Conserving
Grey Long-Eared Bats
in our Landscape

University of BRISTOL

Bat Conservation Trust

Conserving Grey Long-Eared Bats (*Plecotus austriacus*) in our Landscape: a Conservation Management Plan

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Part 1
Background information

Distribution and conservation status

The grey long-eared bat, *Plecotus austriacus* (Fischer 1829), is one of the rarest and least studied bat species in the United Kingdom (UK). Lack of information on its ecology, behaviour and phylogenetic affinities (evolutionary relationships) has hampered the development of specific conservation management plans (Dietz et al. 2009). The distribution of the grey long-eared bat is restricted to Europe with the exception of the Island of Madeira off the Atlantic coast of Africa. The distribution extends from the North Mediterranean coast in the south to south-west Wales, Germany and Poland in the north, up to 53° N (Figure 1). Grey long-eared bats are relatively common in southern Europe, and therefore their global conservation status determined by the International Union for Conservation of Nature (IUCN) is Lower Risk Least Concern, but they are extremely rare at the northern edge of the range (Juste et al. 2008). A recent assessment of changes in the population status of several European bat species identified a trend of decline in grey long-eared bat populations across Europe (Haysom et al. 2011).

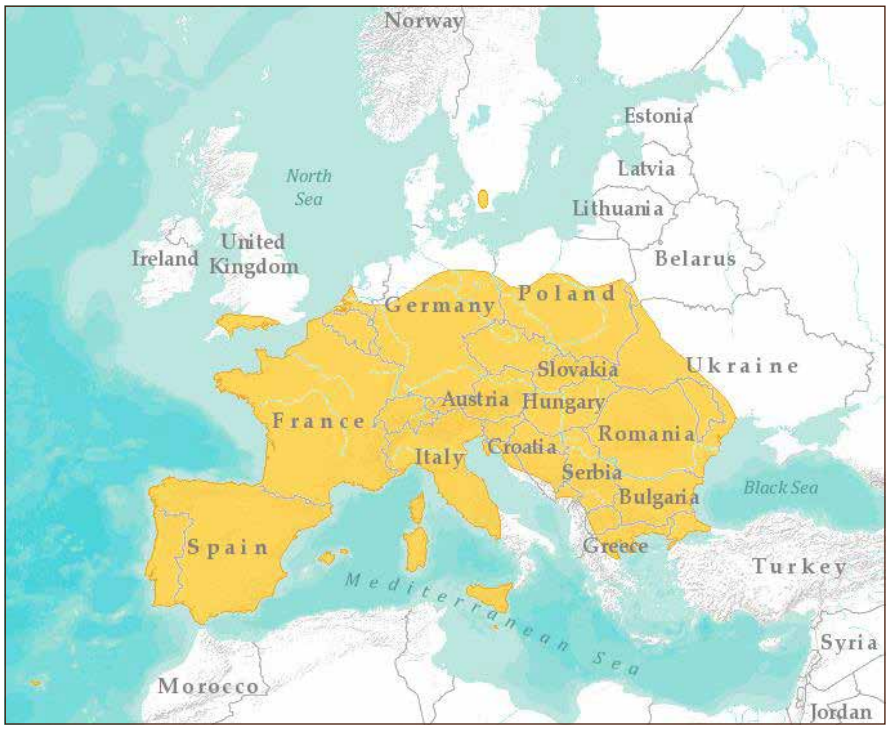

Figure 1 – The global distribution of the grey long-eared bat. The Swedish record is from a single dead individual (figure taken from http://www.iucnredlist.org/details/17597/0)

In the UK, the grey long-eared bat is restricted mainly to the southern coast of England, with a handful of records in Devon, Dorset, Somerset, Hampshire, Isle of Wight and Sussex. Recently evidence of grey long-eared bats was found also in south-west Wales. There are currently around eight confirmed active maternity colonies in England and several known temporary roosts (Figure 2). Ecological niche modelling (with the program Maxent [Phillips et al. 2006]) shows that suitable environmental conditions for the grey long-eared bat in the UK do not extend much beyond the currently known distribution, including the recently discovered Welsh roost (Figure 3). The distribution of the grey long-eared bat in the UK is mainly limited by low winter temperatures, high summer rainfall and the availability of grasslands (Razgour et al. 2011a).

With an estimated English population size of 1000 adults and recorded losses of several maternity colonies in the past few decades, the grey long-eared bat is one of the rarest UK mammals (Harris et al. 1995). Effective population size (N_e: the number of individuals in a population that contribute offspring to the next generation) estimates based on molecular data (N_e = 184 ±110 [Credible Intervals: 107–537]) confirm these population estimates, suggesting that the adult population size is 1000–3000 bats and that the population appears to be declining (Razgour 2012).

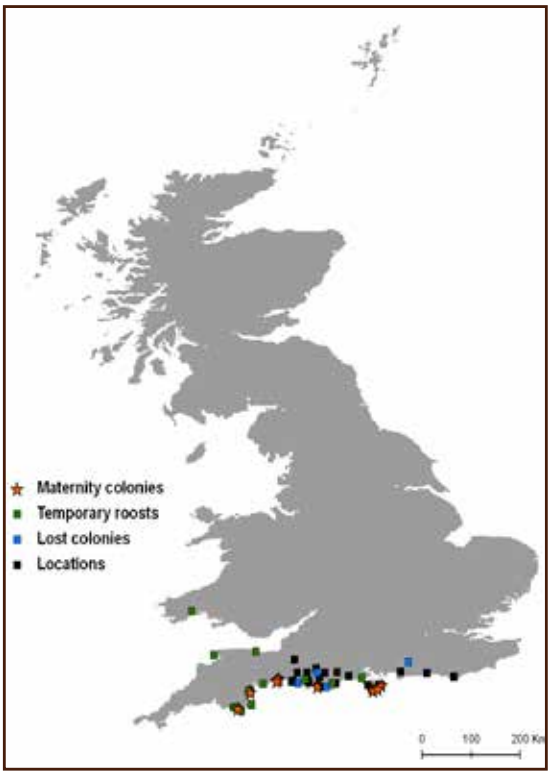

Figure 2 – The distribution of grey long-eared bat records across the UK. Maternity colonies are marked with an orange star, recently lost maternity colonies in blue squares, temporary roosts in green, and other records in black.

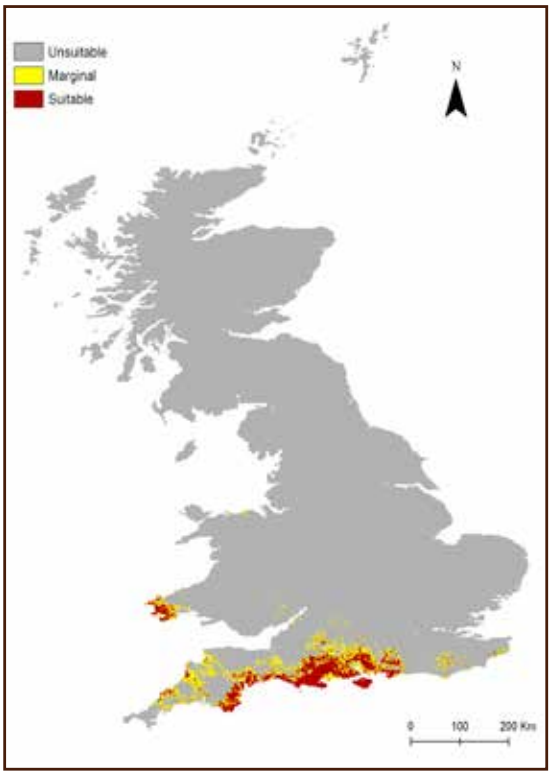

Figure 3 – Predicted suitable areas for the grey long-eared bat in the UK based on ecological niche modelling (Maxent), with grey representing unsuitable areas, yellow marginal and red suitable (based on data from Razgour et al. 2011a).

Conservation genetics of the English population

(based on data from Razgour 2012 and Razgour et al. 2013)

Genetic diversity in the grey long-eared bat is highest in Iberia (41 out of the 54 mitochondrial DNA haplotypes) and much lower at the northern edge of the range. Nevertheless, the English population contains five unique haplotypes, with unique haplotypes in each maternity colony (Figure 4).

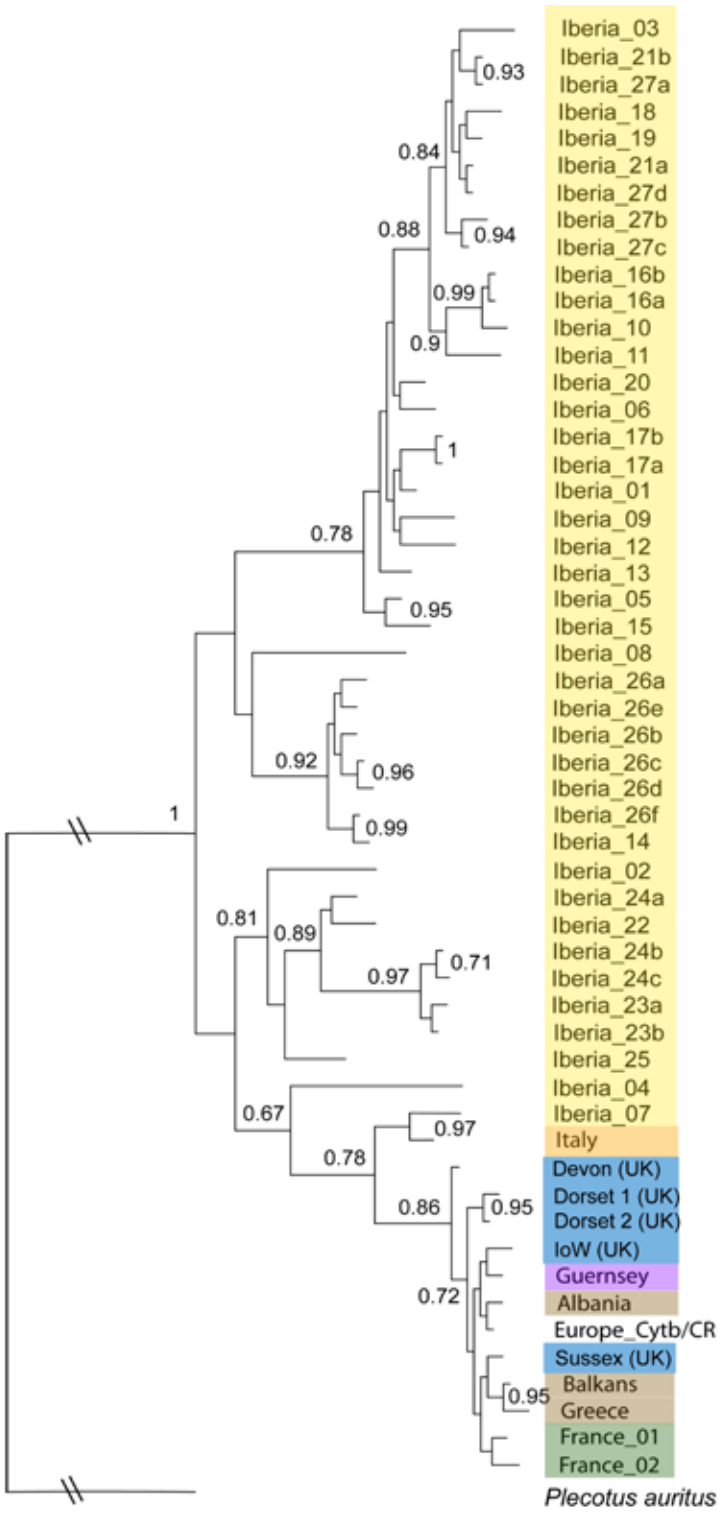

Figure 4 – Bayesian phylogenetic tree of grey long-eared bat combined Cytochrome b and Control Region haplotypes, showing posterior probabilities greater than 0.65. Haplotypes are named and colour-coded based on the geographic location of samples.

Grey long-eared bats across Europe are divided into seven main genetic population clusters (based on 23 microsatellite loci, using the program STRUCTURE [Pritchard et al. 2000]). Grey long-eared bats from both England and the Channel Isles form distinct population clusters, separated from the rest of the range. The English population is further divided into two sub-populations, separating the West Devon colony from the rest of the English samples. Other distinct population clusters include Iberia, Italy and the Balkans (Figure 5).

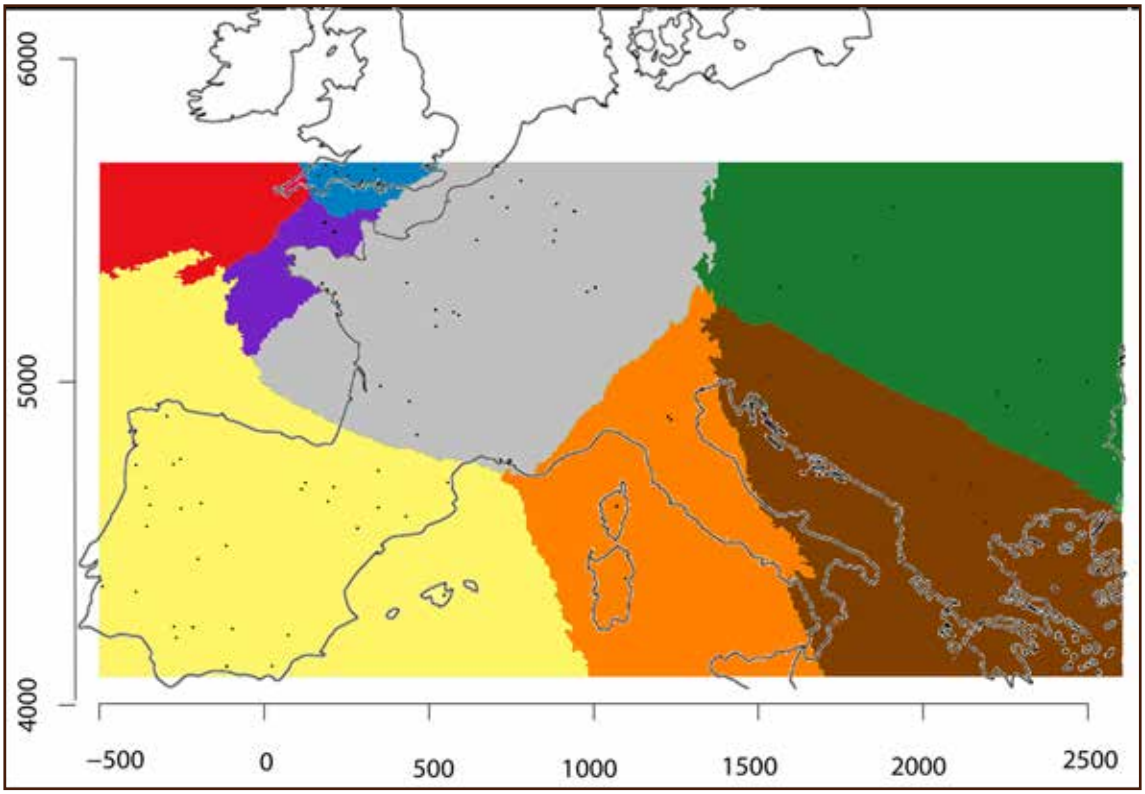

Figure 5 – Genetic population structure of the grey long-eared bat across Europe, with the location of each population marked with a different colour: Iberia - yellow, Italy - orange, Balkan Adriatic coast - brown, Balkans - green, mainland western Europe - grey (admixture population), Channel Isles - purple, England - blue, and Devon - red (Razgour 2012)

General biology

Species identification

The long-eared bat genus Plecotus is a cryptic species complex with up to 19 morphologically similar but genetically distinct species (Spitzenberger et al. 2006). Therefore the two UK resident species, the grey and the brown *(Plecotus auritus*) long-eared bats, cannot be told apart without morphological measurements or molecular tools (genetic analysis of droppings or tissue samples). As a general rule, the dorsal fur of the grey long-eared bat is darker and greyer than that of the brown long-eared bat, the ventral fur is whiter and the face is darker with white tufts under the chin. However, juvenile brown long-eared bats can be easily confused with grey long-eared bats due to their darker colouration.

Important measurements:

Forearm length: 38-43 mm ; **Body mass**: 7–12 g

Tragus: 5.5–6.5 mm
(brown long-eared bat < 5.5 mm)

Thumb: 5–6.5 mm
(brown long-eared bat > 6.5mm)

Wing morphology

Based on its wing morphology, the grey long-eared bat is expected to be highly manoeuvrable, fly slowly, usually close to or within cluttered environments, and have limited long-distance dispersal abilities. These flight characteristics suggests that the foraging mode is both gleaning of insects from surfaces and slow insect hawking through sustained manoeuvrable flight near the vegetation (Norberg and Rayner 1987). The grey long-eared bat is thought to be able

to adjust its flight mode to the foraging habitat, flying fast and straight in open habitats, but adopting a slower, fluttering flight when foraging within vegetation structures (Fluckiger and Beck 1995). Wing loading (7.9 N m^{-2}) and aspect ratio (6.1) values are relatively low (Norberg and Rayner 1987) and not significantly different from the brown long-eared bat. However, differences in flight performance between the two cryptic species may result from the higher wing tip index of the grey long-eared bat (Sevcik 2003).

Echolocation calls

Grey long-eared bats use low intensity, short, multiharmonic, frequency modulated (FM) echolocation calls (Figure 6), characteristic of whispering gleaning bats. Due to their quietness, grey long-eared bat calls can only be detected from short distances, generally < 5m (Russ 2012). Peak frequency is usually in the 1st harmonic, and therefore all given call parameters are based on the 1st harmonic (Table 1).

Table 1 – Echolocation call parameters for grey long-eared bats in the UK (taken from Dahlberg 2004), Italy (Russo and Jones 2002) and Switzerland (Obrist et al. 2004).
FmaxE = frequency of maximum energy (peak frequency); Start Freq. = start (maximum) call frequency; End Freq. = end (minimum) call frequency

	Duration (ms)	FmaxE (kHz)	Start Freq. (kHz)	End Freq. (kHz)
UK Echolocation	2.1 ±0.7	30.8 ±2.8	44 ±2.9	21.8 ±1.5
UK Social calls	8.7 ±1.6	16.9 ±1.9	41 ±3.5	10.7 ±1.4
Italy Echolocation	3.8 ±1.4	32.6 ±8.7	41.4 ±2.1	23.6 ±2.9
Swiss Echolocation	5.8 ±1.4	27.6 ±2.5	45.3 ±3.3	18 ±2.3

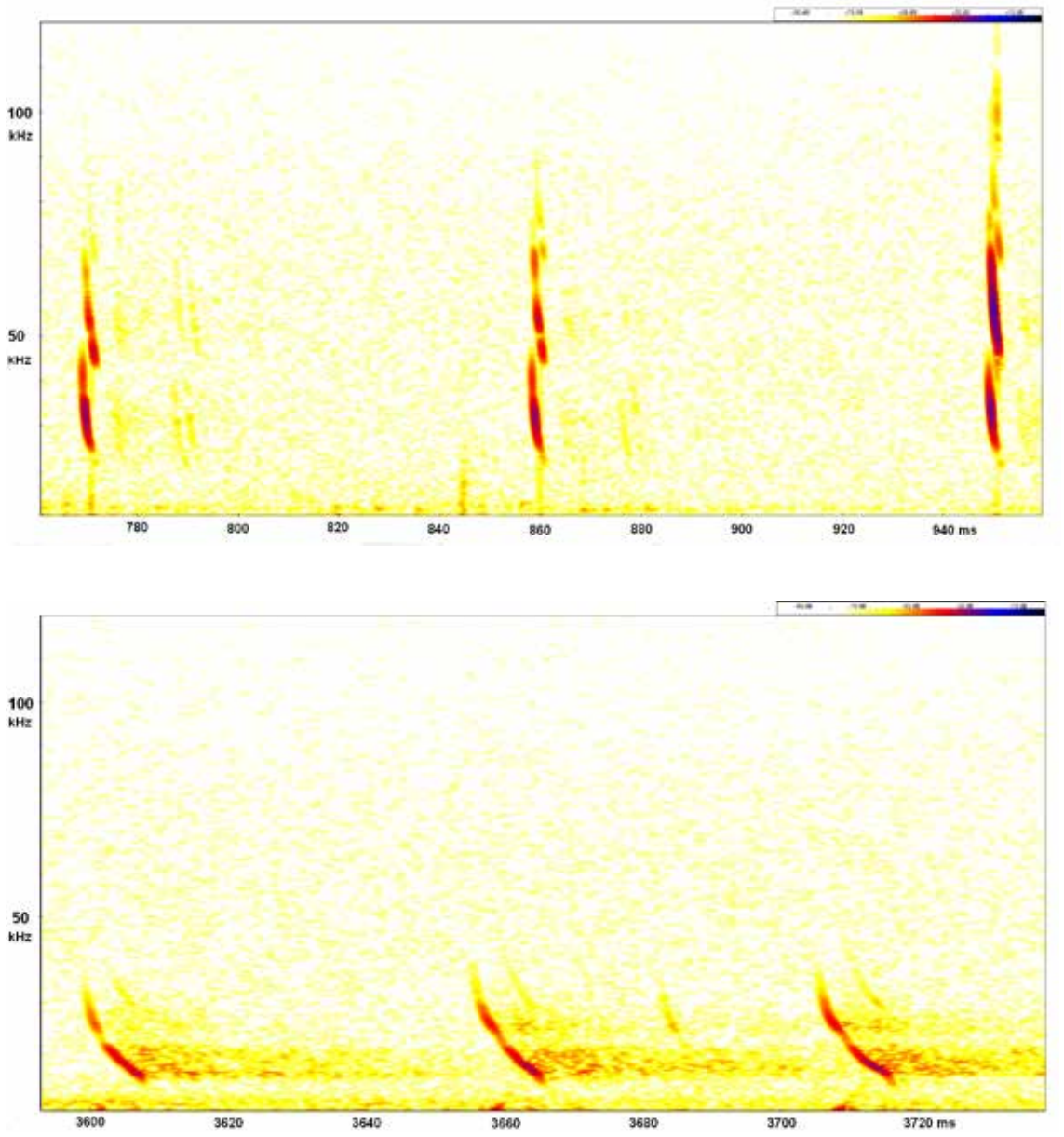

Figure 6 – Example spectrograms of grey long-eared bat echolocation (A) and social (B) calls (provided by E. Dahlberg)

Roosting requirements

Identifying roosts and understanding the roosting ecology of bats is essential for their conservation. Individual grey long-eared bats can be found in summer maternity colony roosts between mid April and late October, but the main colony occupancy period extends between May and mid September. Grey long-eared bats tend to give birth to young relatively late (end of June – mid July) and lactating females can be found until mid–late August. Grey long-eared bats are believed to mainly mate in summer colonies and are rarely found in swarming sites (Horácek 1975; Swift 1998). The mating season lasts from mid-September until mid-Octoberr (Stebbings 1976), though it may continue throughout the hibernation period.

Summer colonies consist of 10–59 bats, and include mature females, juveniles and occasionally adult males. Adult males tend to roost solitarily within the roof space (Stebbings 1970; Horácek 1975; Scheunert et al. 2010). In England, maternity colony sizes range between seven and around 20 adult bats and comprise mainly lactating females and their young, but also a few nulliparous females and adult males. Single adult males are present in maternity colonies throughout the activity period (April–October), though higher concentrations of adult males were observed in April. Juvenile recapture rates in maternity colonies were very low. Only two female juveniles were recaptured in their natal roosts the following year. Relatedness within colonies among adult females was generally low, below half-sibling level (Razgour 2012).

Roost description

In northern Europe and throughout the UK, grey long-eared bats tend to live in close proximity to human settlements and roost almost exclusively in man-made roosts, primarily in the roof space of buildings, churches and barns. It is thought that the availability of buildings as roosts

in the past few hundred years may have allowed some temperate bat species to expand their distribution to more northern latitudes (Fenton 1997). Use of caves and rock crevices is more common in southern Europe, but has also been recorded on the Isle of Wight. Use of bat boxes for roosting has not been recorded in this species in England (C. Morris pers. comm.). Although maternity colonies tend to show high roost fidelity, grey long-eared bats use a network of temporary roosts near the maternity colony both as night and day roosts, especially outside the lactation period.

In the UK and Channel Isles the grey long-eared bat roosts tend to be found in old traditional buildings (pre-Victorian to Victorian) with large roof spaces. Barns and disused farm buildings are commonly used as night or temporary day roosts, although some radio-tracked bats also night roosted in trees, under bridges and in rock crevices. Night and temporary day roosts are often open-fronted or open-access buildings, facilitating access to roosting space.

Maternity roosts are generally located in solid stone or brick buildings with slate roofs. Roof spaces have large wooden beams, often include chimney stacks and tend to be divided into several connected compartments. Some roofs have felt insulation under roof slates. Although roof spaces are generally dark, some contain small windows. Grey long-eared bats require large roof spaces for maternity roosts. Roof floor sizes range from 104 and >220 square meters and maximum roof height is greater than 2.5m. Temporary day roosts may be found in smaller roof spaces, though still large enough to enable free flight and >3m in height.

Within the roof space, grey long-eared bats form clusters or roost individually between roof beams, tucked into the ridge on the ridge board, under ridge tiles, in gaps between walls and roof beams, in wall crevices, behind or on top of roofing felt, or hang freely on roof beams. After giving birth and before the young are volant, reproductive females and their young tend to roost in inaccessible locations within the roof space, for example cavities at the top of chimney stacks or inside walls. A study of maternity colonies in the roofs of five churches in Germany identified the roof ridge and crevices in the roof ridge as the primary roosting locations of grey long-eared bats (Scheunert et al. 2010).

Roost temperatures

Roost ambient temperatures were recorded with Tinytag Talk2 temperature Dataloggers left hanging in the roof space of four maternity colonies and four temporary roosts for 1–2 year periods. During the main colony occupancy period (May–September) average monthly temperatures in maternity roosts ranged between 17.9 (±2.1) and 21.5 (±2.4)°C, with a season average of 20.1 (±1.7)°C. A minimum roost temperature of 7.8°C was recorded on the Isle of Wight in May and a maximum of 42.3°C was recorded in Devon in June (Figure 7). Stebbings (1976) recorded an average temperature of 16.3°C, with a range of 10–38°C, between May and August in roof areas commonly used by grey long-eared bats in a maternity roost in Dorset. In churches in Germany between July and October grey long-eared bat colonies roosted in sections of the attic where temperatures were 20–25°C, and tended to avoid areas with temperatures above 32.5°C or below 19°C (Scheunert et al. 2010).

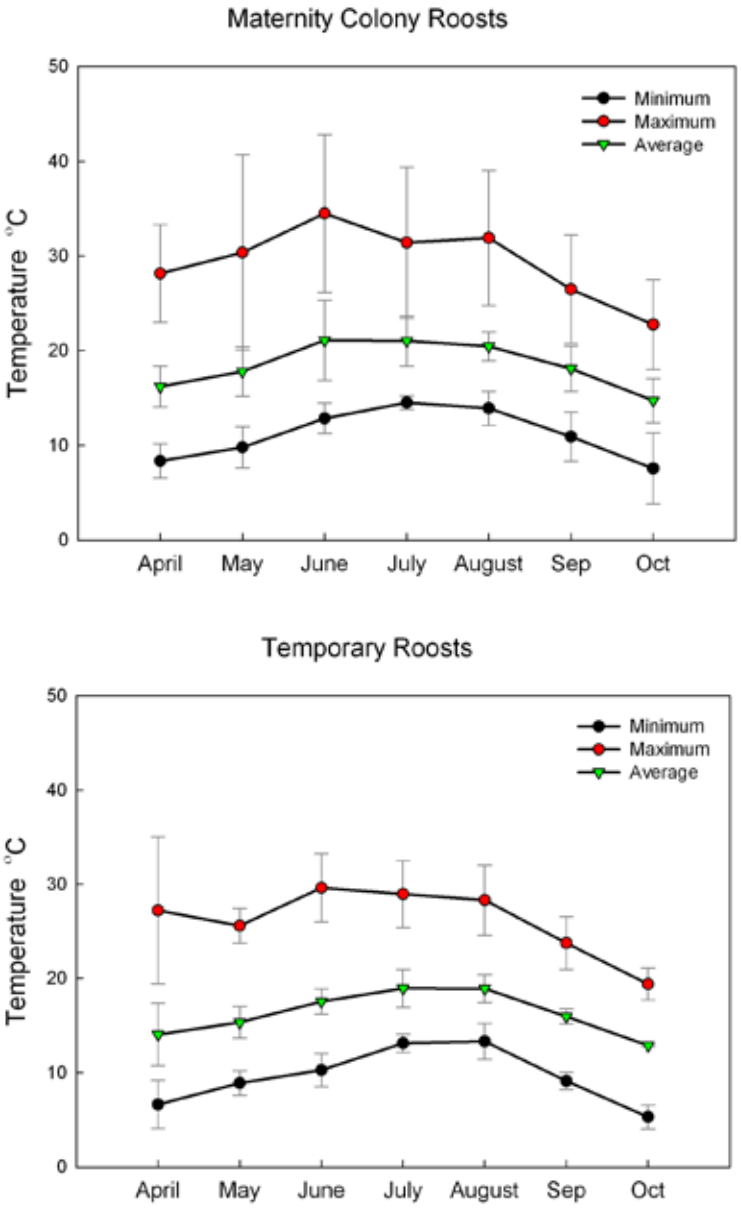

Figure 7 – Monthly values of minimum (black), maximum (red) and average (green) roost temperatures averaged (with standard deviations) at four maternity colonies in England and the Channel Isles (top), and four temporary roosts in England (bottom).

Habitat around roosts

Roosts are often located at the edge of villages, surrounded by open grasslands, well-developed hedgerows and woodland patches. Five of the known maternity colonies in the UK and several temporary roosts are located less than 5 km away from the coast.

Hibernation and winter ecology

Grey long-eared bats across Europe hibernate in cellars, attics, underground galleries, mines, quarries, caves and rock crevices (Horácek 1975; Swift 1998; Dietz et al. 2009). Hibernation sites are usually located within less than 30 km from summer roosts, but distances may range between 5 and up to 61 km (Hutterer et al. 2005). At a site in Dorset, grey long-eared bats hibernated in their summer roost in roof areas where hot water pipes maintained temperatures above freezing throughout the winter. They selected the warmer areas of the roof (average temperatures 12°C) that were subjected to considerable temperature fluctuations, which resulted in frequent arousals and changes of roosting sites (Stebbings 1970). Similarly, in central Europe, grey long-eared bats tended to select warmer hibernacula microclimates with more variable ambient temperatures (2–9°C) than sympatric brown long-eared bats (Horácek 1975).


ERIKA DAHLBERG

Foraging habitat requirements

Information on foraging habitat requirements is based on a radio-tracking study of 20 grey long-eared bats from two maternity colonies in West Devon and the Isle of Wight. The study was carried out between April and September 2009 and 2010 (Razgour et al. 2011a). Information is also included from a radio-tracking study of eight bats from a maternity colony in Sussex carried out in 2002 by Daniel Whitby.

Foraging behaviour & night activity patterns

Grey long-eared bats emerge on average more than half an hour after sunset (range: 16–68 min after sunset) and are active for an average of around six hours (350 ±120 min) before returning to the day roost for the final time (range: 70–505 min per night). Lactating females forage for longer, night roost for longer periods and travel further distances than non-reproductive females. Foraging time is also strongly affected by night temperature, with bats foraging for less than 2.5 hours on nights when temperatures drop below 6°C due to increased foraging costs with reduced prey availability at low temperatures (Razgour et al. 2011a).

Home range sizes are highly variable between individual bats and in particular between seasons, with lactating females having larger home ranges than non-reproductive females (mean home range size with standard deviations: 4.6 ± 3 km^2; range: 0.3–8.7 km^2). Colony range size varies between locations (17.4–37.2 km^2) and may be affected by the number of radio-tracked bats and foraging habitat quality. Grey long-eared bats tend to visit several foraging areas each night. Foraging areas are located up to 5 km away from the maternity colony roost, with around half of all core foraging areas found more than 2 km away from the colony roost.

Foraging habitat selection

The grey long-eared bat is primarily an open or edge habitat forager. Grey long-eared bats across England prefer to forage in semi-unimproved (unmanaged) lowland grasslands (including meadows and marshes), woody riparian vegetation and broadleaved woodland. Out of the available habitats within the colony range, they use to the least extent arable fields, conifer woods and open water. When foraging within the agricultural landscape, grey long-eared bats mainly use field margins, hedgerows, and scattered trees. Bats in Devon also tended to forage in suburban areas, in particular at the end of the lactation period when young become volant, while bats on the Isle of Wight tended to avoid improved grassland due to the greater availability of semi-unimproved grasslands around the colony roost. Non-reproductive females tend to be associated with broadleaved woodland and improved grasslands, while lactating females are associated with unimproved grasslands and scrub, but use to the least extent improved grassland (Razgour et al. 2011a). In Sussex all adult bats foraged in rough set-aside grasslands and open parkland surrounded by ancient woodlands, though bats only used the woodlands for commuting (D. Whitby pers. comm.).

The strong preference for foraging in unimproved grasslands and the avoidance of arable land and conifer woods probably relates to differences in the diversity and abundance of Lepidoptera and other insects in these habitat types (Winter 1983; Rands and Sotherton 1986; Di Giulio et al. 2001; Ekroos et al. 2010). Unlike the brown long-eared bat, which forages primarily in deciduous woodland (Entwistle et al. 1996; Murphy et al. 2012), woodlands are mainly used by grey long-eared bats during periods of low night temperatures or heavy rainfall, when insect availability is limited in more open habitat types (Razgour et al. 2011a).

GARETH JONES

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Diet

Based on both microscopic and molecular diet studies (Razgour et al. 2011b), the diet of the grey long-eared bat in the UK contains up to at least seven arthropod orders and one crustacean (woodlice). The most common prey order is Lepidoptera (percent frequency of occurrence: 62–67% of the diet), followed by Diptera (21–32%). The remaining prey orders (Neuroptera, Hemiptera, Coleoptera, Hymenoptera Trichoptera and Isopoda) contribute to less than 5% of the diet each (Figure 8). The majority of the lepidopteran species in the diet are eared-moths of the family Noctuidae (70%), while Tipulidae (crane flies) is the most common dipteran family (76%).

The diet of 29 grey long-eared bats contained around 90 prey taxa, with each individual dropping containing between one and 17 prey taxa. The most common prey species in the diet, *Noctua pronuba* (large yellow underwing), was consumed by 66% of the bats. Other common prey species include: *Autographa gamma* (silver Y), *Hepialus sp.* (orange swift), *Apamea monoglypha* (dark arches), and *Tipula oleracea* (the common crane fly). All these prey species are common and widespread in southern England. Of the prey species identified in the diet, 45% were habitat generalists, 40% were open grassland specialists, 12% woodland specialists and 3% riparian or water habitat specialists (see Razgour et al. 2011b for full list of prey species).

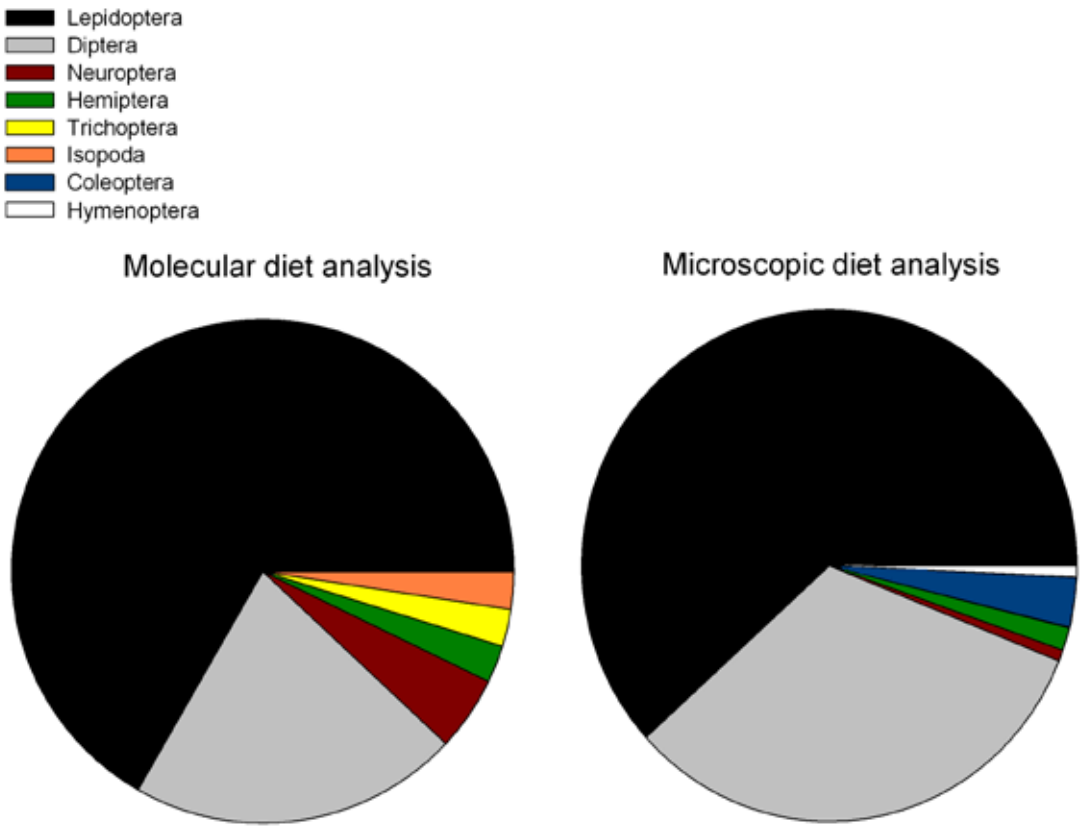

Figure 8 – Pie charts showing the diet composition of the grey long-eared bat in England based on molecular (N=29) and microscopic diet analyses (N=170). The proportion of prey orders in the diet is presented as percent frequency of occurrence. Figure taken from Razgour et al. 2011b.

The diet of the grey long-eared bat varies seasonally, with a higher proportion of Lepidoptera consumed in the summer and autumn relative to the spring, and a higher proportion of Diptera in the spring. Dietary diversity, in terms of number of prey orders consumed, is highest in August when the young start to fly (Figure 9).

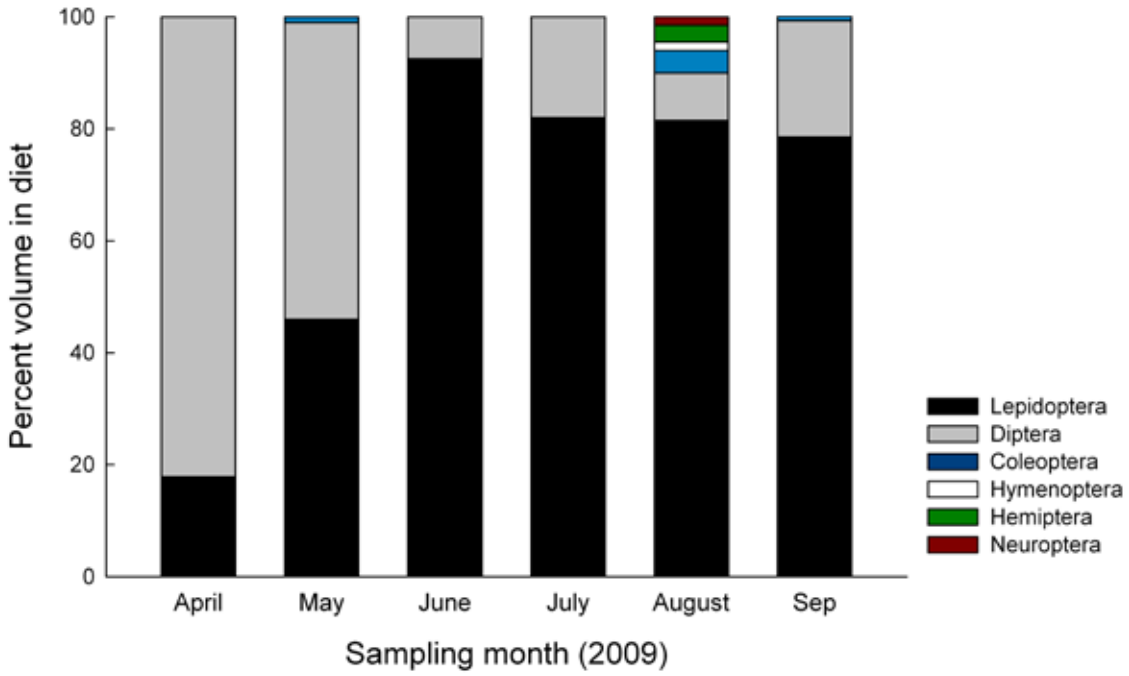

Figure 9 – Seasonal comparison of the percent volume of prey orders identified in the diet of grey long-eared bats in the Devon colony in 2009 based on microscopic diet analysis (based on data from Razgour et al. 2011b)

Part 2
Threats

The grey long-eared bat is predicted to have a high extinction risk due to its habitat specialisation on foraging close to or within the vegetation, small foraging ranges and limited long distance dispersal ability as a result of its flight morphology (Jones et al. 2003; Safi and Kerth 2004). The small UK population size and evidence of population decline and population fragmentation suggest that this edge population is of particularly high conservation concern. Effective population size estimates are below the minimum viable population size necessary for retaining evolutionary potential and avoiding the accumulation of deleterious alleles, but are sufficient to avoid inbreeding depression in the short-term (based on information in Frankham et al. 2010). Colony effective size estimates suggest that all colonies but Dorset may not be able to avoid inbreeding depression unless sufficient levels of gene flow are maintained between colonies (Razgour 2012). This highlights the importance of maintaining gene flow and connectivity between colonies within the UK and between the UK and European populations

Loss of roosts

Building roosts are threatened by efforts to exclude bats by roost owners, insulation improvements, blocking holes in walls and ceilings, re-roofing, and the renovation or redevelopment of old buildings and barns (Stebbings 1995). The presence of grey long-eared bats in a building may not be confirmed until the building is already in the process of being demolished or developed, in particular due to difficulty of distinction from the much more common and widespread brown long-eared bat. That grey long-eared bats have not been recorded in bat boxes complicates mitigation for roost loss.

Loss of foraging habitats

Lowland unimproved grasslands, the main foraging habitat of the grey long-eared bat, have been disappearing from the UK in the past century, with more than 92% of unimproved grasslands in England lost due to changes in farming practices and agricultural intensification (Fuller 1987; Vickery et al. 2001). Increased field and farm sizes has resulted in the loss of landscape elements commonly used by grey long-eared bats within the agricultural matrix, including hedgerows, forest patches, field boundaries and ponds (Robinson and Sutherland 2002). Loss of broadleaved woodlands can also affect grey long-eared bats, though to a lesser extant than obligate woodland bat species. Agricultural intensification and changing forestry practices may also affect prey availability for grey long-eared bats because dramatic declines of even the most common and widespread moths were recorded across the UK in the past few decades (Conrad et al. 2006).

Climate change

Future climate change is predicted to result in increased habitat suitability for grey long-eared bats in the UK, with most of the UK becoming climatically suitable. However, a north-western shift in the distribution of suitable conditions across Europe suggests that much of the core of the range may become climatically unsuitable (Razgour et al. 2013). Therefore climate change represents a major threat to the long-term survival of the grey long-eared bat.

Lack of knowledge

Lack of knowledge on the general UK distribution and the location of summer roosts and hibernation sites impedes roost protection and monitoring of long-term population trends. Difficulties in distinguishing grey and brown long-eared bats have been recently overcome through the use of molecular species identification from droppings collected in roosts. This has already resulted in the identification of at least two new maternity colonies (Barlow and Briggs 2012) and expansion of the known range to Wales. Yet there is still a paucity of knowledge on the winter ecology of the grey long-eared bat and hibernation sites in the UK. More research is also needed into the potential effects of future climate change on this species.

Part 3
Conservation targets

Aim: to maintain a viable grey long-eared bat population in the UK within a wider conservation context.

- Reverse the trend of population decline in the UK
- Monitor changes in the distribution and size of the UK population
- Identify and protect roosts, with an emphasis on maternity colonies
- Identify and protect hibernation sites
- Ensure availability of high quality foraging habitats around roosts
- Facilitate landscape connectivity between roosts
- Manage availability of suitable foraging and roosting habitats within the predicted range under future climate change

Part 4
Management recommendations

The UK population should be manage as part of the wider European population, and conservation management measures should aim to also benefit other UK bat species and UK biodiversity in general.

Priority conservation status

- Allocate the grey long-eared bat a priority conservation status to assure the full protection of all maternity colonies and their surrounding foraging habitats'.
- Building on the example of the South Hams greater horseshoe bat Special Area of Conservation (SAC), create bat protection zones (sustenance zones) around key grey long-eared bat roosts, for example West Devon, East Devon and Dorset, to flag up any development within 10 km of the roosts
- Extend some of the South Hams SAC greater horseshoe bat sustenance zones and strategic flyways to include the West Devon grey long-eared bat roost and key foraging habitats.

Roost protection

- Identify and protect all UK maternity colonies and hibernation sites.
- As grey long-eared bat colonies in the UK may be small, the presence of >3 bats may indicate a maternity colony is present.
- Manage development within 5 km radius of grey long-eared bat maternity roosts to protect barns and farm buildings potentially used as night and temporary roosts.
- Build on existing dropping collection projects for molecular species identification initiatives by the Bat Conservation Trust (BCT), Joint Nature Conservation Committee (JNCC) and local bat groups (e.g. Dorset and Hampshire), and extend efforts to cover the entire suitable range (see Figure 3).
- Lobby local planning authorities to request molecular species identification of droppings collected from all long-eared roosts within the species' distribution that are pending development or bat exclusion.
- Work with local planning authorities, developers and ecological consultants to implement adequate mitigatio for the grey long- and avoid development that will result in the loss or substantial modification of known maternity roosts.

Managing the landscape for grey long-eared bats

- Use the grey long-eared bat as a **flagship species for the conservation of lowland unimproved grasslands.** Unimproved grasslands contain a high proportion of plant, invertebrate and bird species of conservation concern (Crofts and Jefferson 1999), and therefore addressing the decline of this habitat in the UK is an important conservation priority.

- The conservation of the grey long-eared bat within the agricultural landscape can be related to ecosystem services provided by this bat to the wider farming community. Land managed in such a way that grey long-eared bats are able to flourish is an indicator of a landscape that includes some of the most important habitats, not only for the bats and other biodiversity they support, but also for the ecosystem services they provide. In addition, the foraging preferences of the grey long-eared bat include the consumption of agricultural pests, including the cranefly *Tipula oleracea* and the moths *Noctua pronuba, Autographa gamma* and *Agrotis ipsilon* (Razgour et al. 2011b), and so they form part of the natural suppression of populations of these insects – another ecosystem service.


GARETH JONES

Habitat management

- Protect potential grey long-eared bat foraging habitats within 5 km of maternity colonies from development that is likely to impact the favourable conservation status of the bats, including the removal of linear landscape features and changes to habitat structure and composition.

- Build on existing legislative tools and conservation incentive schemes, like Agri-Environment Schemes, set-aside grants and wildlife enhancement schemes, to increase availability of lowland unimproved grasslands (meadows and marshlands) within a 5 km radius around known maternity roosts to provide high quality foraging habitats.

- Increase the availability and quality of riparian habitats, including ponds and streams, around known maternity roosts by increasing water quality and the extent of dense riparian vegetation, especially marshes, shrubs and broadleaved trees.

- Within the Agri-Environment Scheme framework focus on land management practices that increase the availability of wide unmanaged field margins at arable or pasture field edges adjacent to broadleaved woodlands, mature trees and hedgerows, or riparian habitats, including ponds and streams.

- Manage hedgerows to increase mature broadleaf tree cover, in particular around riparian elements like streams and ditches. This provides both commuting and foraging habitats for grey long-eared bats and greatly increases the value of arable land for grey long-eared bats.

Landscape connectivity

- At the broader spatial scale, create wide corridors of suitable foraging habitats, providing continuity of patches of semi-unimproved grasslands, woody riparian vegetation and well-developed hedgerows, to encourage landscape connectivity among roosts and important foraging grounds and also among adjacent grey long-eared bat colonies. The main focus should be connecting West Devon colonies to the rest of the UK population.

- Large-scale landscape management may be greatly aided by cooperative working between adjacent landowners. We would recommend discussing ways to maximise this level of work with your local Natural England officers.

- Protect remaining lowland unimproved grasslands across southern England and Wales to facilitate connectivity, range expansion and population establishment in suitable areas.

Population monitoring

- Monitor changes in the distribution and size of colonies and signs of range expansion. The BCT's National Bat Monitoring Programme (NBMP) provides a framework for monitoring roosts through its annual Roost Count. Although numbers of known grey long-eared bat maternity roosts are small and it may not be possible to produce annual population trends for this species, it is a priority to add the grey long-eared bat to the suite of species monitored through the Roost Count. This will allow ongoing monitoring to be maintained and provide a central location for data to be stored, analysed (to look for overall changes in numbers across all known roosts) and reported on annually, whilst also encouraging and ensuring monitoring of the sites is carried out by roost owners and volunteers.

- Encourage submission of new records of grey long-eared bats to the NBMP as a central storage location of distribution data for this species. This will allow regular updating of a distribution map for this species and publication (subject to data sharing agreements) through the NBMP Annual Report.

- Initiate yearly population counts of known maternity colonies, with information collected in a central database and monitored by BCT.

- Initiate dropping collections from all long-eared roosts within up to 100 km north of the currently known grey long-eared range through the BCT Bat Helpline and Natural England bat volunteer roost visits. BCT will deposit the droppings for analysis pending future funding.

- Develop and test new monitoring tools to improve survey efforts and facilitate the identification of grey long-eared bat roosts and foraging grounds, including adequate acoustic species identification guides and a grey long-eared bat call library for the acoustic lure.

- Form collaborations and working groups with researchers and conservation practitioners across Europe and European initiatives such as BatLife Europe and EUROBATS to monitor global grey long-eared bat population changes and gather evidence of range shifts and loss of genetic diversity.

- Use genetic tools to monitor levels of inbreeding in maternity colonies and gene flow between colonies.

Working with stakeholders

- Raise awareness to the conservation of the grey long-eared bat and the importance of its conservation for wider biodiversity and ecosystem services.
- Work with the general public to highlight the plight of grey long-eared bats and to help identify more roosts.
- Work with roost owners to initiate a regular monitoring programme.
- Work with local planning authorities to encourage molecular dropping identification for long-eared roosts and the application of suitable mitigation practices.
- Encourage ecological consultants to apply the management and mitigation recommendations and to use molecular identification of droppings from long-eared roosts.
- Work with land managers, farmers, foresters and woodland managers to include grey long-eared bat management recommendations into their conservation guidelines and training courses.
- Work with the construction industry and developers to raise awareness to grey long-eared bat conservation and the importance of identifying and protecting roosts.
- Work with conservation organisations, including BCT and other wildlife, plant life and habitat conservation trusts and groups to incorporate grey long-eared bat management recommendations as part of their habitat management practices and to promote the importance of the conservation of the grey long-eared bat and its use as a flagship species for the conservation of unimproved grasslands.
- Work with local bat groups to disseminate information, initiate monitoring programs and dropping collection projects, and to promote grey long-eared bat conservation.


ARTURO MUÑOZ

Part 5
Mitigation recommendations

The grey long-eared bat is of high conservation concern as it is one of the rarest breeding UK bat species. Therefore maternity roost sites should not be demolished or destroyed and should be retained untouched, especially given the mounting evidence that replacement maternity roosts for brown long-eared bats are unsuccessful (D. Whitby pers. comm.). However, if a building becomes dilapidated and requires essential maintenance work, repairs should be carried out to prevent further damage to the building and loss of the roost. In the event of site development or roof maintenance works, strict guidelines should be followed to prevent loss of roosts or to avoid compromising the favourable conservation status of the species.

Guidelines for maternity roosts

For all roost development scenarios, including enhancements of roosts, building new additional roosts, essential roof repairs and creating new roosts due to development, the following recommendations should be followed alongside the Natural England (NE) mitigation guidelines for long-eared bats in general:

- Mitigation with bat boxes is unacceptable and does not work because grey long-eared bats have never been recorded using bat boxes in England.

- **Loft area recommendations:** long-eared bats require large loft spaces where they are able to fly around prior to emergence. Therefore loft dimensions should generally be larger than those required by NE for other bat species and maximum loft height should exceed 2.5 m. Loft dimensions are internal dimensions and should be calculated excluding any additional materials placed inside the loft, such as deep roof insulation.

- It is important to include a range of suitable roosting areas through the roof providing a variety of roosting areas with varying microclimatic conditions.

- Leave felt gaps in ridges.

- Use traditional roof construction (e.g. cut and pitch roof) to create a large uncluttered loft void. Trussed roofs or the use of extensive tie beams must be avoided.

- Modern breathable roofing felts should not be used for re-roofing. Instead, traditional bitumen roofing felt must be used because it does not appear to pose a risk to bats and has a proven record of long-term historical use by bats including long-eared bats.

- No lighting should be installed inside the roof area or on any external access points and flight paths.

- Maintain good connectivity features to commuting routes and existing roost sites.

Although grey long-eared bat maternity roosts should not be destroyed under any circumstances, in the event of new roosts being created for development where the existing roost is to be demolished the following must be strictly followed in addition to the previous recommendations:

- Replacement roosts must be created before existing roosts are affected or demolished.

- Proof of the colony using the new replacement roost must be provided before existing roosts are affected or demolished.

- A range and variety of specific enhancements must be created throughout the new roost to increase suitability for grey long-eared bats across a range of conditions and different times of the year, including suitable hibernation areas within the building.

- It is essential to conduct long-term monitoring for a minimum of 10 years to ensure colony establishment and continued use of the new roost site. In the first five years, monitoring should include a minimum of two visits to inside the roost per year, around mid-May and early August, to confirm bat presence and breeding, as well as at least one dusk or dawn survey, anytime between mid May and early August, to estimate colony size. Droppings should initially be collected from roost floor and sent for DNA analysis to confirm species identification. Once colony establishment has been confirmed, monitoring should consist of a single annual visit to inside the roof space and a single colony count.

Re-roofing of maternity colonies

When re-roofing buildings, the following recommendations should be followed to avoid compromising the suitability of the roof space for grey long-eared bats:

- Maintain the same microclimatic conditions as those present in the current roof space, and ensure that temperatures are within the ranges documented in this management plan.
- Protect the chimney stack and do not remove disused chimney stacks from the loft because they provide an important roosting area for lactating females and newborns before they become volant.
- Avoid blocking cavity holes and access points.
- Maintain access to roosting areas under ridge tiles by not folding roofing felt over the top of the ridge. To prevent loss of access, the bitumen roofing felt should be felted up to 2.5–4 cm from the ridge board, and not folded over the top, leaving a clear gap along the side of the ridge board so bats can access the ridge tiles. This requires that:
    - Ridges are not vented to maintain high loft temperatures
    - Ridge tiles are traditionally cemented on, leaving chamber void under the ridge tile where bats roost. They must not be filled with rubble or cement. Modern dry ridges are not used.

Roost enhancement

- As long-eared bats are crevice roosters and tend to roost inside the ridge tiles or against the ridge board, double / triple ridge boards can be used to increase the availability of roosting sites within a roost. Multiple ridge boards are parallel ridge boards with a 20–30 mm gap present between the ridge boards creating a roosting crevice running along the length of the ridge inside the loft area.
- To increase the roosting potential of the ridge boards, triangular wedges can be added periodically to provide additional hidden roosting crevices.
- A double/triple ridge board needs to have a top covering or to be felted over. This can be done alongside the provision of intermittent access points along the ridge into the cavities under the ridge tiles.
- Ridge boards can be used to create good access points into a loft area by placing the ridge boards protruding from the gable end of the building to provide a crevice for bats entering the loft through the gable end ridge.


ERIKA DAHLBERG

Mitigation recommendations for night and temporary day roosts

- For applications for planning permission for change of use or demolition of farm buildings, in particular barns and old buildings, within 10 km of a known grey long-eared bat maternity roost, extensive surveys should be carried out for use as night or temporary day roosts by grey long-eared bats. Surveys should include searches for feeding perches containing yellow underwing (*Noctua pronuba*) and other moth remains and DNA testing of bat droppings found in the building for bat species identification.

- For night roosts and feeding perches – retain bat access points, providing a sufficiently large entrance for bats to easily fly in with prey.

- Retain wooden beams for bats to perch on, as well as 2–3 cm gap crevices between beams and between ridge tiles to provide resting and day roosting opportunities.

Mitigation recommendations for habitat loss and alteration

- Removal of potential grey long-eared flyways and foraging areas, including well-developed hedgerows, tree lines and broadleaf tree copse, within 5 km of grey long-eared bat maternity roosts will require mitigation in the form of compensation and replanting of alternative flyways.

- Avoid removal of woody riparian vegetation within 5 km of grey long-eared bat maternity roosts, in particular, retain areas with dense vegetation, especially marshes, shrubs and broadleaf trees. If thinning and habitat maintenance works are being carried out, avoid disrupting flylines.

Grey long-eared bat feeding perch inside a night roost showing the characteristic large yellow underwing culled wing remains.

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