Logo

Description automatically generated

BAT MITIGATION GUIDELINES

A guide to impact assessment, mitigation and compensation for developments affecting bats

Beta version 1.0: June 2021

**CONTENTS**

1.0 Introduction 8

1.1 Background and objectives 8

1.2 Scope of the guidelines 8

1.3 Conservation status of bats in the UK 8

2.0 Legislation, licensing and planning policy 10

2.1 Introduction 10

2.2 Legislation in England and Wales 10

2.3 Legislation in Scotland 11

2.4 Legislation in Northern Ireland 11

2.5 Offences 12

2.6 Licensing 12

Exceptional circumstances 13

Enforcement 14

2.7 Habitats Regulations Assessment (HRA) 14

3.0 EcIA 1: Scoping, baseline, and valuation 16

3.1 Introduction 16

3.2 Zone of Influence 16

3.3 Establishing the baseline 17

Survey objectives, methods and standards 17

3.4 Assessing importance 18

Importance of roosts 19

Importance of commuting routes and foraging areas. 23

Assessing the importance of the Important Ecological Features (IEF) 24

Assessing the importance of the bat assemblage 24

Example 25

4.0 EcIA 2: Predicting the impacts of development on bats 28

4.1 Introduction 28

4.2 Identifying development impacts on bats 28

4.3 Impacts on roosts 28

Loss or partial loss of a roost feature 28

Modification of a feature containing a roost 29

Loss or modification of a roost access point 29

Disturbance to bats in their roosts 29

4.4 Impacts on foraging or commuting habitats 31

Loss of foraging habitat or commuting routes 31

Modification of, or disturbance to bats using, foraging habitats or commuting routes 32

4.5 Direct mortality or injury impacts on bats 32

4.6 Characterising impacts on bats 33

4.7 Assessing the significance of impacts on bats 35

4.8 Residual Impacts 38

5.0 EcIA 3: Mitigation and compensation overview 40

5.1 Introduction to mitigation 40

5.2 Principles of mitigation and compensation 41

Mitigation/compensation expectations 41

5.3 Biodiversity Net Gain 41

5.4 Ensuring delivery 42

Consultation and communication 42

Planning controls 42

5.5 Working with clients and contractors 42

6.0 Avoidance, mitigation and compensation: roosts 44

6.1 Introduction 44

6.2 Avoiding disturbance to bats in roosts 47

Timing 47

Screening 49

Lighting and noise 49

6.3 Mitigation for building roost loss (excluding churches) 49

Approach 49

Design criteria 50

Roost height/volume 51

Roost access-point location 51

Roost access-point size 52

Thermal regimes; maternity 53

Perching opportunities within a roof void 55

Roofing membranes 56

Re-use of timber; seeding with droppings from existing roost 56

Timber-treatment 57

Fire doors 57

External environment 57

Location and connectivity; external environment 58

Orientation and construction materials 58

Sharing buildings with humans 58

Protection against vandalism 58

Long-term security and management 59

Other design guidance 59

Bat boxes as compensation for roost loss 60

Non-traditional ‘boxes’ 62

Bespoke designs within properties 64

6.4 Mitigating tree roost loss 65

Pre-construction tree inspections 65

Removing trees with PRFs where the absence of bats is not confirmed 66

Blocking PRFs 67

Compensation for loss of tree roosts 67

Bat boxes 67

Veteranisation 68

Translocation of limbs 69

Standing dead trees (monoliths) 70

BrandenBark 71

6.5 Mitigating the impacts of bats in churches 71

6.6 Working around bats in bridges and tunnels (remedial work) 71

6.7 Working around bats using swarming sites 73

6.8 Mitigation for the loss of hibernation sites 73

6.9 Avoiding killing/injury to bats in roosts 74

Exclusion of bats from roosts prior to works 74

Timing 74

Duration 75

Caveats 75

Bat capture 76

Bats discovered unexpectedly (under licence) 76

Additional considerations in adverse weather conditions 76

6.10 Non-licensable method statements 77

Emergency Works 78

7.0 Mitigation and compensation: habitat loss, degradation and fragmentation 80

7.1 Introduction 80

7.2 Mitigating habitat loss and degradation 80

7.3 Mitigating fragmentation 82

Mitigating the impacts of lighting 83

Mitigating the impacts of noise 84

7.4 Regional and species-specific guidance 86

8.0 Methods to reduce mortality 88

8.1 Overview 88

8.2 Mitigating mortality from linear infrastructure 88

8.3 Wind turbine-related mortality 91

Bat Deterrents 92

9.0 Monitoring 93

9.1 Introduction to post-development monitoring 93

9.2 Setting monitoring objectives 93

9.3 Monitoring effort 96

10.0 Bibliography 99

10.1 Legislation texts, statutory guidance and standing advice 99

10.2 References 100

10.3 Acknowledgements 111

APPENDIX 1: Valuation exercises 112

APPENDIX 2: Case studies 120

Creating a roost behind a fascia board 128

Bat access ‘slate’ 131

Triple ridge system roosting opportunity 133

Eaves access for lesser horseshoe bats 135

Providing additional microclimates for horseshoe bats 136

Stately Home Repairs, Worcestershire 138

Replacement roost using an ‘American style’ bat box 139

‘Bat-friendly’ lighting along a canal path to reduce fragmentation 142

Alternative flyways to guide bats to structures 143

Temporary flight lines 144

Two Mile Bottom artificial hibernation tunnel, Thetford Forest 145

Denbury Lime Kiln 147

Horseshoe access 149

APPENDIX 3: Recommended mitigation by species and roost type 150

APPENDIX 4: Method statement guidance 153

APPENDIX 5: Research needed 158

Acronyms

BCT Bat Conservation Trust

BLE Brown long-eared bat

BMCL Bat Mitigation Class Licence

CEF Continued Ecological Functionality

CIEEM Chartered Institute of Ecology and Environmental Management

CIRIA Construction Industry Research and Information Association

CSZ Core Sustenance Zone

DAERA Department of Agriculture, Environment and Rural Affairs

DEFRA Department for Environment, Food & Rural Affairs

DGHBP Devon Greater Horseshoe Bat Project

EcIA Ecological Impact Assessment

EIA Environmental Impact Assessment

EPS European Protected Species

FCS Favourable Conservation Status

GHS Greater horseshoe bat

IEF Important Ecological Feature

IEMA Institute of Environmental Management and Assessment

ILP Institution of Lighting Professionals

IROPI Imperative Reasons of Overriding Public Interest

JNCC Joint Nature Conservation Committee

LCZ Landscape Connectivity Zones

LHS Lesser horseshoe bat

LPA Local Planning Authority

NE Natural England

NERC Natural Environment and Rural Communities

NPPF National Planning Policy Framework

NRW Natural Resources Wales

NSA No satisfactory alternative

SAC Special Area of Conservation

SNCB Statutory Nature Conservation Body

SNH Scottish Natural Heritage (now NatureScot)

SPD Supplementary Planning Document

SSSI Site of Special Scientific Interest

W&CA Wildlife and Countryside Act

ZoI Zone of Influence

1. Introduction 
   1. Background and objectives
      1. The Bat Mitigation Guidelines were published in 2004 by English Nature (now Natural England) (Mitchell-Jones, 2004). Since its publication, this guidance has been an important resource for bat ecologists involved in development and other land-use change. This update, focused on development, is designed to address advances in our knowledge of bat ecology, understanding of mitigation requirements, changes to legislation and licensing procedures, and development of best practice in approaches to impact assessment[[1]](#footnote-2).
      2. This is intended to be a ‘live’ document, with access freely provided online, to allow updates in response to changes in legislative frameworks and policy, new approaches, good practice and newly published research in relation to bats. The guidelines refer specifically to the legislative framework protecting bats within all member countries within the United Kingdom (UK), and examples and case studies refer to those countries. That said, the principles and good practice provided in this document are applicable elsewhere; in such circumstances, the ecological rationale for referring to these guidelines should be explained.
   2. Scope of the guidelines
      1. This updated guidance:

* extends the scope of the 2004 guidance to cover not just impacts on roosts but also additional impacts from loss of foraging or commuting habitat, and disturbance of bats through, for example, lighting and noise;
* provides a method of valuing bat populations and habitat features used by bats;
* provides specific guidance for assessing impacts on bats as part of an Ecological Impact Assessment (EcIA);
* provides guidance on mitigation in relation to licensable and non-licensable works;
* provides guidance on monitoring the effectiveness of mitigation;
* provides signposts and links to published research and guidance where relevant including up-to-date evidence of the success of implemented interventions and mitigation strategies; and
* provides guidance to allow bat ecologists to advise how to enhance development sites and to achieve net gains for bats.
  1. Conservation status of bats in the UK
     1. In order to assess the potential impacts of a project and to devise successful mitigation measures to offset these impacts, it is necessary to understand the ecology and conservation status of the different species of bats. A useful summary of bat life histories, roosting preferences and foraging preferences is provided in Chapter 3 of the BCT guidance (Collins, 2016) with more detail to be found in ‘Bats of Britain, Europe and Northwest Africa’ by (Dietz & Kiefer, 2016.).
     2. Conservation status “is determined by the sum of influences acting on the species concerned that may affect its abundance and distribution within a given geographical area” (CIEEM, 2018). Of the bat species in the UK, some are much rarer and geographically restricted (making them more vulnerable to extinction), and population trends vary. Horseshoe bat populations are increasing whilst others appear stable. For some, there is insufficient data to be certain (Mathews, 2018) or the various indicators are contradictory (Bat Conservation Trust, 2020). The term Favourable Conservation Status (FCS) refers to how well a species is progressing towards national targets; it alone is not an indication of rarity or level of threat.
     3. Information with respect to the conservation status of the UK bat species can be obtained from the following sources:
* State of UK's bats (BCT and JNCC, 2017);
* Habitats Directive Article 17 reporting[[2]](#footnote-3); and
* The review of the population and conservation status of British mammals (Mathews, 2018).
* Red List of British Mammals (Mathews & Harrower, 2020).

1. Legislation, licensing and planning policy
   1. Introduction
      1. All species of bats are protected throughout the United Kingdom, but there are differences between different countries, and bat mitigation strategies will need to take due account of the relevant legislation and licensing system. At the time of writing, the United Kingdom has left the European Union and is no longer bound by European law. The Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (‘the Habitats Directive’) which underpins the protection of bats across the EU, has been transposed into UK law and will remain in place until expressly changed by further legislation. EU case law up until the date that the UK left the EU will remain relevant to bat work, but the UK courts will not be bound by new rulings from the European Court of Justice after that date.
      2. Links to all of the legislation listed below are provided in **Section 10.1**.
   2. Legislation in England and Wales
      1. All species of bat, their breeding sites and resting places are protected in England and Wales under the Wildlife and Countryside Act 1981 (as amended) (‘the W&CA 1981’) and the Conservation of Habitats and Species Regulations 2017 (‘the Habitats Regulations’).
      2. Under Section 9 of the W&CA 1981 it is an offence to:

* intentionally kill, injure or take any bat;
* possess or control any live or dead bat or anything derived from it;
* intentionally or recklessly damage or destroy any structure or place which a bat uses for shelter or protection;
* intentionally or recklessly disturb a bat while it is occupying a structure or place of shelter or protection;
* intentionally or recklessly obstruct access to any structure or place used by a bat for shelter or protection; and
* sell, offer or expose for sale, or have in their possession or transports for the purpose of sale, any live or dead bat or any part of, or anything derived from a bat.
  + 1. Regulation 43 of the Habitats Regulations makes it an offence to:
* deliberately capture, injure or kill a bat;
* deliberately disturb a bat (which includes any disturbance which is likely to impair their ability to survive, to breed or reproduce, or to rear or nurture their young, or in the case of animals of a hibernating or migratory species, to hibernate or migrate or to affect significantly the local distribution or abundance of the species to which they belong);
* damage or destroy a breeding site or resting place of a bat; or
* possess, control, transport, sell or exchange, or offer for sale or exchange any live or dead bat or part of a bat or anything derived from a bat or any part of a bat.
  1. Legislation in Scotland
     1. The legislation in Scotland differs significantly in parts from that in England and Wales as the Wildlife and Countryside Act 1981 is no longer relevant to bat conservation in Scottish law. All bat species and their roosts are afforded full protection in Scotland by the Conservation (Natural Habitats, & c.) Regulations 1994 (as amended).
     2. For any wild bat species, it is an offence to deliberately or recklessly:
* capture, injure or kill a bat;
* harass a bat or group of bats;
* disturb a bat in a roost (any structure or place it uses for shelter or protection);
* disturb a bat while it is rearing or otherwise caring for its young;
* obstruct access to a bat roost or otherwise deny an animal use of a roost;
* disturb a bat in a manner or in circumstances likely to significantly affect the local distribution or abundance of the species; and
* disturb a bat in a manner or in circumstances likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young.
  + 1. It is also an offence to:
* damage or destroy a breeding site or resting place of such an animal (whether or not deliberately or recklessly); and
* keep, transport, sell or exchange, or offer for sale or exchange any wild bat (or any part or derivative of one) obtained after 10 June 1994.
  1. Legislation in Northern Ireland
     1. The legislation in Northern Ireland is similar to Scotland in that the protection for bats has been transferred to the Conservation (Natural Habitats, & c.) Regulations (NI) 1995 (as amended). For any wild bat species, it is an offence to:
* deliberately capture, injure or kill a bat;
* deliberately disturb a bat while it is occupying a structure or place which it uses for shelter or protection;
* deliberately disturb a bat in such a way as to be likely to affect its ability to
* hibernate or migrate;
* deliberately damage, destroy or obstruct access to a breeding site or resting place of a bat.
  + 1. It is also an offence for any person to:
* have a bat in his possession or control;
* transport a bat;
* sell or exchange a bat;
* offer for sale or exchange a bat; and
* have any dead or live bat, which is taken from the wild or anything derived from such an animal.
  1. Offences
     1. Offences under the above legislation are not as straightforward as they may seem. There is no definition of ‘a roost’, and the term is not used in the legislation. Bats can be found sheltering in very transient places (such as under peeling plaster or even in stored vehicles), and it would be hard to argue that removing such a ‘place of shelter’ would be an offence. This is unlikely to be tested in case law.
     2. The concept of ‘disturbance’ is also ill-defined. Case law suggests that disturbance relevant to impact assessments is that which is sufficient to interfere with bat behaviour to the extent that it impacts negatively on the demography (survival/breeding) of the species at the local population level (Simpson, 2011). There is no threshold set for how many individuals need to be affected because this will vary: for a rare species, a species in decline, or at the edge of its range, a harmful disturbing effect on a very small number of individuals could have a negative impact on demography. The converse must therefore be true where a species is less rare, but the judgement rests with the licensing or planning authority. When assessing the likelihood of disturbance having a significant effect, baseline levels of disturbance need to be taken into account; it is not sufficient for a source of disturbance simply to be noticeable.
     3. Article 12 of the Habitats Directive also introduces potential legal protection of *habitats* from disturbance or deterioration, *where the latter could affect roosts* (Garland & Markham, 2007).
  2. Licensing
     1. The different countries of the UK have slightly different licensing regimes, but the purpose of all of them is to render lawful activities that would otherwise be illegal under the legislation described above. The licensing regimes can be accessed using the links In **Section 10.1**.
     2. Licensing authorities are frequently asked whether a licence is required for a particular activity or project. However, this is a decision to be made by the developer, acting on professional advice from a suitably qualified ecological consultant. If a developer concludes that the proposal will infringe neither Section 9 of the W&CA 1981 nor Regulation 43 of the Habitats Regulations, they are entitled to proceed with the development, but are at risk of prosecution if that conclusion turns out to have been wrong. Note that the decision as to whether or not to grant a licence may be challenged by third parties, but it will be a matter for the courts ultimately to decide.
     3. In order to grant a licence, three broad tests need to be fulfilled:

1. Is one of the statutory purposes for granting a licence fulfilled? (the ‘purpose test’). Such purposes include the preserving of 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’. The licensing regime in the country concerned should be checked for the most relevant purpose for individual cases.
2. Is there no satisfactory alternative? (‘the NSA test’). For example, What is the problem or specific situation that needs to be addressed? Are there any other acceptable solutions that will solve the problem for which the derogation is sought?
3. Will the action authorised be detrimental to the maintenance of the population of the species concerned at a favourable conservation status in their natural range? (‘the FCS test’). FCS[[3]](#footnote-4) is described as a situation where a habitat type or species is doing sufficiently well in terms of quality and quantity and has good prospects of continuing to do so in future. The fact that a habitat or species is not threatened (i.e. not faced by any direct extinction risk) does not necessarily mean that it has favourable conservation status. In order to obtain a licence, it must clearly be demonstrated that the mitigation hierarchy has been followed (see **Box 5.1**) and that all reasonable steps have been taken to minimise/mitigate the impact and that any remaining damage will be adequately compensated. If it cannot be demonstrated that FCS will be maintained, then a licence cannot be issued.
   * 1. In England, the EPS Licensing Policies, which provide additional flexibility in respect of survey data and mitigation required for protected species licensing, may be applicable in certain circumstances[[4]](#footnote-5).
     2. At the time of writing, there are amendments proposed to the Environment Bill which will alter some of the licensing tests in England and may introduce species conservation strategies as a strategic licensing approach.
     3. The current requirements of each licensing regime should always be checked.

Exceptional circumstances

* + 1. Government advice in England[[5]](#footnote-6) states that harm to bats should be avoided by either:
* timing the planned activity
* applying other mitigation methods
  + 1. In exceptional cases, it is recognised that avoiding harm isn’t possible. In these cases the law allows for actions which would normally be illegal if it can be shown that:
* the activity is lawful, such as development with planning permission
* the impact of the activity could not be avoided
  + 1. This exception is often called the ‘incidental result defence’. It can only be used if it can be demonstrated that all parts of the defence have been covered by:
* following good practice in planning and carrying out the works
* trying to reduce the impact of development on the protected species
  + 1. A court would decide whether the defence has been applied properly, and it is recommended that professional advice is sought before relying on this defence.

Enforcement

* + 1. Enforcement of the law in relation to wildlife is primarily the responsibility of the Police. Most Police forces now have full or part-time Wildlife Crime Officers who take the lead in investigating wildlife crime in their force areas. In addition, there is a Police National Wildlife Crime Unit (NWCU[[6]](#footnote-7)) who have a co-ordinating and investigative support role in relation to wildlife crime across the UK.
    2. Where Natural England has issued a licence and conditions have been breached, Natural England has direct investigation and enforcement responsibilities relating to that breach.
    3. Within Wales, Northern Ireland and Scotland, NRW, NIEA and NatureScot (formerly SNH) do not directly investigate; if it is thought likely that an offence has occurred, the case will be referred to the relevant police authority.
    4. The maximum penalty for breaches of a licence issued under Article 16 is an unlimited fine and/or a six-month custodial sentence. In Scotland and Northern Ireland, the fine is £5,000 per offence. Further details are available at the links in **Section 10.1**.
  1. Habitats Regulations Assessment (HRA)
     1. The European Council (EC) Directive on the conservation of natural habitats and of wild fauna and flora 1992 (the "Habitats Directive") requires member states to designate areas of their territory containing a representative sample of important habitats and species. These areas are identified in the Directive as Natura 2000 sites, and they include Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). Article 6(3) and (4) of the Directive require that an ‘Appropriate Assessment’ be carried out for these sites where projects, plans or proposals are likely to have an effect[[7]](#footnote-8). The requirements of Articles 6(3) and 6(4) of the Habitats Directive have been transposed into national legislation in all parts of the UK.
     2. If a project, plan or proposal could have a significant effect on the ‘qualifying features’ of a site (i.e. the species for which the site was designated), then an Appropriate Assessment (Stage 2 of HRA) would be required. SACs may be designated for bats that are listed on Annex II of the Habitats Directive; a search should therefore be made for any such sites that fall within the likely ‘Zone of Influence’ (see Section 3.2) of a project, plan or proposal. The distances over which such SACs should be considered will depend on the nature and scale of the likely effects and the species concerned (it should not be assumed that only large projects in close proximity to a SAC could be affected). The process of screening for ‘Likely Significant Effects’ is Stage 1 of HRA.
     3. Following the departure of the UK from the European Union, the requirement for an HRA remains, but the circumstances in which it is required are likely to differ between the devolved administrations, and the relevant legislation in each country should be consulted. The UK Secretary of State has the power to amend these regulations and their implementation is likely to change in England.

1. EcIA 1: Scoping, baseline, and valuation
   1. Introduction
      1. This section sets out how the importance of bats in a development project can be assessed in an objective and repeatable manner, and at a scale that is relevant to the potential impacts. While the process as described below applies to larger schemes (and could be used to generate an EcIA), the *principles* of determining the area over which a project could have an effect, valuing the bats that could be affected, and characterising the likely impacts, also apply to smaller projects.
   2. Zone of Influence
      1. In EcIA, scoping is the initial stage where the potential for impacts to ecological features are considered, to enable the ecologist to decide what baseline information should be obtained – and at what spatial scale – to inform the assessment. Information on scoping can be found in Chapter 2 of the EcIA guidelines (CIEEM, 2018) and Chapter 4 of the BCT guidance (Collins, 2016).
      2. Establishing the Zone of Influence (ZoI) of the proposed development requires the ecologist to consider the spatial extent within which an impact could occur. As bats are highly mobile species and can use different habitats dependent on the time of year, the ZoI for bats must be carefully considered at the start of the assessment to ensure that surveys can be appropriately planned, and relevant data collected. It is rarely acceptable for the consideration of impacts to be limited to the red line boundary, unless they are limited in nature and extent.
      3. Factors to consider when defining the ZoI of a project on bats are:

* the nature of the project and project activities, and potential for effects at all development stages;
* the nature of the land use and habitats in the vicinity, and how they may be used by bats; and
* the different habits, behaviours and preferences of different bat species that could be affected, and how they vary both spatially and seasonally.
  + 1. Infrastructure projects are often of a large scale, potentially extending beyond county boundaries, and sometimes, country boundaries. Consequently, careful consideration of the appropriate scale at which to assess impacts on bats is necessary (refer to ZoI in **Sections 3.2 and 3.3** in this chapter), which has implications for the baseline data obtained to inform the assessment. Alongside the usual desk-based research and fieldwork to identify roosts, baseline data collection may necessitate a ‘landscape scale’ survey method using. Examples include remote acoustic monitoring to assess the effect of linear infrastructure or district-wide replacement of street lighting on bats at a population level.
    2. Core Sustenance Zones (CSZ)[[8]](#footnote-9), are defined as “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” (Collins, 2016). CSZs are species-specific, e.g. 1 km radius for whiskered/Brandt’s bat, to 6 km for barbastelle. Where they are known, CSZs should be used when interpreting the results of background data searches and survey data to help define the ZoI of a project, though they are not known for all UK bat species. Confidence in the calculated CSZ size is also variable, dependent on the quality of the data available and, for a given colony, the actual CSZ (and hence the ZoI of a project on bats) will depend on factors such as the spatial configuration of the landscape and the presence of suitable and unsuitable habitat, the latter including sea or urban habitat. CSZs are sometimes specified in supplementary planning guidance where a protected bat site could be affected.
    3. Sources that can assist further in the identification of the ZoI and survey scope for different development types relating to bats include:
* onshore wind turbines (Scottish Natural Heritage, et al., 2019) which tailors the guidance of Rodrigues et al (2014) to the UK;
* linear infrastructure (Berthinussen & Altringham, 2017);
* lighting (BCT and ILP, 2018)
  1. Establishing the baseline

Survey objectives, methods and standards

* + 1. How important a given site or area is for bats is informed by baseline data from surveys, and available information from public records, local experts and stakeholders (see for instance Lintott and Mathews (2018)).
    2. Detailed guidance on assessing the baseline with respect to bats through surveys is set out in Chapters 5-9 of BCT’s guidance (Collins, 2016) and is not repeated here. Surveys should be interpreted taking into account the likely sampling limitations; for example, (Richardson, et al., 2019) demonstrated that most acoustic bat surveys will under-record rarer species.
    3. Surveys will always be required within the ‘red line boundary’ of a development. Surveys outside of the red line boundary may require third-party access to be agreed which may not always be forthcoming and hence it may not be possible to fully survey the entire ZoI. In such circumstances, the limitations to the impact assessment should be described within the survey report.
    4. The survey design should:
* set clear survey objectives to assess, as far as is possible, the potential impacts to bats within the defined ZoI of the project on bats;
* refer to published good practice guidance to identify appropriate survey methods and equipment to gather the required data to satisfy the survey objectives;
* use a suitably experienced team;
* ensure robust data are obtained: this aids analysis, reduces limitations of the survey and assessment, and provides greater confidence in the conclusions;
* consider the requirement for post-works monitoring, and utilise a design which can provide comparable data post-development; and
* consider the type of analysis that is appropriate for the data set obtained through survey, to most clearly satisfy the survey objectives.
  1. Assessing importance
     1. In EcIA, it is only important ecological features (IEFs) that are required to be considered. Determining the importance of bats that could be affected by a particular development project is challenging: their highly mobile nature, combined with a high level of legal protection and conservation concern, means that roosting, commuting or foraging bats may be present at some time on almost any development site, but it does not follow that every site is important for bats.
     2. While bats are nationally or internationally protected species, it does not follow that any ecological feature supporting bats is similarly of national or international importance. The following outlines a method which aims to provide consistency across projects, whilst taking regional variations in bat distribution and rarity into account.
     3. The EcIA guidelines (CIEEM, 2018) recommend describing importance by assigning a feature to a geographic frame of reference, i.e. international and European; UK/national; regional; Metropolitan, County, vice-county or other local authority-wide area; and local[[9]](#footnote-10). This approach has been adopted below, with the caveat that the term ‘district’ is used to reflect LPA jurisdictions in England; sub-county areas elsewhere, and ‘local’ has been interpreted to mean the site and relative close surroundings (such as a parish). Obviously, this term is imprecise, but counties themselves do vary considerably in size. The importance chosen should be justified.
     4. Importance should be assessed at an appropriate spatial scale, based on species distribution, conservation status, current population trends, functionality of the site and the ZoI of the project in question as it relates to bats, i.e. whether it supports habitats for roosting, foraging and / or commuting. As data are often incomplete, professional judgement is required to apply the methods described below. However, the rationale behind that judgement should be clearly set out in any ecological appraisal.
     5. Conservation status varies between the different countries of the UK reflecting abundance and distribution. For example, there are seven priority species[[10]](#footnote-11) in England and Scotland, eight in Wales, and three in Northern Ireland, reflecting these differences. There are also differences in abundance and distribution within each country boundary. Table **3.** 1 sets out the species assessed to be in each category of ‘abundant and widespread’, ‘less abundant’ and ‘rare/vulnerable’ (etc) in different regions/countries of the UK. This categorisation is the result of consultation with statutory bodies and recognised regional experts. Note that the absence of a species from this table does not mean that it never occurs in that region. When rarities do occur, their value should be specifically assessed and counted as ‘Rare’ in that region. For example, lesser horseshoe bats are occasionally recorded in Northern England and should be treated in the ‘Rare / Annex II / Red List Vulnerable’ category where they do arise even though they are not on the list of species ‘normally’ encountered in that region.

Table 3. 1: Rarity Category

| Rarity category | SW England & Wales | South-East England to The Wash | Northern England | Scotland, | Northern Ireland |
| --- | --- | --- | --- | --- | --- |
| Abundant and widespread | Common pipistrelle  Soprano pipistrelle | Common pipistrelle  Soprano pipistrelle | Common pipistrelle  Soprano pipistrelle | Common pipistrelle  Soprano pipistrelle | Common pipistrelle  Soprano pipistrelle |
| Less abundant +selected data-deficient | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | Daubenton’s bat  Natterer’s bat  Brown long-eared bat | [Daubenton’s](http://www.habitas.org.uk/nimars/mdaubentonisd.htm) bat  [Natterer’s](http://www.habitas.org.uk/nimars/mnattererisd.htm) bat  [Leisler’s](http://www.habitas.org.uk/nimars/nleislerisd.htm)  Brown long-eared bat |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient | Greater horseshoe bat  Lesser horseshoe bat  Alcathoe bat  Bechstein’s bat  Leisler’s bat  Nathusius’ pipistrelle  Serotine  Barbastelle  Grey long-eared bat | Alcathoe bat  Bechstein’s bat  Leisler’s bat  Nathusius’ pipistrelle  Serotine  Barbastelle  Grey long-eared bat | Alcathoe bat  Leisler’s bat  Nathusius’ pipistrelle | Whiskered bat  Brandt’s bat  Leisler’s bat  Noctule  Nathusius’ pipistrelle | [Whiskered](http://www.habitas.org.uk/nimars/mmystacinussd.htm) bat  [Nathusius’](http://www.habitas.org.uk/nimars/pnathusiisd.htm)  pipistrelle |

* + 1. The geographical variation set out in **Table 3.** 1 (as it is currently understood) underpins the subsequent assessment of importance of roosts (**Table 3.2**), commuting routes and foraging areas (**Table 3.3**) and of the overall assemblage of bats present on a site (**Table 3.4**). The boundaries between categories are not absolute, and should be treated with caution, particularly where species are at the edge of their range. Climate change and other pressures are already having an effect on species distributions and the species listed in each category will therefore be regularly reviewed.

Importance of roosts

* + 1. Bats use many different types of roost, and not all roosts have the same level of importance in supporting a local population of bats. In addition, the mean size of breeding roosts varies between species. A variety of sources exist to inform an assessment of the importance of roosts, including:
* Bat Survey Guidelines; Chapter 3 (Collins, 2016);
* State of UK's Bats (BCT and JNCC, 2017)
* National Bat Monitoring Programme annual reports (e.g. Bat Conservation Trust, 2020));
* Bats of Britain, Europe and Northwest Africa (Dietz & Kiefer, 2016.);
* Habitats Directive Article 17 reporting2;
* County bat atlases;
* Local stakeholders;
* Local record centres and bat groups;
* EPS licensing data (available in England on DEFRA’s MAGIC website[[11]](#footnote-12)); and
* A Review of the Population and Conservation Status of British Mammals (Mathews, 2018);
* Atlas of the Mammals of Great Britain and Northern Ireland (Crawley, et al., 2020);
* IUCN-compliant Red List for British Mammals (Mathews & Harrower, 2020)
  + 1. **Table 3.2** below, identifies the importance of different types of roost. In all cases, the geographic scale set out presents a *likely minimum* and modifying factors may increase but will not usually decrease the importance assigned to roosts.
    2. Modifying factors include (but are not limited to) the following:
* roosting preferences for species should be taken into account[[12]](#footnote-13);
* species behaviours need to be taken into account, such as the tendency to have satellite roosts associated with the main maternity site (e.g. lesser horseshoe bats) or larger male gatherings (e.g. Daubenton’s bats);
* species at the edge of their range may merit a higher level of importance;
* a species behaviour may differ at the edge of its range, or in what seem to be atypical habitats;
* for tree-roosting bats that move roosts frequently and use several roosts at any one time, or hibernate in small numbers, the importance of the roost resource rather than individual trees should be assessed;
* differences in tree-roosting behaviour also need to be considered (for example, Bechstein’s bats can return to specific roost trees over many years (Davidson-Watts, pers. comm.), but barbastelles tend to select more fragile features such as lifted bark or hazard beams, which don’t persist as long). These differences need to be reflected in the way the roost resource is valued (and impacts are assessed);
* there is also uncertainty relating to the importance of transitional and mating roosts, particularly for rarer/data-deficient species; and
* caveats/limitations on data collection or interpretation must be taken into account.
  + 1. In short, **Table 3.2** provides a starting-point for the assessment of importance of roosts, and not ‘answers’. A degree of professional judgement will always be needed, but that judgement must be explicitly supported by sound ecological evidence. It should, of course, be remembered that all roost are legally protected irrespective of their relative ‘importance’.

**Table 3.2: Assessing importance of roosts**1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Rarity category (species in each category are determined by region)** | **Roost category** | | | | | |
| Feeding perches; night-roosts  Individual or very small occasional/ transitional roosts | Non-breeding day roosts  (small numbers of species) | Mating sites (excluding individual trees)  Small numbers of hibernating bats | Swarming sites | Maternity sites3 | Hibernation sites4 |
| Abundant and widespread species | Local | Local | Local | District | Unlikely to exceed District importance unless colonies are atypically large | County/Regional importance dependent on size; importance increased for assemblages |
| Less abundant + selected data-deficient species | Local | Local | Local (may be of greater importance if more than one species) | District/County importance dependent on size2; importance increased for assemblages | County/Regional importance dependent on size2; importance increased for assemblages | County/Regional importance dependent on size2; importance increased for assemblages |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient species | Data deficient. Local (well-used night roosts may be of District or County importance for some species) | May occasionally reach County importance, dependent on species and numbers2 | County/Regional importance dependent on size; importance increased for assemblages | Regional/National importance dependent on size; importance increased for assemblages | Regional/National importance dependent on size; importance increased for assemblages | Regional/National importance dependent on size; importance increased for assemblages |

1. Sites within or functionally-linked to SACs are of International importance for Qualifying Species. Sites that *could* be functionally-linked to SACs may or may not have that level of importance[[13]](#footnote-14). Sites meeting SSSI guidelines are of National importance (though note that many SSSI citations do not reflect the ‘bat’ importance of the sites they describe).
2. In all cases, ‘size’ needs to be interpreted as ‘relative to typical sizes for the species’.

3 Satellite roosts (i.e. alternative roosts found in close proximity to the main nursery colony) should be considered with the associated main colony.

4 For tree-roosting bats that are likely to hibernate in small numbers (which means individual hibernation sites are difficult to detect and many may be missed), the **importance of the roost resource** (i.e. the extent of woodland which contains trees suitable for hibernation) rather than individual confirmed roosts, should be assessed.

Importance of commuting routes and foraging areas.

* + 1. The same approach has been adopted for valuing commuting routes and foraging areas in **Table 3.3**. below. Note, however, that the assessment of value of commuting routes is inherently more difficult and a higher degree of professional judgement will be required. For example, some routes may be used only at certain times of year, and hence show low numbers of bat passes, but may be critical as routes to hibernation sites. As such, interpretation of the importance of commuting and foraging areas should not be made in isolation and should always be made by an experienced ecologist based on the overall knowledge of bat activity in the area. The rationale for professional judgement which deviates from these guidelines should be explicitly stated.

**Table 3.3: Importance of commuting and foraging habitats**1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Rarity category (species in each category are determined by region)** | **Results from survey data** | | | |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers2 of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers2 of bats, or less-regular use by larger numbers2 of bats | High reliance on habitats as demonstrated by regular use by larger numbers2 of bats |
| Abundant and widespread species | Local3 | Local3 | Local3 | District3 or above4 |
| Less abundant + selected data-deficient species | Local3 | Local3 | District3 | County/Regional |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient species | Local3 | Local3 | County/Regional | National  [International if functionally linked to an SAC for species] |

1 The geographic reference ‘site’ is not used, as this is misleading for long linear infrastructure and large-footprint developments.

2 It is inappropriate to place numbers on each category, as colony sizes vary across species and regionally. ‘Numbers of bats’ should be interpreted relatively and explained with regard to survey methods and results, and with reference to region.

3 The CIEEM EcIA guidelines (CIEEM, 2018) note that “*various approaches can be adopted for defining local importance, including assessment within a district, borough or parish context or within other locally defined areas*”. See **para 3.4.3** for a description of District/Local as used here.

4 Care is required to avoid undervaluing common and widespread species; again, the importance chosen should be justified. Similarly, evidence of use by a species at the edge of its range would confer greater importance.

5 In all cases, the ‘evidence’ of level of foraging or commuting activity must be based on an adequate survey; where surveys are incomplete, a precautionary approach should be adopted.

* + 1. In all cases, the geographic scale in **Table 3.2** presents a likely minimum, and modifying factors would be expected to increase but not decrease the importance assigned to commuting and/or foraging habitats. Modifying factors include (but are not limited to) the following.
* A species’ habitat preferences and landscape context should be taken into account. For example, a development site without a waterbody would be of lower value to a population of Daubenton’s bats than a neighbouring site supporting a large waterbody.
* A ‘strategic flyway’ narrowed by encroaching development would increase the importance of connecting habitat.
* The importance of roosts is assessed separately (on- and off-site), as set out above so, when assessing the importance of commuting routes, proximity to roosts shouldn’t be over-emphasised, because this should be drawn out by evidence of use (that said, as bats spread out into the landscape from a roost, activity levels along a specific feature can decrease rapidly with increasing distance from a roost).
* Suitable habitat near to hibernation sites, and connections to such habitat, may not be identified through activity surveys and should not be overlooked.
* Where species are difficult to identify by call alone (e.g. *Myotis*, *Plecotus*), trapping supported by DNA analysis of droppings from captured bats may be required to determine species before assessing importance (though it is important that the project scale and impacts justify this intrusive technique).
* Where trapping is used as a methodology, each species’ likelihood of trapping should be taken into account (for example, high-flying species are less likely to be trapped). Caveats/limitations on data collection or interpretation must be taken into account.

Assessing the importance of the Important Ecological Features (IEF)

* + 1. In EcIA, the level of importance of each IEF should be identified. Professional judgement should be used in deciding what constitutes the appropriate IEF for bats. It is not usually appropriate to have a single IEF for all bat species as this would mask many differences between species and may result in overstatement of impacts.
    2. It will rarely be helpful or necessary to treat components such as roosts, commuting or foraging areas as individual IEFs. Usually individual species would be considered as individual IEFs, but sometimes a group, such as common and soprano pipistrelles, may be combined where the impacts to each are likely to be very similar and can be considered together. It may also be necessary to treat groups of species which have not been adequately distinguished as a single IEF, for example *Myotis* species. When assessing the importance of an IEF, this should be the highest importance assigned to any species within the IEF for either roosts, commuting or foraging.

Assessing the importance of the bat assemblage

* + 1. Sites of importance to bats often support several species, and it can be helpful to consider the importance of the assemblage as a whole after the individual bat species IEFs have been assessed. This would normally be for larger developments or sites supporting many species; assessing importance of the assemblage is not necessary in all circumstances (and note that multi-species roosts are covered in **Table 3.2**). The following provides a standard method for assessing importance of an assemblage, where that is considered useful. As for the importance of roosts, commuting routes and foraging areas, this approach has been developed to reflect geographic variations in species distributions.
    2. To apply this approach, three things need to be determined:
* species present on site (project data);
* local species distributions (desk study); and
* regional species distributions (**Table 3. 1**).
  + 1. To determine the maximum possible score any site could achieve, a score is assigned to each species that (broadly) could be present (as set out in **Table 3.** 1), where:
* abundant and widespread species score 1;
* less abundant +Selected data-deficient species score 2; and
* rare/Annex II /Red List Vulnerable or higher, + selected data-deficient species score 3.
  + 1. Once the maximum score for each has been set, the threshold score needed or any assemblage to meet each geographic level of importance, can be calculated:
* Assemblage score meets or exceeds 45% County importance
* Assemblage score meets or exceeds 55% Regional importance
* Assemblage score meets or exceeds 70% National importance
  + 1. In other words, the percentage score achieved for the site as it relates to the maximum possible determines the importance of the assemblage. As for the assessment of commuting and foraging habitats outlined above, the geographic scale presents a likely minimum and modifying factors may increase the importance assigned. The theoretical maximum score achievable can be modified according to the site’s location. For example, few sites are within the distribution of grey long-eared bat, so this species does not always need to be considered when calculating the maximum score; similarly the distribution of horseshoe bats is well known, and again these species could be discounted from sites in many parts of the UK (see Examples 1-5 in Appendix 1). Any such modification needs to be justified (for example, using desk-study data of local distributions), and sources of distribution data should be cited.
    2. Similarly, where one or more *Myotis* are present, the calculation will need modification to reflect the effort made to separate this genus into species. As in earlier sections, trapping may be required to determine species before assessing importance (though it is important that the project scale and impacts justify this intrusive technique).

Example

* + 1. For example, a site in the south-west of England could have, as a theoretical maximum: two common species (1 point per species - score 2), six less-abundant species (2 points per species - score 12) and nine rarer species (3 point per species - score 27), producing a maximum total score of 41 (see **Table 3.4**).
    2. From this starting-point, any site in the south-west of England achieving a score of 18 (45% of the maximum score) would be classed as of at least ‘County’ importance, a score of 23 (55%) of ‘Regional’ importance, and a score of 29 (70%), of ‘National’ importance. Note, this initial assessment is on the basis of presence only, and factors such as higher-status roosts, or large colonies for a species, would increase the importance of any assemblage (up to ‘International’ importance) and should be used to explain the importance assigned. It is up to the ecologist assigning a particular importance to justify why that value has been selected, justifying any departure (up or down) from the initial importance suggested by the table.
    3. The assigning of a level of importance to an assemblage is to provide contextual information only; it is not expected that the assemblage as a whole would be assessed as a single IEF (receptor).

**Table 3.4: Assessing the importance of a bat assemblage**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Rarity category** | **SW England & Wales** | | **South-East England  to The Wash** | | **Northern England** | | **Southern Scotland[[14]](#footnote-15)** | | **Northern Ireland** | |
| **Abundant and widespread** | Common pipistrelle  Soprano pipistrelle | 2 | Common pipistrelle  Soprano pipistrelle | 2 | Common pipistrelle  Soprano pipistrelle | 2 | Common pipistrelle  Soprano pipistrelle | 2 | Common pipistrelle  Soprano pipistrelle | 2 |
| **Less abundant +Selected data-deficient** | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | 12 | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | 12 | Whiskered bat  Brandt’s bat  Daubenton’s bat  Natterer’s bat  Noctule  Brown long-eared bat | 12 | Daubenton’s bat  Natterer’s bat  Brown long-eared bat | 6 | [Daubenton’s](http://www.habitas.org.uk/nimars/mdaubentonisd.htm) bat  [Natterer’s](http://www.habitas.org.uk/nimars/mnattererisd.htm) bat  [Leisler’s](http://www.habitas.org.uk/nimars/nleislerisd.htm)  Brown long-eared bat | 8 |
| **Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient** | Greater horseshoe bat  Lesser horseshoe bat  Alcathoe bat  Bechstein’s bat  Serotine  Leisler’s bat  Nathusius’ pipistrelle  Barbastelle  Grey long-eared bat | 27 | Alcathoe bat  Bechstein’s  Barbastelle  Grey long-eared bat[[15]](#footnote-16)  Leisler’s bat  Nathusius’ pipistrelle  Serotine | 21 | Alcathoe bat  Leisler’s bat  Nathusius’ pipistrelle | 9 | Whiskered bat  Brandt’s bat  Leisler’s bat  Noctule  Nathusius’ pipistrelle | 15 | [Whiskered](http://www.habitas.org.uk/nimars/mmystacinussd.htm) bat  [Nathusius’](http://www.habitas.org.uk/nimars/pnathusiisd.htm)  pipistrelle | 6 |
| Maximum score |  | 41 |  | 35 |  | 23 |  | 23 |  | 16 |
| 45% | County importance | 18 | County | 16 | County | 10 | County | 10 | County | 7 |
| 55% | Regional importance | 23 | Regional | 19 | Regional | 13 | Regional | 13 | Regional | 8 |
| 70% | National importance | 29 | National | 25 | National | 16 | National | 16 | National | 11 |

1. EcIA 2: Predicting the impacts of development on bats
   1. Introduction
      1. A robust approach to impact assessment is necessary as a baseline from which to design effective and proportionate mitigation. This chapter describes the main ways that impacts arising from developments and other interventions can affect bats, their roosts and their habitats. It then sets out how to assess the significance of impacts on bats in line with the CIEEM guidance on EcIA, (CIEEM, 2018) which provides a standard approach and structure for ecology reports related to development projects, including those affecting bats. EcIA can be applied to projects of all scales. However, the level of detail required in an EcIA should be proportionate to the scale of the development, and the complexity and severity of its potential impacts.
   2. Identifying development impacts on bats
      1. In identifying potential impacts on bats, the entire project life cycle should be considered, including:

* pre-development impacts or advance works, such as ground investigations involving drilling or digging, asbestos survey, or measures to secure derelict buildings;
* construction impacts, including piling, building works and construction-related traffic, noise and light;
* operational impacts, such as the ongoing disturbance from public access, exposure to new predators[[16]](#footnote-17), or collision mortality from trains or road traffic; and
* decommissioning impacts, such as removal of structures, disturbance or waste issues.
  + 1. The main potential impacts on bats that can occur as a result of development are described below.
  1. Impacts on roosts

Loss or partial loss of a roost feature

* + 1. Roost loss can occur through, for example, the demolition of (part of) a building/structure or through tree felling. The impact of the loss of roosts on bat populations is poorly understood, though it is believed to be an important factor in the decline of bat populations. The effects of roost loss on bat populations will vary depending on the type of roost, the number of bats using it, and the availability of other suitable roost features within their territory. For example, where a single roost of a tree-dwelling species which shows low roost fidelity is lost from a woodland containing many such trees, the impact on the local bat population may be limited. In comparison, for a species showing strong roost fidelity, the loss of a single roost may (depending on the type of roost) have an impact on breeding success or recruitment, or over-winter survival, leading to a fall in population numbers or local extinctions. For example, Stone, et al., (2015a)found that all soprano pipistrelle bats excluded from their maternity roost found alternative roosts, with no difference in roosting behaviour in the short-term. Conversely, Zeale, *et al*. (2016) found that excluding Natterer’s bats is likely to have negative impacts on their welfare and conservation status as they are more territorial and faithful to their core foraging areas and roosts.

Modification of a feature containing a roost

* + 1. This can occur either directly (for example, the replacement of a roof or a change in materials, roost volume or layout), or through incidental changes to its internal micro-climate (temperature, humidity, ventilation or lighting regime, or the stability of any of these). Modification of roost characteristics can lead to roosts becoming unsuitable for bats and ultimately being abandoned. This is particularly important in hibernation roosts, where a constant temperature range is required to maintain torpor, and high humidity is required to avoid dehydration or in maternity roosts, where high ambient temperatures tend to be favoured (Dietz & Kiefer, 2016.). If the modifications lead to abandonment, the implications for local bat populations would be the same as for roost loss. If the roost is not abandoned, it may support fewer bats, or their winter survival rate, or reproductive success may be reduced.

Loss or modification of a roost access point

* + 1. This can occur either directly (for example being blocked by construction works), or indirectly (for example through the removal or planting of vegetation close to the roost access point). Although bats generally require an uncluttered flight-line to the access point of the roost, species show different preferences for types of access point and the flight lines leading to them. For some slower-flying species, the flight-line feature leading to the access point can be very important, whilst other species are less reliant on flight-lines. For example, *Pipistrellus* species can use roosts where the flight-path is cluttered or not structurally defined at all, whereas horseshoe bats tend to use larger roost entrances and unobstructed demarcated flight lines to allow direct flight into the roost[[17]](#footnote-18). Removal or modification of a feature used as a flight-line, including introducing lighting where it was not previously present, could result in abandonment or reduction in the size of a roost, or in delayed emergence leading to reduced foraging success.

Disturbance to bats in their roosts

* + 1. Disturbance to bats at their roost can be caused, for example, by noise, lighting or direct human interference. Where lighting illuminates a roost access point, it may delay emergence from the roost, resulting in bats missing the period in which peak invertebrate prey is available (at or soon after dusk), which may result in reduced survivorship, fitness or delayed juvenile growth rates (Boldogh, et al., 2007). Excessive lighting can also result in roost desertion (Packman, et al., 2016) or can entomb bats in the roost (Zeale, et al., 2016). Further information on bats and lighting impacts is available in BCT and ILP guidance (2018) and Voigt, et al. (2018).
    2. Similar effects could be anticipated from direct noise or human intervention. (Reason & Bentley, 2020) reviewed studies of bats and noise and concluded that most had attempted to correlate bat activity with weighted (dBA) rather than unweighted noise levels, which is targeted to human and not bats’ hearing. Low-pitched noises, audible to humans but not to bats, are unlikely to cause significant disturbance; conversely ultrasound, which is rarely measured or modelled for developments, could do so (note, there is overlap in the frequencies that are audible to bats and human). Sudden, loud noises could potentially disturb bats and cause abandonment of roosts (Pearson, Koford and Pearson, 1952; Humphrey and Kunz, 1976; Kunz, 1982; Fenton, 1997; Ferrara and Leberg, 2005), though there is some evidence to suggest that torpid bats are not affected by anthropogenic noise ( (Luo, et al., 2014). However loud, ultrasonic noise is part of a bat’s normal sensory environment and this remains an area where further research is needed.
    3. It has been hypothesised that bats experience some habituation to disturbance caused by chronic noise and vibration, but this is not well evidenced. Five common species of bat roost in Wolvercote Tunnel, Oxfordshire, which supports a live railway (Billington, 2013). Reason (2017) observed breeding lesser horseshoe bats roosting underneath a noisy hotel bar, but it was not clear whether this represented habituation, or the fact that there was insufficient ‘threatening’ noise within the frequency range of bats’ hearing. Schofield (2008) reported the same species reacting ‘in an agitated way’ to sudden noises such as passing cars (the noise experienced is perhaps not dissimilar but less predictable). F. Mathews (pers. comm.) reports horseshoe bats ignoring regular activity by a forklift truck, but abandoning a roost when a generator was temporarily installed outside. R. Green (pers. comm.) has recorded the same species, as well as brown long-eared bats and serotines roosting in/under motorway/A-road viaducts subject to vehicle ‘rumbling’ noise. There are other reports of lesser horseshoe bats (also R. Green, pers. comm.) sharing the living spaces of active dwellings, including a breeding roost. Whilst these are anecdotal (and no measurements were made of the characteristics of the sounds in any of these cases), it seems clear that, when assessing the likelihood of disturbance having a significant effect, baseline levels of noise/disturbance need to be taken into account.
    4. Chronic human disturbance may alter bat activity, particularly during the maternity season ( (Shirley, et al., 2001); (Mann, et al., 2002)) and disrupt critical torpor cycles of hibernating/overwintering bats, forcing them to overuse essential energy resources, which can affect their survival ( (Speakman, et al., 1991); (Thomas, 1995); (Fenton, 1997); (Johnson, et al., 1998)).
    5. There has been very little work on the impacts of vibration. A short literature review carried out for a coal-mining company by Matrix Solutions in Canada (2015) concluded that “*Studies monitoring population responses during periods of mine blasting show that vibration disturbances up to 6.35 mm/sec did not cause a population decrease to local bat populations. There is a lack of literature focussing on vibration levels greater than 6.35 mm/sec*.” This review largely focussed on hibernating bats. More research is needed.
  1. Impacts on foraging or commuting habitats

Loss of foraging habitat or commuting routes

* + 1. Loss of foraging or commuting habitat can occur directly through a development’s land take or indirectly when disturbance may result in abandonment of habitats (for example due to floodlighting or noise).
    2. The foraging habitat preferences and foraging strategies of different UK species are summarised in Chapter 3 of the BCT guidance (Collins, 2016), with more detail to be found in ‘Dietz, *et al*. (2009) and Kyheroinen, *et al.* (2019).
    3. When determining likely impacts on bats as a result of a reduction in access to suitable foraging habitat, consideration should be given to the:
* bat species that could be affected;
* extent of loss of foraging habitat, and the relative importance of this habitat as indicated by its landscape context and use by foraging bats;
* location of habitat loss relative to known roosts (for example, is it within the CSZ and /or juvenile sustenance zone(s)[[18]](#footnote-19) of those roosts (if known);
* proportion of loss in relation to the total area of available foraging habitat for those bats that may be affected, where this can reasonably be estimated;
* timing of loss relative to the life cycle of the species to be affected and their vulnerability to such impacts; and
* the time differential between the impact resulting in the loss or reduction in foraging resource and availability of suitable compensatory foraging habitat as a result of habitat creation, restoration or enhancement.
  + 1. Most bat species tend to choose linear features for commuting that are dark and sheltered from wind, such as hedgerows, tree lines, woodland edge habitat and waterways. (Entwistle, et al., 2001). These features also tend to attract or ‘trap’ (concentrate) invertebrate prey, providing a foraging resource and the dark conditions render bats less vulnerable to predation (Finch, et al., 2020). However even species strongly associated with linear features can use open landscapes (Finch *et al*., 2020).
    2. Fragmentation of bat habitat resulting from removal, obstruction or disturbance of commuting routes, can result in bats being isolated from a roost or important foraging grounds. Where alternative commuting routes exist that necessitate greater distances being covered, these may incur an increased energetic burden, potentially reducing the fitness of bats (Fure, 2012).
    3. When determining likely impacts on bats as a result of impacts on commuting routes, consideration should be given to the:
* bat species that could be affected. For example, some species tend to closely follow landscape features to aid navigation (Finch, et al., 2020);
* importance of the commuting route, informed by survey data including its seasonal use and the existence of alternative routes;
* quantity, quality and diversity of habitats (and associated prey resources) within the commuting route;
* degree of connectivity between resources, the shelter provided and the extent of any existing disturbance or degradation to the route;
* suitability and value of foraging habitats linked by the commuting; and
* proximity of the commuting route to (the) roost(s).

Modification of, or disturbance to bats using, foraging habitats or commuting routes

* + 1. Foraging or commuting habitats can be modifiedeither directly (for example, due to a change in land use or draining of land), indirectly (for example, through use of pesticides which may reduce prey availability) or through disturbance (for example, from artificial lighting or noise which dissuades bats from using them). For example, the brown long-eared bat (*Plecotus auritus*) listens for prey-generated sounds and gleans food items from the ground or other substrates. In a study of greater mouse-eared bats (*Myotis myotis*) which use the same foraging strategy, bats avoided foraging for as long as possible when exposed to playback of road traffic noise. When noise was unavoidable, for example when traffic noise continued throughout their entire active period, they showed reduced foraging efficiency (Schaub, et al., 2008; Siemers & Schaub, 2011; Finch, et al., 2020). Lighting impacts may also affect the use of foraging and commuting habitats; see also Voigt, et al., 2018 and specific guidance produced by BCT and the Institution of Lighting Professionals (ILP) (BCT and ILP, 2018).
    2. Foraging behaviours of bats and their prey (such as moths - see Macgregor *et al*., 2015) may be affected by artificial lighting. Impacts vary between species in accordance with their relative sensitivity to light. Faster-flying species are less inhibited by light (pipistrelles, noctule, serotine and Leisler’s bat) and indeed have been recorded feeding around white metal halide streetlights that attract insects (Blake *et al.*, 1994; Rydell and Racey, 1995); however, bats taking advantage of swarming insects around such lighting may be more prone to collision with traffic (Voigt and Kingston, 2016). Conversely, slower flying species tend to avoid street lights and light generally (i.e. long-eared bats, *Myotis* species, barbastelle and greater and lesser horseshoe bats) (Stone *et al*., 2009; 2012; 2015, Finch, *et al*., 2020) and consequently are put at a competitive disadvantage, being less able to forage successfully and efficiently. There is evidence that insects attracted from dark areas to well-lit areas can result in a reduction in abundance and a so-called ‘vacuum effect’ (Eisenbeis, 2006) that may negatively affect more light-sensitive species. Effects on prey may be widespread but hard to detect; for example, van Geffen *et al.* (2015) found some light spectra had effects on caterpillar pupation that could affect not only how much prey is available for bats, but whether it is available at the right time.
    3. When determining likely impacts on bats as a result of modification to, or disturbance of bats using commuting routes, consideration should be given to the aspects identified in the previous section (loss).
  1. Direct mortality or injury impacts on bats
     1. Bats may be accidentally killed or injured through roost destruction during construction works, or through collision with road/rail traffic, and potentially with stationary infrastructure such as tall buildings. Bats may also die as a result of barotrauma (sudden changes in air pressure that result in internal bleeding in bats) caused by wind turbines (Baerwald, et al., 2008). Some developments, such as new housing schemes may increase predation risk to bats; cats in particular can be a significant predator of roosting bats (Ancillotto, et al., 2013).
     2. In recent years there has been a growing literature on road- and rail-related mortality of bats (see for instance the CEDR reports by (van der Grift *et al.*, 2018 and O’Brien *et al.*, 2018) as well as work by Berthinussen & Altringham (2015). In general, low-flying species, males, and/or juveniles are more likely to collide with vehicles than are high-flying species, females and/or adults (Fensome & Mathews, 2016). In most cases, vehicle collisions on new infrastructure occur where bats had crossed the line of the route before construction. Hence the identification of points where bats cross the proposed infrastructure is important to assess impacts and design appropriate mitigation. The assessment of impact should be precautionary where access has not been available or if species difficult to detect acoustically are present.
     3. The identification and assessment of potential effects of onshore wind farms to bats have been widely studied. Comprehensive guides to baseline data collection, assessment of effects and mitigation requirements have been produced for onshore wind farms (see Rodrigues *et al.*, 2014 and Scottish Natural Heritage *et al.*, 2019).
     4. There has been some concern that there may be collision-related fatalities due to bats mistaking the smooth surface of ground-mounted solar panels for that of water, based on a paper by Greif and Siemers, (2010). This study makes no reference to solar panels and does not quantify collision risk or any potential ecological impact presented by this behaviour, and the fact that bats use echolocation to recognise smooth surfaces, with no collisions reported, suggests that some bat species may be adept at avoiding collision with flat surfaces. Polarotactic insects are known to be attracted to solar panels (Horváth *et al*., 2010), which in turn would suggest that insectivorous bats have the potential to be attracted to solar photovoltaic (PV) arrays, but again there is no evidence of collision risk (and most panels include sufficient texture to be detectable).
     5. When determining likely impacts on bats as a result of direct mortality, consideration should be given to:
* the species of bats affected;
* the numbers of bats which are likely to be affected (for example through probabilistic modelling of collision risk);
* the proximity of the mortality risk to important roosts of valuable foraging resources;
* the sex or life stage of bats likely to be affected; and
* for linear infrastructure, the alternative routes available to bats to avoid collision mortality.
  1. Characterising impacts on bats
     1. Once a potential impact on bats has been identified, further information is required to characterise what effect, if any, it will have on bats. Table 4. 1 below, is based on the parameters for impact characterisation identified in Chapter 5 of CIEEM’s EcIA Guidelines (CIEEM, 2018).

Table 4. 1: Characterising impacts on bats

| Impact parameter | Considerations | Examples |
| --- | --- | --- |
| Is it a positive or negative impact | Will the impact adversely affect bats? | Loss of roost sites; loss or degradation of foraging and commuting habitat. |
| Will the impact be beneficial? Is it in accordance with nature conservation policy or objectives? | Habitat restoration or creation that increases food availability within the CSZ of a roost.  Improving the physical conditions of a roost by, for example, repairing a roof to reduce draughts. |
| Extent of the impact (the area over which the effect may be experienced) expressed in geographic terms where possible) | Is the development likely to be very local in its effect? | New lighting that might affect a single field used by foraging bats at sometimes of year, but not affecting the whole of the CSZ or any roosts. |
| Will the impact be experienced across a larger area? | Loss (through development land take) of important foraging habitat that attracts bats from several roosts, or represents the majority of the CSZ of a particular roost.  Loss of an important swarming site that may attract bats from a wide area. |
| Impact magnitude (the size, amount or intensity of the impact). This should be expressed in absolute terms where possible – hectares lost, % of territory affected. | Will it affect a small number of bats? | Loss of a day roost occupied by a single bat. |
| Will it affect a large roost / population/ a protected site for bats? | Loss of 2ha of grazed pasture within the CSZ for a known roost; fragmentation of a farmed landscape that prevents bats from accessing foraging habitat. |
| Impact duration (expressed in relation to the life cycle of the species involved) | Will the impact be short-term? | A few weeks of disturbance as a result of light or noise/vibration during construction. |
| Will the impact be long-term? | Construction impacts of major infrastructure spanning ten years and hence potentially affecting several generations of bats. |
| Frequency | Will the impact occur once? | Felling a tree containing a bat roost; piling the foundations of a new structure |
| Is it likely to be repeated? | Regular movements of vehicles adjacent to a bat commuting route resulting in risk of collision and mortality. |
| Timing (in relation to the life cycle of the relevant species) | Will the activity take place at a critical life stage or season of activity | Disturbance to a mating site during September; obstruction of access to a maternity roost in summer. |
| Reversibility | Will it be temporary? | Disturbance of a roost from light and vibration that will cease once construction is complete without any other changes to the roost. |
| Will it be permanent? | Destruction of a roost as a result of demolition; loss of ancient woodland habitat |
| Cumulative, synergistic and in-combination effects | Will the impact be greater when combined with impacts of other development in the locality? | Loss of habitat at the same time as alternative habitat is disturbed by another construction project. |

* 1. Assessing the significance of impacts on bats
     1. Impact significance can be assessed pre-mitigation and post-mitigation; it is common practice in many Environmental Statements to report only the post-mitigation significance (the residual impact). Either is acceptable and in line with CIEEM guidance, but it is usually clearer to identify the impact significance before and after mitigation, allowing the effectiveness of mitigation to be outlined.
     2. Defining impact significance requires the fully characterised potential impact (as set out above) to be assessed against the value of the feature potentially affected (as defined in **Chapter 3.0**).
     3. In EcIA, the significance of an impact on an IEF is expressed using the same geographic scale used to assess the importance of the IEF, but will not necessarily be at the same level. The significance of impacts should be considered on a case-by-case basis. The impact significance cannot be at a level greater than the IEF being assessed and is often at a lower level than that at which the IEF is considered important (excluding consideration of in-combination effects).
     4. In situations where the potential impact relates to total loss of a feature, such as a roost, or the modification of such a feature to an extent that it will no longer have the same function, such as the obstruction of a roost entrance, then the significance of the impact should be the same as the valuation of the feature.
     5. In many cases, roosts will not be completely destroyed, and the significance of effects may be more difficult to characterise (particularly effects that are hard to measure or take time to be manifested, such as breeding success or population viability). However different species of bats will respond in different ways to roost modification. For example, lesser horseshoe bats can show remarkable behavioural plasticity and can adapt to significant modifications to their roost access (see, for example, Reason (2017), whereas Natterer’s bats appear to be much more sensitive to change (C. Packman, pers. comm.. The professional judgement of likely significance should be made by a suitably experienced person, along with a full rationale. Table 4.2 sets out some examples of roost modification and disturbance and their potential impact significance before mitigation.

Table 4.2: Modification and disturbance impacts to roosts: simple examples

| Example | Value of roost (from Table 3.2) | Impact | Likely significance |
| --- | --- | --- | --- |
| Feeding perch of brown long-eared bat | Local | Shed used as feeding perch will now experience vehicle movements 24/7 | Negligible; unlikely to be the only feeding perch used |
| Well-used night-roost, lesser horseshoe bat | District | Heater will be decommissioned as gas boiler replaced by ground-source heat pump | Likely to be abandoned or used by fewer bats; District |
| Day roost for up to three common pipistrelle bats | Local | Reroofing proposed | Negligible/local; unlikely to be the only day roost used |
| Day roost for up to five serotine bats | District | Access used will be removed in the repairs, but an alternative provided | District if the replacement is dissimilar (higher risk of not being re-used); Local if similar (higher chance of re-use) |
| Non-breeding roost of five Bechstein’s bats in a tree | District | Tree surgery will reduce canopy of tree outside of period of occupation | Local; very unlikely to be the only day roost used (and canopy will regrow, so importance will be restored over time) |
| Small hibernation roost in a tunnel supporting five Daubenton’s bats and three Natterer’s bats | District (>1 species) | Tunnel will be repaired; to maintain structural integrity, access will be retained but roost cavity size will unavoidably be reduced. | Local (likely to support same species, but in lower numbers) |
| Swarming site used by a few hundred Daubenton’s and Natterer’s bats | County importance | Urgent works to avoid collapse required in November will result in daytime noise and night-time lighting, but for one season only. | Up to County, dependent on availability of other sites (otherwise mating will be disrupted) |
| Maternity roost of 20 brown long-eared bats | County | Roost void will be divided because of the need to fit fire doors | Up to County (because roost may be abandoned) |
| A maternity roost of 50 Natterer’s bats | County | Tree will be subject to light-spill from a new supermarket | Up to County, though colony likely to have other roosts |
| Woodland supporting breeding barbastelle and Bechstein’s bats | National | Woodland edge will be removed to facilitate a waste treatment plant; 5% of the roost resource will be removed (though no identified roosts) and the plant will be lit, with light spill extending into the edge of the wood. | Depends on proportion of woodland affected by each factor; up to County |
| Underground hibernation site used by greater and lesser horseshoe bats every year (about 30 bats in total) | National | Woodland surrounding the cave is to be cleared to facilitate an access road. | Up to National, depending on extent (area and proportion) of habitat loss |

These are illustrative examples and the actual level of significance depends on a range of factors, not all of which are stated here, including the local distribution of each species.

The above examples are all for individual roosts and do not take into account any cumulative impacts, which could result in higher significance.

* + 1. The significance of impacts on foraging habitats can be assessed using the same process; Table 5.3 sets out the likely significance of impacts on foraging habitats and commuting routes for bats. It is important to note that any surveys will only be a snapshot in time, and may not capture the full importance as determined by records of use. The precautionary principle is important: the potential importance of a habitat to foraging and commuting bats within a changing landscape should be considered.

Table 4.3: Significance of impacts on foraging and commuting habitats.

When assessing importance, using the precautionary principle, consider also *potential/likely importance*

| Importance of Foraging Habitat (from Table 3.3) | Use by bats of different rarity (from Table 3. 1) | Likely impact significance |
| --- | --- | --- |
| Local | Limited foraging use by common species, few records of bats. | Local |
| District | High reliance on habitat by larger numbers of common species, or moderate reliance by less abundant species | From District significance (where foraging or commuting activity is functionally lost) to Local where impact is small and continued use is expected |
| County | High reliance on habitat by a less abundant species or moderate reliance by a rare / Annex II species | From County significance (where foraging or commuting activity is functionally lost) to Local where impact is small and continued use is expected |
| Regional | High reliance on habitat by a less abundant species or moderate reliance by a rare / Annex II species | From Regional significance (where foraging or commuting activity is functionally lost) to District where impact is small and continued use is expected |
| National | High reliance on habitat by a rare / Annex II species | From National significance (where foraging or commuting activity is functionally lost) and International is associated with a Natura 2000 site, to County where impact is small and continued use is expected |

* + 1. For developments resulting in direct injury or mortality to bats, the significance of the impact will be directly related to the value of the bat population within the ZoI of the development. So, a population of Regional importance could suffer an impact of Regional significance if mortality was above incidental levels. Unfortunately, it is rare that mortality levels are known or can be estimated in population terms (i.e. percentage affected); nor is the significance of even low levels of mortality well-understood. Every effort therefore needs to be made to avoid mortality (or mitigate it where predicted), and to apply remedial measures if the mitigation proves ineffective.
    2. The examples above give an indication of how to assess impact significance on various features such as roosts or habitats, and the effects of mortality. These may then need to be aggregated, depending upon the scale of the development, to describe the impacts on IEFs which may be local populations of individual species or groups of species roosting or other using habitats within the ZoI.
  1. Residual Impacts
     1. Residual impacts are those that remain after mitigation of impacts on bats has been considered. If an impact has been fully mitigated then there would be no residual impacts; however, if it is not possible to fully mitigate an impact, a residual impact would remain.
     2. In order to determine whether any residual impacts remain, the following should be considered:
* the nature of the mitigation proposed (for example, is it intended to eliminate or simply reduce the severity of the impact);
* the known effectiveness of the mitigation in the particular circumstances of the impact (that is, has such a technique been demonstrated as effective for the same species, or a species with, for example, a similar foraging strategy);
* any factors which may affect the success of the mitigation proposed (for example, levels of human interference).
  + 1. The significance of residual impacts is expressed in exactly the same way as described above, with reference to the geographical level of importance of the bat feature. The assessment of impact significance after mitigation should be conservative. That is, the residual impact should be considered as non-significant only if the mitigation proposed will definitively remove the impact. For example, if the potential impact were light disturbance directly affecting a roost, and the mitigation was to remove lighting from the part of the site close to the bat roost, the impact after mitigation would be non-significant. If, however, the aim of the proposed mitigation was to reduce the lux level of the light or to add a baffle, the residual impacts would be more nuanced. The impact would clearly be reduced from the pre-mitigation levels, but professional judgement, supported but the rationale that led to that judgement, would need to be executed regarding the significance of that impact. The aim of all mitigation strategies should be to reduce impacts to a non-significant level. If this cannot be achieved, appropriate compensation should be proposed.

1. EcIA 3: Mitigation and compensation overview
   1. Introduction to mitigation

This section sets out the key principles and definitions of mitigation and describes how mitigation should be designed and controlled to maximise the chances of successful implementation and good outcomes for bats. The mitigation hierarchy is defined in **Box 5.1** below. ‘Avoidance’ measures considered can include the ‘do nothing’ option.

Box 5.1: The Mitigation Hierarchy

AVOID  
Find alternatives to prevent an adverse effect occurring  
e.g. time works when bats are absent; design to retain roost or commuting route

↓

MITIGATE  
Where options for avoidance have been exhausted and a negative effect remains, design in measures or methods to minimise adverse effects   
e.g. timing of works, lighting design

↓

COMPENSATE  
Where there will be a residual adverse effect after mitigation measures are employed, provide newly created or enhanced alternatives   
e.g. replacement roosts or foraging habitat

and

ENHANCE  
Provide biodiversity gain

* + 1. The terms mitigation and compensation are sometimes used interchangeably but have different meanings, as defined in **Box 5.2**.

Box 5.2: Mitigation, Compensation and Enhancement – definitions

**Mitigation:** measures that *avoid* or *reduce* negative effects, such as changing the timing of works, using different designs, methods or techniques, or making adjustments that reduce the longevity of an effect. Measures may be within a site boundary or extend beyond for mobile species or functionally linked habitats.

**Compensation:** measures that offset the loss of, or permanent damage to, an IEF where residual effects exist after mitigation. Compensation should only be considered where adverse effects cannot be mitigated. Measures may be located outside the site boundary.

**Enhancement:** measures that provide net benefits for biodiversity over and above any requirements for avoidance, mitigation or compensation.

**avoidance, mitigation or compensation.**

* 1. Principles of mitigation and compensation
     1. A strategy for mitigation/compensation should:
* be informed by robust survey data underpinning an accurate assessment of the predicted effects of a project across its zone of influence;
* ensure continued ecological functionality of colonies by considering roosts, habitats and connectivity at a scale proportionate to the development;
* follow the mitigation hierarchy;
* seek to achieve a positive outcome for biodiversity (e.g. biodiversity net gain)
* identify the monitoring surveys required to test ‘success’ and trigger any relevant associated actions (see **Chapter 9.0**); and
* provide a clearly established mechanism for delivery of the proposed mitigation and associated monitoring (normally be controlled through planning and licensing).

Mitigation/compensation expectations

* + 1. Mitigation/compensation should be proportionate to the impacts. In any bat strategy, it should be clear which of the proposed elements are mitigation/compensation and which are enhancement.
    2. The types and requirements for licensing vary between the different UK countries (as set out in **Chapter 2.0**). The acceptable level of mitigation for a given level of impact may also vary, and differ between species. SNCB requirements are not published externally, but reasonable expectations by species and roost type are given in **Appendix 3**. The valuation on which these tables are based is explained in **Chapter 4.0**.
  1. Biodiversity Net Gain
     1. Biodiversity Net Gain is an approach which aims to leave the natural environment in a measurably better state than beforehand.  At the time of writing, the metric produced by Defra provides the mechanism of measuring and accounting for biodiversity losses and gains resulting from development or land management change in England. However, the Defra metric currently only considers habitats as a proxy for biodiversity; it does not take into account requirements of bats and other key species.
     2. BCT has produced a document detailing how bats and their habitats can be considered within Biodiversity Net Gain[[19]](#footnote-20):
  2. Ensuring delivery

Consultation and communication

* + 1. Early consultation with the client and planning authority is required so that:
* the mitigation hierarchy is applied to the design process
* the requirements and constraints, particularly seasonal constraints and programming implications arising from complex projects with significant impacts, are understood and accommodated
* the planning authority and, for larger projects, the SNCBs are engaged
  + 1. The effective and successful implementation of a mitigation plan will almost always require site supervision and/or employment of a suitably experienced and usually licensed Ecological Clerk of Works.

Planning controls

* + 1. The British Standard for Biodiversity 42020:2013 (British Standards Institution, 2013) defines the requirements for ecological input in the planning process and illustrates how this fits with the Royal Institute of British Architects (RIBA) Plan of Work guidance stages. It also includes suitable wording for planning conditions and other controls (e.g. Section 106 Agreements for maintenance of a building as a roost; or conservation agreements under Section 41 of the Natural Environment and Rural Communities (NERC) Act 2006; Section 7 of the Environment Act (Wales); Section 2(4) of the Nature Conservation (Scotland) Act 2004, Section 3(1) of the Wildlife and Natural Environment Act (Northern Ireland) 2011).
  1. Working with clients and contractors
     1. However good a design is on paper, and however detailed the drawings and associated instructions, it is always possible for these to be misinterpreted or mislaid. Bat mitigation is sometimes seen as an obstacle to be dealt with quickly by contractors that have other priorities. Unfortunately, that can lead to costly mistakes that have to be rectified (such as having to remove a new roof to change an unsuitable roofing membrane, despite clear and timely instructions). Sharing drawings at an early stage with contractors so that the correct materials and design details are costed in is essential. Having meetings (or conference calls) to explain the objectives rather than relying on correspondence, is strongly recommended. Similarly, any restrictions that may apply to working practices (such as seasonal windows affecting programme, limits or bans on night-time lighting) should be fully explained and documented.
     2. The same requirements apply to habitat creation and enhancement measures, which can take longer (several years) to fully establish. It is important that measures are in place and the requirements for remedial action are fully understood by contractors, in case of failure (see also **Chapter 9.0**).
     3. Recording communications and actions as they occur is of paramount importance in case things do not go according to plan. The more complex the mitigation, the more likely it is to deviate from what has been planned (Collins, et al., 2020). Clear records may be used by insurers wanting to assess liability for costs, or in legal proceedings, should an offence be committed or suspected. Even in the absence of formal proceedings, such records (including photographs) establish a clear audit trail of actions, roles, agreements, progress and responsibilities.
     4. Monitoring should be seen as an integral part of the project, and its importance, timescales and costs should be highlighted at the earliest possible stage (see **Chapter 9.0** for specifics). This is particularly important given that, in many cases, monitoring will extend beyond the point at which contractors leave site, and responsibilities for subsequent actions may become less clear if not formalised in advance.

1. Avoidance, mitigation and compensation: roosts
   1. Introduction
      1. This section describes methods used to mitigate (or compensate for) impacts to bat roosts. Mitigation is not an exact science and the evidence for success, whilst increasing constantly, is incomplete and sometimes contradictory. This is because the factors which drive success are complicated and because there has been inadequate monitoring and reporting of successes and failures. However, it is important that roost loss is mitigated or compensated, particularly from older buildings, as the materials and techniques used in contemporary buildings can exclude bats or even cause harm, and there is a growing risk that roost sites will become a limiting resource at least for some species and/or in some areas.
      2. Simon *et al.* (2004) go further, and state that not only should existing roosts be preserved where possible, but that is *essential* to create new roosting opportunities to replace those being lost from the roost resource. New opportunities created by ageing/weathering will not be enough to compensate for the likely rate of attrition, and therefore the provision of additional roosts (what might be considered ‘enhancement’ but is really compensation on a landscape scale) is required, along with landscape-scale habitat improvements (Mackintosh, 2016).
      3. Recent studies[[20]](#footnote-21) examining mitigation success include Lintott & Mathews (2018) and Collins *et al.*, 2020. It’s important to note that Lintott and Mathews’ study relied on a self-selected sample of consultants’ reports, and only included cases where monitoring had been carried out and a report was available (these were of varying quality, affecting the subsequent analysis). Collins *et al*. (2020) included cases from SNCBs (not just those volunteered by consultants) and undertook the monitoring themselves.
      4. These two studies found that the probability of bats returning to a site post-development was dependent on the nature of the changes to the roost structure[[21]](#footnote-22). If the roost structure was completely destroyed, the likelihood of bats returning was greatly reduced in comparison to where roost structures were retained but modified in some way.
      5. The outcomes of the two studies sometimes conflict; this is not surprising given the complexity and variability of bat mitigation and the relatively small sample sizes for the level of variation in each study. It is also important to note that both studies focussed on a small sub-set of species so, for these reasons, the outcomes cannot be universally applied, nor taken as confirmation that good quality mitigation fails more often than not in the longer term. This is particularly true when failure in a single critical attribute is likely to result in overall failure (Waring, 2011).
      6. Mackintosh (2016) looked at a series of maternity roost compensation measures in Scotland. This study was relatively small and similarly covered a small range of species and several different compensation types[[22]](#footnote-23), which again makes it difficult to draw firm conclusions about the factors that are critical and those that are contributory in determining whether mitigation provision will be used by the same species for the same purpose post-development. The mitigation implemented had only been in place for a maximum of three years, often far less. The before/after colony counts were limited in number and to single years, therefore it is not possible to judge whether any change in roost status/numbers was an accurate reflection of past, or future *long-term*, use.
      7. Conservation Evidence[[23]](#footnote-24) is a free information resource which summarises global evidence about the effects of conservation interventions. The site collates and examines scientific studies of specific interventions designed to benefit wildlife or ecosystems in order to determine if there is any evidence of effectiveness. ‘Key messages’ for each intervention show the extent and main conclusions of the available evidence over the last few decades. The supporting detail allows an assessment of the quality of the evidence and how relevant it is to a particular situation. To be included as evidence, there must have been an active intervention, and monitoring must include an appropriate comparison (control). In many cases where mitigation is applied for a development, there is no control and therefore such examples cannot be submitted. Many interventions, even those commonly used, are said to have ‘no evidence’ for this reason; i.e. effectiveness has not been adequately tested.
      8. Mitigation success may vary between species and roost types. Lintott and Mathews (2018) found that large pre-development pipistrelle roosts (> 100 individuals) retained similar numbers of bats following mitigation. There are numerous examples of lesser horseshoe bats successfully adopting new roost provision (see Schofield, 2008 *inter alia*). However, rarer species (other than lesser horseshoe bats) are less often found in situations where their roost might be lost (at least, they represent a very small proportion of licence applications), so there are fewer examples to test effectiveness. This indicates the need for licensing to protect those rarer species by the implementation of the mitigation hierarchy, i.e. through avoidance.
      9. For brown long-eared bats, roost sites which were retained (with existing access points), and of a similar size (i.e. where impacts were avoided), unsurprisingly tended to be the most successful in retaining roosts (Shepherd & Stroud, 2010). Creating a bat loft in an existing building on a site, presumably known to the colony, has a good chance of success (Shepherd & Stroud, 2010). Collins *et al.* (2020) found adapted buildings were used more than retained roosts, although the retained roosts in that study were typically lower-status day roosts, whereas the adapted buildings represented larger, more important roosts. The success of new lofts in new builds varied. Whilst Shepherd and Stroud (2010) found them little-used, and Collins *et al.* (2020) found them unused, Lintott & Mathews (2018) recorded brown long-eared bats in ~20% of new lofts, at least some likely to represent maternity colonies which can comprise as few as five individuals (Dietz & Kiefer, 2016.). For this species, even in ideal habitat, time may be a critical factor, maybe because a small number of individuals takes longer to find new roosts[[24]](#footnote-25), or because new construction materials are (at least initially) unattractive.
      10. In compiling these guidelines, where measures have little or no supporting evidence, we have attempted to make this clear. However, monitored examples that have resulted in use by bats have been included, even where there is uncertainty as to what made the mitigation successful, or which factors were critical.
      11. In addition to the examples included here, case studies are available at the locations listed below. Some of these are ‘live’ sites, and consultants are strongly urged to contribute studies to these sites, and to consult them for updates and examples.

* BCT’s Mitigation Case Studies Forum 2017 (BCT, 2017)
* BCT’s Roost website[[25]](#footnote-26), which promotes good practice through the sharing of bat roost mitigation and enhancement case studies.
* Eurobats Report of the Intersessional Working Group on Purpose-built Roosts[[26]](#footnote-27)
  + 1. A recurring theme of the Eurobats review cited above26 (*inter alia*) is that the uptake of purpose-built (i.e. artificial replacement) roost structures can be slow. This is an extremely important point. In some cases, it may be many years before bats fully adopt them, as demonstrated by a number of specific examples in that review. Thus, designs for new roosts in many cases may be perfectly adequate in terms of the roosting ecology of the target species, but a range of other factors, such as the social structure of colonies or the existence of other known roost sites may influence their uptake. In addition, it is not yet known *how* bats find new roosts (this may differ between species). This means both that there may be a short term impact on the local population, and that long term monitoring may be necessary to fully appreciate the beneficial impacts on bats of adding to the local roost resource.
    2. As sites vary in their characteristics and the species they support, and developments differ in their impacts, consultants may make a case for different techniques and levels of effort. Importantly, all interventions must be monitored for an adequate period of time, and the results reported, so effectiveness (or otherwise) can be improved.
    3. There is a responsibility to make sure that any proposed mitigation meets other ‘non-wildlife’ legal requirements. For example, the incorporation of bat access points into new or refurbished buildings must comply with planning requirements and Building Regulations. Older buildings may require listed building consent[[27]](#footnote-28), and there is a separate consent for scheduled monuments[[28]](#footnote-29). Separate rules apply to churches. Who is responsible will vary depending on the nature of the project and whether a licence is needed or not, e.g. consultant, client, architect, or building contractor. Additional requirements may also be imposed by insurance or warranty organisations, such as the National House-Building Council. Adopting the options in this document does not indicate or ensure compliance with any such requirements.
  1. Avoiding disturbance to bats in roosts

Timing

* + 1. The great majority of roosts are used seasonally, so there is usually some period when bats are not present. Consequently, the most common and effective method of avoiding offences is to carry out work at the time of year when bats will be absent.
    2. Bats are most vulnerable during the breeding season (when vulnerable non-flying pups may be present) and the hibernation period (when untimely arousal from hibernation may affect fitness and even survival).
    3. Although there are differences between species, maternity sites are generally occupied between May and August (some into September) and hibernation sites between October/November and March, depending on the weather. Note bats are unlikely to be fully hibernating in October in most areas of the UK, given that mean temperatures average a daily high of 14 °C and a low of 7 °C[[29]](#footnote-30).
    4. In principle, the optimum time for works of all types is likely to lie outside the breeding season and hibernation seasons. Spring and autumn therefore represent the periods when bats are least vulnerable to disturbance. The recommended times shown in **Table 6.1** below should be modified in the light of site-specific species information and latitude.

Table 6.1: Optimum season for works in different types of roosts.

The period of works may be extended if the way in which the bats use the site is well understood.

| **Roost type** | **Months to avoid** | **Optimum period for carrying out works (some variation between species and weather-dependent)** |
| --- | --- | --- |
| Maternity | May-August (potentially September) | September to end April |
| Hibernation | November to March | April to end October |
| Non-breeding summer roost | None | No restrictions – assuming bats can be excluded if present in small numbers |
| Mating/swarming: not used for hibernation | August to October (key); potentially until mid-November  Also April-early May in at least some species1 | Mid-November – end March (potentially later, maybe species-specific).  Broader restrictions if site also used for hibernation: see above. |

1 Furmankiewicz *et al*., 2013

* + 1. Annual (and regional) variations in temperature affect bat behaviour, and these assumptions are likely to be increasingly challenged by climate change. The table above therefore needs to be interpreted with caution, supported by survey data. It should be used as a planning tool, in combination with inspections to confirm absence.
    2. An adequate survey and good understanding of the seasonal activity patterns of the species involved will help in determining the optimum time to carry out the proposed work. For instance, Davidson-Watts, *et al*., (2006) recorded common pipistrelles moving roosts early, between pregnancy and lactation, which would provide a potentially longer window in the summer to get works completed. Conversely, some species –notably long-eared bats and lesser horseshoe bats – tend to use summer sites until well into autumn or even winter in some sites, so care is needed when drawing up works timetables where these species are present. Evidence rather than doctrine should be used to determine when it is safe to undertake works.
    3. Timing the works to avoid periods when roosts are occupied will only be sufficient to avoid the need for a licence if the functionality of the roost is maintained for when the bats return. Specifically, you would not need a licence[[30]](#footnote-31) if:
* the existing materials are replaced like-for-like (i.e. similar type of roofing slates, similar felt or membrane);
* the same access points are retained and there are no structural changes made to the roost;
* the work is done whilst bats are absent and is completed before they would normally return to the roost.
  + 1. ‘Maintaining appropriate environmental conditions’ does not mean that a roost could be reinstated with different materials during unlicensed works; a particular issue has been the increasing use of inappropriate roofing materials (see below). However, re-roofing while bats are absent, using traditional materials and reinstating access points, could be undertaken without a licence.
    2. Activities which could cause temporary roost disturbance but leave roosts and access points unaffected (e.g. works resulting in short-term noise or lighting) are good examples of where a licence could be avoided through appropriate timing. Where the same structure is used throughout the year, it is not likely to be possible to avoid licensing.
    3. When determining whether a licence could be avoided by timing the works at an appropriate time of year, the likelihood of discovering bats outside of the anticipated season of occupation, and potential for programme slippage, should both be considered.
    4. As a starting point, the best times for building or re-roofing operations are spring and autumn, when bats are active and least vulnerable. However, where buildings are only used opportunistically by individual or very small numbers of non-breeding bats for (likely) short periods of time, it may be possible to undertake such operations with care during the summer. Active bats will usually keep out of the way of any operations (Mitchell-Jones, 2004).
    5. Note: while it would not be possible to rule out the possibility of uncovering a torpid bat if re-roofing during the hibernation season, this would be the case whether or not surveys had established the presence of an opportunistic/transitional roost[[31]](#footnote-32). Repeated disturbance to bats during the winter can seriously deplete their food reserves, but, unless significant numbers of bats are known to be hibernating in a building, there is no advantage in requesting a deferment of scheduled works (Mitchell-Jones, 2004). Where the likelihood of small numbers of hibernating bats is higher (for example, roosts have been identified nearby, and/or the property being re-roofed is close to good habitat), then the risk of uncovering a torpid bat can be reduced by only stripping tiles when it is dry and mild and after temperatures have not dropped below 8°C for four days.
    6. Very large rebuilding or renovation projects may take many months to complete and may need to continue through the summer, which is the favoured season for re-roofing. Where a maternity roost is affected, the aim should be to complete and secure the main roosting area before the bats return to breed. Where an important swarming site is affected, works should be timed to avoid the autumn swarming and hibernation periods[[32]](#footnote-33). For longer-term projects where the impacts could otherwise be severe, it may be necessary for works to be carefully phased, with pauses between phases.

Screening

* + 1. If bats are present, works may be able to continue through the use of methods such as temporary screening to partition works from the roost and temporary exclusion methods (see **Section 6.9** for exclusion methods).
    2. Such measures may avoid or reduce the severity of impacts, but any measures that significantly reduce roost area, block entrances, change the thermal regime of the main part of the roost or require bats to be excluded using a device would be licensable.

Lighting and noise

* + 1. To avoid repetition, these issues are covered under Section 7.3.
  1. Mitigation for building roost loss (excluding churches)

Approach

* + 1. Roost loss may be temporary or permanent. Where possible (temporary loss), the roost should be reinstated in the same location, with the same attributes (effectively avoidance of impacts if the work is completed while the bats are seasonally absent).
    2. Projects such as the refurbishment of derelict or semi-derelict buildings, barn conversions, alterations to non-domestic premises and other structures used by bats, can all provide opportunities to incorporate existing roosts into the final structure (mitigation). This option is to be preferred to the destruction of an existing roost and the provision of a new roost in compensation, though there may be physical constraints which make this impossible.

Design criteria

* + 1. Understanding species’ roosting preferences[[33]](#footnote-34) is critical to designing appropriate mitigation, as is the context in which that roost provision is located (Mackintosh, 2016, *inter alia*). For all types of building roost (whether retained, modified or newly-created), the physical characteristics of the final roost, the arrangement and number of entrances, and the flight paths leading to those entrances (including the location of any exterior lighting or vegetation) all need to be considered. For retained roosts, some of these characteristics will already be established, but could be subject to adverse change, particularly lighting and connectivity. A perfectly designed roost (whatever that looks like) in a poor location is unlikely to be successful.
    2. Design principles for repairing/reinstating building roosts, providing compensatory bat roosts in an alternative or modified roost space, or building a dedicated stand-alone ‘bat house’ overlap, though their relevance will depend on the specifics of any particular situation. For this reason, no distinction has been made between these different types of mitigation for most of the elements described, and they should be applied as needed.
    3. A small number of additional criteria are provided for new constructions, where the risks of non-adoption by bats can be reduced through careful site selection and orientation.
    4. In developing proposals for replacement bat roosts, due regard must be paid to any planning requirements. If planning permission is needed, this may take time to acquire and conditions may be imposed by the planning authority. Such requirements need to be clarified and any planning issues resolved before a replacement roost can be proposed. Replacement roosts, depending on their position and construction, may be subject to the requirements of Building Regulations, again to be clarified before a licence application is made.
    5. Where possible (in terms of layout, access, buildability), replacement roosts should be ready for use by bats (i.e. installed as per all requirements) before the existing roost is destroyed. It is sometimes suggested that a newly provided roost should be *in use* before the existing roost is destroyed. This is almost never appropriate, as there is unlikely to be a strong driver for bats to explore new opportunities until they are excluded from the old roost.
    6. In some circumstances (i.e. where a new roost requires the old to be removed before it can be constructed), a temporary alternative may need to be in place for a period of time, so bats always have a roost to use during their normal periods of use. This is not usually the case for feeding roosts, night roosts (unless well-used by rarer species – see **Table 3.2**), small/non-breeding day roosts (as defined by Natural England[[34]](#footnote-35)) or transitional/occasional roosts.

Roost height/volume

* + 1. Crevice-dwelling species tend to use very small spaces and can be found within a wide range of external components of a building: below tiles, under flashing or the ridge, behind soffit boards, and so on[[35]](#footnote-36).
    2. Species that tend to roost within the roof void and fly within the roof void before emerging (long-eared bats, *Myotis* species, horseshoe bats) require a space uncluttered by roof timbers (e.g. purlin and rafter). Based on a sample of known roosts Mitchell-Jones (2004) stated that an ideal roof void would have an apex height in excess of 2.8 m and a length and width of 5m or more, and there are insufficient UK data to give confidence in reducing these[[36]](#footnote-37). Collins *et al.* (2020) found that internal height and volume (which are correlated) in adapted lofts displayed highly significant positive relationships with bat counts. The highest bat loft measured 6m; no bats were recorded in lofts where the highest internal point was less than 1.5m[[37]](#footnote-38).
    3. Not providing pre-emergence flight space can lead to roost abandonment, as demonstrated by (Briggs, 2002). In her barn study, although Natterer’s bats were roosting in the small gaps provided by mortise joints (which presumably mimic tree cavities), the lack of an internal area in which to fly following conversion led to roost abandonment even when the roost sites themselves were retained. [See also ‘light-sampling’.]

Roost access-point location

Table 6.2: Considerations when locating access-points

|  |  |
| --- | --- |
| Design principle | Evidence/comment |
| It is preferable to maintain entrances in their original position and of a similar size, type and orientation. | Changing the access point can reduce numbers of bats using the roost (Mackintosh, 2016; Berthinussen, Richardson and Altringham, 2019; Collins et al., 2020). Even minor alterations to access points may deter bats initially, acting as an “invisible barrier” (C. Packman, as reported at the Bat Mitigation Forum, 2017).  Where practicable, it may be beneficial to ‘train’ bats to use a new access-point before the existing access is removed (Reason, 2017). |
|  |  |
| New access points should be at a sufficient height and, for vesper bats, the landing area surface should be roughened | Based on a very large sample of access points in Germany, Simon *et al.* (2004) recommend new access points should be located between 7 and 10 m above ground. In UK guidance, Williams (2010) recommends a more conservative 2-7 m height. In practice, height is likely to be dictated rather than a choice. |
| More than one access-point may be beneficial; noting that at least one should be close and similar to the original access-point. | Lintott and Mathews (2018) found a marginal but significant relationship between the number of roost entrances installed and the probability of bats returning to a roost at comparable levels with pre-construction surveys. However, there may not be a relationship between the number of access-points available and those actually used (Collins et al., 2020).  Packman *et al.* 2016, found that Natterer’s bats used many existing exit points from churches, and sometimes used different points to re-enter (C. Packman, pers. comm.). Assuming thermal conditions are maintained, offering additional access-points may improve the likelihood of one being used. |
| Access-points should be sheltered | Siting an access point adjacent to a corner or overhang may increase its effectiveness (Collins *et al.,* 2020). |
| Some species appear to require larger sheltered/ covered areas for ‘light-sampling’ or socialising, during which they fly in and out of roost entrances before finally emerging. | The purpose of this behaviour is not confirmed (and sometimes vigorously disputed) but providing a large roof void or a covered area can lead to earlier emergence times[[38]](#footnote-39). |
| Access-points should be close to cover. | A short distance to cover may increase the attractiveness of an access point (Mackintosh, 2016). |
| Other considerations | New access-points should not compromise the thermal regime of the roost by causing draughts (see below), allow in light, nor allow birds access[[39]](#footnote-40).  Access-points should not be located above domestic windows and doors to avoid issues with droppings, and light-spill onto roost entrances. |

Roost access-point size

* + 1. Access points for crevice-dwelling bats can be as small as 15-20mm high x 20-50 mm wide (Williams, 2010), and can be as simple (and low-cost) as creating a gap between a soffit and the wall. There are also numerous adapted bricks and tiles available, or gaps can simply be left in masonry, under raised lead flashing, or over the top of a cavity wall. Lead used to create bat access tiles should be at least Grade 6 to prevent the entrance dropping closed, and the lead entrance-way should be roughened or removed (so that the roof tile surface is the entrance), to allow bats’ enough grip to crawl in.
    2. **Access gaps** can be created under ridge tiles by leaving out mortar (particularly at the end of the ridge) and removing ventilation structures within them. The roofing felt should be cut to allow access into the roof void. See also **Appendix 2** for access into dry ridge systems.
    3. **Larger access-points are required for horseshoe bats** which fly into their roosts rather than crawl. The Bat Workers’ Manual (Mitchell-Jones & McLeish, 2004) suggested 400x300mm for greater horseshoe bats and 300 x 200mm for lesser horseshoe bats; the Bat Mitigation Guidelines (Mitchell-Jones, 2004) did not differentiate, and stated 600mm wide and 300-400mm high. The Lesser Horseshoe Bat Handbook (Schofield, 2008) recommends an overall area of 2500cm2, as long as the height exceeds 200mm (the width can be reduced for small numbers of bats). Others have noted that greater horseshoe bats can have a negative impact when a roost is shared[[40]](#footnote-41) so smaller entrances may be appropriate for roosts designed for lesser horseshoe bats (unless the colony is large).

Thermal regimes; maternity

* + 1. A study of summer roosts in central Germany (Simon *et al.*, 200433) demonstrated that most maternity colonies showed a preference for warmer aspects; where bats were found on cooler aspects, these tended to be non-breeding individuals. When creating a maternity roost, this should therefore have a southerly or westerly aspect33. Some species (e.g. whiskered bats, who avoid northerly aspects) are more conservative than others (e.g. pipistrelle species) 33.
    2. Species-specific roost temperature ranges were collated by Shepherd and Stroud (2010) and in the study cited above. The ‘ideal’ temperature is difficult to discern from the available research; some studies provide a range (which can be as wide as 30°C); some a mean; some both. There are likely to be species-specific preferences and tolerances between species (as there are for hibernation, see **Section 6.8**). Those differences are likely to apply to the maximum and minimum temperatures that a colony will tolerate, but also to the degree of stability (buffering from outside variations) and the degree to which individuals can control this by moving closer together (clustering) or further apart. Where temperatures rise or fall too far, some may respond by moving roost. To add complexity, the relative importance of temperature compared to other factors (relating to the roost and/or its external environment) may similarly vary between species.
    3. It would seem reasonable, certainly for larger/breeding colonies, to provide a range of microclimates (Kayikcioglu and Zahn, 2004; Reason, 2017; Schofield, 2008; Simon *et al.*, 2004 *inter alia*), with **at least one area reaching at least 25°C** that offers some buffering from the variations in external temperature. To achieve this:
* access-points should not be installed too high in a roof void as they will lose warmth as heat rises (poorly-designed dormer-style access points can have a similar effect);
* draughts should be avoided (missing soffits and open eaves can mean that the roost space never becomes warm enough to maintain a colony).
  + 1. According to Simon *et al.* (2004), the temperature in the roost should not exceed 35°C. More than one study has demonstrated that bats can overheat, both in artificial roosts26 and in bat boxes (Flaquer, et al., 2014). Schofield (2008) provides a design for a ‘cool tower’ for horseshoe bats[[41]](#footnote-42), where bats can go into torpor, functioning as a transitional roost space in spring and autumn and in periods of poor weather, or for respite if the roost becomes too hot.
    2. It is preferable to design the roost to provide a warm thermal regime, rather than providing artificial heat sources (heater or radiator). This can be achieved through:
* passive heating via insolation from the sun
* creating a ‘hot box’ which traps warm air (designs available for this in (Schofield, 2008)). A low-cost option for this is also shown in Appendix 2.
  + 1. Artificial heat sources carry a number of risks, which include:
* ongoing costs
* the need for maintenance
* equipment failure or a lack of long-term funding could adversely affect heating provision and cause roost abandonment
* fire risk
  + 1. The only circumstances where heating should be considered include:
* roost locations where the roost is surrounded by trees (Schofield, 2008)
* locations where an existing colony have adapted to heat from boilers or pipework which has been decommissioned (see, for example, Reason, 2017)
* situations where the risks from heating can be controlled (through formal agreements to secure long-term funding, oversight and monitoring), or reduced (fire detection equipment).
  + 1. The benefits/uses of artificial heating:
* Prior to the installation of heated roost incubators at Woodchester Mansion from 1994, the sex ratio of the greater horseshoe bat babies born there was biased towards male babies. After installation, this bias was towards female babies, resulting in faster colony growth (R. Ransome, pers. comm.).
* Heated mats have been used in the Bats in Churches project in England (see 6.3.60) to encourage bats to move into a cooler restricted roost location to reduce church-wide distributions of droppings whilst retaining the colony (Zeale, et al., 2014).
* Heating has been used to encourage bats from an unsuitable location to a more suitable but temporary location, and then to a permanent location on a long-running project in Portugal26.
* Heating elements may be used throughout winter. For example, soprano pipistrelles in a church (see 6.3.60) use a box within the church has year-round; horseshoe bats use incubators year-round at Woodchester Mansion (N. Downs, pers. comm.) and Coombe Down (F. Mathews, pers. comm.).
  + 1. Note that the effect of solar panels on a roof are unknown. Presumably as they absorb energy from the sun, the roof void beneath could end being up being cooler (but not necessarily too cool).
    2. In all circumstances where a roof void is retained, enhanced or created with the aim of providing a roost space for bats, a range of microclimates should be included within that void. Modern methods of insulation (such as deep floor insulation (e.g. wool) preventing heat rising into loft, affixed to the tiles (e.g. Celotex) preventing thermal gain, or within cavity walls (preventing access) all serve to reduce roof void temperatures. Conversely, climate change makes extreme weather events more likely and, with these, a risk of over-heating[[42]](#footnote-43). A check, using temperature loggers, should be made that at least one (and preferably more) areas are within the broad temperature preferences of the species concerned (as far as these are known).
    3. (Collins, et al., 2020) found the number of small internal cavity types inside lofts showed a highly significant positive relationship with bat counts. Internal crevices (see below) can extend the range of micro-climates available. Crevices on the cooler aspects of buildings could also be provided for use by males.

Perching opportunities within a roof void

* Rough timbers such as battens or Oriented Strand Boards (OSB), fastened close to the roof apex, are a simple means of providing something for bats to hang from or roost against.
* Natural materials should be used in preference to synthetics (that said, chicken-wire is frequently used by horseshoe bats and is long-lasting). A semi-rigid plastic mesh with a 2mm x 2mm diamond hole size (insect mesh) can be suitable but should be tightly applied to the surface (A. Glover, pers. comm.). Netlon or wide-gauge mesh can trap some species, so should be avoided.
* Timber cladding mounted on 20-30 mm counter battens with bat access at the bottom or sides can provide cost-effective crevices. Although Collins *et al.* (2020) found internal boarding and panels to be almost the least-used feature within a roost, evidence of use may under-estimate actual use; they did find a relationship between the number of bats (all species) and the number of small internal cavities provided. Lintott & Mathews (2018) similarly found such roost enhancements (rough sawn timber crevices etc) significantly increased the probability of pipistrelle bats returning to the roost (Insufficient data were available to permit analysis of use).
* Pipistrelle bats have been found using the gap under boarding used to protect windows from vandalism in neglected buildings, even in winter (P Reason, own observations). This provides a space similar to the above roost enhancements, indicating they have some value.
* The low cost of these features means that it is worthwhile including them.

Roofing membranes

* + 1. A wide range of roofing membranes are now available; many pose a danger to bats. The underfelt to be used in bat roosts therefore needs to be carefully specified.
* Use only bituminous roofing felt that does not contain non-woven spunbonded polypropylene filaments (i.e. bitumen 1F);
* No non-bitumen coated roofing membranes (NBCRMs); formerly referred to as breathable roofing membranes; BRMs) are currently considered safe to use in bat roosts (Waring, et al., 2013);
* BCT maintain a regularly updated news feed on NBCRMs[[43]](#footnote-44), which should be consulted.
  + 1. Where an NBCRM is already installed and re-roofing is not an option, this should be covered to prevent bats coming into contact with it[[44]](#footnote-45). This intervention should only be used as a last resort, and not as a method to make NBCRMs acceptable in a bat roost (in any case, it does not protect bats roosting above the membrane).

Re-use of timber; seeding with droppings from existing roost

* + 1. As noted in the Eurobats review26, new roost provisions may take many years to be adopted. The inclusion of old timbers and/or droppings may help with this, and olfactory cues seem to be important (para **6.3.61**).
* Dedicated roost provision for brown long-eared bats (and other species), provided in compensation for a demolished old farmhouse, re-used timber materials, including rafters, the ridge beam, tie beam, purlins and battens. The original fibre insulation and associated droppings were rolled up and installed in the new roost, and the roof was mostly covered using tiles from the demolished farm buildings. The maternity colony re-established itself in the new bat house (Garland, et al., 2017).
* The contribution of the re-used materials to success in the above example is unproven, but in many circumstances, their low cost means that it is worthwhile including them.
* If re-using timbers, this should be stated so that this measure can be tested; currently, there is insufficient cases where this has been done to be able to examine success.
* Droppings should only be transferred from the colony for which the compensation is designed, to avoid the risk of transferring zoonoses between colonies.
* If seeding with old droppings, they should be placed where they are unlikely to obscure evidence of new droppings (e.g. not under the ridge beam if that is where bats are most likely to roost).

Timber-treatment

* Only approved products/application methods should be used for remedial timber treatment and pest control [[45]](#footnote-46) (this should also be checked for new treated timbers).

Fire doors

* + 1. Fire regulations require that larger roof voids are separated into sections with fireproof walls to prevent the spread of fire through the roof void. Such walls will prevent access to bats to all sections of a roof so, where required, need to take bats into account.
    2. Access can be provided using a bat door, bat flap or bat shutter, set to automatically close in the event of a fire and preserve the separation of the roof sections. The different options, with their advantages and disadvantages, are described in Bats in Traditional Buildings (English Heritage *et al*., 2009). The main disadvantage with several systems is the need for the doors to be re-set if there is a fire alarm or power-cut, which relies on human intervention. If there is no warning sign to alert staff that a door has been closed, or the doors are hard to access, there is a high likelihood they will remain closed, or at least not be re-opened promptly. A fail-safe is to ensure each section of the roof has its own access point, which will avoid bats being trapped whilst the doors remain closed (R. Crompton, pers. comm.).
    3. An alternative – a fusible link – only closes the doors in an actual fire, but may function a little late i.e. once the fire has taken hold sufficiently for temperatures have risen. There are several examples demonstrating how a fusible-link system has been implemented on BCT’s ROOST web-site[[46]](#footnote-47). A commercial bat hatch with door is also available[[47]](#footnote-48).
    4. Another option is an intumescent collar, made of a substance that swells as a result of [heat](https://en.wikipedia.org/wiki/Heat) exposure (the substance increases in [volume](https://en.wikipedia.org/wiki/Volume) whilst decreasing in [density](https://en.wikipedia.org/wiki/Density)). Again, this would only close the doors in an actual fire, which may be too late, but they were accepted by Building Control in a castle in Wales (R. Crompton, pers. comm.).
    5. It is important that any system proposed is appropriate for the type/level of building use and checked against the fire regulations in force at the time and buildings insurance conditions.

External environment

* Existing flight lines should be retained and, if necessary, enhanced.
* Roost entrances and commuting routes should not be lit. No new sources of lighting should be introduced.
* Existing lighting should be reviewed; it may be possible to modify its type, location, and timing and reduce any impacts this causes (enhancement).
  + 1. Where roosts cannot be retained and incorporating roost space within a new development is not possible, free-standing bat lofts are often provided. They structurally resemble a typical building and incorporate features as set out in the previous sections. The cost may be reduced or made more palatable by incorporating a duel function to the construction, such as a car-port or shed.
    2. Additional criteria for stand-alone (new) bat buildings are as follows:

Location and connectivity; external environment

* The replacement roost should normally be situated as close as possible to the roost to be lost.
* The location should be chosen to maximise the chances of the bats finding and adopting it. Ideally, it should be close to existing flight-lines and have an entrance close to appropriate habitat.
* External lighting should be avoided.
* Good quality foraging habitat including a source of permanent fresh water such as a stream, pond, river or lake is likely to increase adoption.

Orientation and construction materials

* Passive heating generally requires a broadly south-facing fairly steep roof pitch that isn’t shaded by other buildings or trees. Dark-coloured roof coverings, such as black slates, will help to produce higher temperatures. Natural slate has much better thermal properties than man-made slate, which does not heat up from insolation and also loses heat through radiation as well (R. Green, pers. comm.).
* An L-shaped structure will give more opportunities for different micro-climates.
* Temperatures should be monitored to ensure they achieve the right thermal regime given that the building will (in most cases) not be heated for human use but also (conversely) may experience extended periods of unusually high heat in summer due to climate change.
* Some species avoid concrete (Schofield, 2008); building (or rebuilding) with brick or stone is preferable. If it is necessary to build in block-work, internal walls should be rendered.
* A bespoke building may allow the construction of a cool room on the ground floor or basement (see Schofield, 2008 for guidance on decreasing solar gain and increasing humidity).

Sharing buildings with humans

* + 1. Schofield (2008) suggests a number of measures to ensure bats and humans can share a resource without conflict:
* locate roost entrances away from windows and doors;
* ensure flight-lines direct bats away from areas of human activity
* include insulation to reduce noise from human activities

Protection against vandalism

* The building should be made as resistant to damage by vandalism as possible. Doors can be reinforced and sited some way above ground level to make it difficult to damage them; rainwater goods can be carried internally; flammable materials that can be reached from ground level should be avoided.
* Planting thorny shrubs around the building may help to discourage trespass by making access difficult (these need to be maintained to ensure they don’t block access-points).
* Creating a water body immediately outside the (human) entrance can also act as a deterrent, if deep enough to require waders to access the roost.

Long-term security and management

* Arrangements must be in place for securing the long-term integrity, security and management of the replacement roost. This may require S106 planning agreements or the transfer of ownership of the building to a suitable organisation. Those agreements should consider restrictive covenants to control/prevent the later erection of external lighting and the maintenance of flight lines.
* Planting will need to be managed so access-points are not blocked; species used should be chosen to suit. Mitchell-Jones (2004) recommends coppiced species which can take regular management to avoid them growing above the building apex.

Other design guidance

* + 1. Design guidance (some more than ten years old, but still useful), on which some of the above is based, has been published as follows:
* **Lesser Horseshoe Bat Conservation Handbook** (Schofield, 2008): a comprehensive and practical guide to creating and enhancing roosts for lesser horseshoe bats, must of it also applicable to greater horseshoe bats.
* **Conserving Grey Long-Eared Bats in our Landscape:** a management plan (Razgour, et al., 2013) which includes recommendations for roosts as well as habitat management.
* **Biodiversity for Low and Zero Carbon Buildings: A Technical Guide for New Build** (Williams, 2010): includes advice, off-the-shelf product descriptions and architectural drawings to incorporate bats into new buildings whilst complying with carbon standards.
* **Bats in Traditional Buildings** (English Heritage, National Trust, Natural England, 2009): contains advice and techniques for those involved in building maintenance, adaptation or repairs, or owning/managing traditional buildings.
* **Bat roosts in the Alpine Area: guidelines for the renovation of buildings** (Reiter & Zahn, 2006) describes the roosting ecology of a range of species, and . collates knowledge and experience relating to the renovation of buildings. Note that species may behave differently to the way they do in the UK.
* **Ecology and conservation of bats in villages and towns**: (Simon, et al., 2004). Results of the scientific part of the testing and development project "*Creating a network of roost sites for bat species inhabiting human settlement*". This is a very comprehensive study which expended over 13,000 hours in identifying bat roosts over a single large district, identifying over 500 summer roosts and ringing over 20,000 individual bats (1997-2001), with recommendations based on those findings.
* **Recueil d’expériences des aménagements pour une meilleure cohabitation Chiroptères - Homme en milieu bâti. Tome 2.** (Arthur & Chretien, 2019) 9. A collection of projects to ameliorate conflicts between people and bats, with detailed photographs and plans. French language publication. Note that species may behave differently to the way they do in the UK.

Bat boxes as compensation for roost loss

* + 1. Conservation Evidenceprovide a synthesis of over 40 studies of bat box schemes[[48]](#footnote-49), looking specifically at uptake, use and design and location (though most are not from the UK, and include non-UK species). Some of the reported results were encouraging; others contradictory; however, the studies are a mixture of mitigation and enhancements, and cover a wide range of circumstances, not just replacements for building roosts. Some of the contradictions may result from a poor choice of model(s), poor siting/surrounding environments, or competition with other animals, notably birds. In other cases, bats may already have alternative roosts to go to (Stone, et al., 2015a), which they use in preference to artificial roosts, or indeed, the bat boxes may have been provided as enhancements rather than primary mitigation that was used in preference. Overall, the review rated ‘effectiveness’ of bat boxes as a tool to be 30% (highly effective would be 100% - see web-site for details).
    2. Lintott and Mathews, 2018 found that the provision of a bat loft as mitigation was usually more effective than the use of bat boxes at providing compensation for bats. Collins *et al.* (2020) found similar results, with 33% of bat lofts occupied compared to 20% of all bat boxes combined.
    3. These findings support the general consensus that bat boxes are inappropriate substitutes for significant roosts in buildings and do not constitute the ‘like-for-like replacement’ that the SCNBs require to maintain FCS. Bat boxes are also often neglected after a short period of time, can be removed or deteriorate, and are more vulnerable to vandalism. **Appendix 3** indicates circumstances where the use of boxes is likely to be accepted.
    4. Bat boxes are made by a number of manufacturers, and come in a wide variety of shapes, sizes and materials. They can be built-in, attached to a wall or tree, or free-standing. Collins *et al.* (2020) found that wall-mounted bat boxes were more successful than tree-mounted, wall integrated and internally-mounted bat boxes (17%, 15% and 13% occupied respectively). However, which type of box should be selected will depend on the target species, where it will be sited, whether there are any maintenance considerations, whether the box needs to be accessible for monitoring checks and so on. Error! Reference source not found. provides a list of design parameters set out by BCT as part of their partnership with manufacturers[[49]](#footnote-50). A further consideration is the quality of manufacture and the robustness of materials, especially for those parts that have a tendency to fail over time (doors, hinges and clips in particular).
    5. For species-specific preferences for individual box types, refer to Conservation Evidence for the latest research available[[50]](#footnote-51). Note that all of the studies necessarily focus on a small selection of box types and species in specific situations, so their findings need to be interpreted with that caveat.
    6. Competition with birds is cited by a number of studies, including Collins *et al*. (2020). Meddings *et al.* (2011) suggested that erecting bird boxes may help divert nesting activity away from bat boxes, but that was not supported by Dodds and Bilston, 2013). Choosing models which do not encourage access by birds is therefore more likely to improve effectiveness. Collins *et al.* (2020) found no evidence of birds in bat box designs where the access point apertures were ≤17 mm; box models with the highest bird presence featured access apertures at least 25mm wide.
    7. Lintott and Mathews (2018) found that increasing the number of boxes increased the probability of at least one being used. Although they state that, even when a large number of bat boxes was deployed (i.e. >20 boxes), the occupancy rate remained relatively low (fewer than 50% of boxes were used), the study was looking at compensation for building roost loss; higher rates may be expected where replacing roosts in trees. Occupancy overall is likely to vary over time and in response to different environmental conditions and may increase over time.

Box 6.1: Design Principles for bat boxes and access products

Crevice dwelling bats crawl into their roosts: the entrance slit should be at least 20mm (w) and ideally 13 – 17mm (h), maximum 25mm (h), to prevent bird access

Roughened vertical surfaces or landing areas allow better access for bats (by landing and crawling); horizontal landing perches should be avoided as these may even deter bats and can encourage birds to nest within the bat box

A vertical opening at the base of the box aids the expulsion of droppings, making the box self-cleaning and preventing a horizontal area being used by birds for nesting

Materials used should be non-toxic and present no risk of entanglement for bats

In addition, for wooden bat boxes:

The wood should be rough-sawn for grip and untreated

There should be no gaps where the sides and top join - the box should be well put together to prevent drafts

A box that cannot be opened is best - it will lessen the chances of the bats being harmed through becoming trapped under the opened lid, or disturbed by non-licensed people opening the box. For monitoring this can be done from beneath with a torch or by endoscope by a suitably experienced licensed person without the need to open the bat box

To increase longevity of the box, use screws rather than nails

Any screws, hardware or staples used must be exterior grade (galvanized, coated, stainless, etc)

* + 1. Siting boxes requires the same considerations as any other roost compensation; i.e. boxes should be erected in a sheltered location, in close proximity or with a strong unlit linear connection to good quality foraging habitat and preferably a source of permanent fresh water such as a stream, pond, river or lake is likely to increase adoption.
    2. For all types of boxes, Collins *et al.* (2020) found that the box height most frequently occupied was 4m (2020). A height of at least 3 metres is desirable to avoid interference, but the higher the box, the more difficult the access to clean/maintain and monitor.
    3. Boxes integrated into buildings offer much greater longevity but need to be considered in the design process. One study found that incorporating bat boxes into walls could cause cold spots on the interior, leading to condensation and possibly mould. They recommend additional insulation to prevent this; advice from an architect is advisable.
    4. Boxes erected on trees need to be fixed to allow for tree growth and to avoid damage to the tree supporting them, and should be sited away from public footpaths in case they fall (this will also minimise disturbance and interference).
    5. Providing a range of boxes of different sizes, types and/or materials (including multi-chambered options) and in different locations/aspects (particularly in terms of the amount of exposure to sun and shade) is likely to be increasingly important in the face of climate change. As noted above, over-heating in boxes has been reported; see also ‘the Goldilocks approach’ – providing multiple options so one is always ‘just right’[[51]](#footnote-52). This applies to boxes of all types, not just tree-mounted boxes. Boxes should be grouped to reduce day-time exposure to predators as bats move between them (the risk, however slight, might create an aversion to moving over larger distances).
    6. When boxes are erected, they should be numbered and a detailed plan should be made of each box’s location, together with details of its height, aspect and type.
    7. All boxes should be monitored, and detailed records kept against each box number. The monitoring, including responsibilities for repair and replacement, should be set out in a formal agreement between relevant parties. A partner, such as a local bat group or wildlife trust, should be secured (with a budget) to maintain and monitor the boxes in the longer term.

Non-traditional ‘boxes’

* + 1. In the USA, large crevice-type bat-boxes or ‘bat houses’ are successfully used by certain species as maternity roosts[[52]](#footnote-53).
* Collins *et al.* (2020) noted that a bespoke timber, unheated, American-style model supported an average of 48 bats/box, and was the only type to feature > 6 bats at any one time in their review (though this is not representative of bat box use generally). This model provided a large surface area-to-volume ratio and wide range of internal microclimates, and was installed following the exclusion of a soprano pipistrelle maternity colony directly behind one of the boxes.
* Richard Green Ecology describes two successful so-called ‘American’ style bat houses[[53]](#footnote-54) close to a site where a small number of soprano pipistrelles roosted. These were positioned adjacent to tree-lined rivers, in full sunlight and painted matt black, to maximise solar thermal gain. The mitigation was almost immediately successful, with bats recorded using both houses on the first monitoring visit. Subsequent visits also confirmed bats present in January when there was frost on the ground. Ten years later, piles of guano were found under the houses.
* A case study from Ireland is included in Appendix 2, where a bat box of this design was selected on the basis of previous successes elsewhere in Ireland.
  + 1. Another design is the so-called ‘rocket box’[[54]](#footnote-55), a tall, thin pole-mounted design successfully used in the US (Hoeh, et al., 2018).
    2. VWT have pioneered the Cathedine Night Roost[[55]](#footnote-56), a design on wheels which could be moved into different positions (and, as a temporary structure, does not require planning consent). This is a useful solution where a low-status roost is lost, and two VWT trials have proved successful; both were adopted fairly rapidly (within a few weeks), and one has been used by up to 30 individuals (A. Glover, pers. comm.). In both cases, the locations chosen were based on existing knowledge that the woodlands were/were likely to be foraging areas for the colony. However, this should not be considered an adequate replacement for a permanent structure because of their relatively short life-span.
    3. Small structures based around concrete drainage rings, with an internal baffle and upper chamber have been created in the Forest of Dean[[56]](#footnote-57). Radio-tracking data from an existing main roost site, habitat suitability assessments and future Forestry Plans were used to select locations which were considered likely to be the most useful to the bats and reduced chance of substantial disturbance. Monitoring shows they have been regularly used. These are substantial structures likely to have a long life-span, at relatively low cost.
    4. Including boxes like these in a mitigation scheme will generate useful information about their wider value as replacement roosts, if adequately monitored.
    5. Swift (2004) found heated bat boxes were the only type which came close to replicating conditions of roosts in buildings and therefore might be used by maternity colonies. They have been used with mixed results in review papers, as set out in Swift (2004), Mackintosh (2016) and Collins *et al.* (2020), though each study only examined five or six boxes. In these small samples, not all of the heaters could be confirmed as working, not all of the boxes were located in or adjacent to suitable commuting or foraging habitat and some were affected by artifical lighting. These issues obscure the likely value of heated bat boxes if placed in optimal conditions, and more case studies are needed.
* ERAP described a larger heated roost (somewhere between a heated bat box and a small bat house) at Boot Station, Ravenglass and Eskdale Railway, Cumbria[[57]](#footnote-58), successfully adopted by an excluded maternity colony of common pipistrelles.
* The Kingfishers Bridge nature reserve provides a summer roost for bats in a sheltered spot attractive to flying insects. This bat house has a solar radiator which heats water, which in turn heats bricks within the house to maintain consistently warm temperatures both day and night.
  + 1. As for roosts integrated into buildings, the use of heating in bat boxes is often not recommended due to unpredictability around management, the potential fire hazard, the cost of electricity, the risk to dependent bat roosts if heating fails and so on. However, there may be circumstances where the benefits outweigh the risks (or the risks can be adequately managed).

Bespoke designs within properties

* + 1. Large colonies can be problematic and one possible solution is to allow bats continued access to one or more of their roost sites, but restricting their access within a property. Early attempts have had mixed success according to a limited review (Bat Conservation Trust, 2006) which recommended:
* It must be possible to prevent access to any other part of the roof. All gaps of 6mm or over must be blocked, since it has been shown that bats can gain entry through any gap of this size. It is important, however, to ensure that measures taken do not conflict with the ventilation requirements of the roof.
* The temperature within the box should be at least that within the existing roost spaces; an additional source of heat may be required.
* The entrance should be designed to be similar to the existing one, and should be composed of suitable rough(ened) material.
* The size of the box should be adequate to accommodate the species and the number of bats roosting.
* Construction of the box should be done outside the season in which bats normally occupy the roost (i.e. usually during November to March).
* The position of the box should be within part of the roof already used for roosting.
  + 1. The pilot study for the Bats in Churches project in England tested the concept by providing a large artificial roost built into the church interior for soprano pipistrelles57, with the following features:
* original bat access route to interior retained;
* new roosting space provided, which also blocked access to the rest of the church interior
* the access route was on cold north side, but the original roost was on the warm south side, so the temperature difference was compensated for with a heat mat in the artificial roost, and a temperature gradient created;
* a range of different niches were provided within the artificial roost, mimicking those of the original roost site (horizontal slots, vertical slots, forward & backward-facing ‘wedges’, loft space)
* the box was ‘seeded’ with powdered droppings from the church roost;
* the artificial roost was installed after emergence in early May, i.e. in the pre-maternity period.
  + 1. The maternity roost was successfully excluded from church interior (despite being a very ‘bat-porous’ building), and retaining the original roost access meant bats quickly found way into the artificial roost. As with many examples presented in this document, uptake was gradual; bats started to visit/investigate the artificial roost, then night-roosted, then small numbers day-roosted, and so on. This was only part of the mitigation strategy; nonetheless, the early signs were encouraging. Of interest is that olfactory cues appeared to be very important (infra-red cameras recorded many hours of footage of bats sniffing the roost entrance) – which perhaps gives an insight into how bats adopt new provision.
  1. Mitigating tree roost loss
     1. The different roosting habitat of bats and the difficulty of locating roosts in trees requires separate consideration from roosts in buildings. The Bat Tree Habitat Key[[58]](#footnote-59) describes species-specific roost requirements and is under continual review. The survey and assessment of trees is covered by Collins (2016) and is under review at the time of writing. This material is not repeated here.
     2. This section assumes that the necessary surveys have been undertaken, the value of the tree resource has been established, an impact assessment has been undertaken, and consent is in place for removing the trees that are to be felled. The aim of this section is to provide guidance on **mitigating the impacts of tree-felling**, both during the felling process itself and for roost loss.

Pre-construction tree inspections

* + 1. Where trees are to be felled, a variety of inspection and survey techniques can be used to establish the likelihood of a roost being present at the time of felling and, if so, what type of roost it is. Figure 6.1 below shows the decision-making flowchart for felling a tree.
    2. For simplicity, this flow-chart does not refer to licensing though **felling a roost or obstructing access to a roost would require a licence** to be in place.
    3. It also does not specify how many emergence or return surveys or repeat inspections are required, as this will be determined by the survey results. Visual aids such as infra-red or thermal cameras are strongly recommended.

Figure 6.1: Flow-chart for inspections and felling [*see caveats in paras 6.4.2 et seq regarding the surveys and assessment that need to take place prior to this point*.]



Note: the prescription against fitting exclusion devices between mid-May to mid-August does not need to be enforced where it is certain that a roost feature does *not* contain pregnant females or non-volant young.

Removing trees with PRFs where the absence of bats is not confirmed

* + 1. When managing or removing trees with PRFs, it may be necessary to employ reasonable avoidance measures to reduce the likelihood of killing or injuring bats. These measures should only be used once all survey options have been exhausted, as they are time-consuming, costly and put the arborist at increased risk. The most widely used avoidance measure is section-felling.
    2. Section-felling involves removing parts of the tree in sequence rather than the tree being felled in one. This technique is usually employed in arboriculture when there is insufficient space to fell a tree in one operation, or to reduce the risk of people or property being harmed or damaged during the operation.
    3. Section-felling is a complex task and requires the arborist to undergo additional training. Before specifying this type of avoidance measure, it is important to discuss with the arborist who will undertake the work, what is safe and feasible for the tree in question. It should not be assumed that the same approach can be used for all trees. When recommending the use of section-felling, the ecologist should be clear what objectives they are trying to achieve and whether section-felling is the best solution. It should not be used to make up for poor survey data.
    4. A more detailed consideration of the practicalities and pitfalls of the section-felling technique is provided by Mulholland (2015).  This article also describes the practice of translocating tree sections, discussed further below. The Arboricultural Association have a series of Technical Guides that provide guidance on a range of topics, including Rigging (the lowering of tree parts during the process of section-felling), Crane Use in Tree Work and MEWP Use in Tree Work. The arborist should follow guidance in these documents when planning the work.

Blocking PRFs

* + 1. Where the absence of bats is confirmed, PRFs can be filled or blocked to prevent bats gaining access. The choice of materials will depend on whether the block is required to be permanent (i.e. the PRF or roost is certain to be removed) or temporary (for example, there is some doubt over whether a particular tree will be felled on the boundary of an area which is covered by all necessary consents to fell).
    2. Removable materials include sticks (for simple holes), rags or upholstery foam blocks. Sticks will need shaping to fit but have the advantage of being natural and unobtrusive (mimicking a dead branch once in place). Blocks must remain fully in place; if they are dislodged, the PRF will need to be re-inspected. Permanent materials include expanding polyurethane foam, but this is not recommended as it is difficult to use and adversely affects climbing equipment.
    3. Where trees may have more than one PRF, the best course of action for each may differ within the same tree.
    4. The decision to block PRFs from which an absence of bats has been confirmed, prior to consents/licences having been obtained, is controversial. BCT have released a Position Statement[[59]](#footnote-60) noting that pre-emptive blocking of PRFs, when carried out significantly in advance of confirmed operations is poor practice, and on a case-by-case should be scrutinised for the appropriateness of the approach.
    5. If blocking a PRF is justifiable, then precautionary mitigation to ensure ‘no net loss’ should be put in place at the time of the blocking.

Compensation for loss of tree roosts

Bat boxes

* + 1. Loss of tree roosts can be compensated by provision of bat boxes, provided that:
* the species that are displaced from the lost tree roosts readily use bat boxes;
* the boxes selected are of a suitable type for the species concerned;
* they are located appropriately;
* monitoring is adequately resourced to ensure longer-term maintenance, repair and replacement.
  + 1. That said, bat boxes are not always suitable, and may only provide partial compensation, particularly for rarer species (see Chapter 9 for determining mitigation ‘success’). Lintott and Mathews (2018) and Collins *et al.* (2020) both found that, where bats were present in bat boxes, the overwhelming majority were identified as *Pipistrellus* species.
    2. The use of bat boxes should therefore not be used to justify the removal of mature trees, as they will not be able to provide the same robust long-lived roosting opportunities as trees supporting features such as woodpecker holes. A broader mitigation strategy that retains such trees, and considers the future roost resource (a younger pool of trees that will develop such features in the longer term) is required for species that are woodland specialists to be maintained. Bat boxes cannot provide the same level of long-term opportunity, particularly since their longer-term maintenance, repair and replacement is hard to secure. It is important therefore that the roost compensation strategy provides compensation for the entire roost resource affected (current and future roost potential), and not just for confirmed roosts.
    3. There are limited circumstances where they are appropriate as the primary means of compensating roost loss (see **Appendix 3**). However, they can be a useful ‘interim’ solution, provided as an alternative roost resource as new plantings mature, and/or as a ‘safe haven’ to place bats found during tree-felling works, out of the reach of harm.
    4. Where there is an abundance of natural roost opportunities for a target species, it is possible that additional artificial roost sites will be ignored (though not necessarily by all species). For example, at Bernwood Forest, Buckinghamshire, numerous bat boxes are used by Natterer’s and brown long-eared bats but not by Bechstein’s bats (though they do use boxes in other sites), and no purpose would be served in this location by replacing Bechstein’s bat roost trees that are to be lost with additional boxes. Resources would be better directed to other measures that might have greater benefit to bats, for instance introducing nocturnal insect-friendly planting.
    5. Consideration should be given to tree growth and boxes may need rehanging over time. Headless or domed nails not fully hammered home should be used to allow for tree growth. Aluminium alloy nails are less likely to damage saws and chipping machinery.
    6. Other considerations for bat boxes are covered in paras **6.3.38** *et seq*.

Veteranisation

* + 1. It’s clear that the natural development of hollows within newly planted trees will not occur fast enough to offset the ongoing loss of mature trees caused by activities such as land clearing for agriculture, logging, and urban expansion (Griffiths, et al., 2020). Veteranisation is a tool to help speed up the processes of habitat development that normally take many decades. It should not be used on trees that support or are developing value, nor where safety may become an issue, such as in parks or towns (Bengtsson, et al., 2012). However, where appropriate, it can be used to increase the amount of potential habitats that can be used by bats and other species.
    2. Veteranisation techniques mimic the effects of the natural tree ageing process and decay, as well as events such as lighting strike/storms and damage caused by deer, grey squirrels, and woodpeckers. Bengtsson *et al.* (2012) have set up a trial of five veteranisation methods (not all of which are designed to create roost features for bats): Treatment one - nest box in a living oak; Treatment two - woodpecker hole; Treatment three – ‘horse damage’ to the trunk; Treatment four - a broken branch; Treatment five – ringbarking a branch. The project is being monitored in the long-term (over 25 years) but is already showing promising results in relation to bats (V. Bengtsson, pers. comm.); data from 2020 yet to be published.
    3. Temperature may be one factor in the success of features created through veteranisation. Griffiths *et al.* (2018) compared the thermal profiles of natural tree hollows with three types of artificial hollows; designed for small marsupial gliders and tree-roosting insectivorous bats: (1) ‘chainsaw hollows’ carved directly into the trunks and branches of live trees; (2) ‘log hollows’; and (3) plywood nest boxes. Chainsaw hollows had thermal profiles that were similar to natural tree hollows: they were consistently warmer than ambient conditions at night, while remaining cooler than ambient during the day. In contrast, glider and bat boxes had the opposite pattern of heating and cooling, being slightly cooler than ambient at night and substantially hotter during the day. Glider log hollows had greater variation in internal temperatures compared to natural hollows and chainsaw hollows, but fluctuated less than glider boxes. The cavities generated by veteranisation therefore had better capacity for buffering their occupants from temperature extremes.
    4. Similar results were found in relation to humidity (Maziarz, et al., 2017) i.e. relative humidity is higher in tree cavities than in nest-boxes, indicating that nest-boxes cannot be treated as a direct substitute for tree cavities.
    5. If veteranisation may be an appropriate option for a development (in combination with other techniques), the involvement of an arborist is essential. It is important to use a practitioner that understands tree physiology and can create features which are very close to natural features, rather than simply cutting a ‘bat box’ into a tree.
    6. There is a distinction between creating instant features and those that will develop over time, and each has its role to play. Instant features provide short-term (perhaps 2-5 year) habitat that is created by cutting the feature required into the tree; these will change over time as the tree continues to grow. Future features are created by wounding the tree in such a way that the woundwood response will create the desired feature in the medium term (2-5 years). This is where the arboricultural expertise is required.

Translocation of limbs

* + 1. Translocation of bat roosting features from one tree to another has been undertaken on rare occasions. Key aspects to consider are outlined in Mullholland (2015) and summarised as follows:
* are there suitable trees nearby on which the feature can be erected?
* can the translocated limb be safely attached; will it stay safe in the longer term, allowing tree-safety inspections to be properly conducted?
* will the section have sufficient life left to merit translocation, or will it decay quickly and/or affect the host tree adversely?
* would other mitigation/ compensation measures be more practical, longer-lived or more effective?
  + 1. Mullholland (2015; Figure 2) shows a re-erected feature and bat boxes; monitoring has shown that the boxes have been used as frequently as the feature (though not necessarily by the same species) and are considered likely to last longer.
    2. In 2011, an ash tree known to support a large noctule roost was accidentally felled out of safety concerns. The felled trunk was reinstated against the nearest suitable tree (another ash), using a high-lift and straps. The mitigation was shown to work in the short term, and allowed the noctule colony time to adapt to alternative roosts in woodpecker holes within the woodland (Damant & Dickins, 2013). Informal monitoring indicated the bats were still using the translocated limb in 2017 demonstrating success[[60]](#footnote-61). Elmeros *et al.* (2016) notes that this is ‘the only successful example’ despite providing photographs of other translocated limbs.
    3. In summary: limb translocation can be expensive and difficult; increases the risk of recipient tree-failure; some locations would create a hazard (e.g. hanging a section of deadwood in the crown); and is likely to provide short-lived benefits, including limited uptake by bats. However, it may be useful in a limited set of circumstances where rapid response is required (i.e. not as a planned mitigation tool).
    4. The principles of translocation (assuming the key aspects above have been satisfactorily addressed) are:
* the height and aspect of the roost feature should be replicated as closely as possible;
* the top end of the limb should be protected against the elements by capping it with timber or roofing felt, to slow down the onset of wood decay;
* the translocated limb must be securely attached to the receptor tree by means that will not compromise tree health, and in a safe location not used by the public;
* the attachment should be adjustable and re-inspected on a regular basis. Current guidance for cable bracing in trees (the closest thing with which to compare) indicates an annual inspection from the ground and a 5-yearly aerial inspection.
  + 1. As with other ‘new’ roosts, finding the translocated limb may be a factor in success.

Standing dead trees (monoliths)

* + 1. Unsafe, dying and dead trees can be retained as habitat for wildlife, after making them stable, if they would otherwise be felled. This can be achieved by removing some or all of the main branches and/or shortening the stem over time. Whilst the retention of standing deadwood is considered good ecological practice[[61]](#footnote-62),[[62]](#footnote-63), its value for roosting bats is limited to roosts that are low enough to be retained safely. Data on roosting heights (Bat Tree Habitat Key , 2018) indicates that most roosts below 5m are occupied by small numbers of bats (1-4 bats) during the spring flux, autumn flux or winter period, whereas maternity roosts are generally found between 5-10m.
    2. The action of removing branches and/or shortening the stem will increase dysfunction, accelerating rates of decay and altering the internal conditions of features (temperature, humidity, size of cavity). These changes, over-time, will make the feature unsuitable for roosting.
    3. In summary, for bats, this approach may provide a short-term fix for roosts that are low enough to be safely retained. Arboricultural advice should be sought to ensure the tree is (or can be made) adequately safe, and is subject to periodic inspection, since the decaying stem and decayed roots may mean that tree itself become hazardous over time.

BrandenBark[[63]](#footnote-64)

* + 1. BrandenBark™ is an artificial bark used as a long-term mitigation/habitat enhancement tool, specifically designed for bark-roosting bats in the US. BrandenBark™ roosts have been regularly monitored, and the company which developed this material (Copperhead Environmental Consulting, Inc.) have reported impressive results. BrandenBark™ roosts provide roost temperatures similar to that found under natural bark, are adopted rapidly, used by large numbers of bats (including the rare Indiana bat), require little to no maintenance, and are easy to monitor.
    2. The cost to purchase and ship BrandenBark™ is much higher than a single traditional bat box, but this approach could be tested on projects that affect tree-roosting bats with a preference for lifted bark (notably barbastelle), particularly if alternative roosts are in short supply. Rocket-boxes may be an alternative (see para6.3.52).
  1. Mitigating the impacts of bats in churches
     1. Many medieval churches are used by bats, and occasionally there are conflicts between the desire to keep bats in a church and the needs of the congregation, or when repair work is required. The aim should always be to retain bats within a church (they are often reliant on what can be a limiting resource), but practical solutions are only now being developed and tested. Following a pilot project (Zeale, et al., 2014), the ‘Bats in Churches’ project[[64]](#footnote-65) is currently studying issues and solutions in 100 churches across England.
     2. Issues include droppings and urine, resulting in additional cleaning and sometimes damage to artefacts. These can be particularly challenging where the bat colony is large and/or the congregation small. Solutions being tested include: the use of deterrents and the provision of alternative or restricted artificial roosts.
     3. As solutions are currently being tested and modified, this section of the Mitigation Guidelines will be completed during a subsequent revision. More information is available on the BCT website[[65]](#footnote-66), including how and where to get help and advice, practical solutions to issues around bats in churches, and a limited number of case studies[[66]](#footnote-67).
  2. Working around bats in bridges and tunnels (remedial work)
     1. Bats roost in many different locations within old and new bridges, including any holes, cracks and crevices leading to voids. Roosting locations in which bats have been recorded in bridges include expansion joints; gaps at the corner of buttresses; widening gaps; cracks and crevices between stonework and brickwork where mortar has fallen out; drainage pipes and ducts; and internal voids within box girder bridges. There are often good opportunities where bridges have been widened, at the interface of different materials between the old and new elements.
     2. There are similarities between bridges and tunnels, notably that it can be difficult to assess the use that bats are making of this type of structure. They are infrequently used as maternity sites as they often do not provide warm stable conditions. There are exceptions; for example, where a cavity is directly behind an unshaded south-facing surface. They may be used as pre-hibernation or hibernation roosts (which makes it is harder to establish use) or swarming sites (see **Section 6.7**).
     3. For these reasons, bridge and tunnel repairs can be difficult to plan and manage cost-effectively. This is particularly true if access requires specific equipment (such as a boat, scaffolding, or a mobile elevating work platform (MEWP)), training (confined spaces), permits, and/or road or rail closures, any of which can prevent close inspection. Larger bridges can be difficult to view effectively, and potential emergences can be confused with commuting/foraging bats, particularly over water, and for late-emerging species. Visual aids such as infra-red or thermal cameras are recommended.
     4. Timing the works is key to avoiding impacts. If a bridge has cavities that might be suitable for hibernation and the presence of bats cannot be ruled out, it is preferable to undertake works in the bats’ active season (assuming a breeding roost is not present). If non-breeding roosts are present aside of the hibernation season, they may need to be temporarily excluded from the site of the works.
     5. The impacts of construction lighting need to be considered, particularly for structures on the road and rail network, where night-working is often required to avoid daytime transport disruptions.
     6. It is therefore important to establish, as far as possible, both the likely seasonal value of the bridge to bats *and* the likely extent of any work that might affect bats to determine the approach to mitigation.
     7. Not all works require the presence of bats to be confirmed. For example, when pinning bridges to provide stability (a process which creates a short-lived and fairly limited amount of disruption), it may be sufficient to ensure that bats are absent from the trace of the pins (R. Crompton, pers. comm.) rather than from the whole bridge. This avoidance approach minimises the extent of survey work required and reduces seasonal constraints.
     8. The possibility of avoiding/minimising the extent of works that affects cavities where use by bats cannot be ruled out should also be explored (though may not be possible for safety reasons).
     9. If cavities or other roosting opportunities will be lost, they will need to be compensated. Permanent features integrated into the non-structural elements of bridges are preferable. These generally take the form of bat bricks, but occasionally it is possible to build in larger chambers. It is important that the flightpath from such replacement roosts does not result in a vehicle collision risk.
  3. Working around bats using swarming sites
     1. The potential for a mine, cave or tunnel to be an autumn swarming site is recognised, but the potential for other types of site to support swarming bats, and at times outside of autumn (see Table 6.1), is less often considered when determining survey effort, which may lead to important swarming sites being missed. Less obvious swarming sites include castles, stately homes and large barns. Mass swarming events of common pipistrelle bats in the autumn (followed by mass hibernation in a diverse range of building types in urban environments) has been seen in the Netherlands (Korsten, et al., 2016), and although there are anecdotal reports this has not yet been recorded in the UK.
     2. Where a swarming site is identified, the most important part of any mitigation approach will be timing the works, but design modifications may also be needed to safeguard the site. As swarming sites differ, a bespoke approach is likely to be required[[67]](#footnote-68).
  4. Mitigation for the loss of hibernation sites
     1. Hibernation preferences differ between species: according to (Dietz & Kiefer, 2016.), common pipistrelle and noctule are found in frost-sensitive crevices outside the entrances of caves; just inside are the cold-hardy species (long-eared bats, barbastelle, serotine). Small *Myotis* are found further into a cave, in the middle zone; larger *Myotis* and horseshoe bats in the climatically stable deep zone, at around 7-9°C. Larger hibernation sites would therefore be needed to encompass the temperature preference of different species (though other factors such as geology and airflow are involved in creating ideal conditions for particular species).
     2. Creating successful artificial hibernation sites for bats is challenging, requiring the correct air-flow, an optimal temperature range buffered against external conditions and high humidity. Most failures are due to too higher movement of air through the structure, which leads to low humidity. However, there have also been many examples of successful projects26.
     3. Guidance on all aspects of the conservation and management of underground sites used by bats is given in Eurobats Publication No. 2 (Mitchell-Jones, et al., 2007). In addition to protecting and maintaining sites (legally and physically), there is a short section on creating sites for use by hibernating bats. Whilst this draws heavily on The Bat Workers’ Manual (Mitchell-Jones & McLeish, 2004), there are further examples from Wiltshire (UK) and Portugal. The former is a disused railway tunnel and the latter a bespoke design (broad details provided).
     4. Two further UK examples include hibernacula built at Kingfisher Bridge, Cambridgeshire[[68]](#footnote-69) and Two-Mile Bottom, Suffolk[[69]](#footnote-70). The Kingfisher Bridge ‘cave’ (overall dimensions 2 m x 2 m x 30 m long) is a trench dug into the underlying limestone with a pre-cast concrete roof containing elongated bat bricks (constructed 2004). The door (steel and oak boards) restrict access of predators and humans; slots at the top of the door allow bats to enter; fine wire mesh on the bottom of the door allows air flow. The cave is used by brown long-eared bats and Natterer’s bats each winter, either attached to the cave roof or in between the concrete cave roof sections.
     5. The Two-Mile Bottom site was also completed in 2004, and consists of a 95 m long ‘Y’ shaped concrete block tunnel with an access grille, ventilation pipes and bat bricks built into the ceiling. Hanging planks and logs with slots cut into them were included. Although there was a slow start to bat occupation (one bat in 2007), by 2013 over 60 hibernating bats of four species were recorded.
     6. Eurobats has collated a number of other examples, some with plans, from across Europe. Currently only a draft report is publicly available, shortly to be updated26.
     7. If a replacement hibernaculum is required, the guidance and examples cited above collectively are a good source of advice on location and design considerations, as well as costs, potential pitfalls and longer-term management.
  5. Avoiding killing/injury to bats in roosts

Exclusion of bats from roosts prior to works

* + 1. This section applies to all types of roosts, and needs to be carried out under licence where a roost has been identified.
    2. Bats can be excluded from a roost by blocking the access points once all bats have been recorded leaving and preventing their return. For this to be successful, all of the roost access points must be known and there must be confidence that all bats have emerged to avoid entrapment (this is easier for species such as horseshoe bats). Works during the maternity period should be avoided to avoid trapping non-flying young. This type of exclusion (where bats need to be monitored as they leave) can only be undertaken during the bats’ active period.
    3. Where it is not possible to be certain all bats have left a roost, exclusion devices will be required. These allow bats to exit but not return and come in a variety of forms. SNH (now NatureScot, 2018) have produced a comprehensive report[[70]](#footnote-71) giving several different examples of devices in place, and detailed instructions.

Timing

* + 1. SNH state that exclusion devices must only be fitted in April or during September to October, when bats are active because this is the optimum time to maximise the likelihood of success. These short periods are defined to avoid the periods when bats are either heavily pregnant, have dependent young or are hibernating.
    2. It is SNH’s view that, if an exclusion device was fitted during winter, it would still need to remain in place until April and, because it would be affected by the weather it would require more monitoring and maintenance to ensure that it had not moved or become dislodged. It is therefore unlikely that any licence to exclude bats outside of the periods stated above would be granted in Scotland.
    3. In England (K. Walsh, pers. comm.) the presumption against fitting exclusion devices from May to October is only routinely applied to maternity roosts. Natural England would not permit the fitting of exclusion devices in winter, but there may be circumstances where devices fitted before winter remain on a structure during the winter. In southern parts of the country it may be acceptable to install exclusion devices in March (depending on conditions).

Duration

* + 1. Advice on the length of time that exclusion devices should be left varies across the UK, presumably related to differences in average weather conditions at different latitudes. SNH state that, as bats do not always leave the roost every night to feed (e.g. due to cold temperatures, heavy rain or winds), their licences require that an exclusion is left in place for at least 14 days to be confident that all bats have left the roost before access points are sealed. They expect this period to be extended if the weather has been unusually cold and/or wet for much of that time, which means that weather conditions need to be monitored. In Northern Ireland, a period of ten days is usually specified, at least for domestic exclusions.
    2. Shorter periods have been accepted on licences issued in England, and in letters issued via the Bat Helpline (the latter largely the householders): a minimum period for each device of at least seven consecutive nights throughout a spell of suitable weather conditions (i.e. conditions in which bats would be foraging). In colder weather this period should be extended to two weeks, and there should be at least three consecutive days in those two weeks with no ground frost. Exclusions should not be attempted when heavily pregnant females, dependent young or hibernating bats are present.
    3. Once the exclusion has been effected, the exclusion device(s) should be replaced with permanent exclusion measures to ensure re-occupation does not occur. If this is not possible for a roost space that is being removed, the exclusion device should be left in place, but such devices may be less secure. If there is any doubt as to whether bats may still be present, an inspection of the relevant areas should be carried out where practicable and safe to do so, either directly or using endoscopes etc (dependent on structure and species).

Caveats

* + 1. Note that it has previously suggested that leaving lights on (or bringing in mobile lighting) might help to exclude bats from roosts prior to works. However, this technique can have the reverse effect, discouraging bats from emerging, giving the impression that they have left the roost when they are in fact ‘entombed’, and therefore it cannot be advocated. See Zeale *et al*. 2014 for an example which suggests that this is a behavioural response that is shared among *Myotis* spp. It’s not clear if other species are affected in the same way, but the technique is best avoided and indeed is highly unlikely to be licensed.

Bat capture

* + 1. Occasionally, it may be necessary to capture and relocate bats (assuming that the licence allows, and that the species to be captured are included on that licence, unless bats are in imminent danger of injury). The following assumes that weather conditions are suitable for bats to be active (see following section for adverse weather).
    2. Bats should be captured by gloved hand or hand-held net, given a health check and then placed carefully inside a draw-string, calico cloth holding bag or similar for transport (one bat per bag). The bag should be suspended. Captured bats must be:
* relocated to a suitable roosting feature for the species; or
* released on site at dusk into suitable foraging / commuting habitat in safe areas that are close to the site of capture.
  + 1. When weather conditions are less suitable and bats may go into torpor, it may be necessary to temporarily hold bats prior to release under more suitable conditions.

Bats discovered unexpectedly (under licence)

* Works must stop immediately. If the named ecologist[[71]](#footnote-72) or an accredited agent is not present, they must be contacted immediately to attend site.
* The bat must not be exposed or ‘encouraged’ to fly out of the roost of its own accord. It should be left undisturbed unless this would be unsafe.
* Unless it is in immediate danger, the bat must only be handled by the named ecologist, accredited agent or an assistant. If there is a suitable alternative roosting location on site then, assuming the bat is checked and in good health, it should be placed there to minimise stress and holding time. If not, it must be carefully placed in a lidded ventilated box with a piece of clean cloth and a small shallow container with some wetted cotton wool. The box must be kept in a safe, quiet location.
* The named ecologist, accredited agent or assistant must re-assess the location where the bat was found and determine whether works can continue under the licence in force, whether further survey is required, and/or whether a modification to the licence is required before works re-commence. A written record must be kept of this decision and made available to the relevant SNCB or any police officer on request. This incident must also be reported on the licence return form.
* If capture and relocation is already included on the licence, then details of suitable carer(s) will have been included as part of that licence for bats that cannot immediately be released. If not, and no carers are known, the National Bat Helpline (0345 1300 228) should be called to be put in contact with a bat carer or, where there are none, then a local wildlife rescue centre or vet may take the bat.

Additional considerations in adverse weather conditions

* + 1. If individual bats are discovered unexpectedly during periods of adverse weather, then following steps must be taken:
* If the bat is in torpor, care must be taken to avoid rousing the bat during transfer to a suitable location, which may be a suitable hibernation box or another alternative roost that provides a quiet environment with a stable, suitable temperature and relatively high humidity, safe from further disturbance.
* Any underweight or injured bats must be taken into temporary care by an experienced bat carer and looked after until such time that the bat can be transferred to a suitable replacement roost at or close to the same site, and/or weather conditions are suitable for release at the same site.
  1. Non-licensable method statements
     1. Natural England (2013) states:

“...A licence is not always necessary. Natural England advocates the use of good practice and avoidance measures to minimise the impact of a proposed activity on wildlife, and in particular EPS, to avoid committing offences. Licensing should be seen as the last resort where all other alternative ways of avoiding impacts on the species have been discounted.”

* + 1. The need for a licence may be avoided through appropriate timing (see **Section 6.2**).
    2. Another example where a non-licensable approach to works can be adopted includes buildings of ‘low potential’ with no evidence of use, but where the presence of a bat (or very low numbers of bats) cannot be ruled out even where the requisite number of surveys have been completed. In these circumstances, a precautionary approach to design and construction methods is sensible.
    3. If such an approach is recommended, then a precautionary working method statement[[72]](#footnote-73) (PWMS) should be produced, and the reasons why a non-licensable approach is recommended should be documented. **Box 6.2** outlines what a PWMS should include, and a more detailed template is set out in **Appendix 2.0**.
    4. The use of a PWMS documents the thought process behind any decision not to apply for a licence, and demonstrates that (and how) risks were minimised. However, the failure of the client, or anyone working under the client’s direction, to follow the method statement may result in a breach of the law and leave the client or others open to prosecution.
    5. It is helpful, therefore, to ensure that all parties understand the PWMS and how, when and where it will be applied, and physically sign up to the document as evidence of that commitment.
    6. Where a bat is found unexpectedly and not covered by a licence, then Natural England’s Licensing Team advise that all work must stop and an ecologist should advise on the most appropriate course of action (it is not Natural England’s role to advise on all of these situations). This would depend on the exact circumstances and the ecologist on the ground would be best placed to make a judgement call. For example, it may be appropriate for the bat’s welfare to remove it; or conversely to re-instate the roost.
    7. If a bat is unexpectedly found, then it is possible that this will result in delays to avoid a breach of the law. The Bat Mitigation Class Licence (BMCL) allows for many of these situations to be resolved relatively swiftly, but only applies in England. Note that if a roost has already been destroyed, then the law will already have been broken and there would be no reason to apply for a licence.
    8. However if urgent consultation is required, for example where it is an emergency situation (ref emergency works below), then the country licensing team should be contacted.

Emergency Works

* + 1. Some emergency operations where there is an immediate danger to the public can be undertaken outside of licensing. Natural England’s view, for example, is that immediate danger

“should reasonably be interpreted to mean that the structure or tree will fail or collapse, and is at risk of harming the public, within a short timescale (e.g. hours or days rather than weeks) and thus gives little scope for obtaining a licence”.

* + 1. In these cases, all possible measures should be employed to minimise damage and disturbance to bats. Natural England provide further guidance on the approach for emergency operations (Natural England, 2013), which include:
* informing the police that an offence is about to be committed (or has been committed by exposing a roost, and works need to continue)
* ensuring detailed written records of all planning/survey work undertaken to demonstrate good practice (this will strengthen the case for the actions being ‘reasonable’)
* ensure that appropriately qualified persons plan and carry out the work to minimise ecological impacts
  + 1. Ideally, suitable compensation for any impacts would be agreed with the police (and preferably the SNCB) prior to works commencing.

Box 6.2: PWMS and tool-box talk contents

Outline technical contents of a PWMS

Site details, responsible parties, summary of proposals, planning status, relevant legislation; justification that licence is not required

Site and survey information relevant to the activities covered by the PWMS, supported by maps and photographs

impact assessment as relevant to subject of PWMS, supported by maps and photographs

Mitigation, compensation and enhancement strategy, to include details of each of the measures to be employed

Supporting materials such as toolbox-talks and signage

Emergency provisions

Proposals and responsibilities for monitoring and management/after care

Programme

Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided.

Outline contents of a toolbox-talk

Best practice and reasonable avoidance measures to prevent killing/injury during construction should include, as relevant:

the activities that require supervision by a licensed bat worker

how to recognise a bat; what to do if a bat is found during work (notably for unexpected discoveries when a licensed bat worker is not present)

methods to minimise killing and injury (e.g. removing roof tiles by lifting not sliding to avoid injuring bats that may be underneath and checked on their underside prior to stacking/disposal to ensure no bats are clinging to the underside)

methods to minimise disturbance (including timing restrictions)

lighting restrictions

legislation (setting out how bats are protected, penalties)

1. Mitigation and compensation: habitat loss, degradation and fragmentation
   1. Introduction
      1. This section describes methods used to mitigate (or compensate for) impacts to bat habitat, following the mitigation hierarchy. In line with the aim to avoid repetition, where standard recent texts are available, these are signposted not condensed. Only a brief summary of what each text covers is provided, to direct consultants to appropriate resources.
      2. As for the previous chapter, obvious methods to avoid impacts such as leaving a commuting corridor or important area intact by changing an element of a design that would have removed or degraded it are not described here but should always be considered first. The involvement of an ecologist at an early stage is always advisable, as the many factors that could affect habitat quality (as well as habitat loss) may not be readily apparent to the design team.
      3. As in the previous chapter, timing is an important tool in avoiding or reducing impacts, and the same periods of vulnerability apply. When assessing impacts, the focus is often on avoidance during the bat active season, but note that bats are not dormant throughout the entire hibernation season, and rely on habitats close to their winter roosts.
   2. Mitigating habitat loss and degradation
      1. Habitats may be lost temporarily or permanently, directly or indirectly, as outlined in **Chapter 4.0**). While these factors dictate the *extent* and *duration* of mitigation required, the principles are the same. Understanding a species’ ecology is key to the design and implementation of habitat provision for specific impacts, though more than one species or species group may benefit.
      2. Such habitat provision will also contribute to net gain (as mandated in the [forthcoming] Environment Act [2021] in England), and BCT have recently (2020) published Good Practice Principles for Biodiversity Net Gain with a focus on bats and their Core Sustenance Zones[[73]](#footnote-74).
      3. EUROBATS (Kyheroinen, et al., 2019) has recently published guidance on the conservation and management of critical feeding areas and commuting routes for bats. It includes general management principles for the protection and enhancement of woodland, waterbodies, agricultural landscape, urban areas/ parks and linear features, and details successful case studies of habitat enhancement for barbastelle and greater horseshoe bats (three of these from the UK). For each species, they provide a summary of their feeding ecology (habitat and diet) and commuting behaviour, and a bullet-point list of recommendations. The guidance is freely available and the prescriptions for each species are not repeated here[[74]](#footnote-75), but include:

* Seek up-to-date data on bat species and their habitats (roosts and feeding areas).
* Pay attention on the connectivity of landscape, especially between roosts and feeding areas.
* Secure good habitat close to important maternity (to support newly-volant juveniles) and hibernation sites.
* Avoid fragmenting the landscape by reducing or removing existing structures (especially linear elements) or creating large open areas.
* Preserve and create landscape elements such as hedgerows and treelines.
* Favour small-scale forest management practices (no clear-cutting).
* Retain deadwood and trees with cavities.
* Avoid the use of pesticides in forests and anti-parasitic drugs for livestock.
* Increase the availability and quality of riparian habitats, including ponds and streams.
* Support ecological measures to increase insect biomass and arthropod diversity within feeding areas.
* Maintain dense riparian vegetation, especially marshes, shrubs and broadleaved trees.
* Avoid light trespass to bat habitats.
  + 1. These principles are universal. For the species-specific measures, as the guidance covers the entire EUROBATS range, it should be supplemented with UK and regional guidance so that it is locally relevant. Examples related to habitat management in the UK include:
* Habitat management for bats – A guide for land managers, landowners and their advisors (Entwistle, et al., 2001)
* The complete hedge good management guide (Hedgelink, 2013);
* Hedge management for greater horseshoe bats (Devon Greater Horseshoe Bat Project, 2018a); and
* Rivers, streams and ponds for greater horseshoe bats (Devon Greater Horseshoe Bat Project, 2018b)).
* Landscape and Urban Design for Bats and Biodiversity (Gunnell, et al., 2012)
* BCT collate a wide-range of woodland/tree management resources on their web-site1.
* The Ancient Tree Forum web-site provides links to resources which the Ancient Tree Forum and its partners have produced[[75]](#footnote-76)
* Conserving Grey Long-Eared Bats in our Landscape: a management plan (Razgour, et al., 2013) which includes recommendations for habitat management.
  + 1. There is also regional/local planning guidance, some of which includes habitat management advice (see **Section 7.4**)
    2. Importantly, any habitat measures should be secured via planning conditions, legal consents or alternative funding mechanisms, and their management safeguarded in the longer term. These should be sufficiently comprehensive that important features, whether retained, created or enhanced, should be buffered and protected from further development or land use change.
  1. Mitigating fragmentation
     1. Linear infrastructure can act as a direct physical barrier to movement by making bats reluctant to cross, or unable to cross safely. Part of the solution to this is to provide safe crossing-points to reduce mortality, and this is detailed in **Chapter 8.0**.
     2. Fragmentation is often caused by habitat loss, particularly the severance of commuting routes between roosts and foraging areas. However, even low-medium traffic roads can have a major negative impact on bat activity, with negative effects said to extend to about 300 m from the roads in woodland and >500 m in open field habitat (Medinas *et al*., 2019). They also found that habitats that were of high suitability for bats buffered the negative effects of roads. Mitigation measures considered should therefore include:
* bolstering existing alternative commuting routes (preferred) by filling gaps;
* retaining suitable buffers, and securing long-term management;
* measures to improve habitats in the vicinity of roads (even in the absence of direct habitat loss); and
* providing new alternative commuting routes.
  + 1. Evidence for the effectiveness of alternative commuting routes is summarised in Elmeros *et al.* (2016), though more research is needed. Alternative commuting routes can be temporary (to address disruption during construction) or permanent.
* All such routes should be well-connected to existing flight paths.
* Plants used to create a permanent commuting route should be of an adequate size; Elmeros *et al*. (2016) recommend 3-5m high trees of fast-growing species which should be planted as early in the construction phase as possible.
  + 1. Temporary hedging may be needed to provide continuity in the short- to medium- term while permanent plants mature.
* Temporary bat flight paths should be at least 2m high, without gaps, and left in-situ and maintained until permanent flightpaths have become established.
* Temporary hedging may comprise a line of potted shrubs/trees, screening, and/or fencing (e.g. willow-woven fencing or close-boarded).
  + 1. Green bridges can provide safe crossing-points (thereby reducing mortality; see **Chapter 8.0**) as well as mitigating the impacts of fragmentation. Few substantial green bridges have been created in the UK to date; a notable example is the Scotney Castle landscape bridge over the A21 Lamberhurst bypass in Kent. This is a substantial (30 m-wide) structure and, although it carries a paved minor road, it is well vegetated with dense and continuous mature trees and shrubs along each side that are well connected with treelines and surrounding woodland. (Berthinussen & Altringham , 2015) judged this structure to be effective in guiding bats safely over roads with 97% of bats using it to cross. It has subsequently set the template for five green bridges along the HS2. These ‘Type 1’ bridges, located within the Bernwood Forest area in Buckinghamshire, which supports Bechstein’s bats, will similarly have an overall minimum vegetated width of approximately 30m[[76]](#footnote-77). ‘Type 2’ bridges, designed to minimise fragmentation effects on bats where there are no Bechstein’s bats recorded, will be 15m wide. As these bridges are yet to be built, their effectiveness is yet to be confirmed; their monitoring will inform design principles to be included in the next iteration of these guidelines.
    2. Fragmentation can also occur where there is disturbance through noise and light-spill, resulting from both linear and footprint developments, effectively degrading habitats by making them inaccessible or unattractive to bats, or acting as a barrier.

Mitigating the impacts of lighting

* + 1. The Institution of Lighting Professionals (ILP), BCT and, separately, Eurobats have published detailed guidance on the impacts of lighting on bats and how to mitigate these when designing lighting schemes (BCT and ILP, 2018; Voigt *et al.*, 2018). The guidance highlights the importance of early involvement and collaboration between a lighting professional and the ecologist. This will help to ensure that the design is informed by a baseline lighting survey, that all features of importance to bats are considered, and both internal and external lighting are modelled. Lighting assessments on the vertical plane are also recommended, and increasingly requested by planning authorities, as they are a more effective way to demonstrate that retained habitat will remain dark.
    2. The UK guidance includes the following mitigation techniques:
* dark buffers, illuminance limits and zonation;
* appropriate luminaire specifications;
* sensitive site configuration;
* internal lighting mitigation options;
* screening;
* glazing treatments;
* creation of alternative valuable bat habitat on site; and
* dimming and part-night lighting.
  + 1. It is important to note (and often overlooked) that lighting engineers often model the *contribution* of a new lighting scheme and not the overall light that will be experienced following a development. It is important, therefore, to request baseline lighting levels (horizontal and vertical planes) and likely changes to those levels to get the overall picture. A commuting route where the existing light levels are tolerated by bats, augmented by additional light which seems to be relatively low as modelled, may cumulatively render the post-development commuting route unattractive to light-averse species.
    2. Lighting from headlights (rarely modelled or even considered) may also need to be controlled/limited by screening if there will be frequent vehicle movements next to features used by bats. In these cases, permanent structures such as bunds are preferred to e.g. fencing which can be lost over time.
    3. Case study: ‘Bat-friendly’ wildlife crossing installed in Worcestershire*[[77]](#footnote-78)*

[Worcestershire County Council](http://www.worcestershire.gov.uk/news/article/1890/the_first_bat_highway_in_the_uk_to_light_up_in_worcestershire) have provided a ‘bat-friendly’ crossing approximately 60m in width across the A4440, near to Warndon Wood nature reserve, comprising LED lights which emit a red light.

* + 1. Case study: ‘Bat-friendly’ wildlife crossing installed in Netherlands[[78]](#footnote-79)

In a ‘world-first’, the Rijkswaterstaat in the Netherlands (Directorate-General for Public Works and Water Management) installed ‘Batlamps’ in the construction of an ‘ecoduct’ over the A74 motorway near Tegelen in 2011. The Batlamp, which has a long lifespan and requires little maintenance, contains LED lights that emit UV-free amber light. This has been chosen as bats do not avoid this light, but people can still clearly perceive the traffic situation. In addition, the lighting columns are no higher than 6 m; the road lighting only comes on when cyclists or pedestrians pass; and an astronomical clock determines the switching on and off of the lighting. When switched on, the lamps come on slowly; when switched off they dim gently. The Batlamp has now been used in many projects in the Netherlands. Rijkswaterstaat now generally prescribes bat-friendly lighting in project plans and it is anticipated that, in the long term, about 5% of the total number of lighting columns will be equipped with bat-friendly lighting. The lighting avoids fragmentation, but does not provide safe crossing-points, so the impact of mortality remains. They have mostly been installed in situations where bats would pass underneath highways, and vegetation has been removed along the carriageways where the Batlamps are installed so there are no structures to guide bats across the road (Victor Loehr, pers. comm.).

* + 1. Case study: ‘Bat-friendly’ river lighting

In Worcester, bat-friendly solar lights (solareye®80) have been installed along the River Avon to avoid disturbing lesser horseshoe bats[[79]](#footnote-80); this and other bat species have now been recorded using this dark corridor.

Mitigating the impacts of noise

* + 1. The study of noise impacts on bats is in its relative infancy, and the circumstances in which noise mitigation might be needed are uncertain. Berthinussen & Altringham (2015) summarised the operational impacts of roads as barriers, concluding that noise and light are only likely to have a significant effect over relatively short distances. The operational impacts of noise from many other types of developments may be similar; more research is needed.
    2. Tolerance to noise will (almost certainly) differ between species and behaviours (roosting, hibernating, foraging, commuting). The need for mitigation in any circumstance will similarly differ (Reason & Bentley, 2020). Baseline conditions indicate existing levels of tolerance; to be considered significant, change to the baseline needs to be sufficient to cause disturbance, and the disturbance needs to be sufficient to interfere with bat behaviour to the extent that it impacts negatively on the demography (survival/ breeding) of the species at the local population level (Simpson, 2011). It would be difficult to argue that temporally limited noise over a limited area, even if significantly higher than the baseline, but affecting only very small numbers of non-breeding bats, would have such an impact.
    3. In most situations, the distance at which project noise attenuates to background noise levels would provide a cautious noise level criterion for assessing potential adverse effects in bats (West, 2016).(In many cases, such information will be lacking, and professional judgement will be required to decide whether the impacts are likely to be sufficient to trigger detailed bat-specific, i.e. unweighted high-frequency, noise assessments (Reason & Bentley, 2020) so that the extent of impacts can be quantified, and appropriate mitigation determined. Possible options for mitigation are set out in **Table 7.1** (which includes references to roosts as well as foraging and commuting routes).

Table 7.1: Mitigation options (could be combined)

| Mitigation options | Likely effectiveness |
| --- | --- |
| Managing the times during which noise is produced. | Easier to do for smaller projects or activities of limited duration; very hard to achieve for larger long-term infrastructure projects where noisy processes may be prolonged or part of a critical path. |
| Site noise-generating activities away from receptors. | May be difficult to achieve, especially if reliant on data calculated for human receptors to achieve background noise levels, which may over-estimate the distance over which impacts to bats are significant. |
| Reducing the noise at source (barriers, different types of plant). | Easier to do for small-scale plant; very hard to achieve otherwise (though high-frequency noise is easier to block). |
| Protecting the receptor (barriers). | May be possible for building roosts where the building fabric itself will interrupt some of the noise; very hard to achieve for tree roosts at height.  May be possible for commuting routes or foraging areas but could be costly if extensive. |
| Compensating for lack of access to resources (roosts or foraging areas) should these be affected to the extent that they are no longer attractive to bats, resulting in abandonment or avoidance. | If large-scale effects are predicted (geographical/temporal), compensatory roosts or foraging areas linked by commuting routes are likely to be required. |

* 1. Regional and species-specific guidance
     1. Local planning guidelines are designed to be applied within a specific area and (often) to benefit specific species. Some contain relatively specific guidance on habitat management/creation, or aspects such as lighting. The *principles* can often be applied elsewhere to drive a robust design process, and therefore are included here.
* **Somerset County Council’s Habitat Evaluation Procedure** (Somerset County Council, 2016) to evaluate the site’s suitability to support bats, in order to determine the minimum area of compensation habitat to mitigate habitat loss. The methodology adopts the CSZ principles for assessing the importance of foraging habitat relative to roost location.   
  The methodology is detailed in the North Somerset and Mendip Bats SAC: Guidance on Development (North Somerset Council, 2017), Technical Guidance Mendip District SAC Bats (Mendip District Council, 2019b) and Technical Guidance Hestercombe House SAC (North Somerset Council, 2019a);
* **South Hams SAC Greater Horseshoe Bats HRA Guidance** (Dartmoor National Park Authority; Devon County Council; South Hams District Council; Teinbridge District Council; Torbay Council, 2019) clarifies HRA requirements and provides advice on which planning applications may have a likely significant effect on the SAC greater horseshoe bat populations. It identifies sustenance zones (4km from the roosts) and Landscape Connectivity Zones (LCZ), (landscape between designated roosts and up to 10km from the designated maternity roosts) and recommends measures to reduce impacts and ensure no adverse effect on the SAC.
* **Waterspace Design Guidance, Protecting Bats in Waterside Developments** (BANES, 2018) applies where developments have the potential to impact on watercourses or key bat habitat linked to the Bath and Bradford on Avon SAC. It provides specific advice on avoiding fragmentation through appropriate lighting design.
* **Bat Special Areas of Conservation (SAC) Planning Guidance for Wiltshire**, (Wiltshire County Council, 2015) produced by Wiltshire County Council is aimed at applicants, agents, consultants and planners involved in producing and assessing development proposals in the landscapes surrounding Wiltshire’s most sensitive bat roosting sites
* **Trowbridge Bat Mitigation Strategy**[[80]](#footnote-81) produced by Wiltshire Council (Wiltshire Council, 2020) is aimed at developers, consultants and planners involved in assessing development proposals in the landscapes in and surrounding Trowbridge, and provides a clear and detailed approach to considering impacts of development in the Trowbridge area on the Bath and Bradford on Avon Bats Special Area of Conservation (SAC).
* **Exmoor and Quantocks Oak Woodlands Special Area of Conservation (SAC)[[81]](#footnote-82)** (Exmoor NPA, Sedgemoor District Council, Somerset West and Taunton Council, Somerset County Council, 2019)**:** guidance aimed at developers, consultants, and planners involved in planning and assessing development proposals in the landscapes used by barbastelle and Bechstein’s bats surrounding the SAC. This includes some detailed habitat/prey information.

1. Methods to reduce mortality
   1. Overview
      1. The previous chapters largely relate to impacts arising from implementing a development (from siting and design through to site clearance), i.e. construction in the broadest sense. This chapter relates to the risk of mortality from the normal operation of wind farms and linear infrastructure. However, in keeping with the aim to avoid repetition in this document, where specific and detailed guidance has already been published, these are signposted, not condensed. Only a brief summary of what each text covers is provided, to direct consultants to appropriate resources.
      2. There is cross-over between the measures needed to address fragmentation (such as green bridges) and mortality (safe crossing-points). Green bridges are discussed in relation to fragmentation in the previous chapter but are obviously also provide safe crossing-points.
   2. Mitigating mortality from linear infrastructure
      1. Under- and over-passes are widely used as mitigation measures to allow bats to cross road and rail schemes safely, reducing mortality (and also fragmentation).
      2. Comprehensive reviews of the effectiveness of mitigation measures implemented for highway severance have been published by O’Connor and Green (2011) and Berthunissen and Altringham (2015). Based on the available evidence, Berthunissen and Altringham (2015) provided a series of ‘Best practice principles’ for bat mitigation along linear transport infrastructure, as follows:

* **Mitigation should be integrated into the scheme from the earliest opportunity**  
  Mitigation should be considered during the planning and design stage of the infrastructure so that it can be incorporated effectively.
* Crossing structures should be placed on the exact location of existing bat commuting routes   
  Attempts should not be made to divert bats from their existing commuting routes.
* **Crossing structures should not require bats to alter flight height or direction**   
  This will depend on the topography of the site. If the road is to be elevated above ground level an underpass may be used to preserve the commuting route below it, or if the road is in a cutting a green bridge may be used to carry the commuting route over the road.
* **Crossing structures should maintain connectivity with existing bat commuting routes**  
  Connectivity must be maintained with undisturbed bat flight paths (e.g. treelines, hedgerows, woodland rides and streams), and bat habitat (e.g. woodland) within the surrounding landscape. Crossing structures should not be exposed or sited within open ground.
* **Over-the-road structures such as green bridges should be planted with vegetation**   
  Vegetation should be continuous and connected (see above) and sufficiently mature before road construction (e.g. by planting either relatively mature trees or fast growing tree species in advance of construction commencing).
* **Underpasses should be of sufficient height**Underpasses should be as spacious as possible with height being the critical factor. The minimum requirements for underpass height will be species--‐specific. Required heights will generally be lower for woodland--‐adapted species (~3 m) compared to generalist edge--‐adapted species (~6 m), but larger underpasses will accommodate more species. [*see the CEDR report* (Elmeros & Dekker, 2016)*and the A40 case-study* (Davies, 2019) *for specific information on culvert dimensions, both described below.*]
* **Green bridges should be of sufficient width**  
  In addition to being vegetated, green bridges should be as wide as possible, to provide a large area for bats to commute across. Further research is needed to determine exact dimensions. [*see Section 8.3 Fragmentation for more on green bridges.]*
* **Crossing structures should be unlit**   
  The effects of light on bats are species-specific and lighting should be avoided. [*See the A487 Llanwnda to South of Llanllyfni Case Study below* (O'Connor & Green, 2011) for how lighting has been used in combination with safe crossing-points to reduce mortality.]
* **Access and connectivity must be maintained**  
  It is important that access to crossing structures is maintained (e.g. grilles should not be installed on underpasses) and that connecting vegetation is retained indefinitely or for as long as the mitigation structure is required.
* **Disturbance should be minimised during installation of mitigation structures**  
  For example, by limiting noise and light pollution along the bat flight path, minimising vegetation clearance, installing suitable temporary crossing structures (which should also be subject to monitoring and evaluation), completing the installation as quickly as possible and ideally avoiding the summer months when bats are most active.
  + 1. Clearly these principles must be integrated into the design from a very early stage, based on a sound knowledge of bat presence, status and behaviour.
    2. As for all interventions specified in this document, further research, appropriate monitoring and documenting results from future mitigation schemes, will improve the evidence base and these principles. In addition, effectiveness must be properly defined and measured. To characterise a crossing structure as effective, at least 90% of crossing bats should use the structure to cross the road safely, and the number of bat passes at the site should not be substantially lower than before the road was constructed (Berthinussen & Altringham , 2015).
    3. Advice has also been published in Europe by the CEDR Transnational Road Research Programme (Elmeros, et al., 2016). The guidelines comprise three main parts:
* relevant bat biology and species differences which must be considered when planning and developing road and railway infrastructures;
* methods for pre- and post-construction surveys and monitoring of effectiveness of mitigation measures;
* best practice mitigation recommendations based on reviews of published evidence of bats’ use and the effectiveness of bat mitigation measures.
  + 1. Particularly helpful is the division of bats into five functional groups, dependent on the ecological niche they occupy (e.g. bats that feed in clutter or in the open), and relating this to the types and sizes of mitigation that would be suitable in different circumstances (for example, culvert dimensions). These groups are reproduced in **Table 8.1**.

Table 8.1: Functional groups of UK bat species (taken directly from Elmeros *et al.*, (2016))

| Group | Behaviour | UK species |
| --- | --- | --- |
| Group A | Extremely manoeuvrable bats, which often fly within foliage, or close to vegetation, surfaces and structures at variable flight heights. When commuting, they often follow linear and longitudinal landscape elements. Low-flying (typically < 2m) when commuting over open gaps. | Lesser horseshoe bat  Natterer's bat  Bechstein's bat  Brown long-eared bat  Grey long-eared bat |
| Group B | Very manoeuvrable bats that most often fly near vegetation, walls, etc. at variable heights but occasionally hunt within the foliage. When commuting, they often follow linear and longitudinal landscape elements. Flying at low to medium height when commuting over open gaps (typically < 5 m). | Greater horseshoe bat  Daubenton's bat  Brandt's bat  Whiskered bat  Alcathoe bat |
| Group C | Bats with medium manoeuvrability. They often hunt and commute along vegetation or structures at variable heights, but rarely close to or within the vegetation. May also hunt in open areas. Commuting over open stretches generally takes place at low to medium heights (typically 2 –10 m) with no clear tendency to lower flight. | Greater mouse-eared bat  Common pipistrelle  Soprano pipistrelle  Nathusius’ pipistrelle |
| Group D | Bats with medium manoeuvrability with a [more direct] flight pattern than bats in Category C. They hunt and commute ... away from vegetation and structures [at] a variety of flight heights. May occasionally fly but never hunt within vegetation. Commuting over open stretches tend to occur at medium heights (2 –10 m) with no clear tendency to lower flight. | Serotine  Barbastelle |
| Group E | Less manoeuvrable bats that most often fly high and in the open airspace away from vegetation and other structures. These bats generally commute over open stretches at medium heights or higher (10 m and often higher). It must be stressed that even these species may fly quite low over open areas under certain conditions, e.g. when hunting insects over warm (road) surfaces, or when they emerge from a roost site. | Noctule  Leisler's bat |

* + 1. The mitigation reviewed, and its effectiveness, includes bat gantries (very limited effectiveness); hop-overs (limited circumstances and species-specific responses); wildlife overpasses; modified overbridges and other technical structures; underpasses, culverts and tunnels; and viaducts and river bridges.
    2. Best-practice principles for each type of mitigation, supported by a literature review and links to case-studies, are set out. The guidelines also cover related impacts of lighting and noise as contributors to fragmentation, to a limited extent.
    3. Examples illustrating some of the principles outlined above are provided below.
    4. **Case study:** Monitoring the effectiveness of mitigation for horseshoe bats associated with a new road in Wales (Davies, 2019).

Mitigation for foraging habitat loss, fragmentation and traffic collisions was provided for greater and lesser horseshoe bats associated with the Slebech Park roost within Pembrokeshire Bat Sites SAC. ‘Safe’ bat crossing points were provided on existing flight lines, in the form of open-span bridges, equestrian underpasses, a cattle underpass and over-sized drainage culverts. Mitigation areas were created to replacement foraging habitat (swales, hazel translocation, hedgebanks) and to guide bats towards the new crossing structures. The mitigation measures were designed and positioned to increase the likelihood of their use by bats. The cross-sectional area of a crossing was positively correlated to the proportion of bats crossing safely, ranging from 15% for a 750mm culvert, to >85% for cattle/ equestrian underpasses and a box culvert. In hindsight, it would have been cost-effective to over-size even more of the culverts and increase permeability further (but in fact, the scheme is very permeable to bats given the crossings that were over-sized).

* + 1. **Case Study:** A487 Llanwnda to South of Llanllyfni (O'Connor & Green, 2011)

The road improvements in vicinity of Glynllifon SAC severed links between a lesser horseshoe colony and its foraging grounds. To mitigate, culverts were created below the road, with landscape planting and fencing used to direct bats toward safe crossing points. Monitoring surveys recorded that bats continued to cross the road at low height, resulting in casualties. Bollard lighting was then installed along the new road (1m high bollards, spaced 6-7m apart, providing 50 lux at face and minimum 5 lux between lights). 2014 – 2015 monitoring confirmed that low level bollard lighting is an effective mitigation measure for lesser horseshoe bats (and other light-averse species) dissuading them from crossing the road, with an average of 99.9% bats passing under the road instead of over it.

* 1. Wind turbine-related mortality
     1. EUROBATS (Rodrigues, et al., 2014) reviewed the evidence of the impacts of wind turbines on bat populations, and developed guidelines for assessing potential impacts on bats, taking into account their ecological requirements. These guidelines were designed to form the basis each country to develop their own national guidelines.
     2. The EU have subsequently published broader guidance on wind energy developments and nature legislation (European Commission, 2020). This supersedes the 2011 EU guidance which focussed on Natura 2000 sites and the species for which they were designated, thereby excluding the majority of bat species known to be most at risk from mortality caused by wind farms. The more recent volume builds on Rodrigues *et al.* (2014) and summarises recent research from across Europe.
     3. The EUROBATS guidelines have been adapted and interpreted in a UK context by the UK SNCBs (and a Steering Group consisting of BCT, the University of Exeter, Renewable UK, Scottish Power Renewables and Ecotricity) which have published comprehensive guidance relating to bats and onshore wind turbines (Scottish Natural Heritage, et al., 2019). These supersede guidance published by Natural England in 2012 (Natural England, 2012) and BCT (Hundt, 2012).
     4. Mitigation begins with an assessment of risk, which considers both the likelihood of high-risk species and site-based risk factors, using a two-stage process which takes local bat activity records into account through reference to Ecobat[[82]](#footnote-83). This process is intended to identify those sites which are of greatest concern in terms of potential collision risk, though caution and professional judgement are required in interpreting the results, even where the results suggest the risk could be low.
     5. Avoidance is the primary means of avoiding impacts
* siting turbines away from bat migration/ commuting routes and important foraging/ roosting areas;
* creating buffer zones around nationally and regionally important roosts;
* establishing a buffer to other habitats specifically important for bats (tree lines, hedgerow networks, wetlands, waterbodies, and watercourses);
* adjusting the layout of turbines.
  + 1. It is important to note that UK advice diverges significantly from Eurobats in relation to the recommended distance from woodland and other important habitats.
    2. Strategies to reduce mortalities by altering blade rotation (Scottish Natural Heritage, et al., 2019) comprise:
* reduced rotation speed while idling (feathering).
* curtailment (raising the cut-in speed for power generation)
  + 1. These systems can be applied bluntly (between dusk and dawn over the entire bat active period), or using more sophisticated mechanisms which respond to environmental data (wind speed, temperature, acoustic bat records): ‘smart curtailment’.

Bat Deterrents

* + 1. Sonic bat deterrents modify bat behaviour and have been trialled for use in a range of situations, including churches (to control the areas to which bats have access), tunnel-like structure (Burton, 2019) and wind turbines.
    2. While deterrents show some promise for reducing mortality at wind turbines (Weaver, et al., 2020), the results indicate species-specific responses i.e. only some species show reductions in fatalities, and more research is required to improve species-specific effectiveness. As of now, they cannot be recommended in place of the measures outlined above.

1. Monitoring
   1. Introduction to post-development monitoring
      1. There is a very wide consensus that monitoring to date is often incomplete, inadequate and/or poorly reported (even when the mitigation itself is successful). Building the evidence-base of what works and what does not is essential to reduce impacts on bats, improve outcomes and avoid ineffectual expenditure (a poor conservation message).
      2. There are two distinct stages of post-development monitoring (PDM):

* ensuring all mitigation is implemented as stated (not least, to ensure compliance with any licences and planning conditions in force); and
* assessment and reporting of outcomes.
  + 1. Every mitigation scheme should be supported by a monitoring strategy, however brief, which should identify:
* who is responsible for monitoring;
* how it will be funded;
* how the monitoring will be carried out (methods, equipment, survey effort);
* how access for monitoring will be ensured;
* where and when the results are to be reported, and to whom; and
* the party(ies) responsible for any remedial measures that are required.
  + 1. Funding can be contentious, and it can be difficult to ensure all monitoring commitments are met and all remedial measures secured. This is particularly true for long-running projects where the last few years of after-care and monitoring may take place well after contractors have left site. **It is therefore advisable for funds to be secured and ring-fenced upfront** (perhaps linked to a s106 agreement or equivalent) to ensure long-term compliance.
    2. The monitoring strategy should:
* clearly define its objectives;
* define success for each objective;
* use proportionate and appropriate methods for data collection and analysis;
* outline triggers (thresholds) for remedial action, and what that remedial action should be;
* contribute to a wider understanding of the measures applied
  1. Setting monitoring objectives
     1. The first stage, ensuring that all mitigation has been implemented as designed, begins during construction, and continues until all elements are in place (and all remedial requirements resolved). Complex proposals will require the involvement of other disciplines such as lighting engineers or landscape architects, and their roles and responsibilities should all be defined. As noted in **Section 5.5**, this stage extends throughout construction and beyond, and requires compliance checks against design objectives at regular intervals.
     2. For the second stage, the level of detail collected should be sufficient to meet the monitoring objective being tested. Simple examples are set out in Table 9.1 below.

Table 9.1: Tests for monitoring objectives and triggers for remedial actions. This assumes that all measures have already been implemented as intended, and there are no remedial actions outstanding. (Note that ‘implemented as intended’ should be interpreted in spirit; it should not prevent improvements being made to the original mitigation proposed should new information come to light).

| Objective (suitability determined by nature of impacts) | Test | Trigger for remedial action  [notes] |
| --- | --- | --- |
| The low-value compensation roost is being used by bats  or  The low-value compensation roost is being used by bats of the same species as the roost lost | Evidence of occupation by bats, using the most appropriate survey technique | None [there will be an element of chance to re-occupation] |
| The compensation roost is being used by the same species of bats, using the roost for the same function (night-roost, maternity etc) as the roost lost | Evidence of species, status, numbers at relevant time(s) of year | None, assuming all measures are implemented as intended and an appropriate temperature regime is in place.  [There will be an element of chance to re-occupation] |
| The compensation roost provides an acceptable range of temperatures (or humidity) | Temperature logger data, ideally compared to temperature measurements in the original roost | Temperature data indicates no areas of the roost reach the temperatures required, and amendments are needed (e.g. a hot box added) |
| New access-points are being used  [it may be possible to test this before existing access-points are lost – see Reason, 2017] | Observations of bats exiting and returning to the roost via the new access points | Potentially none. If roost is not in use, consideration should be given to amending, moving or adding access-points  [will not be appropriate or possible in all circumstances, and will depend on the value of the roost] |
| Commuting route is still being used | Bats recorded/observed using the commuting route | Bats are not using the new commuting route.  [If not used, look for reasons: is the roost still in use; is the commuting route subject to new disturbance; has connectivity been breached – and address these as necessary] |
| An alternative commuting route is being used | Bats recorded/observed following the new commuting route *or* where critical, number or proportion of bats doing so is within specified range. |
| Light levels (to be specified) are acceptable on commuting routes | Light levels (observations of bat behaviour may also be warranted) | Light levels exceed levels specified in conditions/ lighting strategy |
| New habitat is increasing in value to foraging bats | Habitat condition assessments  Bat passes increase over time (standardised measure using the same equipment)  Insect biomass increases over time (moth-trapping or dung-beetle counts[[83]](#footnote-84)) – for highest value sites | Habitat fails conditions assessments  If bat passes do not increase over time, but the habitat has improved, confirm that bats are still using the roost and there are no local trends in numbers |
| Bats are crossing a new road (or railway) safely | 90% of bats that are crossing the road on any given night are crossing safely, rather than crossing the road at traffic height | Effectiveness is below 90% |

* + 1. **Case Study:** Hopyard Farm Underpass, A465 Heads of the Valleys, Section 1[[84]](#footnote-85)

Monitoring showed that the Hopyard Farm Underpass continued to be used by lesser horseshoe bats after it was extended and slightly reduced in cross-section during road improvements. It was therefore assumed that the bats were not hindered by new grilles fitted during the improvements, as ‘good numbers’ were crossing safely.  However, later monitoring for a slightly different purpose indicated that a significant number of bats were flying over the road, exposing them to the risk of collision.  This observation triggered detailed monitoring, which revealed that up to 30% of bats were crossing the road unsafely.  The grilles were removed, and replaced with a palisade fence with a gap above; this resulted in 93-98% of bats observed crossing safely by flying through the underpass.  This example shows the importance of setting appropriate monitoring objectives: the initial test of ‘use’ was met, but was inadequate to identify that a significant proportion of individuals avoided the grille and crossed unsafely.  The test here should have been effectiveness from the outset.  Applying that test subsequently meant that modifications could be made that resulted in effective mitigation.

* + 1. To make valid pre- and post-development comparisons, consistent survey methods should be employed. It may be that specific data need to be collected to allow pre-/post-construction comparisons that are robust and repeatable. This means (where possible) selecting and recording parameters in sufficient detail they are accessible even when personnel change. For example:
* survey types;
* surveyor/equipment locations (grid references);
* equipment makes, models, settings and locations; and (but not limited to)
* dates, weather and other data pertinent to the interpretation/comparison of results.
  + 1. Ideally, at least some methods should be applicable before and after the development, taking into account the way the site is likely to change. For example, on a linear scheme, designing transects through habitats that are just outside the red-line boundary may make little difference to the habitats sampled, but allow the transects to be repeated post-development (the same could be done with the placement of static detectors).
    2. For compensation roosts, to understand the reasons for success or failure, data relating to the original roost(s) such internal temperatures, humidity[[85]](#footnote-86), volume, adjacent habitat (particularly the presence and placement of vegetation cover, water, artificial lighting and so on) should be collected.
    3. Post-construction monitoring should be reported in sufficient detail to inform a wider understanding of effectiveness. For example, not just the number of bat boxes deployed, but the make and model of bat boxes used, their location, aspect and height, and how this relates to their subsequent use.
    4. Bat ecologists are strongly encouraged to share their successes and failures by publishing in Conservation Evidence or uploading to BCT’s Roost website.
  1. Monitoring effort
     1. If the monitoring objectives are well-defined and proportionate to the impacts of a development, and take into account the importance of the resource affected, then the monitoring effort will be driven by the objectives and the effort needed to test these. **Table 9.** 2 gives indicative monitoring periods for features (roosts, commuting routes and foraging areas) that were impacted and those impacts mitigated. These are a starting-point not absolutes; deviations should be justified.

Table 9. 2: Suggested years of monitoring

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Importance of resource affected | | | | |
| Scale of impact (before mitigation) | Less than district | District | County | Regional | National |
| Less than district | Up to 1 year | Up to 1 year | 1 year | 1 year | 1-3 years |
| District | n/a | 1 year | 3 years | 3 years | 5 years |
| County | n/a | n/a | 5 years | 5 years | 10 years |
| Regional | n/a | n/a | n/a | 10 years | 10 years |
| National | n/a | n/a | n/a | n/a | 10 years |

* + 1. Several studies have determined that the uptake of building roosts26 and bat boxes ( (McAney & Hannify, 2015); (Poulton, 2006)) increases over time, suggesting bats need a period to find and/or become accustomed to new roosting opportunities. For this reason, fewer later surveys are better than intense early effort. Once the mitigation has been correctly implemented (Year 0), the following schedules could be adopted:
* Year 2; Year 4; Year 5 (five-year monitoring schedule)
* Year 3; Year 5; Year 7; Year 10 (ten-year monitoring schedule)
  + 1. Note that Natural England do not currently require post-development monitoring for proposals affecting feeding, night, or transitional/occasional roosts where these affect up to three of the more common species[[86]](#footnote-87), and are used by low numbers of each species. For higher levels of use (more bats or more species), or for serotine and lesser horseshoe bat roosts, a single presence/absence survey at an appropriate time of year is to be undertaken (not in the first year after completion). Confirmation of the condition and suitability of the roost is only stated as a requirement for lesser horseshoe bats for these types of roosts. However, as these guidelines make clear above, that requirement should apply to all mitigation and, arguably, is more important for these lower-value roosts than a presence/absence survey for occasionally used roosts (unless the roost can be directly inspected for evidence).
    2. It is not necessary for every monitoring technique to be used in every single year. The frequency at which each technique should be repeated will depend on the objectives set at the outset, and the likelihood of change between monitoring events for each technique. For example, light levels could be measured immediately after a modification; habitat condition assessments or prey biomass assessments at two- to three-year intervals.
    3. Where factors outside the site’s control may have affected results (e.g. a particularly harsh winter), the monitoring period may need to be extended to allow general trends to be identified (this may mean longer gaps between monitoring events rather than more monitoring).

1. Bibliography
   1. Legislation texts, statutory guidance and standing advice

|  |  |  |
| --- | --- | --- |
| The Habitats Directive: | <http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm> | |
| England and Wales | | |
| Wildlife & Countryside Act (1981): | | <https://www.legislation.gov.uk/ukpga/1981/69> |
| The Conservation of Habitats and Species Regulations (2017): | | <http://www.legislation.gov.uk/uksi/2017/1012/contents/made> |
| Scotland | | |
| Conservation (Natural Habitats, & c.) Regulations 1994 | | <https://www.legislation.gov.uk/uksi/1994/2716/contents/made> |
| Legislation relating to leaving the EU | | <https://www.legislation.gov.uk/sdsi/2019/9780111041062> |
| Northern Ireland | | |
| Conservation (Natural Habitats, & c.) Regulations (NI) 1995 | | <https://www.legislation.gov.uk/nisr/1995/380/regulation/34/made> |
| Licensing | | England: [www.gov.uk/government/collections/bat-licences](http://www.gov.uk/government/collections/bat-licences)  Scotland: <https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/licensing/species-licensing-z-guide/bats-and-licensing>  Wales: <https://naturalresources.wales/permits-and-permissions/protected-species-licensing/european-protected-species-licensing/bat-licensing/?lang=en>  Northern Ireland: <https://www.daera-ni.gov.uk/articles/wildlife-licensing#toc-1> |
| Enforcement | | For further information see: [www.gov.uk/guidance/enforcement-laws-advice-on-protecting-the-natural-environment-in-england#natural-englands-compliance-and-enforcement-position](http://www.gov.uk/guidance/enforcement-laws-advice-on-protecting-the-natural-environment-in-england#natural-englands-compliance-and-enforcement-position)  To report a suspected breach of a species licence issued by Natural England email:  [speciesenforcement@naturalengland.org,uk](mailto:speciesenforcement@naturalengland.org,uk)  In Wales, the NRW Species Licensing team should be emailed:  [trwyddedrhywogaeth@cyfoethnaturiolcymru.gov.uk](mailto:trwyddedrhywogaeth@cyfoethnaturiolcymru.gov.uk)  In Scotland, the NatureScot Licensing team should be emailed:  [licensing@nature.scot](mailto:LICENSING@nature.scot)  In Northern Ireland:  <https://www.wildlifecrimeni.org/> |

* 1. References

# References

Environmental Law Foundation, 2020. *Bats and Pine Martens.* [Online]   
Available at: https://elflaw.org/past-cases/bats-and-pine-martens/  
[Accessed February19 2021].

Abbott, I., Butler, F. & Harrison, S., 2012. When flyways meet highways - the relative permeability of different motorway crossing sites to functionally diverse bat species. *Landscape and Urban Planning,* 106(4), pp. 293-302.

Abbott, I., Harrison, S. & Butler, F., 2012. Clutter-adaptation of bat species predicts their use of under-motorway passageways of contrasting sizes - a natural experiment. *Journal of Zoology,* 287(2), pp. 124-132.

Amorim, F., Rebelo, H. & Rodrigues, L., 2012. Factors affecting Bat Activity and Mortality at a Wind Farm in the Mediterranean Region. *Acta Chiropterologica,* 14(2), p. 439.

Ancillotto, L., Serangeli, M. & Russo, D., 2013. Curiosity killed the bat: Domestic cats as bat predators. *Mammalian Biology - Zeitschrift fur Saugetierkunde,* 78(5), pp. 369-373.

Arnett, E. B. et al., 2008. Patterns of Bat Fatalities at Wind Energy Facilities in North America. *Journal of Wildlife Management,* 72(1), pp. 61-78.

Arthur, L. & Chretien, A., 2019. *Recueil d’expériences des aménagements pour une meilleure cohabitation Chiroptères - Homme en milieu bâti,* Bourges: Societe Francais pour l'Etude et la Protection des Mammiferes.

Ashrafi, S. et al., 2013. Habitat selection of three cryptic Plecotus bat species in the European Alps reveals contrasting implications for conservation. *Biodiversity and Conservation,* 22(12), pp. 2751-2766.

Azam, C. et al., 2015. Is part-night lighting an effective measure to limit the imoacts of artificial lighting on bats?. *Global Change Biology,* 21(12), pp. 4333-4341.

Baerwald, E., D'Amours, G., Klug, B. & Barclay, R., 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. *Current Biology.*

BANES, 2018. *Protecting bats in waterside development,* s.l.: WaterSpace Design Guidance .

Bat Conservation Trust, 2006. *A review of the success of bat boxes in houses,* Edinburgh: Scottish Natural Heritage Commissioned Report No. 160.

Bat Conservation Trust, 2020. *Natural England Bat Advice Service contract summary.* [Online]   
Available at: https://cdn.bats.org.uk/pdf/Resources/Bat-Groups/Useful-NE-Links-Pages/Bat-Advice-Service-contract-summary-vFeb-2020.pdf?mtime=20200401163640&focal=none  
[Accessed 23 December 2020].

Bat Conservation Trust, 2020. *The National Bat Monitoring Programme Annual Report 2019.* London: Bat Conservation Trust.

Bat Conservation Trust, n.d. *Cat Attacks.* [Online]   
Available at: https://www.bats.org.uk/about-bats/threats-to-bats/cat-attacks  
[Accessed 19 February 2021].

Bat Tree Habitat Key , 2018. *Annual Account of Tree Species Occupied By Bats in the UK - 2018.* [Online]   
Available at: http://battreehabitatkey.co.uk/?page\_id=18  
[Accessed 4 January 2021].

BCT and ILP, 2018. *Bats and Lighting in the UK: Bats and the Built Environment Series. Version 3.* London: Bat Conservation Trust (BCT); Institute of Lighting Professionals (ILP).

BCT and JNCC, 2017. *The state of the UK's bats 2017: National Bat Monitoring Programme Population Trends.* London: Bat Conservation Trust (BCT).

BCT, 2017. *Mitigation Case Studies Forum.* London: Bat Conservation Trust.

Bengtsson, V., Hedin, J. & Niklasson, M., 2012. *Veteranisation of oak - managing trees to speed up habitat production.* Sheffield, Pro Natura.

Bernithussen, A., Richardson, O. & Altringham, J., 2019. Bat Conservation. In: W. Sutherland, al & et, eds. *What Works in Conservation.* Cambridge: Open Book Publishers, pp. 67-140.

Bernithussen, A., Richardson, O. & Altringham, J., 2020. Bat Conservation. In: L. D. N. O. S. P. &. R. S. W.J. Sutherland, ed. *What Works in Conservation.* Cambridge: Open Book Publishers, pp. 65-136.

Berthinussen, A. & Altringham , J., 2015. *WC1060 Development of a Cost Effective Method For Monitoring the Effectivness of Mitigation for Bats Crossing Linear Transport Infrastructure,* London: Department of the Environment, Food and Rural Affairs.

Berthinussen, A. & Altringham, J., 2012a. Do Bat Gantries and Underpasses Help Bats Cross Roads Safely?. *PLoS ONE,* 7(6).

Berthinussen, A. & Altringham, J., 2012b. The effect of a major road on bat activity and diversity. *Journal of Applied Ecology,* 49(1), pp. 82-89.

Berthinussen, A. & Altringham, J., 2017. *Bats and linear infrastructure: A summary of Defra research project WC1060,* Cardiff: Natural Resources Wales.

Berthinussen, A., Richardson, O. & Altringham, J., 2019. Bat Conservation. In: L. D. N. O. S. P. &. R. S. W.J. Sutherland, ed. *What Works in Conservation.* Cambridge: Open Book Publishers, pp. 67-140.

Billington, G., 2013. *Wolvercote Railway Tunnel,* s.l.: Presented to BCT National Conference.

Boldogh, S., Dobrosi, D. & & Samu, P., 2007. The effects of the illumination of buildings on house-dwelling bats and its conservation consequences. *Acta Chiroperologica,* Volume 9, pp. 527-534.

Bontadina, F., Schofield, H. & and Naef-Denzer, B., 2002. Radio-tracking reveals that lesser horseshoe bats (Rhinolophus hipposideros) forage in woodland. *Journal of Zoology,* 258(3), pp. 281-290.

Borda-de Agua, L., Barrientos, R., Beja, P. & Pereira, H. (., 2017. *Railway Ecology.* s.l.:Springer International Publishing.

Briggs, P., 2002. *A study of barn conversions in Hertfordshire in 2000,* Hertford: Hertfordshire Biologcal Records Centre.

Briggs, P., 2004. Effect of barn conversion on bat roost sites in Hertfordshire, Eng;and. *Mammalia,* 68(4), pp. 353-364.

British Standards Institute, 2013. *BS42020: Biodiversity Code of Practice for Planning and Development.* London: BSI.

British Standards Institution, 2013. *BS42020:2013 Biodiversity - Code of practice for planning and development,* London: British Standards Institution.

Burton, N., 2019. Acoustic deterrents as a bat mitigation strategy. *Environmental Scientist: Journal of the Institution of Environmental Sciences,* 28(3), pp. 14-19.

Ciechanowski, M., 2015. Habitat preferences of bats in anthroogenically altered, mosaic landscapes of northern Poland. *European Journal of Wildlife Research,* 61(3), pp. 415-428.

CIEEM, CIRIA, IEMA, 2016. *Biodiversity Net Gain: Good practice principles for development,* Winchester: CIEEM.

CIEEM, 2018. *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine..* Version 1.1 ed. Winchester: Chartered Institute of Ecology and Environmental Management (CIEEM).

Claireau, F. et al., 2019. Bat overpasses as an alternative solution to restore habitat connectivity in the context of road requalification. *Ecological Engineering,* Volume 131, pp. 34-8.

Collins, J., 2016. *Bat Surveys for Professional Ecologists: Good Practice Guidelines.* 3rd ed. London: Bat Conservation Trust.

Collins, J. et al., 2020. The implementation and effectiveness of bat roost mitigation and compensation measures for Pipistrellus and Myotis spp. and brown long-eared bat (Plecotus auritus) including in building development projects completed between 2006 and 2014 in England and W. *Conservation Evidence,* Volume 17, pp. 19-26.

Council, C. C., 2018. *Cornwall Planning for Biodiversity Guide.* Truro: Cornwall County Council.

Crawley, D. et al., 2020. *Atlas of the Mammalas of Great Britain and Northern Ireland.* s.l.:Pelagic Publishing.

Damant, C. & Dickins, E., 2013. Rapid response mitigation to noctule Nyctalus noctla roost damage, Buckinghamshire, UK. *Conservation Evidence,* Volume 10, pp. 93-94.

Dartmoor National Park Authority; Devon County Council; South Hams District Council; Teinbridge District Council; Torbay Council, 2019. *South Hams Special Area of Conservation (SAC) Greater Horseshoe Bats Habitat Regulations Assessment Guidance,* s.l.: Devon County Council.

Davidson-Watts, I. & Jones, G., 2006. Differences in foraging behaviour between Pipistrellus pipistrellus (Schreber, 1774) and Pipistrellus pygmaeus (Leach, 1825). *Journal of Zoology,* 268(1), pp. 55-62.

Davidson-Watts, I., Walls, S. & Jones, G., 2006. Differential habitat selection by Pipistrellus pipistrellus and Pipistrellus pygmaeus identifies distinct conservation needs for cryptic species of echolocating bats. *Biological Conservation,* 133(1), pp. 118-127.

Davies, J., 2019. Effectiveness of mitigation of the impacts of a new road on horseshoe bats Rhinolophus ferrumequinum in Wales, UK. *Conservaton Evidence,* Volume 16, pp. 17-23.

DEFRA, 2011. *Biodiversity 2020: A strategy for England’s wildlife and ecosystem services,* London: Department for Environment Food and Rural Affairs.

Devon Greater Horseshoe Bat Project, 2018a. *Hedge management for greater horseshoe bats,* s.l.: Devon Greater Horseshope Bat Project.

Devon Greater Horseshoe Bat Project, 2018b. *Rivers, streams and ponds for greater horseshoe bats,* s.l.: Devon Greater Horseshoe Bat Project.

Dietz, C. & Kiefer, A., 2016.. *Bats of Britain and Europe..* London: Bloomsbury Wildlife.

Dietz, C., Von Helversen, O. & Nill, D., 2009. *Handbook of the Bats of Europe and Northwest Africa.* First ed. London: A&C Black Ltd.

Dodds, M. & Bilston, H., 2013. A comparison of different bat box types by bat occupancy in deciduous woodland, Buckinghamshire, UK. *Conservation Evidence,* Volume 10, pp. 24-28.

Durr, T., 2007. Die bundesweite Kartei zur Dokumentation von Fledermausverlusten an Windenergieanlagen - ein Ruckblick auf 5 Jahre Datenerfassung. *Nyctalus,* 12(2/3), pp. 108-114.

Eisenbeis, G., 2006. Artificial Night Lighting and Insects: Attraction of Insects to Streetlamps in a Rural Setting in Germany. In: C. L. T. Rich, ed. *Ecological Consequences of Artificial Night Lighting.* s.l.:s.n., pp. 281-304.

Elmeros, M. et al., 2016. *Bat mitigation measures on roads - a guideline,* s.l.: Conference of European Directors of Roads (Austria, Denmark, Germany, Ireland, Norway, Sweden, Netherlands and United Kingdom).

Elmeros, M. & Dekker, J., 2016. *Fumbling in the dark: effectiveness of bat mitigation measures on roads - Final report,* s.l.: Conference of European Directors of Roads.

English Heritage, National Trust, Natural England, 2009. *Bats in Traditional Buildings.* s.l.:English Heritage.

Entwhistle, A., 1996. Habitat exploitation by a gleaning bat, Plecotus auritus. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 351(1342), pp. 921-931.

Entwistle, A. et al., 2001. *Habitat management for bats: A guide for land managers, land owners and their advisors.* Peterborough: Joint Nature Conservation Committee (JNCC).

European Commission, 2020. *Guidance document on wind energy developments and EU nature legislation.* s.l.:s.n.

Exmoor NPA, Sedgemoor District Council, Somerset West and Taunton Council, Somerset County Council, 2019. *Exmoor and Quantocks Oak Woodlands Special Area of Conservation (SAC) Guidance on Development,* s.l.: Somerset County Council.

Fawcett-Williams, K., 2019. *Thermal imaging: bat survey guidelines ,* London: Bat Conservation Trust.

Fensome, A. & Mathews, F., 2016. Roads and bats: a meta-analysis and review of the evidence on vehicle collisions and barrier effects. *Mammal Review,* 46(4), pp. 311-323.

Fenton, M., 1997. Science and the Conservation of Bats. *Journal of Mammalogy,* 78(1), pp. 1-14.

Ferrara, F. & Leberg, P., 2005. Characteristics of positions selected by day-roosting bats under bridges in Louisiana. *Journa of Mammalogy,* Volume 86, pp. 729-735.

Ferrara, F. & Leberg, P., 2005. Infuence of investigator disturbance and temporal variation on surveys of bats roosting under bridges. *Wildife Society Bulletin,* 33(3), pp. 113-1122.

Finch, D. et al., 2020. Modelling the functional connectivity of landscapes for greater horseshoe bats Rhinolophs ferrumequinum at a local scale. *Landscape Ecology,* 35(3), pp. 577-589.

Finch, D., Schofield, H. & Mathews, F., 2020. Habitat Associations of Bats in an Agricultural Landscape: Linear Features Versus Open Habitats. *Animals,* 10(10).

Finch, D., Schofield, H. & Mathews, F., 2020. Traffic noise playback reduces the activity and feeding behaviour of free-living bats. *Environmental Pollution,* 263(August), p. 114405.

Flanders, J. & Jones, G., 2009. Roost Use, Ranging Behavior, and Diet of Greater Horseshoe Bats (Rhinolophus Ferrumequinum) Using a Transitional Roost. *Journal of Mammalogy,* 90(4), pp. 888-896.

Flaquer, C. et al., 2009. Habitat Selection in Nathusius' Pipistrelle (Pipistrellus nathusii): The Importance of Wetlands. *Acta Chiropterologica,* 11(1), pp. 149-155.

Flaquer, C. et al., 2014. Could overheating turn bat boxes into death traps?. *Barbastella,* 7(1).

Fure, A., 2012. Bats and lighting - six years on. *The London Naturalist,* Volume 91, pp. 69-88.

Furmankiewicz, J., Duma, K., Manias, K. & Borowiec, M., 2013. Reproductive Status and Vocalisation in Swarming Bats Indicate a Mating Function of Swarming and an Extended Mating Period in Plecotus auritus. *Acta Chiropterologica,* 15(2), pp. 371-385.

Garland, L. & Markham, S., 2007. *Is important bat foraging and commuting habitat legally.* [Online]   
Available at: http://biodiversitybydesign.co.uk/cmsAdmin/uploads/protection-for-bat-habitat-sep-2007.pdf  
[Accessed 23 December 2020].

Garland, L., Wells, M. & Markham, S., 2017. Performance of artificial maternity bat roost structures near Bath, UK. *Conservation Evidence,* Volume 14, pp. 44-51.

*Grace and Sweetman vs An Bord Pleanala* (2018). https://www.bailii.org/eu/cases/EUECJ/2018/C16417\_O.html (Accessed 23 June 2021)

Greif, S. & Siemers, B., 2010. Innate recognition of water bodies in echolocating bats. *Nature Communications,* November.Volume 1.

Griffiths, S. R. et al., 2018. Chainsaw-Carved Cavities Better Mimic the Thermal Properties of Natural Tree Hollows than Nest Boxes and Log Hollows. *Forests,* Volume 9.

Griffiths, S., Semmens, K., Watson, S. & Jones, C., 2020. Installing chainsaw-carved hollows in medium sized live trees increases rates of visitation by hollow-dependent fauna. *Restoration Ecology,* 28(5), pp. 1225-1236.

Gunnell, K., Grant, G. & Williams, C., 2012. *Landscape and Urban Design for Bats and Biodiversity.* London: Bat Conservation Trust.

Harris, S. & Yalden, D. W., 2008. *Mammals of the British Isles.* London: The Mammal Society.

Hedgelink, 2013. *The complete hedge good management guide,* s.l.: Hedgelink.

Hernández-Brito, D. et al., 2018. Nest-site competition and killing by invasive parakeets cause the decline of a threatened bat population.. *Royal Society Open Science,* 5(5).

Highways England, 2015. *Our plan to protect and increase biodiversity,* Guildford: Highways England.

HM Government, 2011. *Natural Environment White Paper - The Natural Choice: securing the value of nature,* London: HM Government.

HM Government, 2018. *A Green Future: Our 25 Year Plan to Improve the Environment,* London: HM Government.

Hoeh, J., Bakken, G., Mitchell, W. & O'Keefe, J., 2018. In artificial roost comparison, bats show preference for rocket box style. *PLoS ONE,* Volume 13.

Horvath, G. et al., 2010. Reducing the maladaptive attractiveness of solar panels to polarotactic insects. *Conservation Biology,* Volume 24, pp. 1644-1653.

Humphrey, S. & Kunz, T., 1976. Ecology of a Pleistocene Relict, the Western Big-Eared Bat (Plecotus townsendii), in the Southern Great Plains. *Journal of Mammalogy,* 57(3), pp. 470-494.

Hundt, L., 2012. *Bat Surveys: Good Practice Guidelines.* 2nd ed. London: Bat Conservation Trust.

Ijas, A., Kahilainen, A., Vasko, V. & Lilley, T., 2017. Evidence of the Migratory Bat, Pipistrellus nathusii, Aggregating to the Coastlines in the Northern Baltic Sea. *Acta Chiropterologica,* 19(1), p. 127.

JNCC, 2013. *Guidelines for the Selection of Biological SSSIs.* s.l.:Joint Nature Conservation Committee.

Johnson, S., Brack, V. & Rolley, R., 1998. Overwinter weight loss of Indiana bats (Myotis sodalis) from hibernicula subject to human visitation. *The American Midland Naturalist,* Volume 139, pp. 255-261.

Kayikcioglu, A. & Zahn, A., 2004. High temperature and the use of satellite roosts in Rhinolophus hipposideros. *Mammalian Biology,* Volume 69, pp. 337-341.

Kelm, D. et al., 2014. Seasonal Bat Activity in Relation to Distance to Hedgerows in an Agricultural Landscape in Central Europe and Implications for Wind Energy Development. *Acta Chiropeterologica,* 16(1), pp. 65-73.

Kokurewicz, T., 2004. Sex and Age Related Habitat Selection and Mass Dynamics of Daubenton's Bats Myotis daubentonii (Kuhl, 1817) Hibernating in Natural Conditions. *Acta Chiropterologica,* 6(1), pp. 121-144.

Korsten, E. et al., 2016. Swarm and Switch: On the trail of the hibernating common pipistrelle. *Bat News,* Issue Summer.

Kunz, T., 1976. Observations on the winter ecology of the bat fly Trichobius corynorhini.. *Journal of Medical Entomology,* Volume 12, pp. 631-636.

Kunz, T., 1982. Roosting ecology of bats. In: T. Kunz, ed. *Ecology of Bats.* New York: Plenum Press, p. 425.

Kurta, A., 2014. The Misuse of Relative Humidity in Ecological Studies of Hibernating Bats. *Acta Chiropterologica,* 16(1), pp. 249-254.

Kyheroinen, E. et al., 2019. *Guidance on the conservation and management of critical feeding areas and commuting routes for bats,* Bonn: Eurobats Publication Series No. 9.

Laforge, A. et al., 2019. Landscape context matters for attractiveness and effective use of road underpasses by bats. *Biological Conservation,* Volume 237, pp. 409-422.

Lichfield District Council, 2015. *Local Plan Strategy 2008 - 2029,* Lichfield: Lichfield District Council.

Lichfield District Council, 2016. *Biodiversity and Development - Supplementary Planning Document,* Lichfield: Lichfield District Council.

Lintott, P. et al., 2018. Ecobat: An online resource to facilitate transparent, evidence-based interpretation of bat activity data. *Ecology and Evolution,* 8(2), pp. 935-941.

Lintott, P. & Mathews, F., 2018. *Reviewing the evidence on mitigation strategies for bats in buildings: informing best-practice for policy makers and practitioners.,* Winchester: CIEEM.

Lonsdale, D. (., 2013. *Ancient and other veteran trees: further guidance and management.* s.l.:Ancient Trees Forum.

Lourenço, S. & Palmeirim, J., 2004. Influence of temperature in roost selection by Pipistrellus pygmaeus (Chiroptera): Relevance for the design of bat boxes. *Biological Conservation,* 119(2), pp. 237-243.

Luo, J., Clarin, B. & Borrisov, I. &. S. B., 2014. Are torpid bats immune to anthropogenic noise?. *Journal of Experimental Biology,* Volume 217, pp. 1072-1078.

MacGregor, C., Pocock, M., Fox, R. & Evans, D., 2014. Pollination by nocturnal Lepidoptera, and the effects of light pollution: a review. *Ecological Entomology,* 40(3), pp. 187-198.

Mackie, I. & Racey, P., 2007. Habitat use varies with reproductive state in noctule bats (Nyctalus noctula): Implications for conservation. *Biological Conservation,* 140(1-2), pp. 70-77.

Mackintosh, M., 2016. *Bats and Licensing: A report on the success of maternity roost compensation measures (Report No. 928),* Edinburgh: Scottish Natural Heritage.

Mann, S., Steidl, R. & Dalton, V., 2002. Effects of cave tours on breeding Myotis velifer. *Journal of Wildlife Management,* 66(3), pp. 618-624.

Mathews, F., 2018. *Britain's Mammals 2018: The Mammal Society's Guide to their Population and Conservation Status.* Blandford Forum: Mammal Society.

Mathews, F. & Harrower, C., 2020. *IUCN – compliant Red List for Britain’s Terrestrial Mammals. Assessment by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage. Natural England,* Peterborough: Mammal Society.

Maziarz, M., Broughton, R. & Wesolowski, T., 2017. Microclimate in tree cavities and next-boxes: implications for hole-nesting birds. *Forest Ecology and Management,* Volume 389, pp. 306-313.

McAney, K. & Hannify, R., 2015. *The Vincent Wildlife Trust's Irish Bat Box Schemes,* s.l.: Vincent Wildlife Trust.

Meddings, A., Taylor, S. B. L., Knowles, M. & Latham, D., 2011. Managing competition between birds and bats for roost boxes in small woodlands, North-East England. *Conservation Evidence,* Volume 8, pp. 74-80.

Medinas, D. et al., 2020. Spatiotemporal persistence of bat roadkill hotspots in response to dynamics of habitat suitability and actviity patterns. *Journal of Environmental Management,* Volume 7, p. 277.

Medinas, D. et al., 2019. Road effects on bat activity depend on surrounding habitat type. *Science of the Total Environment,* Volume 660, pp. 340-347.

Mendip District Council, 2019b. *Mendip District Council Mells Valley Special Area of Conservation (SAC) North Somerset and Mendips SAC Bath and Bradford on Avon Bats SAC Guidance on Development,* s.l.: North Somerset District Council.

Ministry of Housing, Communities & Local Government, 2019. *National Planning Policy Framework.* London: HMSO.

Ministry of Housing, C. a. L. G., 2018. *National Planning Policy Framework,* London: Secretary of State for Ministry of Housing, Communities and Local Government.

Mitchell-Jones, A., 2004. *Bat Mitigation Guidelines.* Peterborough: English Nature.

Mitchell-Jones, A., Bihari, Z., Masing, M. & Rodrigues, L., 2007. *Protecting and managing underground sites for bats. EUROBATS Publication Series No. 2,* Bonn: UNEP / EUROBATS Secretariat.

Mitchell-Jones, A. J. & McLeish, A., 2004. *Bat Workers' Manual, 3rd edition.* Peterborough: Joint Nature Conservation Committee (JNCC).

Motte, G. & Libois, R., 2002. Conservation of the lesser horseshoe bat (Rhinolophus hipposideros Bechstein, 1800) (Mammalia: Chiroptera) in Belgium. A case study of feeding habitat requirements. *Belgian Journey of Zoology,* 132(1), pp. 49-54.

Mulholland, J., 2015. Soft Felling and Translocating Bat Roosts in Trees - Arboricultural Considerations. *In Practice*, September.

Natural England , 2012. *Natural England Technical Information Note TIN051: Bats and onshore wind turbines Interim guidance.* Second edition ed. Peterborough: Natural England.

Natural England, 2013. *European Protected Species: Mitigation Licensing - how to get a licence (WML-G12).* [Online]   
Available at: http://publications.naturalengland.org.uk/publication/4727870517673984  
[Accessed 23 December 2020].

Natural England, 2014. *Bats and onshore Wind Turbines Interim Guidance. Natural England Technical Information Note TIN051,* Peterborough: Natural England.

Natural England, 2018. *A Review of the Population and Conservation Status of British Mammals (JP025).* [Online]   
Available at: http://publications.naturalengland.org.uk/publication/5636785878597632  
[Accessed 24 December 2020].

Natural Resources Wales, 2017. *Bats and linear infrastructure. A summary of DEFRA research project WC1060 by Dr Anna Berthinussen and Professor John Altringham,* Cardiff: Natrual Resources Wales.

Nicholls, B. & Racey, P., 2006. Habitat selection as a mechanism of resource partitioning in two cryptic bat species Pipistrellus pipistrellus and Pipistrellus pygmaeus. *Ecography,* 29(5), pp. 697-708.

North Somerset Council, 2017. *Somerset and Mendip Bats Special Area of Conservation (SAC): Guidance on Development.* [Online]   
Available at: https://www.n-somerset.gov.uk/wp-content/uploads/2017/02/ED29-Guidance-Note-North-Somerset-and-Mendip-Bats-SAC.pdf  
[Accessed 23 December 2020].

North Somerset Council, 2019a. *Hestercombe House Special Area of Conservation (SAC) Guidance on Development,* s.l.: North Somerset Council.

O'Brien, E. et al., 2018. *The Roads and Wildlife Manual,* Brussels: Conference of European Directors of Roads (CEDR).

O'Connor, G. & Green, R., 2011. *A Review of Bat Mitigation in Relation to Highway Severance,* England: Highways Agency.

Packman, C., Zeale, M. & Harris, S. a. J. G., 2016. *Management of bats in churches - a pilot.,* s.l.: English Heritage.

Pearson, O. & Koford, M. &. P. A., 1952. Reproduction of the lump-nosed bat (Corynorhinus rafinesqueii) in California. *Journal of Mammalogy,* 33(3), pp. 273-320.

Poulton, S., 2006. *An Analysis of the Usage of Bat Boxes in England, Wales and Ireland,* s.l.: Vincent Wildlife Trust.

Razgour, O. et al., 2013. Conserving Grey Long-Eared Bats in our Landscape: a Conservation Management Plan. *Bat Conservation Trust*, May, pp. 5-27.

Read, H., 2000. *Veteran Trees: A guide to good management.* London: Engliah Heritage.

Reason, P., 2017. Designing a new access point for lesser horseshoe bats, Gloucestershire, UK. *Conservation Evidence,* Volume 14.

Reason, P. & Bentley, C., 2020. Noise impacts on bats - a sound assessment?. *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management,* Volume 108, pp. 15-18.

Reiter, G. & Zahn, A., 2006. *Bat roosts in the Alpine Area: Guidelines for the renovation of buildings,* s.l.: INTERREG IIB Living Space Network.

Richardson, S., Lintott, P. & Hosken, D. &. M. F., 2019. An evidence-based approach to specifying survey effort in ecological assessments of bat activity. *Biological Conservation,* Volume 231, pp. 98-102.

Rodrigues, L. et al., 2014. *Guidelines for consideration of bats in wind farm projects – Revision 2014.,* Bonn, Germany: Eurobats.

Roemer, C., Coulon, A., Disca, T. & Bas, Y., 2020. Influence of local landscape and time of year on bat-road collision risks. *bioRxiv.*

Rollins, K. et al., 2012. A forensic investigation into the etiology of bat mortality at a wind farm: barotrauma or traumatic injury. *Veterinary Pathology,* 49(2), pp. 362-371.

Russ, J., Briffa, M. & Montgomery, W., 2003. Seasonal patterns in activity and habitat use by bats (Pipistrellus spp. and Nyctalus leisleri) in Northern ireland determined using a driven transect. *Journal of Zoology,* 259(3), pp. 289-299.

Russ, J. & Montgomery, W., 2002. Habitat associations of bats in Northern Ireland: implications for conservation. *Biological Conservation,* 108(1), pp. 49-58.

Rydell, J. & Racey, P., 1995. Street lamps and the feeding ecology of insectivorous bats. *Symp. Zool. Soc. Lond,* Volume 67, pp. 291-307.

Schaub, A., Ostwald, J. & Siemers, B., 2008. Foraging bats avoid noise. *Journal of Experimental Biology,* Volume 211, pp. 3174-3180.

Schofield, H., 2008. *The Lesser Horseshoe Bat Conservation Handbook.* Ledbury, Herefordshire: The Vincent Wildlife Trust.

Scottish Natural Heritage, 2018. *Annex II - Preventing bat access in domestic dwelling houses Introduction.* Edinburgh: Scottish Natural Heritage.

Scottish Natural Heritage, et al., 2019. *Bats and Onshore Wind Turbines: Survey, Assessment and Mitigation,* Edinburgh: Scotish Natural Heritage.

Seckerdieck, A., Walther, B. & Halle, S., 2005. Alternative use of two different roost types by a maternity colony of lesser horseshoe bat (Rhinolophus hipposideros). *Mammalian Biology,* 70(4), pp. 201-209.

Sedgeley-Strachan, J., MacMillan, H., Jermyn, D. & Kidwell, H., 2015. *Our Beacon for Bats Project - end of project report 2010-2014,* s.l.: Vincent Wildlife Trust.

Shepherd, P. & Stroud, J., 2010. *Mitigation for roosts in buildings,* s.l.: Presentation to a workshop at the National Bat Conference 2009/2010.

Shirley, M. et al., 2001. Assessing the impact of a music festival on the emergence behaviour of a breeding colony of Daubenton's bats (Myotis daubentonii). *Journal of the Zoological Society of London,* Volume 254, pp. 367-373.

Siemers, B. & Schaub, A., 2011. Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators. *Proceedings of the Royal Society Biology,* Volume 278, pp. 1646-1652.

Simmons, A., Hom, K., Warnecke, M. & Simmons, J., 2016. Broadband noise exposure does not affect hearing sensitivity in big brown bats (Eptesicus fuscus). *Journal of Experimental Biology,* Volume 219, pp. 1031-1040.

Simon, M., Hüttenbügel, S. & and Smit-Viergutz, J., 2004. *Ecology and conservation of bats in villages and towns.* Bonn: BfN.

Simpson, P., 2011. Ecology legislation update. *In Practice - Bulletin of the Chartered Institute of Ecology and Environmental Management,* Issue 71, pp. 35-36.

Smith, P. & Racey, P., 2008. Natterer's bats prefer foraging in broad-leaved woodlands and river corridors. *Journal of Zoology,* 275(3), pp. 314-322.

Somerset County Council, 2016. *Somerset Habitat Evaluation Procedure.* Taunton: Somerset Councty Council.

Speakman, J., Webb, P. & Racey, P., 1991. Effects of disturbance on the energy expenditure of hibernating bats. *The Journal of Applied Ecology,* 28(3), pp. 1087-1104.

Spoelstra, K. et al., 2017. Response of bats to light with different spectra: Light-shy and agile bat presence is affected by white and green, but not red light. *Proceedings of the Royal Society B: Biological Sciences,* Volume 284, pp. 1-8.

Stone, E., 2013. *Bats and Lighting: Overview of current evidence and mitigation,* s.l.: University of Bristol.

Stone, E., Jones, G. & Harris, S., 2009. Street lighting disturbs commuting bats. *Current Biology,* 19(13), pp. 1123-1127.

Stone, E., Jones, G. & Harris, S., 2012. Conserving energy at a cost to biodversity? Impacts of LED lighting on bats. *Global Change Biology,* 18(8), pp. 2458-2465.

Stone, E. et al., 2015a. Managing conflict between bats and humans: The response of soprano pipistrelles (Pipistrellus pygmaeus) to exclusion from roosts in houses.. *PLoS ONE,* Volume 10.

Stone, E., Wakefield, A. & Harris, S. &. J. G., 2015b. The impacts of new street light technologies: experimentally testing the effects on bats of changing from low-pressure sodium to white metal halide. *Phil. Trans. R. Soc. of London B: Biological Sciences,* Volume 370.

Swift, S., 2004. *The use of heated bat houses as alternative roosts for excluded nursery colonies. Report to MTUK, SNH, EN, CCW & DOENI,* s.l.: s.n.

Thomas, D., 1995. Hibernating Bats are Sensitive to Nontactile Human Disturbance. *Journal of Mammalogy,* 76(3), pp. 940-946.

Tink, M., Burnside, N. & Waite, S., 2014. A Spatial Analysis of Serotine Bat (Eptesicus serotinus) Roost Location and Landscape Structure: A Case Study in Sussex, UK. *International Journey of Biodiversity,* pp. 1-9.

Tuttle, M., Kiser, M. & Kiser, S., 2013. *The Bat House Builder's Handbook.* Austin, Texas: Bat Conservation International.

van der Grift, E. et al., 2018. *Roads and Wildlife Final Programme Report,* Brussels: Conference of European Directors of Roads (CEDR).

van Geffen, K. G. et al., 2014. Artificial light at night causes diapause inhibition and sex-specific life history changes in a moth. *Ecology and Evolution,* 4(11), pp. 2082-2089.

Voigt, C. et al., 2018. *Guidelines for consideration of bats in lighting projects. EUROBATS Publication Series No. 8,* Bonn: UNEP/EUROBATS Secretariat.

Voigt, C. & Kingston, T., 2016. *Bats in the Anthropocene: Conservation of Bats in a Changing World.* London/New York: Springer.

Wang, J. et al., 2010. Seasonal habitat use by greater horseshoe bat Rhinolophus ferrumequinum (Chiroptera: Rhinolophidae) in Changbai Mountain temperate forest, Northeast China. *Mammalia,* 74(3), pp. 257-266.

Waring, P., 2011. *Snowdonia Bat Mitigation Pilot Project Report. ,* Penrhyndeudraeth: Snowdonia National Park Authority.

Waring, S. D., Essah, E. A., Gunnell, K. & Bonser, R. H. C., 2013. Double Jeopardy: The Potential for Problems when Bats Interact with Breathable Roofing Membranes in the United Kingdom. *Architecture & Environment,* 1(1), pp. 1-13.

Weaver, S. et al., 2020. Ultrasonic acoustic deterrents significantly reduce bat fatalities at wind turbines. *Global Ecology and Conservation,* Volume 24, p. e01099.

West, E., 2016. *Technical guidance for assessment and mitigation of the effects of traffic noise and road construction noise on bats.* Sacramento: California Department of Transportation.

Williams, C., 2010. *Biodiversity for Low & Zero Carbon Buildings: a technical guide for new build.* London: RIBA.

Wiltshire Council, 2020. *Trowbridge Bat Mitigation Strategy SPD,* s.l.: Wiltshire Council.

Wiltshire County Council, 2015. *Bat Special Areas of Conservation (SAC) Planning Guidance for Wiltshire.* s.l.:Wiltshire County Council.

Wray, S., Wells, D., Long, E. & Mitchell-Jones, A., 2010. Valuing Bats in Ecological Impact Assessment. *In Practice,* Volume 70, pp. 23-25.

Zeale, M. et al., 2016. Mitigating the Impact of Bats in Historic Churches: The Response of Natterer's bats Myotis nattereri to Artificial Roosts and Deterrents. *PLoS ONE,* Volume 11.

Zeale, M. et al., 2014. *Improving mitigation success where bats occupy houses and historic buildings, particularly churches,* London: Defra Research Project WM0322.

* 1. Acknowledgements

A huge number of people have contributed to the development of this guidance, answering questions, giving advice and the benefit of their experience, and providing case studies. We are all hugely grateful for their input and for submitting to Paola’s tenacious chasing of every relevant case study! While we have not included a comprehensive list here in the beta version, one will be included at the end of the consultation period when we publish a final version.

Valuation exercises

**Example 1:** large footprint development on the east coast of England, supporting ten species, including breeding barbastelle, Natterer’s bats and brown long-eared bats. The site boundary has been amended to avoid the most valuable habitats, and much of the proposed development is currently arable land.

| **Example 1: Results from survey data** | **Importance of roosts (summary of justification only)** | **Assessing the Importance of commuting and foraging habitats (summary of justification only)** | | | |
| --- | --- | --- | --- | --- | --- |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers of bat, or less-regular use by larger numbers of bats | High reliance on habitats as demonstrated by regular use by larger numbers of bats |
| Abundant and widespread (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | Local (Table 3.2) | Districtor above (Table 3.2) |
| Common pipistrelle  Soprano pipistrelle  *Score 2 for this part of the assemblage (of a maximum of 2)* | Limited evidence of roosts on site for either species (though smaller roosts undoubtedly exist).  Maternity colony of 50 **soprano pipistrelles** in a bat box within 200m (outside) of site boundary.  Do not exceed District importance |  |  |  | **Common and soprano pipistrelle:** High numbers of passes recorded; widespread around the site, higher in retained habitats within ZoI. Earliest recordings are generally not close to sunset. Does not exceed District importance |
| Less abundant +Selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | District (Table 3.2) | County/Regional (Table 3.2) |
| Daubenton’s  Natterer’s  Noctule  Brown long-eared  *Score 8 for this part of the assemblage (of a maximum of 12)* | Maternity colony of **Natterer’s bat** using complex of sites (counts 50+). Identified roosts were all off-site, but the small number of individuals radio-tracked had home ranges overlaying suitable habitats within and adjacent to the site indicating other roosts likely to be present. County importance  Maternity colony of 20 **brown long-eared bat** (average for region) within 100m of site boundary. County importance  No evidence of roosts for **Daubenton’s bat** or **noctule**, though smaller tree roosts undoubtedly exist.  Local importance (Local) |  | **Daubenton’s bat**: small numbers trapped/recorded. Foraging associated with water, so largely in habitats outside of the red-line boundary but within ZoI; likely to use some woodland areas close to red line boundary. Local importance (Local) | **Brown long-eared bat:** widespread throughout suitable habitat. Low numbers of passes recorded, reflecting low detectability, but higher numbers trapped.  District importance  **Noctule**: thought likely to be present in moderate numbers (based on project data, including trapping results and relative activity etc.).  District importance | **Natterer’s**: known to use a wide range of habitats. Likely to be reliant on ZoI based on project data and species preferences (presence of roosts, average foraging distances etc.).  County importance, as locally widespread |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | County/Regional (Table 3.2) | National (Table 3.2)  [International if functionally linked to SAC for species] |
| Serotine  Leisler’s  Nathusius’  Barbastelle  *Score 12 for this part of the assemblage (of a maximum of 12\*)* | Breeding colony of **barbastelle** centered on and extending beyond site; individuals also likely to hibernate. National importance (no SAC).  No evidence of roosts of other three species, though likely within ZoI.  No more than District importance | **Leisler’s**: Very uncommon; assessed as very low numbers; however, this species is edge-of-range.  District importance, because edge-of-range | **Serotine and Nathusius’**: Both species uncommon; present in very low numbers from  Local importance |  | **Barbastelle**: wide range of habitats used. Recorded on static detectors throughout red line boundary and into ZoI. Radio tracking shows high-reliance of breeding colony on land within red line boundary, particularly early in summer – use of habitats further afield (particularly to the north) increases later in season  National importance |
| *Assemblage score 2+8+12 = 22. Maximum score\* in this part of the south-east = 24.*  *Percentage score for assemblage: 92%, therefore of National importance.* | | | | | |

\* Outside the known range of Alcathoe bat, Bechstein’s bat and grey long-eared bat, so theoretical maximum of 33 for south-east reduced to 24 on this site.

**Example 2:** Large site, major infrastructure. Isolated in an area where bats are less diverse and populations smaller. This site has woodland which is rare for this area of north-west Wales meaning species probably have high reliance on it.

| **Example 2: Results from survey data** | **Importance of roosts** | **Assessing the Importance of commuting and foraging habitats** | | | |
| --- | --- | --- | --- | --- | --- |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers of bat, or less-regular use by larger numbers of bats | High reliance on habitats as demonstrated by regular use by larger numbers of bats. |
| Abundant and widespread (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | Local (Table 3.2) | Districtor above (Table 3.2) |
| Common pipistrelle  Soprano pipistrelle  *Score 2 for this part of the assemblage* | Many buildings within the red line boundary contain individual roosting bats and/or non-breeding day roosts. A single building has been recorded supporting a small maternity roost of approximately 30 soprano pipistrelles Do not exceed District importance |  |  |  | **Common and soprano pipistrelle**: High activity levels recorded on static detectors in areas of habitat of higher foraging value for bats District |
| Less abundant +Selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | District (Table 3.2) | County/Regional (Table 3.2) |
| Brown long-eared bat  Natterer’s bat  Whiskered/Brandt’s  Noctule  *Score 8 or 10 (of a possible 12) for this part of the assemblage (possible both whiskered and Brandt’s bats present)* | Several buildings within red line boundary support individual or small non-breeding roost for brown long-eared and Whiskered/Brandt’s. Local importance  No noctule roosts detected with the red line boundary.  Maternity roost for Natterer’s bat containing 40 bats located on site. This is a rare occurrence within the county. County |  | **Noctule:** Irregular occurrence during transects and static detector monitoring  Local importance | **Whiskered/Brandt’s bat:** Regular use by smaller numbers District importance  **Brown long-eared:** Regular small number ~10 bats use the site however the isolated woodland within the red line boundary gives high reliance on site however the species is more abundant in region than Natterer’s bat. District importance | **Natterer’s bat:** The bats from the maternity roost are heavily dependent on the woodland due to its isolated nature and significant activity for the species is recorded via transects and static detectors in the wooded areas of the site. County |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | County/Regional (Table 3.2) | National (Table 3.2)  [International if functionally linked to SAC for species] |
| Nathusius’  *Score 3 for this part of the assemblage (but note that a maximum score for this area would only be 6)* | Despite absence of prior evidence from numerous emergence surveys, a single Nathusius’ was located during the supervised demolition of a building within the red line boundary. This was assumed a transitory animal and the roost of low significance to the site. Local importance | **Nathusius’ pipistrelle:** Single occurrence via static detector survey.  Local importance |  |  |  |
| *On the basic score sheet, the assemblage score would be 13-15, which would not be exceptional for “SW England & Wales” (range for importance is because whiskered/Brandt’s not distinguished). However, in this particular low-diversity region, only two of the rarest species are within range, so a maximum score would be 20, suggesting an assemblage of at least Regional importance (65-75%). This illustrates the importance of local modification, but also the issue of undistinguished* Myotis*.* | | | | | |

**Example 3:** Linear infrastructure scheme in Snowdonia: diverse habitat and species assemblage.

| **Example 3: Results from survey data** | **Importance of roosts** | **Assessing the importance of commuting and foraging habitats** | | | |
| --- | --- | --- | --- | --- | --- |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers of bat, or less-regular use by larger numbers of bats | High reliance on habitats as demonstrated by regular use by larger numbers of bats. |
| Abundant and widespread (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | Local (Table 3.2) | Districtor above (Table 3.2) |
| Common pipistrelle  Soprano pipistrelle  *Score 2 for this part of the assemblage* | No roosts have been identified within the red line boundary however there are records of maternity roost within 500m of the boundary. Do not exceed District importance |  |  |  | **Common and soprano pipistrelle:** High levels of pipistrelle activity were recorded during static surveys showing high reliance on the habitat by the species. District |
| Less abundant +Selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | District (Table 3.2) | County/Regional (Table 3.2) |
| Brown long-eared bat  Natterer’s bat  Whiskered/Brandt’s  Noctule  *Score 8 or 10 of a possible 12 for this part of the assemblage* | No roosts have been identified within the red line boundary however there are records of non-breeding day roosts within 500m of the boundary. Local |  |  | **Noctule:** Semi regular occurrence of small numbers of noctules recorded through static surveys District  **Brown long-eared:** regular occurrence of small numbers of brown long-eared recorded through static surveys District | **Natterer’s** High levels of Natterer’s activity at certain times/locations were recorded during static surveys showing high reliance on the habitat by the species. County  **Whiskered/Brandt’s bat:** High levels of Whiskered/Brandt’s activity at certain times/locations were recorded during static surveys showing high reliance on the habitat by the species. County |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | County/Regional (Table 3.2) | National (Table 3.2)  [International if functionally linked to SAC for species] |
| Greater horseshoe bat  Lesser horseshoe bat  Barbastelle  Serotine  Nathusius’ pipistrelle  *Score 15 for this part of the assemblage* | No roosts have been identified within the red line boundary however there are records of maternity and non-breeding day roosts within 200m of the boundary for lesser horseshoe. District | **Nathusius’:** Occasional passes detected via static surveys Local importance  **Barbastelle:** Occasional passes detected via static surveys Local importance  **Serotine:** Occasional passes detected via static surveys Local importance | **Greater horseshoe bat:**  Irregular recordings of this species in low numbers via static surveys Local importance | **Lesser horseshoe bat:**  Moderate activity levels frequently recorded at multiple locations within the red line boundary County |  |
| *On the basic score sheet, the assemblage score would be 25-27 (range for importance is because whiskered/Brandt’s not distinguished, although highly likely both were present), suggesting an assemblage of at least Regional importance. However, in this area of north Wales, outside of the distribution of at least three of the rarest species (if not 4) reducing the possible maximum to 32 (or 29), this assemblage comfortably meets the benchmark for National importance.* | | | | | |

**Example 4:** Swale creation for flood alleviation, northern Gwynedd: Diverse habitat. Close to Natterer’s roost.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Example 4: Results from survey data** | **Importance of roosts** | **Assessing the Importance of commuting and foraging habitats** | | | | |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers of bat, or less-regular use by larger numbers of bats | High reliance on habitats as demonstrated by regular use by larger numbers of bats. |
| Abundant and widespread (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | Local (Table 3.2) | Districtor above (Table 3.2) |
| Common pipistrelle  Soprano pipistrelle  *Score 2 for this part of the assemblage* | A non-breeding roost of 2 soprano pipistrelles was located within a tree inside the red line boundary. Local importance |  |  |  | **Common and soprano pipistrelle:** High levels of pipistrelle activity regularly recorded as habits offered high value foraging potential. District importance |
| Less abundant +Selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | District (Table 3.2) | County/Regional (Table 3.2) |
| Natterer’s  Noctule  ‘*Myotis* spp’  *Score at least 4, possibly 6 for this part of the assemblage* | **Natterer’s**: A roost of approximately 30 bats has been identified within 50m of the red line boundary County  No roosts have been identified for any other species. |  | ***Myotis* sp:** Irregular usage by small numbers of other myotis noted from static detector surveys Less District importance | **Noctule:** During some static detector survey sessions **activity was very high for noctules but timings suggested usage by lower numbers of bats** District importance | **Natterer’s:** Observation of the know roost and connecting hedgerow showed the high reliance on a hedgerow within the red line boundary. The roost identified is of county significance and therefore the commuting value reflects this. County |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | County/Regional (Table 3.2) | National (Table 3.2)  [International if functionally linked to SAC for species] |
| Lesser horseshoe  *Score 3 for this part of the assemblage* | No lesser horseshoe roosts have been identified within 500m of the red line boundary |  |  | **Lesser horseshoe bat:** Regular use by low numbers of bats throughout all surveyed seasons was recorded.County |  |
| *On the basic score sheet, the assemblage score would be 11, which would not be exceptional for “SW England & Wales”. It could be a little higher if the unidentified* Myotis *included more than one species, but it would still be below County importance.* | | | | | | | |

**Example 5:** Moderate sized greenfield development site for ~100 residential units, on the edge of existing residential town in Northern Ireland. Adjacent farmland (low value rye grass grazing for the most part) with two nearby water bodies and small-scale light industrial use. 5km from a major river, little or no woodland and poor-quality hedging.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Example 5: Results from survey data** | **Importance of roosts** | **Assessing the Importance of commuting and foraging habitats** | | | |
| No or very limited evidence of commuting or foraging | Low reliance on habitats as demonstrated by irregular use and generally by small numbers of bats | Moderate reliance on habitats as demonstrated by regular use by smaller numbers of bat, or less-regular use by larger numbers of bats | High reliance on habitats as demonstrated by regular use by larger numbers of bats. |
| Abundant and widespread (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | Local (Table 3.2) | Districtor above (Table 3.2) |
| Common pipistrelle  Soprano pipistrelle  *Score 2 (of a maximum of 2)* | A maternity roost of 40+ **common pipistrelles** in a house adjacent to the site. 5+ **common pipistrelles** identified in a tree within red-line boundary Do not exceed District importance | Soprano pipistrelle: low number of passes recorded long after emergence times suggesting commuting |  |  | **Common pipistrelle**: high numbers of passes recorded; widespread around the site, higher in retained habitats within ZoI  District value |
| Less abundant +Selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | District (Table 3.2) | County/Regional (Table 3.2) |
| Leisler’s bat  Score 2 for this part of the assemblage (of a maximum of 8) | An ash tree had previously been identified as a **Leisler’s bat** roost. Local |  | Moderate **Leisler’s bat** activity in vicinity of roost tree; regular passes recorded elsewhere. Local |  |  |
| Rare/Annex II /Red List Vulnerable or higher, + selected data-deficient (see Table 3.3) | | Local (Table 3.2) | Local (Table 3.2) | County/Regional (Table 3.2) | National (Table 3.2)  [International if functionally linked to SAC for species] |
| Whiskered bat  *Score 3 for this part of the assemblage (of a maximum of 6)* | Small whiskered bat maternity roost recorded in building just outside site boundary. Regional importance | Early whiskered bat activity adjacent to roost building, but limited passes recorded within site boundary. Local |  |  |  |
| *Assemblage score 2+2+3 = 7. Maximum score in Northern Ireland = 16.*  *Percentage score for assemblage: 44%, therefore approaching County importance.* | | | | | |

Case studies

|  |  |
| --- | --- |
| **Stables at Croxteth Park** | |
| *This case study is included to demonstrate successful mitigation for brown long-eared bats*.  During the daytime assessment during 2012, it was evident that a brown long-eared bat maternity roost was using a loft space which opened up into the adjacent upper floor of a stable. Proposals involved complete re-roofing, work to timber beams, timber-treatment to eliminate woodworm and the installation of a fire wall which would reduce the available free flight area by approx. 50%. | |
| **Overview of mitigation**  Due to the work and building requirements, notably the installation of a dividing firewall, it was not possible to maintain the roost in its entirety. However, gaps were provided above the fire wall that would still allow bats to access both areas. In addition, a bat stat twin-panel heater was installed, and the existing access points were retained. | |
| **Design principles**  **Roost height/volume:** the free-flight area was reduced; however, the loft where the majority of droppings was located has approx. measurements of 18x7x4m, with a link to the adjacent upper floor of the stables maintained.  **Access points**: existing access points at eaves level retained to the east and west aspects and to the north elevation through a window opening.  **Thermal regime:** temperatures in original roost: minimum 11 degrees and maximum 33.9°C; average reading 21.4°C.  Current temperatures within the roost now average 23.6°C; with the heater set at 30°C.  **Perching opportunities:** original timbers retained with the addition of pre-treated rough sawn planks (150mm wide x 25mm thick) affixed to the rafters from the ridge beam down to a distance of 600mm. These were designed to encourage the bats away from the breathable membrane (BRM) and provide a localised and constant heat source.  **Roofing membranes:** No roof lining was originally present; however, to secure funding for the work, a guarantee of ten years by the contractor was required They would not provide that guarantee using bitumen felt; only do so with a BRM. We were asked to formulate a scheme that Natural England would be able to approve and, whilst not 100% happy, decided on the above method which unexpectedly was approved by Natural England. | Dotted line shows loft space above the property which connects to the upper floor of adjoining stables |
| cid:7bee3f39-fb14-45a6-a4d7-ffcc147fbdbe@winuk.mail  Interior of roost with additional timber provision, heating panel and droppings below this feature  All existing timbers were maintained and droppings retained in the loft space after the works. |
| **Location and connectivity; external environment:** The roost was in the same location, but the bats were heavily dependent on the dark shelter that a yew tree provided during emergence and re-entry. The importance of this feature was emphasised to the Local Authority to ensure it remained. | **Protection against vandalism**: The building is within the grounds of council-owned land and is secured from general public  **Long-term security**: The council has a long-term obligation to maintain the building which is Grade II listed. Notices have been provided at loft hatches to ensure no unauthorised access. |
| **Overview of monitoring results** | |
| In May, June and July 2012, numbers prior to the work comprised of 8 emergent brown long-eared bats, with 17 and 18 brown long-eared bats respectively re-entering during the two dawn surveys.  Monitoring was undertaken in line with the terms of the licence during 2013 with 30 individuals recorded; 2014 saw an increase to 68 individuals, with large accumulations of droppings clearly demonstrating that the mitigation was successful. | In 2021, a daytime inspection revealed droppings had increased significantly especially in the location of the heating panel. Additionally, levels of droppings in the upper floor of the stables saw a large increase, notably where the firewall divides the main roost. This indicates the bats are using both areas, possibly at different times of the active season (they are still able to access and utilise both areas without restriction).  The roost will continue to be monitored in 2021. |
| **Challenges** | **Lessons learned** |
| The main challenge with this site was the use of the BRM; the council would have lost the grant for the works without the guarantee secured by the use of a BRM.  Had the work not taken place, there would have been a rapid deterioration in the roof, more wood worm damage and, as a consequence, the loss of the roost.  It was important that the bats were discouraged from coming into contact with the BRM; this was achieved by offering alternative roosting opportunities in the form of extensive rough-sawn timbers and a localised heat source. | The reduction in the size of the loft space and of the associated draughts increased mean temperatures within the roof and was achievable without compromising the roost because the initial space was so large.  It may have been possible to challenge the use of BRM more strongly so that traditional bitumen was used, but the council were keen to use the appointed contractors who stipulated BRM, and it was not possible (or appropriate) to influence that choice.  The BRM has been closely inspected and has not to date revealed any wear or droppings to suggest the bats are roosting on it or in close proximity. |
| *Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photographs* | |

|  |  |  |
| --- | --- | --- |
| **Peckforton Castle** | | |
| *This case study is included to demonstrate the modification of a Natterer’s bat breeding roost*  A daytime survey revealed evidence of a Natterer’s bat breeding roost within stone wall cavities in a room of the castle. The west wing was originally redundant; however, plans for this area were for conversion to provide additional guest accommodation for the hotel, and this proposed refurbishment would have resulted in the loss of a roost for over 60 bats. | | |
| **Overview of mitigation**  Originally there was no viable alternative to keeping the room that contained the roost; the hotel were adamant that they needed to provide their guests with additional accommodation. A proposal was negotiated that would retain the roost by reducing the height of the ceiling within the ‘new guest room’ but still allow free flight by the bats. The existing access / ingress was also retained. | | |
| **Design principles**  **Roost height/volume:** The existing area previously available for bats was *c*.36m2, following the conversion of the room with a corridor construction this was reduced to *c.*27m2.  **Access point**s: The bats left the building via a window opening. This area could be retained; however, it was partially closed off with glazing incorporated to the lower section (within the hotel room used for guests)  **Thermal regime:** Previous temperatures of the roost were not taken in the first instance as the West wing was highly exposed. Recording of the new roost area provided temperatures averaging 21.1°C. The ceiling that partitions the roost area and the guest room was thermally and acoustically insulated to avoid transfer of heat or noise.  **Perching opportunities:** original features and roost locations retained.  **Roofing membranes:** n/a - original wall cavities retained.  **Location and connectivity; external environment:** All maintained and unaffected  **Orientation (if relevant):** n/a  **Protection against vandalism**: the loft hatch is not accessible to the public  **Long-term security**: The roost is well documented and under the protection of the hotel | | Exterior of Peckforton Castle |
| Existing and retained roost locations in wall cavities |
|  | | Summary of the provision and retention of the roost with reduced area for free flight prior to emergence |
| **Overview of monitoring results** | | |
| During the initial surveys in 2009, a maximum of 61 Natterer’s bats were identified as roosting with the room of the castle | During subsequent monitoring at the new roost in 2010, 81 Natterer’s bats were observed emerging from the roost at the beginning of August with 25 emergent bats towards the end of September. However, numbers recorded in 2013 noted a slight decline respectively observing the emergence of 57 (June), 0 (July) and 42 (August). These results demonstrated the roost continued to be used with bats still *in situ* until late September. There was some suspicion of roost obstruction in 2013 which could account for the reduction; however, this was discussed and rectified and the bats were still using the property in August. | |
| **Challenges** | **Lessons learned** | |
| It was difficult to persuade the hotel to keep the roost *in situ* as they were keen to provide the roost in its entirely; however, the proposal outlined above meant they were happy to keep the roost at the castle even though it resulted in a reduced height within the guest accommodation. | Try wherever possible to retain existing roost features and work with site owners to achieve the best results for bats but also consider their commercial operations. | |
| *Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photographs* | | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Holiday Inn Hotel** | | | | | |
| *This case study is included to demonstrate the creation of soprano pipistrelle maternity roost*  During a daytime assessment and following dusk surveys, a large soprano pipistrelle roost was identified. The hotel was having complaints about odour caused by the bats as the roost was located within a void above an external staircase with the smell permeating into the corridor and hotel rooms, especially in hot weather. If a solution hadn’t been provided, this roost would have been excluded as a number of rooms could not be used (a direct financial impact). | | | | | |
| **Overview of mitigation**  Under licence and outside of the breeding season, the roost was dismantled and a new void constructed above the existing staircase void. Droppings were collected and transferred into the new void and measurements replicated what was currently being used by the bats. Access points were provided within the same locations as previously identified. | | | | | |
| **Design principles**  **Roost height/volume:** New void above the existing replicating the dimensions: i.e. flat roof (top of the staircase) 1m x 1.5m x 150mm and 4m x 1m x 150mm deep (running down the staircase) – see photograph showing access-points.  **Access point**s: Several access points with a gap of approx. 15-18mm wide x 200mm long were located behind the barge board providing access to the roof void. approx. 13m above ground level. These replicated the emergence locations identified from the dusk surveys.  **Thermal regime:** n/a  **Perching opportunities:** Roost was replicated above the original roof void.  **Roofing membranes:** New flat roof covered in bitumen with three layers of felt (the standard procedure for these systems).  The existing roost was covered in bitumen and green mineral felt to seal the roof and internal ceiling from the new roost to prevent seepage and odours into the hotel. Droppings were collected and transferred into new roost and existing barge boards were re-used at the newly created loft void.  **Location and connectivity; external environment:** n/a - roost modified in situ.  **Orientation (if relevant):** n/a  **Protection against vandalism**: The area in which the roost is located cannot be accessed by the general public.  **Long-term security**: The hotel needs to stay in a good state of repair and the roost is well documented with the hotelier.    Newly constructed loft void above existing – area sealed and purely dedicated for the soprano pipistrelle bat roost | | | | Holiday Inn Hotel | |
|  | |
| **Overview of monitoring results** | | | | | |
| **Before the works**: soprano pipistrelle count | | **After the works**: soprano pipistrelle count | | | |
| May 2009 | 199 | 8 July 2010 | | | 140 |
| July 2009 | 137 | 16 August 2010 | | | 162 |
|  |  | 16 June 2011 | | | 214 |
|  |  | 14 August 2011 | | | 225 |
|  |  | 17 July 2012 | | | 422 |
|  |  | 14 August 2012 | | | 246 |
| **Challenges** | | | **Lessons learned** | | |
| Persuading the hotel owners not request exclusion | | | Innovative methods to secure the roost and alleviate the problems were possible by being mindful of the problems (and commercial impacts) the hotel were experiencing. This meant the ‘easy option’ of just providing external bat boxes (which may not have been as successful or had the same longevity) was not necessary. | | |
| *Thanks to Kylee Wilding, Tyrer Ecological Consultants Ltd, for text and photographs* | | | | | |

|  |  |
| --- | --- |
|  |  |
|  |
|  |

Creating a roost behind a fascia board

Diagram, engineering drawing

Description automatically generated

|  |  |
| --- | --- |
| **Fascia board roost in practice (1)**  Extension of semi-detached dormer bungalow on northern gable elevation (north-west Leicestershire).  Common pipistrelle bats were using the underside of the flat roof of the dormer windows as a maternity roost in the southerly part of the semi-detached property. Additional bat roosting features were installed in the extension to improve roosting opportunities for crevice-dwelling bats.  On the western gable elevation, when the property was being extended, an Ibstock Brick Built Bat Box was inserted into the gable wall apex. This was monitored for six months with weekly visits from March to the end of September. No bats were seen to use the bat box.  A barge board was required on the western elevation (as a local architectural feature, adjacent to the brick-built bat box, to be created in uPVC-faced timber.  In order to create access to the rear of the fascia board for crevice-dwelling bats timber packers were inserted at the rear of the barge board. These resulted in the barge board being ‘bowed’ away from the brickwork in the parts of its length.  Common pipistrelle bats began to use the rear of the barge board within two months of completion of the work and individual common pipistrelle bats were recorded regularly using the feature throughout the six-month summer monitoring period.  *Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.* |  |

|  |
| --- |
| **Fascia board roost in practice (2)**  Refurbishment of a flat-roofed extension to a dwelling (North Warwickshire).  Replacement of the white uPVC fascia boards with brown/imitation timber fascia boards was undertaken at the same time as the flat roof was covered with a butyl sheet.  The original fascia boards were uPVC with no timber backing. When the fascia boards had been fitted, there was a gap of 20mm under the fascia board as it had been fixed to the roof joist ends. A single common pipistrelle bat was found under the fascia boards as they were being removed.  There was no access to the cavity wall, the wall plate closing off the cavity. The bat was found on the northern elevation at the end of February and was immediately returned when the flat roof was completed. The uPVC fascia board was replaced with the access for bats re-created. Individual common pipistrelle bats were recorded emerging from the feature during the spring of that year.  *Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.* |
|  |

Bat access ‘slate’

Chart, diagram, schematic

Description automatically generated

|  |  |
| --- | --- |
| **Bat access slate in practice**  During roof repairs to a care home in Staffordshire, a maternity roost of brown long-eared bats was discovered. The roof spaces were complex with four inter-connected roof spaces with different aspects.  There was water penetration through missing slates and, in the past, contractors had used a breathable roofing membrane when undertaking repairs on a part of the roof.  The proposal was to replace the breathable roofing membrane with a bitumous type 1F underfelt and to install lead bat slates, one on each external face of the roof where bats had been seen emerging and commuting to adjacent woodland.  The roof works were undertaken one roof section at a time after the maternity roost had dispersed so that repairs would minimise any disturbance (should any bats remain), and before the hibernation period so that there was no likelihood of disturbing hibernating bats.  Lead bat slates were installed and the maternity roost of brown long-eared bats were recorded back in the property in the following summer, using the bat slates as access to the roof spaces.  To aid bats accessing the roof space a timber platform was constructed internally so that the bats could fly and land on the platform before emerging through the bat slate.  *Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.* | 23 Brown long eared bats at the ridge    Extensive bat droppings under the ridge board    Bat slate in position (neat and unobtrusive) |

Triple ridge system roosting opportunity

Diagram, engineering drawing

Description automatically generated

|  |  |
| --- | --- |
| Triple ridge system roosting opportunity in practice  A sandstone store building annexed to a dwelling (Derbyshire) was to be re-roofed because of water penetration. Individual brown long-eared bats had been recorded using the building and the re-roofing was to be undertaken with the bats allowed back into the roof space. The rotten rafters were to be replaced but the method of construction was such that there was no ridge board.  A new ridge board was to be installed to strengthen the roof, helping brace the rafters. The roof was then to be covered with a bitumous underfelt and the ridge tile access recreated.  When the ridge board was installed a triple ridge board was created so that there would be new crevices for the brown long eared bats.  In one area the bitumous underfelt was cut to allow the brown long-eared bats access to the underside of the ridge tiles. A ventilation ridge tile was then installed adjacent to this access, in the same place that the bats had originally emerged.  One brown long eared bat was recorded using the roost again within six months when a monitoring visit was undertaken.  *Thanks to Chris Smith, Tamworth Property Services, for text, plan and photographs.* |  |

|  |  |
| --- | --- |
| Eaves access for lesser horseshoe bats  *This case study shows a low-level access which reduces heat loss compared to a dormer.* | |
|  | |
|  |  |
|  |  |
| The access shown in the photographs was just under 400mm when installed. The roost was used by low numbers of lesser horseshoe bats before and after the access was created, but similar access-points (several gaps along the same eave) are in use at the roost described in Reason (2017), which supports large numbers of the same species.  *Thanks to Richard Green, Richard Green Ecology, for plan and photographs.* | |

|  |  |  |  |
| --- | --- | --- | --- |
| Providing additional microclimates for horseshoe bats  *This case study shows low-cost enhancements to existing roosts made by the Devon Bat Group. The boxes have fine greenhouse mesh sewn into them from which the bats hang. Both species of horseshoe bats use the small fish boxes (up to nine greater horseshoe bats have been recorded in a single box).* | | | |
| Around 70-80 individuals used the fibreglass pot...  Avon Valley roost: a plant pot with greenhouse shading fixed inside and lined with expanding foam has been added. As the photo shows, many of the bats cluster together in the pot. | | | Holne roost: these polystyrene food boxes were placed in the maternity roost. The concentration of droppings shows the boxes are well-used, which makes it easier to clear out any build-up. |
| A picture containing wood, stone  Description automatically generated | Kingsbridge: underground roost used by small numbers of greater horseshoe bats as a hibernation and day roost. | | The greenhouse mesh: a solid fine mesh plastic which is available from garden centres. |
| Devon Bat Group provided funding for the materials. | | A picture containing oven, open, kitchen appliance, stone  Description automatically generatedBerry Head: a cave maternity site for greater horseshoe bats (part of a SAC); numbers of pups have been declining over the years for a number of reasons.  A box was designed and fitted into the breeding chamber in March 2018; in 2019, first recorded use (six pups); in 2020, fourteen pups were recorded.  This project was designed, built and installed by ecologists David & Colin Wills, with permission from Natural England. | |
| *Thanks to Sylvia Bevis, Colin Mills and David Willis (Devon Bat Group) for text and photographs* | | | |

|  |  |  |
| --- | --- | --- |
| **Primary School, Forest of Dean, Gloucestershire** | | |
| *This case study is included to demonstrate the value of retaining access points in modified roosts.*  During repair works to the roof of a primary school in March 2009 a bat was found and works stopped. Subsequent surveys in summer 2009 identified a maternity colony of brown long-eared bats, along with non-breeding roosts of lesser horseshoe, common and soprano pipistrelle. The proposed works comprised replacement and re-lining of the roof, and replacement and repair of internal roof timbers, soffits and bargeboards due to rot and beetle infestation. | | |
| **Overview of mitigation**  The mitigation strategy was to retain the roosts in situ, avoiding disturbance to bats by timing works to avoid the breeding season. As presence of hibernating bats was unlikely, work took place during December to March. | | |
| **Design principles**  **Access point**s: The access point used by brown long-eared bats was a gap between the stonework and bargeboard at the apex of a gable end. Bats crawled over the wall-top to gain access to the lofts. As existing purlins were retained, the spacing between bargeboard and wall, and spacing between wall tops and rafters remained unchanged.  **Perching opportunities:** Some rafters in poor condition required replacement, majority of timbers retained.  **Roofing membranes:** at the time the licence was granted, use of non-bitumen coated roofing membranes was still allowed although there were increasing concerns about its use in roosts. The re-roofing used non-bitumen coated roofing membrane but a single sheet of 1F underfelt was specified along each side of the ridge beam.  **Location and connectivity; external environment:** Unchanged.  **Protection against vandalism**: Premises are fairly secure, as in active use as a school. | | **Roost height/volume:** Unchanged.  **Thermal regime:** Unchanged.    Interior of building during works |
| Bat access point at gable apex |
| **Overview of monitoring results** | | |
| Pre-development surveys identified a peak count of at least 35 brown long-eared bats (end July count), plus up to six common pipistrelle bats, and one soprano pipistrelle bat. | Monitoring in mid-July 2011 (yr 2 following works) recorded 31 brown long-eared bats emerging from the same access point, and four common pipistrelle bats emerging elsewhere on the building. Further surveys in 2016 (yr 7) found peak counts of 35 brown long-eared bats (post-breeding), two common pipistrelle and one soprano pipistrelle emerging. | |
| **Challenges** | **Lessons learned** | |
| Contractors failed to implement the required 1F, and due to restricted access to the building once re-occupied by the school, this was not picked up in time to correct it (though it has been done retrospectively during a subsequent phase of works). Fortunately, no evidence of fluffing or trapped bats has been found. | Access should have been gained during replacement of the roof membranes, to check implementation of the 1F underfelt strip, but current best practice and licensing policy would in any case require use of 1F or timber sarking throughout. | |
| *Thanks to David Wells and Rebecca Collins, Collins Environmental Consultancy, for text and photographs.* | | |

|  |  |  |
| --- | --- | --- |
| Stately Home Repairs, Worcestershire | | |
| *This case study is included to demonstrate the value of re-instating roosts and access points as closely as possible during repair and refurbishment works*  Repair works were proposed to a Grade II\* listed building in 2004, which was known to support a common pipistrelle maternity roost. Proposed works included the strengthening of roof timbers, repairing of gutters, re-pointing of chimneys and repairing brick work. Bats were roosting in a soffit box supporting the lead gutter, in voids between the lead and the soffit box and, to a lesser extent, in the roof void. | | |
| **Overview of mitigation**  The mitigation strategy was to retain the roost *in situ*, avoiding disturbance to bats by timing works to avoid the breeding season. As presence of hibernating bats was unlikely, work took place during October to March. | | |
| **Design principles**  **Roost height/volume:** Unchanged.  **Access point**s: The access point used by bats was a gap between the wall top and the underside of the soffit, either side of a gutter downpipe.  **Thermal regime:** Unchanged.  **Perching opportunities:** Some rafters in poor condition required strengthening, and much of the soffit timber needed replacing. A quantity of droppings was removed from the old soffit and spread in the replacement one prior to fitting of the lead gutter.  **Roofing membranes:** As was common at that time, the 1F membrane present prior to works was replaced with non-bitumen coated roofing membrane, though dark-coloured membrane was specified, and the main roosting site was not in contact with this membrane.  **Location and connectivity; external environment:** Unchanged.  **Protection against vandalism**: The roost is fairly secure against vandalism being at eaves height on a two-storey building. | | Access point against wall top |
| Gutter with lead removed showing droppings |
| **Overview of monitoring results** | | |
| Pre-development surveys identified a peak count of at least 247 common pipistrelle bats (June count). | Monitoring in mid-July 2005 (yr 1 following works) recorded 181 common pipistrelle bats emerging from the same access point. | |
| **Challenges** | **Lessons learned** | |
| The contractors’ programme was delayed due to poor weather so that works extended into April, when bats may have been wanting to re-occupy the roost. It is clear that bats did so almost immediately on completion of works. | With hindsight, given the time of year and potential for weather-related delays, it should have been specified that the roost area was completed earlier in the programme, to avoid the risk of bats returning before works were complete. | |
| *Thanks to David Wells and Rebecca Collins, Collins Environmental Consultancy, for text and photographs.* | | |

|  |  |
| --- | --- |
| Replacement roost using an ‘American style’ bat box | |
| An extension to the east side of the main Mallow General Hospital, Co. Cork, was required. Prior to the development commencing, a maternity colony of soprano pipistrelles was found roosting within the building and the roost access, a ventilation grille, would be lost, covered by the new extension. | |
|  |  |
| Ventilation grille used by soprano pipistrelles | The grille allowed bats to enter the wall cavity |
| Work that did not impact on the roost began in July 2012 before the bats were excluded under licence in September 2012. An American-style bat box (supplied by Bat Roost Ireland) was recommended as it had been proven to be favourable for soprano pipistrelle-use in similar situations in Ireland, is maintenance free and self-cleaning. This large box design offers bats a safe, dark and warm haven with a space large enough for 100 animals or more. The box was fitted on the south-facing gable end of an adjacent, older building outside of the area being developed, approximately 30m from the existing roost. On the same day (mid-September 2012), the bats were excluded from the original roost using a one-way flap constructed of stiff plastic, secured by duct tape, over the ventilation grille. This flap, which allowed bats to leave the roost but prevented access on their return, was left in place for a period of seven days to ensure that all animals had vacated. The grille was then permanently sealed with concrete | |
|  |  |
| Mounting the American-style bat box on the adjacent building | The large bat box positioned high on the nearby building. |
| **Overview of monitoring results** | |
| A dusk emergence survey in July 2012 recorded 72 soprano pipistrelles exiting the building via a ventilation grille. | Following completion of the extension, the box showed signs of bat use in spring 2014. That  summer, 78 soprano pipistrelles were counted exiting the box, with 77 in 2015 and 74 in 2016. |
| **Challenges** | |
| The recommended location for mounting the bat box was beneath the eaves of the main hospital building and as close as possible to the original roost entrance. However, due to the presence of windows at this location, it was decided to choose another site for the box to avoid the likelihood of bats entering the hospital wards when returning to their roost. | |
| *Thanks to Conor Kelleher, Aardwolf Wildlife surveys, for case study and photographs.* | |

|  |  |
| --- | --- |
| **Exclusion of bats from an inaccessible mine adit using smoke** | |
| *This case study is included to demonstrate the process of exclusion from a winter site using unorthodox methods*  Coal Tar Adit was one of a number of mines and caves along the Clydach Gorge used by roosting lesser horseshoe bats (maximum number: three). These underground sites are a qualifying feature of the Usk Bat Sites SAC. Coal Tar Adit was closed and filled in under NRW licence to enable construction of the A465 Heads of Valleys Section 2 Improvement Scheme. | |
| Initially inspected internally (from 1994), roof collapse in 2000 prevented human access, but would have allowed bats continued use (extent of use, and of passageways, unknown).  Monitoring using an Anabat Express detector inside the entrance confirmed use by lesser horseshoe bat in early September 2015, despite dense bramble scrub growth over the grilled entrance (*pictured right*) which suggested it might be inaccessible to bats.  Measures to exclude any bats first involved clearance of all vegetation around the entrance and continuing to monitor bat presence. |  |
| After bats were still recorded during the five following nights, the entrance of the adit was lit with tower flood lights (*pictured right*). On the first night of deployment, the lighting was switched on at midnight (to allow any roosting bats to emerge without disturbance) and left on until after dawn.  On the second and subsequent nights, the lighting was turned on one hour after sunset, to allow any bats still roosting in the adit to emerge but reducing the risk of bats returning to roost before the light was switched on. | A close up of a hill  Description generated with high confidence |
| The entrance was also partially closed (*pictured right*) to further discourage bats from returning and to allow easy closure once it was confirmed that bats were absent.  Anabat Express monitoring continued each night following installation of these measures but lesser horseshoe bats were still recorded using the adit, i.e., the measures had not dissuaded them from returning to roost. |  |
| After clearance of vegetation and lighting of the entrance had failed to exclude bats from the adit, we resorted to using smoke.  A 16-hour duration sawdust food-smoking tray was used to generate smoke in the entrance of the adit (*pictured right*) on 20 October 2015. The spirally arranged metal tray was filled with sawdust and lit one hour after sunset and left smouldering inside the entrance on an extendable piece of wood for the following 16 hours, i.e., until after dawn the following day. | Image result for sawdust food smokerA close up of a rock  Description generated with very high confidence |
| On the first night of smoker deployment, two lesser horseshoe bat passes were recorded shortly after the smoker was deployed. It was assumed that one or two bats emerged from the adit due to the presence of smoke. No further calls were recorded that night.  On the second night of smoker deployment, one lesser horseshoe bat pass was recorded in the middle of the night. It is possible that this bat was returning to the adit. It may have entered the roost or may have opted not to because of the smoke.  No further bat passes were recorded on the following three nights, which were also subject to smoker deployment. The entrance was therefore closed using a timber board over the entrance, enabling an Anabat Express detector to be deployed and collected from inside the entrance. Three further nights’ monitoring was undertaken inside the adit after the entrance had been closed. The detector was analysed each day and no bats were recorded. It was therefore assumed that bats had successfully been excluded from the adit.  The adit was then dug back from the entrance during the day using a machine excavator under an ecological watching brief. No bats were encountered or seen to emerge during the excavation. The adit was excavated to its conclusion over several days, closing the entrance at the end of each day to prevent bats from returning overnight. | |
| **Take-home messages** | |
| Lesser horseshoe bats continued to use the adit despite the cluttered entrance and subsequent lighting, demonstrating high roost fidelity in the face of disturbance.  The adit was in use from early September (i.e. prior to the main hibernation season), underlining the need for confirmatory surveys of ‘winter’ sites outside of winter. | |
| *Thanks to Richard Green for the case-study, supplied with the permission of the Welsh Government.* | |

|  |  |
| --- | --- |
| ‘Bat-friendly’ lighting along a canal path to reduce fragmentation | |
|  | |
| Pic 22 - R | The towpath along the Grand Canal (Dublin) was upgraded to a cycle path for use as a greenway and the entire route had to be lit during the hours of darkness.  The canal is designated as a proposed Natural Heritage Area and five bat species were known to occur to use the site for foraging and commuting: Daubenton’s bat, common and soprano pipistrelle, brown long-eared and Leisler’s bats. |
| The greenway along the Grand Canal in Dublin | The low-intensity, computer-controlled towpath lighting. |
| Closer from bridge 3 - R | |
| To safeguard the canal’s bat populations, it was necessary to install a sophisticated, computer-controlled lighting system which was devised specifically for the project.  This system ensured that light-intensity levels were kept to a minimum throughout the route during the active bat seasons and also prevented any overspill of light onto the surface of the canal.  The system was trialled along a short section in 2009 which demonstrated that the lighting could be designed, constructed and operated to satisfy on-site health and safety needs within the required ecological parameters. Bat activity levels were assessed before and during the trial, prior to consent being granted.  The strategy included a bespoke lamp design with targeted louvres and computerised seasonal light intensity controls. The system allows the light intensity of the lamps to be seasonally adjusted so that the lux levels are reduced during the active bat seasons of spring, summer and autumn to between 0.5 and 1 Lux between sunset and sunrise times. | |
| *Thanks to Conor Kelleher, Aardwolf Wildlife surveys, for case study and photographs.* | |

|  |
| --- |
| Alternative flyways to guide bats to structures |
| A picture containing tree, outdoor, grass, dirt  Description automatically generatedA picture containing tree, grass, outdoor, cement  Description automatically generated |
| *Thanks to Kate O’Neill for photographs.* |

Temporary flight lines

|  |  |
| --- | --- |
| A close up of a brick building  Description automatically generated  Dead painted birch twigs in boxes (light-weight and inexpensive); could give more height to a temporary flight line.  Instant ‘textured’ plastic hedgerow (front and rear faces).  Spotted in Europe (not in use as mitigation); efficacy not tested. | A picture containing outdoor, hydrant, fire, grass  Description automatically generated |
| A house covered in snow  Description automatically generated |

|  |  |
| --- | --- |
| Two Mile Bottom artificial hibernation tunnel, Thetford Forest | |
| This tunnel was designed by John Goldsmith and Nick Gibbons based on a similar extension to the bat hibernaculum at High Lodge. Since its construction in 2004, the use of this purpose-built hibernaculum by bats over the years has gone from strength to strength.  The Two Mile Bottom tunnel has proved to be a great success, undoubtedly the best purpose-built hibernaculum in the UK and a good general recipe for others to follow. The tunnel at Two Mile Bottom continues to provide a safe hibernation roost for *Myotis* bats – Daubenton’s and Natterer’s – as well as brown long-eared bats. | |
| **Overview of mitigation**  The hibernaculum consists of a 95 m long asymmetrical Y-shaped concrete-block tunnel with an access grille, ventilation pipes, escape hatches and bat bricks built into the ceiling. | |
| **Design principles**  **Roost height/volume:**  95m tunnel constructed in a Y-shape with a long main stretch and a short spur, high enough for upright inspection  **Access points:**  Grille at north eastern end facing north towards the river.  **Thermal regime**: For details see <https://issuu.com/suffolknaturalistssociety/docs/tsns49a>.  **Perching opportunities:** Numerous Norfolk bat bricks and modified London bricks. Both horizontal and vertical planks hang on the walls and slotted logs stand on concrete blocks on the tunnel floor  **Roofing membranes:** None  **Location and connectivity; external environment**:  The site was chosen where a small, shallow valley, possibly an area of old sand diggings ran down almost to the Little Ouse river in the Thetford Forest. Key points were that the site was  near a river where there was lots of bat activity  north-facing  shaded and  away from areas of disturbance  little light pollution  **Orientation:** The tunnel was constructed in a Y-shape with a long main stretch and a short spur with ventilation shafts at the end of both, to provide a range of conditions within the site.  **Protection against vandalism:** Lock & bolt system to prevent unauthorised access via secure grille and post and rail fencing to prevent accidental damage from cyclists and forestry operations with large brash placed on track created over the roof either side of the tunnel to dissuade cyclists. Damaged was caused to air vent when grille could not be forced open by vandals.  **Long-term security:**  Forestry England staff particularly the Conservation Manager make regular inspections. | Overview photo [Credit Nick Gibbons] |
| Detail photo  [Credits; Log - Sue Hooton; Tunnel plan – Nick Gibbons] |
| **Overview of monitoring results**  The artificial hibernaculum was first used by one brown long-eared bat in January 2007, the third winter after it was built. In 2008, two brown long-eared bats were counted in the hibernaculum. From 2009 to 2013, three bat species were counted in the hibernaculum brown long-eared bats, Daubenton’s bats, and Natterer’s bats with the total number increasing each year (2009: max 16 bats; 2010: max 31 bats; 2011: max 31 bats; 2012: max 50 bats; 2013: max 62. Hanging planks and logs with slots cut into them were placed inside the tunnel to increase the roost features and **in January 2019, a maximum total of 91 bats were recorded** (28 Daubenton’s, 62 Natterer’s and 1 brown long-eared bat). |
| **Lessons learned**  The original concept was to have one arm of the ‘Y’ sloping up and the other down but, due to the unstable nature of the sandy soil, digging down deeper to achieve this was not possible for safety reasons. As a result, both arms are almost horizontal.  Ideally, a floated roof with reinforced concrete would have been better but not possible logistically.  Using beam and block roof meant the risk of the metal in the reinforced beams rusting. Ends of the beams were coated in bitumen and later encased in concrete to give some protection.  Bigger air ducts in the initial stages, that could be adjusted down, would have meant fewer modifications later on to increase air flow.  However discrete this location seemed at the time of its design, its location is not unknown and regularly attracts unwanted attention/vandalism. Better signage explaining what it is, its legal status etc would probably be beneficial. |
| *Case study supplied by Sue Hooton, Suffolk Bat Group, with input from Forestry England as landowner (Neal Armour Chelu, District Ecologist, East England and Andy Palles-Clark, Conservation Manager, Thetford Forest) as well as Suffolk BG stalwarts Arthur Rivett and Nick Gibbons.* | |

|  |  |  |
| --- | --- | --- |
| Denbury Lime Kiln | | |
| **Overview of mitigation**  Hibernaculum designed for horseshoe bats as mitigation for a local road improvement scheme. | | |
|  | | In 2010, prior to conversion, the front shelter was used as a night roost for lesser horseshoe bats and the ‘burning pit’ (see plan) was filled with soil and rocks.  Post-conversion monitoring:  08/10/2020: nine greater horseshoe bats;  25/11/20: eight greater horseshoe bats;  26/01/2021: one greater horseshoe & two lesser horseshoe bats. |
|  | | |
|  | | |
|  |  | |
| Inside lean-to showing the archway leading to the burning pit | Entrance to burning pit | |
| *Case study supplied by David Wills, Devon Bat Group.* | | |

Horseshoe access

A picture containing outdoor, building, bench, sitting

Description automatically generated

Shielded letter-box access to lesser horseshoe bat basement hibernaculum, in place now for over 15 years. The cover prevents draughts and access by birds.

The access-point is quite low but, before the new door and access-point were fitted, the bats gained access through a two-inch gap at floor level. Photo: Paola Reason (2018)

Recommended mitigation by species and roost type

Table A2.1: Roost loss: mitigation and compensation guidelines by roost type and species.

The table assumes all options for ‘avoid’ have been fully considered, all alternatives have been explored; and **compensation for loss is unavoidable**.

| **Species**  **Roost type** | **Abundant and widespread:**   * common pipistrelle, soprano pipistrelle (all regions) | **Less abundant and selected data-deficient:**   * Daubenton’s bat, Natterer’s bat, brown long-eared bat (all regions) * whiskered bat, Brandt’s bat * noctule (England) * Leisler’s (Northern Ireland) | **All other species except Annex II**  For what is covered under this category in each region, see *Table 4.1 rarity category* | **Annex II**  Building roost compensation targeted to greater horseshoe bat, lesser horseshoe bat; tree-roost compensation targeted to barbastelle, Bechstein’s bat.  [This does not apply to winter roosts] |
| --- | --- | --- | --- | --- |
| Feeding perches; night-roosts | Buildings: typically, no licensing requirement for compensation. | Buildings: typically, no licensing requirement for compensation. | Buildings: typically, no licensing requirement for compensation. | Well-used night roosts should be replaced on a like-for-like basis. |
| *Following Table 4.2, all are considered ‘less than district importance’, other than well-used night roosts for rarer species.* | | | |
| Individual or very small occasional/ transitional roosts  Non-breeding day roosts (small numbers of species) | Building or tree roosts: one feature (e.g. a bat box/tile/brick/crevice), suitable for the species to be impacted, per roost necessary.  Bat boxes not acceptable unless they are known to be used by the species concerned, and maintenance/replacement arrangements are in place. | Building or tree roosts: one feature (e.g. a bat box/tile/brick/crevice), suitable for the species to be impacted, per roost necessary.  Bat boxes not acceptable unless they are known to be used by the species concerned, and maintenance/replacement arrangements are in place. | Building or tree roosts: one feature (e.g. a bat box/tile/brick/crevice), suitable for the species to be impacted, per roost necessary.  Bat boxes not acceptable unless they are known to be used by the species concerned, and maintenance/replacement arrangements are in place. | Building roosts: provision of one roost void suitable for the species concerned.  Tree roosts: dependent on the nature of the remaining roost resource   * if abundant natural roost opportunities exist, compensation should be directed to foraging enhancements. * if roost resource limited, or features are transient, at least one box of a type known to be used by the species concerned, and maintenance/replacement arrangements are in place. |
| *Following Table 4.2, all are considered ‘less than district importance’* | | *Following Table 4.2,* may *reach County importance (this is unlikely)* | |
| Maternity sites (including satellite roosts associated with the main colony)  For all maternity roost compensation, any replacement roost **must be available to bats in advance of the breeding season**.  Bats must not be left without a roost.  For satellite roosts, the relationship with the main colony should be respected in the provision of replacement features. | New maternity roost provision either by recreating within the existing/replaced roof (etc), or re-creating within a suitable adjacent building or tree.  If using ‘typical’ tree-mounted bat-boxes: at least three (rather than one) maternity boxes, suitable for the species and in a suitable location, with different microclimates (choice of aspect/orientation). | Building roosts: new maternity roost measures either by recreating within the existing/replaced roof (etc), or re-creating within a suitable adjacent building.  Small maternity roosts of some species may be replaced qualitatively (i.e. of a different size as long as it provides the same quality in terms of access, temperature, humidity, etc).  For species that fly within the roof void, minimum dimensions (see Section 7) must be respected.  Stand-alone features should ideally be located as close as possible to the original roost (or in a position that offers enhanced characteristics to the original).  Tree roosts: dependent on the nature of the remaining roost resource (as explained above). | Building roosts: like-for-like new maternity roost measures either by recreating within the existing/replaced roof (etc), or re-creating within a suitable adjacent building.  For species that fly within the roof void, minimum dimensions (see Section 7) must be respected.  Stand-alone features should ideally be located as close as possible to the original roost (or in a position that offers enhanced characteristics to the original).  Tree roosts: dependent on the nature of the remaining roost resource (as explained above). | Building roosts: like-for-like new maternity roost measures either by recreating within the existing/replaced roof (etc), or re-creating within a suitable adjacent building.  Minimum dimensions (**see Section 6.0** must be respected.  Stand-alone features should ideally be located as close as possible to the original roost (or in a position that offers enhanced characteristics to the original).  Tree roosts: dependent on the nature of the remaining roost resource (as explained above). |
| Additional requirements for larger maternity roosts: like-for-like mitigation (i.e. ‘typical’ tree-mounted bat-boxes are not an appropriate compensation measure for larger roosts).  A compensation roost can be of a reduced size but must provide suitable conditions for breeding (airflow, temperature, humidity, light etc). | Additional requirements for larger maternity roosts: a range of microclimates needs to be provided, which may require more than one roof void or a larger stand-alone building. |
|  | *Following Table 4.2, unlikely to exceed District importance unless colonies are atypically large* | *County/Regional importance dependent on size; importance increased for assemblages* | *Regional/National importance dependent on size; importance increased for assemblages* | |
| Hibernation sites  [excludes sites where only a small number (<5) of a single species of torpid bats found]  For all other hibernation roost compensation, any replacement **must be available to bats in advance of the hibernation season**.  Bats must not be left without access to their winter roost. | Either re-create within the new structure OR if this is not possible provide at least two hibernation boxes, suitable for the species, in a suitable location ensuring options for orientation and aspect are provided. | Like for like replacement. Either re-create within the new structure OR if this is not possible provide at least two hibernation boxes, suitable for the species, in a suitable location ensuring options for orientation and aspect are provided. | Like for like replacement  Either re-create within the new structure OR provide a standalone bat feature as close as possible to the original roost. Provision may be of a different size as long as it provides the same quality in terms of access, temperature, humidity, etc). | Like for like replacement  Either re-create within the new structure OR provide a standalone bat feature as close as possible to the original roost. Provision may be of a different size as long as it provides the same quality in terms of access, temperature, humidity, etc). |
| Additional requirements for larger hibernation roosts: like-for-like replacement (i.e. ‘typical’ tree-mounted bat-boxes) are not an appropriate compensation measure for larger numbers of hibernating bats).  A compensation roost can be of a reduced size but must provide suitable conditions for breeding (airflow, temperature, humidity, light etc). | Additional requirements for larger hibernation roosts: like-for-like replacement (i.e. ‘typical’ tree-mounted bat-boxes) are not an appropriate compensation measure for larger numbers of hibernating bats).  A compensation roost can be of a reduced size but must provide suitable conditions for breeding (airflow, temperature, humidity, light etc). | Additional requirements for larger hibernation roosts: these are likely to be more substantial structures, to be agreed on a case-by-case basis. | Additional requirements for larger hibernation roosts: these are likely to be more substantial structures, to be agreed on a case-by-case basis. |
| *Following Table 4.2, County/Regional importance dependent on size; importance increased for assemblages* | | *Following Table 4.2, Regional/National importance dependent on size; importance increased for assemblages* | |

Method statement guidance

The following sets out the requirements for a Precautionary Working Method Statement (PWMS) that describes the mitigation measures required to avoid impacts to biodiversity during any works.

PWMSs must be completed by a suitably qualified ecologist – who has, through relevant education, training and experience, gained recognised qualifications and expertise in the field of ecology and environmental management (see BS42020:2013 Clause 3.24) and has the required relevant experience of the biodiversity features potentially affected by the proposed works.

This guidance does not cover licensable mitigation which typically follows templates provided by SNCBs.

The following is comprehensive, and not all sections will be relevant to every project. It is very important to consider the audience for the PWMS, which should be proportionate to the impacts.

Whether or not a full PWMS is considered appropriate for the scale of development using the template below, it will also be necessary to provide a toolbox talk supported by a brief illustrated practical guide no more than 3-4 pages long (**template included below**). This should outline the important methods and restrictions that are relevant to those undertaking the work and most likely to directly encounter bats.

Table A4.1: Information required for a PWMS

| Headings | Content |
| --- | --- |
| Cover page | Date of issue and a version number  Confirmation that the client, contractor and ecologist have all read and agreed with the PWMS in advance of the works (sign-off could be combined with the names and contact details below).  This may be required for submission to LPA to discharge a condition of planning if secured as part of an ecological report. |
| Contents page | Table of Contents |
| Background information  Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided. | Site name  Site address  Ordnance Survey Grid Reference  Site location map (with a suitably scaled Ordnance Survey base)  Name and contact details of developer  Name and contact details of contractors involved with the works (as far as they are known)  Name, contact details and evidence of the competence of the ecologist that has produced the method statement  Description of the proposed works  Description of the purpose and objectives of the proposed works  Planning status (including reference numbers) if appropriate – does the project have consent? Is it permitted development? Is it essential maintenance? Is this method statement accompanying a planning application or discharging planning conditions?  Legislation relating to the species concerned and justification for a licence not being required  Consideration of other environmental constraints  Reference to guidance documents used to inform the preparation of the method statement |
| Site information and survey  Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided. | Description of site location and habitats (including surrounding habitats)  Description of desk study undertaken, including sources used and dates of searches  Description of field surveys undertaken, including details of the methods used, competence of personnel involved, level of effort, dates, times, weather conditions, etc.  Survey results summary, to include: status of the population (assessed in a national, regional and local context if appropriate), assessment of habitat quality, estimate of population size to be affected, etc.  Detailed results to be provided in an appendix if appropriate  Clear identification of whether the survey accords or does not accord with current good practice guidance (and justification and explanation of the implications if it does not accord)  Summary of any survey limitations and an explanation of the implications of these  Where a precautionary approach is being taken due to inadequate survey information resulting from survey restrictions during the Covid-19 outbreak, gaps in survey data and additional precautionary measures undertaken should be detailed with any potential implications stated  Appropriately scaled map(s) showing survey area and results  Photographs of site and specific habitat features, as necessary |
| Impact assessment as relevant to subject of PWMS  Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided. | Quantity (in hectares/m2 or linear metres, as appropriate) and type of habitat permanently lost in relation to the species concerned  Quantity (in hectares/m2 or linear metres, as appropriate) and type of habitat temporarily lost in relation to the species concerned, and specify the timeframe of the loss  Quantity (in hectares/m2 or linear metres, as appropriate) and type of habitat permanently damaged in relation to the species concerned  Quantity (in hectares/m2 or linear metres, as appropriate) and type of habitat temporarily damaged in relation to the species concerned, and specify the timeframe of the damage  Identification and assessment of other impact on the species concerned, such as the risk of killing, injury, disturbance, fragmentation, pollution, increased predation  Assessment of the overall impact of the works proposed on the population of the species concerned, with reference to appropriate contextual information  Scaled map to show impacts |
| Mitigation, compensation and enhancement strategy  Existing documents may be referenced but the PWMS should include sufficient information to ensure that legislative infringements are avoided. | Describe the measures to be employed to avoid / minimise impacts, including, for each measure:  Justification for the measure to be used – is it a recommended measure in relevant good practice guidance, or not? If not, why is it proposed?  Likely effectiveness of measure with justification, based on good practice guidelines and / or relevant research  Quantity (in hectares/m2 or linear metres, as appropriate) of any new habitat being created, or existing habitat being improved  Full details of any capture methods, including timings  Design drawings of specific features, such as bat roost access features or bat boxes, and details of materials to be used  Details of persons and their roles and responsibilities for implementing the mitigation/compensation works  Details of any operations needing to be overseen by an ecologist  Details of any tool-box talks or signage required to raise awareness and ensure appropriate behaviours  Name, contact details and requirements for the competence level of ecologists overseeing any specific operations  Details of specific machinery or equipment to be used  Disposal of any wastes arising from mitigation/compensation works  Scaled map(s) to show extent & location of mitigation/compensation measures. |
| Emergency provisions | What should happen and who needs to be contacted/informed when the provisions of the PWMS are not followed and/or species are found in unexpected circumstances |
| Monitoring  [Longer-term monitoring may be in a separate document, but responsibilities and remediation mechanisms must be clear] | Proposals for monitoring, including methods, timing, survey effort, personnel competence level, frequency, start and end dates  Details of how monitoring will be reported and to whom  Details of baseline to be used and criteria for determining success/failure  Mechanisms for remediation |
| Management  [as set out for monitoring] | Details of responsibility for any ongoing management or maintenance of habitat/features from initial aftercare to any long-term management |
| Timetable | Start and finish dates for all activities proposed, identifying activities that are seasonally constrained (i.e. must take place at a specific time of year) and any assumptions made with dates that may change, such as start of construction or phases of development. |
| Declaration | A form to be provided at the end of the PWMS for site operatives to sign and date to confirm they have read and understood the PWMS and will implement it. |
| References | As appropriate |
| Supporting figures | As needed |
| Supporting appendices | As needed |

Reproduced from CIEEM (2021), with minor amendments. Guidance on Ecological Survey and Assessment in the UK During the Covid-19 Outbreak. Version 4. Published February 2021. Chartered Institute of Ecology and Environmental Management, Winchester, UK.

|  |  |
| --- | --- |
| TOOL-BOX TALK  BATS | COMPANY LOGO |
| FINDING EVIDENCE OF BATS  A bat is a small, nocturnal, flying mammal   * Bats can get into gaps as small as 1 cm and may be tucked up in cracks and crevices * Other bats hang free or squeeze up together where the roof timbers meet * Signs of bats include droppings, urine-staining, grease marks or cobweb-free entrances * Bat droppings can be obvious in a roof void, or hidden in crevices or under tiles * Bat droppings look similar to mouse droppings, but crumble to dust in the hand when rubbed. Sometimes they are curved or segmented   HOW BATS USE BUILDINGS  Bats use buildings for different uses, breeding, hibernation (winter), or day roosts   * Maternity roosts are larger colonies of bats in summer, typically from about 10 to 500 individuals, depending on species * Hibernation roosts in buildings are often only a single or a few bats in winter, potentially more in colder areas such as basements and cellars * Day roosts are generally only a single or a few bats | Add thumb-nail pictures   1. Bat in crevice 2. Bat hanging free (horseshoe) 3. Bat cluster on roof timbers 4. Droppings on a roof void floor 5. Droppings and/or bat under tile 6. Bat in a gloved hand showing small size |
| LEGAL PROTECTION  All species of bat, their breeding sites and resting places are protected under:   * The Wildlife and Countryside Act 1981 (as amended) & The Conservation of Habitats and Species Regulations 2017 (as amended)\* * It is illegal to kill, injure, capture or disturb, possess or offer for sale any bat\* * It is illegal to damage or destroy a bat roost (even if bats aren’t occupying that roost at the time), or obstruct access to that roost\*   \* Amend in line with legislation in force – varies between the devolved administrations, as set out in Chapter 2, and is likely to change in 2021. |
| |  |  | | --- | --- | | WORKING METHODS: ROOF STRIP   * You must wear gloves at all times * Strip the tiles from the roof by lifting them away by the leading edge of the tile to prevent crushing of any bats that may be beneath the tile (do not slide). * Turn each tile to view the underside as bats may cling beneath; look under each one carefully as you go: lift – look – remove if nothing there. * Examine the space exposed for signs of bats, particularly droppings. These can be in large piles or just a few droppings. This confirms a roost, even if no bats are present. | WHERE YOU MAY FIND BATS   * Bats like ridge tiles and bonnet tiles and frequently roost in spaces around mortar used to secure these tiles, but they will roost under any tile, including pan tiles. * They may also creep into spaces under lead flashing and hanging tiles, or use spaces behind soffits, fascias and bargeboards, or gaps alongside windows and doors. * Droppings can vary in colour from black to grey and also brown. They are often very small and can be easily missed. | | |
| IF YOU FIND A BAT OR EVIDENCE OF BATS   * If any bat(s) or evidence of bats is found, work must stop immediately and an ecologist must be contacted. * Any tile that is removed must be replaced carefully to preserve the roost, and any evidence of bats, without crushing any bat present. * No attempt should made to catch or handle any bats by any person, unless under the direction of an ecologist. | |
| IF YOU FIND A BAT, CONTACT:  ECOLOGIST NAME  ECOLOGIST NUMBER / E-MAIL | |
| SAFE INSPECTIONS   * Most ecologists have not been trained to work from roof ladders. Anyone undertaking an inspection should not stray beyond their competence or confidence with heights. * For this reason, from some locations (for example, under a ridge tile), it may be necessary for a roofer to pick up a bat under direction from the ecologist. * If anyone does need to handle a grounded or injured bat, they must always do so under the direction of an ecologist and wear thick gloves to avoid getting bitten. | |
| IN THE UNLIKELY EVENT OF A BAT BITE | |
| Bats are not normally aggressive and will avoid contact with humans. **This means that there is no risk if you do not handle bats.** Some bats in the UK carry rabies viruses called European Bat Lyssaviruses (EBLV). The risk of encountering a bat carrying EBLV is low.   * The rabies virus is transmitted via a bite or scratch from an infected animal, or from its saliva coming into contact with your mucous membranes (in your eyes, mouth or nose). * In the unlikely event that any person encountering a bat gets bitten, then that person MUST wash the bite site immediately with hot water and soap continuously for at least 5 minutes. * That person MUST attend A & E whether they can see puncture marks or not. Bats can puncture the skin with no visible sign being present. Their saliva can also penetrate the skin through existing cuts and lesions. | |

Research needed

The following may be useful subjects for student or other projects (some are more complex than others):

* Many types of bat access tiles, bricks, etc are available[[87]](#footnote-88). Which (if any) are the more successful?
* The use of lures has been suggested to help bats, notably tree-roosting bats, find new roosts. Could this work, and are there any impacts/disbenefits of doing so?
* Could there be any effects from high-voltage transmission lines on bats (e.g.avoidance)?
* How do solar panels affect the micro-environment within the roof supporting them?
* The impacts of high-frequency noise on bats
* The impacts of vibration on bats

1. BCT highlight a range of resources directed at woodland and forest management at: <https://www.bats.org.uk/our-work/landscapes-for-bats/bats-and-woodland/further-reading> [↑](#footnote-ref-2)
2. <http://jncc.defra.gov.uk/page-6387> [↑](#footnote-ref-3)
3. Summary reference explaining FCS here <https://ec.europa.eu/environment/integration/research/newsalert/pdf/what_is_favourable_conservation_status_for_species_457na4_en.pdf>, with a more detailed article available here: https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/conl.12200 [↑](#footnote-ref-4)
4. <https://www.gov.uk/government/consultations/wildlife-licensing-comment-on-new-policies-for-european-protected-species-licences> [↑](#footnote-ref-5)
5. <https://www.gov.uk/guidance/construction-near-protected-areas-and-wildlife> [↑](#footnote-ref-6)
6. [www.nwcu.police.uk](http://www.nwcu.police.uk) [↑](#footnote-ref-7)
7. Sites designated under the Ramsar Convention (Ramsar sites) are afforded the same consideration, but are unlikely to have been designated for bats in the UK. [↑](#footnote-ref-8)
8. <https://www.bats.org.uk/our-work/landscapes-for-bats/core-sustenance-zones>. [↑](#footnote-ref-9)
9. Various approaches can be adopted for defining local importance, including assessment within a district, borough or parish context or within other locally defined areas (CIEEM, 2018). [↑](#footnote-ref-10)
10. See <https://jncc.gov.uk/our-work/uk-bap/> for lists of priority species in each country [↑](#footnote-ref-11)
11. <https://magic.defra.gov.uk/> [↑](#footnote-ref-12)
12. The Mammal Society is developing a tool for assessing the significance of roost count data and, like the Ecobat tool for activity survey data, it will produce a comparison with data from other locations in the area selected. [↑](#footnote-ref-13)
13. Example: a small lesser horseshoe bat maternity roost from a multi-component ‘bat’ SAC may be too far away to be a direct satellite of a maternity roost within the SAC, but may be part of the same population through intermediate unidentified roosts. [↑](#footnote-ref-14)
14. This approach may work less well in Scotland (particularly in the north), where the northern edge of range for several species is unknown, making it difficult to compare what *could* be present with what is present. For almost all of Scotland north of the Central Belt, there are far fewer species, and the maximum possible score may be as low as 8 (the five most widespread species). Sites with several species in the northern half of Scotland are therefore likely to be of County-level importance, and should be judged on a case-by-case basis. [↑](#footnote-ref-15)
15. Unlikely to be present in most of south-east England [↑](#footnote-ref-16)
16. An increase in predation risk may arise from domestic cat ownership (<https://www.bats.org.uk/about-bats/threats-to-bats/cat-attacks>), but also from alien species increasing their range (e.g. parakeets: (Hernández-Brito, et al., 2018) or edible dormice, both in limited geographies); and potentially from reintroduction programmes which aim to restore the natural components of an ecosystem (e.g. pine marten: <https://elflaw.org/past-cases/bats-and-pine-martens/>). [↑](#footnote-ref-17)
17. They can certainly fly through harp-traps, which demonstrates ability to negotiate obstacles. There is also some anecdotal evidence that lesser horseshoe bats can occasionally land and crawl into roosts. [↑](#footnote-ref-18)
18. Refer to Section 3 of this guidance; also <https://www.bats.org.uk/our-work/landscapes-for-bats/core-sustenance-zones> [↑](#footnote-ref-19)
19. <https://cdn.bats.org.uk/pdf/Bat-Species-Core-Sustenance-Zones-and-Habitats-for-Biodiversity-Net-Gain.pdf?mtime=20200706162754&focal=none>.   [↑](#footnote-ref-20)
20. A number of earlier studies are summarised in Mackintosh (2016) and Lintott and Mathews (2018), and those studies are therefore not revisited in these guidelines. [↑](#footnote-ref-21)
21. [Comparing-BCT-and-CIEEM-mitigation-studies-FINAL-16.06.21.pdf (bats.org.uk)](https://cdn.bats.org.uk/images/Comparing-BCT-and-CIEEM-mitigation-studies-FINAL-16.06.21.pdf?mtime=20210616101723&focal=none) [↑](#footnote-ref-22)
22. Compensation roosts were categorised as being a bat box, heated bat box, retained roost with access points or a bat loft (free standing structure with internal flight space). [↑](#footnote-ref-23)
23. <https://www.conservationevidence.com/> [↑](#footnote-ref-24)
24. The Bat Mitigation Guidelines (Mitchell-Jones, 2004) reports a case study (No. 4) where a new roost was built for a maternity roost of 30-40 brown long-eared bats. The first signs of bats were recorded within two months of completion of construction, and bats bred there in the first year, with a similar colony size (35-45). [↑](#footnote-ref-25)
25. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement> [↑](#footnote-ref-26)
26. <https://www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/Doc.StC14-AC23.31-Report_Purpose-built_Roosts.pdf> [↑](#footnote-ref-27)
27. https://historicengland.org.uk/advice/planning/consents/lbc [↑](#footnote-ref-28)
28. <https://historicengland.org.uk/advice/planning/consents/smc> [↑](#footnote-ref-29)
29. Figures based on the normal maximum and minimum daily temperatures based on weather data collected from 1981 to 2010 <https://www.currentresults.com/Weather/United-Kingdom/temperature-october.php> (website uses Met Office data). [↑](#footnote-ref-30)
30. <https://naturalresourceswales.gov.uk/permits-and-permissions/species-licensing/european-protected-species-licensing/do-i-need-a-european-protected-species-licence/?lang=en> [↑](#footnote-ref-31)
31. Note that it is not possible to apply for a licence on a precautionary basis. [↑](#footnote-ref-32)
32. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/avoidance-of-swarming-site-loss-during-restoration-works-at-cliveden> [↑](#footnote-ref-33)
33. <https://www.eurobats.org/node/2563> - this was a very comprehensive study which expended over 13,000 hours in identifying bat roosts over a single large district of central Germany, identifying over 500 summer roost and ringing over 20,000 individual bats (1997-2001). Details are given for very many different roosts so this is a valuable resource, with the caveat that roost preferences on the European mainland may not be precisely replicated in the UK (and not all UK species are included). See also Table 3.2 of (Collins, 2016) and Dietz & Kiefer (2016). [↑](#footnote-ref-34)
34. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment\_data/file/782874/bats-method-statement.doc [↑](#footnote-ref-35)
35. See <https://cdn.bats.org.uk/pdf/About%20Bats/Living_with_Bats.pdf?mtime=20181101151301&focal=none> for a guide/illustration to where bats might be roosting withing a residential dwelling. [↑](#footnote-ref-36)
36. The Eurobats review of artificial roosts26 includes two examples of non-traditional roosts created for greater and lesser horseshoe roosts. These low-cost structures are made of prefabricated concrete. The larger of the structures was 2.6m square and 4m high, the smaller was 2m square and 3.2m high. Both new roosts have been successful with the larger site hosting a colony of 48 of greater horseshoe bats, and the smaller 33 lesser horseshoe bats. [↑](#footnote-ref-37)
37. Where bats are roosting in a loft that is lower than the recommended 2.8m height, and it is not possible to provide an alternative loft that meets this ideal, then aiming for ‘no worse than’ (i.e. replicating the existing situation, and improving it where possible (even if not to the desired height of 2.8m) has to be an option. Brown long-eared bats are found in lofts of 1.5m high, and in lofts with trussed rafters (R. Green, pers. comm.). [↑](#footnote-ref-38)
38. <https://www.vwt.org.uk/wp-content/uploads/2015/04/morris-c-effect-of-grilles-at-bryanston-bat-roost.pdf> [↑](#footnote-ref-39)
39. See ROOST website for an example of this which includes a ‘daylight tunnel’: <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/llwyn-celyn-abergavenny-2> [↑](#footnote-ref-40)
40. VWT are currently investigating this phenomenon; visit their site to contribute to their research: <https://www.vwt.org.uk/projects-all/greater-and-lesser-horseshoe-bat-interaction> [↑](#footnote-ref-41)
41. Detailed instructions also found here/; <https://www.vwt.org.uk/wp-content/uploads/2017/02/The-Lesser-Horseshoe-Cool-Tower.pdf> [↑](#footnote-ref-42)
42. While such events may be rarer in the UK than in southern Europe, there have been cases of bats coming into the living-spaces of house (Bat HelpLine, pers comm.) in periods of unusually hot weather. [↑](#footnote-ref-43)
43. <https://www.bats.org.uk/our-work/buildings-planning-and-development/non-bitumen-coated-roofing-membranes> [↑](#footnote-ref-44)
44. A example of this, and the potential pitfalls, is included here: <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/retrospective-measures-to-prevent-death-and-injury-to-bats-from-non-bitumen-coated-roofing-membranes> [↑](#footnote-ref-45)
45. <https://www.gov.uk/guidance/bat-roosts-use-of-chemical-pest-control-products-and-timber-treatments-in-or-near-them> [↑](#footnote-ref-46)
46. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/maintenance-of-bat-access-in-roof-voids-after-fire-door-installations-1> [↑](#footnote-ref-47)
47. https://envirograf.com/product/animal-door-flap/ [↑](#footnote-ref-48)
48. [https://www.conservationevidence.com/intervention/view/1024#](https://www.conservationevidence.com/intervention/view/1024) [↑](#footnote-ref-49)
49. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/partnerships> [↑](#footnote-ref-50)
50. <https://www.conservationevidence.com/intervention/view/1024>. For example, Dodds and Bilstone (2013) found *Natterer’s, brown long-eared bats and Daubenton’s bat ... preferentially selected boxes in shaded, stable, non-intervention woodland with closed canopy above and lapsed coppice underneath*, and assessed preferences for different box models. There is a growing number of such studies focussing on different sub-sets of parameters including species and box types, and space precludes including all their results in these guidelines. [↑](#footnote-ref-51)
51. <https://therevelator.org/bat-houses/> [↑](#footnote-ref-52)
52. <https://www.batcon.org/about-bats/bat-houses/> [↑](#footnote-ref-53)
53. <https://www.richardgreenecology.co.uk/successful-bat-mitigation/> [↑](#footnote-ref-54)
54. <https://www.batcon.org/files/RocketBoxPlans.pdf> [↑](#footnote-ref-55)
55. <https://www.vwt.org.uk/wp-content/uploads/2015/04/lesser-horseshoe-night-roost-design.pdf> [↑](#footnote-ref-56)
56. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/lesser-horseshoe-bat-night-roosts-forest-of-dean> [↑](#footnote-ref-57)
57. Mitigation Case Studies Forum 2017 proceedings document [↑](#footnote-ref-58)
58. <http://battreehabitatkey.co.uk/> [↑](#footnote-ref-59)
59. <https://www.bats.org.uk/news/2019/10/blocking-potential-roost-features-in-trees-in-advance-of-clearance-felling-non-forestry> [↑](#footnote-ref-60)
60. See videos: 2012 [https://youtu.be/J-t6Rmehscg](https://gbr01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fyoutu.be%2FJ-t6Rmehscg&data=04%7C01%7CPaola.Reason%40biocensus.co.uk%7Ce1bc7cc48fc5489952c308d871a729eb%7C5ef3ea3b97df42ee9bd911ae7068b6f3%7C0%7C0%7C637384310257117520%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=z6TTHz2REGpd6RSyHTWqpdUPkiGssbdS70Q00E1JVsM%3D&reserved=0); 2012 [https://youtu.be/vhGKF24UmpQ](https://gbr01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fyoutu.be%2FvhGKF24UmpQ&data=04%7C01%7CPaola.Reason%40biocensus.co.uk%7Ce1bc7cc48fc5489952c308d871a729eb%7C5ef3ea3b97df42ee9bd911ae7068b6f3%7C0%7C0%7C637384310257127516%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=P%2FXGv5aj%2BXeTJSZ4zBgnArZhdTj43DLfEsbCwmoppmc%3D&reserved=0);   
    2013 [https://youtu.be/0dg\_0kVNJQ4](https://gbr01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fyoutu.be%2F0dg_0kVNJQ4&data=04%7C01%7CPaola.Reason%40biocensus.co.uk%7Ce1bc7cc48fc5489952c308d871a729eb%7C5ef3ea3b97df42ee9bd911ae7068b6f3%7C0%7C0%7C637384310257127516%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=ZHVFaJMVlXNrqnuwNHKPePymWEFUTfsD%2BZTS2IQtJ%2Bs%3D&reserved=0). [↑](#footnote-ref-61)
61. <https://www.trees.org.uk/News-Blog/Latest-News/Dead-standing-trees-%E2%80%93-to-keep-or-not-to-keep> [↑](#footnote-ref-62)
62. <https://www.ancienttreeforum.co.uk/ancient-trees/ancient-tree-sites-to-visit/veteran-tree-trails/hampstead-heath/i-chubb-path/> [↑](#footnote-ref-63)
63. <http://copperheadconsulting.com/brandenbark/>. There is currently no distributer for BrandenBark™ in the UK, but it can be ordered directly from Copperhead Environmental Consulting, Inc. [↑](#footnote-ref-64)
64. <https://batsinchurches.org.uk/> [↑](#footnote-ref-65)
65. <https://www.bats.org.uk/our-work/buildings-planning-and-development/bats-and-churches> [↑](#footnote-ref-66)
66. <https://www.bats.org.uk/our-work/buildings-planning-and-development/bats-and-churches/church-case-studies> [↑](#footnote-ref-67)
67. <https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/case-studies/avoidance-of-swarming-site-loss-during-restoration-works-at-cliveden> [↑](#footnote-ref-68)
68. <http://www.kingfishersbridge.org/bat-cave.html> [↑](#footnote-ref-69)
69. <https://issuu.com/suffolknaturalistssociety/docs/tsns49a> [↑](#footnote-ref-70)
70. <https://www.nature.scot/sites/default/files/2018-01/Licence-guidance-Annex-II-Excluding-bats-from-buildings.pdf> [↑](#footnote-ref-71)
71. The devolved administrations may use different terms, e.g. nominated ecologist (Wales). [↑](#footnote-ref-72)
72. Other names also in use: e.g. Non-licensed Method Statement (NLMS) and so on. [↑](#footnote-ref-73)
73. <https://www.bats.org.uk/resources/guidance-for-professionals/bat-species-core-sustenance-zones-and-habitats-for-biodiversity-net-gain> [↑](#footnote-ref-74)
74. A small caveat is that the guidance applies Europe-wide and, while they are relatively high-level, the individual recommendations prescriptions *may* need to be interpreted differently within the UK regions. [↑](#footnote-ref-75)
75. <https://www.ancienttreeforum.org.uk/resources/ancient-trees-books-shop/>; in particular, publications by Read (2000) and Lonsdale (2013) on veteran tree management. [↑](#footnote-ref-76)
76. <https://www.gov.uk/government/publications/high-speed-rail-london-west-midlands-bill-register-of-undertakings-and-assurances> [↑](#footnote-ref-77)
77. <https://www.theguardian.com/environment/2019/sep/01/worcester-led-lighting-help-bats-cross-road> [↑](#footnote-ref-78)
78. <https://www.rijkswaterstaat.nl/wegen/wegbeheer/natuur-en-milieu/verbinden-natuurgebieden/vleermuisvriendelijke-verlichting/> [↑](#footnote-ref-79)
79. <https://www.solar-eye.com/case-study-worcester-riverside/> [↑](#footnote-ref-80)
80. <https://www.wiltshire.gov.uk/media/3928/Trowbridge-Bat-Mitigation-Strategy-SPD/pdf/whsap-trowbridge-bat-mitigation-strategy.pdf?m=637273390249630000> [↑](#footnote-ref-81)
81. Available at: <https://www.somerset.gov.uk/waste-planning-and-land/habitat-regulations-assessment/> [↑](#footnote-ref-82)
82. A measure of relative bat activity can be obtained using the secure online tool *Ecobat* (<http://www.mammal.org.uk/science-research/ecostat>/) initially designed by the University of Exeter and now hosted and developed by the Mammal Society and the University of Sussex (Lintott *et al.,* 2018). The tool compares data entered by the user with bat survey information collected from similar areas at the same time of year and in comparable weather conditions. [↑](#footnote-ref-83)
83. <https://www.bsg-ecology.com/portfolio_page/landscove-holiday-park-devon-resolving-sac-issues-and-delivering-biodiversity-benefit-to-horseshoe-bats/> [↑](#footnote-ref-84)
84. Case supplied by Richard Green with consent from the Welsh Government. [↑](#footnote-ref-85)
85. See Kurta (2014) for a review of the use/interpretation of humidity measurements. [↑](#footnote-ref-86)
86. Defined as common pipistrelle; soprano pipistrelle; whiskered bat; Brandt’s bat; Daubenton’s bat; Natterer’s bat; brown long-eared bat. [↑](#footnote-ref-87)
87. https://www.bats.org.uk/our-work/buildings-planning-and-development/roost-replacement-and-enhancement/partnerships [↑](#footnote-ref-88)