Timber treatment, pest control and building work

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10.1 Introduction

Apart from commensals, such as the house mouse, bats are the only group of mammals that rely heavily on buildings for shelter. This reliance on man-made structures, together with their colonial habits, make bats very vulnerable to a wide range of human activities, either directly, by being killed or injured, or indirectly by roost loss. This chapter provides guidance on dealing with activities that are likely to affect bats incidentally.

Legally (see Chapter 1 for full details), the protection afforded to bats against killing or injuring and the damaging or destruction of their roosts is limited by two defences in the Wildlife and Countryside Act and the Habitats Regulations. These provide a defence against prosecution where the alleged offence took place in a dwelling house (applies to disturbance of bats or damage or destruction of roosts) or was the incidental result of a lawful operation and could not reasonably have been avoided (applies to all offences). However, these defences cannot be relied on unless the Statutory Nature Conservation Agency (SNCO) had been notified and allowed a reasonable time to advise as to whether the proposed operation should be carried out and, if so, the method to be used.

In practical terms, this complex section may be interpreted as giving the SNCOs a statutory role in advising how damage to bats and their roosts can reasonably be avoided or minimised, but it does not give them the power to prevent lawful and necessary works. It is not, in itself, an offence to fail to consult the SNCO or even to ignore the advice, but to do so could lay an individual or company open to prosecution. In this circumstance, the onus of proof would be on the defendant to show that the alleged offence, whether killing or injuring bats or damaging or destroying roosts, was either the incidental result of a lawful operation and could not reasonably have been avoided or took place in a dwelling house. Although no true case law has yet been established, cases in Magistrates' Courts have shown that Magistrates take a serious view of offences where the defendant failed to consult and took action that the SNCO would have advised against. Note that in England and Wales it is sufficient to show that someone acted recklessly to disturb bats or damage or destroy roosts whereas in Scotland (until 2004) and Northern Ireland it is necessary to demonstrate intent.

Bat worker using fiberscope to inspect mortice joints in barn.
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The word 'reasonable' in the 'incidental result' defence gives considerable scope for negotiation and interpretation in any particular case. In law, only a court could decide what is reasonable in any particular circumstance, so in practice, and in the absence of case law, common-sense decisions must be made.

The situation is further complicated by the existence of a licensing system under the Habitats Regulations which is administered separately by Departments in the four countries of the UK (see Chapter 1 and Appendix 6). This is available where work that might affect bats is required for preserving public health or public safety or other imperative reasons of over-riding public interest. Guidance is available from each of the Departments or SNCOs about how the system operates in their territory, but it is likely to apply mainly to operations on structures other than dwelling-houses or to major alterations to dwelling-houses.

In situ remedial timber treatment with organochlorine insecticides and some fungicides has been considered an important, although largely invisible, source of bat mortality in Europe. Evidence for its importance comes from a number of sources. Experiments have shown that bats kept in wooden cages treated with lindane, formerly a common insecticide in treatment fluids, die within a few days, even if the cage had been treated 2 weeks previously. Although this was a severe test, the speed with which the bats died was both surprising and alarming. Similar results were obtained with the fungicide, pentachlorophenol (PCP), and bats still died when placed in a cage that had been treated 14 months previously with a mixture of lindane and PCP (Racey & Swift, 1986; Boyd *et al*., 1988). As well as the acute poisoning that was observed in these experiments, bats can suffer from chronic poisoning by accumulating doses of a range of pesticides, particularly the organochlorines. In such cases it is unlikely that corpses will be found within the roosts and the only sign would be the disappearance of bats from a traditional roosting site. Such disappearances have been recorded many times after remedial timber treatment.

Pest control – for wasp or bee nests, cluster-fly swarms or possibly for rodent infestations – is much less of a problem than remedial timber treatment but can be treated similarly from a legal point of view. Many of the remarks about chemicals in the timber treatment section apply equally to pest control, although a wider range of chemicals is available for the latter use because there is not the same requirement for persistence.

Roof repairs and any other building work likely to affect bat roosts are covered by the same legal requirements as remedial timber treatments, although fewer consultations are received from roofing contractors. In many respects, the problems associated with such works are more readily definable, because the main dangers are either direct physical disturbance of bats, killing of bats (especially when torpid) or loss of the roost site. Experience has shown that bats will generally tolerate quite considerable changes to their roosts provided that they are not subjected to excessive disturbance during the course of the work.

10.2 Remedial timber treatment

10.2.1 Types of infestation

There are three species of wood-boring insect of economic significance.

Common furniture beetle or ‘woodworm’ *Anobium punctatum* is the most widespread species, occurring throughout the British Isles. Adults are about 2–3 mm long and can be identified by the extended thorax, which almost obscures the head (Figure 10.1). This species attacks the sapwood of hardwoods and softwoods, particularly when these are damp, so timbers consisting largely of heartwood are resistant to attack. Some hardwoods are virtually immune.

Eggs are laid on irregularities in the surface of timbers by the adults, which emerge throughout the summer, and the larvae tunnel into the wood, where they remain for up to 3 years. Prior to pupation, the larva makes its way to just beneath the surface of the wood, and the emerging adult later bores a small circular ‘flight-hole’ 0.8–1 mm in diameter and emerges to mate and complete the life cycle. Relatively few eggs are laid by each female, so infestations of this species are slow to build up.

Death-watch beetle *Xestobium rufovillosum* (Figure 10.2) is most common in southern Britain and absent from Scotland. Adults are 6–8 mm long and dark brown with a golden mottled appearance caused by hairs on the wing-cases. They do not fly readily, except under extremely warm conditions, so that infestations are not readily spread between buildings. The larvae are up to 10 mm long and 2–3 mm in diameter. Death-watch beetle generally attacks only hardwoods, preferring areas that are damp and already subject to fungal decay. The larval stage of the life cycle can last up to 10 years, depending on the state of the wood. Wood with a high moisture content and active fungal attack will cause rapid maturation of the larva, while dry wood, if attacked at all, will result in slow maturation. Temperature is also an important factor. Adults emerge from March to June after boring a circular ‘flight-hole’ 2–3 mm in diameter. In churches or similar buildings, the adults can often be found crawling on the floor or window ledges after falling from the beams. As with *Anobium*, only small numbers of eggs are laid, so infestations are slow to build up. In severely attacked wood, adults can emerge into cavities within the wood and thus complete their life cycle without ever appearing on the surface.

The house longhorn beetle *Hylotrupes bajulus* (Figure 10.3) is the largest of the wood-borers. Adults are about 16 mm long with, as might be expected from the name, strikingly long antennae. (Note that there are a number of superficially similar species which do not cause damage in houses.)

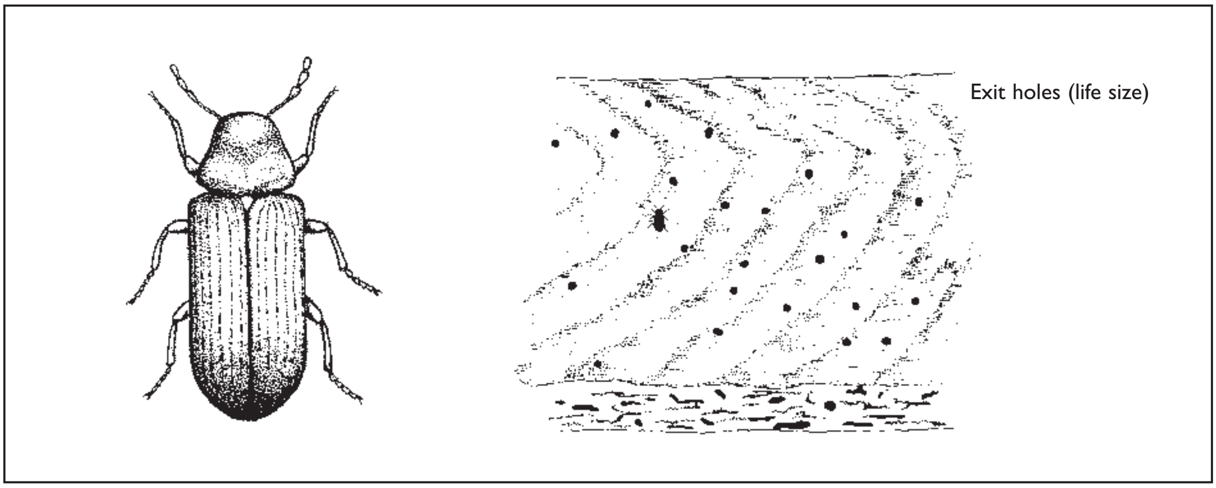


Figure 10.1
Common furniture beetle *Anobium punctatum*

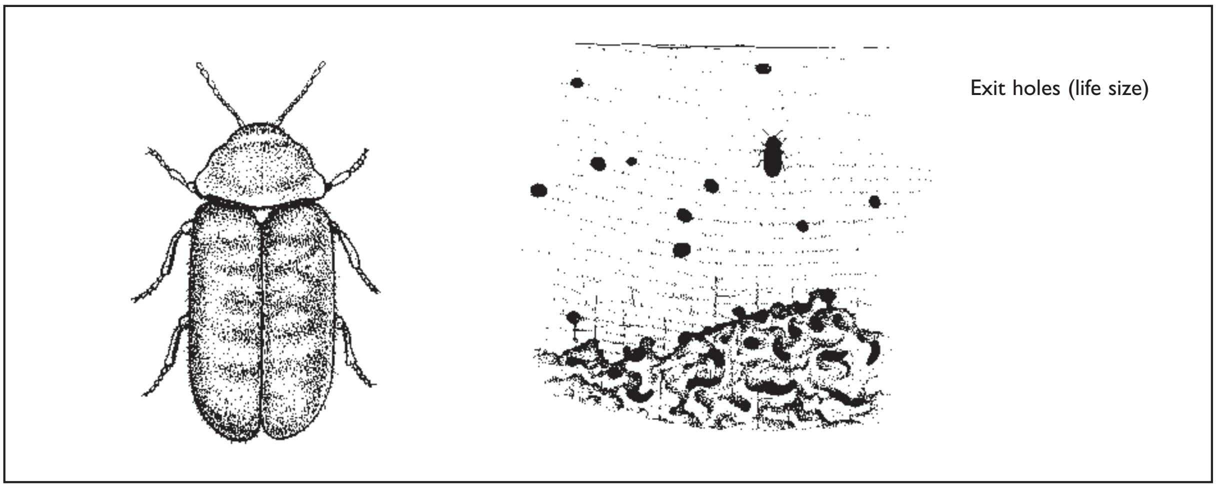


Figure 10.2
Death-watch beetle *Xestobium rufovillosum*

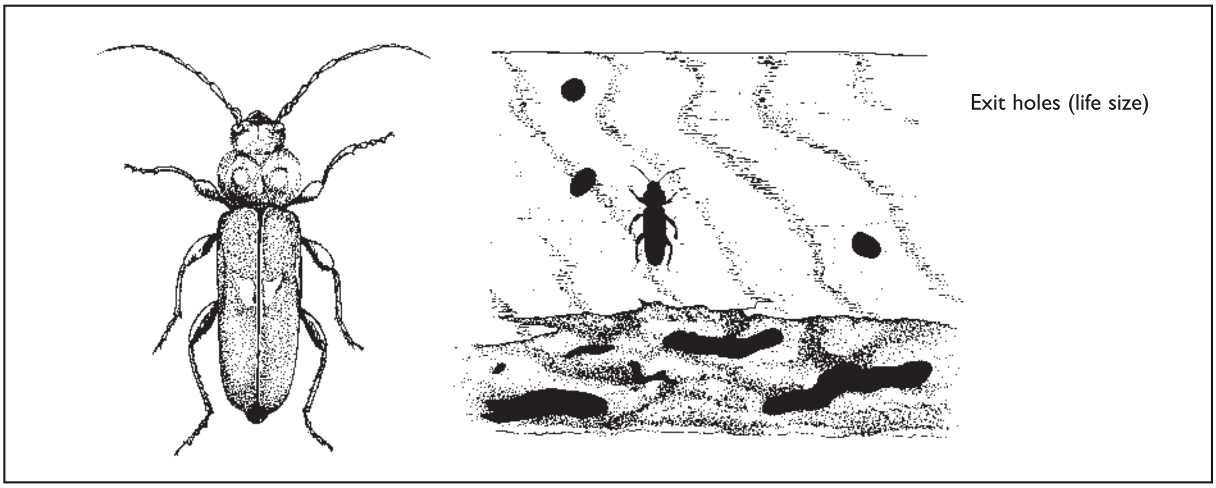


Figure 10.3
House longhorn beetle *Hylotrupes bajulus*

The larvae grow to a length of up to 25 mm and bore tunnels up to 4 mm in diameter. The 'flight-hole' is oval, about 7 x 3 mm. This species attacks the sapwood of softwoods and can be extremely damaging as the larvae can bore up to 25 mm of tunnel per day. Often there is no sign of damage to roof timbers until the adults begin to appear and reveal that the structural timber is just a shell. Fortunately, the species is confined largely to Surrey and parts of Hampshire, although it is widespread in continental Europe. In the local authority areas in Britain in which it is established, pretreatment of timbers is mandatory.

There are two fungi of significance:
Dry rot *Serpula lacrymans* attacks wood with an initial moisture content above 20% and can be extremely damaging. Once established in a damp area, fungal hyphae can travel considerable distances over masonry to reach other wood, because nutrients can be transported through the hyphae. Sound wood can be attacked provided that there is a damp area adjacent and humidity is high. When mature, the fungus forms a rust-coloured fruiting body, which releases millions of spores. Attacked timber develops cuboidal splitting and becomes dry and powdery. The fungus can survive for considerable periods within masonry, providing there is a source of nutrients, so treatment must be thorough and can be difficult.

Wet rot is a generic term covering a number of species such as pore fungus *Poria vaporaria* and cellar fungus *Coniophora cerebella*. These require moister conditions than those required to start dry rot. In practice, this means that in buildings they are always associated with defects that allow water to soak into timbers under sheltered conditions or through lack of ventilation or damp courses. Although considerable structural damage can be caused, wet rots do not have the same invasive capabilities as dry rot, so damage is usually more localised.

10.2.2 Treating beetle infestations

Although there are differences in the types of timber attacked, the three wood-borers have a broadly similar life history. The majority of the life cycle is spent in the larval form, feeding on cellulose or breakdown products of cellulose, and the adult does not feed but lives only long enough to mate and lay eggs. Thus the insect could spend almost its entire life deep inside timber, appearing on the surface for only a short period, first as an egg and later as an adult. This is of vital significance when attempting to halt the infestation.

When newly felled, timber is susceptible to attack by a wide variety of wood-boring insects including powder post beetles (*Lyctus* species) and wood-boring weevils (*Euophryum* species). However, these species all require fresh wood with a moisture content above 20% and, once the timber has been seasoned or kiln-dried, only the three species under discussion can survive. Even these need some moisture, and this fact provides the basis for an effective treatment, though one that is not always practicable. For example, furniture beetle infestations are uncommon in timbers in centrally-heated buildings as the wood is too dry. In some European countries, a well-established disinfestation treatment is to blow hot air into the roof void, thus heating the timbers. Once a critical temperature has been reached deep in the wood, all the larvae are killed and instant disinfestation is achieved. Of course there is no protection against reinfestation, but this is normally very slow.

In the UK, chemical treatment is almost universal, and this seems likely to continue in the foreseeable future. There are a number of factors that have to be taken into account when designing an effective treatment, but perhaps the most important are the relative impermeability of wood and the long life cycle of the beetles. With spray or brush treatment it is virtually impossible to achieve a significant loading of insecticide more than a few millimetres below the surface of the wood. Beneath this toxic 'envelope' the larvae can survive and continue to burrow. The only time the insects must approach this treated layer is during metamorphosis and as eggs. This means that, to be effective, the insecticide must persist at a toxic concentration for longer than the maximum lifespan of the beetle; longer persistence carries a bonus of protection against further attack.

For common furniture beetle, the continuing activity of the larvae beneath the treated layer is of little significance, because they are small, and structural weakening of timber will only occur after many years of uncontrolled infestation. A single brush, spray or fogging treatment with a persistent insecticide will therefore end an infestation over a 3-year period, both by killing the emerging adults and by preventing the establishment of new larvae. New flight-holes may appear during this time as some beetles may survive to complete their emergence.

For death-watch beetle, and even more so for house longhorn, the longer life cycle of the larvae means that their continuing activities after a surface treatment can cause an unacceptable increase in damage. In addition, the adults are much larger than furniture beetles and need a larger dose of insecticide, which can sometimes be difficult to achieve in practice. The death-watch beetle's habit of emerging into inaccessible areas or cavities in the wood can also lead to problems, so this species is considered difficult to eradicate. Attempts to increase the effectiveness of treatments include pressure injection (in which solvent-based treatment fluid is forced into the wood under pressure through injector nozzles), and the use of paste formulations, (in which a thick gel of insecticide is painted on to the timber to increase the time during which the insecticide is able to penetrate the wood). Both methods are widely used. Pressure injection is usually used for limited areas of heavy infestation such as the ends of joists or wall plates. Paste application is quicker and probably more widely used.

10.2.3 Choice of chemicals and fluids

The primary requirement for persistence greatly reduces the number of possible chemicals to use, because most insecticides are either broken down too rapidly or are too volatile or are unacceptably

Emergencies – bats discovered during remedial timber treatment

Legal position (simplified)

The killing, injuring, taking or disturbance of bats and the damage or destruction of roosts may be covered by the legal defences that 'the action took place in a dwelling-house' (disturbance or damage/destruction of roosts only) or that this was 'the incidental result of a lawful operation and could not reasonably have been avoided' (all offences). However, these defences may only be relied on if the SNCO had been consulted and allowed a reasonable time to advise as to whether the proposed operation should be carried out and, if so, the method to be used.

If the SNCO had been consulted, the defence could be relied on; if not, illegal activity may be taking place, so the police could be involved, but only a court can ultimately determine the legality of the situation. If the 'incidental result' defence is used, the decision of the court may depend on the interpretation of the word 'reasonably'.

Advice

The remedial timber treatment industry has had a considerable amount of publicity about bats and companies should have no excuse for not knowing what they are supposed to do. Nevertheless, some difficult situations can arise, particularly outside the maternity season where it is difficult to know what advice to give.

Outside the breeding season (where a small number of bats are present, suggest <5)

If bats are torpid

Catch carefully (do not handle bats, use box, gloves or cloth), keep safely and release nearby at dusk the same day. Proceed carefully with the work.

If bats are active

If a significant numbers of bats are present (suggest >5), abandon work and try again at a time of year when bat numbers may be lower (autumn to spring). You should consult with the appropriate SNCO as well. If small numbers are seen, wait a while or continue brushing down the roof to see if the bats disperse. If the bats are unwilling to leave, it may be possible to divide the roof with plastic sheeting and treat one section at a time. If appropriate fluids are used (see advice elsewhere in this Chapter), these are unlikely to harm bats unless sprayed directly on to them.

During breeding season

Breeding unlikely

(Only a very small number of bats present. No pregnant females or young and no significant quantity of droppings).
Treat as for the non-maternity season.

Breeding possible

Stop treatment until after the maternity season. In large roofs, it may be possible to continue treatment in part of the roof, particularly if a water-based treatment is used. Dividing up the roof with plastic sheeting may also be a possibility here.

Illegal action

It is well established that the synthetic pyrethroid insecticides and a range of fungicides including boron esters, IPBC, propiconazole and zinc compounds are 'reasonable' replacements for lindane or TBTO–based products. These latter two compounds are now either no longer Approved or not available commercially. However, if you have reasonable grounds for suspecting that a non-Approved product is being used, insist that work is halted immediately while the SNCO is informed. Call the police if it is not. All timber-treatment product containers, whatever their contents, should now carry a warning about bats.

toxic to humans. Until the early 1980s dieldrin, an organochlorine, was a common choice, but concern about its safety led to its withdrawal in 1984.Lindane, also known as gamma-BHC (benzene hexachloride) or gamma-HCH (hexachlorocyclohexane), another organochlorine but with lower mammalian toxicity and less environmental persistence, has also been widely used since the 1950s, but is now rarely used, though some products still hold statutory Approvals. There is a statutory requirement to label remedial timber treatment products containing lindane as ‘Dangerous to bats’.

Currently, the most commonly used chemicals are the synthetic pyrethroids, a class of chemically synthesised compounds related to naturally occurring pyrethrum. Like pyrethrum, they have considerable insecticidal activity but are not generally very toxic to mammals (although they are very toxic to fish). They are fairly stable in air and light but are easily metabolised by mammals and broken down by bacteria in soil and other media. Two compounds, permethrin and cypermethrin, are now widely used. Tests on bats have shown that these both appear safe for use in bat roosts. In no case has there been any greater mortality than in bats kept in untreated cages.

Boron compounds, such as disodium octoborate and boric acid have an increasing use in the treatment of furniture beetle infestations. They are now considered as effective as the chemicals previously discussed but are relatively non-toxic to mammals and have been recommended for sensitive situations such as bakeries or other food preparation areas.

A new type of product for remedial timber treatment is Flufenoxuron, also known as Flurox®. This acts specifically as an insect chitin synthesis inhibitor and has a very low mammalian toxicity.

All products containing pesticides must be approved under the Control of Pesticides Regulations 1986 (COPR), which governs the advertising, supply, storage and use of pesticides. The Health and Safety Executive is responsible for administering these regulations for timber treatment products and all approved fluids will be labelled with an HSE number as well as statutory hazard warnings and directions for use. It is a criminal offence to misuse these products.

The properties of some insecticides are summarised in Table 10.1a.

There are two main types of fluid:

Solvent-based fluids consisting of the active ingredients (pesticide) dissolved in a hydrocarbon solvent such as odourless kerosene or white spirit. Water-based emulsions consisting of pesticides, emulsifiers, organic solvent and water. They are often supplied as concentrates to be diluted with water on site. Microemulsions are emulsions with particularly low solvent levels, which appear to give better penetration of the wood.

The main advantages of solvent formulations are the greater penetration into wood and the toxic effects of the solvent itself. In some instances, a solvent-based fluid may also be chosen because of possible damage to furnishings or decor. Penetration and solvent toxicity are probably most important in treating death-watch and house longhorn infestations, where a rapid kill of the larvae is advantageous, but are of less consequence when treating furniture beetle. The flammability of the solvents is a very real hazard. If fibreglass insulation is fitted, this usually has to be removed, as solvent-soaked fibreglass is a considerable fire risk.

The great advantages of emulsions are their lower cost and their lower flammability. When applied in emulsions, the pesticides probably do not penetrate as deeply as with solvent fluids because of swelling of the wood fibres. This could be a disadvantage when treating death-watch beetle, but could be a positive advantage when treating furniture beetle. Here, the lower penetration means that the pesticide is concentrated in a tight band within the top 2–3 mm of the wood rather than being diffused and diluted through perhaps 4–6 mm.

Emulsions have become increasingly popular over the past few years and this trend seems likely to continue. However, there may be a continuing requirement for solvent-based fluids for the spray treatment of death-watch and house longhorn beetles and for pressure injection, because even high-oil emulsions are unlikely to be successful when used in this way. In bat roosts, emulsions obviously have an advantage of low toxicity, although in practice any toxic effect of organic solvents is likely to be temporary, because evaporation is quite rapid, especially in a warm, well ventilated roof, and there is no residual effect. The SNCOs welcome the wider use of emulsions for the treatment of furniture beetle infestations, although there is no evidence that

Table 10.1 Common active ingredients in remedial timber treatment products.

a. Insecticides

Common name	Usual solution strength	Toxicity to mammals	Acceptable uses within bat roosts/ comments
Permethrin	0.2%	Low	Any remedial use
Cypermethrin	0.1%	Low	Any remedial use
Deltamethrin	0.1%?	Low	Any remedial use
Boric acid, Disodium octoborate, Tri(hexylene glycol) biborate	5-20%	Low	Any remedial use
Flufenoxuron (Flurox®)	0.025%	Low	Any remedial use
Cyfluthrin	0.1–0.5%	Low	'May cause harm to bats' (HSE labelling requirement)

b. Fungicides

Common name	Usual solution strength	Toxicity to mammals	Acceptable uses within bat roosts/comments
3-iodo-2propynyl-N-butyl carbamate (Polyphase/IPBC)	0.5%	Low	Any suitable application
Benzalkonium chloride		Low	Any suitable use
Boric acid, Disodium octoborate or tetraborate, Tri(hexylene glycol) biborate	3.5%	Low	Any suitable application
Dichlofluanid		Low	Decorative stains and finishes
Dodecylamine salicylate or laurate		Low	Any suitable application
Phenylphenol (+sodium salts)	2-5%	Low?	Wall sterilant for dry rot
Propiconazole	1.5%	Low	Any suitable application
Quartenary ammonium compounds	3.0%	Low	Any suitable application
Tebuconazole	0.1 – 1.5%	Low	'May cause harm to bats' (HSE labelling requirement)
Zinc naphthenate, Zinc octoate, Acypetacs zinc, Zinc versatate	1-3% Zn	Low	Any suitable application

solvent-based fluids, when applied at the recommended time, cause deaths of bats.

Fogging systems have recently been adopted by some companies which enable operators to treat buildings using a remote controlled fogging machine, which disperses the insecticide throughout the treatable area. The fog droplets are deposited on all exposed timber surfaces and provide a protective layer of insecticide. This considerably reduces the volume of fluid required to treat a given area and also greatly reduces the operator's exposure to pesticide and / or organic solvent. However, the effects of such treatments on any bats that may be present are unknown. Permethrin is now being replaced in many cases by boric acid in a glycol base.

Remedial fluids sometimes contain a fungicide (see Table 10.1b) as well as an insecticide. The fungicide is included to give some protection against moulds or surface fungi, but is unlikely to be effective against wet rot or dry rot, for which specialist treatment is necessary.

10.2.4 Treating fungal attack

Serious fungal attack always leads to structural damage of the affected timbers, so successful treatment must include remedial building works to prevent the further ingress of moisture and the removal and replacement of severely affected timbers. Simply treating affected areas with fungicide is not an effective treatment, because the structural damage remains and the fungus may continue to grow deep in the wood beyond the penetration of the fungicide. In addition, all fungicides break down with time and some can be leached out of damp wood. It is wise to view fungicidal treatment of wood, certainly for wet rot, as a temporary measure to slow down the fungus while remedial works allow the timber to dry to a moisture level at which the fungus cannot survive. However, there is considered to be a need for fungicidal treatment of areas surrounding any area of dry rot because of this fungus's ability to survive in masonry.

Fungal problems in roofs are uncommon, generally develop slowly and are associated with poorly maintained roofs or guttering.

A wide range of fungicides is in common use, many of which have not been tested specifically on bats, though some are known to have a low toxicity to rats or mice.

Pentachlorophenol (PCP) was, until recently, widely used, but is now carefully controlled and only available in exceptional circumstances. It is very toxic to bats.

Zinc- and copper-based fungicides generally have a low mammalian toxicity and all are likely to be suitable for use in bat roosts. Only zinc octoate, copper naphthenate and acypetacs zinc have been tested on bats and these proved to be safe. Similarly, boron compounds such as tri-hexylene glycol biborate or Polybor (disodium octoborate) have a low mammalian toxicity because they hydrolyse to form boric acid. They are not such potent fungicides as some of the others discussed and in some circumstances they can be leached out of the wood. However, they are perfectly adequate for preventative treatment in areas not subject to excessive damp.

10.2.5 Time of treatment

The replacement of lindane by the synthetic pyrethroids, which are known to be relatively harmless to bats, has largely removed any problems over the choice of chemical, so that the only variable factor is the time of year at which treatment takes place. Because the synthetic pyrethroids do have some toxicity and organic solvents may be used, the guiding principle is that treatment should take place at a time when no bats appear to be present.

In house roofs, the timing of treatment for species such as the pipistrelle, which is usually only present seasonally, is relatively simple. Treatment should take place after the bats have left in late summer or autumn or before they return in the spring. In some cases, treatment could safely be carried out between 1 October and 15 April, but this season could be extended into May or September, or possibly even further, if an inspection shows that bats are not present.

Long-eared bats and other species, such as the whiskered bat and serotine, which may be present throughout the year, present a much more acute problem for which there is no ideal solution. With these species, bats may be most obvious during the summer, when they are breeding, but at other times bats may still be present but concealed in crevices, under ridge tiles or behind roofing felt and even the most careful inspection may fail to reveal them. Many roosts of these species may be occupied throughout the year, whereas others may be used for short periods, perhaps during the spring or autumn.

If a roost is known to be used through the summer, it would be safest to assume that it is a maternity roost, regardless of the amount of evidence of droppings, so that, unless there are compelling reasons, no timber treatment should be carried out between approximately the beginning of May and the end of September. Outside this period bats may still be present, and a number of factors will have to be taken into account when deciding on the optimum time for treatment. If an inspection during the possible treatment period (October to April) reveals no bats and no fresh droppings, there would be no advantage in delaying treatment (although the area to be treated should be carefully inspected and any concealed bats persuaded to leave, perhaps by leaving lights on or by beginning to brush down the roof). In some cases it will still be wise to avoid key hibernation periods, e.g. January and February, and instead aim to carry out treatment towards the end of winter.

If one or two bats appear during the treatment, these should be caught and released outside, preferably at dusk, because it is vital that bats are not sprayed directly. This is ‘common-sense’ advice and so the catching can be justified when the treatment is in accordance with the SNCOs advice. In the autumn, if significant numbers of bats are still present, a delay of a few weeks before treatment may allow many to move elsewhere. In most cases, signs of bat activity will decrease as the weather cools, although it is generally not possible to determine whether this is because the bats have moved on or because they are still present but less active. If bats are still present in November even after a hard frost, it is likely that some at least will overwinter in the roost, so there seems little advantage in delaying treatment further. In spring, bats may be visible and active in roof voids as early as March or April, sometimes in quite large numbers. At this time of year bats are active enough to move elsewhere if disturbed but they are not yet breeding, so that timber treatment may be possible provided that the bats are persuaded to leave first. Usually, the disturbance caused by cleaning operations before spraying will cause the bats to disappear temporarily, but placing lights in the roof void may also be helpful.

10.3 Pretreatment of timber

There is no legal requirement to pretreat structural timbers in Britain with either insecticide or fungicide except in a designated area of Surrey and Hampshire where house longhorn beetle occurs and in other areas with local byelaws. Apart from timbers below the damp-proof course, which are routinely treated, it appears that the only treatment the majority of timber receives is a low dose of water-soluble fungicide to prevent sapstain fungi, which affect the colour of the wood. Pretreatment of timber does not, therefore, appear to be a major hazard to bat populations generally, although there is a continuing interest in the industry in extending the proportion of structural timber that is pretreated.

On some occasions, it may be necessary to replace damaged timbers in a bat roost with pretreated timbers to give protection against further attack by insects or fungi. In such cases, care must be taken to specify a treatment that is non-toxic to bats. The two main types are described below.

10.3.1 Solvent or emulsion processes

In this type of process, a fungicide or insecticide in organic solvent or as an emulsion is forced into the wood by a combination of vacuum and pressure treatment. Such processes generally end with a vacuum cycle to remove the solvents from the wood. The most common active ingredients include boron compounds, zinc compounds, pyrethroids, triazoles (propiconazole and tebuconazole) and TBTO, though the latter is being replaced by the less toxic alternatives.

Timber pretreated with TBTO is best avoided for use in bat roosts, although it is probably less dangerous than wood that has received only a superficial treatment because the pesticide is distributed deeper into the wood rather than being concentrated at the surface. Timber pretreated with other active ingredients is perfectly acceptable.

10.3.2 Copper chrome arsenic (CCA)

Treatment with an aqueous solution of copper, chromium and arsenic salts, often known as Tanalisation, a trade mark of Hicksons Ltd, provides protection against fungal and insect attack. The chemicals are applied using a vacuum and pressure cycle and the treated wood is then stacked to dry. During the process, the mixture of salts reacts to form insoluble compounds, so that very little is lost by subsequent weathering and leaching. If the process is carried out correctly, very little preservative is left on the surface of the wood and there appears to be no safety hazard. Occasionally a white powdery deposit may be seen on the surface; this is either hydrated sodium sulphate (Glaubers salts), a harmless by-product of the CCA salts, or some resin that has exuded from the wood during treatment. Both these deposits are easily removed by scrubbing or brushing, and such treatment will also reduce the minimal amounts of arsenic, which may be present on the surface of the wood.

Provided that the treatment is carried out to the appropriate British Standard and the wood is allowed to dry before use, CCA treatment appears to present no hazard to bats. In fact, the use of such timber should be encouraged because its use obviates the need for any subsequent in situ treatment with more hazardous chemicals.

10.4 Pest control

10.4.1 Wasp, bee and hornet nests

Wasp nests are the most common problem and are usually dealt with by Environmental Health Departments, although some local Councils have now contracted out pest control activities to commercial businesses. The usual control method is by spray application of an insecticide into the nest, if accessible, or by local application of powder around the nest entrances. A wide range of insecticides is used. If the nest is accessible and not close to an area used by bats, strictly localised treatment with a pyrethroid is unlikely to harm or disturb the bats so that in these circumstances consultation with the SNCO would not be necessary.

If the bats and wasps share a common access point or the nest is very close to the area used by the bats, greater care is needed and advice should be sought from the SNCO. If the wasps are not causing any particular problems, it is usually possible to arrange for treatment to be deferred until after the bats have left, usually by late August, but in a few more difficult cases treatment with pyrethroids may be possible provided that the pesticide application is confined to the nest and the minimum amount of pesticide is used.

Hornets appear to be more common than formerly but still account for relatively few treatments every year. Most nests are quite small, so localised treatment, if required, can be carried out.

Bee nests are rarely found in houses and may be of interest to local beekeepers. A local contact can often be found by enquiring at the police station and in some cases it may be possible to have the bees removed rather than killed.

10.4.2 Cluster-flies

Cluster-flies and other swarming flies enter houses during the autumn for hibernation and remain until spring the following year. The term 'cluster-fly' generally includes the true cluster-fly *Pollenia rudis*, which is parasitic on earthworms, the autumn-fly or face-fly *Musca autumnalis* and the green cluster-fly *Dasyphora cyanella*, both of which breed in cow dung.

In the autumn, flies congregate on the outside of buildings and later move inside to hibernate in the roof void or other suitable areas. The criteria used by the flies to select hibernation sites are not known, but one building apparently indistinguishable from its neighbours may attract hibernating flies for many years in succession. It may be that the aspect of the building, the particular surface finish or perhaps even pheromones deposited by previous flies are important in attracting the flies, as obviously there is no 'tradition', as with bats. If the area that the flies have chosen remains cold throughout the winter, there are unlikely to be complaints during this time, although intermittent heating can cause the flies to become active and perhaps descend to inhabited parts of the building. Similar problems can arise during the spring, when warm weather rouses the flies and they attempt to disperse from their hibernation sites.

Because they do not breed or feed on meat or domestic waste, cluster-flies do not cause any hazard to human health, although large numbers can be a considerable nuisance. In any conflict between bat conservation and cluster-fly control, therefore, the requirements of bat conservation must take priority, although this does not mean that nothing can be done.

The majority of enquiries about cluster-flies in bat roosts are in late autumn or early winter when the flies are moving in to hibernate. Fortunately, few bats are present in roofs during this time, reducing the possibility of conflict over treatment, and it is usually possible to advise on control measures. If bats are present, obviously no chemical treatment should be permitted, but it may be possible to alleviate some of the nuisance by blocking the routes by which flies enter the living area of the house. If no bats are present, as is commonly the case, treatment with a synthetic pyrethroid, either as a spray or as a smoke treatment, would normally be permissible, though the recommended method is to use a vacuum cleaner to collect the flies. More persistent or toxic insecticides such as lindane (γ-HCH), fenitrothion or dichlorvos should not be recommended in view of the ready availability of less toxic alternatives. Vacuum cleaners have been used successfully to remove flies. In dealing with such cases, it is worth emphasising that the influx of flies is likely to be an annual problem and that insecticidal treatment is in no sense a 'cure'. Possible long-term solutions include changing the colour or reflectance of the building or blocking any gaps under the soffits that allow the flies to land on the wall and crawl up into the roof, but care should be taken that such measures do not obstruct any access points for bats.

10.4.3 Rodents

A need to control rodents in the roof voids of domestic properties is uncommon, but many larger institutions such as hospitals or hotels routinely practice rodent control, often as part of a pest control contract.

The most common methods of control are baiting with anticoagulants, such as warfarin, brodifacoum or difenacoum, snap-trapping or the use of tracking dusts (contact rodenticides).
Bats are not, of course, attracted to rodent baits, so these present no hazard from this point of view. However, there is a possibility that bats, particularly babies, could fall into open trays of bait or poorly-sited trays of contact rodenticide and accumulate poison on their fur. They could then be poisoned when this is groomed off. If the bait or tracking dust has been placed in position by professional pest control operatives, the possibility of such occurrences are remote, but cases have been recorded where bat droppings have been misidentified as rodent droppings and open trays of poison have been placed directly under the bats' roost site. Such practices are both undesirable and ineffective and should not be allowed to continue. Often this is simply a matter of pointing out the error that has been made and suggesting that, if rodent control is required, the baits are placed in more appropriate places. It is, of course, illegal deliberately to attempt to poison bats.

The only other possible interaction between rodent control and bats is the disturbance to roosting bats caused by the routine visits of the rodent control operative. As such visits are generally made at intervals of several weeks, this seems most unlikely to be a problem unless the operative deliberately interferes with the bats. In general, the SNCO would not wish to limit such visits unless particularly large numbers of bats or particularly sensitive species (e.g. horseshoe bats) were involved.

10.5 Building work

Building work, in its most general sense, can result in the total loss of bat roosts and disturbance to or death of the bats. Much of this damage can be avoided if operations are correctly timed and planned; although the loss of the roost is sometimes unavoidable. The earlier advice is sought, the easier it is to accommodate the needs of bats in building work.

Experience has shown that bats will accept considerable changes to the structure of a building without abandoning it as a traditional roost site. For example, several greater horseshoe bat breeding roosts have recently been modified and re-roofed but all are still used by the bats. Bats' strong adherence to traditional sites and apparent willingness to accept change to them mean that roost loss is by no means an inevitable result of alterations, and efforts should always be made to allow the bats continuing access.

10.5.1 Timing of operations

Bats are at their most vulnerable in buildings during the summer, when large numbers may be gathered together and young bats, unable to fly, may be present. Operations to known breeding sites should therefore be timed to avoid the months of June, July and August if possible. Very large rebuilding or renovation projects may take many months to complete and may need to continue through the summer, which is naturally the favoured season for re-roofing. The aim in such cases should be to have the work sufficiently advanced by May or June for returning bats to be dissuaded from breeding in that site for that year. The bats will know of other less favoured sites, which can be used temporarily, but will return, if possible, to their primary site in the following summer. Another possible solution is to divide the roof with a temporary barrier and work on half at a time. This procedure has been used successfully on a number of occasions.

In most cases it is not known if a building is used for hibernation, except occasionally in the case of lesser horseshoe and long-eared bats in cellars. In such cases, excessive disturbance during the winter must be avoided and work should be delayed until after hibernation if possible.

The best times for building or re-roofing operations are spring and autumn. At these times of the year the bats will be able to feed on most nights and may be active or torpid during the day, depending on weather conditions, but will not have begun breeding. Active bats will usually keep out of the way of any operations, but torpid bats can be moved gently to a safe place (see Chapter 7), preferably without causing them to fly in daylight. 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.

Emergencies – bats discovered during re-roofing

Legal position (simplified)

The killing, injuring, taking or disturbance of bats and the damage or destruction of roosts may be covered by the legal defences that 'the action took place in a dwelling-house' (disturbance or damage/destruction of roosts only) or that this was 'the incidental result of a lawful operation and could not reasonably have been avoided' (all offences). However, these defences may only be relied on if the SNCO had been consulted and allowed a reasonable time to advise as to whether the proposed operation should be carried out and, if so, the method to be used.

If the SNCO had been consulted, the defence could be relied on; if not, illegal activity may be taking place, so the police could be involved, but only a court can ultimately determine the legality of the situation. If the 'incidental result' defence is used, the decision of the court may depend on the interpretation of the word 'reasonably'.

Advice

The advice to be given here would depend primarily on a number of factors, including:
Season;
number and species of bats involved;
type of roost;
state of progress of the work;
cost of delay (financial and human).

Outside breeding season (NB small numbers of bats only)

If bats are torpid

Catch (don't handle bats; use a box, gloves or cloth), keep safely and release nearby at dusk the same day. Proceed carefully with work. Leave access for bats to return in future.

If bats are active

If bats are uncatchable, leave roost partially exposed to encourage bats to disperse naturally overnight. Then proceed carefully with work. Leave access for bats to return in the future.

During breeding season

Breeding unlikely (for example, small numbers of bats)

Leave roost partially exposed overnight for bats to disperse naturally, then proceed carefully with the work. Leave access for bats to return in the future.

Probable nursery roost

Stop work and seek advice from the appropriate SNCO. If work has just started, consider reinstating it and postponing work until the bats have dispersed. If work is well advanced, consider sheeting roof and waiting until bats have dispersed. In many cases, the disturbance or exposure that has already taken place will persuade the bats to move elsewhere, taking any young with then, so the delay may not be long. On a large building, it may be possible to divide the roof into sections so that the work can proceed a section at a time. This technique has already been used successfully.

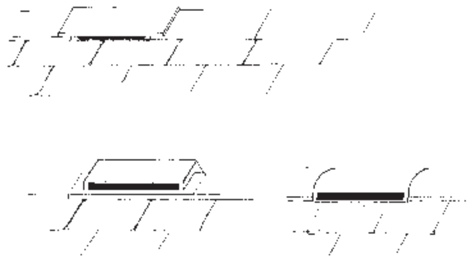
Illegal action

Generally, if roofers are concerned enough about the bats to seek advice from the SNCO or a bat group, they will be prepared to make at least some concessions and, it is hoped, enable the situation to be resolved without the threat of legal action. If roofers have found bats in a roof during the breeding season and refuse to stop to allow time for a consultation with the SNCO, there would be reasonable grounds for calling in the police on the basis that a roost was being destroyed and bats disturbed and possibly injured and killed.

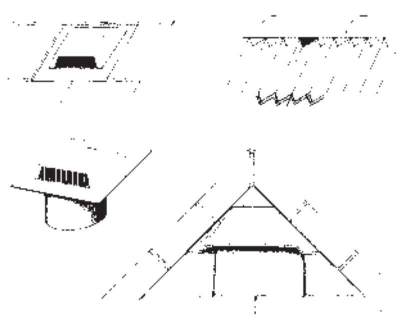
10.5.2 Direct effects on bats

Bats are occasionally encountered during the course of building works. Usually, small numbers are discovered hibernating singly during roof repairs or repairs to exterior cladding, but a few reports are received each year of large hibernation colonies. These colonies, almost invariably of pipistrelles, are found in a variety of situations such as in wall cavities or under flat roofs and generally there are no obvious external signs of their presence.

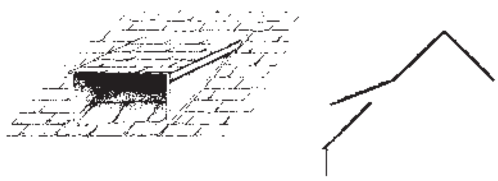
Although bats may be inadvertently or deliberately killed by workmen, the main problems are disturbance and the permanent or temporary loss of a hibernation site. As the bats will already have been disturbed, the most appropriate solution is to collect any torpid bats into a box and either release them nearby at dusk or move them to a part of the building, which provides suitable conditions but is not going to be affected. Active bats can be left to make their own escape. Only bats that are apparently unhealthy or injured need to be taken temporarily into care, and these should be released at the site of capture as soon as practicable, preferably within 2 weeks. Healthy bats can be released safely in any weather except gales, when they should be kept temporarily.



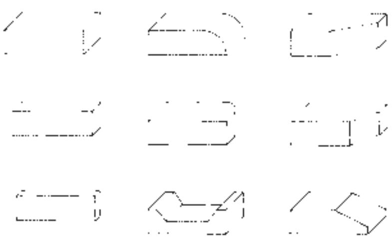
Ridge ventilators can be adapted as bat access points. It may be necessary to remove internal mesh or plastic mouldings.



Lead saddle in place of a slate to allow bats access to ridge or roof void. Lead flashing around chimneys or other features can also be moulded to form bat access points.



Dormer entrance, particularly suitable for horseshoe bats.



Walling bricks for creating bat access points. A standard brick is shown top left. Purpose-made bat bricks can also be used.

Access slits in soffits.

Figure 10.4
Bat access holes. Horseshoe bats prefer to fly into their roosts, but only small holes or slots are needed for other species and this also helps to deter colonisation by birds.

Fire doors in roof voids used by bats

Large roof voids, for example in historic houses, sometimes need to be partitioned in order to prevent fire spreading through the void. Access through these fire partitions is generally provided for maintenance purposes through 'fire doors'. Where bats that routinely fly through the roof void (such as long-eared or horseshoe) are present, access to and from their roost sites needs to be safeguarded and fire doors need to be kept open and close only in the event of fire. There are two types of fire door that can provide this:

Fusible link shutters operate when the temperature rises above 72°C. This system would not provide adequate fire protection in lofts, where heat or flame might travel between compartments prior to the fusible link operating. It is, however, routinely used in metal duct work with smaller aperture in boiler rooms, where it is designed to disconnect the oil or air supply in case of a boiler overheating or catching fire.

Electromagnetic doorstops are connected to the fire alarm system and close automatically when a smoke detector is activated. The National Trust in a Fire Guidance Policy Note recommends the use of electromagnetic door stops with the following system specifications in roof voids used by bats:

- the doors close on activation of smoke detectors only in the part of the roof occupied by bats;
- doors are connected to a backup battery that will keep them open for at least 72 hours if the power is cut;
- doors are connected to a security alarm that would go off if the doors are closed due to fire, accident or failure;
- the system is excluded from regular fire alarm tests and will only be tested annually outside the season when bats are present.

The SNCOs must be consulted in cases where fire doors are to be installed in roofs occupied by bats.

Source: The National Trust, pers. com.

10.5.3 Alterations to roosts

In some cases, such as demolition, the loss of the roost site is inevitable, but during repairs it is often possible to arrange for appropriate access holes and roost sites to be left so that the bats can reoccupy their roost at a later date. The size, shape and location of the access points and roosting areas will depend on the type of work being carried out and will need to be determined for every case, but some general guidance can be given (Figure 10.4). Ensure that the roost site is not made unsuitable for bats, for example by the use of inappropriate timber treatment chemicals or by the installation of large amounts of loft insulation near the access points (e.g. at the eaves of buildings).

Try to locate the new access points as close to the old ones as possible. This will ensure that they are found easily by the bats. If the main access point has to be moved, it is helpful if the old and new access points can both be available for a time so that the bats can become used to the new one.

If the roosting area is to be reduced in size or otherwise limited, ensure that the temperature regime is not altered too drastically. Breeding colonies of bats will generally choose the warmest parts of a roost but need to have some choice of temperatures. Hibernating bats need cool and stable temperatures, so heat ‘leakage’ from occupied parts of a building should be avoided. The installation of central heating boilers or uninsulated hot pipes in cellars used for hibernation is inadvisable, but, if it is unavoidable, try to isolate the heated parts from the rest by walls or doors.

If part of a roof is to be converted for human occupation, a good layer of sound insulation should be installed between the two areas. This will benefit both bats and humans. If ceilings are to be replaced or altered, a layer of boarding covered with polythene on top of the insulation will facilitate the removal of accumulated droppings.

Access holes should be kept small or birds may move in. For most bat species a slit 15 mm wide by at least 20 mm long is adequate and the ideal position appears to be between soffit and wall. The bats can then land on the vertical wall and climb up through the gap; most birds cannot manage this. Building regulations specify that roofs must have adequate ventilation around the soffit, so access for bats can easily be incorporated into this. Other suitable access points for bats are at gable ends, around lead flashing or through gaps between slates or tiles.

Horseshoe bats need special consideration because they may require an access hole large enough to fly through. This should, wherever possible, be modelled on the size and shape of the previous access hole, but new holes should ideally be at least 400 x 300 mm for greater horseshoes and 300 x 200 mm for lesser horseshoes. The hole can be either in a vertical wall or in a horizontal surface such as a soffit or ceiling. Use of the latter position may help to discourage birds.

All alterations to roost sites have the potential to damage the site, so the SNCO must always be consulted before any work begins.

Bat access and bat roost bricks are an innovation that, where sited appropriately, can provide access to roost sites (e.g the Marshall’s bat access brick) or provide new roosting/hibernation opportunities. Bricks suitable for roosting (such as the Norfolk bat group‘bat-zzz-brick’, see Appendix 6), consist of a series of slots or holes of exactly the correct size for species such as Daubenton’s, Natterer’s, brown long-eared, Brandt’s, whiskered and barbastelle bats to hide in. These bricks would typically be used by replacing an existing, perhaps crumbling brick in a brick-lined tunnel or in a bridge. Roost units, suitable for incorporating into new structures have also been made; these are much larger and have the potential to be used as nursery roosts.

Case study - window and lintel replacement

English Nature in Kent was contacted by a property owner who knew that bats were roosting in a cavity brick wall above a bedroom window. The bats were gaining access through a hole in the mortar. The owner needed to replace a brick lintel beneath the window, which was disintegrating. The window frame was also to be renewed. If the work had been carried out immediately the roost would have been damaged and, possibly, the bats using it would have been injured or killed. A member of the Kent Bat Group visited the property and the owner was advised to delay carrying out the work until the autumn, after checking that the bats had departed. It was also suggested that bricks with circular holes in them, or bat bricks were used. An access slit being left close to the original access point was also considered to be an option. The work was carried out during the autumn and the operation was a success, with bats continuing to use the roost thereafter.

Source: English Nature/Kent Bat Group, pers. com.

Case study - roof refurbishment

Early consultation between owners of properties where work is to take place, which may affect bats or their roosts, is essential. SNCOs and bat workers can increase the probability that the outcome will be successful. The maintenance of good liaison between the parties involved avoids misunderstandings and lessens the risk of damage being caused to bats or their roosts.

In Somerset an architect approached English Nature in February, requesting advice regarding some bats found in the roof of a large property, which, although in use, had been neglected for many years. Now under new ownership, major refurbishment of the roof of the building was planned. This was a project costing £250,000 (at 1991 prices) and work was due to start in May. The work included complete re-roofing, including the replacement of defective timbers, localised timber treatment, removal of a number of chimney stacks and the rebuilding of others, rebuilding parapet walls, installation of smoke detectors and lights in the roof void and the laying of glass fibre insulation.

A site visit revealed copious amounts of bat droppings, with concentrations throughout the roof. The roof was probably being used by three or four species of bats. Particularly large concentrations of lesser horseshoe droppings, one at least 0.6 m in depth and covering an area of about 1 square metre, were found in one part of the roof, indicating a sizeable summer roost. Six lesser horseshoes and two brown long-eared bats were seen on this initial visit.

The early consultation and subsequent good liaison with the architect, main and subcontractors resulted in an agreed plan to carry out the necessary works in phases. The lesser horseshoes' main nursery roost was worked on first. This was completed in good time to allow the re-establishment of the summer nursery of 60–70 bats. Brown long-eared bats were forced to move through the roof voids as work progressed. Both species remained in the roof during the whole summer and, as far as it was possible to determine, both species bred successfully.

The Somerset Bat Group has monitored the roost since the completion of re-roofing and has confirmed the successful outcome of this exercise by continuing to record similar numbers of bats using the roosting site each year.

Source: English Nature/Somerset Bat Group, pers. com.

Case study – timber treatment and roof renovation

In May, the Kent Bat Group visited a farmhouse, which required timber treatment. Building work on the property had already begun. A cluster of 10 brown long-eared bats was discovered in the oldest part of the roof void. The owners of the property were advised to delay the application of timber treatments until the autumn and they agreed to do this. However, it was not possible to delay the building works and so provisions enabling bats to continue using the roost were required. The alterations to the property included dismantling a free standing chimney in the roof space. While work on the exterior of the property continued, access points were left for bats when soffit boards were replaced. Prior to the dismantling of the chimney the bats' side of the attic was separated using a hardboard screen, which was stapled, rather than nailed into place to reduce noise. A dust cloth was also hung between the two areas to minimize dust and to keep the bats' side of the attic dark. Good relations were established with the builders, who were given an explanation of the need for the actions taken, and they carried out their work with the minimum of noise and disturbance. The outcome was successful, with the bat population continuing to use the roost.

Source: English Nature/Kent Bat Group, pers. com.

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A Natterer's bat in hibernation. © Frank Greenaway

Conserving and creating bat roosts

A. J. Mitchell-Jones

11.1 Conservation measures in underground sites

Caves, mines and structures such as ice-houses, tunnels, lime-kilns and cellars provide the protected and stable conditions that many bats seek during hibernation. Within such sites, there is relatively little variation in temperature and humidity throughout the year, although each site will provide a range of conditions. Bats use such sites both as mating and gathering areas in early and late summer, as night roosts and as hibernation sites. A few species will form maternity roosts near the entrance of caves or mines if conditions are suitable. Table 11.1 summarises the usefulness of subterranean sites to the various species, although it is difficult to give hard and fast rules. In late summer a wider variety of species uses these sites at night than can be expected to hibernate in them.

11.1.1 Threats

Excessive disturbance

Although bats can tolerate a degree of disturbance during hibernation and can apparently become conditioned to a low level of human activity, excessive disturbance will cause bats to abandon a site. In one extensive cave system, bats seem to co-exist with cavers, who are aware of their vulnerability and take reasonable care not to disturb them, but bats in other sites have been adversely affected.

An artificial bat roost. © Frank Greenaway

The increasing use of a growing number of sites by outdoor pursuits centres, adventure holiday groups, tourism and the like is also a cause for concern, because members of such parties generally have less understanding of the impact of humans on these sites and their fauna than members of specialist clubs. Frequency of visits is also a problem: outdoor centres generally operate throughout the week, so that visits to sites by relatively large parties of inexperienced people can be frequent.

Some sites are readily accessible without any special equipment or preparation. Here, casual disturbance by the curious can be a problem, as can vandalism, the lighting of fires, the dumping of

Table 11.1 Occurrence of bat species in caves, mines and other similar situations

	Light zone	True cave	Notes
Greater horseshoe	HBO	HO(B)	Use caves almost throughout the year.
Lesser horseshoe	HBO	HO(B)	Use caves almost throughout the year.
Daubenton's	HBO	HBO	
Whiskered/Brandt's	HO	HO	
Natterer's	HO(B)	HO	
Bechstein's	HO	HO	Very rare
Common pipistrelle	H	Very rarely	Hibernates in caves in eastern Europe.
Soprano pipistrelle	H	Very rarely	Hibernates in caves in eastern Europe.
Nathusius's pipistrelle	H	Rarely	
Serotine	(H)O	Very rarely	
Noctule	-	-	
Leisler's	-	-	
Barbastelle	(H)O	-	Cave entrances in very cold weather.
Brown long-eared	HO	HO	Uses caves during cold weather.
Grey long-eared	HO	HO	Uses caves during cold weather.

H - hibernating B – breeding O - other

toxic waste or even the deliberate killing of bats. The Bat Conservation Trust's leaflet 'Bats Underground' gives guidance on conservation issues and site assessment.

Destruction, maintenance or change of use

Subterranean sites can suffer from a variety of operations, which can affect their use by bats. Safety considerations and concern over legal liability have persuaded many local Councils or land-owning organisations to seal disused shafts and, in some cases, block caves or adits. In some areas the loss of potential hibernation sites is continuing at an alarming rate. Tunnels have been repaired, converted to storage areas or rifle ranges, or reopened for their original use; caves have been opened for public access as show caves, and caves and mines have been quarried away as part of commercial quarrying operations. Even if a cave or mine is to remain open, gating or grilling in an inappropriate way can also affect the bats, so the SNCO should always be consulted.

Even quite subtle changes to the topography of a site, both inside and outside, can have far-reaching effects on its suitability for bats, mainly by altering the air-flow through the system and hence the temperature and humidity. Some changes, if carefully planned, can benefit the bats, but others can certainly degrade the usefulness of the site.

Bats tend to prefer dynamic cave systems, where there is a flow of air through the system and hence some variation in temperature. Horseshoe bats tend to prefer warmer sites than other species, though there is much overlap. In simple dynamic systems, such as blind tunnels or adits, which rely on convection currents, the size, configuration and aspect can affect the temperature within the site to a considerable degree. Convection will pull in warm air in summer and cold air in winter. Domes and recesses in the roof can trap warm air and cold air can be trapped in areas lower than the entrance. In the UK, the coldest sites are usually the best midwinter hibernacula for vespertilionid bats. The surrounding vegetation and topography are also very important because bats require cover around the site access. Figure 11.1 gives some examples. Non-dynamic systems with no air movement tend to be too warm for hibernation, although they may be used as temporary summer roosts.

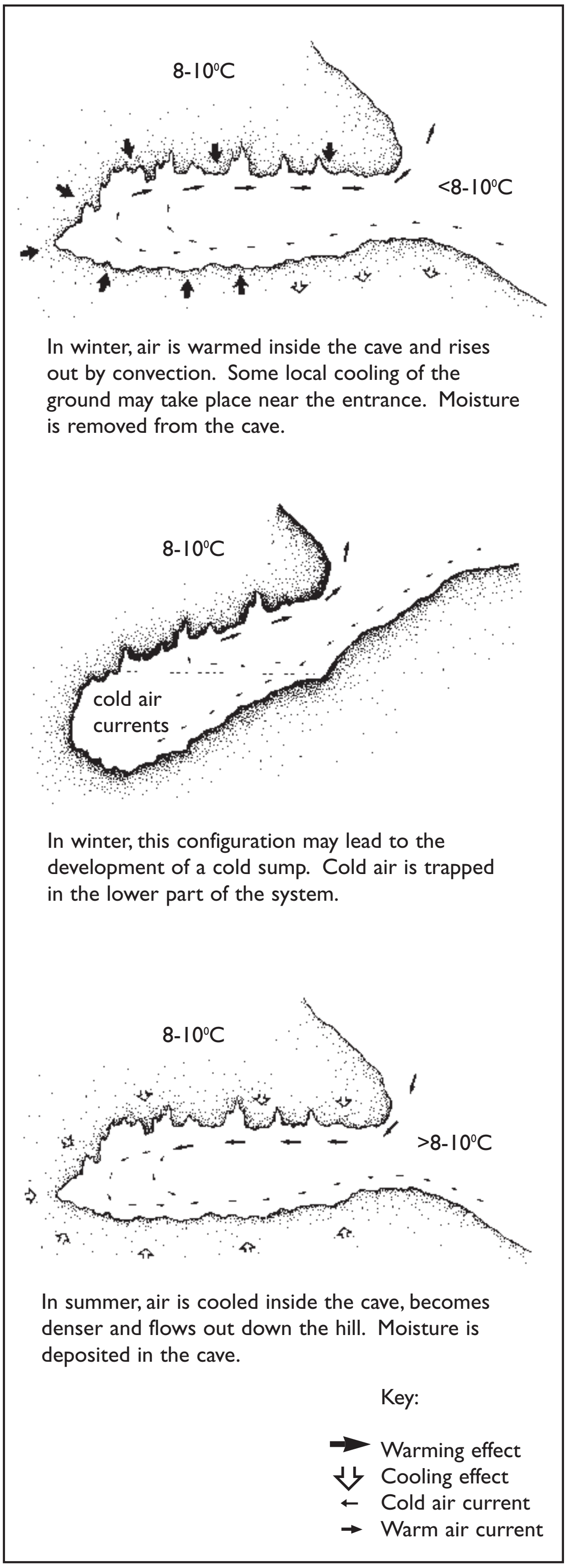


Figure 11.1
Convention currents in caves and mines. The extent and direction of the currents depends on the temperature differential between inside and out as well as the size and configuration of the site.

Bat conservation: site grading and protection

Site grading

Caves, mines and other underground sites can be graded according to their importance to bats. This grading takes into account not only the number and species of bats involved but also the physical nature of the site and the pattern of usage by the bats. Compared with other European countries, numbers of bats recorded in British sites are small; there are fewer than 30 known sites with more than 100 bats.

Grading gives an indication of where limits on human access would help bat conservation. Many sites also have access control for other reasons and these may take precedence over control for bat conservation.

The grading of particular sites is agreed by negotiation between the bat conservation organisations and either the National Caving Association (NCA) or the National Association of Mining History Organisations (NAMHO) in co-operation with their member groups. In many cases a more detailed statement on access control will be available from these organisations. Access control does not necessarily mean access is prohibited. Significant populations would have to be recorded before any access restrictions would be requested. Incidental observations of bats can be made without infringing the Wildlife and Countryside Act and reports are welcomed by the nature conservation organisations.

Grade 1 (fewer than 10 sites)

Sites used by bats throughout the year for hibernation and breeding. Access controlled throughout the year. Visits by prior arrangement with the key holder, in agreement with the relevant national or regional caving organisations or NAMHO, normally during spring or autumn.

Examples: Swan Hill Quarry, Shropshire (used by up to 80 lesser horseshoe bats throughout the year); Rock Farm Cave, Devon (used by several hundred greater horseshoe bats throughout the year).

Grade 2 (fewer than 100 sites)

Sites used by large or locally significant numbers of bats during the winter (normally 1 November to 30 April, but extended in a few cases) where seasonal access control is considered desirable or is already in effect. Control over activities such as blasting may also be required.

Grade 2a: sites already gated or grilled.

Unrestricted access by arrangement with the key holder during the summer or restricted access by agreement between the key holder, NAMHO or NCA or other relevant caving body during the winter. This agreement may cover activities such as blasting.

Examples: Agen Allwedd, Powys (used by more than 200 lesser horseshoe bats during the winter. Access controlled by a management committee that takes account of the bat interest. Blasting banned during the winter [1 October to 20 May]); Hangman's Wood Deneholes, Essex (used by up to 70 Natterer's, Daubenton's and long-eared bats. Recent restriction on visiting during the winter has significantly increased the number of bats).

Grade 2b: sites without protection.

Unrestricted access during the summer but winter visits and blasting should be avoided unless agreed with NCA / NAMHO.
Examples: West Llangynog Slate Mine, Powys (used by more than 50 lesser horseshoe bats); Ettington, Warwickshire (used regularly by the rare barbastelle bat as well as small numbers of Natterer's, Daubenton's and long-eared bats); Sandford Hill, Mendip, Somerset (various cave and mine sites used by greater horseshoe bats).

Grade 3 (many sites)

Sites known to be used by small numbers of bats during the winter. No formal access control but proceed with caution and follow the conservation code. Avoid winter visits if practical. Report numbers of bats seen.

Examples: Eglwys Faen, Powys (small numbers of lesser horseshoe, whiskered and Daubenton's bats); Gnomeys, Godstone, Surrey (used by small numbers of Natterer's, Daubenton's, whiskered, Brandt's and long-eared bats).

Grade 4 (many sites)

Sites not known to be used by bats or with only occasional records. Follow the conservation code and report any bat sightings.

Source: Bats Underground/BCT, pers. com.

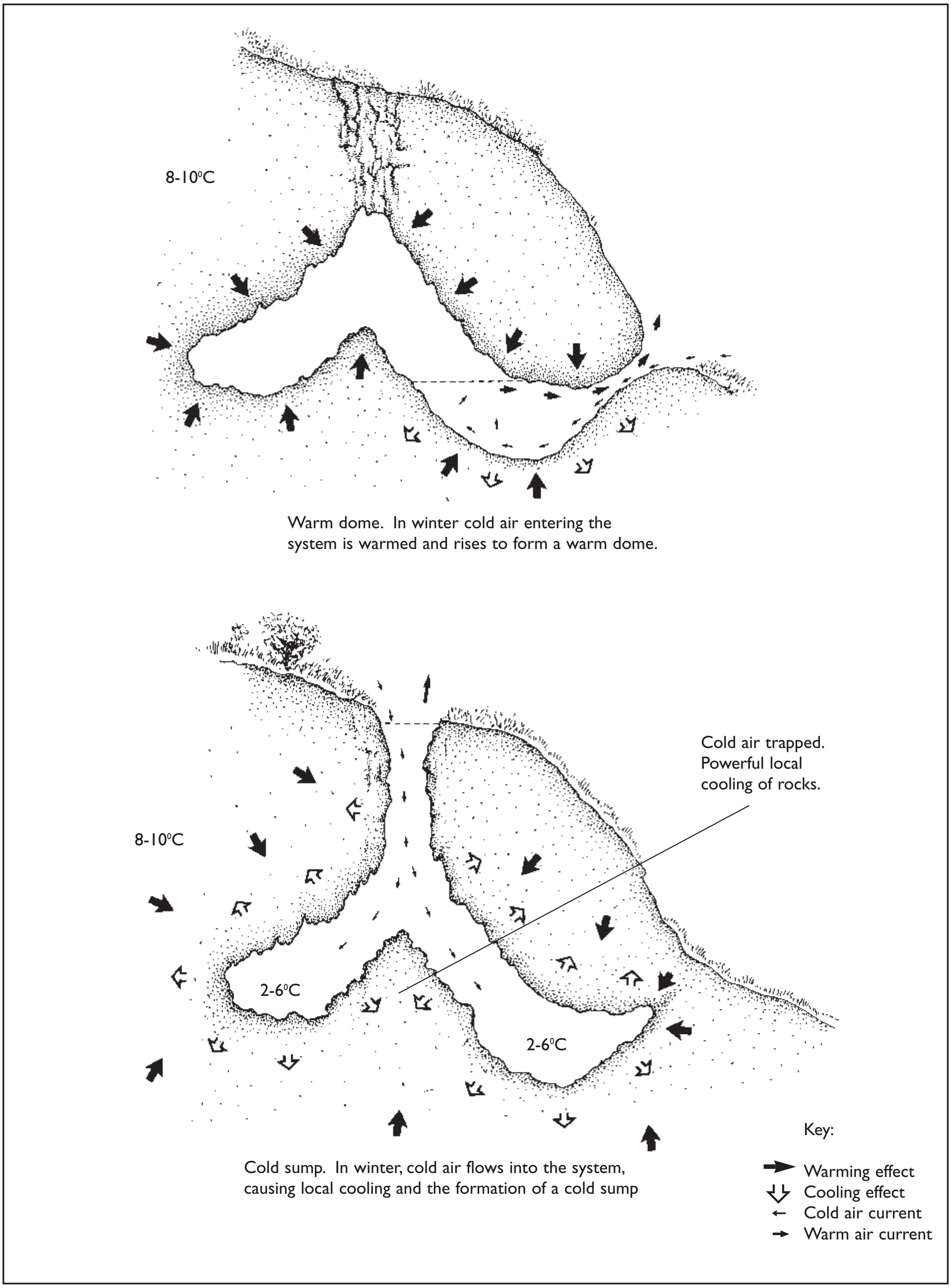
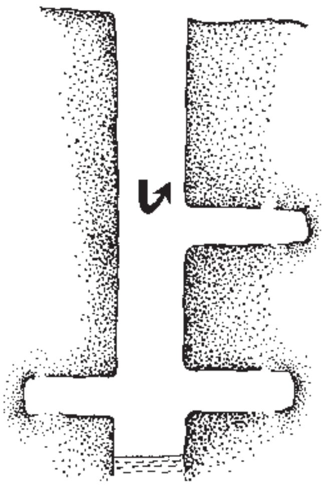
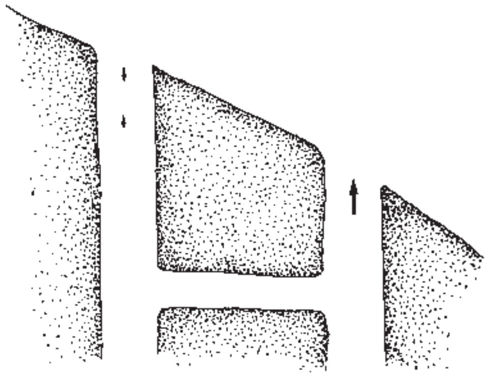


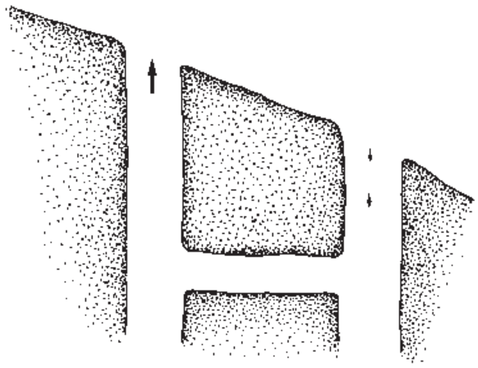
Figure 11.1
(Continued)



A single vertical shaft has little air flow, but can act as a cold sump.

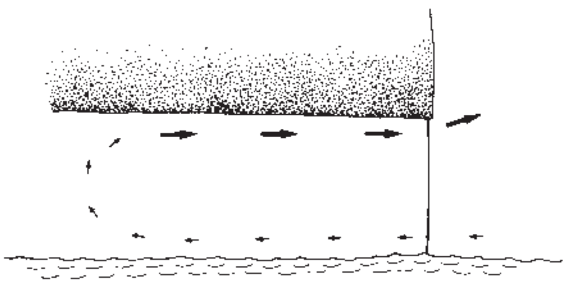


Air temperature higher than cave temperature.

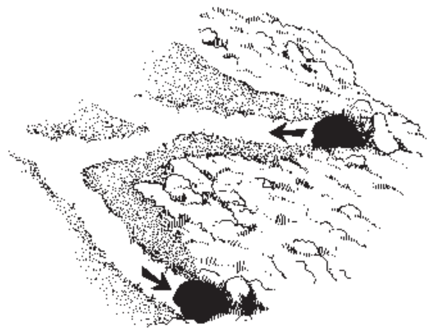


Air temperature lower than cave temperature.

Caves or mines with multiple entrances at different levels will have air currents. These may vary in direction seasonally and will tend to lower the humidity.



In adits or tunnels the extent of the convection current will depend on the temperature difference between inside and outside, the volume of the system and the size of the passage.



Key:

Warming effect
Cooling effect
Cold air current
Warm air current

Figure 11.1
(Continued)

11.1.2 Grilles

The most frequently required conservation measure for caves and mines is protection against excessive disturbance. This is generally achieved by fitting a grille, which permits the free passage of bats but not people, although other measures such as security fencing may be appropriate in a few cases. If a grille is to be fitted, it is important to monitor bat numbers before and after fitting to check for any beneficial or adverse effects.

Grilles must be carefully planned if they are to be successful and a number of points must be taken into account.

- The SNCO must be consulted if the site is already used by bats. Grilles have the potential to damage bat roosts if not correctly designed and fitted, so advice must be sought on this. TheSNCOs also wish to keep records of all bat sites and all grilling works. Grilles can be expensive items and the SNCO may be able to grant-aid the cost of grilling known bat hibernacula and suggest other sources of funding.

- The species using a site should be identified before a grille is installed. Summer, as well as winter, use should be taken into account. Grilles should not be installed at times when disturbance is likely to result, e.g. during hibernation.

- Permission must be sought from the landowner and any tenants. A management agreement will help to set out responsibilities and any arrangements that have been made for access. Many owners will welcome the installation and maintenance of a grille, because this will help to ease fears about safety and discourage trespass. Many conservation and wildlife trusts have experience of such agreements and they may be willing to help.

- If the site is used by cavers, mine historians or similar groups, suitable arrangements for access by these groups must be negotiated before any work begins. Failure to do so will severely upset relations with responsible caving groups and may also lead to repeated damage or to destruction of the grille.

- The grille must be of appropriate design and construction (Figure 11.2). The bar spacing is one of the most important variables, because some bats, particularly horseshoes, are known to be reluctant to fly through narrow gaps. An air space of 150 mm between horizontals is recommended for greater horseshoe bats, but this may be large enough to allow children through and a slightly narrower spacing may be appropriate for sites used only by other species; a 130 mm gap seems to be a reasonable compromise. Vertical supports should be more widely spaced, although too wide a spacing will make the grille vulnerable to vandalism because the bars can be forced apart more easily. The exact spacing can be chosen to suit the size of the grille but should be in the range of 450–750 mm, with greater horseshoes being given the larger spacing. All grilles should be constructed to permit access for authorised persons and for safety. For small entrances, it may be most convenient to have the whole grille hinged and fitted on a subframe. This is particularly appropriate when doorways have to be grilled, as the subframe, hinges and lock can be con cealed behind the door frame. Larger grilles will need to be fixed permanently in position and fitted with a door of at least 500 x 500 mm. This can be either hinged or sliding, depending on the circustances. If hinges are fitted, these should be of robust construction or concealed so that they cannot easily be hacksawed through.

- It is generally agreed that the lock should be the weakest part of the grille so that a determined intruder may be tempted to break this relatively cheap and replaceable component rather than the grille itself. However, it should not be made too vulnerable and should be fitted so that it cannot easily be cut or levered off, although if the lock becomes seized or someone fills it with epoxy resin it needs to be accessible for replacement.

- The construction material should be chosen to suit the vulnerability of the site and the finance available (Figure 11.3). For sites where there is a low risk of vandalism, mild steel may be an appropriate material. This is cheap but is not resistant to cutting and rusts rather quickly. Its main advantage is that the grille can be cut and fitted in situ and welded with portable equipment. For sites at higher risk or where the grille is to be prefabricated, some form of toughened steel should be used for those parts of the grille that are most at risk. Reinforcing rod of 20 mm diameter is readily available and provides reasonable resistance to rust and to hacksaws. Tougher steels are available, but these are generally expensive and can be difficult to cut and weld. For particularly high-risk sites, a grille

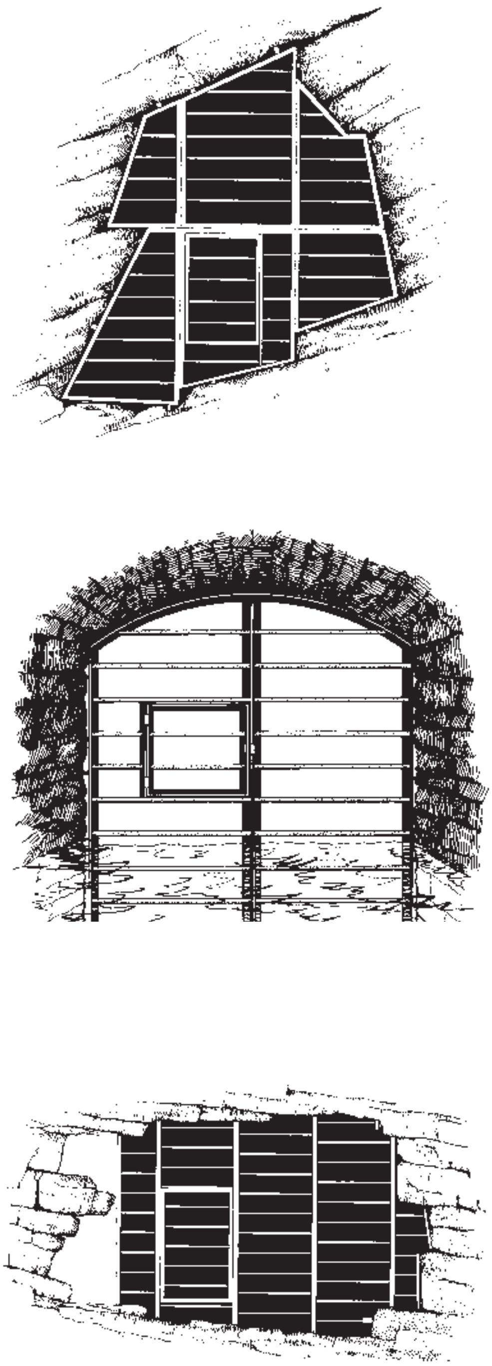


Figure 11.2a
Bat grilles. Grilles for large or irregular entrances are best constructed in sections and bolted or welded together on site. Bars can be extended beyond the frame to fill awkward corners, but long unsupported bars will be a weak point in the grille.

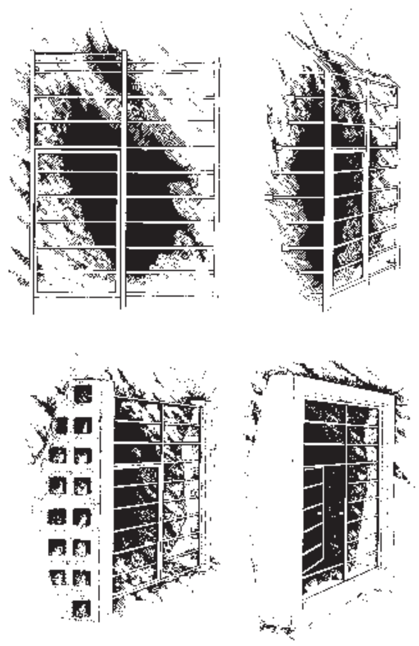


Figure 11.2b
Bat grilles. For vertical rock faces the grille can be made larger than the entrance and pinned to the wall. Irregular vertical surfaces may need a cage with side arms cut to length on site. Blockwork or shuttered concrete provide useful ways of squaring up entrances and stabilising soft or unstable strata.

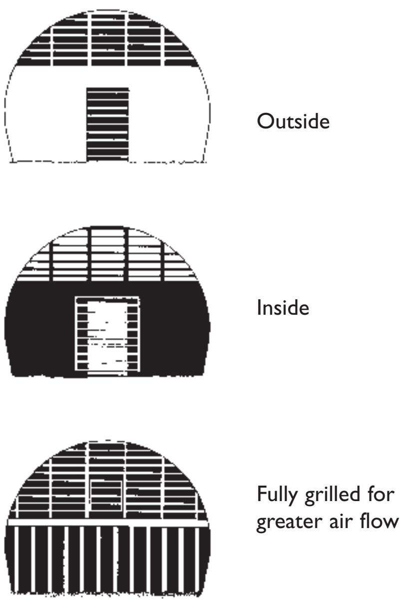


Figure 11.2c
Tunnels, such as railway tunnels, with brick or block end walls, can have a grille fitted to the inside of the wall so that only the bars are visible. Full grilles can incorporate a lower section of vertical bars, which are hard to climb.

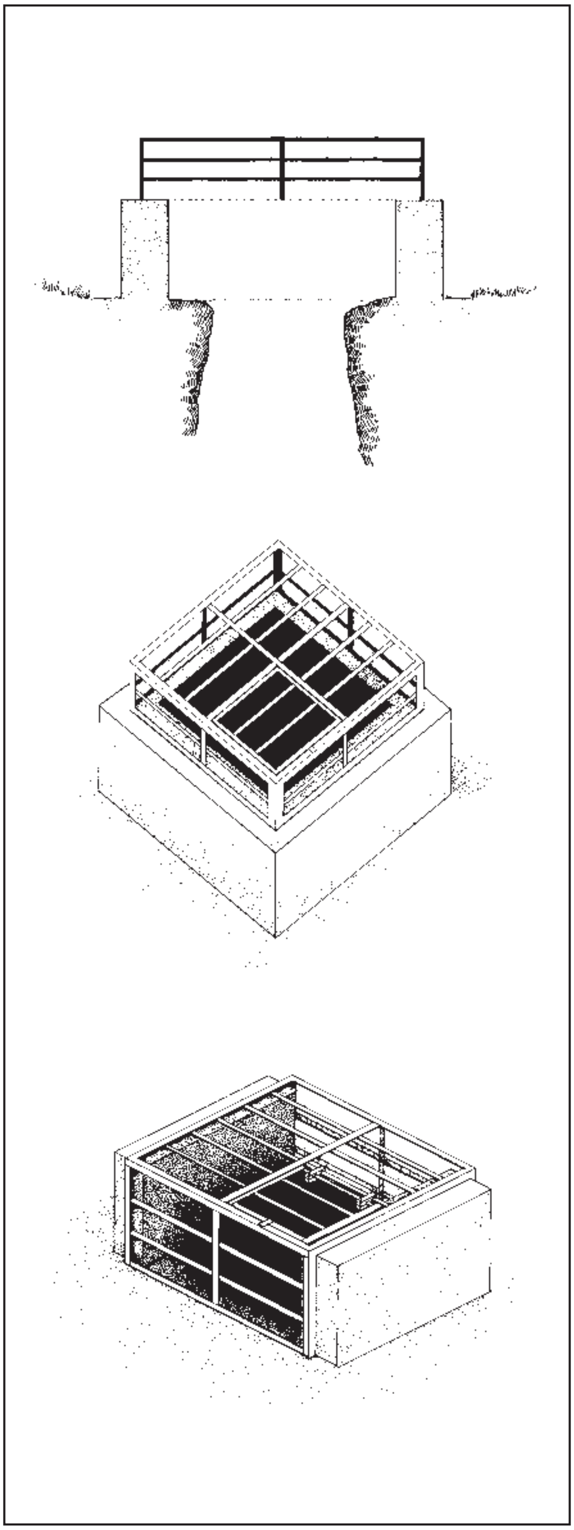


Figure 11.2d
Bat grilles. Vertical shafts usually require stabilisation of the edges. Grilles should be fitted above ground level so they are not inadvertently walked on by people or animals. At least one vertical grille face about 50cm high should be provided so that bats do not have to fly vertically upwards through the grille.

based on the roller principle may be suitable. The main grille is made from 30–35 mm diameter steel tube, welded in the usual way, and hardened steel rods are then inserted into the tubes and left loose. If any attempt is made to hacksaw through the combination, the rod will simply revolve rather than being cut. Small and medium-sized grilles can generally be prefabricated out of a mixture of rod and angle and then trimmed to size, if necessary, on site. Large grilles may need to be prefabricated in sections and then bolted or welded together as they are fitted.

- It is often advantageous to protect grilles against rust. This is preferably done by galvanising at the time of manufacture (a hot-dip process) or by coating the grille with an anti-rust preparation such as 'Norusto' or 'Nutrarust'. Epoxy resin paints may also be used, but paints with a persistent smell, such as bitumen, should be avoided.

- By careful design and construction it is possible to make a grille that is extremely strong and resistant to damage. However, it must be remembered that no grille can be proof against powerful welding or cutting equipment and that a prolonged and determined attack will eventually breach any grille. Repair costs are likely to be proportional to the cost of the original grille. It is best to site the grille where it is visible from outside the cave or mine so that potential vandals are deterred.

- The grille must be fitted so that it does not impede air flow into the site. It is generally inadvisable to fit the grille into the narrowest part of an entrance, where it could critically affect air flow. If the narrowest point is the only logical place to put the grille, for example in a doorway, care must be taken to keep the obstruction to a minimum, particularly at floor and roof level.

- The grille must be securely fitted into solid rock, if available (Figure 11.4). It is no use fitting a carefully constructed grille, only to have it dug round or pulled out. A common method of fitting is to drill a series of holes around the entrance and cement in steel rods, which are then welded to the main grille. This is not always a convenient method because it requires the use of on-site welding equipment of adequate power and it is rarely possible to weld large-section high-carbon steel with a portable welder. An alternative is to fit the grille with lugs or a rim of steel angle and then pin it to the wall with rock-bolts. The heads of the bolts can then be rounded off or welded to the frame for additional security. Hard rock sites need only relatively short bolts, but sites in chalk or other soft strata may need long auger-type bolts screwed up to 900 mm into the rock. Sites with unstable or awkwardly shaped entrances may need a concrete or block surround to be built in place before a grille can be fitted. In very poor ground conditions, it may be preferable to create a new site close by rather than try to grille a system that would soon collapse anyway.

- In most cases, the base of the grille can be set into a trench cut into the floor of the site, which is then back-filled with concrete. Care must be taken that the original floor-line is preserved so that air flow is not impeded. The trench should be a minimum of 300 mm deep, otherwise intruders may tunnel underneath. In soft earth or clay, it may help to hammer rods vertically into the earth at the bottom of the trench and set their tops into the concrete. At smaller entrances it might be better to use a door with small (letter-box) type access.

- The grille must be inspected regularly and maintained when necessary. A strongly made grille in a low-risk area is unlikely to need repair for many years but should be inspected regularly. In high-risk areas, the prompt repair of any damage will eventually discourage intruders who discover that they have to work hard to gain access at every visit.

An ice-house

The properties that made ice-houses so valuable in times before the invention of the refrigerator now make many of them suitable as bat hibernacula. The bats in an area near Maidstone were given a hand in being able to make better use of an ice house by English Nature and the local bat group. Firstly, the building was made secure against vandalism by fitting and strengthening the door with metal plates. However, this did not make the place immediately attractive to bats and it was not until fine plastic mesh was attached to one side of the door, across the top and down the other side, that hibernating bats were found to be using the site. It is surmised that the mesh allows the bats to land and grip the mesh. They are then able to crawl up and over the top of the door and into the ice house.

Source: English Nature/Kent Bat Group

Railway Tunnel Enhancement

Disused railway tunnels can be valuable bat hibernation sites. The Wiltshire Bat Group has been managing a project that has increased the value of one such site. Hibernating bats were found in a tunnel during an initial survey in 1993 but conditions were less than ideal, with internal winter temperatures being similar to those outside. In 1994 the ends of the tunnel were sealed and bat access grilles were installed. This succeeded in reducing air movement, maintaining a relatively stable temperature of around 8°C, and increasing relative humidity from 80 to 95%.

During the summers of 1994 and 1995 wood was attached to the tunnel walls in order to create crevices suitable for hibernating bats.

The value of all of the hard work carried out is indicated by the increase in the number of bats using the site.

Hibernating bat populations have been surveyed three times each winter. At the end of 1993, prior to the construction of the end walls, a maximum of 41 bats was recorded. By the winter of 1996/97 this number had increased to 82 and by 2001/02 the maximum count was 168. More than 90% of the bats have been Natterer's bats. Other species found include brown long-eared, Daubenton's, whiskered/Brandt's and, occasionally, the rare barbastelle. Over 30% of hibernating bats are found to be using the crevices formed by the attachment of wood to the tunnel walls.

This successful project has suffered several problems. The end walls have twice been vandalised and damaged once by subsidence after heavy rain. On each occasion has repairs have been carried out.

Source: Wiltshire Bat Group

11.1.3 Creative conservation and site management

Many subterranean sites are potential bat hibernacula but are unsuitable for one reason or another or are suitable for improvement, as measured by the numbers of bats recorded hibernating there. Protection from disturbance has already been dealt with, but other measures that may be taken include the following.

Manipulation of air-flow and temperature

Largely static cave or mine systems with little air movement are often too warm for most species and can be improved by the creation of additional entrances or air vents, so as to increase the proportion of the system subject to a dynamic air flow. The aim is to achieve an internal temperature of 0–6°C in January during frosty weather. If such manipulations are attempted, the numbers and positions of hibernating bats must be monitored carefully to try to gauge the success of the project. In contrast, tunnels that are open at both ends fluctuate too much in temperature and are too dry for bats. They can be improved by fitting partial barriers at the ends or in the middle of the tunnel (Figure 11.5). The resulting decrease in air flow allows the temperature to rise towards that in a similar static system. Simple straight adits or tunnels with a relatively high passage and entrance are often very suitable for bats because, although there is no through draught, the relative stability of the cave temperature in the tunnel can give rise to convection currents and a dynamic air flow (see Figure 11.1). Such currents can be prevented by mounds of rock or earth at the entrance, and it may be advantageous to clear these.

Reopening of blocked sites

Many subterranean sites have become unavailable to bats either through deliberate blockage or through collapse. These include caves, mines, tunnels, grottoes, ice-houses, lime-kilns and cellars. The reopening of such sites can lead to their rediscovery by bats and re-establishment as hibernacula. Before such work is undertaken, the permission of the landowner must be sought and it may be necessary to enter into an agreement over the long-term protection of the site. Immediate grilling is usually a condition of reopening what might be regarded as a dangerous place.

Provision of additional roosting points

Although bats can hang on to surprisingly smooth surfaces, many species prefer to roost in cracks or crevices. Some sorts of artificial tunnels or natural caves are lacking in these, and the provision of additional places can sometimes increase the attractiveness of the site to bats. Bats will roost in almost any sort of crevice, and successful devices have ranged from planks of wood leant against the walls to loose piles of bricks, bat-bricks or building blocks.

Provision of new hibernacula

Some areas of the country have very little in the way of underground sites. Others have tunnels in soft or dangerous strata. Both could provide suitable sites for artificial hibernacula. The positioning of new sites and the design of the structures are fundamental to their success and some suggestions are given in Figures 11.6 and 11.7. A specific example, the conversion of a pill-box, is illustrated in Figure 11.8 and many of the techniques used here can be applied to other types of hibernaculum.

It should be remembered that the majority of hibernacula in the UK are man-made, mostly as the products of former mining activities, and that their use by bats may take many years to develop. Site protection of a new hibernaculum is vital from the start, both from the point of view of the responsibility of the owner of the land and to limit site disturbance.

A design life of 100 years should be envisaged and professional assistance should be sought at all stages. The costs incurred in building new hibernacula are high, but funds from mandatory or voluntary mitigation works and suchlike are available from time to time.

Cave construction

About two dozen purpose-built bat caves have been constructed in the UK, many of them being of concrete pipe construction with added brickwork. The success rate (occupancy rate) has so far been poor, although their use will almost certainly increase over time. Creating the precise environmental requirements (particularly with regard to humidity) for bats in a purpose-built roost site is difficult, particularly when so little is known about what those requirements are. Over time, as our understanding of the needs of different species improves, it is likely that designs will reflect better the needs of bats and consequently be more successful.

The Bat Conservation Trust holds information about many of the projects undertaken to date and some of the projects have been reviewed in Bat News. Eurobats is currently reviewing measures taken for the preservation, protection, enhancement and creation of underground sites in order to produce further guidance on successful practices.

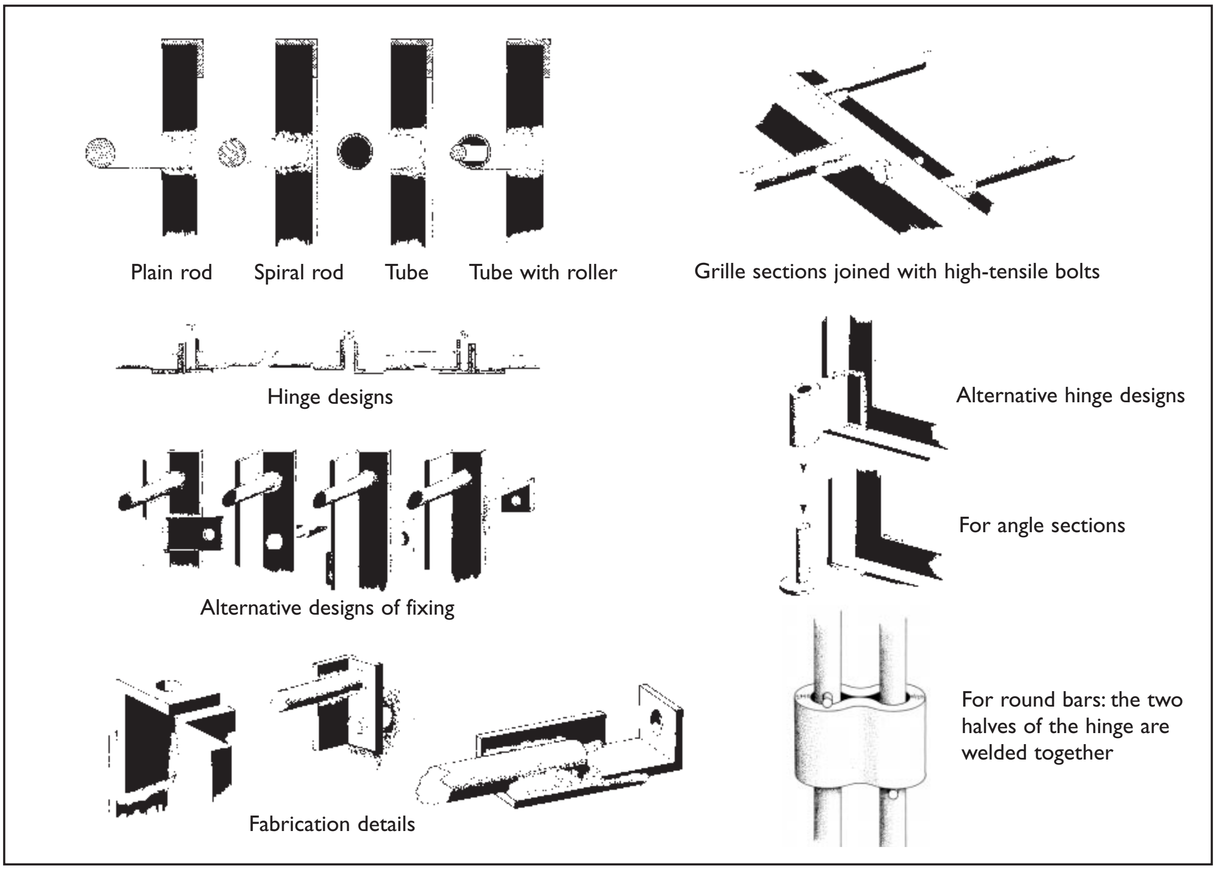


Figure 11.3
Constructing grilles. The choice of materials and method of fabrication are often determined by what is available locally and the vulnerability of the site being grilled. A grille that looks strong can deter vandalism.

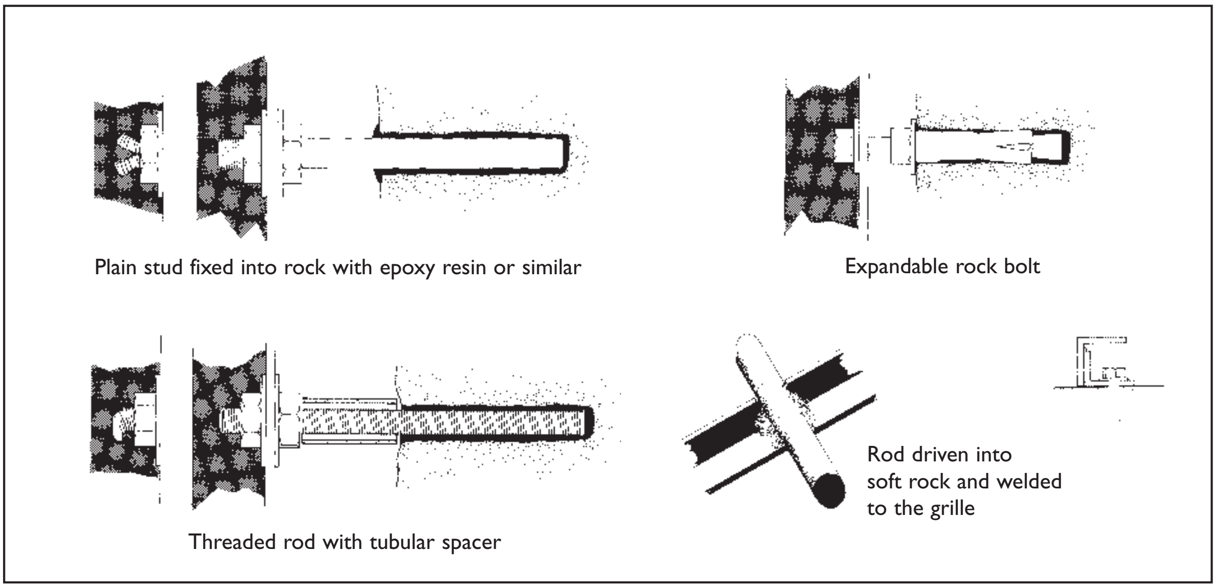


Figure 11.4
Alternative methods of fixing grilles in position.

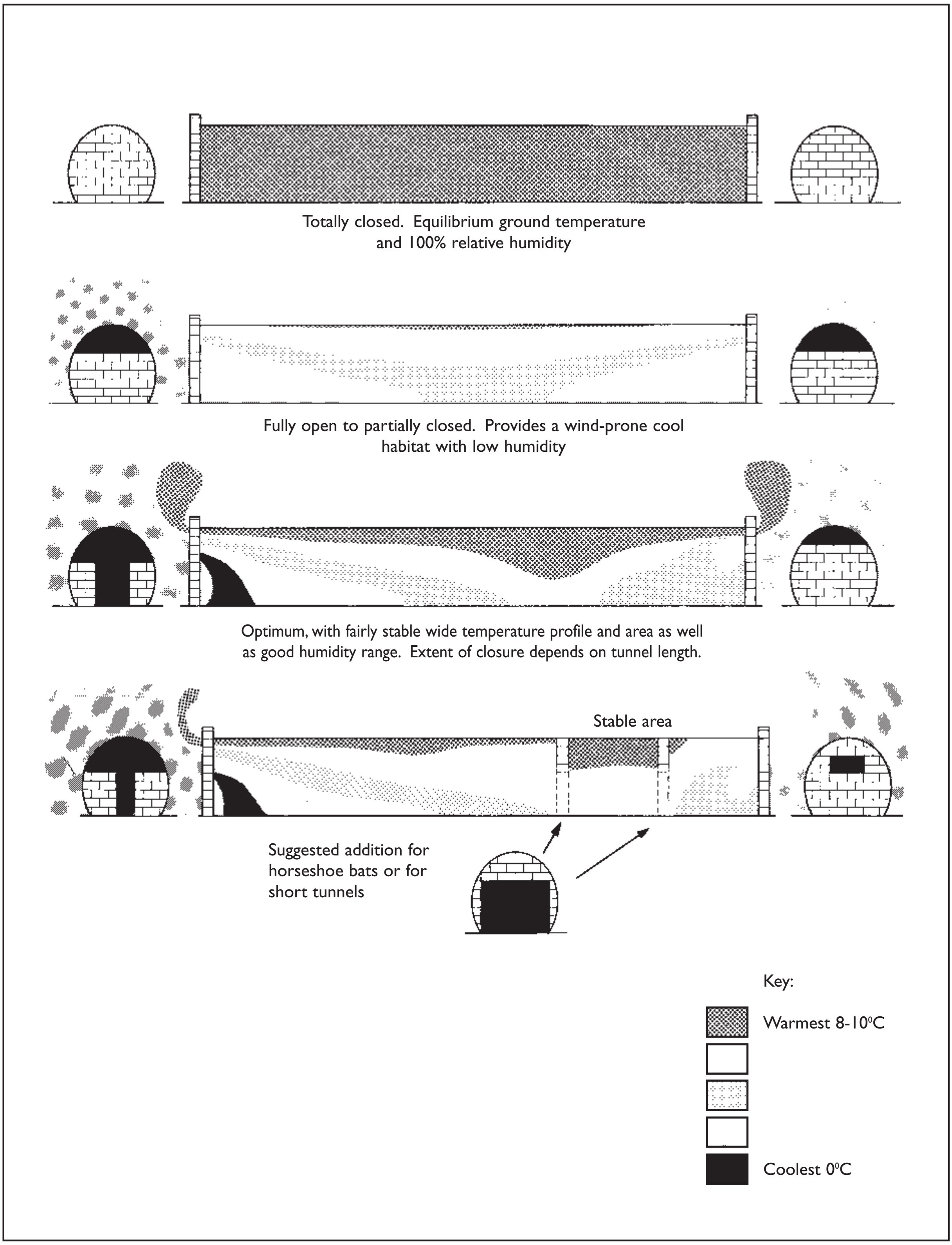


Figure 11.5
Creating bat hibernacula from tunnels. Air flow, temperature and humidity can be controlled by the design of the end-walls. Winter temperatures and air flows are shown.

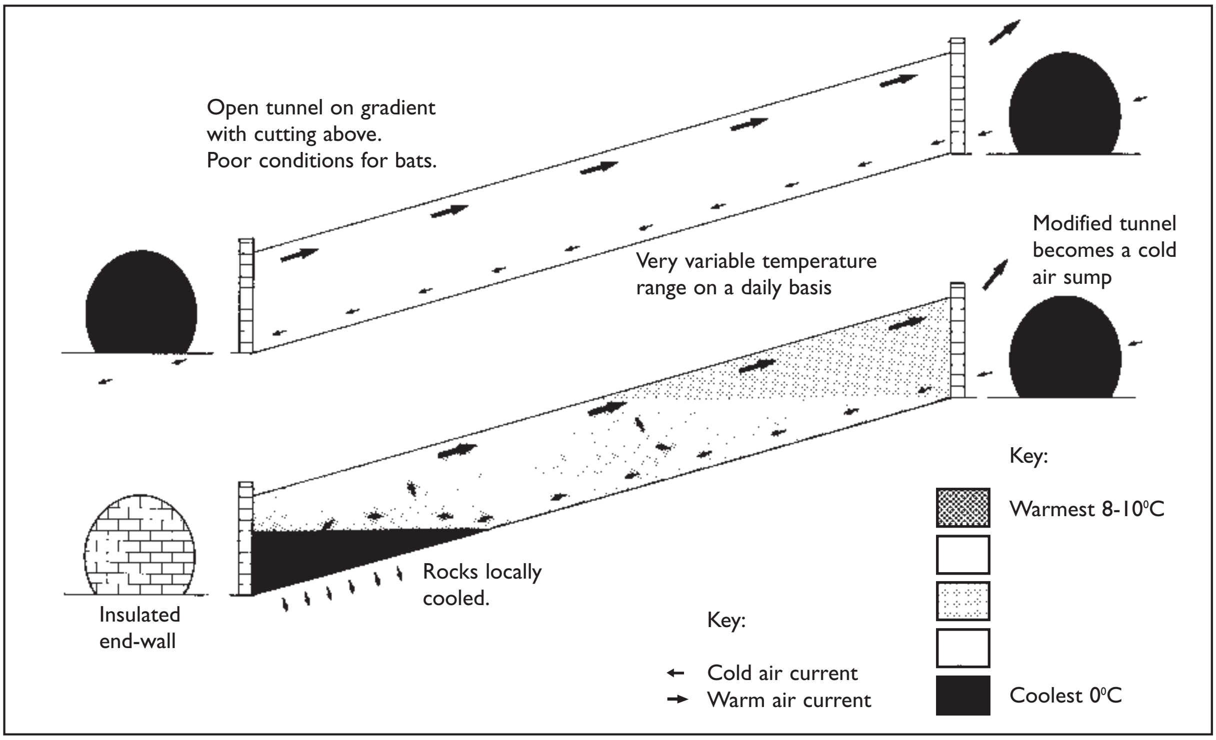


Figure 11.5 (continued)

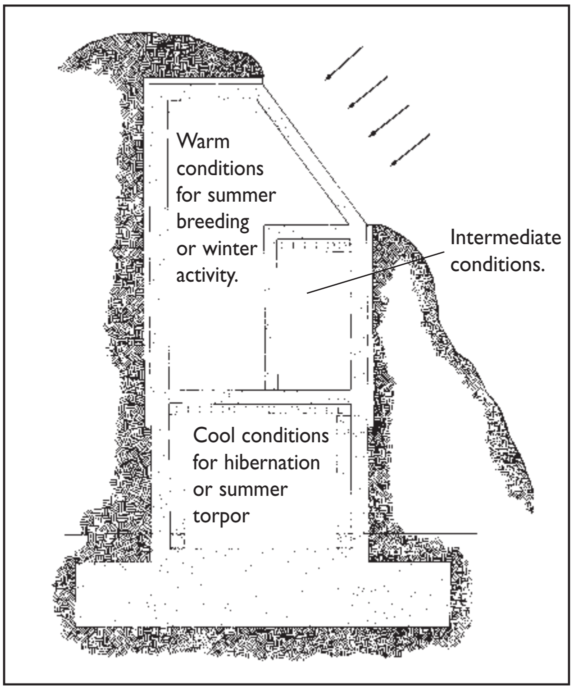


Figure 11.6
Artificial roost site. A wide range of environmental conditions have been provided by using the cooling effect of the ground at the bottom and the warming effect of the sun at the top. Where such a structure can be placed over the entrance to an adit or shaft, convection currents will greatly aid the development of the warm conditions.

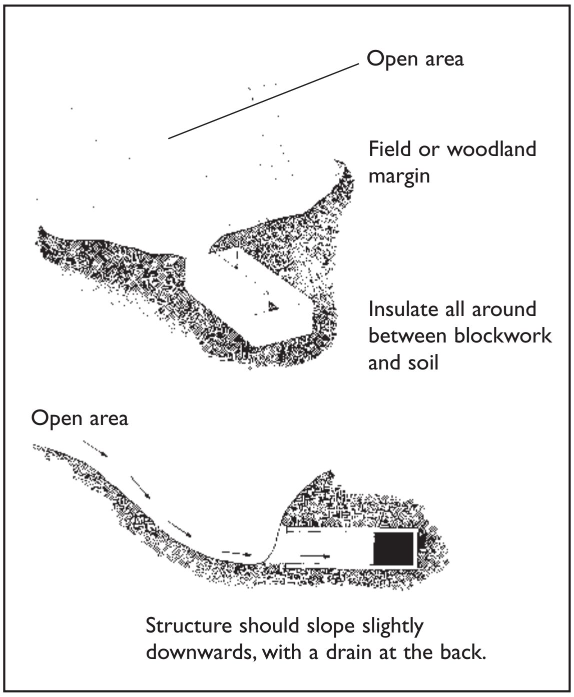


Figure 11.7
Creating an artificial hibernaculum. Constructing this tunnel at the base of the slope will allow cold air to flow into the site, resulting in temperatures lower than the local rocks (8-10°C). The inner end of the tunnel will be the warmest area.

1 2 3 4 5 6 7 8 9 10 11

Converting a pillbox for bats

The standard hexagonal pillbox, most common in the south-east of England, can be converted quickly cheaply and easily to a hibernaculum and occasional summer roost for bats (Figure 11.8a). The choice of box for conversion needs some thought; because one of the main threats is disturbance, boxes near to houses, roads or footpaths should be a lower priority than remote boxes on private land. Unconverted sites are often already in use as summer night or feeding roosts, although not normally as day roosts. This means a converted box may be readily adopted, even in its first year.

Step 1 The first requirement is to stabilise the interior temperature, humidity and light levels. Cut 100 mm medium-density concrete blocks in half and, from the inside, cement one into each of the firing slits at its narrowest point (Figure 11.8b).

Step 2 Three-quarters of a similar block is now cemented into the outside, widest, part of each firing slit. Leave a 200 mm by 20 mm gap at the bottom of the cement layer. You have created a hollow between the inner and outer blocks with bat access to the outside.

Step 3 Next, air flow into the building needs to be controlled. Two walls built of 200–250 mm concrete blocks will do this. The first wall should be flush with the outside of the box, up to two-thirds of the height of the entrance. The second wall, supported on a lintel, should extend two thirds of the way down from the roof at the innermost point of the entrance passage. The lintel can be supported on two columns of bricks (Figure 11.8c).

Step 4 The major part of the conversion is complete, but bats like cracks and holes to hide in. You must create these well out of the reach of rats and foxes. Nail wooden boards (Figure 11.8d) to walls, leaving 15–20 mm narrow gaps between wall and board. The inner shelf of each firing slit can also be built up leaving 20-mm gaps. Tiles can also be nailed to battens on the walls and ceiling to provide further roosting crevices (Figure 11.8e). The more crevices, the greater the possibility that bats will move in.

Step 5 If a security grille is needed, this can be fitted where the entrance passage is closed by the new wall. The grille should be constructed as described in this chapter, using the recommended bar spacing.

The conversion is now complete (Figure 11.8f).

Source: Frank Greenaway/Surrey Wildlife Trust

Bat Conservation Code

Caves and mines, their formations, artefacts and fauna, are all part of our national heritage. All visitors to underground sites should strive to maintain these sites for current and future generations.

Always follow the safety and conservation codes published by the caving and mining history organisations and liase with local groups over access and safety requirements.

Remember also that bats need your help to survive the winter. Most hibernating bats are very difficult to see – many squeeze into cracks and crevices and only the two horseshoe bats normally hang free. Just because you cannot see them does not mean they are not there. Remember the grading system and seek advice about any activity that might affect bats.

Those visiting known bat sites for purposes such as recreation, are asked to observe the voluntary conservation code and respect any special restrictions that have been placed on particularly important bat sites. Because disturbance can be so damaging, only a limited number of people are licensed to disturb or handle hibernating bats in underground sites and licences are issued only after training has been given. Such licences are issued for controlled, carefully considered basic survey and monitoring and occasionally for scientific research.

Contact with bats

- Do not handle bats (unless licensed). Also beware of dislodging bats from their roosting position particularly when you are moving through low passages.
- Do not photograph roosting bats. Flashguns can be very disturbing.
- Do not warm up hibernating bats. This can arouse them. Try not to linger in confined spaces as even your body heat is sufficient to cause arousal.
- Do not shine bright lights on bats. Both the light and the heat can trigger arousal.
- Do not use carbide lamps in bat roosts. Carbide lamps are particularly undesirable because of the heat and fumes.
- Do not smoke or make excessive noise underground. Any strong stimulus can arouse bats.
- Do not take large parties into bat roosts in winter. Rescue practices should also be avoided when bats are present.
- Do seek advice before blasting or digging. Explosives can cause problems both from the blast itself and from the subsequent fumes. In known bat sites blasting should be limited to the summer or to areas not known to be used by bats.
- Digging operations may alter the microclimate of bat roosts.

Source: Bats Underground/BCT

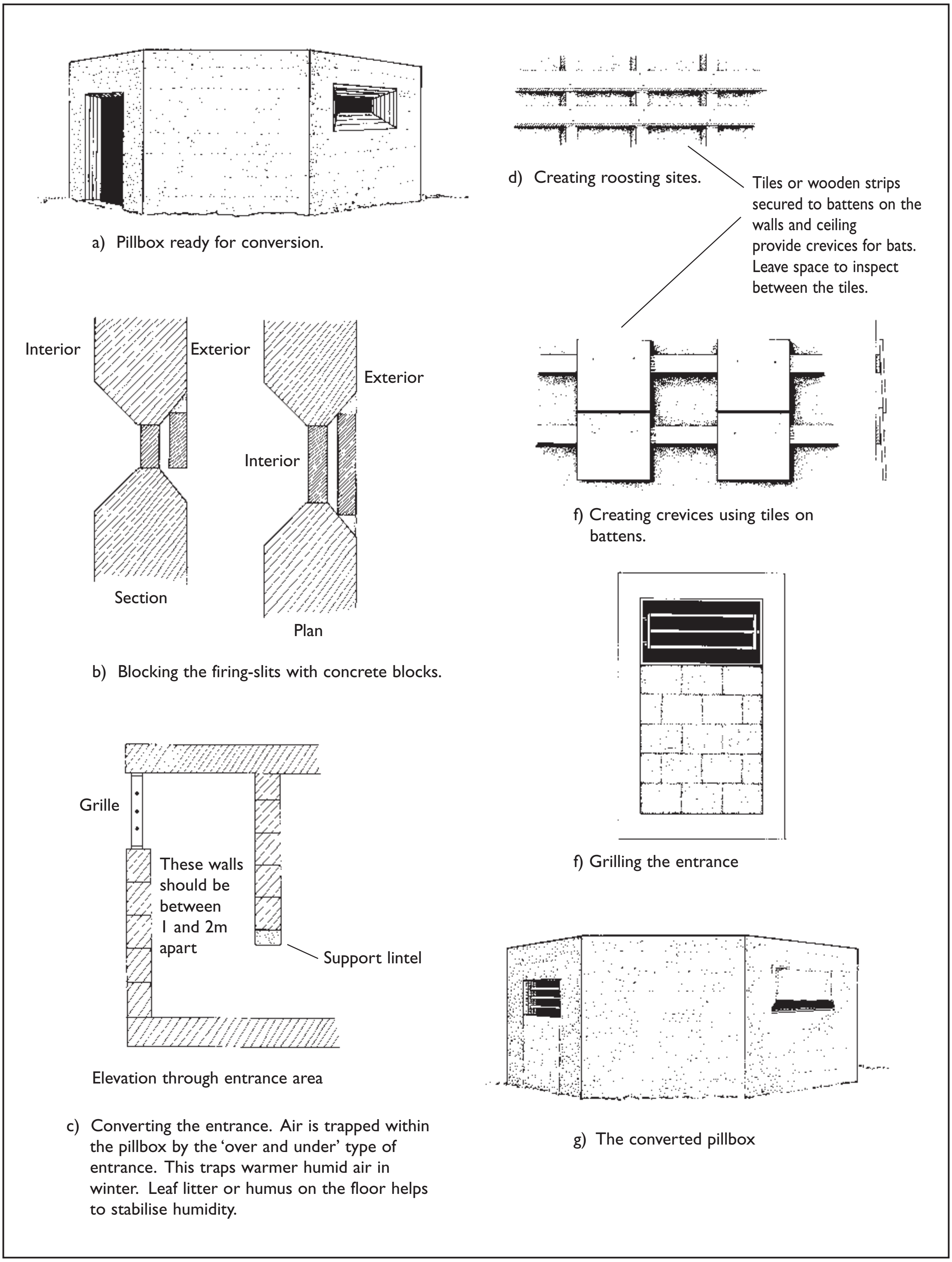


Figure 11.8
Pillbox conversion for bat use. Many of the design details illustrated could be adapted to other situations.

1 2 3 4 5 6 7 8 9 10 11

11.2 Bats and trees

11.2.1 Hollow trees

Most of our bats are woodland animals. Hollow trees are used by a wide variety of species, for both summer and winter roosting, and bats will also roost in crevices in otherwise sound trees. Noctules and pipistrelles are most frequently associated with tree roosts, but many other species have been recorded using them. Naturally, these are the species that have also been found in bat boxes.

The major threat to tree roosts is the destruction of the site. Reports are received every year of bats, usually noctules, being discovered in trees that have been cut down or in boughs that have been removed. Invariably, the workmen are unaware of the presence of the bats until it is too late to save the roost. The most that can be done in such cases is to rescue the bats and release them nearby the same evening if they are fit and well. Attempts could also be made to provide an alternative roost nearby. Either a large bat box or a hollow limb from the felled tree could be used.

If bats are known to use a tree habitually, steps should be taken to ensure that the tree is not destroyed either deliberately or inadvertently.

11.2.2 The value of trees

All the species of bats in Britain are to some extent dependent on trees; for some just as a source of insect food, for others to provide roost sites as well. Horseshoe bats are in the first category, but noctules and Bechstein's bats use trees almost exclusively for roosting.

As a source of insect food

Native tree species are host to numerous insects and when the trees are felled this source is denied them. Not only are trees used as part of the life cycle of the insects, but they also provide shelter, so swarms can build up and the trees act as foci for them. Both standing and fallen dead wood are also sources of insect food for the bats: they should not be cleared away.

Roost sites

Bats may use any crack or hole in a tree as a roost site. Such sites are provided by woodpecker holes, hollows caused by rot and natural ageing and cracks from wind damage and lightning strikes. They may sometimes be found behind loose bark or ivy. Birds, other mammals, and insects such as bees all compete for these sites. Bats are least able to defend their roosts so can only use suitable sites when other animals have finished with them. Holes may be used as gathering sites in spring, maternity roosts in summer and mating places in autumn. Bats will hibernate in such sites if they are deep enough and buffered from temperature changes outside. Summer sites can be in more exposed places that are warmed by the sun.

11.2.3 Recognition of roost sites

It is not easy to find bat roosts in trees. Roosts occur in trees of all ages, sizes and types, but mature beech, oak and ash seem to be favoured. Signs to look for include:

- woodpecker holes, natural cracks and rot holes in trunks or branches that have a black streak below them where bat droppings have oozed out;
- smooth edges with dark marks at the entrance where the bats have rubbed against the wood and left natural body oils;
- droppings under the access point, although these are not easy to find among leaf litter, and are usually washed off the trunk by rain;
- chattering coming from the tree in summer – it is possible to hear some bats such as noctules either when it is hot or when they are about to emerge;
- bats swarming around the site on their return at dawn;
- bats present at the roost seen either emerging or by viewing tree holes using a mirror on a rod with a light or sophisticated probe such as a fibrascope or endoscope.

Hibernation sites are even more difficult to find because the bats leave no signs. The surest way to confirm the presence of bats is to wait for their emergence at dusk during the active season.

11.2.4 Management of trees

Bat workers should make all those involved in tree management aware of the needs of bats and the damage that can be done by felling and lopping of old branches. Although trees that are used by bats are protected by legislation, they are sometimes considered dangerous and so it is assumed that they should be felled.

Such action should be discouraged if at all possible, but may be unavoidable when the tree is near to a public place. Advice on how to make such trees safe rather than fell them can be obtained from the Bat Conservation Trust (The BCT leaflet ‘Bats and Trees’ gives guidance on the management of trees for bats); see also Cowan (2003).

If there is no option other than felling, the tree should be checked carefully for signs of bats. If they are found then the SNCOs must be asked for advice and felling should be delayed until the bats have gone or been removed. Once felled, the roost section should be cut out and strapped to a nearby, sound tree in a similar situation to its original position. If the bats are in the trunk then it is possible that the tree will be safe when reduced to the trunk alone. Try to persuade the owners to leave the trunk standing. Often a tree will become safe if the canopy is reduced or it is pollarded. If bats are present then it would be better to carry out this operation when the bats have left (again negotiate with SNCOs). If bats are in a crack of a branch kept open by stress, care must be taken when cutting so that the crack does not close and crush the bats. Holes may contain bats so care must be taken not to cut into the holes or directly above them. Tree management is best carried out in spring or autumn if bats are to be disturbed as little as possible because this would coincide with the least vulnerable parts of their life cycle. Woodland management should also include management of wide rides with diverse flora to encourage insect diversity.

11.2.5 Liaison with authorities

It is important that bat workers have good working relationships with various bodies involved with trees and woodlands, both public and private. In this way bats are more likely to be considered when tree management work is undertaken. Contacts with planning departments, highway authorities, wildlife trusts, tree wardens and estate managers are all important.

Informal agreements

Voluntary agreement by the landowner or tenant is often an appropriate way of protecting tree roosts. It is most important to ensure that all personnel engaged on woodland management or tree surgery work are made aware of the importance of the roost.

Wildlife and Countryside Act 1981 & Conservation (Natural Habitats &c.) Regulations 1994

Trees that are known to be bat roosts fall within the scope of this legislation, and the SNCO must be consulted before anything is done which would affect the bats or their roost. Deliberate damage or destruction is illegal, but the roost may be destroyed if this is ‘the incidental result of a lawful operation and could not reasonably have been avoided’ (section 10[3][c]). There could therefore be problems in preventing the destruction of roost trees as part of commercial forestry operations, or if there were a genuine danger of the tree falling down. However, the requirement to consult the SNCO does mean that there is at least an opportunity to put forward proposals to save the site. If clearance for building or development is proposed, the destruction of the roost would need to be covered by a Habitats Regulations licence from the appropriate government department.

Tree Preservation Orders

Tree Preservation Orders (TPOs) are a mechanism whereby local Councils can protect individual trees or groups of trees, particularly for their amenity value. An Order confers some protection on the trees that are specified and the permission of the Council is required before they can be pruned or felled. There seems no reason why known bat roosts should not be covered by a TPO, although trees which are in a dangerous condition may be exempt from the provisions of the Order. TPOs are almost invariably administered through the Planning Department of the District, Borough or City Council, many of which have a Tree or Woodland Officer. When first applied, the Order will run for an interim period of 6 months, during which time objections may be lodged by the landowner or other interested parties. If these are not forthcoming or are not upheld, the Order is confirmed and becomes permanent.

There appears to be no restriction on who can propose trees as candidates for a TPO, although clearly applications from responsible organisations are more likely to succeed. Advice on procedures may be sought from the SNCO or by a direct approach to the local Council.

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The Hedgerow Regulations (1997)

These regulations protect important hedgerows in England & Wales. Under these regulations no landowner may remove a hedge without permission from the local planning authority. Many criteria are used to decide if a particular hedge is 'important'. One of these criteria is the presence of a species protected under Schedule 5 of the Wildlife and Countryside Act, e.g. all bats. A bat roost occurring within a tree in a hedgerow or a validated record of a roost within the hedgerow in the 5 years prior to the date of any application to remove the hedge would automatically result in the protection of the hedge. While the roost itself is protected under the Wildlife and Countryside Act, the protection of the hedgerow would be important in order to maintain cover and feeding habitat for bats using the roost.

11.2.6 Bat boxes

Bat boxes of many different designs can be erected on trees and buildings to provide roosting opportunities. Boxes are most commonly made of untreated softwoods, but increasingly boxes made of 'woodcrete' (a mixture of wood shavings and cement) are proving to be successful in attracting bats, having the advantages of better thermal insulation and resistance to rot and damage by woodpeckers and squirrels.

The most common design of bat box is that described in Stebbings & Walsh (1991) but a vast array of alternative designs have been field-tested with varying degrees of success. The Bat Conservation Trust publishes a leaflet covering the design and siting of boxes.

Correct siting of bat boxes is important to increase the chances of occupancy. Boxes should be at least 4 metres from the ground and species such as the noctule *Nyctalus noctula* are more likely to be attracted to boxes placed at 5 or 6 metres above ground. As a general rule boxes should be sited with the front facing SW to SE, which will ensure that the box warms up during the day. Boxes facing other aspects may be used and a common practice is to site three boxes on a single tree, all with different aspects, giving bats a choice of roost sites with different environmental conditions.

Occupancy rates of boxes vary, with many factors such as type of box, geographic location, season and weather conditions influencing a particular bat's choice of roost site. Some bat box schemes in the UK return a 10 % occupancy rate, others 40% and in rare cases 70% or more. Occupancy does not imply long-term usage. Many boxes are used for short periods by a small number of bats. Occasionally boxes are used as maternity sites and impressive numbers of bats (40+) can be found in a single box. Current research suggests that boxes painted black to absorb more solar radiation enhance the internal temperature of the box and therefore make the box more attractive to bats.

Boxes can be erected almost anywhere with some chance of success but results will be significantly better if some thought is given to location. It is also important to make the job of checking the boxes a simple process. Erect boxes where there is easy vehicular access and create a location map of where the numbered boxes are sited. Avoid exposed sites.

Bat boxes should not be seen as an alternative to natural roosting sites such as tree-holes. Bat workers should encourage tree-planting as a long-term solution to lack of natural roost sites. However, boxes are an important resource to bats and have obvious value in conifer plantations, for example they can soon attract bats when sited along rides. They are essentially summer roost sites, standard boxes lacking the required insulating properties to make them suitable as hibernation sites.

Checking bat boxes is also a useful way of introducing potential bat workers to bats. It is simpler than clambering around in a roof space and offers the opportunity for all those participating in the box survey to see a bat with minimal disturbance.

When checking a bat box there are a few important rules to remember:

- Safety is paramount – climbing ladders on uneven ground is risky and the guidelines listed in Chapter 2 of this manual should be adhered to. Safety related to handling bats is also covered in Chapter 2.
- Before opening the box place an empty cloth bag in the exit hole or you will find that half the bats escape.
- Open the box carefully, to ensure that no bats (particularly their feet) are at risk of being trapped by the lid.
- If removing a bat for identification, sexing etc. have a cloth bag to hand with a tie to ensure

that it does not escape from the bag.
- When returning a bat to a box it is generally safer for the bat and easier for the bat worker to encourage the bat back into the box through the base slit rather than placing into the box through the open lid and then closing it.
- Beware of other animals, such as hornet and wasps, which also use bat boxes.

11.3 Bats in bridges

11.3.1 Roosting requirements for bats in bridges

Many bridges have suitable roost crevices for bats offering safety, stable temperature conditions, high humidity, nearby drinking water and feeding areas, and access to linear habitat features used for commuting. The cool, stable conditions found in many bridge crevices are ideal for bats of both sexes roosting in spring and autumn, and for males in summer, when bats may wish to enter daily torpor. Nursery roosts in bridges are presumably heated by the sun due to a southerly aspect or close proximity to the road surface, by the clustering of large numbers of females, or a combination of the two. Bridges with deep crevices may also offer good hibernation sites if they are sufficiently isolated from external temperature fluctuations. Partially blocked arches appear to be particularly suitable as hibernacula. A typical arched bridge design is illustrated in Appendix 1.

All bridges can provide suitable night roosts for resting, eating large prey or socialising. Male pipistrelle bats have used bridges as mating stations (Rydell *et al*., 1994; Russ, 1995).

A high proportion of stone bridges are suitable for bats, with a smaller proportion of brick, concrete and steel bridges being suitable. The majority of bat roosts occur in crevices in stonework of bridges spanning watercourses. However, roosting sites have been recorded from a wide variety of bridge types.

Bats have been found roosting in gaps between stonework and brickwork; in expansion and construction joints; in drainage holes and pipes; in steelwork and occasionally within large enclosed voids within bridges. A range of crevice sizes are used from 100–1500 mm depth and 13–40 mm width. Daubenton's and Natterer's bats most often use crevices 30–400 mm wide and 300–500 mm deep.

Most bat roosts occur in bridges of at least 1m in height and they have been encountered in sites of up to 460 m altitude. In areas of broad-leaved woodland or slow flowing water there is a greater likelihood of bats using bridges.

Even though a number of bridges have been identified as nursery sites, the majority of bats do not appear to rear their young in bridges. Many bats move to bridges in late August. The highest occupancy of bridges generally occurs in September, although a few sites are used in deep winter.

11.3.2 Maintaining and creating roosts in bridges

Maintaining roosts

Bat roosting sites (crevices/holes) can and have been lost during maintenance and strengthening works on bridges. Engineers have been hesitant to retain voids for fear of creating weaknesses or water entry points and lack of knowledge about the importance of bridges for bats.

Holes in stonework and concrete are infilled by pointing (with concrete mortar), spraying (with gunite or shotcrete concrete) or pressure injection (with cementitous grout). Any of these processes may fill roost crevices and prevent access to other cavities within the bridge. More major works may cause even greater amounts of disturbance and potential death of bats.

Determining the presence of roost sites within a bridge is not always easy, particularly during the winter when there is likely to be little bat activity. Frequently, bridges may be too high or otherwise inaccessible to determine if crevices and holes are being used. However, knowledge of use of bridges by bats within a given area is useful particularly when you know that engineering works are proposed.

Bridges have to be inspected regularly and engineers carrying out the inspection may have the necessary equipment in place such as ladders, scaffolding or a hoist to enable an assessment of likely bat use within the structure. Engineers may also have access to specialised equipment such as fibrescopes which allow optical observation within deep crevices.

It is important to establish a working relationship with council engineering and/or highways departments in cases such as those above but there is also much that can be achieved by bat workers alone. The Conservation of Bats in Bridges Project (Billington & Norman, 1997), found that the greatest occupation of bridges by bats was in the period September–October when dispersed maternit colonies, non-breeding groups and harems may be present along with males using sites as mating stations. However, bats may use bridges at almost any time of year and it is important that timing of maintenance works take into account bat activity at each specific site.

Creating roosts

Where bat roosts in bridges are lost due to demolition, re-building or engineering constraints, new bat roosting sites should be created within the structures, duplicating the original crevice dimensions. Engineers have often suggested fitting a bat box to structures after the works have been completed, but to date no bat box has been confirmed to re-create the same thermal capacity, conductivity and microclimate conditions that would be found deep inside a bridge. Bat boxes are useful in their own right but should not be seen as replacements for a lost bridge roost.

Crevice-width selection by bat species encountered in the Cumbria survey (Billington & Norman, 1997), suggests that any artificial roosting sites should contain a variety of crevice widths (13–70 mm) and depths (350–>1000 mm) for summer roosts, and deeper for winter hibernation sites. Bats generally avoid wider crevices, but they can occasionally roost in open situations on the walls of enclosed voids, for example. Where opportunities arise to incorporate bat roosting crevices into sites during repairs, rebuilds or construction of new sites these should be taken up. If possible, roosting sites should be incorporated into bridge spans because this is where 75% of bat roosts were found in bridges in Cumbria. Otherwise they should be sited as high as possible in the abutment walls. Some examples of bat roosting sites and roost creation techniques are shown in Figure 11.9.

Few ready made artificial roost units are available for use. A bat roost unit consisting of a hollow cube with three open sides is available from Marshalls Clay Products. This is designed to be placed inside a structure and faced with bat access bricks, which have slits to allow bats into a void of 110 mm x 150 mm x 215 mm.

The z-z-z clay bat brick from The Norfolk Bat Group has proved successful in underground sites. Concrete bat boxes of various designs, including a multi-crevice concrete box (by Billington) have been widely used in the UK.

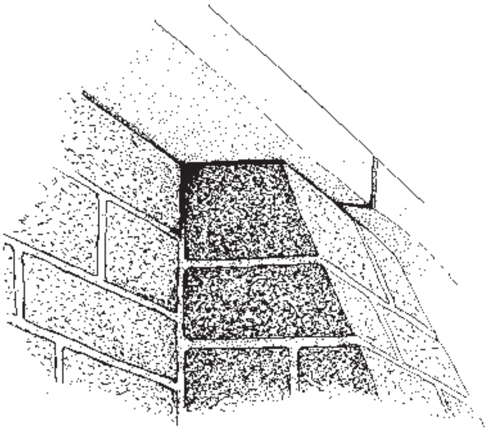
Case histories of bridge maintenance works

Barth Bridge
A single-arch stone bridge with low flood inverts. Major re-pointing and pressure grouting was scheduled for May 1995. Bat signs were discovered in September 1994. Scaffolding was erected 2 weeks ahead of works to take account of any bats present. A detailed survey was carried out using a fibrescope and several bat holes were identified and marked. A site meeting was held with the engineer. A further survey and exclusion (after removing one Daubenton's bat) was carried out at the beginning of June, but due to contractors not following instructions most of the holes were lost.

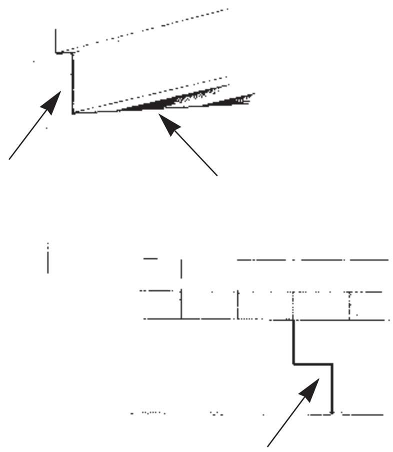
Rash Bridge
Double-arch stone bridge in which the main roosts of Daubenton's (12) and Natterer's (3) bats are situated in the northern arch. Major re-pointing and pressure grouting works were carried out in 1994 and 1995. Works were delayed after bats were found. A fibrescope survey was carried out from scaffolding on the southern arch. Several bat holes were marked and successfully retained, some more than 700 mm deep. Works were delayed on the northern arch until May 1995 (in case hibernating bats were present). Holes were surveyed with a fibrescope and marked. Problems arose because some of the bat holes extended upwards for almost 1 metre. English Nature contracted an independent engineer to produce a report on retaining deep crevices. Before works on the northern arch were carried out several bats had to be excluded. Daubenton's bats were observed at the bridge in 1995 but Natterer's bats do not seem to have returned.

Examples of roost creation within bridges

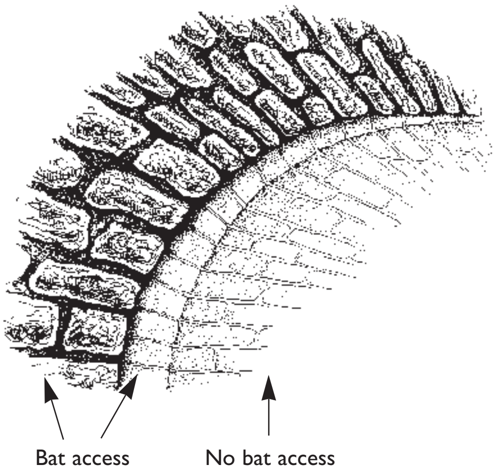
Figure 11.10a-g show examples of roost creation from various sites. Cambeck footbridge was a new bridge of steel and concrete deck over stone faced abutments. Roost crevices were incorporated into the abutments (Figure 11.10g/h).
At Fort Augustus, Inverness, Forest Enterprise drew up a design for an artificial roost site for their Civil Engineers. The roost was built into a bridge abutment about 650 mm above water level. The roost cavity is approximately 450 mm cubed and has a layer of bricks on the outside face with access slits between the brickwork. Drainage holes of 6-mm diameter were incorporated into the wall. The interior was filled with loose rock (Figure 11.10e/f). No bat use has yet been confirmed.



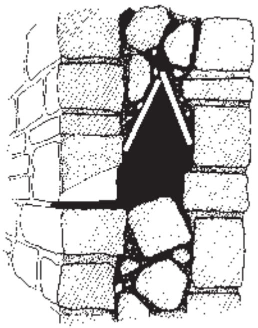
a) Bat access at corner of bridge buttress



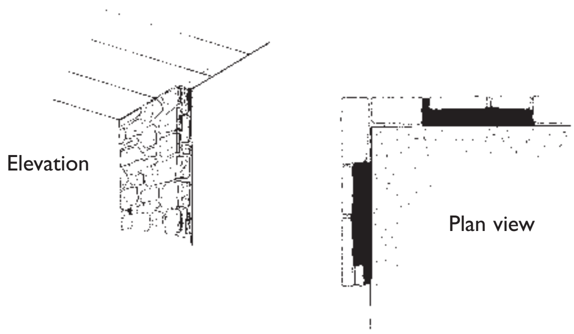
c) Bat roosting crevices in concrete bridges



b) Bats can find roosting crevices in the older section of the arch or in the gap where the bridge has been widened. The repointed section provides no roosting opportunities.



d) Two tiles can be used to roof a cavity in a rubble filled wall. Access is created by omitting mortar from one of the joints.



e) Creating bat accommodation behind stone facings on concrete construction. As the facing is not a structural support, this does not compromise the integrity of the structure.

Figure 11.9
Bats in bridges

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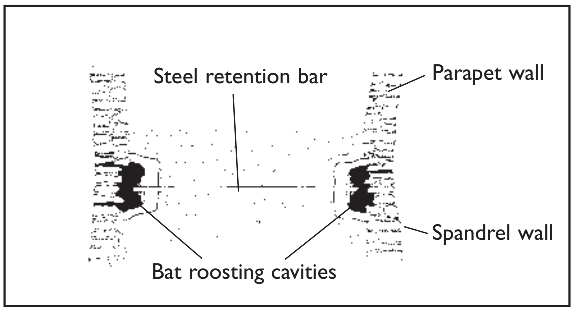

Figure 11.10a
Vertical cross-section of bat roosting cavities created during spandrel wall retention works (redrawn from Turner (1995)).

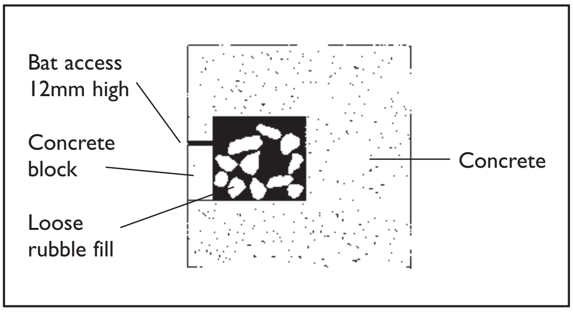

Figure 11.10e
Vertical section of bat roost built into a Forest Enterprise bridge abutment (redrawn from Whittaker (unpub.)).

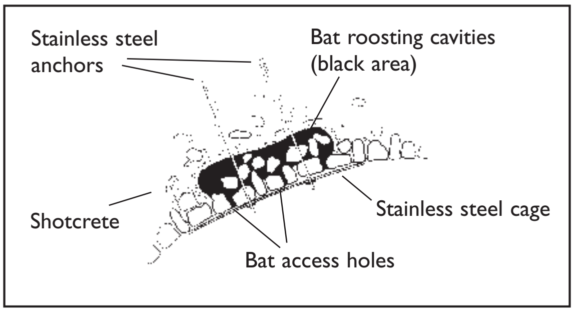

Figure 11.10b
Vertical cross-section of bat roosting cavities constructed by excavating into the underside of the archway (redrawn from Turner (1995)).

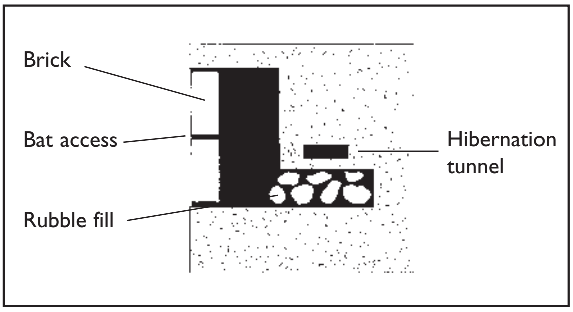

Figure 11.10f
Design modification of Figure 11.10e (redrawn from Whittaker (unpub.)).

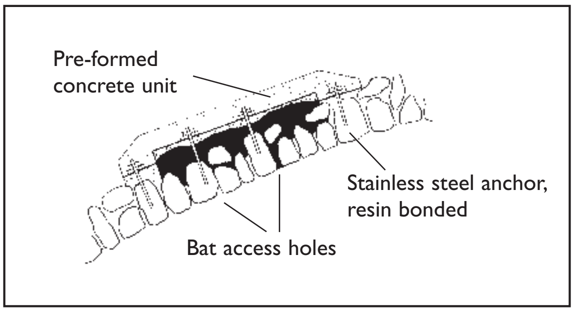

Figure 11.10c
Details of pre-formed roost unit fitted over arch stones during saddling works (redrawn from Turner (1995)).

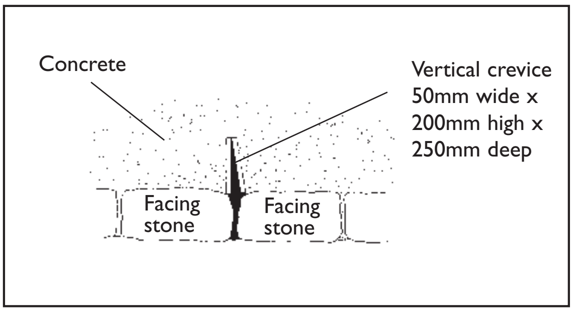

Figure 11.10g
Bat roosting crevice created during Cambeck footbridge construction (horizontal section through abutment).

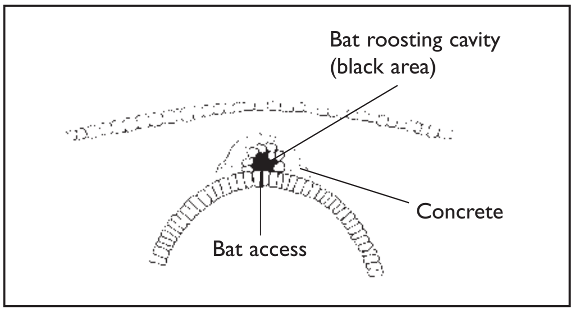

Figure 11.10d
Details of bat roosting cavity created at Garsdale Church Bridge during saddling works (designed by Billington & Donnison).

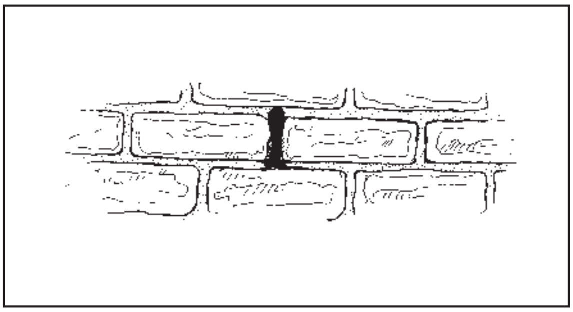

Figure 11.10h
External view of bat roost crevice shown in Figure 11.10g.

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Daubenton's bat by a bridge. © Frank Greenaway

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Greater mouse-eared bat. © Frank Greenaway