (Goerlitz *et al*., 2010). Flight is relatively fast, so recordings tend to be of short duration.	Use of broad-band recordable detectors has helped to demonstrate that this species is present more frequently and across a wider range of habitats than previously believed. Calls were often missed by ecologists listening in the field as they are often indistinct, not repeated and masked by calls of other species. Attempt to intersect bats with detectors on flight-paths, when calls are potentially of higher intensity. Barbastelle calls can be distinctive, and auto-ID software can usually readily identify this species (depending on the call quality and software). However, the calls can be lost if the software can only identify one species in a recording, because any louder calls will be selected in preference. Other methods such as DNA analysis of droppings and trapping surveys (see Chapter 9) may be useful for this species.
Plecotus species	Low-amplitude and FM calls are often used. Foraging bats often make no sound and use eyes or ears to hunt by gleaning (Swift and Racey, 2002). Additionally, difficult to detect whilst foraging in understorey.	Attempt to intercept bats with detectors on flight-paths, when calls are potentially of higher intensity. NVAs can be used to identify long-eared species bats by their distinctive appearance. Inside buildings, placing a detector high up usually increases the number of passes recorded. Other methods such as DNA analysis of droppings and trapping surveys (see Chapter 9) may be more useful for this species than acoustic surveys, both of which can also distinguish the brown from the grey.

3.9.2 Research by Scott and Altringham (2014) analysed the probability of detection of different species according to the intensity and directionality of their calls in woodland habitats. Table 3.8 provides information on the number of surveys required to achieve 95% certainty of detection of different species on walked transect surveys in the study (in woodland habitats, starting 30 minutes after sunset and continuing for 90 minutes, using Pettersson D500x and D240x detectors and software developed for the project to automatically isolate and identify bat calls). This table is included to illustrate the relative likelihood of picking up different species rather than to recommend the protocol, which was developed specifically for monitoring purposes.

Table 3.8. Sources of data on distribution and rarity of bat species.

Species	Number of surveys to achieve 95% certainty of detection for walked transect survey
Pipistrelle	1
Brandt’s bat	2
Whiskered bat	2
Barbastelle	2
Horseshoe bat	4
Natterer’s bat	5
Brown long-eared bat	Up to 9[a]

a It may be reasonable to assume that brown long-eared bats are likely to be present in most broadleaved woodland. Alternative methods (such as existing records or trapping surveys) may be more effective if proof of presence is required.

Chapter 4

Preliminary ecological appraisal (PEA) for bats

4.1 Introduction

4.1.1 A project often starts with a **PEA** covering ecological features of interest (although smaller projects may not require all elements of a PEA, as discussed below). CIEEM has published *Guidelines for Preliminary Ecological Appraisal* (CIEEM, 2017b). These guidelines acknowledge that there is a wide range of terminology used for such surveys but that their purpose is to:

- identify the likely ecological constraints associated with a project;
- identify any mitigation measures likely to be required, following the 'Mitigation Hierarchy' (see para 2.2.5);
- identify any additional surveys that may be required to inform an EcIA; and
- identify the opportunities offered by a project to deliver ecological enhancement.

4.1.2 PEAs generally include a desk study and fieldwork, often based on the Phase I or UK Habitats survey method (JNCC, 2016 or Butcher *et al*, 2020 respectively). The PEA is generally extended to identify habitats present that have the potential to support protected species.

4.1.3 As with all surveys, survey design should be based around the questions that require answers. These include:

- Is the site close to any internationally or nationally designated sites for bats or with bats as part of the reason for designation[50]?
- Which species are known from the area, what is their conservation status and what types of habitats are they likely to be found in?
- Are there likely to be species listed in Annex II of the Habitats Directive?
- Are there likely to be species particularly at risk of being impacted by the type of activities proposed?
- What habitat types are present on site and in the surrounding area that are (a) likely to be used by bats for roosting, foraging or flight-paths, and (b) likely to be impacted by the proposal? Are any of these likely to represent a limited resource in the landscape?
- What is the likely suitability of those habitats for bats?
- How do the habitats on site connect to habitats in the surrounding area to create an ecological network?

4.1.4 In order to answer the questions outlined above, a PEA for bats, consisting of a desk study and fieldwork, is generally carried out. This is described in the following sections. This assessment will enable an ecologist to proceed with further bat surveys as necessary using an iterative approach where each stage informs the next.

4.1.5 A full PEA for bats may not be necessary for smaller projects (e.g. projects impacting a single house or barn). Relevant elements, such as a study of maps, aerial photographs and site photographs, may provide enough information to skip straight to a PRA (Chapter 5) or a GLTA (Chapter 6) without a PEA. This is likely to save both time and financial resources.

4.2 Preliminary ecological appraisal (PEA) – desk study

Sources of information for desk study

4.2.1 The aim of a desk study for bats is to collate and review existing information about a site and its surroundings to inform the design of subsequent bat surveys (if needed) and inform the impact assessment for the project. More information on the 'Background Data Search' part of the desk study can be found in PBP (2019) and CIEEM (2020b).

4.2.2 When using or referring to materials obtained from external sources, rules of copyright should be noted and adhered to. There may also be restrictions on the commercial use of Internet resources.

4.2.3 Existing information about a site and its surroundings includes the following:

- Photographs and descriptions of the site (these may provide enough information, in combination with aerial photographs, to eliminate the need for further bat survey).
- Maps and aerial photographs, which can be viewed using applications such as Google Maps[51] which also provides a street view option. These allow an ecologist to identify habitats and features that are likely to be important for bats and assess their connectivity. Note when the photographs were taken; if old, conditions may have changed.
- Records of statutory and non-statutory designated sites (where bats form all or part of the reason for the designation) can be found on the Multi Agency Geographic Information for the Countryside (MAGIC) website,[52] although less information is provided for Scotland. Scottish users should refer to the NatureScot SiteLink system.[53]
- Existing bat survey reports, which can be obtained from the client or may be available from the relevant planning portal.

50 Some SSSIs that are clearly very suitable for bats may not be specifically designated for them and this should be considered in carrying out background searches.

51 https://www.google.co.uk/maps

52 https://magic.defra.gov.uk/

53 https://sitelink.nature.scot/home

4.2.4 It is essential for consultants to ask their clients if previous bat/ecology surveys/reports have been carried out/written and, if so, (a) who completed them, (b) what were the recommendations and (c) why a new survey/report is being commissioned. Previous reports should be provided by the client on request. A record of these communications should be kept by the ecologist, including the names of the people involved, the date and what was communicated. Previous reports should always be made available so the context can be understood.

4.2.5 It is usually necessary to contact the LERC or LPA to obtain records of non-statutory sites such as County Wildlife Sites (CWS) or Sites of Importance for Nature Conservation (SINC), because there is no national Geographical Information Systems (GIS) layer showing these sites. These are often designated for botanical reasons, but their descriptions can provide useful information about habitats and may contain records of bats. LERCs are found in most counties and generally charge a fee to search for records of designated sites and protected species. A list of active centres can be found on the website of the Association of Local Environmental Records Centres (ALERC)[54].

4.2.6 Records of bats in the area can be obtained from a number of organisations by providing a grid reference or site boundary and stating the required radius for the search and the type of records required. It is important to note that the absence of bat records does not confirm the actual absence of bats because records are not always collected in a systematic and thorough way. Organisations that hold local bat records are listed below.

- NBN Atlas[55]. Only data published under one of the open data licences (OGL, CC0, CC-BY) can be used in commercial activity, and only data published at capture resolution will be detailed enough to be useful, although blurred open data may help with context. The responsibility for ensuring that the quality, resolution and permissions are appropriate for use in a BDS lies with the end user of the Atlas. All data must be correctly cited, and proven misuse will result in a fixed penalty issued by the NBN Trust on behalf of data providers[56]. The NBMP at BCT shares data with the NBN Atlas under an Open Government Licence (OGL) at public resolution only (1km for all surveys except for hibernation survey, which is shared at 10km resolution). At the time of publication work is underway to introduce enhanced access functionality on the NBN Atlas, where data users can request finer resolution data via the Atlas, filtered by various attributes such as species, location, date range etc. It is anticipated that this will be available at some point in 2024 so please check the NBN Atlas for updates to data access functionality.
- LERCs (see above). BCT has data sharing agreements for NBMP data with many of the LERCs.
- LBGs – found in most counties, sometimes have a database of records or a county bat distribution atlas, will sometimes carry out a background data search for a fee although many share their records with LERCs, may also provide information on the local and regional status of populations. Contact details for each LBG can be obtained from the BCT website[57] (search for 'local bat groups'). The NBMP has data sharing agreements with many of the LBGs.

4.2.7 Other sources of bat records or information may include the following:

- County Ecologists (or Biodiversity or Nature Conservation Officers) – employed by some local, county or district councils.
- Local Wildlife Trusts (LWTs)[58].
- County mammal recorders – volunteers who collate records of mammal sightings in their county; contact details are available from the Mammal Society website[59].
- Local publicly funded research projects, e.g. data from all Natural Environment Research Council funded research projects on bats are published/available free of charge online.
- Other planning applications for the area – may provide some insight into local bat species and activity levels; planning applications can be found on county/district/borough council websites.
- The MAGIC website[60] provides information on bat EPS licences in England up to 2022 at the time of writing.
- The Mammal Society's Count Bat[61] and Ecobat[62] apps (although Ecobat is offline for maintenance at the time of writing).
- English Nature Research Reports[63].
- Local or national mining history or caving groups and clubs, and caving councils – these may have useful information on hibernation roosts and some cave systems have biological recorders who publish records in club or regional journals; see the BCA's website[64] for information.
- On-site personnel such as site security guards, caretakers or gardeners may provide anecdotal evidence that gives useful pointers, although data may not be reliable enough to be used in a PEA.

4.2.8 Other relevant literature, for example, on species distribution and status. This information is particularly important when analysing survey data and carrying out an impact assessment.

Geographical extent of desk study

4.2.9 As a minimum, it is recommended that background data searches should be carried out up to 2km from the proposed development boundary (including all temporary works). However, the data search should be related to the scheme's ZoI and consider the CSZs of species likely to be present so may need to extend up to 10km or beyond for larger projects.

4.2.10 Statutory designated sites such as SACs or SSSIs relevant to bats within 10km should also be considered. Where an SAC could be affected, the screening stage of a HRA should be completed (see 1.2.27). For road schemes, the screening distance is 30km (Highways England *et al.*, 2020a).

4.2.11 In areas where bat roosts and foraging areas are more sparsely distributed, the background data search radius may need to be increased. In some areas, particularly at the coast

54 https://www.alerc.org.uk/lerc-finder.html
55 https://nbn.org.uk/
56 https://nbn.org.uk/news/nbn-atlas-revised-terms-of-use-and-guidance-for-using-data/
57 https://www.bats.org.uk/support-bats/bat-groups
58 https://www.wildlifetrusts.org/
59 https://www.mammal.org.uk/science-research/surveys/county-mammal-recorders/
60 https://magic.defra.gov.uk/
61 https://www.mammal.org.uk/countbat/#:~:text=What%20is%20Count%20Bat%3F%20Count%20Bat%20is%20the,you%E2%80%99ve%20recorded%20100%20common%20pipistrelles%20at%20a%20roost.
62 https://www.mammal.org.uk/science-research/ecostat/ecobat/
63 http://publications.naturalengland.org.uk/category/47017
64 https://british-caving.org.uk/

where bats may arrive or depart in larger numbers, migrating bats may need to be considered. Ringing and recent work using the Motus network[65] has now confirmed that some of our bat species migrate between the UK and the continent (by 2023, there are now ten long-distance migratory records of Nathusius' pipistrelle[66] and the Motus network has detected Nathusius' pipistrelle bats travelling between the UK and the Netherlands in a single night)[67].

Interpretation of desk study data

4.2.12 The desk study records provide contextual information for the survey design stage as well as the evaluation of the survey results. They should be interpreted to identify:

- if proposed activities are likely to impact on a SAC or the qualifying feature of a SAC;
- if the proposed activities are likely to impact on other designated sites and thus require consultation with relevant bodies[68];
- any species (or genera) confirmed/thought to be present;
- any bat roosts that will be impacted (on or off-site);
- if it is likely that the CSZs of bats from roosts off-site will be impacted; and
- if there are any rare species in the area that may require species-specific survey methodologies.

Next steps

4.2.13 It is usual for a desk study to be followed by the fieldwork element of a PEA (although, as discussed above, this may not be needed for smaller projects).

4.2.14 There may be some cases where aerial photographs and descriptions of the site confirm there is no habitat suitable for bats on site or in the surrounding area. Ecologists and their clients may want to keep a record of the rationale behind the decision not to survey.

4.3 Preliminary ecological appraisal (PEA) – fieldwork

Description and aims

4.3.1 We have termed a PEA for bats as a **Daytime Bat Walkover** (DBW) of the proposed development site to observe, assess and record any habitats suitable for bats to roost, commute and forage both on site and in the surrounding area (it is important that connectivity within the landscape is also considered at this stage). The aim is to determine the suitability of a site for bats, to assess whether further bat surveys will be needed and how those surveys should safely be carried out. For smaller sites, a PRA for structures (see Chapter 5) or a GLTA (see Chapter 6) may also be carried out at the same time.

Equipment

4.3.2 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

4.3.3 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Unless an ecologist intends to enter buildings or investigate PRFs in trees with a torch or endoscope (which may be the case on smaller sites), a DBW is unlikely to cause disturbance, so a licence is generally not needed.

4.3.4 However, this survey should be carried out by an ecologist with the appropriate level of competence for the project (see Table 2.3). For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate but for anything more complex BCT Level 3 (CIEEM Accomplished) competence is essential. For the most complex sites, an ecologist at BCT Level 4 (Authoritative) may be needed. The results of this survey cascade into further survey design – this is an essential stage to get right!

Method

4.3.5 Ecologists should identify and record any structures, trees and other features that could be suitable for bats to roost in and any habitats that could be suitable for bats to commute, forage or swarm in/at. If potential suitability is assessed at this stage, the scheme presented in Tables 4.1 and 4.2 should be used. Please note that low-suitability roosting habitats may be present in habitats that are of high suitability for flight-paths and foraging, and vice versa. Roosting and foraging habitats and flight-paths should be assessed separately.

4.3.6 **These categories are allocated irrespective of the presence of a roost. If a roost is confirmed to be present then the categorisation still stands (because other roosts may be present but undiscovered) but 'confirmed roost' should be added, e.g. Low – confirmed roost, Medium – confirmed roost, High – confirmed roost.**

65 https://www.motus.org/

66 https://www.bats.org.uk/our-work/national-bat-monitoring-programme/surveys/national-nathusius-pipistrelle-survey

67 https://www.wur.nl/en/Research-Results/Research-Institutes/marine-research/show-marine/Nathusius-pipistrelle-crosses-the-North-Sea-in-one-night.htm

68 NE has developed the concept of Impact Risk Zones (IRZs) around SSSIs. They define zones around each SSSI (found here: http://magic.defra.gov.uk/MagicMap.aspx) which reflect the particular sensitivities of the features for which it is notified and indicate the types of development proposal which could potentially have adverse impacts. The IRZs also cover the interest features and sensitivities of sites included in the National Site Network, the post-Brexit name for Natura 2000 sites. Information on MAGIC relating to IRZs is updated monthly. More information on IRZs can be found here: https://www.gov.uk/guidance/construction-near-protected-areas-and-wildlife

Table 4.1. Guidelines for assessing the potential suitability of proposed development sites for bats, based on the presence of habitat features within the landscape, to be applied using professional judgement.

Potential suitability	Description	
	Roosting habitats in structures	**Potential flight-paths and foraging habitats**
None	No habitat features on site likely to be used by any roosting bats at any time of the year (i.e. a complete absence of crevices/suitable shelter at all ground/underground levels).	No habitat features on site likely to be used by any commuting or foraging bats at any time of the year (i.e. no habitats that provide continuous lines of shade/protection for flight-lines, or generate/shelter insect populations available to foraging bats).
Negligible[a]	No obvious habitat features on site likely to be used by roosting bats; however, a small element of uncertainty remains as bats can use small and apparently unsuitable features on occasion.	No obvious habitat features on site likely to be used as flight-paths or by foraging bats; however, a small element of uncertainty remains in order to account for non-standard bat behaviour.
Low	A structure with one or more potential roost sites that could be used by individual bats opportunistically at any time of the year. However, these potential roost sites do not provide enough space, shelter, protection, appropriate conditions[b] and/or suitable surrounding habitat to be used on a regular basis or by larger numbers of bats (i.e. unlikely to be suitable for maternity and not a classic cool/stable hibernation site, but could be used by individual hibernating bats[c]).	Habitat that could be used by small numbers of bats as flight-paths such as a gappy hedgerow or unvegetated stream, but isolated, i.e. not very well connected to the surrounding landscape by other habitat. Suitable, but isolated habitat that could be used by small numbers of foraging bats such as a lone tree (not in a parkland situation) or a patch of scrub.
Moderate	A structure with one or more potential roost sites that could be used by bats due to their size, shelter, protection, conditions[b] and surrounding habitat but unlikely to support a roost of high conservation status (with respect to roost type only, such as maternity and hibernation – the categorisation described in this table is made irrespective of species conservation status, which is established after presence is confirmed).	Continuous habitat connected to the wider landscape that could be used by bats for flight-paths such as lines of trees and scrub or linked back gardens. Habitat that is connected to the wider landscape that could be used by bats for foraging such as trees, scrub, grassland or water.
High	A structure with one or more potential roost sites that are obviously suitable for use by larger numbers of bats on a more regular basis and potentially for longer periods of time due to their size, shelter, protection, conditions[b] and surrounding habitat. These structures have the potential to support high conservation status roosts, e.g. maternity or classic cool/stable hibernation site.	Continuous, high-quality habitat that is well connected to the wider landscape that is likely to be used regularly by bats for flight-paths such as river valleys, streams, hedgerows, lines of trees and woodland edge. High-quality habitat that is well connected to the wider landscape that is likely to be used regularly by foraging bats such as broadleaved woodland, tree-lined watercourses and grazed parkland. Site is close to and connected to known roosts.

a Negligible is defined as 'so small or unimportant as to be not worth considering, insignificant'. This category may be used where there are places that a bat could roost or forage (due to one attribute) but it is unlikely that they actually would (due to another attribute).

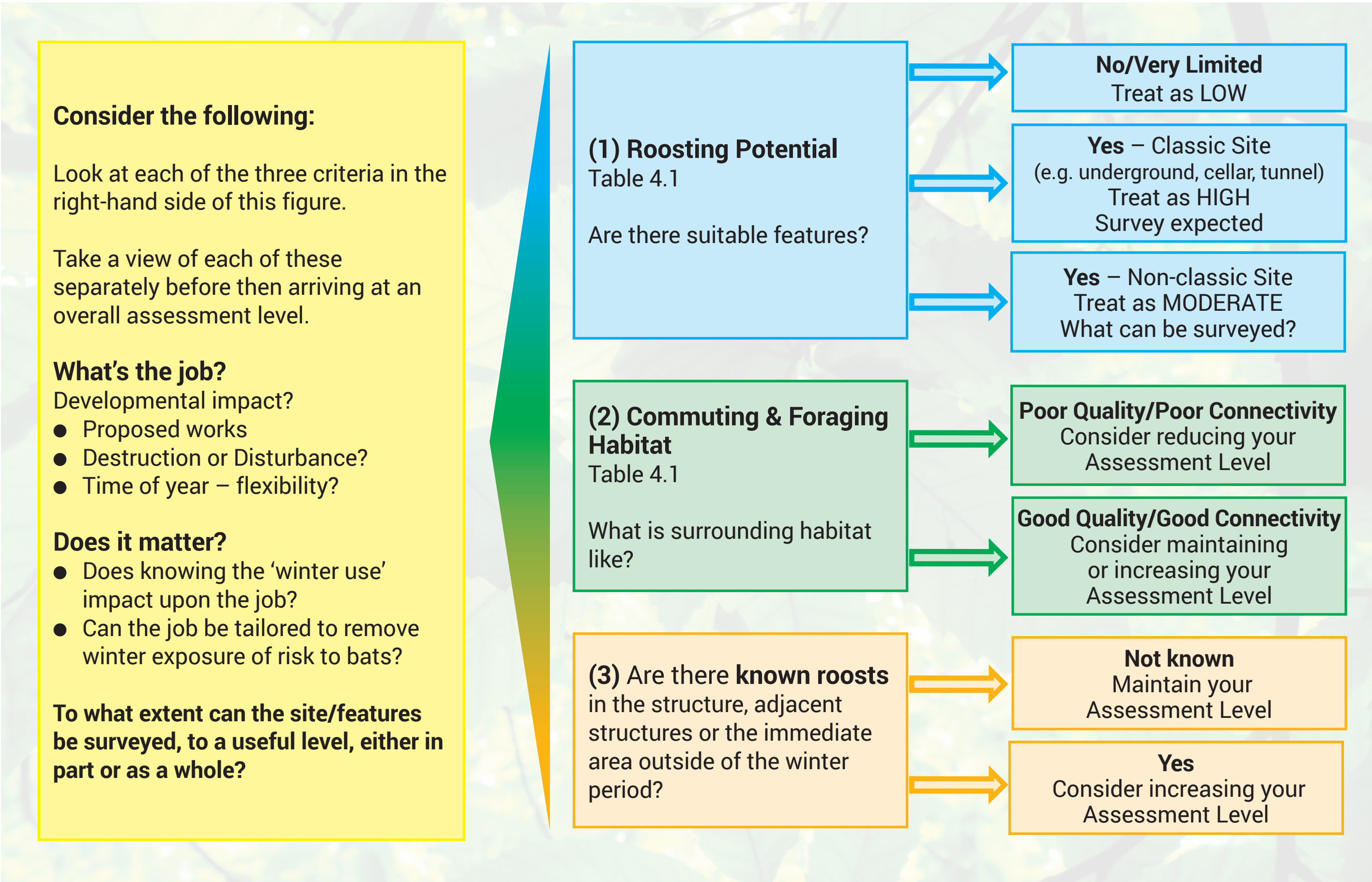
b For example, in terms of temperature, humidity, height above ground level, light levels or levels of disturbance.

c Evidence from the Netherlands shows mass swarming events of common pipistrelle bats in the autumn followed by mass hibernation in a diverse range of building types in urban environments (Korsten *et al.*, 2016 and Jansen *et al.*, 2022). Common pipistrelle swarming has been observed in the UK (Bell, 2022 and Tomlinson, 2020) and winter hibernation of numbers of this species has been detected at Seaton Delaval Hall in Northumberland (National Trust, 2018). This phenomenon requires some research in the UK, but ecologists should be aware of the potential for larger numbers of this species to be present during the autumn and winter in prominent buildings in the landscape, urban or otherwise.

4.3.7 Assessment of 'non-classic' winter potential is not always undertaken for planning or re-roofing projects and doesn't fit easily into Table 4.1 above. A rationale for undertaking a winter assessment is shown below in Figure 4.1 (from Middleton, 2019). The assessment should consider:

- the suitability of features to support roosting bats or to allow access for roosting bats;
- the temperature and humidity conditions likely to be present within the structure during the winter period and the suitability in this respect for it to be used by hibernating bats;
- the surrounding habitat, in terms of its potential for use by bats outside of the hibernation period for commuting and/or foraging purposes (i.e. is it reasonable that bats are familiar with the area and therefore may be aware of suitable roosting locations within the site?); and
- the presence of known roosts within the structure, or adjacent structures, or surrounding area during the active season.

Figure 4.1. A rationale for undertaking an assessment of roosting potential for winter roosting in non-classic hibernation sites (e.g. most buildings).



4.3.8 The proposed schemes of categorisation above do not work well for trees and therefore trees should be categorised as per Table 4.2 below.

Table 4.2. Guidelines for assessing the suitability of trees on proposed development sites for bats, to be applied using professional judgement.

Suitability	Description
NONE	Either no PRFs in the tree or highly unlikely to be any
FAR	Further assessment required to establish if PRFs are present in the tree
PRF	A tree with at least one PRF present

4.3.9 The assessment of suitability will be further refined for roosts during a GLTA.

4.3.10 These assessments inform subsequent survey effort for roosts, flight-paths and foraging habitats. The early assessment of suitability for bats, however, should not be confused with the later assessment of the conservation value of a site, which relates to the species, numbers and roost types **actually present**.

4.3.11 Assessment of potential suitability, carried out as per the tables and text above, informs the design of subsequent survey work, although the elements outlined in Section 2.2 should also be considered, in particular the potential impacts and proportionality.

4.3.12 During the DBW, the ecologist should consider the further surveys needed (if any), their logistics (resources, emergence survey locations, night-time bat walkover (NBW) routes, static detector locations, timings), and any potential health and safety hazards reported.

4.3.13 If no suitable habitat for bats is found, then further surveys are not likely to be necessary. Ecologists and their clients should keep a record of the rationale behind the decision not to carry out further surveys, including evidence that an adequate assessment has been made by a suitably qualified ecologist and the conclusion is reasonable.

Timing

4.3.14 A DBW should be done during daylight; sufficient time should be allowed to walk the entire site. It may be necessary to use multiple ecologists or survey over a number of days if the site is very large and/or complex.

4.3.15 The survey can be done at any time of year, but it is recommended that at least some of the results of the desk study are available to assist in planning and carrying out the survey and before making decisions about subsequent surveys.

Survey effort

4.3.16 The survey area should be determined by the ZoI (para 2.2.10 onwards) and the nature of the proposals and their likely impacts (para 2.2.5 onwards).

Weather conditions

4.3.17 The DBW can be carried out under any weather conditions, providing that the weather conditions do not affect the ecologist's ability to carry out the survey and record the results effectively and safely.

Next steps

4.3.18. The DBW informs the design of subsequent, more detailed surveys. The following questions should be considered:

- Are further, more detailed bat surveys needed?
- What types of detailed bat surveys would be appropriate to enable the impact assessment that is needed relative to the nature and current status of the project?
- Are any specialist techniques required arising from the potential presence of particular species, for example, the use of acoustic lures to detect the presence of Bechstein's bat?
- Are any specialist techniques required arising from the presence of particular habitats, for example, the need for confined spaces training to access underground sites?
- Are any specialist techniques required arising from the potential for project-specific impacts, for example, the need to survey at crossing points on a proposed road scheme?

4.3.19 **Where further surveys and mitigation are required, the DBW report in isolation will not be adequate for submission to an LPA in support of a planning application. The report will only be adequate for this purpose if there is no need for further surveys and mitigation.**

Chapter 5

Bat roost inspection surveys – buildings, built structures and underground sites

5.1 Introduction

5.1.1 This chapter provides information on carrying out inspection surveys for bat roosts in buildings, built structures and underground sites, collectively referred to as structures.

5.1.2 These surveys may be required where development proposals include demolition of a structure or a structure will be modified in such a way that bats or their roosts could be *directly* impacted if present.

5.1.3 These surveys may also be needed where bats roosting in a structure could be *indirectly* impacted by development activities outside the roost, such as lighting/removal of vegetation or the construction of a new road/railway, where severance of flight-lines and collision impacts are a possibility. In these cases, it is necessary to consider whether bat roosts both on and off site may be indirectly impacted and consider surveying at least for maternity and hibernation roosts and swarming sites where appropriate.

5.1.4 The above principles apply regardless of the size of the development.

5.1.5 Roost surveys of structures should be designed to answer specific questions, such as:

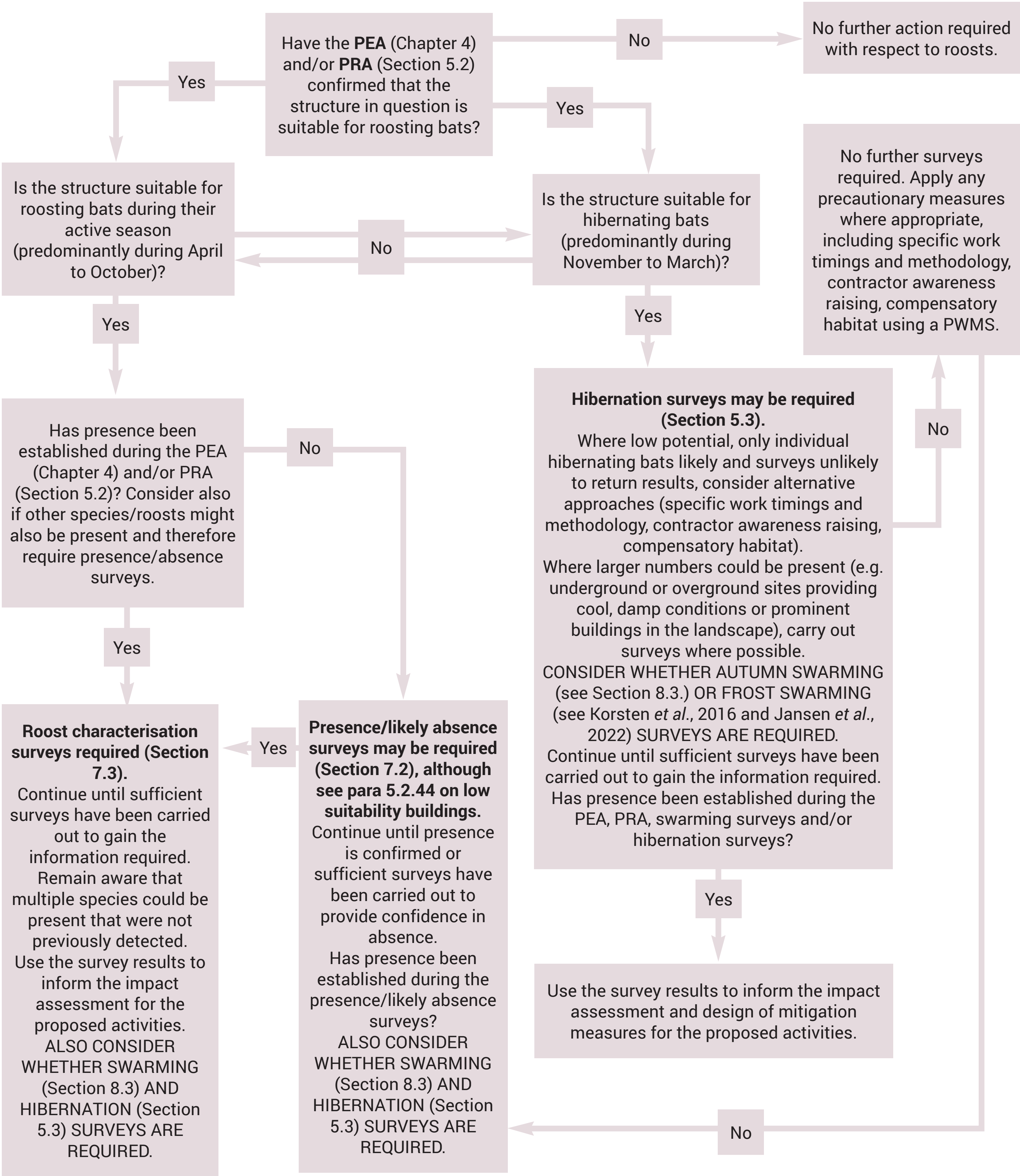
- Are actual or potential bat roosts present (and if so, where)?
- Which bat species use the site for roosting?
- How many bats do these roosts support?
- Where are the bat roost access points?
- Where are the bat roosts and how do the bats get to them from the access points (although this is not always possible to establish if the roosts are inaccessible for humans)?
- What is the current arrangement of vegetation and lighting in relation to the access points?
- At what times of the year are bats present? How does use change seasonally?
- What types of bat roost (Section 3.3) are present?

5.1.6 Answering some or all of these questions allows an ecologist to carry out an impact assessment and design a mitigation, enhancement and monitoring strategy, where relevant.

5.1.7 Roost surveys of structures generally take a staged approach, with the first step being a PRA (possibly preceded by a DBW – see Chapter 4), which may be followed up by winter hibernation (Section 5.3), presence/likely absence (Section 7.2) and/or roost characterisation surveys (Section 7.3). Survey design should be iterative; each stage informing the next, as per the flow chart provided in Figure 5.1. The effectiveness of the surveys should be considered at each stage.

Figure 5.1 - *see over*

Figure 5.1. Flow chart illustrating the process used to establish which types of surveys are necessary for roosts in structures, to be applied using professional judgement.



Note on Figure 5.1: In some situations, bats may use the same structure throughout the year and in these situations, both arms of the flow chart need to be fully considered.

5.2 Preliminary roost assessment (PRA) – structures

Description and aims

5.2.1 A **PRA** is a detailed inspection of the exterior and interior of a structure to look for features that bats could use for entry/exit and roosting and to search for signs of bats. The aim of this survey is to determine the actual or potential presence of bats and the need for further survey and/or mitigation. In many situations it is not possible to inspect all locations where bats may be present and therefore an absence of bat evidence does not equate to evidence of bat absence.

Equipment

5.2.2 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

5.2.3 PPE for entering confined spaces, entering spaces with asbestos, working at height or working in derelict buildings may also be required but specialist advice and training should be sought in such scenarios. More on health and safety can be found in Section 2.7.

Expertise and licences

5.2.4 Para 2.5.1 discusses expertise and para 1.3.1 onwards provides information on licences. The fieldwork involved in a PRA could result in disturbance to bats and therefore ecologists **should hold a survey licence covering the relevant activities**. The use of endoscopes requires specific training and the relevant licence. Bat handling should only be carried out by ecologists licensed to handle bats (or their trainees, under direct supervision) and only when the information cannot be gained by any other method. In most circumstances, hibernating bats, heavily pregnant bats or bats with dependent young should not be handled.

5.2.5 For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate for a PRA, but for anything more complex, BCT Level 3 (CIEEM Accomplished) competence is essential. For the most complex sites, an ecologist at BCT Level 4 (Authoritative) may be needed. The results of this survey also cascade into further survey design.

5.2.6 Training relating to health and safety may also be required for PRAs; examples include the safe use of ladders or asbestos awareness training (see Section 2.7).

Method

5.2.7 A PRA involves a detailed external and internal inspection of the structure to compile information on potential and actual bat entry/exit points; potential and actual bat roosting locations; any evidence of bats found and the number of ecologists that will be required for any subsequent surveys. *The Bat Workers' Manual* (Mitchell-Jones and McLeish, 2004) provides useful diagrams and definitions of architectural terms.

5.2.8 Sufficient time should be allowed to complete the external and internal inspection during daylight hours. The inspection should be carried out systematically and consistently through all parts of the structure and the results recorded in a standard format.

5.2.9 Definitions of potential value of roosting habitat are provided in Table 4.1 and Figure 4.1. The evaluation at this stage is more precise than during the DBW (see Chapter 4).

External survey

5.2.10 A systematic search should be made of the exterior of the structure to identify potential or actual bat access points and roosting places (although it should be noted that some may not be visible from ground level) and to locate any evidence of bats such as live or dead specimens, bat droppings, urine splashes, fur-oil staining and/or squeaking noises. Bat specimens and droppings are the most reliable type of evidence; the other types are not always the result of bat activity. **Sometimes bats leave no visible sign of their presence on the outside of a building (and even when they do, wet weather can wash evidence away).**

5.2.11 The search should include the ground, particularly beneath potential access points, any windowsills, windowpanes, walls, behind peeling paintwork or lifted rendering, hanging tiles, weatherboarding, eaves, soffit boxes, fascias, lifted lead flashing (particularly around chimneys), gaps under felt (including those of flat roofs), under tiles/slates and in existing bat boxes. Any gaps in brickwork or stonework should be identified and searched (where possible) because they may allow access to cavity- or rubble-filled walls. **This list is not exhaustive – all areas should be searched thoroughly and systematically in as far as is possible to do so. See Figure 5.2, which illustrates places where bats frequently roost.**

Figure 5.2. illustrates places where bats frequently roost **(© Historic England with the permission of BCT)[69].**

Places that bats may use in buildings:

1 Cellar
2 Barge board and soffit
3 Lead flashing
4 Gable end
5 Space between downpipe and wall
6 Window sill
7 Guttering
8 Porch
9 Sash window
10 Attic
11 Ridge tiles
12 Broken tiles
13 Roofing felt
14 Eaves
15 Wood or tile cladding
16 Quoins
17 Loose mortar between bricks
18 Roof joists

5.2.12 Crevices will require inspection using torches, mirrors and endoscopes. Care should be taken when using an endoscope; it should be inserted into crevices slowly whilst the ecologist is looking through the viewfinder or at the visual display to check for bats and their signs. An endoscope should never be forced into a crevice or inserted without viewing and the endoscope should not therefore come into contact with a bat. If a bat is seen through the endoscope, disturbance should be minimised.

5.2.13 The status of the structure (with respect to structural integrity) should be established prior to the visit but, during the external survey, this information should be corroborated and any new information added to the risk assessment. This assessment is essential to ensure safety when entering a structure.

Internal survey

5.2.14 Where safe, a systematic search should be made of the interior of the structure to identify potential or actual bat access points and roosting places and to locate evidence of bats. Bat specimens (live or dead) and droppings are the most reliable type of evidence. Other evidence found can include urine splashes, fur-oil staining, feeding remains (moth wings), squeaking noises (which can sometimes alert an ecologist to an otherwise hidden roost and can be heard with the naked ear or using a bat detector), bat-fly (Nycteribiid) pupal cases (Hutson, 1984) or odour. These latter types of evidence should, however, not be relied upon in isolation to confirm presence. **Sometimes bats leave no visible sign of their presence even on the inside of a building, particularly where there are hidden cracks, crevices and voids.**

5.2.15 Ecologists should work quietly and check structures in a systematic manner, working upwards from the entrance and checking any cellar space last. Upon entering an individual space, the places bats are most likely to be should be checked first. For example, on entering a loft space, always look up and check the ridge beam and other beams for free-hanging bats first. Following this, the space should be checked systematically for evidence of bats.

5.2.16 In derelict or abandoned structures, all areas should be surveyed where it is safe to do so. However, before entering upper floors or attics, the ceilings below should be inspected for any damage/concealed hatches that may indicate it is unsafe to walk above. It may also be necessary to seek professional advice (e.g. from a structural engineer, via the client) as to the safety of a building before entering or proceeding to upper floors and attics.

5.2.17 Where buildings are in use for residential or commercial purposes, it may not be necessary to inspect all of the rooms, instead concentrating on upper floors (evidence stuck to exterior windows, walls and windowsills may be more apparent

69 See also https://www.nature.scot/sites/default/files/2023-01/Bats%20and%20People%20leaflet%20-%20January%202023%20accessible%20%28A3906357%29.pdf

from upper rooms than from the ground-level survey), roof spaces, boiler rooms or other dark spaces or spaces not in daily use.

5.2.18 Within rooms in buildings, ecologists should inspect:

- the floor and surfaces of any furniture or other objects;
- behind wooden panelling;
- in lintels above doors and windows;
- behind window shutters and curtains;
- behind pictures, posters, furniture, peeling paintwork, peeling wallpaper, lifted plaster and boarded up windows; and
- inside cupboards and in chimneys accessible from fireplaces;

5.2.19 Frequently-used roost locations within roofs include:

- the top of gable end or dividing walls;
- the top of chimney breasts;
- ridge and hip beams and other roof beams;
- mortise and tenon joints;
- all beams (free-hanging bats);
- the junction of roof timbers, especially where ridge and hip beams meet;
- behind purlins;
- between tiles and the roof lining; and
- under flat felt roofs.

5.2.20 A search of a roof void should pay particular attention to the floor, water tanks, stored materials and other surfaces beneath such locations to look for evidence of bats. Searching beneath and around the edges of insulation may also uncover historical evidence of bats as listed above. Any internal access to cavity or rubble-filled walls should be noted along with the range of conditions provided by a structure.

5.2.21 **The above lists are not exhaustive – the ecologist should use professional judgement based on experience to decide where inspection is necessary.**

5.2.22 Turning all torches off whilst in a dark space (e.g. a roof space or dark barn) will allow ecologists to look for light spilling in, which will indicate gaps that bats may use for entry points.

5.2.23 Where bat droppings are present, samples should be carefully collected for DNA analysis (see Appendix 4 for collection protocol) unless species identification has been reliably established by other means such as observation of bats in the roost or from echolocation calls. Some species groups, for example, those from the genus *Myotis* and *Plecotus*, are difficult/sometimes impossible to tell apart by these methods (Parsons and Jones, 2000; Walters *et al.*, 2012), so DNA analysis of their droppings may be necessary. DNA analysis of droppings is a more reliable method than identifying droppings by their shape, texture or colour, which can be variable and overlaps between species. Various organisations offer this service. Fabric, plastic or paper sheets (e.g. dry lining paper) can be placed down in structures on the initial visit to collect droppings for this purpose on subsequent survey visits.

5.2.24 Sometimes a space may have been cleaned and evidence of bats may have been removed so this needs to be taken into consideration. If this appears to be the case, then the client should be consulted to establish if and when any cleaning was carried out and why. A record of these communications should be kept by the ecologist, including the names of the people involved, the date and what was communicated.

5.2.25 If any parts of a structure cannot be surveyed due to accessibility or other limitations, this should be clearly detailed in the report.

5.2.26 The following sections provide information on some structure-specific considerations.

Timber-framed and stone barns

5.2.27 Timber-framed and stone barns may be used by bats throughout the year and can support a range of roost types for a variety of different species. Barns are often very open and can be tall, making preliminary assessment and detailed surveying of potential roost sites difficult and time-consuming. They may also contain farm machinery and other materials that can impede bat surveys.

5.2.28 When surveying barns, the features that should be given particular attention during an inspection survey include:

- gaps between ridge tiles and ridge and roof tiles, usually where the mortar has fallen out or the tiles are broken or lifted;
- the ridge area of the roof (particularly between the ridge beam and roofing material);
- lifted lead flashing associated with roof valleys, ridges and hips, or where lead flashing replaces tiles;
- spaces between external weatherboarding/cladding and the timber frame or walls;
- gaps behind window frames, lintels and doorways including the main doors;
- tenon and mortise joints between truss beams and braces and the principal support columns;
- cracks and crevices in timbers;
- gaps between stones or bricks (especially where purlins enter the wall and by the wall plate); and
- surfaces such as the ground, ledges, windows, sills or walls, machinery or stored material within the barns (which should be searched for bat droppings and/or urine spots or stains).

5.2.29 Close inspection of cavities and behind timbers should be undertaken using endoscopes, torches and/or mirrors. This often requires the use of ladders to access a safe working platform. Inspection of the roof timbers and ridge beam often requires binoculars and powerful torches to illuminate the roof from the ground.

Churches

5.2.30 Churches, because of their age, structure and location, often support more than one species of bat. Survey considerations specific to churches are given below.

- Bats often share the main spaces of a church with worshippers (even if there is a separate roof void), therefore the internal survey should include all areas, including accessing any underground crypts not immediately obvious.
- Most churches are regularly cleaned, so bat droppings may be removed. Make first contact with the Church Warden, ask about current knowledge of bats using the church, and ask the cleaning staff if they are aware of any bats. Find out the cleaning schedule and do not carry out a PRA immediately after the church has been cleaned.

- Search lower ledges, higher areas (if safe to do so), in the corners, behind radiators, where cleaners may have missed. Churches can be tall buildings, and use of ladders might be impractical. Other safety consideration includes care in bell towers, where it is dangerous to enter the bell chamber if the bells are in the upright position.
- Urine splashes or droppings can leave a permanent and obvious stain on pews, polished wooden, stone and metal surfaces. However, stains can persist for many years and so do not always indicate recent use of the church by bats.
- Features of churches are given specific terms: use the correct technical terminology in recording and reporting. *The Bat Workers' Manual* (Mitchell-Jones and McLeish, 2004), and the Bats in Churches project web site[70] provides useful guidance, including diagrams and e-learning on working with churches.

Bridges

5.2.31 Many bridges cross watercourses or other linear features providing flight-paths and foraging habitats for bats. This means that many bridges are used for roosting. Some examples are given in Billington and Norman (1997), Shiel (1999), Keeley (2003) and Masterson *et al*. (2008). Survey considerations that are specific to bridges are given below.

- Bats roost in many different locations within old and new bridges. Features offering potential include any holes, cracks and crevices leading to voids, particularly where there is clear access.
- Roosting locations in which bats have been recorded in bridges include expansion joints; gaps at the corner of buttresses; widening gaps; gaps between old and new sections; cracks and crevices between stonework and brickwork where mortar has fallen out; drainage pipes and ducts; and internal voids within box girder bridges.
- Features of bridges are given specific terms: use the technical terminology in recording and reporting. *The Bat Workers' Manual* (Mitchell-Jones and McLeish, 2004) provides useful guidance, including diagrams.
- Bridges require specific health and safety consideration because they are often associated with watercourses, roads or railway lines. Access for survey may require a boat; scaffolding; a Mobile Elevating Work Platform (MEWP); a Permit to Work; Personal Track Safety (PTS) training and qualification; or a Track Visitor Permit (TVP). Survey may even require a road or rail closure. Confined spaces training may be required to access box girder bridges. All requirements should be discussed with the client and agreed with the relevant operating authority.

Underground sites

5.2.32 Underground sites can provide the specific microclimatic conditions that bats favour during hibernation in the winter (although they may also be used at other times of the year). A PRA carried out at any time of year can assess the potential for winter use, look for droppings (which can be subject to DNA analysis for species identification) and other signs and look for bats using the site at other times of the year. However, only the winter hibernation surveys will provide information on numbers of hibernating bats.

5.2.33 This section describes the considerations required for a PRA and Section 5.3 provides information on how to carry out a winter hibernation survey. The site in question may also be suitable for swarming bats and this should be checked; see Section 8.3. for survey methods.

- It is essential that ecologists entering sites where bats are hibernating have the appropriate licence to do so. In all except England, permission is defined in specific licence clauses; in England, it is part of the Level 2 class licence.
- Ecologists entering hibernacula should be familiar with the latest information and guidance on WNS; see para 2.8.11.
- The LBG or NBMP may be aware of the site and carrying out regular monitoring already.
- It is advisable to consult mining history organisations, the BCA[71] or local caving groups before undertaking visits to natural caves and abandoned mines. These organisations frequently have important site-specific information about safety precautions, site layout, history, records of bats and details of any access agreements.
- The BCA has published Minimal Impact Caving Guidelines, which are downloadable from their website[72].
- Caving groups may be available to provide training or practical assistance for survey work.
- Entering underground sites may require confined spaces training or rope access. A full risk assessment should be carried out and often a method statement is also required. Equipment and training specific to the site should be identified and obtained.

Complementary methods

5.2.34 As a last resort, it may be possible to capture bats by hand and handle them in order to identify their species, gender and age during a PRA.

Timing

5.2.35 PRAs can be carried out at any time of year providing any related limitations are recognised and reported.

5.2.36 If a maternity roost is identified, disturbance should be minimised during June and early July, when females are heavily pregnant or dependent young are present. Roost characterisation surveys (see Section 7.3) can be used to gain more information about maternity roosts.

5.2.37 If a hibernation site is discovered, then any subsequent disturbance should be minimised during the coldest months of December to February.

5.2.38 Further information about these roosts can also be gained from DNA analysis of bat droppings (to establish species), though it may be appropriate to collect these outside these sensitive periods.

Survey effort

5.2.39 The time needed for a PRA will vary according to the complexity of the structure and the number of ecologists deployed. Large structures with multiple roof spaces, multiple human access points and/or abundant voids and crevices will clearly take some time to understand and search thoroughly. Also, structures may contain several different bat roosts of different species each with their own access point and used at different times of the year. This all adds time to the survey.

70 https://batsinchurches.org.uk/
71 https://british-caving.org.uk/
72 https://british-caving.org.uk/our-work/cave-conservation/

5.2.40 As a guide, an internal inspection of a single roof area of a four-bedroom domestic property is likely to take one ecologist (with an assistant remaining outside the loft) approximately one to two hours; an internal inspection of a traditional timber-framed farm building may take one ecologist plus assistant between four hours and one day; an internal inspection of a large complex building such as a former hospital or stately home, with numerous roof voids and buildings, is likely to take one ecologist plus assistant several days. This is, of course, heavily dependent on the individual situation.

5.2.41 It is often difficult to have confidence in negative PRA survey results. For example, evidence of bats can be weathered away or bats could roost in inaccessible cracks and crevices, leaving little or no external evidence. It may therefore be necessary to spend more time searching and employ equipment such as mirrors and endoscopes.

Weather conditions

5.2.42 PRAs can be carried out under any weather conditions providing the survey is safe and any related limitations are recognised and reported.

Next steps

5.2.43 Where the possibility that bats are present cannot be eliminated or evidence of bats is found during a PRA, then further surveys (such as winter hibernation (Section 5.3), presence/likely absence (Section 7.2) and/or roost characterisation (Section 7.3) surveys) are likely to be necessary if impacts on the roosting habitat (or the bats using it) are predicted. If it has not been possible to access the structure internally, then an increased number of subsequent surveys may be necessary. The ecologist should consider the further surveys needed (if any), their logistics (resources, emergence survey locations, timings), and any potential health and safety hazards reported.

5.2.44 If the structure has been classified as having low suitability for bats (see Table 4.1), an ecologist should make a professional judgement on how to proceed based on all of the evidence available and the balance of probabilities. Thought processes and decision making should be adequately recorded as a paper trail. If all areas (including voids, cracks and crevices) of a structure have been inspected and no evidence found (and is unlikely to have been removed by weather or cleaning or be hidden), then further surveys are not appropriate. If complete inspection is not possible then proportionality must be considered. A single survey during the summer months may be adequate to ensure nothing obvious has been missed and/or precautionary measures could be applied during works. This is likely to be a more proportionate approach than carrying out multiple surveys.

5.2.45 Information (photographs and detailed descriptions) should be presented in the survey report to justify this conclusion and the likelihood of bats being present at other times of the year estimated. If there is a reasonable likelihood that bat roosts could be present, and particularly if there are areas that are inaccessible for survey, then further surveys may be needed, but these should be proportionate to the circumstances.

5.2.46 If no suitable habitat for bats is found, then further surveys are not necessary. In this scenario, it is necessary to document how this decision has been reached; photographs and detailed descriptions should be made available as evidence of a robust survey and assessment.

5.3 Winter hibernation surveys – structures

Description and aims

5.3.1 A **winter hibernation survey** includes a detailed inspection of a structure during the winter to look for and identify hibernating bats or other evidence of bat occupation. These surveys are appropriate where the DBW (Chapter 4) or PRA (Section 5.2) has identified a site as having moderate or high suitability for hibernation and the structure is likely to be impacted by proposed activities. The aim of this survey is to determine the actual or potential presence of bats and the need for further survey and/or mitigation. In many situations, it is not possible to inspect all locations where bats may be present and therefore an absence of bat evidence does not equate to evidence of bat absence. Further information on hibernating bats is provided below.

5.3.2 'Classic' hibernation sites are often underground (e.g. tunnels, caves, mines, cellars) but may also be above ground (e.g. some ice houses and lime kilns) and they provide cool, stable and damp conditions favoured by some species for winter torpor and hibernation. It is worth noting that environmental conditions are likely to be species-specific, for example Downs & Wells (2021) showed that brown long-eared bats favoured lower humidity levels than lesser horseshoe bats. The remainder of this section is devoted to surveys of this type of site but see below for information on the different species. It should be noted that sites used for hibernation may also be used by bats at other times of the year and therefore other surveys may also be necessary. In particular, swarming surveys are often appropriate (see Section 8.3).

5.3.3 Hope and Jones (2012) used temperature-sensitive radio transmitters to measure patterns of torpor, arousal and activity in wild Natterer's bats in Hampshire. They found that arousal from torpor in this species in this location occurred frequently and was often timed according to prey availability. Bats with poorer body condition also aroused more frequently. However, arousals also happened when conditions were not favourable for foraging and the authors concluded that arousal from torpor is a requirement driven by factors as yet unknown. Bats do move around during the winter!

5.3.4 Ransome (2008) identifies three different types of horseshoe hibernacula based on the age and gender/reproductive status of the occupying bats. Variables that influence horseshoe hibernacula use include: increased use if in close proximity to cattle (bat winter foraging), and increased use of hibernacula with an air flow later in the season (so that bats with decreased food reserves are able to tell when external temperatures rise, and wake up to forage). These variables may result in movement within the same hibernation system, or moving to a different one.

5.3.5 'Non-classic' hibernation sites (see para 4.3.7 onwards) should also be considered. Void dwelling species (notably brown long-eared bat) can linger in buildings into the winter but may not be visible to surveyors during inspection. Pipistrelles are often found roosting individually in more exposed/thermally unstable locations (National Trust, 2018) and possibly possess more physiological flexibility than some of the other species. Avery (1985) observed pipistrelles in flight in all winter months and on one-third of winter nights in total. Sendor (2002) showed that roost switching between a variety of different hibernation sites, presumably providing different microclimatic conditions, is an important energy saving strategy for the common pipistrelle, resulting in high winter survival rates. Bell (2019) undertook acoustic and temperature monitoring at a viaduct showing highest activity of *Pipistrellus* at temperatures above 7°C but a secondary peak in activity in termperatures below -1°C. This was interpreted as bats moving to more thermally stable roosts during periods of frost and is consistent with the work described below.

5.3.6 Korsten *et al*. (2016) report on studies carried out in Germany and the Netherlands where common pipistrelle bats have been observed exhibiting autumn swarming behaviour at midnight outside large structures such as castles, apartment blocks and factory buildings (prominent structures in the landscape). These buildings are then used as mass hibernation sites, with swarming also observed during frosty periods in the winter. The bats enter the hibernacula during frosty periods and leave again when conditions are warmer. This is something to be aware of and survey methods are outlined by Jansen *et al*. (2022) that can be applied to appropriate buildings.

5.3.7 One notable example of mass hibernation in common pipistrelle in the UK is at Seaton Delaval Hall in Northumberland where 61 bats were observed (more were likely to be hidden) in stone crevices and in the arches of a balcony in February and March (National Trust, 2018). When such behaviour occurs, it may include longer distance migrants in addition to bats of local origin (Nusova *et al*., 2020).

5.3.8 Some species use tree roosts during the winter, often at lower levels which may be insulated from temperature fluctuations by the understorey. Species that have been found in tree roosts during January and February are barbastelle, Natterer's bat, Leisler's bat, noctule, Nathusius, common and soprano pipistrelle, and brown long-eared bat (Bat Tree Habitat Key, 2018). It is possible to search for hibernating bats in tree roosts during the winter, using a PRF inspection survey (see para 6.8.1 onwards), although hibernation should be assumed (without the need for survey) in woodlands with appropriate PRFs and tree-roosting species present.

5.3.9 Finally, bats can also roost in crevices and cavities in rock faces and in loose rock such as scree. More information on bats roosting in these types of situations can be found in Bat Roosts in Rock (Bat Rock Habitat Key, 2021) and on the Bat Rock Habitat Key website, which also hosts a database of records and recording forms to submit further records.

Equipment

5.3.10 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

5.3.11 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. A winter hibernation survey could cause disturbance to bats and therefore should only be carried out by ecologists with a survey licence that includes the relevant activities (some exclude hibernation surveys). Standard survey licences for hibernacula do not permit handling of hibernating bats and this is only rarely permitted by a specific project licence. The handling of hibernating bats should generally be avoided[73] except in the event of an emergency where the bat is in danger.

5.3.12 For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate for a hibernation survey but for anything more complex BCT Level 3 (CIEEM Accomplished) competence is essential. For the most complex sites, an ecologist at BCT Level 4 (Authoritative) may be needed.

5.3.13 Training relating to health and safety may also be required for hibernation surveys; examples include the safe use of ladders or confined spaces training (see Section 2.7).

Methods

5.3.14 This type of survey requires close and systematic inspection of all cracks, crevices and voids for hibernating bats using torches, mirrors and endoscopes. With the exception of the horseshoe bats, which usually hang freely from the walls and ceilings of hibernacula (Parsons *et al*., 2008), hibernating vesper bat species are often under-recorded because they crawl deep into crevices and can be difficult to find. Their presence is sometimes given away by droppings or oil staining around cracks and crevices or droppings beneath.

5.3.15 Bats periodically arouse to drink (Ben-Hamo *et al*., 2013), to feed if it is warm enough for insects to be active (Mas *et al*., 2022) and for unknown reasons (see para 5.3.3.). Arousal may also be triggered by disturbance through increased levels of noise, light or heat (Speakman *et al*., 1991). As these could result from the presence of ecologists, the number of ecologists and the amount of time they are present should be minimised. The disturbance is not always obvious to the observer at the time, as bats do not necessarily arouse immediately. There is evidence that the longer the bats have been in a torpid state, the more sensitive they are to arousal stimuli (Thomas, 1995). Bats should therefore be identified with minimal disturbance. The location and species (or genus) of all bats should be marked on a map of the structure or photographs or diagrams of features used.

5.3.16 Identification can be challenging with vesper bats because often only part of the bat can be seen. Experience is essential to gain as much information in as short a time as possible. If it is only possible to identify the bats to genus level (for example, with the *Myotis* species) then it may be possible to gain positive identification through other methods such as DNA analysis of droppings (Appendix 4) or collection of acoustic data (see para 5.3.23).

5.3.17 The presence of any significant accumulations of droppings, *Nycteribiid* pupal cases (Hutson, 1984) and stained or marked areas should be recorded, as these may indicate the presence of large numbers of bats at other times of the year. Further visits during different seasons may be required in such situations to assess use of the site. Visits at a particular time may also be needed if a future impact is predicted at that particular time.

5.3.18 See Appendix 4 regarding the collection of droppings for DNA analysis. This can be particularly useful in situations where species identification is not possible because bats are tucked too far into crevices for ecologists to see their diagnostic features.

5.3.19 Ecologists entering hibernacula should familiarise themselves with the latest information on WNS and Covid-19, provided in Section 2.8 on Biosecurity.

5.3.20 For 'non-classic' hibernation sites (see para 4.3.7), particularly those within/behind external features of buildings or cavity walls, the extent to which they can be surveyed is limited. Often only a destructive search would be definitive, and therefore counter-productive. A static detector placed outside a structure might pick up bats flying past on warmer nights rather than confirm winter use. This may give a useful understanding of winter bat activity if a number of buildings are being affected, but is unlikely to be helpful in relation to a specific building.

5.3.21 For void-dwelling species which can linger into winter (notably brown long-eared bat, serotine) but not always visibly so (e.g. where there is deep insulation obscuring joists or the peak of the void is well above head height, preventing close inspection), visual inspections supported by static detectors within the void, during conditions which include periods suitable for bats to be

73 Handling hibernating bats has been shown to have a detrimental effect (Speakman *et al*., 1991).

active (Park *et al*., 1999, Hope and Jones, 2012) can indicate continued presence or almost-certain absence.

5.3.22 It may or may not be possible to survey these 'non-classic' sites (see para 4.3.7) in buildings; in such circumstances, an assessment of the likely presence of bats will need to be made and projects progressed accordingly (see Reason & Wray, 2023).

Complementary methods

5.3.23 Deploying automated/static bat detectors can be useful in gaining information about hibernating bats (although these may also record bats outside the structure so caution should be exercised and the echolocation calls of *Myotis* species are notoriously difficult/sometimes impossible to separate (Parsons and Jones, 2000; Walters *et al*., 2012). Because the detectors can be left for long periods of time, they are more likely to pick up bats when they become active, which may be particularly useful at sites with deep crevices that cannot be inspected or at non-classic sites where void-dwelling species may linger (see paras 4.3.7 and 5.3.21.).

5.3.24 Detectors should be deployed with temperature and humidity loggers to provide context (in terms of environmental conditions) for the survey results collected.

Timing

5.3.25 A PRA at any time of year may indicate the suitability of a site for hibernation and the presence of droppings can confirm that the site is used by bats (although an absence of droppings does not confirm absence of bats). Further surveys may be required to determine when and how many bats use the site.

5.3.26 The period during which bats hibernate is generally considered to be November to March, however the timing of hibernation in any given winter can vary depending on factors such as location, ambient temperature, humidity, species and life stage. Different sites are likely to be used at different times, dependent on the types of conditions they offer. Some species may only hibernate for extended periods when temperatures fall below freezing.

5.3.27 In order to fully establish presence/absence of bats, surveys across the hibernation season of November to March would be necessary because bats can move around and may be present at different sites at different times (due to ambient conditions and conditions provided at the site). However, peak numbers of hibernating bats are generally recorded in main hibernacula during the coldest months, particularly January and February (and perhaps December) and this is the time they are at their most vulnerable. Conversely, bats may tuck very deeply into crevices during very cold conditions making it impossible to find them. Where there are deep and inaccessible crevices, this scenario should be acknowledged and surveying at an alternative time or using alternative methods may be appropriate.

5.3.28 The aims of the survey should guide survey design – some considerations are provided above but another consideration is the type and timing of works and their impact.

5.3.29 **As a minimum, surveys should usually be spread four weeks apart during what are predicted to be the coldest months of the year in question (although see comment above regarding deep crevices).** Cold weather in the week preceding the surveys is likely to result in larger numbers of bats entering hibernacula. If these surveys reveal interesting results (e.g. rare or edge-of-range species, species assemblages, larger numbers of bats) then it may be necessary to carry out further surveys over and above these, to identify bats moving around between sites.

5.3.30 Ecologists should note that numbers may vary considerably between years depending on the ambient conditions and, where an important site is to be impacted, it may be appropriate to carry out multi-year surveys.

5.3.31 Automated/static surveys in structures during the late autumn, winter and early spring period should be undertaken between November and March. This less invasive approach may be more appropriate, e.g. the Department for Agriculture Environment and Rural Affairs (DAERA) in Northern Ireland are generally reluctant to licence inspection surveys for hibernation, instead favouring the use of statics to detect winter activity.

Survey effort

5.3.32 Because winter surveys may disturb hibernating bats, visits should be limited to the minimum necessary to gain the required information. **If it is necessary to assess the numbers of bats using a site, two visits spread four weeks apart during the coldest months of the year in question (generally January and February but could be December) are recommended, although this could be adjusted if very deep and inaccessible crevices are present, or if bats are suspected to be hibernating but are absent at the time of the surveys, or if an impact is predicted at a particular time, or if felt appropriate due to species-specific considerations.**

5.3.33 Since horseshoe bats do not crawl into crevices, they are easier to reliably count. Horseshoe bats feed during winter and respond to both weather and local foraging conditions (Ransome, 1990). For example, caves near winter livestock grazing are more likely to be used for hibernation than those not (Ransome, 2002). For these reasons, consideration should be given to surveying potential horseshoe bat hibernation sites (within their UK range) three times per season to more fully assess site importance. This should consist of an early visit (late October/November) in addition to the two described above. This additional early survey may also capture transitional usage and mating sites.

5.3.34 Automated/static surveys for winter activity within structures with a moderate to high likelihood of bats being present should be undertaken over a minimum of two weeks per survey each month from November to March.

5.3.35 Absence is more difficult to demonstrate and, in some cases, it may be prudent to assume that a suitable site underground in good habitat and close to other known roost sites is used by bats.

Weather conditions

5.3.36 Ambient weather conditions have a big impact on hibernation in bats. The largest numbers of bats are often found during the coldest months and after periods of cold weather. As this can vary year to year, numbers of bats present in hibernacula can vary considerably between months and between years and this should be considered in designing surveys and interpreting survey results.

Next steps

5.3.37 Hibernation sites should be surveyed to check for bats exhibiting autumn swarming (see Section 8.3).

5.3.38 Where bat hibernation roosts are likely to be impacted by proposed activities, it will be necessary to carry out an impact assessment and design an appropriate mitigation strategy with habitat enhancements for bats where appropriate. This information is essential to inform a planning application or EPS licence application to allow the proposed activities to proceed legally.

Chapter 6

Surveying trees and woodland for bat roosts

6.1 Introduction

6.1.1 This chapter provides information on carrying out surveys of trees and woodland for bat roosts. Additional sources of information are BS 8596:2015 Surveying for bats in trees and woodland (BSI, 2015), Bat Roosts in Trees (BTHK, 2018) and BTHK website[74], containing up-to-date reports.

6.1.2 These surveys may be required where development proposals include tree removal or surgery, where bats or their roosts could be *directly* impacted if present.

6.1.3 Some of these surveys may also be needed where bats roosting in a tree could be *indirectly* impacted by development activities such as disturbance from lighting, noise, vibration or removal of trees or vegetation from the area.

6.2 Questions to ask

6.2.1 Some basic questions that a PEA (for projects of all types/scales) should aim to answer are:

- Which bat species are already known to be present in the area?
- Are there any existing records of bat roosts in trees?
- What is the availability of different habitats in the landscape? How connected are the different landscape elements that are likely to be of value to bats?
- Are PRFs likely to be a limited resource?
- Roughly how many trees with PRFs are likely to be impacted directly and indirectly by the proposed activities?
- Can impacts be avoided either by retaining the trees or reducing the amount of tree surgery?

More detailed surveys may then be designed to establish the roosting resource available:

- Are there PRFs present in the trees likely to be impacted directly and indirectly?
- What is the spatial distribution of the trees with PRFs?
- Which tree species are the PRFs in, what type of PRFs are present and where?
- What is the temporal distribution of the bat activity, i.e. when might different species be using tree roosts?
- Are roosts of high conservation significance (e.g. maternity roosts or hibernation roosts supporting larger numbers of bats) present?

Actually finding all roosts (or showing that roosts are absent) is, however, a much more difficult proposition and bespoke survey design requires the application of professional judgement.

6.3 Survey design

6.3.1 Survey design will need to be tailored according to the situation and should always be proportionate and iterative, with each survey informing the next (which means data must be analysed as it is collected and not left until the winter).

6.3.2 The 3rd edition of these guidelines recommended a subjective system for categorising individual PRFs and trees and a set approach to subsequent surveys depending on this categorisation. This edition moves away from that approach, acknowledging that subjectivity but also recognising the many constraints associated with surveying trees for bats.

6.3.3 Projects vary in their type and scale, and larger projects that extend over a number of years are likely to require a staged approach to bat surveys of trees and woodland (see Table 6.5.). For example, linear infrastructure projects will undergo early route options appraisal, preferred route selection, detailed design, planning, licensing, delivery and monitoring stages – all of which will require different levels of detail. A full suite of all survey types at every stage would be onerous and inefficient. Initially, it is likely to be more important to understand landscape context, the species present and the risks involved for bats.

6.3.4 Trees and woodland present a much more dynamic roosting environment than buildings and this should be considered when designing surveys over longer periods of time. Bats in trees switch roosts and PRFs may appear or disappear over a period of several years. Box 6.1 provides more information on these constraints and others and Box 6.2 provides some potential solutions.

74 http://battreehabitatkey.co.uk/?page_id=43

Box 6.1. Constraints of surveying trees and woodland.

Surveying trees for bat roosts can be more challenging than surveying buildings because many species that use trees for roosts are known to exhibit roost-switching behaviour, including barbastelle, Bechstein's bat, Daubenton's bat, Natterer's bat, Leisler's bat, noctule, common pipistrelle and brown long-eared bat (Harris and Yalden, 2008, Dietz and Kiefer *et al.*, 2016, Harris, 2020). Some UK examples are as follows. Waters *et al.* (1999) observed roost switching in Leisler's bat between every 2 and 10 days; Smith and Racey (2008) observed roost switching in Natterer's bat on average every 3 days; and Ngamprasertwong *et al*. (2014) recorded roost switching in Daubenton's bat every 1.5 days in non-breeding females and every 5 days in lactating females. Frequent roost switching has also been observed in barbastelle (Billington, 2003; Greenaway, 2001; Zeale, 2011) and Bechstein's bat (Kerth *et al*., 2001a 2001b; Dietz and Pir, 2011), two of our rarest species. In woodland situations, it may be more appropriate to consider that the whole woodland is a roost rather than individual features.

Estimates have been made as to the number of trees used by breeding colonies of different species, as reported in BTHK (2018). These figures are included for illustrative purposes only, to show that colonies need large numbers of trees, rather than to suggest that all colonies of these particular species will have this exact number of roosts. Actual numbers will be hugely site dependent.

- Barbastelle 27 trees
- Bechstein's bat 35-40 trees
- Daubenton's bat up to 40 trees in one year
- Leisler's bat up to 50 trees in one year
- Noctule up to 60 trees in one year

Additional difficulties inherent in finding tree-roosting bats are as follows:

- some tree features cannot be seen from the ground – in a study of tree roosts known to be occupied by radio-tagged bats by Davidson-Watts (*pers. comm*., 2021), in 26% of cases the features could not be identified from ground level;
- trees and woodlands are dynamic and continually subject to change – some tree features can be particularly unstable (e.g. lifting bark);
- some tree features cannot be safely accessed for inspection (e.g. in dead trees/limbs);
- bat droppings do not persist in trees in the same way as they do in buildings, they can decay much more quickly;
- some tree-roosting bats echolocate very quietly (and sometimes not at all, even on emergence) and are therefore difficult to detect using bat detectors;
- some tree-roosting bats emerge from their roosts very late and return very early; and
- emergence surveys are often constrained due to the height of tree roosts above ground level and restricted observation due to foliage or lack of light under the canopy, making it hard to pinpoint any emergence to a specific tree.

Andrews and Gardener (2015) presented a summary of evidence and an encounter probability model for PRF inspections for tree-roosting bats (based on the known roost-switching behaviour of Bechstein's bat) showing that a high number of repeat visits is required to detect bats.

Because tree-roosting bats move around and surveys are constrained, it is very difficult to establish absence. However, some of our rarest species are heavily reliant on tree roosts and most of our other species also use trees for roosting at some point.

Box 6.2. Some useful solutions.

Night vision aids (NVAs): In a presentation to the UK Bat Steering Group[75] Davidson-Watts compared the results of emergence surveys of known roosts in trees from surveyors and from infra-red cameras. Seventy-four roosts were included in the study, found through radio-tracking tagged bats. The study found that surveyors could not see PRFs on average 20 minutes after sunset in woodlands and 29 minutes after sunset outside of woodlands. When all the data was pooled, bats emerged on average 8 minutes after PRFs could no longer be seen by surveyors. Whilst overall 22% of surveys saw bats emerging in conditions light enough for surveyors to see them, this was species-specific, with a much higher probability of observing the emergence of noctule and soprano pipistrelle (which tend to emerge earlier) than all of the other species. It is also true that emerging bats do not always echolocate, further reducing the likelihood of detecting the presence of a roost, or accurately counting the bats using a roost. Infra-red camera technology has become much more accessible, and this research shows that most situations require use of such visual aids in order to carry out effective surveys of trees.

Motion-activated camera monitoring: At the time of writing, there have been significant advances in the development of motion-activated camera monitoring for PRFs (see Lang, 2022, and Mullholland[76]). This technology can be used to remotely monitor PRFs continuously over a number of nights in order to detect any emerging and returning bats. This technology

75 https://cdn.bats.org.uk/uploads/images/Can-you-see-what-I-see-Ian-Davidson-Watts.pdf?v=1625596227&_gl=1*dbhhyq*_ga*MjEwNDcwMTA2Ny4xNjIxNDEyMTg1*_ga_G28378TB9V*MTY5MTMxMjk4My4xMDMuMC4xNjkxMzEyOTgzLjAuMC4w

76 https://www.batlicence.co.uk/trail-camera-equipment/

Box 6.2. Some useful solutions. *continued*

could potentially change the face of tree surveys for bats. At the time of writing, a number of motion-activated camera beta units (adapted for bat surveys) are being trialled (Peter Shepherd, *pers. comm*., 2023)[77].

The BTHK: The BTHK Project has advanced our understanding of how bats use trees for roosting. The associated database of records of bat roosts in trees, though incomplete, can be interrogated to find out which bat species and roost types (e.g. maternity, hibernation) have been found in which habitats, tree species, PRF types and at which times of the year. Thus, once an understanding of which habitats, tree species and PRF types are present, and acoustic surveys have identified which species are (or are likely to be) present, the database can potentially be used in a predictive way. A worked example of this can be found on the BTHK website under the 'References' tab[1]. It is important that data continue to be added to the BTHK database to improve its predictive capabilities (it is only as good as the data submitted). The BCT have taken over the management of the BTHK.

Bat Roost Tree Tag Project (BRTT): The BCT have also set up the BRTT[78], which aims to reduce the accidental felling of trees with bat roosts by providing a clear tag indicating the presence of a bat roost following surveys. This project has committed to contributing data to the BTHK database where all the relevant data fields are available to inform our understanding. The BRTT Project is also collecting data separately, where this is insufficiently complete for the BTHK database. This will further inform our understanding of bats roosting in trees.

6.4 Survey types available – pros and cons

6.4.1. Table 6.1 details the different types of surveys that are available for bat roosts in trees and their pros and cons.

Table 6.1. Different types of surveys for bat roosts in trees and their pros and cons.

Survey type	Description	Pros	Cons
PEA	A desk study and follow-up fieldwork involving a DBW to record trees/groups of trees suitable for bats to roost. May involve categorisation on smaller sites (NONE, FAR, PRF), see Table 4.2	Can identify if roosts are already known to be present. Identifies which species are known to be present in the area. Gives information to start planning further surveys.	Doesn't identify roosts and species that are present but not known of from records. Very high level.
GLTA	A ground-level search to look for PRFs in trees and describe them.	Catalogues the available roost resource.	Crude because PRFs at height cannot be inspected. Some PRFs may not be visible from ground level.
PRF aerial inspection survey	An elevated search to inspect PRFs in trees either by climbing or the use of equipment such as ladders, MEWPs, or scaffold towers.	Catalogues the available roost resource in a more accurate way. Allows a search for evidence of bats in low and higher level features. Whilst in the tree can look for PRFs that are not visible from the ground. More valuable than an emergence survey, which can only provide a snapshot of a single night	Requires appropriate licence to be in place. Rope work requires specific training in Tree Climbing and Aerial Rescue and may not be for every ecologist. Use of ladders, MEWPs and scaffold towers also requires specific training. Scaffold towers may need to be hired. MEWPs require hiring the vehicle plus a qualified driver and safety harness training for the ecologist. May not be able to fully inspect features because they are too extensive or complex. May not be able to access features for safety reasons (e.g. dead trees/limbs,

77 https://bsg-ecology.com/first-batcams-distributed/
78 https://www.bats.org.uk/our-work/landscapes-for-bats/bats-and-woodland/bat-roost-tree-tag-scheme

Table 6.1. Different types of surveys for bat roosts in trees and their pros and cons.

Survey type	Description	Pros	Cons
			close to a highway, cables, over water). Can damage transient PRFs such as lifting bark. Likelihood of bat presence at the time of the survey is low due to roost-switching by tree roosting bats. Evidence of bats quickly decays in PRFs. Can provide a low rate of return in terms of roosts found.
Bat activity surveys	Observation and acoustic (manual or static) surveys using bat detectors to establish species and an measure of bat activity.	Establishes the species that are present in the area that could use the trees for roosting. Early registrations can indicate the presence of a roost.	Species recorded may be present in the area but not roosting in the trees impacted by proposed works. Some species call quietly and are difficult to pick up on detectors (or do not echolocate). Species echolocation call parameters overlap so it can be difficult to identify some calls to species level.
Backtracking surveys	Backtracking surveys are based on observations of bats flying away from or towards roosts in order for surveyors to locate the roost.	Backtracking may locate roost trees.	Backtracking surveys can be difficult/ineffective underneath the canopy and in large areas of woodland. Some PRFs may not be visible from ground level. Some bat species leave and/or return to roosts when it is too dark to see them without NVAs.
Dusk emergence surveys (in person)	Observation (preferably using NVAs) and acoustic surveys (using bat detectors) to count bats emerging from their roosts.	Is best deployed for roost characterisation, when occupation of a PRF has been established by the presence of bats during same-day inspection surveys or by the presence of a radio-tagged bat. Could potentially be used instead of PRF inspection surveys if features cannot be safely accessed for inspection, e.g. in dead tree or where PRF is delicate such as lifted bark. Enables accurate counts of number of bats where visual aids are used.	Likelihood of bat presence at the time of the survey is low due to roost-switching by tree-roosting bats therefore not suitable to confirm absence of a roost used at other times of the year. Not a suitable method for presence/likely absence surveys unless other reasons prevent close inspection. Can be very inefficient and expensive, particularly if there are a large number of trees. Some PRFs may not be visible from ground level. [Other constraints such as quiet-calling and late-emerging species can be overcome by use of NVAs.]
Motion activated trail cameras	Use of motion activated trail cameras attached to trees to record bats emerging from or returning to roost features.	Can be deployed over a period of time without the need for a surveyor.	Technology is not yet available off the shelf and full guidance is not yet available on deployment, frequency of visits to check equipment is operational etc.

Table 6.1. Different types of surveys for bat roosts in trees and their pros and cons.

Survey type	Description	Pros	Cons
		No disturbance to the bats at the time they are emerging or returning. Records accurate, retainable evidence of bat emergence/return activity.	Deployment could potentially cause disturbance to bats or damage to roost features. Need qualified climbers – or MEWPs to fit the cameras. Need a lot of units if there are a lot of PRFs.
Hand netting	Using a hand net to trap bats as they emerge from a known roost at dusk.	Can accurately identify bats in the hand. Can assess gender, age class and breeding status of the bats at a known roost, so good for roost characterisation.	Invasive. Requires appropriate licence to be in place. The presence of a roost should already be established before attempting this method. Most features cannot be seen or reached safely with a hand net from the ground so need to consider health and safety implications.
ALBST	Trapping and radio-tracking bats to find roosts.	Can find important maternity and other roosts used by tagged bats. Much more efficient than other types of surveys in locating roosts and may be best method if there are a large number of trees.	Invasive. Requires appropriate licence to be in place. Sampling method – unlikely to use this method to find all of the roosts present. Resource-heavy, so can be difficult to source enough suitably-trained personnel. Can cause injury to bats if used incorrectly. Increased health and safety considerations for surveyors due to night-time working and driving.

6.5 Decision-making on tree surveys

6.5.1 Figure 6.1 illustrates the decision-making process and recommended baseline surveys of sites with trees. Table 6.2 provides a new system of categorisation for PRFs. Table 6.3 shows the types of survey approaches that might be relevant in different scenarios following completion of the steps in Figure 6.1. Box 6.1 provides an example comparing tree-climbing with ALBST. Table 6.4 shows an approach to summer inspection surveys. Where there are many PRFs and bats roosting in trees at other times of the year, then hibernation use should be assumed and accounted for in mitigation and compensation strategies.

Figure 6.1. Flow chart illustrating decision-making process and recommended baseline surveys of trees/site.

Note that for larger-scale projects that extend over a number of years, survey design will need adjustment, see Table 6.5. For these types of projects, bespoke approaches are normally drawn up between ecologists and the relevant SNCB. Consultation is essential.

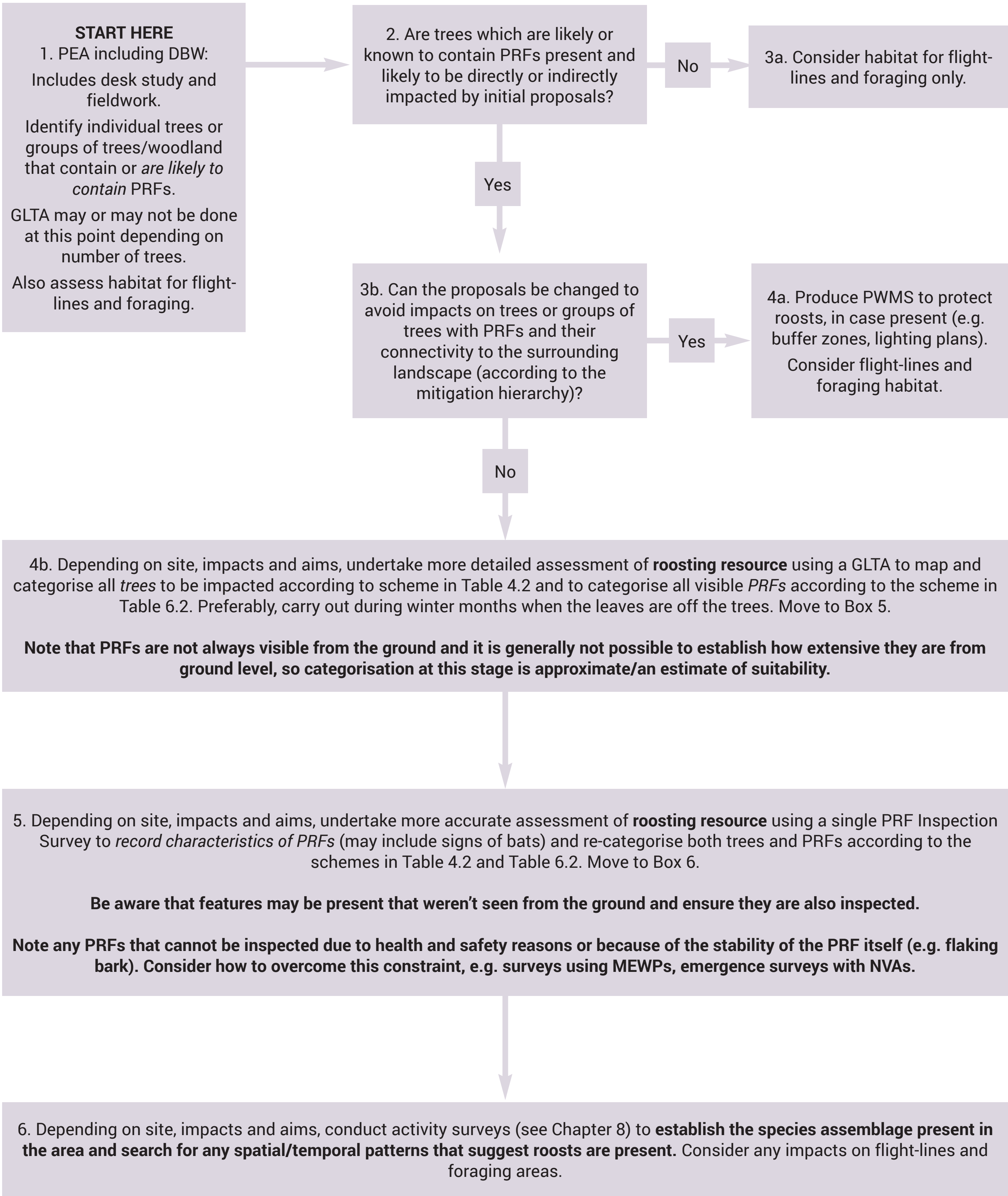


Table 6.2. Guidelines for categorising the potential suitability of PRFs on a proposed development site for bats, to be applied using professional judgement.

Suitability	Description
PRF-I	PRF is only suitable for individual bats or very small numbers of bats either due to size or lack of suitable surrounding habitats.
PRF-M	PRF is suitable for multiple bats and may therefore be used by a maternity colony.

Table 6.3. Showing types of survey approaches that are relevant to tree surveys following steps taken in Figure 6.1.

Scenario	Types of approaches after considering impact avoidance as first step in mitigation hierarchy.
Known bat roosts	Roost characterisation surveys (see Section 7.3) followed by EPS licensing (for loss) or PWMS (for e.g. disturbance impacts where buffers are required).
INCREASING: numbers of trees number of PRF-Ms likelihood of maternity/hibernation roosts likelihood of nationally or locally rare tree-roosting species	**ALBST** Consider trapping, tagging and radio-tracking to find roosts of high conservation significance (see Chapter 9). This method is likely to be appropriate on (a) nationally significant infrastructure projects, (b) projects that impact sites designated for tree roosting bats, and/or (c) areas of woodland with high suitability for bats or ancient woodlands. See Box 6.1. CONSULTATION WITH RELEVANT SNCB IS ESSENTIAL, A BESPOKE APPROACH MAY BE REQUIRED[79]. **FURTHER SURVEYS APPROACH (but consider cost-effectiveness when compared to ALBST)** PRF inspection surveys for PRF-M features in summer (see Table 6.4. and Section 6.8). Where features inaccessible or too extensive for PRF inspection, carry out emergence surveys in summer with NVAs (see Table 6.4. and Section 7.2). Consider winter roosting potential. MAY NEED TO CONSULT WITH RELEVANT SNCB. **ROOST RESOURCE APPROACH (if only PRF-Is[a])** No further surveys. Provide appropriate compensation for all PRF-Is in advance of impacts and a PWMS for works (see Reason & Wray, 2023).

a If there are larger numbers of trees with features categorised as PRF-I then this increases the likelihood of a roost being present. Conversely, if there are very few trees in the landscape then PRF-I features may have increased importance. Context should always be understood and considered.

79 One such bespoke approach – the Woodland Roost Resource approach – is described in Davidson-Watts and Hinds (2022).

Box 6.1. Example comparing large-scale tree climbing to the ALBST approach.

On one major landscape-scale project near London covering 42km^2 with a range of habitats present, 567 trees were identified as having moderate or high bat-roosting potential. Tree climbing to inspect PRFs on suitable trees was conducted over 2 years and identified a total of 12 roosts including one satellite maternity roost. ALBST surveys conducted over the same period, including trapping and radio tracking all species present in the area, identified a total of 115 roosts, 57 in trees and an additional 58 in buildings. As a cost comparison, the ALBST surveys were slightly cheaper than the tree-climbing surveys. However, the ALBST surveys provided much added value in confirming the locations of maternity roosts of all species either on or off the site in structures or trees. It also accurately identified the species, sex and breeding status of bats on the site, more accurate proportions of each species present, flight-lines, core foraging areas, core roost areas and patterns of movement by members of the same maternity colony.

Table 6.4. An approach to aerial inspection surveys for bats in trees.

Type of bat activity	Approach to PRF-M aerial (close) inspection surveys[a]
Pregnancy, nursery and mating[b]	3 visits[c] between May and September[d], with at least two in the period May to August. Where access is not possible for aerial inspection either by ladder, climbing or MEWP, or features are too extensive to survey thoroughly, these could be emergence surveys supported by NVAs, as described in Section 7.2. Once an inspection survey has identified a maternity roost then it would be better to switch to a less invasive method to gain more information (if needed), such as an emergence count with NVAs (advisable to do so as soon as possible after the roost is identified).

a Note that the PRF inspection survey in Box 5 of Figure 6.1 could count as one of the visits described in this table.

b Note that hibernation checks of trees are not covered here but bats do hibernate in trees and, if there are suitable PRFs and tree-roosting bats present in the area, then inspections can be carried out. Alternatively, hibernation could be assumed and mitigation planned accordingly.

c Multiple survey visits should be spread out to sample as much of the recommended survey period as possible; it is recommended that surveys are spaced **at least three weeks apart,** preferably more. Survey timings **should consider the prevailing conditions in the year of survey, which will vary geographically**.

d In years with a cold spring, the surveys should not be started in early May. The surveys should maximise the possibility of detecting maternity roosts, and the **optimum coverage includes the pre-parturition, post-parturition and mating periods.**

6.5.2 Table 6.5 provides a framework for the planning of large, long-running projects involving many trees. The questions are framed around the route of a linear project as an example, but the process is similar for a footprint development. The division between stages is not absolute, and stages may be compressed. The list of surveys is not exhaustive, but indicative. The important point is to frame the questions that need to be answered at each stage and tailor the survey effort to answer those questions.

6.5.3 The framework used should always be discussed and agreed with the relevant SNCB and consenting body.

Table 6.5. Survey effort for a large long-running project involving many trees (see notes above).

	To inform route options	To inform selection of preferred route (maybe two-three options of a road scheme or route modifications of an overhead line within a broad corridor)	To inform detailed impact assessment and detailed design	To inform any licence(s) required
Questions	➢ Will any of the route options pass close to (or within the ZoI of) any internationally or nationally designated sites for bats or with bats as part of the reason for designation? ➢ Which species are known or likely to occur given distribution; what is their conservation status; what types of habitats are they likely to be found in and are these habitats present? ➢ Are there likely to be species listed in Annex II of the Habitats Directive? ➢ Are there likely to be species particularly at risk of being impacted by the type of activities proposed?	➢ What habitat types are present that are (a) likely to be used by bats for roosting, foraging or commuting, and (b) likely to be impacted by the proposal? ➢ What is the likely suitability of those habitats for bats? ➢ How do the habitats that would be directly affected connect to habitats in the surrounding area to create an ecological network? Note that in impoverished landscapes, small areas of woodland (or other resources) may have greater importance than in a richer landscape. In some areas: ➢ Are any specialist techniques required arising from the potential presence of particular species; for example, the use of trapping with acoustic lures to detect the presence of Bechstein's bat? For some types of project: ➢ Are any specialist techniques required arising from the potential for project-specific impacts (for example, the need to survey at crossing points on a proposed linear scheme).	➢ Which bat species are present within the ZoI of the project? ➢ Which bat species are roosting within area(s) directly and indirectly affected by the project? ➢ Are actual roosts present within the roost resource affected? ➢ If so, how many bats do these roosts support (time of year and numbers will enable an assessment of roost type)? ➢ At what times of the year are bats likely to be present; how is use likely to change seasonally? ➢ What are the activity levels of bats on the site and can this tell us anything about the abundance (number) of bats using different areas of the site? ➢ What is the temporal and spatial distribution of recorded bat activity on site?	➢ Have sufficient surveys been undertaken to inform a licence[80]? ➢ Consider direct/ indirect impacts.
Survey Methods	➢ Desk study, to include aerial photographs. Should be used to answer the questions above, and determine the best route option(s), noting that many other factors will determine the preferred route. ➢ An initial walkover may be undertaken at this stage	➢ Assess the size and connectivity of woodland blocks as well as the type and quality of their surrounding habitats. This will determine whether a strategic or site-targeted approach is required. Strategic/landscape scale approach ➢ ALBST surveys preferred to find roosting hotspots, determine species assemblage and general activity pattern. This can be done over a wide area. ➢ In tandem, if woodlands are extensive and several route options are still being considered, consider dividing the woodlands that could be affected into representative blocks and undertaking an assessment of a representative proportion of the trees present within each woodland block (e.g. based on aerial photography and a walkover, and taking into account woodland area). ➢ Results to be scaled up to give an indication of the overall bat tree roost resource, and how it could be affected by the project options. Site-targeted approach ➢ GLTAs of the woodland roost resource. ➢ Static detector deployments to identify the bat species using the woodland habitats likely to be affected, and the nature of that use (based on timing/season). ➢ Trapping within woodlands to determine presence of rarer/cryptic species (geography and impact-scale dependent).	➢ GLTAs ➢ Aerial inspections ➢ Static detector deployments ➢ Ground-truthing hotspots of activity with manual observers, *if required.* ➢ Undertaking ALBSTs if the results and the nature of impacts suggest this would be advisable (i.e. if rarer species impacted, and/or need to confirm breeding status or assess landscape-scale effects). Further surveys dependent on results and impacts. However, for a project where the planning phase spans several years, it is not necessary to repeat surveys every two years unless there is a very specific reason to do so.	➢ Complete the requisite number of surveys. *Excludes pre-construction surveys such as pre-felling checks: see Reason and Wray, 2023.*

80 Or, for an NSIP in England, a Letter of No Impediment: see https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/10/PINS-Advice-Note-11_AnnexC_20150928.pdf

6.6 Notes on tree surveys, licensing, mitigation and compensation

6.6.1 Due to the survey limitations identified, and from what is known about the ecology of tree-roosting bats, it is arguable that all trees with bat-roosting potential should be considered part of a roosting resource that will be used at one time or another by tree-roosting bats.

6.6.2 More information on avoidance, mitigation and compensation can be found in the UK Bat Mitigation Guidelines (Reason & Wray, 2023). However, some overarching principles are given below as they relate to the statement above.

6.6.3 Precautionary measures such as careful timing of felling/pruning are appropriate, and PRF inspection surveys are likely to still be essential immediately before works, even where earlier surveys have not identified occupancy of PRFs by bats.

6.6.4 There should be no reduction in the roosting resource following development and preferably the roosting resource should be increased, providing enhancement. Careful and appropriate mitigation needs to be provided to ensure that the resource is sufficient and available immediately, from the outset, or other alternate methods used to ensure bats are not without a suitable resource.

6.7 Ground level tree assessment (GLTA)

Description and aims

6.7.1 A **GLTA** is a detailed inspection of the exterior of the tree from the ground to look for features that bats could use for roosting (PRFs). The aim of this survey is to determine the available roosting resource and the need for further survey and/or mitigation. This survey should be carried out before any PRF inspection surveys (para 6.8).

Equipment

6.7.2 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

6.7.3 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. A GLTA is unlikely to result in disturbance to bats unless the ecologist intends to investigate low-level PRFs in trees with a torch or endoscope. Disturbance through noise should be kept to a minimum during the survey, bearing in mind some tree-roosting species can be sensitive to disturbance. If disturbance to bats is a possibility, then a survey licence is required covering the relevant activities.

6.7.4 BCT Level 2 (CIEEM Capable) competence is adequate for a GLTA, but when it comes to making decisions relating to the results, BCT Level 3 (CIEEM Accomplished) competence is likely to be needed on all but the most simple sites. The most complex sites may require a higher level of competence than this.

Method

6.7.5 The method involves a detailed inspection of the tree from the ground to compile information about the tree, PRFs (or lack of), and any evidence of bats. Sufficient time should be allowed to complete the inspection during daylight hours. Poor light conditions can mean that PRFs are missed in trees. The inspection should be carried out systematically and consistently around all parts of the tree (from all angles and from both close to the trunk and further away) and the results recorded in a standard format. High-level PRFs can be identified by shining bright torches on cavities and shaded areas of the branches and binoculars help to focus in more detail. PRFs that appear to point upwards should not be eliminated at this stage as it cannot be assumed that conditions would preclude use. It should also be noted that some features can appear inappropriate at one time of year (e.g. wet during the winter months) but become appropriate at other times of the year (e.g. during the summer). The presence of other organisms at one time doesn't mean they will be present year-round. Trees and tree roosting bats are dynamic and this should be factored in.

6.7.6 PRFs that can be exploited by bats are detailed in Table 6.6.

Table 6.6. PRF types that can be exploited by bats and how they form (adapted from Bat Roosts in Trees, BTHK, 2018).

PRFs formed by disease and decay	PRFs formed by damage	PRFs formed by association
woodpecker holes squirrel holes knot holes pruning cuts tear outs wounds cankers compression forks butt rots	lightning strikes hazard beams subsidence cracks shearing cracks transverse snaps welds lifting bark desiccation fissures frost cracks	fluting ivy

6.7.7 Bat Roosts in Trees BTHK (2018 and 2020) provide more information on these types of features and how/why they form in trees. It is important that arboricultural terms are used by ecologists in order for them to work effectively with arborists and vice versa.

6.7.8 All trees surveyed should be numbered and marked on a map or plan of the site (in most situations, even trees with no PRFs may need to be mapped as a record). The most efficient way to do this is to use tablets in the field to position tree locations onto a GIS map (although GPS error may be a problem and back-up methods may need to be applied).

6.7.9 Information collected about the tree should include (as a minimum) the recorder name, site name, county, date, location (grid reference), Phase 1 habitat type/UK Habitat Classification, tree species, tree height, whether the tree is alive or dead and the tree tag number where one is present. Diameter at breast height can also be measured using a specialist tree tape (logger's tape); the number of stems can be recorded if the tree has been coppiced. This information will enable ecologists to locate the tree on subsequent visits.

6.7.10 It is often difficult to find trees in a group or in woodland on a second survey visit and therefore marking individual trees with a tag or some tape is very helpful. Tags to identify confirmed bat roost trees, along with guidance on their use, are available from the BCT as part of the BRTT

Project[81]. The permission of the landowner should always be sought before any marking of trees.

6.7.11 Information collected about PRFs should include whether the PRF is on a stem or a limb and the PRF type, height and what direction the PRF faces. The height and orientation of the entrance can also be recorded if this is different. This information will enable ecologists to locate the PRF on subsequent visits.

6.7.12 The only conclusive sign of a bat roost is actual bats or their droppings. The latter, where found, should be collected, dried and sent off for DNA analysis unless the identification of roosting bats has been established reliably via other means (see Appendix 4 regarding the collection of droppings for DNA analysis). However, droppings are less likely to persist in tree roosts than in buildings and the absence of droppings does not mean that bats are absent from a PRF. Another sign of presence may be bat fly puparia (pupal cases) (Hutson, 1984).

6.7.13 Other signs that could indicate a bat roost are odour (an ammonia-type smell), staining below the entrance or inside, smoothing of the entrance and audible squeaking at dusk or in warm weather. These are not conclusive alone or in combination because they could result from other animals such as birds or squirrels, and staining may be the result of wet rot, which would preclude roost presence. However, many bat roosts in trees exhibit no external signs.

6.7.14 During a GLTA, the suitability of trees and PRFs can be categorised according to the categories outlined in Tables 4.2. and 6.2 respectively. However, at this stage, the PRFs are not inspected in any detail and therefore this is only an *estimate* of their potential for supporting roosting bats.

Timing

6.7.15 GLTAs are best carried out in winter (after the leaves have fallen and before new ones replace them – around December to March) and even then it may not be possible to see all PRFs from ground level. If it is necessary to carry out these surveys when the leaves are on the trees, or it is suspected that trees support PRFs that are not visible from the ground, then these constraints should be taken into account. When these surveys are carried out in the summer, it may be possible to hear bats making audible social calls (or non-audible calls, using a bat detector) from roosts in trees.

Survey effort

6.7.16 The time needed for a GLTA will vary according to the size of the trees, the number of PRFs and the number of ecologists deployed.

6.7.17 As a guide, it may be possible for a single ecologist to inspect 20-30 trees in a day if those trees are large, veteran oaks with multiple PRFs. It may, however, be possible to inspect double the number or more if the trees are smaller and with less potential for roosting bats.

Weather conditions

6.7.18 GLTAs are best carried out in dry and calm weather because these conditions maximise the chances of seeing PRFs, although bright sunshine can make it difficult to see features in a tree due to glare. In addition, health and safety considerations may prevent access to a woodland in particularly bad weather such as strong winds.

6.8 Potential roost feature (PRF) inspection surveys – trees

Description and aims

6.8.1 A **PRF inspection survey** involves the use of tree-climbing or access equipment such as ladders, MEWPs or scaffold towers to gain access to PRFs. This will allow a more detailed assessment of their likely suitability for bats and to look for more conclusive evidence of bats such as live or dead bats and droppings (staining or odour may also be present). These surveys are valuable to more accurately assess suitability. Tree-climbing is often the most effective way to access all features but may be constrained by health and safety issues (e.g. trees may be unsafe to climb) or because PRFs are delicate. It may therefore be more appropriate to use alternative access equipment or consider other survey options.

6.8.2 The aim of this survey is to re-assess PRFs and determine the presence/likely absence of bats at the time of the survey and the need for further survey and/or mitigation.

Equipment

6.8.3 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13; survey-specific equipment is listed in Appendix 1.

Expertise and licences

6.8.4 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. A PRF inspection survey to look for bats could cause disturbance and therefore ecologists should hold a survey licence covering the relevant activities. Where bats are present, this allows immediate identification, reducing the risk that the bats will remain unidentified if not present on a subsequent visit.

6.8.5 BCT Level 2 (CIEEM Capable) competence is adequate for a PRF Inspection, but when it comes to making decisions relating to the results, BCT Level 3 (CIEEM Accomplished) competence is likely to be needed on all but the most simple sites. The most complex sites may require a higher level of competence than this.

6.8.6 In order to carry out PRF inspection surveys using tree-climbing, ecologists should be trained, qualified and experienced in tree climbing and aerial rescue and only work in pairs. Skills should be kept up-to-date through regular use and refresher courses are essential for those who use these skills only infrequently. If this is the case, teaming up with a more experienced climbing ecologist or a trained arborist (see below) will ensure that surveys are carried out as safely and efficiently as possible.

6.8.7 Training is available for arborists to understand basic bat ecology and biology specifically relating to bat roosts in trees, so that they can identify the types of features that bats may use. More advanced training is available for arborists in the use of endoscopes specifically to carry out further investigation of features to establish their true potential for bats following a GLTA (see BCT *et al*., 2015). Unless they hold a survey licence covering endoscopes, arborists should not be using endoscopes at known roosts or where disturbance to bats is likely.

6.8.8 If using ladders, then ecologists should be trained in their safe use. Owner- or operator-specific training may also be

81 See https://www.bats.org.uk/our-work/landscapes-for-bats/bats-and-woodland/bat-roost-tree-tag-scheme/

required when ecologists employ the use of MEWPs or scaffold platforms to access PRFs for inspection.

Method

6.8.9 The method involves accessing PRFs using a harness and ropes (or other access equipment) to carry out a detailed internal inspection using torches, mirrors and endoscopes. Information is compiled on the dimensions and protection from the elements and a search is made for evidence of bats. PRFs that appear to be of high suitability from the ground may only be of low suitability because, for example, they are filled with rainwater or are shallower than they initially appeared. Conversely, tree scar tissue can make good PRFs look less valuable than they actually are. Close inspection of features can therefore be extremely useful because it facilitates a much more reliable assessment of suitability and provides an opportunity for bats and bat droppings to be found if they are present at the time.

6.8.10 Care should be taken when using an endoscope, it should be inserted into PRFs slowly whilst the ecologist is looking through the viewfinder or at the visual display to check for bats and their signs. An endoscope should never be forced into a crevice or inserted without viewing and the endoscope should not therefore come into contact with a bat. If a bat is seen through the endoscope, disturbance should be minimised.

6.8.11 Sufficient time should be allowed to complete PRF inspection surveys during daylight hours. Poor light conditions could jeopardise safety and cause disturbance to bats at emergence time. The inspection should be carried out systematically and consistently around all parts of the tree and the results recorded in a standard format, preferably digitally to collect consistent data and avoid transcription errors.

6.8.12 During a PRF inspection survey, the ecologist should collect the following information (taken from BTHK database recording form):

- the diameter of the stem or limb where the PRF is;
- whether there are multiple entrances to the PRF;
- the PRF entrance width;
- the internal height, width and depth of the PRF;
- the substrate within the PRF;
- the PRF apex shape;
- whether the PRF is dry, damp or wet;
- whether any competitors are present;
- whether bats are absent or present;
- whether droppings are absent or present;
- if evidence of bats is lacking;
- if present – bat species, number of bats, whether bats are awake or torpid, location of bats, distance of bats from entrance; and
- any odour.

6.8.13 Again, it is worth considering that tree features will change during the year, e.g. from wet to dry or from occupied by other organisms to available.

6.8.14 Where bats are present, a photograph should be taken. Any droppings should be taken, dried and sent off for DNA analysis (unless identification can be confirmed using other methods). See Appendix 4 regarding the collection of droppings for DNA analysis. The lab used and the test results should always be included in reporting.

Timing

6.8.15 PRF inspection surveys can be carried out at any time of year, although the likelihood of discovering evidence of bats at different times should be considered (see Table 6.4.). Using the BTHK database, the timing can be organised to reflect the suitability of the PRF and the predicted seasonal use by bats. It is likely that more evidence will be deposited during the maternity season as bats come and go whilst they care for their young or switch roosts. However, it is at this time of year that the bats are more sensitive to disturbance, which should be minimised.

6.8.16 Tree-climbing surveys should also consider other protected species such as birds and red squirrels and, if present, the timing of surveys may need to be adjusted accordingly or a specific licence may be required. Be aware also of the potential presence of bees, wasps and hornets. If the species of hornet can be identified and it is an alien species (e.g. Asian hornet), this should be reported[82].

Survey effort

6.8.17 The time needed for PRF inspection surveys will vary according to the size of the trees and the number of PRFs. For tree-climbing, time taken often depends on experience. Efficiency can be gained by teaming up ecologists with arborists, who are often more experienced in accessing difficult areas of trees. For PRF inspections using access equipment such as cherry pickers, the time required is likely to depend more on ground conditions and barriers to movement such as hedgerows.

6.8.18 As a guide, it may be possible for an ecologist to inspect only two to four trees in one day if those trees are large, veteran oaks with multiple PRFs. It may, however, be possible to inspect two or three times this many if the trees are smaller and with less potential for roosting bats.

Weather conditions

6.8.19 Tree-climbing surveys are best carried out in dry and calm weather for safety reasons.

6.9 Emergence and re-entry surveys

6.9.1 Emergence and re-entry surveys are described in Chapter 7.

6.10 Bat activity and back-tracking surveys

6.10.1 Bat activity and back-tracking surveys are described in Chapter 8.

6.11 Hand netting

6.11.1 Hand netting is described in para 7.3.17.

6.12 Advanced Licence Bat Survey Techniques (ALBST)

6.12.1 ALBST are described in Chapter 9.

82 https://www.gov.uk/government/publications/asian-hornet-uk-sightings

Chapter 7

Emergence surveys – structures and trees

7.1 Introduction

7.1.1 This chapter provides information on carrying out dusk emergence surveys for bat roosts in structures and trees.

7.1.2 Emergence surveys are only recommended for trees *in a limited number of circumstances*. This includes where bat presence is already known (for example because a radio-tagged bat has returned to a roost or a roost has been identified through inspection surveys during the daytime before the survey) and roost characterisation is necessary. These surveys may also be required where a feature cannot be safely accessed for inspection (e.g. dead tree) or may be damaged by close inspection (e.g. lifted bark) – these are circumstances where emergence surveys might be the only option.

7.1.3 These surveys may be needed when structures or trees will be directly (through demolition, modification, pruning, felling) or indirectly (through lighting, noise or vibration disturbance, or changes to surrounding habitats) impacted by development proposals.

7.1.4 Emergence surveys should be designed to answer specific questions, such as:

- Are bat roosts present or likely to be absent?
- Which bat species use the site for roosting?
- How many bats do these roosts support?
- Where are the bat roost access points?
- Where are the bat roosts?
- At what times of year are bats present? How does use change seasonally?
- What types of bat roost (see Section 3.3) are present?
- What flight-lines do the bats use after emerging from the roost?

7.1.5 Answering these questions will allow an ecologist to carry out the impact assessment and design a mitigation, enhancement and monitoring strategy, where relevant.

7.1.6 Emergence surveys may be carried out to establish **presence or likely absence**, where previous surveys have not discovered evidence of bats, or to **characterise a roost**, where previous surveys have discovered evidence of bats. Survey design should be iterative; each stage informing the next. The effectiveness of the surveys should be considered at each stage.

7.2 Determining presence/likely absence

Description and aims

7.2.1 **Presence/likely absence surveys** include dusk visits (roost re-entry visits prior to dawn are no longer routinely recommended for presence/absence surveys due to the risk of bats returning early and being missed). Surveyors watch, listen for and record bats exiting bat roosts. If the presence of bats has been confirmed, then roost characterisation surveys (see Section 7.3) may be required (depending on how much information on species, numbers, access points, roosting locations, timing of use and type of roost has already been collected).

7.2.2 Presence/likely absence surveys would be needed if:

- the PRA (structures) has not ruled out the reasonable likelihood of a roost being present (because there are locations with potential for bats to roost undetected in concealed cracks, crevices or voids or evidence of a roost may have been removed), but no definitive evidence of the presence of bat roosts has been recorded;
- a comprehensive inspection survey of a structure is not possible because of restricted access, but there are features with a reasonable likelihood of supporting bats;
- there is a risk that evidence of bat use may have been removed by weather or human activities;
- a tree feature cannot be safely accessed for inspection (e.g. dead tree), or may be damaged by close inspection (e.g. lifted bark).

7.2.3 The aim of this survey is to determine the presence or absence of bats at the time of the survey and the need for further survey and/or mitigation.

Equipment

7.2.4 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

7.2.5 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Presence/likely absence surveys are unlikely to disturb bats if carried out correctly.

7.2.6 For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate for an emergence survey but, for anything more complex, an ecologist at BCT Level 3 (CIEEM Accomplished) competence should at least design and may need to lead these surveys.

Method

7.2.7 The method involves ecologists visiting at dusk to listen/record (using a bat detector and, usually, an NVA) and observe bats emerging from their roosts. Information is compiled on species, numbers, access points, roosting locations and flight-paths. It is important for surveyors to minimise noise and lighting disturbance, avoiding the use of torches whilst setting up and during the survey, particularly in situations where ambient noise and light levels are low and bats are less likely to be habituated to human disturbance. The use of torches, lit screens on some detector/camera models and high visibility clothing can also temporarily spoil a surveyor's night vision.

7.2.8 Surveys should usually be carried out using NVAs (night vision, infra-red camera, thermal imaging camera) as bats often emerge after it is too dark for surveyors to observe them. This is particularly important where there is potential for late-emerging species (see Section 3.5) and in very dark conditions (e.g. under the tree canopy and among fluttering foliage). Occasionally, the use of NVAs may be less important (e.g. for known roosts where bats are confirmed to emerge early or in situations/locations with higher levels of natural or artificial lighting), although not using NVAs should be fully justified in reporting. Surveyors using this equipment should be trained and experienced in its use and the right equipment should be used to achieve the aims. Licence applications will require information on this.

7.2.9 Guidelines are now available for the use of thermal imaging cameras (Fawcett-Williams and BCT, 2021) for bat surveys. At the time of writing, guidelines on the use of NVAs for bat surveys are also being developed.

7.2.10 Infra-red systems require a separate source of true infra-red illumination (not a red light filter) to be most effective. Footage should be recorded, so that it can be analysed afterwards and footage of bats emerging should be retained as a record of the survey. A still shot **must** be taken at the darkest point of the survey to show the field of view and that appropriate illumination has been used – this should be provided in any reporting and also be retained as a record of the survey. If NVAs are *not used* then adequate justification should be provided in the survey report (e.g. high levels of natural or artificial lighting).

7.2.11 When used appropriately, NVAs can be used to *reduce* the number of surveyors. This requires the camera, lenses, lamps and techniques, complemented by a bat detector soundtrack, to **reliably match or exceed what a surveyor can achieve and evidence provided**. The camera should be turned on before the survey starts and turned off after completion of the survey.

7.2.12 The positioning of NVAs/ecologists should be informed by the PRA (see Section 5.2), which should have identified potential roosting and access points, or by the GLTA and other tree surveys (see Chapter 6), which should have identified PRFs for bats. These places should be the focus of the survey and their number and arrangement should inform the number and arrangement of NVAs/ecologists required to complete the survey. However, ecologists should be aware that bats may emerge in unexpected places.

7.2.13 There should be sufficient surveyors on site for all aspects of a building or tree to be in view and for all equipment to be under constant observation for security purposes, to ensure it is operational throughout the survey and to adjust infrared lamps if necessary. Ecologists should be adequately briefed about which NVAs they are responsible for. The surveyors can observe bat activity away from the immediate vicinity of the building, which can provide important context, and surveyors should remain in constant contact using equipment such as hand-held radios to communicate easily and quickly about any observations or issues arising. Survey effort **must** be checked by those assessing surveys and reports.

7.2.14 Comparison of results from cameras and independent surveyors can help to understand the relative efficacy of each. This may change during the survey as visible light levels drop.

7.2.15 More complex structures or multiple structures require more NVAs/ecologists, particularly if there are many potential access points, as all areas with potential should be covered. It may be necessary to visit the site (covering different locations each time) over several consecutive nights (collectively considered to be one survey visit) to cover all areas. However, it is important to ensure that survey effort is not overly 'diluted' when surveying large or complex structures because this approach could lead to over- or under-estimating numbers of bats if the bats change their access points between nights.

7.2.16 Reviewing of the footage recorded by NVAs should be done as soon as possible after the survey, whilst the survey is fresh in the minds of the ecologists. Different screen setups will vary in terms of what can be seen on recorded footage – this variation should be tested and screen use optimised.

7.2.17 If bats are observed emerging from structures, this does not necessarily mean they are roosting in the same location as the exit point; it may be necessary to identify roosting locations separately. Sometimes this can be established during the PRA or, alternatively, an NVA/ecologist could be stationed within the structure at dusk to observe emergence from a roosting point into the building. Survey design should be iterative, each survey informed by the previous one.

7.2.18 It may be possible to use fewer ecologists to watch for bats exiting; for example, a whole block of buildings or a whole woodland unit, but this would only identify that roosts were present within the block/woodland and would not identify individual buildings, trees or roosts. The choice of method depends on the amount of detail required to meet the survey aims.

7.2.19 The results of the surveys should be recorded in a standard format using a pre-designed, preferably digital, survey form.

Complementary methods

7.2.20 Deploying NVAs and automated/static bat detectors inside a structure can be particularly useful in gaining information about late-emerging species that often fly around inside the roost prior to emergence. Caution should be exercised in using automated/static detectors for this purpose, however, because sometimes they can detect bats flying outside a structure, not just those flying inside. Detector settings should therefore be appropriately calibrated for the intended use, to increase confidence in the results. Detector settings can be tweaked to try and target only bats within buildings (e.g. turning sensitivity down, microphone type, position).

7.2.21 When recording is carried out inside a roost, surveyors should also be aware that echolocation calls are often atypically short in duration (in extreme clutter), and a broad range of social calls are often produced in this situation that are not encountered outside a roost. The recordings can therefore often be atypical, distorted, and / or of poor quality. If it is necessary to record inside a roost, it should be accepted that the challenge of manually assigning recordings to species is likely to be greater than for free-flying bats, and the performance of automated systems for bat sound identification will be reduced.

Alternative methods

7.2.22 See Chapter 6 for alternative methods to detect the presence of bats in trees.

Timing

7.2.23 Recorded bat activity is dependent on the prevailing conditions at the time of the survey, which vary temporally (through the night, between nights, through the seasons and between years) and spatially (dependent on latitude and longitude).

7.2.24 Bat activity is also determined by what the bats are doing at different times of the year (although this is also dependent in part on prevailing conditions); the bat life cycle is given in Section 3.2.

7.2.25 The bat active period is generally considered to be between April and October inclusive (although the season is likely to be shorter in more northerly latitudes).

7.2.26 In general:

- April surveys may detect transitional roosts.
- May to August surveys may detect maternity colonies and males/non-breeding females in summer roosts. As maternity colonies can switch roosts during the breeding season, one survey pre-parturition and one survey post-parturition is appropriate if maternity roosts could be present and two or more surveys are carried out.
- August counts can include both adults and juveniles. However, caution should be exercised as many maternity colonies will disperse during this month.
- August and September (perhaps into October) surveys may detect mating bats. Ideally, this period should be covered where three surveys are carried out. If appropriate habitat is present, these surveys could be extended into the night to carry out swarming surveys (see Section 8.3).
- September and October surveys may detect transitional roosts (September and October are less suitable for surveys in more northerly latitudes and October surveys are not considered appropriate in Scotland).

7.2.27 It is important to stress that prevailing conditions and local trends in bat activity (for example, when were the young born in the year in question?) should be considered and recorded to provide context to survey results.

7.2.28 Surveys should be designed around the information that is required to achieve the survey aims. Recommended timings for surveys are given in Table 7.1 below. This should be adjusted (earlier or later) if necessary by the ecologist, bearing in mind the site-specific circumstances, although this should be justified in the survey report.

Table 7.1. Recommended timings for presence/absence surveys to give confidence in a negative result for structures (also recommended for trees where other methods such as PRF inspection are not possible, but unlikely to give confidence in a negative result). To be used in tandem with Table 7.2.

Low roost suitability or PRF-I	Moderate roost suitability	High roost suitability or PRF-M
May to August (structures) No further surveys required (trees)	May to September[a], with at least one of surveys between May and August[b]	May to September[a], with at least two of surveys between May and August[b]

a September surveys are both weather- and location-dependent. Conditions may become more unsuitable in these months, particularly in more northerly latitudes, which may reduce the length of the survey season. September surveys are likely to miss maternity roosts due to dispersal before this time, but may pick up mating roosts.

b Multiple survey visits should be spread out to sample as much of the recommended survey period as possible; it is recommended that surveys are spaced at **least three weeks apart**, preferably more. Survey timings **should consider the prevailing conditions in the year of survey, which will vary geographically**. In years with a cold spring, the surveys should not be started in early May or all completed in May. The surveys should maximise the possibility of detecting maternity roosts, which can switch roosts between pregnancy and lactation, and the **optimum coverage includes the pre-parturition, post-parturition and mating periods**.

7.2.29 Please note that these are the timings recommended for presence/absence surveys. Some roost characterisation surveys (see Section 7.3) may be appropriate in April (to identify transitional roosts) and October (to identify transitional and mating roosts) depending on the findings of previous surveys, the weather and the location (although please note that October surveys are not considered appropriate in Scotland).

7.2.30 Bats are often active during the winter months: feeding, drinking or moving roost, and therefore activity can be recorded in winter too (winter hibernation surveys of structures are covered in Section 5.3). Because this is likely to be more sporadic, however, automated surveys are generally more appropriate than emergence surveys.

7.2.31 Different species vary in the time they tend to emerge from the roost according to their flight and predator avoidance capabilities (see Section 3.5). In general, dusk emergence surveys should start (i.e. ecologists in place) 15 minutes before sunset and finish 1.5-2 hours after sunset, with survey times adjusted depending on the observations made during previous surveys.

7.2.32 These time periods mean that some of the survey will be in complete darkness, making the use of NVAs essential.

7.2.33 Other considerations in terms of timing are as follows:

- if a roost emergence point is not lit by the setting sun, it is likely to be darker and bats may emerge earlier;
- if bats have vegetation cover close to the roost they may emerge earlier because the vegetation offers protection;
- if the evening sky is overcast, the darker conditions may encourage earlier bat emergence (Downs, *pers. comm.*, 2022);
- if there have been periods of prolonged bad weather, bats

may adjust their behaviour to increase foraging times by emerging earlier;

- ❍ disturbance from lighting, noise or vibration may impact emergence times;
- ❍ poor weather conditions may cause bats to alter their emergence times (see para 2.6.5.); and
- ❍ if the roost is very large, some of the bats may emerge earlier.

7.2.34 Timings may be adjusted (earlier or later) if necessary by the ecologist, bearing in mind the site-specific circumstances, although this should be explained in the survey report.

Survey effort

7.2.35 Increasing the survey effort generally increases the likelihood of discovering bats. However, surveys should always be proportionate to the circumstances, which can only be assessed using professional judgement.

7.2.36 Froidevaux *et al.* (2020) studied 155 bat survey reports (involving structures, not trees) submitted with planning applications in two counties of the UK. They concluded that daytime inspections were efficient in detecting bats when they roost in the open (e.g. some *Plecotus* species roosts) but were likely to miss the presence of bats roosting in crevices (e.g. *Pipistrellus* species). They recommend a minimum of three emergence surveys in good weather conditions for bats to be 95% confident that a building does not host a roost of *Pipistrellus* and four emergence surveys for *Plecotus* species. However, this study did not include consideration of how buildings had been classified in terms of their suitability (low, moderate or high) or the impact of NVAs on the accuracy of these surveys. Further study is required on these topics and for now it is considered that not enough information is available to change the survey regime previously recommended.

7.2.37 Table 7.2 provides the minimum recommended numbers of survey visits to give confidence in a negative result for structures. Confidence in a negative result is not possible for trees due to limitations outlined in Chapter 6, although emergence surveys of trees should only be used in a limited set of circumstances. The number of visits could be adjusted (up or down) if necessary by the ecologist, bearing in mind the site-specific circumstances, although this should be fully justified in the survey report.

Table 7.2. Recommended minimum number of survey visits for presence/absence surveys to give confidence in a negative result for structures (also recommended for trees but unlikely to give confidence in a negative result).

Low roost suitability or PRF-I	Moderate roost suitability	High roost suitability or PRF-M
One survey visit. One dusk emergence survey[a] (structures). No further surveys required (trees).	Two separate dusk emergence survey visits[b].	Three separate dusk emergence survey visits[b].

a Structures that have been categorised as low potential can be problematic and the number of surveys required should be judged on a case-by-case basis (see para 5.2.44). In some cases, more than one survey may be needed, particularly where there are several buildings in this category.

b Multiple survey visits should be spread out to sample as much of the recommended survey period (see Table 7.1) as possible; it is recommended that surveys are spaced at least three weeks apart, preferably more.

7.2.38 Numbers of surveys may need to be increased from those recommended in Table 7.2 where thorough internal inspections have not been possible; the number should be decided using professional judgement and rationale reported. Internal inspections (of structures and PRFs) can provide historical evidence of bat presence whereas emergence surveys only provide information about bat presence or absence at the time of the survey.

7.2.39 It would be disproportionate to apply the survey effort outlined above (which is designed for individual or small numbers of buildings) to large-scale projects where buildings require maintenance/re-roofing rather than demolition. When determining survey effort, there will be a need to determine the likely species and status of roosts, taking into account building structure, building condition and local context. The survey effort should be at least adequate to determine species and identify (or rule out) maternity roosts. Information is being gathered to provide case studies illustrating different approaches and will be made available as a separate piece of guidance.

Weather conditions

7.2.40 Please refer to para 2.6.2 onwards for guidance on weather.

Next steps

7.2.41 If presence of a bat roost(s) is established, the next stage of the process is to carry out roost characterisation surveys (see Section 7.3 – depending on how much information on species, numbers, access points, roosting locations, timing of use and type of roost has already been collected), although it may be necessary to continue with presence/likely absence surveys of other parts of the site.

7.2.42 In structures, where likely absence has been adequately established, then no further action is required in relation to bats. However, it may be appropriate for contractors to be briefed about the risk of discovering bats unexpectedly during works and the need to stop work in this scenario. Clients should also be made aware of this risk and the potential implications in terms of delay.

7.2.43 In trees, it is very difficult to have confidence that roosts are absent (see Chapter 6) and therefore, even where no bats are found, it may still be necessary to apply precautionary measures when carrying out tree-felling and pruning activities.

7.3 Roost characterisation surveys

Description and aims

7.3.1 When presence is established, this should trigger **roost characterisation surveys** unless sufficient information has already been collected (using robust survey methods with no significant constraints) to inform the impact assessment and design of mitigation measures. Roost characterisation surveys include emergence surveys. They also include the collection of information about the physical characteristics of the roost and surrounding area.

7.3.2 The aim of these surveys is to answer the questions outlined in Section 7.1, and to ascertain the features and characteristics of the roost (for example size, perching points, aspect, orientation, temperature, humidity, lighting) and the surrounding area (for example proximity of vegetation to exit points, availability of foraging areas locally) that are of importance.

7.3.3 All of this information can then be used to assess the potential impacts of the proposed development activity and design suitable mitigation and monitoring strategies. For example, information on roost characteristics may be required to inform the construction of a like-for-like replacement roost where the original roost will be lost. This information is essential when applying for planning permission or an EPS licence.

7.3.4 The additional limitations of tree surveys (in comparison to surveys of structures) are highlighted in Chapter 6.

Equipment

7.3.5 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

7.3.6 The expertise and licences required are the same for both presence/likely absence surveys and roost characterisation surveys (see para 7.2.5).

Method

7.3.7 The method used is the same for both presence/likely absence surveys and roost characterisation surveys (see para 7.2.7 onwards).

7.3.8 Some bat species will not waste energy echolocating upon emergence (maybe because of higher light levels or landscape familiarity, the reason is not totally clear), which means other methods should be used to gain the species identification information required; for example, DNA analysis of droppings (see Appendix 4) or handling of bats in the roost (see para 5.2.34). Visual cues such as behaviour, size, wing shape and ear shape may also contribute to identification, but in most cases these cannot be used in isolation.

Box 7.1. A note on roost re-entry surveys.

The routine use of roost re-entry surveys (previously known as dawn surveys) for presence/absence has been removed from this edition of the guidelines. This is due to: (a) the use of NVAs increasing the accuracy of dusk emergence surveys, and (b) the variability in roost re-entry times within and between species. Andrews and Pearson (2022) carried out a review of empirical data on re-entry times of different species and found huge variability, such that returning bats can easily be missed.

Whilst the authors of the guidelines take no responsibility for how surveys are scheduled and surveyors deployed (individuals and companies are responsible for their own health and safety and that of their staff), removing the use of roost re-entry surveys as standard for presence/absence is also likely to be important from a health and safety perspective.

However, ecologists may choose to use a roost re-entry survey for roost characterisation *if there are very specific reasons, constraints are acknowledged and all of this is provided in the reporting*. Positive data from dawn surveys (e.g. confirmation of roost entrance points) may be valuable but negative data (i.e. bats are absent) and counts are less reliable. Re-entry surveys should be carefully timed, bearing in mind the likely time of return of the species concerned (see Andrews and Pearson, 2022 and Section 3.5).

Roost re-entry times are influenced by the night length/time of year, the age and reproductive status of the bats, the availability of preferred prey at different times and the temperature. Swift (1980) showed that pipistrelle bats in north-east Scotland had a unimodal peak in activity during pregnancy in May and June but after parturition they showed bimodal peaks in activity after dusk and immediately before dawn. Ransome (1973) showed that when external temperatures reached 8°C as a minimum the feeding activity of greater horseshoe bats was curtailed during the night. Ruzinska *et al.* (2022) found that older adult females exhibited a gradual increase in swarming from midnight to dawn but younger females and juveniles swarmed later before dawn.

Roost re-entry surveys can potentially be effective for accurately detecting points of access, providing they are timed correctly. NVAs should be used to improve accuracy.

7.3.9 The collation of information about the physical characteristics of the roost and surrounding area is discussed below.

Size and nature of roost

7.3.10 In structures, the size of the roost, including the presence and location of timber joints and other features supporting roosts, should be documented if it is likely that a replacement roost will be required. The size and nature of the internal space appears to be important to bats that fly around inside prior to emerging, most notably *Plecotus, Rhinolophus* and some *Myotis* species. The number and location of all access points (and their dimensions, which can be important for some species) should also be documented. In trees, the dimensions of the roost feature should have been documented during the PRF Inspection survey (see Section 6.8) if accessible.

Roosting surfaces

7.3.11 In structures, the availability of appropriate roosting surfaces (e.g. natural materials such as wood) is a key measure of the ecological functionality of a site, and should be recorded if it is likely that the roost will need to be replaced.

Aspect and orientation

7.3.12 Aspect and orientation affect how the roost is heated by the sun, although in structures heating may also result from man-made features such as boilers. The aspect, orientation and shading of the roost and associated access points should be documented (along with any artificial heat sources), so that this can be replicated (where possible) in a replacement roost if necessary.

Temperature and humidity

7.3.13 Williams (2010) and Gunnell *et al*. (2013) state that one of the factors making structures suitable for roosts is their ability to provide a stable microclimate and that temperature plays a key role in roosting ecology and selection. A range of microclimatic conditions within one structure gives bats options to move around. It should be noted, however, that bats may be roosting in what appear to be suboptimal conditions in terms of temperature and humidity, so this must be taken into consideration when taking measurements and determining future characteristics. Where proposals will result in the loss of a maternity or hibernation roost, the temperature and humidity inside and outside the roost **must** be monitored using data loggers to understand how conditions fluctuate in relation to ambient temperatures throughout the season the roost is used (although this may be constrained by limited access to the areas bats are actually using). In structures that are used by bats at different times of the year, it may be necessary to collect data during more than one season. It may be the damping of temperature variation, rather than absolute temperatures, that make a roost suitable for bats. Collecting data inside and outside the roost will help to determine this and replicate conditions, where appropriate, in replacement roosts, particularly since assumed knowledge is not always correct (Downs & Wells, 2021). Different conditions are likely to suit different species (see, for example, Davidson-Watts and Jones, 2006; Smith and Racey, 2005; Boonman, 2000, Shepherd and Stroud, 2009); a literature search will provide extra information.

Lighting

7.3.14 Current lighting levels and locations should be noted to provide a comparison with new lighting proposals. Even one change such as an outside security light can have an impact and lighting needs to be considered in relation to current and proposed new bat access points. In cases where no lighting change is proposed, it may not be necessary to measure the light levels at all, but current lighting fixtures should be plotted. Guidance is available from BCT and ILP (2023).

Habitat

7.3.15 Vegetation in close proximity to a roost can be extremely important for some species of bat that seek cover from predators and the weather immediately after emerging. It also provides structure for acoustic orientation and navigation and opportunities for foraging. Features likely to be important to bats should be noted so that these can be retained or replicated post-development as necessary. The importance of different habitat features varies from species to species (see, for example, Davidson-Watts *et al*., 2006; Entwistle *et al*., 1997), influencing both emergence (Schofield, 2008) and foraging site arrival/departure times (Downs & Racey, 2006).

Complementary methods

7.3.16 The complementary methods are the same for both presence/likely absence surveys and roost characterisation surveys (see para 7.2.20 onwards).

7.3.17 It may also be possible to capture bats using a hand net in order to identify their species, gender and age during a roost characterisation survey. The correct licence (see para 1.3.1 onwards), knowledge and skills (see para 2.5.1 onwards) should be in place to carry out this activity and sensitive times of year should be avoided (such as when bats are heavily pregnant or with dependent young).

Alternative methods

7.3.18 See Chapter 6 for considerations regarding tree surveys and alternative methods to detect presence of bats.

Timing

7.3.19 See para 7.2.23 onwards; comments on timing are the same for both presence/likely absence surveys and roost characterisation surveys. It may be appropriate to carry out surveys in April and/or October depending on the need to characterise transitional roosts or mating roosts, the findings of previous surveys, the weather and the location (although please note that October surveys are not considered appropriate in Scotland).

Survey effort

7.3.20 Survey effort required to collect the relevant information that is needed for an impact assessment and the design of mitigation strategies is very much site-specific. Appropriate surveys should be repeated until the information outlined in Sections 5.1 and 7.1 is reliably collected, although appropriate methods and equipment should be used to minimise the number of repeat visits required and effort should always be proportionate to impact.

7.3.21 If presence has been confirmed by droppings found during a PRA (Section 5.2) but roost characterisation surveys have not recorded any bat presence, it may be necessary to carry out further surveys at alternative times of year. If presence has been confirmed by droppings found during a PRF inspection survey (Section 6.8) then DNA analysis should be carried out on the droppings, but further surveys may provide no return and it may be necessary to proceed with the information already collected. Licensing policy 4 in England may cover this scenario.

Weather conditions

7.3.22 Please refer to para 2.6.2 onwards for guidance on weather.

Next steps

7.3.23 Where bat roosts are likely to be impacted by proposed activities, it will be necessary to carry out an impact assessment and design an appropriate mitigation and monitoring strategy with habitat enhancements for bats, where appropriate. This information is essential to inform a planning application or EPS licence application to allow the proposed activities to proceed legally.

Chapter 8

Bat activity surveys

8.1 Introduction

8.1.1 This chapter provides information on carrying out bat detector surveys for bats, which may be on flight-paths, foraging or exhibiting social behaviour (such as calling for mates during the mating season or swarming in the autumn). Acoustic surveys enable identification of species/species groups and provide a measure of bat activity. Actual numbers of individuals can often not be established unless acoustic data are coupled with direct observations in the field by an ecologist before it gets too dark, or through recordings made by an NVA.

8.1.2 These surveys may be required where development proposals are likely to impact on habitats suitable for bat flight-paths, foraging and social behaviours (see Section 3.6). It is good practice to carry out at least three manual surveys (to make observations about the site, and how bats interact with it, that cannot be made without human observation) alongside automated surveys.

8.1.3 In designing surveys, ecologists should be considering what questions need to be answered, where the impacts are and what are the practicalities of using different types of surveys on different sites. For the purposes of development and planning, some important questions with respect to bats in flight away from their roosts are as follows:

- Are bats present or absent?
- Which bat species use the site?
- What are the activity levels of bats on the site and can this tell us anything about the abundance (number) of bats using the site?
- What are bats using the site for?
- What is the temporal (both seasonally and nightly) and spatial distribution of recorded bat activity on site?
- Are peaks in bat activity associated with particular temporal and/or spatial locations, e.g. times of night or particular features on the site?
- How are the habitats used on site connected to habitats in the surrounding area?
- How does lighting impact bat behaviour on site?

8.1.4 Answering some or all of these questions should allow an ecologist to carry out a robust impact assessment.

8.1.5 In order to answer these questions, bat activity surveys generally begin with the PEA, which includes a desk study and fieldwork (see Chapter 4). The desk study (Section 4.2) identifies the species known or likely to be present and if there are any designated sites in the area. Fieldwork (Section 4.3) identifies the different habitats and features in the survey area that will be impacted by the proposed activities to allow a determination of their suitability for bats. A **DBW** (often carried out during the PEA fieldwork) is essential for understanding the layout of the site and those elements not readily revealed by the desk study, such as topography and areas likely to be more sheltered, as well as practical issues relating to safe access (e.g. fences, soft areas, steep slopes).

8.1.6 The survey design should not be fixed; it should be constantly adapted according to emerging information (this should be made clear to clients when costing for work). Survey data should be analysed **as soon as it is collected** because it may contain key information to inform next steps. Waiting to analyse data until the end of the season is not an acceptable approach.

8.1.7 Reporting should include the detailed rationale behind original survey design, acknowledging any iterative changes in approach (and the reasoning applied) as the surveys progress.

8.1.8 The following sections describe **manual and automated/static bat activity surveys, back-tracking surveys** and **swarming surveys**.

8.2 Bat activity surveys – manual and automated/static

Description and aims

8.2.1 **Manual bat activity surveys** involve the deployment of ecologists to observe, listen for and record bats in flight away from their roosts using bat detectors and sometimes NVAs. Surveys during the evening and night provide a different perspective from those carried out during the day, with the obvious benefits being that bat behaviour and artificial lighting conditions can be observed.

8.2.2 **Automated/static bat activity surveys** involve bat detectors being deployed at fixed locations to record bat activity remotely in order to establish species richness, provide a measure of relative abundance and establish the importance of different landscape features to bats.

8.2.3 Activity surveys should provide a representative sample of the bat activity in all habitats present at the proposed development site, including open habitats. Even species strongly associated with linear features can use open landscapes (Finch *et al.*, 2020). This seems more likely when it is dark and predation risk is reduced (Downs *et al.*, 2016b), but the degree of use of open landscapes has been less frequently studied. Sampling should be designed to provide sufficient data to assess the potential impacts of the development on bats.

8.2.4 The aim of these surveys is to answer the questions posed in Section 8.1. The results can then be used to facilitate an impact assessment and the subsequent design of appropriate avoidance and mitigation measures.

Equipment

8.2.5 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

8.2.6 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Activity surveys are unlikely to disturb bats if carried out correctly.

8.2.7 For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate for an activity survey but, for anything more complex, an ecologist at BCT Level 3 (CIEEM Accomplished) competence should at least design and may need to lead these surveys.

Method

8.2.8 **All habitats should be sampled during the bat activity surveys** but the habitats perceived as having moderate or high suitability for bats would normally receive more attention. The extent and arrangement of the different habitats on site should inform the number and arrangement of manual and automated/static activity surveys required to complete the survey (the questions that need to be answered). The ease of accessibility and navigation and the security of both surveyors and equipment will have an influence. Where impacts are likely to be greater, for example where bats may be impacted by fragmentation or woodland loss, then effort should be increased. Some habitat types (e.g. wetlands, dense scrub/woodlands or heavily urbanised locations) may constrain some types of surveys. If the impact occurs in an area perceived as having low suitability for bats, then this may still need to be surveyed to evidence this or to detect unforeseen importance.

8.2.9 It is important to consider the ecology of the different species known or likely to be present as this can impact survey design (see Chapter 3). All available information should be used to inform survey design, which should be iterative; each stage should inform the next.

8.2.10 The Technical Review Board for this 4th edition debated the ongoing use of transects (which were recommended as standard in the 3rd edition), bearing in mind prevailing practice at the time of writing and efficacy in relation to cost. Table 8.1 outlines some of the comparative benefits and limitations of transect surveys in comparison to automated/static detector surveys.

Table 8.1 outlines some of the comparative benefits and limitations of transects and automated/static detectors.

Survey type	Benefits	Limitations
Transect	Bats can be counted and behaviour observed (provided NVAs are used after conditions become too dark for the human eye) Observations may help with species identification if bats are not echolocating Can cover large areas over a short period of time Can be a good starting point on large sites where bat activity is likely to be dispersed/infrequent Can be used as an alternative in locations where it is not safe to leave equipment out Can give an impression of bat activity across the site as a whole Can observe 'live' the impact of weather on bat activity Can observe the response of bats to features on site such as livestock, dung heaps, compost heaps, water bodies, sheltered areas etc. Enables an immediate response to new information Works well in combination with statics Promotes fieldcraft	Snapshot in time only Ecologist is only in one location at any given time so could miss activity elsewhere Subjectivity of ecologist can limit consistency, repeatability and quantitative analysis Security of ecologists Difficult in some habitat types (e.g. dense woodland or scrub or open homogenous habitats) Labour-intensive fieldwork Access may change at the last minute Can't be used at height Can give a misleading impression Human eyes are not reliable in poor light
Automated/ static	Can be deployed for long periods to pick up variability in bat activity in the absence of ecologists Can be left for longer periods to accommodate/counter times of poorer weather Can be deployed in different locations simultaneously, therefore achieve good coverage of a site Objective and therefore consistent, repeatable and allows quantitative analysis Can be used effectively for at-height surveys Presents fewer health and safety challenges than transects Works well in combination with transects	Bats cannot be counted; 100 passes may be 1 bat or 100 bats Bat behaviour cannot be observed Large amount of data generated, requiring significant storage capability Data must be analysed to get maximum benefit Security of detectors

8.2.11 There are a number of papers comparing different survey methods. Many suggest that static surveys are more effective (Stahlschimidt and Bruhl (2012), Braun de Torrez *et al*. (2017) and Teets *et al*. (2019), whilst others conclude that a combination of methods is important (Perks and Goodenough (2021).

8.2.12 Here, a new approach is proposed to transect surveys, which have been renamed **'Night-time Bat Walkover'** (NBW) surveys. These, and automated/static surveys, are described below.

Manual surveys

8.2.13 A limitation of data from automated/static systems is that there is no observational context. One hundred bat passes could represent one bat passing 100 times or 100 bats each passing once. Reality is likely to be somewhere between these two extremes. In addition, automated/static detectors don't record behaviour. Below, a number of manual survey methods are described.

Night-time bat walkover (NBW) surveys

8.2.14 NBW surveys should be informed by the DBW survey.

8.2.15 At the start of the NBW surveys, ecologists should be on site before sunset and stationed on potential flight lines close to potential roost sources such as groups of buildings or woodland. Ecologists should remain in position to count, observe behaviour and make acoustic recordings of commuting (or foraging) bats for up to an hour after sunset. Alternatively, if streams of commuting bats are observed, the ecologist may want to use back-tracking methods to move towards a roost, responding live to observations made.

8.2.16 The surveyor should not start walking around the site before 30 minutes after sunset: (see Goodenough *et al*., 2015); the starting time (up to 60 minutes after sunset) should be determined by live observations in the field. Are there still commuting bats to count? Are non-*Nyctalus* and *Pipistrellus* species likely to be out of their roosts yet? Are useful observations still being made or not?

8.2.17 It is appropriate for this work to be carried out in pairs; for ecologists to know where other colleagues will be on site; and for the method of communication to be identified. This may require hand-held radios in the absence of mobile phone signal.

8.2.18 Ecologists should walk the pre-determined walkover route taking acoustic recordings and recording a time-stamped narrative about their observations. It may be appropriate to occasionally stop or make a detour to observe bat behaviour. The approach should be responsive and dynamic to gain the most information.

8.2.19 All echolocation calls should be recorded and subsequently analysed to species or genus (see Chapter 10) even if the ecologist has attempted to identify the species by ear in the field. Technology is available to record each bat echolocation call and link it to a specific location (using GPS points) and time to enable the data to be easily mapped and presented in reports.

8.2.20 The time-stamped narrative might include observations of:

- numbers of bats;
- flight direction;
- flight height;
- type of flight, e.g. direct, in a straight line, or more meandering?;
- apparent behaviour, e.g. are there feeding buzzes or social calls?;
- appearance, to help with identification if bats are not echolocating or acoustic recordings are unclear;
- how bats respond to permanent or temporary features on site, e.g. water bodies, watercourses, sheltered areas, artificial lighting, livestock, dung heaps and compost heaps; and
- how bats respond to different weather conditions, e.g. the use of sheltered areas such as woodland or the leeward side of hedgerows in windy or rainy conditions.

8.2.21 Much of this is qualitative information that cannot be recorded using automated systems, although is obviously constrained by light levels (more so in cluttered habitats). These surveys could make use of easily portable NVAs (such as night vision scopes) to overcome this constraint.

8.2.22 Using this method, different areas of the site can be rapidly compared and the surveyor can respond immediately to observations made (as described above).

8.2.23 NBW surveys are useful where bats may be dispersed over a very wide area, e.g. urban environments, open habitats. They can become more important where security prevents the deployment of automated/static detectors (manual surveys should be increased where automated surveys are not possible).

8.2.24 NBW surveys provide quantitative (bat records plotted on a map) and qualitative (how bats interact with the site) information about the site to inform static detector deployment and to facilitate interpretation of the data collected. However, being responsive to observations on site creates bias and the walkover data *should not be subject to data analysis* (other than species identification) for this reason.

8.2.25 Because ecologists can't be everywhere at a given time, it is likely that bat activity will be missed – NBWs aim to record a *representative sample* of the bats rather than every bat on site. However, options to increase coverage include repeating a short walkover twice during the course of one evening or varying the starting point through the year. Data from static detectors will provide much more coverage.

8.2.26 NBW surveys can be undertaken as:

- **dusk surveys only** – this is likely to be the most effective method in the spring and autumn when conditions are likely to deteriorate in the night and may cause bats to go back to their roosts and not emerge for a second time before dawn;
- **dusk to dawn surveys** – this is most useful on short summer nights, or where the aim is to record particular types of bat activity in the middle of the night such as mating or swarming along with dusk and dawn activity.

8.2.27 Ideally, all habitats represented on site should be sampled during a single survey visit to allow a comparison of bat activity across the site. However, if few ecologists are available and the site is particularly large, it may be necessary to visit the site (covering different walkover routes each time) over several consecutive nights (collectively considered to be 'one survey visit') to cover all areas.

8.2.28 Where multiple walkovers are carried out at one site, they should all be approximately the same length. A good guide is 3-5km, but walkovers may be shorter than this depending on the site, ground conditions and levels of bat activity.

Vantage point surveys

8.2.29 Vantage point surveys can provide information about the behaviour of early-emerging high- and fast-flying bats (e.g. noctule) and can be useful to ground-truth results from the static detector surveys. Ecologists are located at vantage points around the site, so that all areas are covered. They then observe and listen for bats in flight. These surveys can provide information about numbers of bats and direction of travel, which gives an indication of the direction of the roost and the direction of early evening foraging grounds. Other observations can be made such as flight height and behaviour.

Automated/static surveys

8.2.30 The use of automated/static detectors facilitates quantitative analysis of the data. Some examples of strategies for deploying bat detectors are given below:

- **Judgemental:** using this method, sampling locations in the survey area are chosen subjectively. Sample locations are determined on expert opinion (after the DBW but may be adapted based on the NBW; see earlier text) or historical information. This approach is commonly used by consultants. However, to avoid just sampling convenient places and/or missing areas that may have a significant bat interest, the sample sites could be paired. For example, perceived good habitat/poor habitat, hedgerow/open field; canopy/ no canopy; bats observed historically/ no bats previously observed. Ecologists should not be afraid of recording few or no bats – this is important for determining the relative importance of different locations of interest. Simple data analysis could then be applied (Mann-Whitney-Wilcoxon) to see the difference. This allows the consultant to be judgemental about sampling locations while providing a **systematic** approach that lends itself to more rigorous analysis.
- **Stratified:** the survey area is divided into sub-areas, where sub-area(s) of particular interest are surveyed more intensively (identified by the DBW but may be adapted based on the NBW; see earlier text). Sub-areas can be analysed individually or together, as long as the survey effort employed in different sub-areas is considered when analysing and interpreting the data. One way of looking at the whole area, while surveying sub-areas more intensively, is to pair or group sample locations by factors and use the factors in the analysis, which helps to compare the relative value of different habitats on site. Factors are most useful when they are simple and easily defined:
    - Field 1 – Field 2 (adjacent to Field 1 and same area)
    - Hedgerow – Watercourse (same length)
    - Woodland – Open field (same area)

8.2.31 The convention in bat surveying is to use timings that are systematic, for example, collecting five nights of data each month from May to September. Dependent on site and impacts, it may be relevant to collect data outside of these periods and detectors may need to be deployed for longer periods outside the summer months.

8.2.32 The same model of automated/static bat detector should be used across the site, and all detectors should be deployed with the same settings. All detectors should be subject to regular testing/calibration to allow a meaningful comparison of the results.

8.2.33 The microphone should be positioned to maximise the quality of bat activity recorded – this requires knowledge and consideration of the directionality/sensitivity of the particular microphone used. The choice of microphone (uni- or omnidirectional) will depend on the objectives of the survey – both types have their uses. Good positioning of bat detectors and / or microphones is essential for getting good recordings, that are needed to have a chance of identifying some species (particularly for more cryptic species).

8.2.34 Automated/static detectors may be deployed at varying heights depending on site and project-specific factors. Ideally the microphone, or detector (if the microphone is inbuilt) would be pole-mounted, raised up into the bat's (likely) flight-path (dependent on the species), and positioned at least 1.5 meters away from any flat surfaces or vegetation. Placing the detector or microphone on a tree (as shown in many promotional photographs by manufacturers) should ideally be avoided, as should 'hiding' microphones in vegetation, as this will compromise the quality of the recordings. The microphone should also be located so that the recording of ambient (e.g. wind, running water, rustling vegetation) or any other source of extraneous noise (e.g. electrical signals) is minimised. It is important to consider whether solid objects nearby will impede the passage of sound to the microphone and adjust its position accordingly.

8.2.35 It may also be necessary to fence the detector if livestock are present or use alternative (e.g. manual) methods. Removal of livestock can be considered, although livestock can provide an important foraging resource for bats (Downs & Sanderson, 2010) and their removal could impact on bat activity.

8.2.36 If recording around emergence time and close to roosts, the calls of bats are often elevated in frequency at the point of emergence and are not very typical of the calls of free-flying individuals which makes identification more challenging. Social chatter of bats from inside the roost, prior to emergence may also be recorded, which can be difficult to assign to species. Therefore, when recording close to a bat roost, surveyors should position the bat detector at a minimum distance of 10-15 metres away from emergence itself. This will improve the prospects of manually assigning recordings to species, but also automated systems for bat sound identification, which have been trained on free-flying bats, will perform better.

8.2.37 The results of the surveys should be recorded in a standard format. It is essential that analysis is completed immediately following each survey in order for any issues with the detector to be picked up and to allow for the design of any supplementary surveys or additional survey techniques (see below). Survey design should be iterative, each survey informed by the previous one.

Notes on interpretation of data from activity surveys

8.2.38 The results of the activity surveys should be interpreted with the following considerations in mind.

- Some bat species will emerge earlier if they can emerge into shade/cover (Schofield, 2008).
- Proximity to a roost can be assessed by the time of the first/last bat relative to sunset/sunrise. This should be done with reference to published bat roost emergence and return times (see Section 3.5).
- All UK bat species are capable of crossing large open spaces. However, earlier arrival at foraging sites (when foraging can be most productive) can be facilitated by a landscape linked by continuous shaded vegetated lines (hedges/tree-lines etc) (Greenaway, 2004; Downs & Racey, 2006; Schofield, 2008). This is more important to the bat species which are slower flyers.
- In some situations where there is sufficient motivation to do so, slower flying bats can cross open gaps upon first

emergence (Downs *et al*., 2016b), typically minimising the length of gap and flying low to the ground.

- A number of UK bat species will use dark/shaded foraging areas for a period of time upon first emergence (Entwistle *et al*., 1996; Zeale *et al*., 2012). This will continue until it is sufficiently dark to allow safe commuting across the landscape.
- Bats do not always echolocate (Swift, 1998), particularly in lighter conditions, and manual observations of size, shape and behaviour may be required for identification.
- Bats will use both sides of a hedge/tree-line for commuting/foraging, being more likely to use the side that is most sheltered from the prevailing wind (Verboom & Spoelstra, 1999). Hedgerows have important effects upon the distribution of aerial insects (Lewis 1969a; 1969b; 1970). These effects include reduction of windspeed, concentration of insects from adjacent habitats into regions of drag (particularly on the leeward side during winds), and generation of substantial insect numbers from hedgerow plant biomass. Advantages increase with taller and thicker hedges.
- Bats use of the landscape will change depending on insect availability. This is directly related to both weather and insect life cycles (i.e. has a seasonal influence) (Ransome, 1996; 1997; 2000; 2002).
- Bat habitat use within a site will be partially dependent on other habitat availability in the near vicinity (Ransome, 1997). For example, seemingly low-value habitat will be of increased value if that is all there is.
- Localised high insect sources (dung heaps/compost heaps/ livestock etc) should all be considered important bat foraging areas (McAney & Fairley, 1988; Downs & Sanderson, 2010).
- Bats' use of the landscape will change depending on the weather conditions (Verboom & Huitema, 1997). Sheltered areas will be more valuable for commuting/foraging when windy/rainy (Verboom & Spoelstra, 1999). Conversely bat activity in open areas (e.g. on moorland) will be higher during warm, dry, still nights.
- Variables unconnected to habitat and weather can influence bat presence and activity. Examples include roads (Berthinussen & Altringham, 2012), predation (Hernández-Brito *et al*., 2018), and agricultural management (notably use of antihelmintic drugs reduce the number and variety of insects in dung (Ransome, 1996)).
- Bat landscape use is usually negatively impacted (to varying degrees depending on species) by artificial light (BCT and ILP, 2023; Voigt *et al*., 2018) and noise (Luo *et al*., 2015; Reason & Bentley, 2020). Bat habituation to light/noise is poorly studied.
- Water (of all types), woodland (of all types), and grassland/moorland (particularly when wet/marshy, organic, species-rich, and/or containing livestock), should all be considered habitats of importance to foraging bats. For species-specific information, Entwistle *et al.* (2001), Kyheröinen *et al.* (2019), and Table 3.4 (within these guidelines) should be consulted.

Complementary/alternative methods

8.2.39 Transect surveys have been carried out using **bikes or cars** to cover more ground (or boats in aquatic habitats). However, the limitations of these methods should be recognised. Car surveys are particularly constrained because they focus the survey only on roads/tracks and the noise and lights of the cars could disturb some bat species (particularly species that avoid light). Quieter-calling species can easily be missed so these methods should not be used in isolation.

8.2.40 It may be necessary to **capture bats** using mist nets or harp traps in order to identify their species, gender and age to supplement activity survey information. More information on timing, capture and handling is provided in Chapter 9.

Timing

8.2.41 Recorded bat activity is dependent on the prevailing conditions at the time of the survey, which vary temporally (through the night, between nights, through the seasons and between years) and spatially (dependent on latitude, longitude, altitude, habitat, etc.).

8.2.42 Bat activity is also determined by what the bats are doing at different times of the year (although this is also dependent on prevailing conditions); the bat life cycle is given in Section 3.2.

8.2.43 The UK bat active period is generally considered to be between April and October inclusive, although April and October surveys are both weather- and location-dependent (October surveys are generally not acceptable in Scotland). Conditions may become more unsuitable in these months, particularly in more northerly latitudes, which may reduce the length of the survey season. Surveys in the 'shoulder' seasons may, however, help to identify activity close to transitional or hibernation roosts. Some useful data may be collected outside these months or weather conditions may render surveys ineffective – professional judgement should be applied to determine the most effective activity survey period for a particular project.

8.2.44 It may be appropriate to survey for bat activity in the winter, particularly if there are hibernation roosts in, or close to, the survey area. Foraging habitats close to hibernacula may be particularly important because, during the winter, bats need to minimise energy used to gain food during milder weather conditions. Generally, automated/static surveys are likely to be the most efficient way of collecting data on winter bat activity, although these may need to be supplemented with manual surveys as appropriate.

Table 8.2. Recommended start and end times for activity surveys.

Survey type	Start time	End time
Automated bat detector survey[a]	30 minutes before sunset	30 minutes after sunrise
NBW surveys	Sunset[b]	2/3 hours after sunset
Vantage point survey	Sunset[b]	When surveyors can no longer see bats due to falling light levels, unless supported by NVAs

a Set detectors with location to track sunset/sunrise as the season progresses.
b Adjust to earlier if in darker habitats such as woodland or if data justifies (e.g. if bats are already out by sunset on previous surveys or automated detectors show pre-sunset activity).

8.2.45 Table 8.2 provides recommended start and end times for activity surveys.

8.2.46. Timings may be adjusted (earlier or later) if necessary by the ecologist, bearing in mind the site-specific circumstances, although this should be fully justified in the survey report.

Survey effort

8.2.47 When planning surveys it is important to take a proportionate approach. The number and arrangement of manual and automated/static surveys undertaken should be determined in consideration of the following factors:

- likelihood of bats being present;
- likely species concerned;
- levels of activity/relative abundance;
- type and diversity of habitats affected;
- predicted impacts of the proposed development on bats;
- type and scale/size of proposed development.

8.2.48. Table 8.3 below recommends a minimum number of repeat activity surveys.

Table 8.3. Minimum recommended number of repeats for activity surveys.

Survey type	Low suitability habitat for bats[a]	Moderate suitability habitat for bats	High suitability habitat for bats
NBW	One survey visit[b] per season (spring – April/May, summer – June/July/August, autumn – September/October)[c]. Further surveys may be required if these visits, or the results of static detector surveys, reveal activity of interest that requires more observation on site.		
Automated/static bat detector surveys[d] The same locations should be used for each survey for comparison.	Data to be collected for a minimum of five consecutive nights per season (spring – April/May, summer – June/July/ August, autumn – September/October)[c] in appropriate (or the best available) weather conditions for bats.	Data to be collected for a minimum of five consecutive nights per month (April to October)[c] in appropriate (or the best available) weather conditions for bats.	

a If the habitat has been classified as having low suitability for bats, particularly on small sites with relatively few features, an ecologist should make a professional judgement on how to proceed based on all of the evidence available. It may or may not be appropriate for bat activity surveys to be carried out in low suitability habitats. However, caution should be exercised in fringe areas (e.g. some areas of Scotland) where 'low suitability habitat for bats' may be important to local bat populations due to the relative scarcity of better habitats. In such situations, bats are likely to also be more widely dispersed and may use a larger number of sites, therefore survey effort may actually need to be increased to detect use on the proposed site in question.

b A survey visit should aim to cover all habitats represented in the survey area that could be impacted by the proposed activities. This may consist of a single walkover carried out on a single night for small sites (e.g. small housing developments) with low habitat diversity, but could range up to multiple walkovers carried out over one or several nights (depending on number of ecologists) on a larger site (e.g. road schemes) with greater habitat diversity.

c April and October surveys are both weather- and location-dependent. Conditions may become more unsuitable in these months, particularly in northern England and Scotland. Surveys in the 'shoulder' seasons may, however, help to identify activity close to transitional or hibernation roosts or help to understand how bats adapt their behaviour in different weather conditions. Professional judgement should be used on the necessity for surveys during these months.

d Detector locations should be assigned to provide a representative sample of all habitats in the survey area that could be impacted by the proposed activities. This could mean a single detector location at a small site with only one habitat represented but could range up to many detector locations on larger sites. Automated/static surveys are also useful when assessing collision risk, e.g. detectors can be placed at crossing points on proposed roads or railways. However, these surveys should generally be complemented by manual surveys where observations of how bats interact with the site can be made.

Note: Multiple survey visits should be separated by at least three weeks, preferably longer, to observe temporal changes in activity.

8.2.49 Bat activity is inherently variable from night to night, with this variability not explained by weather conditions alone (Scott and Altringham, 2014), and so at least five consecutive nights of survey with automated systems per survey location are recommended (in good weather conditions for bats to be active).

8.2.50 It is important to consider how effective the surveys are in recording species that are more difficult to detect (see Section 3.9) or exhibit highly variable or seasonal patterns of activity (such as migration by Nathusius' pipistrelle). It may be appropriate to adjust the survey methods, increase the number of survey nights or adjust the survey frequency to ensure these species are not under-recorded. Skalak *et al.* (2012) reported that relatively few nights are needed to detect common species but longer sampling periods may be necessary to detect rarer species. The same is true of those species that use quiet echolocation calls (see Tables 3.7 and 3.8).

8.2.51 Comparing automated/static data with manual surveys may also indicate that species are being recorded by one type of survey but not another, so that subsequent surveys can be adjusted accordingly.

Weather conditions

8.2.52 Please refer to para 2.6.2 onwards for guidance on weather.

Next steps

8.2.53 The next steps will depend on what has been recorded during the activity surveys. It may be necessary to carry out further activity surveys in subsequent years, or use alternative methods to gain specific information (e.g. using a trapping survey to distinguish between *Myotis* or *Plecotus* species or to define the breeding status of the bats; see Chapter 9).

8.2.54 Where enough information has been collected, the data should be used to inform an impact assessment and the design of a mitigation strategy.

8.3 Swarming surveys – acoustic

Description and aims

8.3.1 Swarming surveys are carried out to identify if a site is used by bats for autumn swarming. This was described by van Shaik *et al*. (2015) as follows: *'The assembled bats display intense flight activity, circling in and around the entrance of the site….'*. Autumn swarming behaviour has been recorded mostly at the entrances to and outside underground sites such as caves, mines and tunnels but has also been observed around other structures such as castles, stately homes, large barns and other prominent structures in the landscape. These sites are often then used for hibernation during the winter months. Autumn swarming should not be confused with what is commonly termed 'dawn swarming', where one or more bats fly around outside their roosts prior to entry at dawn.

8.3.2 Autumn swarming usually occurs in the UK from August to October inclusive. There is good behavioural and genetic evidence to show that mating is an important function (Thomas *et al.*, 1979; Kerth *et al*., 2003; Rivers *et al*., 2005; Furmankiewicz and Altringham, 2007), which enables gene flow between otherwise isolated summer colonies. Other studies have suggested that swarming at hibernation sites allows bats to find and assess the condition of hibernation sites prior to the winter (van Shaik *et al*., 2015).

8.3.3 Swarming behaviour is common among *Myotis, Plecotus* and *Barbastella* species, often known as the 'classic' swarming species. However, trapping by the Dorset Bat Group (Tomlinson, 2020) provides evidence of swarming in common pipistrelle and serotine, which exhibit seasonal activity peaks (both in August), activity peaks during the night (although an hour or so earlier than the classic swarming species, which may reflect their earlier emergence time) and sex ratios (male-biased). Evidence from the Netherlands shows mass swarming events of common pipistrelle bats in the autumn followed by mass hibernation in a diverse range of building types in urban environments (Korsten *et al*., 2016). Swarming by common pipistrelle has also been recorded in the UK (Bell, 2022 and Tomlinson 2020). Work in Shropshire has also highlighted lesser horseshoe bats as swarming species (see presentation by Worsfold from UK Bat Steering Group meeting, 2022[83]).

8.3.4 Rivers *et al*. (2006), in a study of four North Yorkshire caves, found that Natterer's bats undertook seasonal migration between the caves and their nursery sites over an area of at least a 60km radius. Between 300 and 400 bats visited the caves each night, with many more present at the peak of the season. Numbers of bats tend to vary between sites and from night to night at the same site. Activity typically starts in August and rises to a peak in September or early October before slowly declining. Many thousands of bats may visit some sites, but swarming behaviour may involve no more than a few bats each night at minor sites.

8.3.5 Swarming sites can therefore be important mating sites for large numbers of bats and are important for gene flow (Kerth *et al*., 2003; Rivers *et al*., 2005; Furmankiewicz and Altringham, 2007). Many underground swarming sites are also hibernation sites and it is likely that at least some of the bats swarming at a site go on to hibernate in the same site (Glover and Altringham, 2008; van Shaik, 2015). Individual bats show very high fidelity to a single swarming site (Rivers *et al*., 2005, 2006; Glover and Altringham, 2008) and few bats are recaptured at other sites, even those close by.

8.3.6 Swarming activity generally peaks 3-4 hours after sunset (Rivers *et al*., 2006; Glover and Altringham, 2008), although see Tomlinson (2020), who describes a slightly earlier peak for species not considered to be 'classic' swarming species. Observations made during the first few hours after sunset may therefore not detect swarming.

8.3.7 The impact of destroying or changing a swarming site for development purposes is likely to be severe, so it is particularly important to investigate suitable sites to determine if swarming occurs. The aim of carrying out acoustic bat activity surveys at potential swarming sites is to establish the extent and nature of use by swarming bats and therefore determine the need for further surveys (see Chapter 9) and the extent of potential impacts.

Equipment

8.3.8 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

8.3.9 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Acoustic swarming surveys are unlikely to disturb bats if carried out correctly.

8.3.10 Due to the potential complexity of surveying swarming sites and assessing any impacts, an ecologist at BCT Level 3 (CIEEM Accomplished) competence should design and lead these surveys.

Methods

8.3.11 The most efficient way to investigate whether bats are swarming is to deploy automated/static bat detectors within, outside and/or close to the entrance to an underground site (or complex structure). Repeated peaks in ultrasonic activity,

83 https://www.bats.org.uk/our-work/project-collaborations-partnerships/uk-bat-steering-group

reaching a maximum 3–4 hours after sunset, indicate the site is used by swarming bats and the echolocation calls recorded can be analysed to species or genus after the survey. This method is likely to generate a large amount of data because of the high levels of activity generally observed. However, it is unlikely to be necessary to scrutinise all recordings made (depending on the aims and objectives of the survey).

Complementary methods

8.3.12 It may be appropriate to trap bats at a swarming site if it is necessary to confirm species, particularly if Annex II species such as barbastelle and Bechstein's bat may be present. Wherever and whenever possible, harp traps should be used in preference to mist nets due to the possibility of catching large numbers of bats. More information on trapping is provided in Chapter 9.0. Trapping to establish gender is unnecessary because the pattern of use at swarming sites is well documented: both sexes are present, but males outnumber females, consistent with mating behaviour during swarming (Thomas *et al*., 1979; Kerth *et al*., 2003; Parsons *et al*., 2003a; Rivers *et al*., 2005; Furmankiewicz and Altringham, 2007; Glover and Altringham, 2008). Further work establishing gender ratios is perhaps best left to targeted research.

Timing

8.3.13 Swarming surveys should be carried out during August to October inclusive. Species composition varies throughout the swarming season, with *Plecotus* and most *Myotis* species either peaking early (during August) or showing no discernible peak, and Natterer's bat peaking late in the season (Parsons *et al*., 2003b; Rivers *et al*., 2006; Glover and Altringham, 2008). Tomlinson (2020)'s study reports that brown long-eared bats show a slight bias for September and Bechstein's and barbastelle activity tends to be spread across the season. Tomlinson (2020) also reports that serotine more commonly swarms in August and common pipistrelle exhibits an August peak.

Survey effort

8.3.14 At least five nights of survey with an automated/static detector (in appropriate weather conditions for bats) in each month of the swarming season of mid-August to the end of October is recommended to establish whether a site is used for swarming or not.

8.3.15 If trapping is undertaken, then recommendations on survey effort are provided in Chapter 9.

Weather conditions

8.3.16 Please refer to para 2.6.2 onwards for guidance on weather.

8.3.17 Many studies have noted that bat activity at swarming sites varies markedly from night to night: bat activity is significantly suppressed by rainfall and positively correlated with residual maximum ambient temperature. Grubb (2012) also found high winds depressed activity. Moon phase does not appear to influence swarming activity (Parsons *et al*., 2003a), but a bright moon has been known to lower capture success (if trapping) at exposed locations. Swarming activity appears to be more likely when weather conditions are more stable so targeting periods of high pressure may be helpful.

Next steps

8.3.18 See Chapter 9 regarding trapping bats at swarming sites. Species assemblages using underground swarming sites are well documented from other studies (Parsons *et al*., 2003b; Rivers *et al*., 2006; Glover and Altringham, 2008). However, it may be pertinent to carry out trapping if Annex II species are likely to be present or to establish the presence/absence of other species that are rare but difficult to separate using echolocation, for example Alcathoe. A cautious approach should be taken regarding a decision to trap or not. It is not always necessary to trap if impacts can be avoided or mitigated.

8.3.19 Swarming sites are also used for hibernation so it may be necessary to also carry out hibernation surveys as described in Section 5.3.

8.4 Back-tracking surveys

Description and aims

8.4.1 **Back-tracking surveys** involve ecologists making visual observations of bats flying away from their roosts at sunset and flying back to their roosts before sunrise then atempting to track back to the roost based on these observations. Bat detectors are also used to record echolocation for identification of species, where possible. This technique was first developed in the Netherlands and is based on four principles:

- The earlier a bat is seen after sunset, the closer it is likely to be to its roost (the exact time depends on the species).
- Bats fly away from their roost at sunset, so ecologists should move in the opposite direction to the bats at this time to locate the roost.
- Bats fly towards their roost before sunrise, so ecologists should move in the same direction as the bats at this time to locate the roost.
- Before sunrise, some bat species swarm at roost access points for between 10-90 minutes before entering.

8.4.2 The aim is to find roosts by making observations of bats in flight. These surveys are often used after a manual bat activity survey if numbers of bats were seen all flying in one direction and follow up is required or in situations with many potential roost sites that are difficult to survey using alternative methods (e.g. in highly urbanised areas). However, note earlier comments on the constraints of pre-dawn surveys, as bats can return to their roosts at different times of the night (see para 3.5.3).

Equipment

8.4.3 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1.

Expertise and licences

8.4.4 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Back-tracking surveys are unlikely to disturb bats if carried out correctly.

8.4.5 For very simple sites, BCT Level 2 (CIEEM Capable) competence may be adequate for a backtracking survey but, for anything more complex, an ecologist at BCT Level 3 (CIEEM Accomplished) competence should at least design and may need to lead these surveys.

Methods

8.4.6 Ecologists should be deployed on potential or actual flight-paths close to likely/potential roosts and note the time and direction of travel of each bat encountered on a detailed plan of the site. As ecologists approach potential roosts, they should watch for bats.

8.4.7 If multiple ecologists are involved, they should be in constant contact via hand-held radio to communicate their observations. The data from multiple ecologists can also be pooled for a bigger picture of bat activity across the site, which can be used to design subsequent surveys where necessary.

8.4.8 In theory, back-tracking surveys work best for species with loud echolocation calls which form large roosts, but they can be used to locate the roosts of any bat species with care. It is, however, worth mentioning that most species of bats (even pipistrelles) will stick to dark shady places for a period of time immediately after emerging. This is evidenced by them arriving earlier at shaded foraging areas in comparison to open ones (Downs & Racey, 2006). This may mean that they initially appear to commute from something that is not their roost (such as a tunnel).

8.4.9 An initial aim could be to determine what bat species are roosting in a small area such as a small copse/area of woodland (e.g. by surrounding the area and adjoining commuting routes with surveyors). Once it is known that there are some roosts in an area, a more detailed attempt can be made to find exact locations (possibly with additional use of technology).

Complementary methods

8.4.10 Back-tracking surveys are rarely used in isolation; they are most effective when combined with roost (Chapters 5 and 6) and bat activity surveys (Section 8.2).

Timing

8.4.11 As back-tracking surveys are most effective for larger roosts, the best time to carry them out is between May and August, when maternity colonies are gathered. However, results may be gained if carried out in April, September or October, depending on the individual situation (although October surveys are not considered appropriate in Scotland). Back-tracking surveys should start 15 minutes before sunset and cease when it is too dark to observe bats or when the source roost has been found. If using this method to detect bats returning to roosts then likely return times should be factored in (see para 3.5.3.). Timings may be adjusted (earlier or later) if necessary by the ecologist, bearing in mind the site-specific circumstances, although this should be justified in the survey report.

Survey effort

8.4.12 The survey effort for back-tracking surveys is not fixed. These surveys have the specific aim of locating roosts using flying bats for guidance and should be continued until this aim is reached, or alternative methods adopted.

Weather conditions

8.4.13 Please refer to para 2.6.2 onwards for guidance on weather.

Next steps

8.4.14 If a roost is found during a back-tracking survey, it may be necessary to follow up with a roost characterisation survey (see Section 7.3) to count the numbers of bats present at the roost.

Chapter 9

Advanced licence bat survey techniques (ALBST)

9.1 Introduction

9.1.1 Being small, nocturnal and with many species being morphologically and acoustically similar, bats remain one of the most challenging groups of species to survey for the purposes of determining impacts from development, especially when working to the deadlines often associated with a commercial project. While there has been some research on the ecology of many UK species and a few, like greater horseshoe bats, have been quite extensively researched, there are still great gaps in our knowledge of the ecology of most species.

9.1.2 Trapping bats and radio-tracking them are powerful survey tools that can be used to obtain information on bats and bat populations potentially affected by a proposed development. However, trapping and radio-tagging do involve significant levels of risk to bats, and therefore these guidelines have been written to take account of EUROBATS Resolution 4.6, which provides *'Guidelines for the Issue of Permits for the Capture and Study of Captured Wild Bats.'* (EUROBATS, 2003). This states that *'radio-telemetry should only be used for well-organised and authorised projects where essential data cannot be acquired with less-intrusive methods'*.

9.1.3 This chapter provides guidelines on using ALBST and principally concerns the trapping of free-flying bats and, where required and appropriate, the subsequent attachment of radio transmitters. The techniques covered in this chapter need to be specifically licensed by the relevant licensing authority.

9.1.4 Deciding when to use ALBST is a process of balancing the data requirements to meet the objectives of the survey with the level of potential impact on bats or bat populations from using the technique. The decision-making processes should also fully consider the potential level of impacts from the proposed development; for example, the loss of woodland roosting habitat over large areas. The more detailed information gained from ALBST is likely to be required on projects with greater impacts on 'difficult to survey' bat species such as tree-roosting or quiet-calling species; more sensitive bat populations (generally Annex II bat species); and where there are SACs or SSSIs designated for bats.

9.1.5 Where the required information can be obtained using non-invasive techniques, these should clearly be used in preference. However, while non-invasive methods such as bat activity surveys have dramatically improved data-gathering for development-related projects, such techniques have limitations. In particular, the reliable identification of some bat species, for example the *Myotis* bats, from their echolocation calls alone remains difficult/sometimes impossible (Parsons and Jones, 2000; Walters *et al*., 2012). In addition, species that produce quiet echolocation calls and those that use passive listening for foraging often go under-recorded (see Section 3.9.).

9.1.6 Non-invasive survey methods are unable to confirm the sex, age class or breeding status of individual bats. It is also becoming evident that tree-roosting bat species are perhaps the most challenging to survey using standard techniques, given the frequent movements of these species between roost trees, the shade and vegetation complexity such roosts are often surrounded by, and the low bat encounter rates from standard techniques such as tree climbing inspections and emergence surveys (Andrews & Gardener, 2015).

9.1.7 If the potential impact of development activities is unlikely to significantly affect bats or their habitats, the use of ALBST is unlikely to be necessary. Equally, projects or developments that are likely to have high direct or indirect impacts on bats (particularly for rarer or tree-roosting species or for landscape-scale projects where impacts may affect multiple bat species and populations) will be required to have much more detailed and comprehensive data sets, potentially justifying the use of ALBST. Box 9.1 provides an example of the effective use of ALBST and Box 9.2 provides an example comparing ALBST to activity surveys.

Box 9.1. Example of effective use of ALBST.

A series of trapping and simultaneous full-spectrum bat detector surveys were undertaken in the same woodland habitat over six months during the bat-active period of 2014. In total, 82 bats were captured and approximately 3,500 bat recordings were made over 17 survey nights. Only six bat detector recordings could be assigned to long-eared bats whereas 41% of the bat captures were of brown long-eared bats. Furthermore, three Bechstein's bats, two of which were from a nearby newly discovered breeding population, were captured. These results highlight the significant under-recording of species that can both echolocate quietly, or listen rather than echolocate, where trapping is often the most effective tool to confirm their presence. Given the scale of the housing development proposals in this case (over 5,000 units), the potential impact on the woodland from the development (lighting and increased recreational use), as well as the possible presence of rare species in the general area, the use of ALBST was appropriate and provided information to inform the EIA that other techniques could not achieve.

Box 9.2. Example comparing activity surveys to ALBST.

One major landscape scale project near London covering 42km^2 with a range of habitats present had a full suite of surveys conducted including 18 transects, 33 static loggers and extensive trapping surveys in multiple areas over two years. The activity surveys collected 486,779 detector recordings of 8 species but trapping caught 1,061 bats of 10 species. Notable differences were identified in the proportions of species identified by different survey methods. *Plecotus* made up 272 of the acoustic recordings, representing 0.05% of all calls. Trapping caught 26 brown long-eared bats, representing 2.5% of all bats caught, a proportion that was 50 times higher than identified from the detector survey methods. Similar trends were evident for all *Myotis* species with detector methods recording far lower proportions that were caught during surveys.

9.1.8 Radio telemetry can provide valuable data on roost use, activity patterns, colony and individual home ranges, foraging behaviour, flight-paths and habitat use. For impact assessments associated with development, these data can provide useful context on how important a proposed site might be within a bat population's home range and whether preferred foraging or roosting habitat, or flight-paths, will be affected, enabling the design of more effective mitigation. Furthermore, radio telemetry can locate roosts of challenging species (especially in trees).

9.1.9 It is important to highlight that radio-tracking surveys are essentially population sampling methods. It would not be possible, nor desirable from a bat welfare perspective, to tag every animal from a population, and only bats sufficient to confidently represent the population being investigated (depending on the objectives of the work and what is already known about bats in the area or typical colony sizes for the relevant species) should be tagged and tracked. For example, roost finding would require fewer tagged bats in comparison to an assessment of home ranges. However, this approach can be misrepresented in development projects, as the focus for impact assessments and/or mitigation is often on only the individual bats being tracked and their movements, rather than using the sampling to identify which type of flight-paths or foraging habitats the population is likely to use. This issue is best overcome by proper study design and appropriate analysis of the data including, where necessary, statistical testing of the samples used. All effort should be made to extract sufficient data from a tagged individual to justify the method and achieve well thought-out objectives. It is not considered acceptable, given the intrusive nature of the methods on bats and the costs of such surveys, for any subsequent analysis to be limited to simple dots on a map (unless roost location is the only objective). More information is provided in Section 10.4.

9.1.10 As highlighted earlier, trapping and radio-tagging/tracking should only be used in cases where other options for obtaining data are ineffective or grossly inefficient and the level of potential impact on important bat populations is considered high, such as the loss of significant high-quality bat foraging or roosting habitat. For example:

- High-impact developments at a landscape scale that may affect substantial roosting and foraging areas for a wide assemblage of bat species, especially those difficult to identify through bat detector systems.
- High-impact developments at a landscape scale affecting rare bat species, for example, Annex II species or features of SSSIs.
- High-impact developments on areas likely to support proportionately higher populations of tree-roosting bats or bats likely to be in inaccessible roost types (quarry faces, etc.), where other methods have not been able to locate roosts likely to be present.

9.1.11 Although these guidelines are focused on single-site/project-related developments, radio tracking of key populations should also be used to provide strategic approaches to land use/development-related planning, particularly around sites supporting Annex II species. For instance, radio-tracking can be used to identify key habitats and sustenance zones around bat SACs to inform local development plans.

9.1.12 Some examples of supplementary planning guidance, written using data from ALBST techniques, are the South Hams SAC Greater Horseshoe Bats Habitats Regulations Assessment Guidance (Devon County Council *et al*., 2019) and Bat SAC Planning Guidance for Wiltshire (NE and Wiltshire Council, 2015).

9.1.13 Advice on the use of these techniques is available for England from NE (WML-G39 2013, NE, 2013[84]).

9.2 Trapping surveys

Description and aims

9.2.1 This section focuses on the capture of free-flying bats with mist nets and harp traps. This technique can be used on flight-paths, in foraging areas, at roosts and at swarming sites.

9.2.2 Given its rarity, quiet echolocation calls and the difficulty of reliably identifying *Myotis* bat species from their echolocation calls alone (Parsons and Jones, 2000; Walters *et al*., 2012), species-specific guidelines are given for surveying Bechstein's bats where developments are likely to affect this species and/or its habitats.

9.2.3 The need to undertake trapping surveys will depend on a range of factors and, in particular, the questions requiring answers to inform an impact assessment. Recommended use of these techniques include:

- To determine species identity: for example, if bat detector surveys have found proportionately high levels of *Myotis* bat activity and the development is likely to have a high impact on the habitats of such species, then it will be important to confirm which *Myotis* species are present to inform the impact assessment and mitigation strategy. Similarly, trapping may be required to separate the two *Plecotus* species when within the range of the grey long-eared bat. It is also essential to identify bats to species level for high-impact licensing purposes when other techniques have been unable to do so.

84 https://webarchive.nationalarchives.gov.uk/20140605150911/http://www.naturalengland.org.uk/Images/wmlg39_tcm6-35872.pdf

- To determine gender and breeding status: particularly important when the impacts of a development are significant (e.g. loss of a high status roost either directly or indirectly) and when knowing the breeding status of a population is crucial to designing the most appropriate mitigation. In addition, understanding the breeding status of bats using foraging or other non-roost sites can be an important element of valuing the importance of the site for impact assessment purposes.
- To gain further information about rare or under-recorded bats: the presence, gender, breeding status, roost locations, foraging areas and flight-paths of rare species such as horseshoe bat species, grey long-eared bat, barbastelle, Alcathoe and Bechstein's bat may need to be confirmed where they could be present and when their potential habitat is affected by the proposed development.
- To find tree and building roosts at a landscape level: if high impacts on bats are anticipated, then trapping can be used to determine the presence of breeding bats and the selection of such individuals for the attachment of radio transmitters. This is an effective approach for locating breeding colonies or bat populations of high conservation significance, particularly those using tree roosts, and such data have been used to inform mitigation licences for major infrastructure projects.

9.2.4 It should be noted that trapping surveys also have their own biases and limitations and may be more effective at determining the presence of certain species (for instance those species generally found in cluttered habitats). Data collected using this technique should be considered alongside the other techniques described in these guidelines to provide a balanced data set for bats using any particular site.

Equipment

9.2.5 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1 and further information about mist nets, harp traps and lures is provided in Appendix 5.

Expertise and licences

9.2.6 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences.

9.2.7 Ecologists should be at BCT Level 5 (Specialist) competence to be using these techniques.

9.2.8 In England, at the time of writing, CL19 and CL20 licences allow the use of mist nets and harp traps respectively (both can be used with acoustic lures) but only for a maximum of three days at any one site and only for development purposes. Otherwise, a specific project licence is required.

9.2.9 These techniques can significantly affect the welfare of bats and therefore bat handling and identification skills need to be regularly practised to be able to extract and process bats quickly. Experience of handling wild bats from a range of species including small, medium and large bats should be kept up-to-date.

9.2.10 If acoustic lures are used (see below), regular training or experience in the most effective use of lures is recommended, because of its evolving nature.

9.2.11 Licences from the relevant licensing authority (see para 1.3.2 onwards) are required to use these techniques, including the use of lures. Using lures without traps to attract bats also requires a licence.

Methods

9.2.12 The first stage of a trapping survey is the identification of potential trapping sites through a review of site plans, aerial imagery, any existing habitat/bat-related data, any relevant acoustic data (if the target species is detectable by this method) and taking into account the proposed development activities. This information helps to identify the sites that would increase the likelihood of catching bats in relation to those areas impacted by the proposed development. This should be followed by a daytime site visit to determine the micro-siting of the traps. Large projects with multiple trapping sessions will need to specify methods and broad trapping locations to be specified in the licence application.

9.2.13 Trapping using mist nets and harp traps can be done passively (without lures) or actively (with lures used to attract bats; see below). The set-up and location of traps and nets will vary depending on which method is being used and whether specific species are being targeted. Mist nets have the advantage of having a greater catch area and being lighter, but they require continuous monitoring in contrast to harp traps and high levels of bat handling skills and experience to extract bats. A considerable amount of training and experience is essential to carry out trapping with mist nets safely, from a bat welfare perspective, and mist nets should not be used where large numbers of bats are expected. Bats can be more easily extracted from harp traps; however, they have a smaller trapping area and are heavy. All of these activities require BCT Level 5 (Specialist) competence.

9.2.14 Recommended trapping locations include areas where vegetation or other structures limit the space through which bats can fly or manoeuvre, therefore increasing the chance that the bat will fly through the restricted space where the net or trap is located, for example:

- woodland rides and edges with overhanging tree branches;
- streams/river corridors and bridges;
- low-hanging branches of large isolated trees;
- gaps in treelines/hedgerows;
- next to water features such as lakes/rivers, especially adjacent to riparian woodland;
- tunnel, cave and mine entrances and passages; or
- barn doors, building entrances/old window frames.

9.2.15 Placing traps next to building features such as hanging tiles can also be effective when trapping at building roosts or swarming sites (see Mitchell-Jones and McLeish, 2004, for more detailed information on such techniques).

9.2.16 When working in or around water, it is essential to ensure that bats will not be drowned if they become trapped and their weight drags the lower shelf of the net or the capture bag of the harp trap into the water.

9.2.17 Mist nets should be continuously monitored, with various considerations taken into account. Standing beside nets or continuously checking nets with bright torches can cause disturbance and reduce the number of bats trapped. NVAs can be used to avoid the need for torches so provide an ideal solution for continuous monitoring without disturbance. Bat detectors can be used to gauge activity levels – nets can be checked immediately following bat detections – although caution should be exercised as bats don't always echolocate or may be echolocating very quietly and not picked up by the detector.

9.2.18 When bats are caught in a net they may attract other bats in by social calling, which means multiple bats then require extraction. They may also attract predators. The longer a bat is trapped by a mist net the higher the likelihood of it getting more entangled and therefore more difficult to extract. Alternatively, this may cause a bat to bite through the net and escape, leaving a big hole. Harp traps should be checked ideally every 15 minutes, but this could be more frequent in cooler conditions to avoid bats entering torpor.

9.2.19 In the event that the number of bats caught in mist nets is unexpectedly high and extracting them quickly becomes challenging, then they should be extracted as quickly as possible and the nets closed.

9.2.20 When a bat is caught it should be extracted from the mist net or harp trap as soon as possible and placed into a soft, clean cloth holding bag (with no loose threads on the inside) for processing. If any heavily pregnant or lactating bats are caught unexpectedly, only the species, ring number (if ringed) and breeding status should be quickly noted, then the bat should be released directly from the trap (not taken for further processing). Surveys should be carefully timed to minimise the likelihood of trapping, in particular, heavily pregnant bats or those with young, dependent pups (non-volant). If heavily pregnant or lactating bats are being caught, then trapping must cease immediately because of potential impacts to breeding success. Local knowledge is helpful to understand when births are happening for given species in any one year because this can vary (see Table 2.2).

9.2.21 Care should be taken to hang any holding bags in a quiet, dry, sheltered and (ideally) warm location (e.g. inside a vehicle). Keeping bats out in cold conditions risks them entering torpor, making effective release more difficult.

9.2.22 Bats should be processed (with handling kept to a minimum) and released as soon as possible after capture, particularly when it is cooler. Any bats appearing stressed should be prioritised for processing first. Bats should not be held unnecessarily.

9.2.23 The trapping datasheet should include: location, date, licence number and details of licensed individuals as well as trainees, weather conditions, time traps opened, time traps closed and a list of the traps used with trap type (with or without acoustic lure), size and 10-figure grid reference recorded.

9.2.24 For each bat captured, the information to be recorded will depend on the aims, but as a minimum: species, sex, age class, reproductive status and if a ring is present, the number (as well as if any impacts from the ring are evident).

9.2.25 Where useful, forearm length and weight may be recorded (and should not add significantly to the processing time). Both forearm length and weight can provide a good indication of bat health and, by association, an indication of surrounding habitat quality/foraging conditions (see Ransome, 1998). There are occasions where this will be useful. Recording weight is essential if the bats will be fitted with radio transmitters.

9.2.26 Other morphological measurements are generally used to help identify the bat species, and the prolonged handling required to obtain these measurements should only be undertaken where identification is proving challenging. If species identification can be made without taking such measurements, then this part of the process is generally superfluous and adds unnecessarily to the processing time, potentially creating problems for release.

9.2.27 Bats can be marked with non-toxic liquid coloured chalk to determine if any bats are recaught on the same night – this method can be specified in a project licence application but is not included on the NE class licences.

9.2.28 While the bat is in the care of the ecologist, it is important to ensure the equipment used to hold the bat(s) and the processing stages comply with licensing conditions and guidance (e.g. NE, 2013 and IUCN SSC BSG, 2021).

9.2.29 Prior to release, ensure bats are sufficiently warm for successful flight. If bats are not sufficiently warm and active or if they flutter to the ground on release, ensure they are fully warmed-up before releasing again. This can be done by carefully placing them in a bat bag and holding them gently under clothing for body warmth and/or in a warm car or on a heat pad. Bats should be released from the hand, held at head height and away from low vegetation. Noctule bats may struggle to launch at this height and it is often necessary to find a suitable tree and allow bats of this species to climb to a height from which they are comfortable to launch. When releasing bats it is important to continually monitor behaviour to identify whether bats are fit to release and have launched successfully. It is essential to watch bats during the release to ensure they have launched and flown away successfully and not grounded, which could happen a few metres from the release location.

9.2.30 Where used, acoustic lures should be placed close to the net or harp trap. For harp traps, the most effective technique appears to be placing the speaker just above the catch bag in the centre of the trap as bats are more likely to be caught by the lower parts of the strings of the trap and have less time to escape. Net configurations vary and so the positioning of the lure will also vary. However, placing the lure or speaker close to the mist net will increase the chance of a bat being captured as it investigates the lure.

9.2.31 Some general guidance relating to lures is as follows:

- Do place lures and/or lure speakers close to the trap or net, as this increases the chance of bats being captured when investigating the lure.
- Do move lures between traps and nets where there are more traps/nets than lures as this is more effective than having a stationary lure, to which bats may become accustomed. This also provides greater coverage of a site.
- Do play recognised, tested and effective bat social calls.
- Do have periods of silence to determine whether bat activity is present around the nets when not using the lure.
- Do turn the lure off during extraction to avoid unnecessary stress to the bat, particularly when extracting bats from mist nets.
- Do not use high volumes as abnormally loud calls could be counterproductive by deterring bats, particularly those using cluttered habitats.
- Do not use bat distress calls because the meaning of distress calls to bats is poorly understood and has the potential to have negative consequences for local populations.
- Do not use lures within 50m of known active roosts, as this may cause prolonged disturbance to bats present at the time. If in doubt about impacts on maternity roosts, traps can be used without lures.
- Do not use lures within 100m of swarming sites during late summer/autumn as this may cause prolonged disturbance to bats present at the time.

9.2.32 Some precautionary advice on the use of lures is provided in Box 9.3.

Box 9.3. Note about the use of lures to aid the capture of bats in traps and nets.

Lures have been shown to be very effective at increasing capture rates with harp traps and mist nets for a range of species (Hill and Greenaway 2005, 2008; Lintott *et al*., 2014; Hill and Cook, 2020) and for some species, e.g. Bechstein's, have been shown to be the only reliable way to accurately identify presence. Lures have been shown to be highly effective in habitats where trapping would normally be ineffective, notably where there is an absence of commuting corridors such as in dense woodlands and wide-open spaces. Lures can call bats in to trapping positions that would be otherwise fruitless.

A wide range of social calls has been used for lures. In some cases, the origins of the calls are known, e.g. they are from juveniles, maternity roosts or a specific sex. However, in most cases the full meaning of these calls to bats is unknown. Some calls are highly effective and illicit a territorial response leading to a bat's capture; however, many calls incite no response at all. Others appear to have a seasonal variation in their effectiveness. Any calls used should be naturally occurring social calls, which could be heard by bats in their natural habitats anyway. Distress calls should not be used as the impact of this is not known.

Some studies have reported that the use of lures can lead to a skew of the sex ratio of captures, for example captures of male soprano pipistrelles increased throughout the season from May to September in one study where captures of females were constant (Lintott *et al*., 2014). Hill and Cook (2020) carried out trials with the Sussex Autobat in the Midlands and the south of England in 2018 and 2019 to study the impacts of call type, speaker type and signal strength on captures. 218 bats of 11 species were captured in these trials, with a male-biased sex difference for all species except Daubenton's bat.

However, other studies have had notably different results with some large data sets. One study by Whitby in 2019 caught 1,216 bats including 515 adult soprano pipistrelle bats across a range of sites, with a male-female ratio of 25%-75%. Notably, for juvenile sopranos the sex ratio in this study was virtually identical. The BCT's National Nathusius' Pipistrelle Project has caught 17,704 bats of 17 species using lures, with only slightly more females than males overall across a range of sites. However, for some species the sex ratios are notably different. For soprano pipistrelle there were 5,271 females to only 3,637 males, whereas for brown long-eared bats it was 79 females to 122 males.

The projects referred to above were predominantly targeted around and near large waterbodies, the optimum habitat for soprano pipistrelles. This is suboptimal habitat for other species, such as the brown long-eared bat. As a result, significantly higher numbers of soprano pipistrelles were caught, including much higher proportions of females. Many bat species are known to sexually segregate, with higher proportions of breeding females in optimum habitats (to meet energetic demands) and males found in suboptimal habitats. The capture of different proportions of sexes of a species in different studies may be down to the habitat suitability for those species rather than any biases created by lures. Trapping with lures can be a good way of identifying the sex and breeding status of the bat species present and can therefore be used to indicate the site importance by identifying which species may have breeding females present on a site and which may be predominantly males.

Although lures have been in use by various bat researchers and bat workers since the late 1990s, very little is known about the full effects these devices have on local bat populations. No significant, targeted research has been undertaken to consider whether there are any detrimental effects of using lures, so they should be used with caution when other methods have been considered and only with specific aims and objectives.

9.2.33 More information on acoustic lures is provided in Appendix 5.

Bechstein's bat

9.2.34 Where sites are located within the known distribution of Bechstein's bat and suitable habitat for this species is likely to be impacted (see BCT, 2013), then species-specific surveys are likely to be required. Mist nets and/or harp traps used with a lure emitting Bechstein's bat social calls is the recommended method of surveying for this species as these bats use quiet echolocation and, even when detected using bat detectors, they are very difficult/sometimes impossible to distinguish from other *Myotis* bat species (Parsons and Jones, 2000; Walters *et al*., 2012). The use of a lure constitutes active trapping and, for this species, traps and lures should be placed in the cluttered interior area of woodland. This technique has been used to great effect with Bechstein's bats (Hill and Greenaway, 2005; Davidson-Watts, 2008; Miller, 2012).

Complementary methods

9.2.35 Bat activity surveys (see Chapter 8) are complementary to trapping and the two together provide a more balanced data set than trapping alone, subject to the objectives of trapping. In some situations, acoustic data can be used to inform trap locations, depending on the detectability/identification of the target species by acoustic methods (e.g. this would work for barbastelle but not for Bechstein's). Care should be taken to ensure that acoustic surveys do not record calls emitted by the lures (see below) when active trapping and acoustic surveys are undertaken simultaneously in the same locations.

Timing

9.2.36 Subject to weather conditions, trapping surveys for development-related projects should normally be undertaken between May and September when bats are most likely to be active. Trapping should not be carried out in the potentially vulnerable post-hibernation period of April, unless there is a specific requirement. The exact timing of the surveys will largely depend on the objectives, species and the potential bat habitat of the site affected. For example, the most appropriate time to survey a potential swarming site would be during August and September (perhaps into October), whereas trapping to confirm the presence of breeding bats should be undertaken between May and August, avoiding the most vulnerable times.

9.2.37 Trapping should not take place during the period when bats are likely to be heavily pregnant, giving birth or during early lactation (when they have young, dependent, non-volant pups). Typically, this period falls between June and July, but timings will depend on the target species and location (timings may vary considerably between species, in different parts of the UK and with seasonal variation between years). Where available, local information should be sought to inform timings for the area, target species and relevant context. If heavily pregnant bats are being captured unexpectedly, ecologists should be ready to pack up the traps and cancel the survey.

9.2.38 NE Class licences (Level 3 for mist netting and Level 4 for harp trapping; see para 1.3.9) allow for a maximum of three trapping nights per site for commissioned developments without a specific project licence (this is not the case for the other UK countries, where a project licence is required). These surveys should ideally be spaced across the bat active season, covering both the pre- and post-parturition periods, in good weather conditions.

9.2.39 Trapping the same trap site locations more than once a month would require some justification from a disturbance perspective. Should more than three trapping nights be needed to meet specific objectives, then a project licence would be required.

9.2.40 On the day of the trapping survey, ecologists would normally need to arrive at the proposed trapping site(s) at least an hour before sunset to confirm exact trapping points, identify any additional health and safety issues, and set the traps. A trapping survey would usually commence at dusk and continue until 2–3am (but potentially all night) depending on conditions, capture success, general bat activity and the objectives of the survey. For instance, if the objective was to capture a specific bat species for radio telemetry, then trapping would cease once the target bat or bats had been captured. When trapping for swarming surveys, activity is likely to peak later in the night (see Section 8.3) and therefore survey timings should be adjusted accordingly.

Survey effort

9.2.41 Survey effort depends on a number of factors including the size of the site, the type and quality of habitats present and the objectives of the survey. For example, surveys to trap specific species for radio telemetry will require an assessment of suitable habitat both on and off the site, a review of previous records, recent acoustic data and an appraisal of suitable trapping areas to determine the effort required to meet the objective.

9.2.42 The number of harp traps/mist nets that are deployed simultaneously will depend on the extent of habitat to be surveyed and the team available to check them. Traps/nets should ideally be no less than 100m apart when using lures to avoid bats being able to hear more than one lure simultaneously. A trap/net without a lure can, however, be stationed closer than this to a trap/net with a lure.

9.2.43 For smaller projects where impacts are more confined to specific areas of high-quality habitat (woodlands, treelines and wetland areas), at least three trapping surveys should be undertaken over the active period (late spring, summer and autumn). Swarming surveys may achieve the necessary information in fewer than three surveys and, in the interests of minimising disturbance, could be concluded at that point.

9.2.44 Large infrastructure schemes can impact many trees and/or multiple areas of high-quality bat habitat such as deciduous woodlands, treelines and wetlands. Surveys are likely to have multiple objectives, such as the confirmation of breeding bats and the determination of bat assemblages. In order to meet these objectives, many trapping nights with multiple harp traps and/or nets being used simultaneously over a five- or six-month period during the active bat season are likely to be required. This will be particularly important if regionally or nationally rarer species (e.g. for England Annex II, grey long-eared bat, or Alcathoe) or significant levels of tree-roosting species are predicted to be present, where trapping surveys over consecutive years may be required.

9.2.45 See Box 9.4 for more information on survey effort for Bechstein's bat.

Box 9.4. Survey effort for Bechstein's bat using traps and lures.

To determine the presence/likely absence of Bechstein's bat on a site, the lure and net/harp trap method should be used and trapping surveys conducted for a *minimum* of six trap nights over the active bat season. One trap night is one lure and net or harp trap combination on one night. Therefore, six trap nights can be achieved by six nights of trapping with one set of trap/lure combination or three nights of trapping with two sets of trap/lure combination. Ultimately the total number of traps/nights will depend on the size and nature of the potential Bechstein's bat habitat available. If the site is large with multiple woodland copses or treelines with potential for this species, then more trap nights are likely to be required.

Trapping surveys for Bechstein's bats should be undertaken between May and August to ensure that the key stages of the breeding cycle are covered, with ideally one survey pre-parturition and one survey post-parturition, at least one month apart (avoiding the trapping of pregnant bats or those with dependent pups).

9.2.46 See also Hughes *et al.* (2020) for comment on the number of net hours required to encounter less common species (the minimum survey threshold – 17.4 net hours) and capture the known species assemblage (the known species threshold – 29.8 net hours) in woodlands.

Weather conditions

9.2.47 Please refer to para 2.6.2 onwards for guidance on weather.

9.2.48 Trapping is generally less effective in wet and windy conditions. This is particularly relevant to mist nets, where water droplets and movement in the wind can make nets more visible to bats but a stiff wind can also affect harp traps creating a 'humming' noise. In addition, trapping bats in cool and wet conditions can seriously affect their welfare, because they may go torpid in harp traps, making effective release more difficult.

9.2.49 Weather forecasts should always be consulted before a survey is carried out, to identify whether conditions will be favourable for trapping. **Trapping should be avoided during periods of prolonged rain (more than isolated showers, where trapping can be briefly suspended) and in windy**

conditions. Trapping should not be undertaken in temperatures below 8°C (for the duration of the survey), unless duly authorised by a project licence, because bats are likely to be much harder to release effectively. In any case, activity levels would most likely be low and the data produced would not be representative of the site.

Next steps

9.2.50 Should the presence of rare species be confirmed and/or the trapping results suggest that more information on tree-roosting bats is required, then the next step may be radio telemetry (see Section 9.3), or more focused activity such as roost surveys (see Chapters 5 and 6).

9.2.51 Some bats such as whiskered, Brandt's and Alcathoe are very difficult to identify in the hand and photographs may need to be taken for further analysis, including photographs of teeth in the upper and lower jaw. In addition, droppings from these bats (when left in clean holding bags) can be collected and sent for species identification via DNA analysis (see Appendix 4). Various universities and private companies offer this service.

9.3 Radio-tagging/telemetry surveys

Description and aims

9.3.1 The aim is to attach radio transmitters to target bats (by species and breeding status, depending on the objectives) for radio telemetry to obtain location data and determine the following:

- location of roost sites
- population and individual home ranges and core areas
- habitat use and flight-lines
- activity patterns and distances travelled

9.3.2 When properly analysed, location data obtained through radio telemetry should inform how the proposed development site relates to the bat population's home range, core foraging habitats, flight-lines and roost sites (see Chapter 3). Through methods such as triangulation, the use of radio telemetry enables data to be generated from bats that are not limited by redline boundaries and other site access restrictions, therefore providing context and landscape-level impact assessment not possible through other methods.

Equipment

9.3.3 Generic documentation/equipment required for field surveys for bats is provided in para 2.5.13 onwards; survey-specific equipment is listed in Appendix 1 and more information about radio tags, receivers and antennae is provided in Appendix 6.

Expertise and licences

9.3.4 Para 2.5.1 onwards discusses expertise and para 1.3.1 onwards provides information on licences. Fitting radio transmitters to bats requires a project-specific licence.

9.3.5 Ecologists should be at BCT Level 5 (Specialist) competence to be using these techniques.

9.3.6 There are a number of different skills sets involved in radio-tagging bats:

- **Survey design and scope** – to design an effective radio-tracking survey, ecologists should have done a thorough study of the available literature on the species they are planning to radio-track and have experience of the practical application of these techniques, as well as data collection and analysis methods to obtain the appropriate information to inform the survey objective. No licence is required to undertake this task/role; however, it is unlikely that a suitable scope of works can be developed by ecologists without sufficient experience in using these techniques on the ground.
- **Tagging and ringing/banding bats** – these techniques can significantly affect the welfare of bats and therefore ecologists undertaking this task require very good and regularly practised handling skills with bats of different sizes to be able to process bats and affix transmitters and rings/bands quickly and effectively. These tasks are subject to licensing from the relevant authority.
- **Radio telemetry** – a basic understanding of the physics of radio waves (when tagging with radio transmitters) is required as ecologists need to understand the limitations of this technique and how signals from transmitters are influenced by the environment. Training in radio-tracking methods is needed to ensure accurate and comprehensive data can be collected on rapidly moving species at night. A familiarity with the radio-tracking area is essential. Ecologists will also require excellent map-reading, compass and navigation skills to be able to quickly plot bat locations and take accurate compass bearings at night.

Method

9.3.7 A significant amount of useful information on radio telemetry design, field tracking and analysis techniques can be found in Kenward (2001). Welfare issues are covered in some detail by NE's guidance note WML-G39 (NE, 2013).

9.3.8 Highlighted below are the key steps and considerations that are important for bat radio-tagging and tracking for development-related projects in the UK.

Survey design

9.3.9 This stage is crucial and should be considered well before the bat active season/survey commences. Tags will need to be ordered and a licence application approved, which can take several months.

9.3.10 Survey design will depend on the objectives of the survey. For instance, the approximate number of bats to be marked will need to be calculated/estimated based on whether home ranges are to be determined, or the objective is roost-finding. When released after tagging, there is a risk a bat may either move roosts, or not be found again (Downs *et al.*, 2016a). As such, where possible, multiple bats from the same population (ideally at least three) should be tagged when the aim is to find roosts.

9.3.11 For home range estimation and habitat use, sampling size is one of the most important factors in designing a radio-tracking survey; resources should be prioritised to track more bats for fewer nights, while still surveying a minimum number of nights (five nights, aiming to achieve three nights of good tracking data per bat), rather than fewer bats for more nights or the maximum lifespan of the tag. The number of nights may depend on the species and their behaviour. Tracking should be carried out until no extra data is being gained to inform home ranges.

9.3.12 For surveys to determine habitat use, more bats (the sampling points) than habitat categories are required to be able to use compositional analysis (a common statistical method for the robust assessment of habitat preference of radio-tracked animals; see Section 10.4). This is likely to be more than five bats and may be more depending on colony size. It could involve multiple species, depending on the scale and impacts of the project. There are likely to be differences in behaviour between breeding and non-breeding bats, and between different sexes and age classes (adults/juveniles). It will therefore be important to identify the target bats and the reasons these are being sampled.

Landowner access (for off-site tracking)

9.3.13 This needs to be arranged and, if this becomes a major limitation to data collection, a plan of how data will be collected from roads or other public areas (noting that rights of way comprise a right to cross land, not to undertake any other activity such as surveys) is required.

Resource planning and licensing

9.3.14 Appropriate resources will need to be allocated in terms of equipment, such as tags and receivers and trapping, tracking and roost-counting teams. Tags and equipment will need to be ordered from suppliers with plenty of notice. It may be appropriate to check licensing turnaround times to give more confidence in timescales, particularly for bigger projects where the surveyors and associated logistics need to be booked well in advance.

Tagging bats

9.3.15 When a target bat is captured either in the roost or the wider countryside, it should be weighed initially to both ensure it is a good weight for that species and that it meets the weight requirements for tagging. Radio transmitters and glue should be no more that 5% of total body weight (this is usually a condition of licensing), although there is occasional deviation from this for certain species under certain conditions. This is very much on a case-by-case basis and there should be clear justification for it. In many cases, tags far less than 5% of the bat's weight can and should be used, i.e. 5% is a limit not a guide. The bat should be checked to confirm that it is healthy, in good condition and is free from injury or damage before being tagged. Species, age, sex and breeding status should be noted.

9.3.16 Radio tags are fully customisable and can be tailored to be most suitable for both the project, and species. This can include battery size, and hence weight, pulse rate and pulse length or strength which can affect the overall battery life. These can be modified to be more suitable for the species and intended use, e.g. fast-moving species being night tracked can have a faster stronger pulse to make tracking easier. See Appendix 6.

9.3.17 All UK bats are marked by fixing the transmitter dorsally between the shoulder blades with the antenna trailing behind the bat. Fixing with suitable glue involves carefully parting (or occasionally trimming) the fur and applying glue to the fixing location on the bat and glue to the transmitter before attaching the tag. It can take around 10 minutes, sometimes longer depending on the conditions, for the glue to cure sufficiently before releasing a bat.

9.3.18 Bats should not be held for more than an hour from capture to release. Bats should be released carefully and post-release observations made for up to an hour to ensure the bat can fly freely and is not grounded. This may not be effective for all bats but those that are seriously struggling are most likely not to have made a successful flight in the first instance and therefore successful re-capture is more likely. This observation cannot be made if bats are released back into their roosts and therefore this is not recommended. If a bat cannot fly properly following tagging, the tag must be removed if possible (by carefully cutting the fur of the bat); the antennae should be cut off the tag; and/or advice or assistance sought from a vet.

Radio telemetry

9.3.19 The most basic form of data required from radio telemetry surveys is the bat identification number, its location and the date/time the location record was made. There are two main methods for determining a bat's location using radio telemetry.

9.3.20 The close-approach method involves at least one ecologist with receiving equipment following an individual bat and, when the ecologist considers it has reached the bat's location, a record of the time and usually eight-figure grid reference is made. In addition, this method allows ecologists to make observations of behaviour and the use of habitat if close contact with the bat is maintained. This is the best method of pinpointing a bat's location if the bat is relatively static or slow-moving, but is also constrained by land access. A significant amount of time can be spent approaching the bat before it suddenly moves quickly to another area without its position being confirmed. When approaching bats or their roosts, headphones should be used to avoid bats being disturbed by the bleeping of the tag.

9.3.21 The other method is biangulation, which involves a minimum of two ecologists in different locations taking simultaneous bearings at regular intervals (usually between 5 and 15 minutes) from the direction of the bat's strongest signal. Triangulation involves more ecologists. This method is good for tracking faster bats, tracking multiple bats over a small area and where access to land is not freely available. The accuracy of this method depends on how close the two ecologists are to the bat and their position in relation to each other and the bat. If the ecologists are closer to the bat, are positioned higher within the landscape than the bat is, and the lines of strongest signal are perpendicular (without too many objects in the way), this will increase accuracy.

9.3.22 A limitation of radio-tracking studies relates to accuracy of positional fixes. Accuracy of fixes can be a common problem in studies of fast-moving bats, particularly those species that have relatively large home ranges (Holland and Wikelski, 2009). Whilst methods such as bi- and triangulation can provide relatively rapid and systematic location data for bats, studies have shown that, due to variability of surveyor skill, especially at distance, positional fixes might only be accurate to >250m^2 (Bontadina *et al,* 2002). Therefore, a useful method of determining the accuracy of bi- and triangulation of tagged bats in a particular study area is to use an ecologist with a tag to act as a simulated bat, from which the accuracy of bearings and triangulation fixes can be assessed under controlled conditions.

9.3.23 A number of user and equipment errors can occur, leading to erroneous locations that do not fit surveyor observations on the ground if bat locations are only determined using the data collected at a desk at a later date. In advance of using bi- or triangulation as a tracking method, it is therefore recommended that bearing accuracy is sense-checked in the field, rather than attempting to resolve such errors only during the post-survey data analysis.

9.3.24 It is advisable, where possible, to use a combination of both bi- or triangulation and close approach to get the most accurate data set and maintain contact with a bat.

9.3.25 It should be noted that while both methods are effective at obtaining location data, it is not always a reliable method of obtaining behavioural data. A tracked bat may be flying in a particular location, but whether it is foraging or socialising can be difficult to determine.

9.3.26 Maintaining contact with the bat is the highest priority and, with some long-ranging and fast-flying species, this is a particularly challenging task. Where contact is lost, then searching further areas in the direction the bat was last detected and in particular using high ground will increase the probability of relocating the bat. However, it should be borne in mind that, for the majority of commercial/development-related projects, where access is significantly restricted elsewhere, tracking must at least be able to determine when the bat is using, or not using, the proposed development site and ZoI and for what purpose (roosting, flight-lines, foraging etc.). Negative data (the bat is not present in an area when checked) are important. Any constraints should be clearly reported.

9.3.27 Some species of bat (especially tree-roosting species in closed canopy woodlands) are known to move short distances between tree roosts during the day. Therefore, it should not be assumed that the equipment is faulty if the bat appears not to be in the roost it was last located in at sunrise.

Data analysis

9.3.28 Where home and core ranges are being determined then statistical analysis of radio telemetry data is required to justify this invasive technique. Where statistical analysis is done, this should aim to answer questions such as 'which habitats the population prefers' and 'how much time the sampled bats spend within the proposed development site or ZoI', or 'what proportion of home range or core flying/foraging areas are within the proposed development'. Further information on these techniques is given in Section 10.4.

Complementary methods

9.3.29 Bat activity surveys (see Chapter 8) in foraging areas identified through radio telemetry are a useful complementary method where resources are available, as radio telemetry of a small number of bats does not provide a full picture of bat activity.

9.3.30 Roost inspection surveys (see Chapters 5 and 6) and emergence counts (see Chapter 7) are essential to understand the population size and therefore the appropriate number of bats to mark for radio telemetry to meet the survey objectives. Depending on the circumstances, it might be possible to undertake a population count first and then decide on the number of bats to be marked (usually for obvious and relatively permanent roosts); however, in many situations it is likely that a target bat will be captured while foraging, enabling the roost to be found and a count subsequently carried out. This count would then contribute to the decision-making process about how many more bats to tag. Additionally, it should be noted that bats caught at their roosts are probably more likely to subsequently switch roosts than those caught within foraging areas (Downs *et al.*, 2016a) therefore trapping of free-flying bats (not directly from roosts) is preferred where possible.

9.3.31 Where roosts are located through radio-tracking, emergence surveys would normally be undertaken to understand the roost status, and roost features in use. NVAs are recommended for these surveys as the timing of a tagged bat's successful emergence (or possibility of a tag having been shed) can be confirmed.

Timing

9.3.32 For consultancy purposes, radio-tagging and subsequent radio telemetry would usually take place during the active bat season unless specific objectives for winter foraging information are required. Trapping surveys are usually carried out between May and September depending on the objectives of the survey and the conditions in any one year. Trapping earlier or later in the active season will be constrained by weather conditions and welfare considerations.

9.3.33 The seasonal timing of tagging and tracking bats depends on the objectives of the survey. For instance, to locate maternity roosts, it is necessary to undertake tracking in the pre- and post-parturition periods (timings will depend on the species and location, but the period when females are heavily pregnant or have dependent (non-volant) pups should be avoided, unless specifically licensed). Bats have either dispersed or are dispersing from maternity roosts by September and therefore reliable population counts are unlikely.

9.3.34 It is recommended that marked bat(s) are followed immediately after tagging to gauge behaviour (and to be confident the bat is moving around). If the bat's roost is unknown, it is also advisable to stay in contact with the bat to get a likely direction of the roost as it may return there. If possible, captured bats should be followed until they return to their roost, as most bats are harder to find once inside and the signal strength of the transmitter is reduced. It is recommended that bats are tracked from roost emergence until final return. Sometimes bats will return to their roost during the night and may not re-emerge for the rest of the night. At other times bats will make numerous flying bouts from the roost and use other roosts during the night, all of which can provide essential data. Additionally, bats have been recorded using separate foraging areas, or different habitats at different times of the night, and so it is important for bats to be continually monitored during the period of time they would be expected to be active and away from the roost.

Survey effort

9.3.35 For surveys investigating habitat use and activity patterns of breeding colonies, at least 5–10% of the estimated or known population should be marked, and for rare species up to 25% of the animals of a population if potential impacts are high. Tagging more than five bats from the same roost simultaneously should be avoided (due to the risk of entanglement of the tag's antennae) and, to this end, consideration of obtaining data over the entire season and even over two seasons is required. This is especially important for detecting seasonal changes in habitat use.

9.3.36 The same bat should not be tagged twice in the course of one year unless there is a specific reason. Previously tagged bats may be identifiable in the short-term, due to the rate of fur regrowth. However, to avoid a previously tagged bat being retagged (as part of the survey or by other bat workers active in an area), longer duration marking is required. Ringing/banding of bats is the usual way to allow identification of individual bats throughout their life. Advice on ringing can be found in the Guidance on the capture and marking of bats under the authority of a NE licence (NE 2013), the Bat Workers' Manual (Mitchell and McLeish 2004), and in EUROBATS guidelines (EUROBATS 2003), and requires a project-specific licence.

9.3.37 For habitat use and nightly activity patterns, bats should be tracked for a minimum of three nights post-capture, and tracking should continue on more nights if the bat's movements do not become regular/consistent. A strong indication that sufficient data have been obtained is when cumulative plots of the study animal's home ranges reach an asymptote (for further information see Kenward, 2001). From a survey planning perspective, it is recommended that at least five tracking nights (post-capture) are planned for each bat to take account of bad weather or tag failures to ensure at least three nights' data can be obtained.

9.3.38 Tracking data from the capture night may be considered compromised due to the disturbance of trapping and the process of the tagging the bats. It can take a period of time before tagged bats adopt a settled routine of activity. In one study (Downs *et al*., 2016a), this was always achieved within four days of capture. However, data captured in the first few nights should not be ignored and where appropriate should be included to assist the impact assessment of a development project. The habitats used are still relevant, as are the locations of day and night roosts. In some tracking projects, tagged bats avoided the place of capture and tagging on subsequent nights and therefore the capture location should be included in the data as part of the home range.

9.3.39 If bats are being marked with the objective of finding roosts, then it is advisable to continue to monitor the bat's roost movements for the lifetime of the transmitter, which can be for up to two weeks. A balance needs to be struck between the power of the transmitter and the lifetime of the tag. Increasing the former will decrease the length of time the tag is active, but assist in finding distant roosts for bats which tend to travel greater distances. The aims of the project and the species being tracked will influence tag choice.

Weather conditions

9.3.40 Radio-tagging is associated with trapping bats from either field locations or at the roost. Tracking bats with radio transmitters generally does not suffer the environmental limitations of other survey methods as the survey is wholly reliant on the behaviour and activity pattern of the bats being tracked. There are numerous examples of radio-tracked bats flying in theoretically poor weather conditions for bats. However, tagging bats immediately prior to forecasted prolonged poor weather should be avoided (especially for pregnant or lactating females with high-energy demands) as the bat's foraging activities are likely to be further curtailed (in addition to the trapping/tagging period) and productive data collection may be limited.

Next steps

9.3.41 Radio-tagging and tracking is usually the last in a range of methods that might be used to determine the use of a proposed development site and ZoI by bats. However, where roosts are discovered through radio telemetry, it may then be necessary to carry out roost inspection surveys (see Chapters 5 and 6) or emergence/re-entry surveys (see Chapter 7).

Chapter 10

Data analysis and interpretation

10.1 Introduction

10.1.1 Data collected during bat surveys requires appropriate analysis, interpretation and presentation. The type of data collected depends on the surveys that were completed and what the aims and objectives of those surveys were. Where multiple surveys are proposed, it is essential to analyse the data from the early surveys *immediately* to inform the later surveys, which may need to be adjusted according to the survey results. Analysing data at the end of a suite of surveys means that such opportunities would be missed, potentially resulting in a delay. There would also be no opportunity to resurvey if it is subsequently found that the equipment did not work.

10.2 Bat echolocation call analysis

General

10.2.1 The first stage of data processing is to complete sound analysis of bat calls. Russ (2021) provides a guide to bat call identification. Bat activity may be quantified in terms of bat 'passes' (if both acoustic and observation data are available), the number or proportion of time intervals (e.g. minutes) during which a bat is detected (note this is not equivalent to the number of minutes a bat is present within range of the detector, which is difficult to determine in a systematic manner), or the number of sound files produced (where file duration and recording criteria are standardised). The criteria used to quantify bat activity should be recorded in the report meta data.

10.2.2 It is important to acknowledge that bat calls provide a measure of bat activity rather than the number of individuals in a population. In practice, bat activity (as, for example, represented by 100 recordings) could be from 100 bats passing the detector or one bat passing 100 times. Reality is likely to fall somewhere between the two, because bat activity reflects a combination of the number of bats and their use of the area, and this is where observational data can add context. Bat activity can be more accurately described as the amount of use bats make of an area, which for EcIA purposes is often the metric of greatest importance.

10.2.3 One of the benefits of recording bat activity is that there is an auditable record of work carried out. Bat echolocation data collected during bat surveys should be stored in case this record requires later scrutiny.

Species identification

10.2.4 The complexity involved in identifying bat calls is compounded by variability within the calls used by different species of bats. All species of bat vary the characteristics of their calls (e.g. frequency, call duration, inter-pulse interval) within a given range that is typical of the species. However, there can be a substantial degree of overlap in call measurements between species. Calls are adapted dependent on behaviour (e.g. travelling, searching or approaching prey) and the surrounding habitat (e.g. in open or closed habitats or enclosed spaces) (see, for example, Holderied *et al*., 2006; Murray *et al*., 2001). Bats will also adapt their calls in the presence of conspecifics. Given this complexity, the correct identification most bat calls beyond straightforward examples of common and soprano pipistrelle requires a capable bat acoustic analyst.

10.2.5 In addition to echolocation calls, bats also employ a wide range of social calls, which can be used to aid identification of bat species and to interpret their behaviour. More on interpreting social calls can be found in Middleton *et al*, 2014.

10.2.6 The quality of recorded calls will also depend on the location of the bat detector and the orientation of the bat to the microphone. Frequency has a big effect on how far away a call can be detected: lower-frequency calls can be detected from further away than higher-frequency calls (which attenuate faster).

10.2.7 Given any dataset, it is likely that a proportion of recordings will be difficult to assign to species and it is important to consider and document how bats have been identified, either as single species or to genus (e.g. *Myotis*) or group (e.g. Nyctaloid or 'big bat' (often used for combined *Nyctalus/Eptesicus*) and what level of confidence can be applied to identification. Barlow and Waters (2012) suggested a scheme for describing level of confidence when manually identifying species from their echolocation calls, reproduced in Table 10.1.

Table 10.1: Manual bat call probability levels (Barlow & Waters, 2012).

Probability level	Description
Unknown	There is not enough information from the call, location, habitat or visual observations to make a positive identification. It can however be assigned to a range of species or a genus.
Possible	There is enough information from the call, location, habitat or visual observations to suggest a positive identification, but it could also belong to other species.
Probable	There is enough information from the call, location, habitat or visual observations to suggest a positive identification, and while it could also be from a different species, this is unlikely.
Definite	There is enough information from the call, location, habitat or visual observations to provide a positive identification beyond all reasonable doubt.

Bat sound analysis

10.2.8 A number of sound analysis software options are available to support both manual and automated sound analysis. Some software is brand-specific and can only handle recordings from specific bat detectors; other software is generic and can be used with a wide range of bat detectors. Choice of equipment and sound analysis software is likely to depend on the volume of data collected. Using just manual analysis may be appropriate for surveys which only collect smaller data sets. However, ecologists frequently collect large data sets, using numerous automated/static detectors. Here automated analysis can be a more effective and efficient choice to handle the large volume of data and achieve consistency across a data set and between data sets.

10.2.9 The limitations of any sound analysis method used should be recognised. When using either manual and/or automated methods, a proportion of the resulting data should always be verified for quality assurance (QA) purposes.

10.2.10 Regardless of the detecting equipment and software used, it is essential that an ecologist has the appropriate knowledge and experience to use it, and an experienced bat acoustics analyst is involved in every project. This requires training and practice.

10.2.11 A *purely manual* process might follow a three-stage review, as described below:

- If required, all calls can be examined by someone with a 'basic' level of competence in bat call identification, to assign calls to '45kHz/common pipistrelle', '50kHz/unknown pipistrelle' and '55kHz/soprano pipistrelle' or 'other'.
- A minimum 10% proportion of the output of each basic level analyst should be checked by someone at a 'capable' level with bat call identification, to weed out incorrect IDs of pipistrelles, and ensure all 'others' were being correctly referred. This analyst may assign 'others' to species or species group level.
- A minimum 10% proportion of the output of each capable level analyst should be checked by someone at an 'accomplished' level with bat call identification. Any calls that are difficult, uncertain or outside of the species usual range should be reviewed by someone who is at an 'accomplished' level in bat call identification.
- The last two stages could be compressed and undertaken by someone who is accomplished.
- The process of assigning the level of competence should be documented (and ideally tested).
- Any QA approach needs to be stratified to reflect the ease of identification of each sub-group and *not the representation of species/species groups within the data.* This is critical because some of the species that are harder to identify are also the rarer species and those likely less tolerant to e.g. disturbance/ disruption caused by construction. Thus, the QA process must give more weight to species/groups that are of particular interest or have been identified with a lower confidence level.
- When choosing bat sound analysis software, it is important to understand the capabilities of each, and to use the chosen viewer in such a way as to make best use of its capabilities. For instance, amending the contrast can improve the ability to distinguish calls; also note that some calls may be more obvious, clearer or only viewable in an alternative viewer (some viewers cannot display weak calls). In addition, it is likely that mistakes will be made when individuals are viewing thousands of calls, particularly when inexperienced, tired and/or under time pressure because of the volume of calls.

Auto-identification systems

10.2.12 Auto-identification (auto-ID) systems for bat acoustic data are increasingly being used to process the large acoustic data sets that can be collected as part of bat surveys. A number of commercially available systems now exist, as well as some developed for research purposes. Examples of systems include Kaleidoscope Pro, SonoBat, Bat Classify plug-in for Anabat Insight, British Trust for Ornithology's Acoustic Pipeline and BCT's Sound Classification System. Links are included in Box 10.1.

Box 10.1 Links to auto identification software and services.

Bat Classify plug-in for Anabat Insight (**https://www.titley-scientific.com/uk/anabat-insight.html?SID=ini62ld1nn6o5srvhutgc813p2**)

BCT's Sound Classification System (**https://www.bats.org.uk/our-work/science-research**)

British Trust for Ornithology's Acoustic Pipeline (**https://www.bto.org/our-science/projects/bto-acoustic-pipeline**)

Kaleidoscope Pro (**https://www.wildlifeacoustics.com/products/kaleidoscope-pro**)

SonoBat (**https://sonobat.co.uk/**)

10.2.13 Auto-ID systems for bats can be thought of as a workflow or pipeline, where data is inputted or uploaded in the form of sound files, a classifier is used to detect and identify bat calls within those files, and data for different species presence in those files is then provided. Error estimation or classification confidence is sometimes provided as part of these systems. It is strongly recommended to apply further processing of the data, including some level of manual identification to quantify and later report on the level of error. Outputs from classifiers should not be used in an unvalidated state and methods for validation are key to obtaining accurate and meaningful results from these systems.

10.2.14 Despite being sophisticated tools for bat call identification, the performance of a given auto-ID system is dependent on the training data used to train it. Some bat species are harder to identify manually from their calls, and this is also the case with auto-ID systems. Added to this, bat calls can vary between habitats. Some bat populations may utilise a different range of echolocation frequencies than is typical due to the presence or absence of other species with overlapping call characteristics, so understanding regional context is important. Where available, a training data set comprising calls specific to that region will result in the best performance from an auto-ID system.

10.2.15 Auto-ID systems may perform poorly where calls of other taxa (e.g. bush crickets), appear frequently in recordings. This is particularly the case when the system reports only one classification per file, or when converting from full spectrum recordings to zero crossing files for analysis.

10.2.16 Below is a guide to using your chosen auto-ID system for bats, to get the best results for your chosen application.

10.2.17 **Step 1 is understanding the auto-ID system.** To be able to understand how to best use your auto-ID system, you first need to understand the methods by which it makes its classifications and the output that it gives you. Most systems use an Artificial Intelligence (AI) classification algorithm trained to detect and assign bat calls to species. You can ask the following questions of your system:

- **Is information provided about the relative performance of the system for different bat species, or the geographic region that the training data has been collected from?** This will provide a guide to its performance for your chosen application.
- **Warning: Do not presume auto-ID system performance will be equal for all species or will match the performance achieved in proprietary testing. All system performance measures are dependent on the nature of the testing dataset and the subset of classifications that are tested, therefore they cannot be interpreted as absolute measures of performance and actual performance in your application will vary from reported performance.**
- **What does the output data look like?** Different systems provide output data in different forms, and understanding this is important when interpreting the results from these systems. Does the auto-ID system provide a classification per call pulse, per call sequence, per file or per given time interval? Some systems will provide a classification probability or confidence score for each classification. It is important to understand how this score has been estimated. For each classification within the output, does the system provide classification probabilities only for the species with the highest confidence score, for one or more alternative species, or for all species on which the classifier has been trained? How does the system handle the scenario in which two species are present in a single recording, or when the characteristics of a call or the quality of the recording mean that it cannot be confidently classified to species or species group? What other call attributes does the output provide? For example, does it provide the time of call, type of call (echolocation, social call) or call metrics such as peak frequency or duration. These can be a useful guide during manual data verification (but should not be interpreted as a diagnostic cut off).
- **Warning: the outputted classifications and probabilities from auto-ID systems are not normally suitable for use without further analysis. Most auto-ID output will require the application of an error/ confidence threshold to validate classifier results and assess classification performance.**
- **What post-classification validation is applied to the classifier output by the system (either automatically or optionally)?** Some systems include automatic or optional post-classification processing designed to reduce errors in the output. This can include discarding records below a certain confidence score, flagging and/or discarding classifications of species outside the species' currently known range, and/or automatically relabelling of classifications based on predefined criteria.

Step 2 is post-classification validation. Due to the nature of auto-ID systems, all auto-ID output will contain a degree of error. Using the raw output and confidence thresholds set by the system can result in a undesirable level of error. Therefore, it is recommended that the user conducts their own assessment of classification performance and applies appropriate error thresholds, above which a species identification is accepted and below which it is discarded. To do this, a random selection of calls is manually verified by an accomplished bat acoustic analyst(s) to determine the rate of false positive classification for each species in the data, and the confidence score equivalent to the desired false positive rate is applied as an error threshold. There are a range of approaches to do this, for example as described in Barré *et al.* (2019), although simpler methods can be carried out for smaller data sets. If the classifier has been trained to identify species that do not occur in the study region, it may misclassify locally-occurring species as species that are not present in the study area. These misclassifications can be removed from the dataset, or, if the correct species is obvious, they can be relabelled. An alternative approach is to manually verify and relabel these misclassifications (see Step 3). Note that, with climate change, species are altering their range and occasional migrant and vagrant species are being recorded more often.

10.2.18 It is important to note that the rate of false positive detections in a dataset is affected by the relative frequency at which different species occur. This is illustrated in Box 10.2 using the case study of common pipistrelle, and should be borne in mind when analysing and comparing auto-ID outputs.

Box 10.2 Common pipistrelle case study.

Common pipistrelles have relatively plastic echolocation calls which they can alter in response to several factors including the degree of physical 'clutter' in their surroundings and the presence of conspecifics. As a result, all auto-ID systems will misclassify a proportion of common pipistrelle calls as other bat species, sometimes with a high degree of confidence. This is not normally a problem where the other bat species occur at high frequencies, as the proportion of false positive classifications will be trivial compared to the proportion of true positive classifications. However, if common pipistrelle is present in an area where other species are rare or absent, the proportion of misclassified common pipistrelle calls will represent a much greater proportion of the total detections of these other species.

Table 10.2 below illustrates this effect in a simplified scenario in which common and soprano pipistrelle occur at equal frequency in location A, while at location B, soprano pipistrelle is much rarer. Using the same system-derived confidence thresholds at both locations results in vastly different rates of false positive detections of soprano pipistrelle.

Table 10.2. The effect of frequency of occurrence on auto-ID false positive detections where error thresholds are held constant:

Location	Calls correctly classified with high confidence as common pipistrelle	Calls correctly classified with high confidence as soprano pipistrelle	Common pipistrelle calls misclassified with high confidence as soprano pipistrelle	Proportion false positive soprano pipistrelle calls in the dataset after the same system-derived confidence thresholds have been applied
A	100	100	5	5%
B	100	10	5	50%

10.2.19 **Step 3 is verification.** Even after post-classification validation is applied, some false positives will remain in the data. This is not normally an issue for frequently detected species, as the number of false positive detections will be low in relation to true positives. However, there are certain situations in which the chance of a false positive will be higher or where little error can be tolerated. In such situations, calls should be manually verified. These include:

- any species that is locally uncommon;
- any species detected infrequently within the data set;
- any species for which the auto-ID system does not perform to the desired level of accuracy; and
- any record detected at an unusual time of day or year.

10.2.20 **Step 4 is to calculate desired metrics.** It is unlikely that the output from the auto-ID system will be suitable for reporting directly. Therefore, after validation and verification of the data, users of auto-ID systems will often want to analyse the data to produce metrics that are easier to understand and/or visualise. Examples of metrics suitable for reporting acoustic data include bat species presence per file, or per night and/or activity levels. It is important to consider what time interval is best for displaying results, per file, per hour, per night or a measure over the whole survey. BCT typically reports presence per survey and, as a measure of species activity, the proportion of minute intervals during the survey in which the species is been recorded (note this is not the same as the duration of time the species is detected in recordings).

10.2.21 **Step 5 is reporting.** It is important to include the details of the auto-ID system and identification process used for the project in any reporting. The following is recommended:

- auto-ID system including version number if available;
- any post-classification validation undertaken either by the system or by the user, including how error threshold levels were selected and what they are;
- details of the criteria used to select records for manual verification, and how the manual verification was done; and
- a caveat for data that are based on auto-ID classification, but also useful where manual verification is carried out, is that false positives may still be present.

10.3 Data science

10.3.1 When the 3rd edition of these guidelines was published in 2016, the phrase *data science* had only recently entered the popular vocabulary. Today, the phrase is unavoidable. Many interrelated developments have made this possible: there is an awareness that understanding quantitative data has tangible benefits; there are better and more widely-available training resources; and finally, the tools for data science have evolved, becoming easier to use and to get started with. Data science is an inter-disciplinary field that uses scientific methods to extract knowledge and insights from many structured and unstructured data, it encompasses statistics and computer science but also communication skills. A dedicated webpage has been created to provide more information that can be given here[85].

10.3.2 It is data science that is applied to bat survey data, turning those data into information; to communicate and engage with often a diverse audience. It allows for more informed decision-making, that can be defended if and when the analysis is put under scrutiny.

10.3.3 Data science is an essential skill for the bat ecologist; not just basic data handling and quantitative skills but the ability to extract information and convey the findings in a meaningful succinct and clear way. Data science is not something that is learned once; skills are developed throughout a career, and it should form a key part of any CPD.

10.3.4 Synonymous with the growth of data science is the availability of training resources to raise competence or train others. There is an abundance of tools to apply data science in the real world; with the added benefit that most of these resources and tools are open source and free to use.

10.3.5 The skill and resources required for managing data and undertaking data analysis should not be underestimated. Bat survey projects can be undertaken over many years, and it is not uncommon for the project team to change during this time; it is therefore good practice to manage information so others can understand and have access to what has been done. This requires the management and analysis of data to be transparent and reproducible by others. There are software tools that make the process of data management, analysis and reporting reproducible; many of the software tools to undertake this are open source and available for all to use.

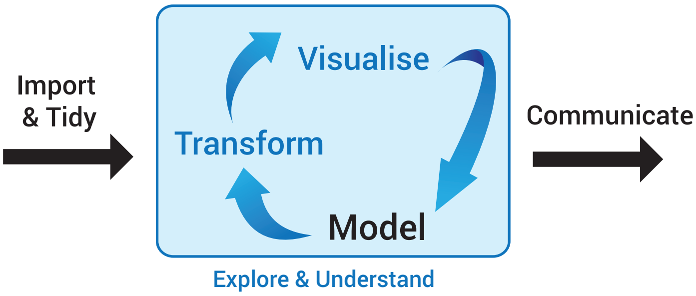
10.3.6 Simple spreadsheets (e.g. Excel or free Google Sheets) offer friendly ways to input small amounts of data and apply data science to bat survey data, e.g. to visualise and undertake some statistical analysis. The advantage of spreadsheets is that they are currently routine and there are excellent textbooks written for ecologists describing how to analyse ecological data using Excel (Gardener 2014, 2017). However, spreadsheets have constraints:

- they are limited in capacity (approximately 1.3 million rows for an Excel sheet);
- they become unwieldy for manipulating data when the number of rows is above a thousand (units of bat activity easily achieved in one night's survey);'
- their ability to analyse the assemblage of bats, for example through cluster analysis or ordination, is difficult to accomplish without *add on* software; and
- the graphs and tables produced require copying and pasting into the report document, which can become tedious when finalising the report or updating with revised data.

10.3.7 It may therefore be necessary to seek alternative approaches that offer more capacity and functionality.

10.3.8 The blue box in Figure 10.1 illustrates data exploration: the art of looking at your data, rapidly generating hypotheses, quickly testing them, then repeating again and again and again. The goal of data exploration is to generate promising leads that you can explore in more depth.

Figure 10.1: The process of data science.



Tidy data

10.3.9 Tidy data is a consistent way to organise your data (Wickham, 2014). Getting your data into this format requires some initial work, but that effort pays off in the long term. Once you have tidy data you will spend *less* time wrangling data from one representation to another, allowing you to spend more time on the analytic questions at hand. Unfortunately, there is a rule of thumb: 80% of time doing data science is spent wrangling data, particularly the effort required in sorting and rearranging the data into a *tidy* and therefore usable format.

10.3.10 There are three interrelated rules which make a data set tidy, such as the data shown in Table 10.3:

- each variable must have its own column;
- each observation must have its own row; and
- each value must have its own cell.

10.3.11 Results of bat sound analysis are often stored in an untidy manner:

- two or more species in one cell (see Table 10.4);
- count of bats (Tables 10.5); and
- two or more columns with species of same date and time.

10.3.12 While the bat survey results shown in Table 10.3 are an example of a *tidy* data set; the data sets in Tables 10.4 and 10.5 are *untidy* and would need to be made tidy to undertake analysis.

10.3.13 Data preparation is not just a first step but must be repeated many times over during analysis as new problems come to light, or new data are collected. Apart from making bat data into a tidy format, there are many other tasks involved in cleaning data: ensuring dates and numbers all appear in the same format, identifying missing values, correcting character encodings, matching similar but not identical values (such as those created by typos).

85 https://bat-survey-reporting.netlify.app/

Table 10.3 Tidy bat data.

Date and time	Bat species	Latitude	Longitude	Location
2016-06-13 01:50:48	*Pipistrellus pipistrellus*	50.33123	-3.591858	Static 4
2016-07-27 01:30:04	*Pipistrellus pipistrellus*	50.33133	-3.591748	Static 4
2016-07-30 00:58:26	*Pipistrellus spp.*	50.33105	-3.590738	Static 5
2016-07-30 01:27:32	*Pipistrellus pipistrellus*	50.33141	-3.591878	Static 4
2016-07-31 01:08:12	*Pipistrellus pipistrellus*	50.33130	-3.591848	Static 4
2016-08-04 23:11:37	*Pipistrellus pipistrellus*	50.33136	-3.591748	Static 4
2016-08-05 01:58:13	*Pipistrellus pipistrellus*	50.33136	-3.591748	Static 4
2016-08-15 21:45:25	*Pipistrellus pipistrellus*	50.33323	-3.592583	Static 2
2016-08-25 01:58:59	*Pipistrellus pipistrellus*	50.33133	-3.591768	Static 4
2016-10-10 19:39:35	*Plecotus spp.*	50.33323	-3.592583	Static 2

Table 10.4 Untidy bat data – too many species in a cell.

Date and time	Species
2019-10-03 20:55:30	PIPPYG
2019-10-03 20:58:30	PIPPYG, NYCLEI
2019-10-03 21:15:30	PIPPYG
2019-10-03 21:25:30	PIPPIP, PIPPYG, NYCLEI
2019-10-03 21:35:30	PIPPIP

Table 10.5 Untidy bat data – multiple bat records on one row.

Date and time	Species	Number
2019-10-05 20:35:15	*Pipistrellus pipistrellus*	1
2019-10-05 20:38:30	*Pipistrellus pygmaeus*	1
2019-10-05 20:49:40	*Nyctalus noctula*	2
2019-10-05 21:05:15	*Pipistrellus pipistrellus*	1
2019-10-05 21:15:30	*Pipistrellus pygmaeus*	3
2019-10-05 21:25:45	*Pipistrellus pipistrellus*	1

10.3.14 Whilst this is important to the analysis it is worth noting that this level of detail would not be included in most reports, even in the appendices.

Minimal data requirement

10.3.15 To undertake meaningful data analysis, it is recommended that data collected from bat activity surveys is wrangled into tidy data that has the following five variables (columns) as a minimum: DateTime, Species, Location, Longitude and Latitude. The rationale for these variables is detailed below.

- DateTime: date and time to BS ISO 8601:2004 i.e. yyyymmdd hh:mm:ss prevents confusion over the date format. Reference bat activity to the local time and specifying an IANA[86] time zone allows for daylight-saving times to be considered; the IANA code for the UK is Europe/London.
- Species: bat species names should follow the "binomial nomenclature" from the International Code of Zoological Nomenclature (CZN)[87] – e.g. *Barbastella barbastellus, Eptesicus serotinus*, etc. A column of local common names can always be added to the tidy data, i.e. in a separate column. Sound analysis may not be able to distinguish calls to species level; in practice, some calls may only be identified to genus or less, e.g. Nyctaloid covers *Eptesicus serotinus* and the two *Nyctalus* species.
- Longitude and Latitude: World Geodetic System 1984[88] (WGS84); as used by Google Earth. A digital, numeric format should be used. Any other spatial reference system can be used (e.g. British National Grid Easting/Northing), as this can be stored as an extra column in the tidy data, the prerequisite is that the reference system can be converted to WGS84; which is the case for most national or state co-ordinate systems. Using a global co-ordinate system such as WSG84 gives access to the many open-source application programming interfaces (API) available that assist with data analysis (e.g. assessing sunset and sunrise times or the adjustment to daylight saving).

10.3.16 In practice, many other columns would be added to a tidy data set including some of those described below.

Meta information from minimal data

10.3.17 Bats are active through the night; the date of the night is the date at sunset and lasts to sunrise the morning of the following day. The Night is a variable column that is added to the *tidy* data; it is a useful convention that helps avoid the confusion of having contiguous bat activity over two dates.

10.3.18 A good anchor for bat data analysis is to relate all bat activity to sunset and sunrise for the night and location the bat was observed. From this anchor, the minutes after sunset and minutes before sunrise that the bat activity occurred can be calculated; these can be converted to decimal hours or integer

86 A full list of time zones can be found here https://en.wikipedia.org/wiki/List_of_tz_database_time_zones
87 https://www.iczn.org/the-code/the-international-code-of-zoological-nomenclature/the-code-online/
88 https://en.wikipedia.org/wiki/World_Geodetic_System

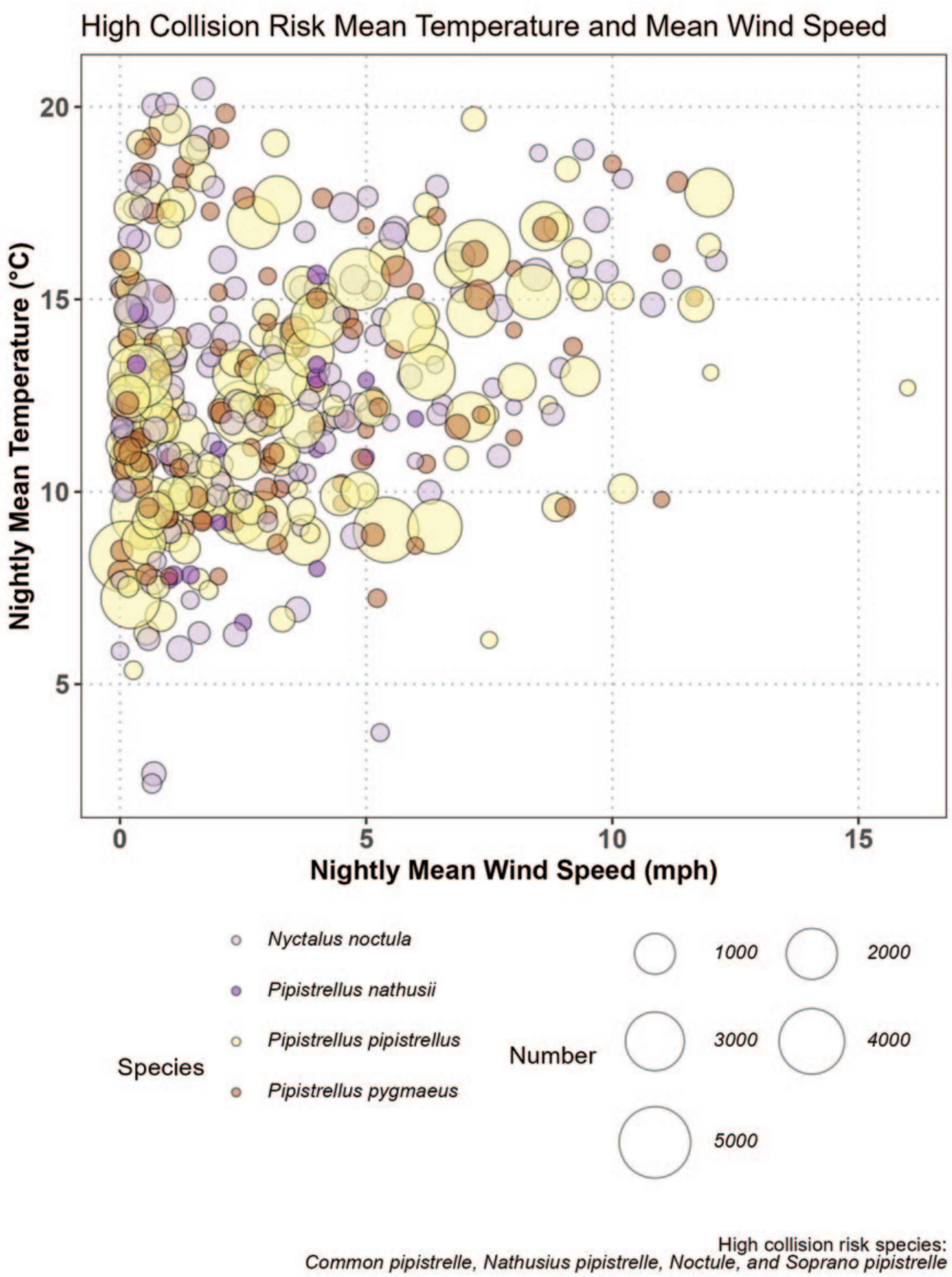
hours so bat activity can be visualised in ways that help interpret the bat activity; see Figure 10.4 for an example.

Additional data

10.3.19 Adding additional data to the minimal data set is desirable as it allows for a more informative analysis. This section describes some of the additional data that could be collected; this list is not exhaustive. For the additional data to be useful it needs to be joined together with the core bat activity data (i.e. the minimal data). This merging or joining of data is achieved with a common key (or keys) present in both data sets.

10.3.20 For example, if weather observations (wind speed, temperature, relative humidity etc.) are recorded every 15 minutes and species presence, bat passes, are recorded within a 15-second period they would need to be aggregated (added up) to give the number of observations every 15 minutes to match the weather data. The weather and bat activity data sets can then be merged with a common key (the datetime column); i.e. matching the weather every 15 minutes and the number of bat passes (or other unit of activity) every 15 minutes. Undertaking this manipulation of data sets helps the interpretation as shown Figure 10.2. However, before this graph could be drawn, the bat activity and weather data had to be manipulated and merged; a common datetime column of 15-minute intervals was used.

Figure 10.2: High collision risk bat species temperature and wind speed.



Examples

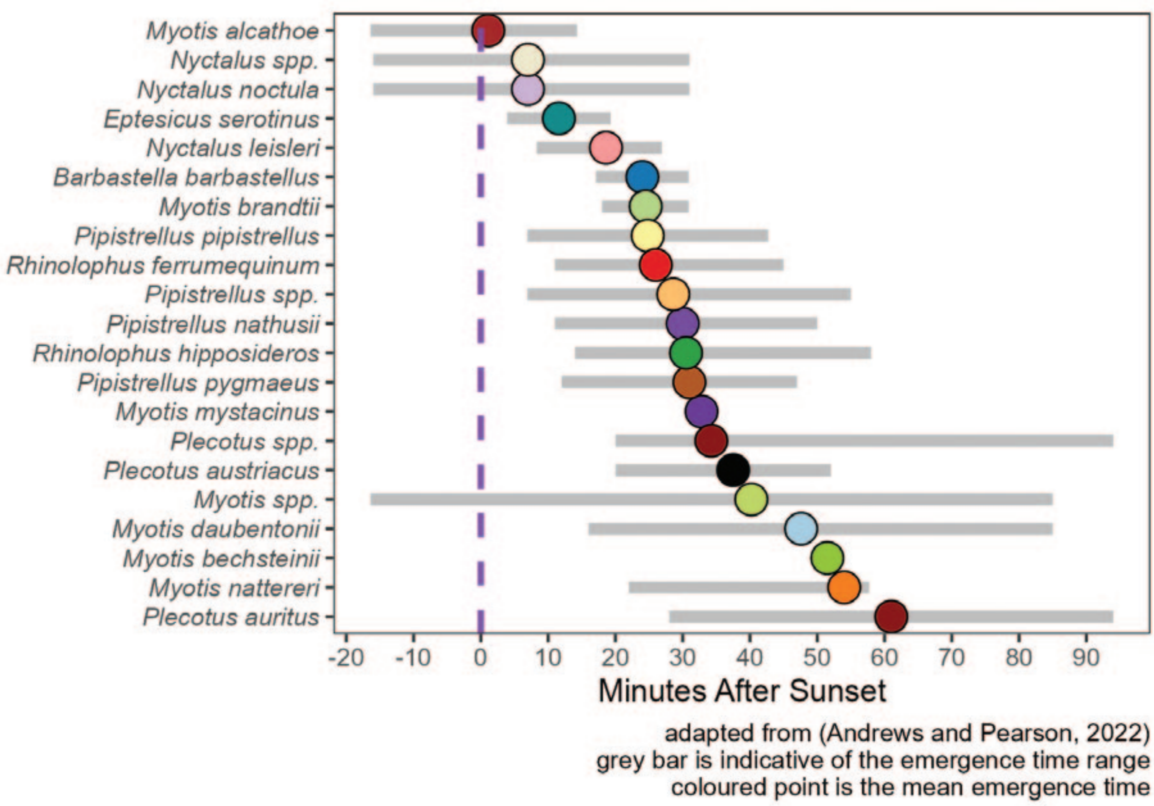
Weather

10.3.21 Weather has a significant effect on bat activity and a record of the weather is essential for any bat survey; the higher the resolution (e.g. every hour rather than just at sunset) and nearer to the bat activity the weather is recorded the better. Weather parameters important to bats are: temperature (°C); humidity (%); wind speed (mph); wind direction (N, NNE, NE etc.); atmospheric pressure (hPa/millibars); rainfall total (mm); rainfall intensity (mm/hr); cloud cover (Oktas/eighths). Note the units of weather parameters can vary; the key is to be consistent with the units used. It is possible to obtain retrospective weather data by the hour[89]; however, this is unlikely to reflect the micro-climate of a small site.

Bat roost emergence times

10.3.22 When bat activity is referenced to sunset and sunrise it allows observations to be related to typical roost emergence and re-entry times. A review of roost emergence and re-entry has been undertaken; Figure 10.3 illustrates roost emergence times for most species of UK bats relative to the sunset time based on the work of Andrews and Pearson (2022).

Figure 10.3: Roost emergence times after sunset.



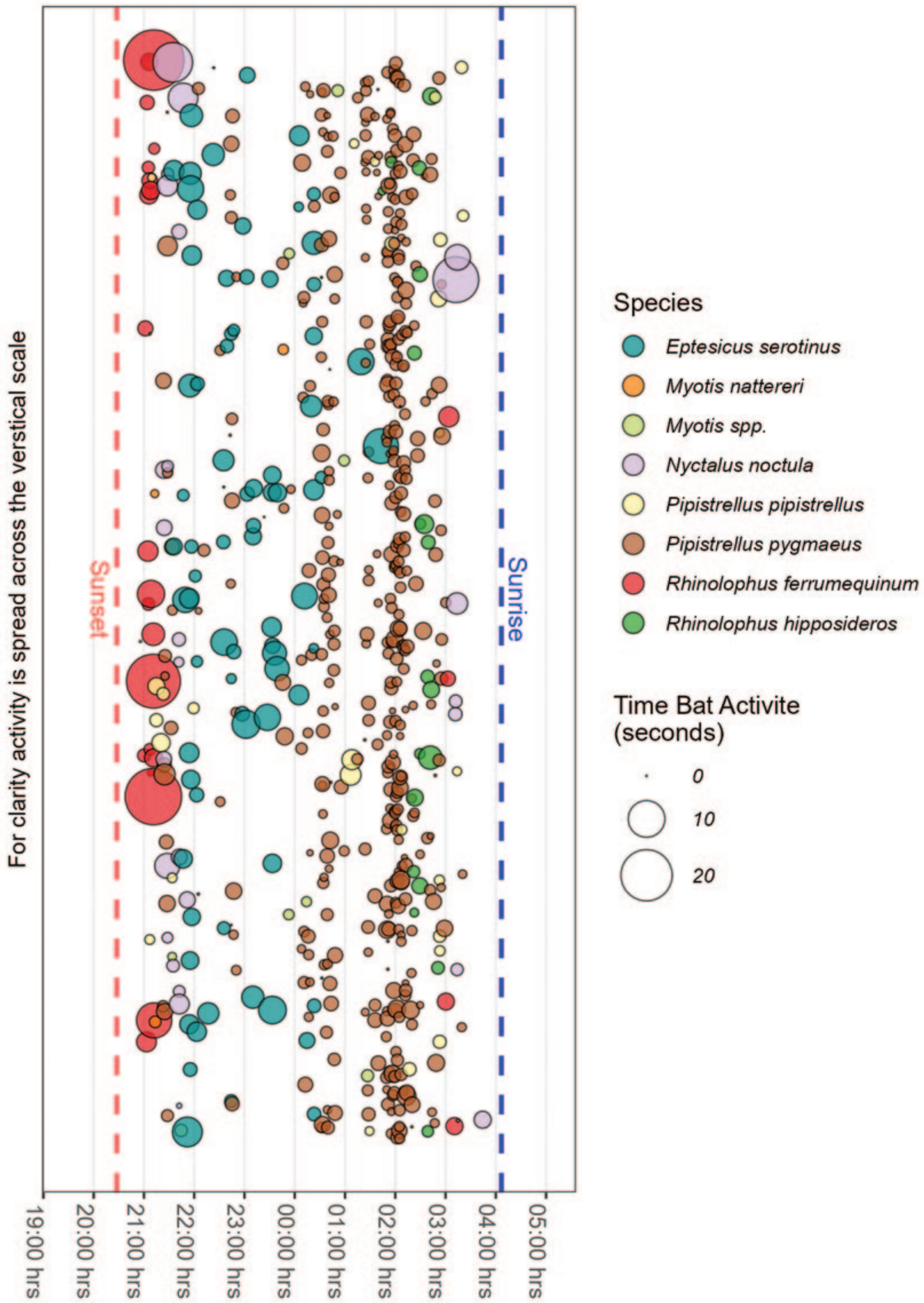
Sound analysis method

10.3.23 Details about the sound analysis method should be recorded: please refer to Section 10.2.

10.3.24 Sound analysis software can calculate the length of time an individual bat was present within the range of the detector's microphone. This is a very informative metric that enhances data analysis, Figure 10.4 illustrates the time bats were present from recordings made from a static bat detector placed for one night under a West Devon oak tree.

89 https://www.weatheronline.co.uk/weather/maps/current?LANG=en&CONT=ukuk&LAND=UK&REGION=&SORT=1&UD=0&INT=06&TYP=temperatur&ART=karte&RUBRIK=akt&DATE=--&CEL=C&SI=mph

Figure 10.4: One night's bat activity around a West Devon oak tree.



Bat detector

10.3.25 Bat detector models vary in their ability to detect bats and the same model can vary in sensitivity. Therefore, details about the bat detector used for the observation should be recorded i.e. make, model, serial number; and where appropriate, firmware version and any other setting that could affect the observation.

Bat pass definition

10.3.26 Bat passes, *observations*, need a definition before monitoring data can be investigated. For example, an observation, a bat pass, could be any call, or series of calls, separated by more than one second from another *call or series of calls* (Reason, Newson, and Jones 2016). This bat pass provides an measure of relative bat activity that can be used in analysis.

- Pass 1s gap: Sequence of echolocation calls separated from other calls by a minimum of 1 second
- Pass 2s gap: Sequence of echolocation calls separated from other calls by a minimum of 2 seconds
- Pulses: Individual calls or pulses (this can also be used to calculate the length of time the bat was present)
- Registration: Species presence within a 5 second sound file

10.3.27 The important thing is to be consistent in this definition where data will be compared.

Detector height

10.3.28 The height of the detector used in the survey, usually given to nearest metre.

Roost proximity

10.3.29 For example, within 25m of known roost or placed on a confirmed flight line from/to known roost location.

Linear features

10.3.30 Detector placed next to or within 25m of a linear feature. The linear feature could be: ditch, hedgerow, running water, standing water, treeline or woodland edge.

Anthropogenic features

10.3.31 Detector placed next to or within 25m of an anthropogenic feature such as: building, fenceline, major road, minor road, lighting, wind turbine.

Data aggregation

10.3.32 Data aggregation is one of the pillars of data analysis, the process where tidy data are gathered and expressed in a summary form. Bat survey data tends to be aggregated in two ways:

- over a given time period; or
- spatially for locations or a factor related to a location (e.g. woodland).

10.3.33 An example of data aggregated for a spatial variable to provide summary statistics is given in Table 10.6; for the common pipistrelle *(Pipistrellus pipistrellus)* for each survey location. The number of bat passes counted through the night is divided by the night length in hours for each night surveyed; this gives a rate of bat passes per hour for each night surveyed.

$$\frac{\textbf{\textit{Bat passes}}}{\textbf{\textit{Night length}}}$$

Where bat passes is the number of bat passes during the night at the location and night length is the length of the night in decimal hours

10.3.34 Summary statistics for the bat passes per hour each night is given in Table 10.6. A standard suite of summary statistics are: minimum, 25% quartile (Q1), mean or median, 75% quartile (Q3), maximum, standard deviation and a count (in this case the number of nights observations were undertaken).

Table 10.6. Summary statistics – bat pass rate per hour.

Location	Minimum	25% quartile	Mean	Median	75% quartile	Maximum	Standard Deviation	Number of nights
Location 1	0.1	0.1	0.8	0.2	0.3	9.4	2.0	23
Location 2	0.1	0.6	1.3	1.2	1.9	4.2	1.0	63
Location 3	0.1	0.5	1.1	0.8	1.0	4.3	1.1	27
Location 4	0.8	3.8	12.8	6.5	17.9	50.8	14.3	31
Location 5	0.1	0.5	0.9	0.7	1.0	3.6	0.8	29

10.3.35 Tables can be hard, or uninteresting to read. To help readability, annotated tables can be created with the cells highlighted with a graduated scale of colour linked to the magnitude of the result; as shown in Table 10.6 for the median bat pass rate per hour column.

10.3.36 Grouping and aggregating data also forms the backbone of visualisation and statistical analysis; where data are manipulated and summarised for use in charts and statistical tests.

Data standardisation

10.3.37 Data standardisation is the process of converting data into a common and consistent format to facilitate an equitable analysis. Bat survey data is invariably inconsistent and where possible should be adjusted before any analysis is undertaken; some common inconsistencies and suggested solutions are given below:

- Bat passes are recorded for a survey for two nights at one location, and one night at another location; the bat passes are inconsistent because two nights is more survey effort than one night. A simple solution is to divide the number of bats passes recorded over two nights by two, this gives the bats passes per night and would be done for the counts of each individual bat species. A constraint of this method is that is doesn't consider the length of the night; a night in June is much shorter than a night in September.
- To take into account the length of the night, so bat activity for a night in June can be compared to a night in September, the average bat passes per hour is calculated – the number of bat passes in the night divided by the length of the night in hours.
- Some bats are easier to detect than others; for example, the noctule can be detected at a significantly greater distance when compared to the quieter brown long-eared, resulting in the undercounting of some bat species when compared to others. Therefore the activity of different species should not be compared because the data is not standardised.
- The common pipistrelle is often the highest number of bats recorded in a night's survey. This can be a problem when looking at the assemblage of bat species. One method of investigating the assemblage is to use distance-based models. Here, standardisation is performed to prevent features with wider ranges (e.g. common pipistrelle passes compared to other species) from dominating the distance metric. Some simple standardisations would be to take the square root, or the fourth root, of all the bat pass counts.

Data visualisation

10.3.38 Data visualisation is the graphical representation of information and data. By using visual elements like charts, graphs and maps, data visualisation tools provide an accessible way to see and understand trends, outliers and patterns in data. Human culture is visual and our eyes are drawn to colours and patterns, red can be identified from blue, square from circle. Visualisation is a key tool for analysing bat survey data; it helps to make sense of the rows of data generated from sound analysis and aggregated meta data. Data visualisation helps to provide a narrative by curating data into a form that is easier to understand, highlighting the trends and outliers. A good visualisation tells a story, removing the noise from the data and illuminating the useful information.

10.3.39 While simple bar graphs or pie charts may be an integral part of visualising data, there are many visualisation methods for presenting data in effective and interesting ways such as: charts, tables, graphs, maps, infographics and dashboards. Bat reports, by convention, are nearly always static and two-dimensional in a format that can be readily printed onto paper; they don't need to be. They can be made dynamic and interactive such as through a dashboard, where the *reader* can explore the bat survey results through a web browser, using the mouse or finger to highlight information of interest.

10.3.40 This chapter illustrates a few of the simple visualisations possible for bat survey data analysis and there are *many* more. An introduction to the range of graphs and charts available for displaying data can be found in the visual vocabulary guide[90] produced by the Financial Times.

Statistical modelling

10.3.41 Statistical modelling is a method of mathematically approximating the world. Statistical models contain variables that can be used to explain relationships between other variables. Hypothesis testing and confidence intervals, for example, are used to make inferences and validate hypotheses. Statistical models are used to find insights given a particular set of data. Modelling can be conducted with a relatively small set of data just to try to understand its underlying nature. Inherently, all statistical models are imperfect, but used to approximate reality.

10.3.42 Bat surveys will increasingly produce large data sets that are often difficult to interpret; interpretation being particularly problematic when assessing the bat assemblage (all bat species) together with other data such as that associated with the weather or habitat. Multivariate methods are especially useful in seeing the signal from the noise with these data sets.

Hypothesis testing

10.3.43 Regardless of the hypothesis test used, the same kind of question is asked: is the effect/difference in the observed data real, or due to chance? To answer this question, it is assumed that the observed data comes from some world where **nothing is going on** (i.e. the observed effect is simply due to random chance). This assumption is called the null hypothesis. *In reality, we might not believe in the null hypothesis at all; the null hypothesis is in opposition to the alternate hypothesis, which supposes that the effect present in the observed data is actually due to the fact that* ***something is going on****.* A test statistic is calculated from the data that describes the observed effect. This test statistic is used to calculate a p-value, giving the probability that the observed data could come about if the null hypothesis was true. If this probability is below some pre-defined significance level[91] α, then we can reject our null hypothesis.

Assess individual species (or a group of species taken as one)

- To compare two samples for bat activity, e.g. two locations or two periods such as a month, use the **Wilcoxon signed rank test**. This is a nonparametric test of the null hypothesis. All the observations from both samples must be independent of each other, the number in each sample can be equal or different.
- To compare three or more samples for bat activity, use the **Kruskal–Wallis test**[92], this is a non-parametric method for testing whether samples originate from the same distribution. It is used for comparing two or more independent samples of equal or different sample sizes. It extends the Wilcoxon signed rank test.
- *Post hoc* testing with the **Dunn's test**, a non-parametric pairwise multiple comparisons procedure based on rank sums, can be applied to determine which samples are different.

Further analysis

10.3.44 The assessment of individual species ignores the species assemblage; the taxonomically-related group of species (i.e. bats) occupying the same geographical area at the same time. The assemblage of bat species can be explored using **multivariate methods**.

10.3.45 Ecologists have a wealth of development and practice in statistical analysis to draw on to address the scientific questions they would like to ask; see (Zuur *et al.*, 2010; Fox *et al*., 2015; Borcard *et al*., 2011; Gardener, 2017; and Legendre & Legendre 2012). Some of the practice of statistical analysis and data science, with specific focus on bats, can be viewed on the companion data analysis web page to these guidelines[93].

Ecobat

10.3.46 Ecobat[94] is a web-based tool offering a standardised method of interpreting bat activity data which can be put into context with other sites by comparing the activity rate with other surveys that have been uploaded.

10.3.47 Ecobat applies the principles of *data science* and uses *tidy data* as its starting point; which is uploaded to the website. Ecobat generates a downloadable, pre-formatted report, containing textual and tabulated summary information, as well as graphical output. The report produced from the uploaded data follows the principle of literate programming producing a Word document from the input data *via* Shiny[95] and R Markdown.

10.3.48 The prime benefit of using Ecobat is its ability to interpret bat activity in the context of other recorded bat activity in the region. As more data sets become uploaded, this interpretation becomes more robust. For this reason, the use of Ecobat is recommended. In its current form Ecobat only compares the activity of individual species and, for example, does not compare the assemblage (diversity) of bats recorded with other locations or habitat types.

90 https://www.ft.com/content/c7bb24c9-964d-479f-ba24-03a2b2df6e85

91 By convention this is 0.05 (a 1:20) chance but the significance level could equally be other values such as 0.01 or 0.001; it is paramount that the significance level is chosen before the test is undertaken.

92 Known as Kruskal–Wallis test by ranks, Kruskal–Wallis H test, or one-way ANOVA on ranks.

93 https://bat-survey-reporting.netlify.app/

94 http://www.ecobat.org.uk/

95 https://shiny.rstudio.com/

10.3.49 Ecobat data-sharing protocol is available from the website[96]. It has the facility to blur 'sensitive' records so they remain confidential but are still available for the Ecobat analysis.

10.3.50 At the time of writing Ecobat is not available but the Mammal Society are working to bring it back online and sustainable in the longer-term.

10.4 Analysis of bat radio telemetry survey data

10.4.1 This section applies primarily to data collected during radio telemetry surveys (see Section 9.3). For a detailed account of radio telemetry and analyses of radio telemetry data please see Kenward (2001). Some of the common analysis techniques associated with radio telemetry and bats are given below. There are a range of software packages that can do this automatically, including Anatrack Ranges 9, and Animal Movement toolkit for ArcGIS. Increasingly, the statistical platform R is being used with packages such as 'Move' to analyse animal movement data.

10.4.2 Establishing home ranges is particularly useful in understanding the extent of use of a proposed development site in relation to the surrounding landscape. This is usually an area-based calculation determined after tracking the bat for a period of time that establishes a regular pattern of activity. From home range calculations, it may be possible to determine what proportion of the home range of the bat or colony the proposed development site is likely to comprise.

10.4.3 Bats often move through large areas to spend time foraging or socialising in smaller 'core' areas. It is often important to quantify these core areas, as overall home ranges do not necessarily determine the 'important' areas/habitats that are used by the bat.

10.4.4 There are a number of methods for estimating the homes ranges and core areas of bats. The common methods are minimum convex polygons (MCP – for external range configuration), and cluster analysis and kernel contours (for internal range configuration). The larger an MCP, the more complex it is likely to be in terms of usage and the greater the need for a form of internal range configuration. Kenward (2001) provides detail on all the main methods.

10.4.5 It is worth noting that several analysis methods (notably including kernel) require 'independent fixes' (i.e. ones that are not influenced by previous fixes). Ranges has an analysis that can determine this 'time to independence'. This will then result in a significant proportion of the data being discarded – hence it is important to have a reasonable amount of data in the first place in order to do this.

10.4.6 It should also be noted that the selection of the home range estimation tool should be appropriate for the behaviour of the bat. Some bats (e.g. Bechstein's bat) may make small movements from roost to foraging areas and the selection of kernel contours might be appropriate, whereas for fast-moving bats that use discrete foraging sites scattered across the landscape, the use of cluster analysis and MCPs would be more appropriate.

10.4.7 Determining bat flight-paths is a challenging part of radio-tracking analysis and, due to location error from methods such as biangulation/triangulation, it is always important to factor in a location error. This should be based on the experience of surveyors in the field (accuracy can be tested, as described in Section 9.3). Often, discrete features such as hedgerows cannot be accurately confirmed as flight-paths unless surveyors were close-tracking the tagged bat and observing that behaviour. It is important to outline these accuracy limitations within any report.

10.4.8 For studies that are seeking to determine habitat preferences of the bats affected by a development proposal, it is important to use statistical techniques to quantify and establish such preferences. A common method of analysis of habitat selection is to compare the proportion of habitats used by the bats the majority of the time (i.e. core areas) to the habitats that were available to the bat within its home range (MCP). Habitat selection of areas used versus available can be determined through the use of statistical tests such compositional analysis methods developed by Aebischer *et al.* (1993). Excel-compatible software (Compos Analysis) has been specifically produced by Smith Ecology (Smith, 2003) to facilitate compositional analysis. To be reliable, these methods require an understanding of where each bat was located for a high proportion of each night tracked, and is more difficult for fast-moving bats.

10.4.9 It is also important that appropriate habitat data are collected covering the areas available to the bat (e.g. the MCP).

96 http://www.ecobat.org.uk/data-sharing

Chapter 11

Writing bat reports

11.1 Introduction

11.1.1 Bat survey reports should be accurate, clear, concise and, most importantly, serve the purpose for which they were intended. A survey report for the purposes of these guidelines is reporting on what is there and may make recommendations for action. A monitoring report reports on action that has been done, whether it has been implemented correctly and whether it has been effective. Reporting on monitoring is not covered by these guidelines.

11.1.2 This chapter covers the essentials of good bat survey report writing and provides a standardised template for a bat survey report. Information can also be found in *Guidelines for Ecological Report Writing 2nd edition* (CIEEM, 2017a).

11.1.3 Put simply, a bat survey submitted in support of a development proposal should show:

- where the site is, and its context;
- what is there and its value and significance;
- how it will be impacted by the development;
- how these impacts can be mitigated; and
- how FCS of the affected bats can be attained and/or maintained.

11.1.4 In general, professional reports should:

- be concise and avoid repetition;
- be accessible to the intended audience;
- avoid jargon and use plain English;
- use clear and simple sentence structures;
- be proofread for grammar, spelling and punctuation;
- list both scientific and common names of species at first mention (thereafter, common names only);
- cite references to back up assertions;
- use a standard, consistent format for references;
- leave no room for misinterpretation; and
- propose clear, definitively stated actions resulting from the findings of the report.

11.2 Standard template for bat survey reports

11.2.1 Box 11.1 provides guidelines on the content of individual sections of a bat survey report produced in relation to planning and development. It may be possible to streamline the process of report-writing by producing reports that are fit for multiple purposes. Not all sections are relevant in all situations; professional judgement should be used in determining the final format. It is important in reporting to consider survey results and further action (avoidance, mitigation, compensation) as they relate to each species of bat found rather than lumping all bat species together as they have different ecological needs. This should be done before considering the assemblage of bats as a whole.

Box 11.1. Sections and content relevant to bat survey reports for planning and development.

Title page

- Concise title explaining the type of survey, the subject of the survey and the location, e.g. 'PRA of Barn at Brook Farm'.
- The date and version number of the report.
- The client's name and/or organisation.
- The author's name an d/or organisation.
- Other relevant information such as 'draft' or 'confidential'.
- Evidence of the report quality control process (e.g. name of checker and approver).

Executive summary

- A non-technical, concise summary of the whole report including the purpose of the report, the site context, survey methods, survey results, limitations and methods to overcome limitations, further survey recommendations, impact assessment, methods to avoid, mitigate or compensate, enhancement measures, post-construction monitoring measures and conclusions as appropriate. The executive summary should also state how long the survey data and report are likely to be valid. This section should be self-contained and may not be needed if the report itself is very short.

Contents page

- List of sections including numbers, titles and page numbers.
- List of all figures, tables, graphs and photographs including numbers, titles and page numbers.

Introduction

- Purpose/context of the report: written by whom, for whom and why.
- Proposed development activities, including future use of site. If not known, this should be stated.
- Site context – size, brief description, brief description of habitat, locational information (description, grid reference, postcode), map showing site boundary, aerial photographs, photographs.
- Brief description of surveys carried out including aims and objectives.

Box 11.5. Sections and content relevant to bat survey reports for planning and development. *continued*

- Reference to other reports or information available prior to the surveys being carried out, e.g. PEA or other ecology reports. Or confirmation that no previous reports are available, as stated by the client in writing on a given date.

Methods

- Desk study: a list of organisations and sources from which designated sites and bat records were requested and obtained, how the search area was specified, the date that the search was made; reasons for not carrying out a data search if relevant.
- For each type of bat survey carried out and for each separate survey occasion (where relevant):
  - bat survey types used;
  - equipment/software used (e.g. model of bat detector, settings used, microphone type, software programme, version, settings used);
  - description of method (including how bat pass was defined and parameters used for echolocation analysis);
  - justification for choice of method and equipment (linking to aims and objectives) including any deviation from good practice (reference these guidelines) and experience/rationale;
  - how the design of the survey was informed by previous surveys (or by the desk study);
  - number of ecologists;
  - ecologist names;
  - relevant ecologist training, experience, licences and licence numbers;
  - area surveyed with justification for choice of survey area and maps/aerial photographs for reference;
  - all ecologist and equipment locations (e.g. emergence ecologist locations and field of view shown, location of NVA and field of view, screen shot from NVA at end of survey to show adequate field of view and illumination, static survey locations using automated detectors, height of bat detectors for static surveys, route of NBW, location of mist nets and harp traps) for each separate survey, with justification for choice of locations and maps/aerial photographs for reference;
  - all survey dates;
  - all survey start and end times;
  - all sunset/sunrise times;
  - limitations of survey methods (e.g. weather, access, timing, health and safety considerations) or equipment.

Results

- PEA – desk study: a list of sites designated for their bat interest plus descriptions and a summary of bat species and roosts in the area, with a map if available/relevant/possible (the amount of detail provided will depend on the terms and conditions of the data provider).
- PEA – fieldwork (DBW): a Phase 1 or UK Habs map with target notes describing and assessing suitability of features for roosting and foraging or flight-paths; a set of cross-referenced' photographs of the site.
- PRA of structures and winter hibernation surveys:
  - descriptions of structures surveyed (including reference number, location, type of building/structure, dimensions, age, construction materials, current use);
  - descriptions of potential and actual access points and roosting places (including height above ground level and aspect);
  - descriptions of evidence of bats found;
  - results of DNA analysis undertaken;
  - description of areas not surveyed and reasons why;
  - all of the above marked onto a plan of the site;
  - a set of cross-referenced photographs highlighting key features.
- GLTA:
  - descriptions of trees surveyed (including reference number);
  - descriptions of trees with PRFs (including reference number, species, diameter at breast height);
  - descriptions of potential and actual roost features (including height above ground level and aspect);
  - description of evidence of bats found;
  - trees not surveyed and reasons why;
  - all of the above marked onto a plan of the site;
  - a set of cross-referenced photographs.
- PRF inspection survey – trees
  - description of potential and actual roost features surveyed (including dimensions, level of protection from elements);
  - description of evidence of bats found;
  - features not surveyed and reasons why;
  - all of the above marked onto a plan of the site;
  - a set of cross-referenced photographs.
- Presence/likely absence and roost characterisation surveys:
  - descriptions of emerging/returning bats (including roost location, time, species, number, exit/entry point, behaviour observed);
  - descriptions of other notable bat behaviour (including internal flight, observations of major flight-paths locally);
  - all of the above marked onto a plan of the site.
- Bat activity surveys:
  - tables of bats recorded/observed (including time, species, number of passes, behaviour observed) where low numbers or this information summarised where higher numbers recorded;
  - the above information summarised on an annotated plan or aerial photograph of the site.
- ALBST (minimum data required):
  - tables of bats captured in relation to trap locations (including time/date, species, age class, breeding status and any other data collected);
  - tables of radio-tracked bat summary data to include tracking dates, number of nights tracked, number of fixes obtained for each bat, home range size and maximum distance from roost.

- figures showing radio-tracking data, allowing comparison across surveyors/years.

Evaluation

- Data visualisation, analysis and interpretation of the results. This section is particularly important because it links the results of the surveys with the impact assessment and subsequent recommendations. There should be enough information to make this link explicit.
- Outputs from Ecobat[97].
- Limitations of survey (with respect to weather, survey methods, timing, equipment, detectability of different species, etc.) and impacts on survey results.
- Relevant European and UK legislation, relevant national and local planning policy, national and local bat species biodiversity action plans, with findings placed into a legal and policy context.

Impact assessment

- Assessment of the impacts of the proposed development pre- and during construction and during operation and decommissioning (where relevant) on designated sites, roosts and foraging areas, and flight-paths, used by bats. Make clear where there is uncertainty regarding the likely impact (e.g. associated with habituation).

Required actions

- Further surveys – ecommendations described.
- Length of time the survey data and report will remain valid before a resurvey will be required to inform planning and licensing purposes.
- Justification on the necessity or otherwise for an EPS licence to be obtained.
- Avoidance, mitigation, compensation and enhancement measures. All measures should be quantified, definitively stated, marked onto diagrams and drawn up in consultation with the client. Language such as 'should' and 'could' must not be used to describe a required measure. Instead, use 'will', as long as this has been agreed with a client (this may not be possible in early iterations of a series of reports). This enables planners to impose clear, enforceable conditions relating to this section of the report.
- Post-construction monitoring. See comments above on enforceability and use of language.
- Post-construction management and maintenance.

References

Glossary or definition of terms

Appendices

Should include supplementary or supporting material that would otherwise interrupt the flow of the main report. May include maps, aerial photographs, GIS files (which can be useful for large and complex schemes), figures, photographs and background/raw data. If GIS files (or similar) are created, it may be worth checking that a client has the means to view such files before submission.

Also, evidence that equipment has been appropriately calibrated and tested according to the manufacturer's recommendations, usually on an annual basis.

11.3 Use of illustrative material

11.3.1 The importance of illustrative material in reports should not be underestimated. A report should convey the required information in the most concise and easy to understand format – a summary table, an annotated map, aerial photograph, diagram, graph, figure or photograph can replace many words. Maps showing the spatial arrangement of the main observations in relation to the proposed development layout are extremely helpful to readers and are far more useful than lengthy descriptions and multiple figures that present the same information but not all brought together in one place.

11.4 Other considerations

Reviewing

11.4.1 Professional reports should not be sent out without a review, generally by a more senior or experienced colleague. This identifies any errors with grammar, spelling and punctuation but also ensures that the content is appropriate for the audience and the recommendations are clear and justified. Many consultancies have a good practice system for signing off reports where the author and the reviewer are identified and signatures are required for final approval and submission.

Submission of bat records

11.4.2 It is good practice for ecologists to state in their terms and conditions that records from surveys will be submitted to record-holding organisations at the time of the planning application. Bat records can then be submitted to LERCs, LBGs or the NBN[98] so that they are available for future background data searches. This information may end up being important in preventing the destruction of a bat roost in the future. Note that submission of data collected to the relevant LERC may be included as a condition on a licence.

11.4.3 In Northern Ireland the ecologist has a choice of who they submit their data to:

- 1. Northern Ireland Bat Group; OR
- 2. Centre for Environmental Data and Recording (CEDaR), which is Northern Ireland's Local Record Centre; OR
- 3. National Biodiversity Data Centre (NBDC) in the Republic of Ireland that hosts the 'Atlas of Irish Mammals' for both Irish jurisdictions and shares all relevant records with CEDaR (above).

11.4.4 This practice should be encouraged, for the benefit of all stakeholders, and only waived in exceptional circumstances where there is genuine justification.

11.4.5 Data should also, where possible, be submitted to apps such as Count Bat and Ecobat and databases such as the BTHK and Bat Rock Habitat Key to improve their functionality over time.

97 http://www.ecobat.org.uk/ see footnote 93
98 https://nbnatlas.org/

Chapter 12

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Appendix 1. Equipment table

Table A1.1 Equipment relevant to different survey types.

Equipment	DBW	PRA - structures	Presence/likely absence survey (structuares)	Roost characterisation survey (structures)	Winter hibernation survey	GLTA	Presence/likely absence survey of trees using PRF	Presence/likely absence survey of trees using dusk visits	Roost characterisation survey – trees	Bat activity survey (manual)	Bat activity survey (automated/static)	Swarming survey (acoustic)	Back-tracking survey	Trapping survey (hand net)	Trapping survey (harp trap or mist net)	Radio-tagging/radio-tracking survey
Binoculars.	✔	✔			✔	✔										
Powerful torch. Preferably non-heat-producing, e.g. LED lamp, particularly in potential hibernation situations. With filter if appropriate.	✔	✔			✔	✔	✔								✔	
Headtorch. Plus spare handy in pocket for extracting bats from traps if trapping.		✔	✔	✔	✔			✔	✔	✔	✔		✔	✔	✔	✔
Small torch.		✔			✔	✔	✔									
Caving helmet and lamp.		✔			✔											
Extendable mirror.		✔			✔	✔	✔									
Ladder. For safe access to a suitable working platform. Follow HSE recommendations on checking/documentation and safe use. Where safe access to a suitable working platform is not available consider alternatives such as the use of a cherry picker, MEWP or scaffold tower.		✔			✔		✔									
Compass.	✔	✔			✔	✔	✔			✔	✔		✔			✔
Tape measure or laser range finder.		✔			✔											
Clinometer.		✔			✔	✔										
Temperature/humidity logger.				✔	✔						✔	✔				
Weather station to record wind and precipitation if required.											✔	✔				
Endoscope.		✔			✔	✔	✔									
Collection pots with labels and disposable gloves.		✔			✔	✔	✔									
Any relevant biosecurity equipment such as masks, hand sanitiser, disinfectant, water etc.).		✔			✔									✔	✔	✔
Bat handling gloves (different types for different-sized species). Multiple pairs may be needed for biosecurity.		✔		✔										✔	✔	✔
Hand-held bat detector and recorder. Heterodyne bat detectors are not acceptable for commercial surveys.Constraints of different detector types should be considered, descriptions are provided in Appendix 2.	✔	✔	✔	✔		✔	✔	✔	✔	✔			✔	✔	✔	✔
Counter.			✔	✔				✔	✔							
Hand-held radios.			✔	✔				✔	✔	✔			✔	✔	✔	✔
Night-vision scopes or infrared or thermal imaging camera.Any associated equipment such as IR illumination, tripods, batteries etc.			✔	✔				✔	✔						✔	
Automated bat detector.		✔	✔					✔	✔	✔	✔					
GPS.	✔			✔	✔				✔	✔			✔	✔	✔	✔
Tree tape (logger's tape).						✔										
Tree tags, nails and a hammer.						✔										
Rope access equipment such as harnesses, ropes, carabiners, prussic loops, strops, climbing helmet etc. (or access equipment such as cherry pickers, MEWPs or scaffold towers).							✔									

Table A1.1 Equipment relevant to different survey types. *continued*

Equipment	DBW	PRA - structures	Presence/likely absence survey (structuares)	Roost characterisation survey (structures)	Winter hibernation survey	GLTA	Presence/likely absence survey of trees using PRF	Presence/likely absence survey of trees using dusk visits	Roost characterisation survey – trees	Bat activity survey (manual)	Bat activity survey (automated/static)	Swarming survey (acoustic)	Back-tracking survey	Trapping survey (hand net)	Trapping survey (harp trap or mist net)	Radio-tagging/radio-tracking survey
Robust kit bag.							✔									
Hand net.				✔					✔							
Thermometer.			✔	✔	✔			✔	✔	✔			✔	✔	✔	✔
Fine scissors to cut nets if needed.															✔	
Callipers.				✔					✔					✔	✔	✔
Bat holding bags. Drawstring to be tied firmly to prevent bat escape. Bags should be hung up rather than laid on the ground. Wash bags regularly and ensure no loose threads are present that may entangle bats inside the bag. Ensure enough bags are available to retain bats in separate bags.															✔	✔
Mist nets*, poles, pegs and guy lines.															✔	✔
Harp traps*, guy lines and possibly, ropes.															✔	✔
Acoustic lures plus associated equipment*.															✔	
Glue. Surgical or colostomy latex glues are generally safe to use for tagging bats and are temporary.																✔
Small brush or cotton bud to apply glue.																✔
Curved scissors. Usually best to part hair but scissors can be used if there is a need to cut the hair.																✔
Weighing scales.																✔
Portable soldering iron and solder. To solder (and start) the contacts some types of radio transmitters. Operate on gas, ensure adequate supplies																✔
Radio transmitters**. VHF radio transmitters are small enough to fix safely to a bat without affecting its welfare to enable tracking. If several bats are being tracked simultaneously frequencies should be well spaced.																✔
Receivers (and headphones**). Scanning receivers can aid the tracking of multiple bats simultaneously.																✔
Antennae. To receive radio transmitter signals/pulses. Antennae usually need to be tuned to appropriate bandwidth. Two types – low-range omnidirectional element useful for vehicle searches of lost bats. Directional Yagi type can be three- or five-element. Five element Yagi provide the best range and more accurate direction fixes.																✔

*See Appendix 5 for more information.

**See Appendix 6 for more information.

Note: The equipment chosen for a survey should make the survey safer, easier, more efficient and more thorough. Requirements for equipment depend on the nature of the survey and nature of the site, therefore this list should be adapted accordingly. As with all equipment, manufacturer's instructions should be adhered to and training/experience may be necessary to ensure safe and effective use.

Appendix 2. Background information on bat detectors

General

12.1.1 The three main systems for converting ultrasound produced by bats into sound that we can hear are **heterodyne, frequency division** and **time expansion**. In addition, **full-spectrum sampling** enables the recording of ultrasound at a high sampling rate without converting frequencies to the audible range. The last three are all 'broad-band' systems that simultaneously sample all frequencies in the bat calls, which means that all bat calls can be sampled if the sampling rate of the detector is at least double the frequency that needs to be sampled, and that recordings from these systems are suitable for sonogram analysis and bat call identification. This enables measurement of call parameters, to varying degrees of precision depending on the bat detector system used, which can help to confirm species identity. Professional surveys should only be carried out using broad-band detectors.

Heterodyne

12.1.2 In a simple heterodyne system, ultrasound is picked up by the microphone and mixed with a signal from a tuneable oscillator in the detector which the user can adjust, normally by turning a dial on the detector. The bandwidth varies between detectors and can affect how accurately the peak frequency of bat calls can be determined, because a narrow bandwidth makes it easier to discern differences in tonal quality (linked to peak frequency) when tuning. Conversely, a wider bandwidth may result in more bats being detected. Heterodyne bat detectors are not considered suitable for commercial surveys.

Frequency division

12.1.3 This is normally the cheapest of the 'broad-band' systems that simultaneously monitor the full range of frequencies contained within all bat calls. A frequency division of eight, for example, refers to counting the average time spent for eight oscillations of the electrical signal (that matches the acoustic signal). The time is measured when the voltage of the transformed sound wave equals zero[99]. This measurement of time allows a calculation of the average frequency of those eight oscillations. A single (dominant) frequency is plotted for each measurement point in time, with many more frequency points recorded in full-spectrum sampling. As a result, low-amplitude bat calls will not be recorded (unlike full-spectrum recordings) if another sound source of higher amplitude is received (e.g. background noise or interference) and harmonic frequencies cannot be recorded at the same time as a higher-amplitude dominant frequency. Sufficient frequency information is preserved using this system to enable basic sonogram analysis; recordings can be recorded and analysed using software that processes the recordings to give us a visual image of the sound to represent frequency against time, but not multiple frequency content and amplitude. As zero-crossing analysis only preserves a small proportion of the detail of recordable sound, it is likely that a reasonable proportion of the bat passes received by the microphone will not be recorded when data are transformed through zero-crossing analysis. This is something to assess on a site-by-site basis and revisit depending on developments in equipment.

Time expansion

12.1.4 Along with full-spectrum sampling (see below), this method gives the most accurate reproduction of the bat calls. In summary, the detector digitally stores the ultrasound signal, and replays it at a slower speed. The recording retains the original signal in high resolution. When the call is replayed slowly (for example, 10 times lower in frequency), it is audible to human ears. Recently developed time-expansion units do not have recording limitations (except the size of the card), and it is now possible to listen back to time-expansion recordings while continuing to record full-spectrum data, rather than having to stop sampling to listen back to previously recorded bat calls.

Full-spectrum sampling

12.1.5 In addition to time expansion and frequency division systems, detectors are available that record ultrasound in 'real time' using a high-speed data acquisition card. A microphone is connected to the A/D card which records sound at very high sample rates, thus enabling high-frequency sounds to be recorded directly. These enable the production of high-resolution sonograms as with time expansion, but also real-time continuous monitoring as with frequency division, so you get the best features of both systems. One disadvantage is that the sounds outputted by the detector are not in the audible range, so it is not usually possible to hear what you are recording in the field, although new technology means that it is possible to record in real time while listening in heterodyne, frequency division or listening back in time expansion. Some models are designed mainly for long-term unattended monitoring while others can also be used hand-held in the field and may display 'live' real-time sonograms (although note that these can be distracting, causing the surveyor to miss visible behaviours).

99 Most frequency division bat detectors do not measure zero-crossing points as the signal at zero is not quiet but includes background noise as well as internal electronic and microphone noise. A sensitivity threshold is set above this to avoid dominant background noise masking bat calls.

Appendix 3. Hazards and risks

Table A3.1. Hazards and risks associated with bat survey work and methods to remove or reduce risk.

Hazards and risks associated with fieldwork	Procedures to remove or reduce risk	Equipment to remove or reduce risk
Lone working.	Lone working should ideally be avoided wherever possible, unless the risks can be reduced to an acceptable level using a risk assessment process. If lone working is unavoidable, a buddy system (and late working procedure if appropriate) should ensure that someone knows where each surveyor is and can raise the alarm if he or she does not return when expected. Surveyors should park so that they can drive away from a site without turning. This is useful in the dark, in case of emergency, and in case of aggression.	A mobile phone (satellite phone in remote areas), map and compass should be carried. In cases where ecologists are on the same site but working remotely, a two-way radio and whistle can be useful.
Tiredness.	Limit the number of surveys carried out during the week (refer to: Working Time Regulations 1998 (as amended)), taking into consideration travel distances, type of survey, difficulty of terrain, etc. Book accommodation with late checkout time if working late/very early. Encourage staff to check into accommodation if tired rather than driving home.	
Bad weather.	Awareness of the weather forecast.	Clothing appropriate to the local situation.
Working in the dark.	Surveyors should familiarise themselves with the site during daylight hours.	Powerful torch (and spare torch, batteries and bulbs).
Working in confined spaces.	Confined spaces training (see Section 2.7).	Specialist equipment such as breathing apparatus, gas monitors, access tripod, winch and harnesses as appropriate to specific confined space following assessment.
Working underground where there may be sudden drops, changes in roof height, unstable rock, decaying fixtures.	Mine safety training (see Section 2.7).	Protective warm clothing, strong boots, helmet and helmet-mounted lamp. Ladders and/or ropes.
Working at height.	(Refer to Working at Height Regulations 2005). Tree climbing and aerial rescue course. Training in use of ladders or MEWPs as relevant.	Safe means of access, e.g. MEWPs, or ropes.
Working on busy roads, on railways, or on farmland with working agricultural machinery.	National Highways training (roads) or Personal Track Safety training (railways). If appropriate, ensure local workers know that a survey is under way.	Fluorescent or reflective jacket (appropriate to site) and other PPE as directed by client.
Working in derelict structures / construction sites / trees where there is risk of falling masonry or branches.	As appropriate, seek advice from a structural engineer on derelict buildings, gain a CSCS card for work on construction sites or for work on trees seek advice from an arborist. Ensure local workers know that a survey is under way.	Hard hat, fluorescent or reflective jacket, safety footwear.

Table A3.1. Hazards and risks associated with bat survey work and methods to remove or reduce risk.

Hazards and risks associated with fieldwork	Procedures to remove or reduce risk	Equipment to remove or reduce risk
Working near water (rivers, streams, ditches, lakes, canals, etc.).	Take care when moving around. Employ safe methods of crossing watercourses such as rivers, streams and ditches. Check flood conditions online. Work in pairs.	Life jacket (consider self-inflating type to allow for greater mobility).
Working near unfenced slurry or silage pits, ponds, grain silos and stores.	Surveyors should take due care and familiarise themselves with the site during daylight hours.	Torch or head torch.
Slips, trips and falls on rough ground.	Take care when moving around, ensure visibility is adequate. Be aware of reduced concentration when using electronic devices.	Torch or head torch.
Sunburn / sunstroke.	Awareness of the weather forecast.	Sunscreen, hat, long-sleeved shirt and drinking water.
Diseases such as Weil's disease, Lyme disease, ornithosis[100] and tetanus (e.g. from rusty barbed wire).	Awareness of diseases, e.g. surveyors should carry a Weil's disease awareness medical card and be familiar with tick identification. Tetanus inoculation.	Protective clothing. Bandages or plasters over any open cuts or wounds. Ornithosis – protective dust mask and gloves.
Insect bites and stings (horseflies, ticks, etc.).	Understand the habitat preferences of different insects; be aware of insect behaviour; avoid obvious nests.	Insect repellent and/or barrier clothing (long sleeves and trousers, nets, etc.). Carry antihistamine if likely to react strongly to bites/stings.
Poisonous plants (e.g. giant hogweed).	Be able to identify these plants; don't touch them.	Wear appropriate PPE.
Bat bite and rabies (European bat lyssaviruses).	All those who handle bats should be vaccinated (and regularly boosted) against rabies because of the risk of European bat lyssaviruses. Care should be taken when handling to avoid bites. See Section 2.8.	Appropriate gloves should be worn when handling bats (advice is available from the BCT).
Asbestos, fibreglass and dust.	Every non-residential building should have an Asbestos Register. Surveyors should ask to see it, particularly if the building being surveyed was built between 1950 and 1985. Asbestos should be avoided and a specialist asbestos consultant called if necessary.	Asbestos – disposable overalls and respirator. Fibreglass and dust – protective dust masks (conforming to BS EN149), safety glasses and overalls.
Sharp objects, such as broken glass or hypodermic syringes.	Take care when moving around, ensure visibility is adequate.	Safety work boots with protective toecaps and reinforced soles, impact-grade gloves, overalls, first aid kit.
Land that has been sprayed.	Surveyors should ask landowners or agents whether pesticides have recently been used on land being surveyed. Many pesticides have a 'harvest interval' between spraying and harvesting; surveys should not take place until after this interval.	

100 An infectious disease that affects birds and can affect humans and other mammals.

Table A3.1. Hazards and risks associated with bat survey work and methods to remove or reduce risk.

Hazards and risks associated with fieldwork	Procedures to remove or reduce risk	Equipment to remove or reduce risk
Aggressive farm animals such as guard dogs, geese, bulls and cows with calves.	Surveyors should ask landowners or agents where animals are kept and avoid those areas if possible.	
Shooting, e.g. for predator control (often takes place at dusk).	Surveyors should ask landowners or agents when any shooting is likely to be taking place, and avoid surveying at those times. Be aware of the potential for illegal shooting.	Fluorescent or reflective jacket.
Verbal and physical assault.	Avoid lone working; work within sight of an accompanying surveyor; park so as to be able to leave quickly. Ask for security personnel in higher-risk areas, which could be identified through contact with the police. Withdraw as soon as practicable if risk is greater than anticipated.	Attack alarm.
SARS-CoV-2 (risk of pathogen transmission from humans to bats)	Wearing of appropriate PPE for the activities being undertaken, e.g. face mask when in close proximity to bats, face mask and gloves when handling bats. Hygiene measures during activities, e.g. use of sanitizer/disinfectant, cleaning of equipment. More information is available in guidance from the IUCN SSC BSG (2021).	Appropriate PPE. If trapping, sufficient bat bags.
Pseudogymnoascus destructans / white-nose syndrome (risk of pathogen transmission between sites)	Follow appropriate biosecurity procedures as set out in BCT guidance (BCT, 2022) including decontamination measures.	Appropriate disinfectant for clothing and equipment.
General disease risk management	Wearing of appropriate PPE for the activities being undertaken, e.g. face mask and gloves when handling bats, and decontamination measures during and after activities, e.g. use of appropriate disinfectant, cleaning of clothing and equipment (IUCN SSC BSG, 2021).	Appropriate PPE and appropriate disinfectant for clothing and equipment.
Unsafe work should not be carried out and ecologists should stop work if a survey becomes unsafe and consider alternative apapproaches to minimise risks.		

Appendix 4. Protocol for bat dropping collection for DNA analysis

12.1.6 Dropping samples should be collected using clean tweezers or, if unavailable, gloves should be worn (or a sample bag turned inside out) to avoid contamination. Care should be taken to avoid breaking droppings during collection.

12.1.7 If droppings of various ages are present, those that appear most recent and most intact should be selected for analysis.

12.1.8 Where it is believed that different species are present, or droppings are present in different locations, these should be collected in separate containers and using different materials to avoid cross-contamination.

12.1.9 Although single droppings are accepted for analysis, if possible it is advisable to send at least five droppings in one sample, in case a retest is needed. However, it is also advisable for the sender to retain a few in the unlikely event of loss in transit.

12.1.10 Containers should be clean and dry, sterile if possible, but this is not essential.

12.1.11 The smallest container that will hold the sample is preferred, to avoid droppings disintegrating in transit. Ideal containers are 2.0ml Eppendorf-type plastic tubes, or small (preferably 10cm × 14cm) resealable plastic bags (Ziploc or similar) are suitable. Samples can be padded with clean non-fluffy material (e.g. paper) to reduce movement in transit. Do not use glass tubes.

12.1.12 Ensure samples are labelled and packaged according to the instructions provided and that a separate note is kept by the sender of which sample numbers relate to which sample locations.

12.1.13 The sample should be dispatched to the lab as soon as possible, but if this cannot be done immediately, then it should be stored in a dry, cool place. Freezing or refrigeration is not necessary. If the sample is particularly fresh and is damp, the droppings should be air dried on a clean sheet of paper at room temperature, to help preserve the DNA and to prevent the dropping becoming squashed together in transit.

Appendix 5. Background information on mist nets, harp traps and acoustic lures

Mist nets

12.1.14 Specialist bat mist nets are manufactured by a range of suppliers and have smaller pockets compared to nets designed to catch birds, although this type of net can also be used. Nets come in a range of sizes, from 2m to 25m in length and 2 to 3m in height, and usually 36mm mesh. Net selection will depend on the habitat. For mist netting in closed woodlands, 6 × 2.6m nets are usually more than adequate when used in combination with an acoustic lure. Shorter nets would be more appropriate for tunnel entrances and, for more open woodlands, 9–18m nets can be used effectively. The height of the mist net is governed by the habitat being surveyed and limited by pole lengths. Guy lines and pegs are also required to stabilise the net. Specialist mist nets such as canopy net systems are also available where it is necessary to work at these heights. However, the advantage of using an acoustic lure is that bats that usually occupy this habitat zone can be drawn to the traps. The main advantage of using mist nets is that the equipment is relatively lightweight and inexpensive; the trapping area is also higher than for harp traps. The main disadvantage of mist nets is that bat extraction is more difficult and thus more risky to the bat's welfare. This in turn requires greater levels of skill and training to be able to use this equipment safety and effectively. In addition, nets are required to be continuously monitored to limit the amount of time bats are in the net.

Harp traps

12.1.15 Harp traps are generally more limited in size than mist nets (usually no larger than 4m2). They are also more expensive and are relatively heavy items of equipment, which is an important consideration when planning the appropriate size of the team. However, their main advantage is that once captured, bats are held in relative safety and the process of collecting bats from a harp trap is less stressful for the bat and safer for the ecologist. Therefore ecologists need less training than those using mist nets. In addition, harp traps do not need continuous monitoring and can be checked on a rotation of 15 minutes, subject to licensing guidance and/or requirements, weather conditions and time of year.

Acoustic lures

12.1.16 Acoustic lures are devices or systems that emit recorded or synthesised social and echolocation calls of bats. Used in combination with mist nets or harp traps, acoustic lures can increase capture rates of bats significantly. Some devices are single unit and compact with built-in amplifiers and sequencers emitting synthesised calls and/or previously recorded calls of bats with either built-in or connected ultrasonic speakers. This makes them portable and easier to manage in the field and protect from the elements. Other systems include the combined use of laptop computers, high-speed sampling devices, amplifiers and ultrasonic speakers to emit recorded bat calls. The laptop-based system provides a flexible platform to alter and change calls in the field; however, the levels of equipment involved often require constant attention and exacerbate the logistical challenges. Common to all systems is that they are expensive. The use of spinning devices can increase the effectiveness of ultrasonic calls emitted by a static speaker by reflecting the highly directional ultrasonic calls in different directions, adding Doppler shift into the call and simulating a moving bat. However, the construction of these needs careful consideration to ensure that any bat that may come into contact with it cannot be injured by the mechanism.

12.1.17 Aylen and Bishop (2022) carried out a global review of acoustic lure use and highlighted that surveys using lures should have a species-specific focus (due to the differing responses of species to calls emitted by lures). Their study involved a global online survey and over half of respondent highlighted ethical concerns relating to the use of lures, suggesting that they may cause stress to bats and result in changing behaviour. This highlights the need for caution and more research in this area.

Appendix 6. Background information on radio transmitters and receivers/antennae

12.1.18 Radio transmitters (tags) are the key component of a radio telemetry system. The weight of the tag plus glue should not exceed 5% of the body weight of the bat (this is usually a condition of licensing), although there is occasional deviation from this for certain species under certain conditions. This is very much on a case-by-case basis and there should be clear justification for it. Lighter tags usually result in a reduction of power and lifetime of the transmitters. Depending on the configuration, the majority of bat tags generally have a life of between 7 and 25 days and, at ground level, a range of 1–3km when the bat is outside its roost. The range of transmitters is considerably reduced when a bat is within its roost. Transmitters can be configured by tag suppliers, see below.

12.1.19 **Transmitter antenna material.** Different antenna materials produce different strength outputs, but have different properties. Some stiff wire antennas have a strong output but are inflexible and unsuitable for small crevice-roosting species. Other flexible antenna, such as titanium, are much better for bats going into crevices but need to be longer.

12.1.20 **Transmitter antenna length.** Transmitters can be ordered to a specified length of antenna, which should be selected depending on the size and foraging behaviour of the species or project methodology. Shorter antennae (10–15cm) reduce range but are less likely to be tangled with the antennae of other bats or become webbed up or jammed/wedged into crevices. Shorter antenna also reduce the drag and whipping effect on bats in flight. These are recommended for use with smaller and close-flying species and when many bats are being tagged simultaneously. Longer antennae (15–25cm) are best used with further-ranging species and very small numbers of bats, such as when the priority is to find roosts. As a guide, antennas should be as short as possible to depending on the species and project plan.

12.1.21 **Range to battery life ratio.** Suppliers of transmitters are able to increase the power of the transmitter, which increases range at the expense of battery life. Therefore if a survey only requires tracking for a week, tags can be adjusted to reduce the battery life to seven days, and increase the transmission power to improve the detection/location range.

12.1.22 **Beep frequency to battery life ratio.** Suppliers of transmitters are able to increase or decrease beep frequency, which shortens/lengthens battery life accordingly. It should be noted that when there is a decreased beep frequency, bats are more likely to be missed (either when searching for them when physically lost after moving roosts, or moving a dial between multiple tagged bats being radio-tracked simultaneously). Pulse length can also be adjusted.

12.1.23 **Contact connection method.** Two methods are generally used for UK bat species. Reed switches are contacts within the housing on the transmitter that are held apart by the use of a magnet taped to the tag. When the magnet is removed, the tag activates, and vice versa. Reed switches make starting tags a very simple exercise in the field. However, they can be less reliable than soldered contacts, and are generally heavier. Reed switch tags should be carefully stored to ensure the magnet remains attached in the appropriate position on the tag to keep the tag switched off, and not stored next to other magnetic items (car mounted antenna bases for instance) that cancel the effect of the tag magnet. Soldered contacts are more reliable but take some skill to use in the field, require extra soldering equipment, and once connected they are harder, if not impossible, to stop. An alternative method for starting tags is the 'wire loop' method, although this is less commonly used in the UK.

12.1.24 At least one receiver, antenna and radio transmitter is required to undertake a radio telemetry survey. Consideration should also be given to vehicle-mounted antennae and masts to increase the effectiveness of receiving signals at range and keeping in contact with the bat. For species with known long-flying ranges, such as noctule and barbastelle, vehicle-mounted antennae are usually essential and should be anticipated as part of the survey design. Logging stations can also be established which, with calibration, can even give some indication of direction and signal strength from low-cost Raspberry Pi based, GSM (mobile phone data) connected antenna stations.

12.1.25 Drones used for tracking bats are not widely available in the UK; however, there is currently research into the approach. This is an emerging area of equipment development and has the potential to make daytime roost finding much easier, especially taking bearings at height. However, there is potential for disturbance to bats through the use of drones, and night-time operations are likely to be complex. Furthermore, in the UK, strict drone commercial regulations apply, and licensed drone operators and landowner permissions (including public roads) would be necessary and require a significant level of planning for landscape level use.

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*Note: page numbers in italics refer to figures; page numbers in **bold** refer to tables; a page number followed by 'n' refers to a note.*

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