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EUROBATS IWG on conservation and management of critical feeding areas and commuting routes

DRAFT Guidance on the Conservation and Management of Critical Feeding Areas

Contents

Abstract

To be included, if needed

Key recommendations

Besides of general information on habitat management and conservation of feeding areas of bats, this guidance includes information at species level. As many bat species benefit of certain types of habitat management, these points summarize the main recommendations for conserving and managing important feeding areas and commuting routes.

- During planning process and other land-use projects seek up-to-date data on bat species and their habitats (roosts and foraging areas) in the area.
- Check species texts of this guidance for detailed advice on each species.
- Pay attention on the connectivity of landscape, especially between roosts and feeding areas.
- Avoid the creation of large open areas.
- Favour linear elements such as hedgerows and treelines in the landscape
- Favour small-scale forestry practices (no clear cutting).
- Avoid felling of trees with cavities.
- Preserve and manage ponds, streams and other small water bodies and riparian vegetation.
- Avoid using of pesticides in forests and anti-parasitic drugs for cattle as these have adverse effects on the insect prey of bats.

1. Introduction

World-wide, habitat loss has been identified as the single most important cause of biodiversity loss. Whilst much attention focuses on global biodiversity hot-spots, such as tropical rain forest and coral reefs, it is unfortunately true that biodiversity loss continues even in Europe, where much of the landscape is already heavily influenced by human activities. Farming and forestry are by far the largest land-users in Europe and thus their wise use of land is very important in global and national efforts to halt and reverse biodiversity loss. In addition, the development of the built environment and its associated infrastructure, such as the road network, can have a significant impact on biodiversity, not only through direct land-take but also through less obvious effects such as light and noise pollution, disturbance and alterations to the local climate.

Bats are an important component of mammalian biodiversity in Europe, second only to rodents, and have certainly suffered declines in the past, though the historical lack of interest in these species means that we have very little information about past populations. As long-lived, slow-breeding species at the top of the food chain, they are quite vulnerable to environmental change and can recover only slowly from population crashes. In addition, their colonial habits make them unusually vulnerable to both natural disasters and human persecution, as a large proportion of the local population can be found together in one place at certain times of the year.

Until recently, much conservation effort for bats focused on protecting their roosting sites, as these are where bats are at their most vulnerable to disturbance or persecution. There is also some evidence, from studies on artificial roosts, that a lack of suitable roosting sites can be a limiting factor for some bat populations, particular those species with specialist roosting requirements. EUROBATS has already published guidance on the conservation and management of bat roosts in a variety of situations.

However, protecting bat roosts alone is not enough to ensure the conservation of bat populations. Outside the roost, bats need suitable habitats where they can hunt and find sufficient food of the right sort, as well as routes that allow them to travel between roost and hunting areas. Until quite recently, very little was known about the movement of bats beyond the roost, but this knowledge gap has been changed dramatically by the development of bat detectors, radio tracking and other technical devices. These new research methods have allowed us to follow bats from their roost and determine how far they fly and the sorts of habitats they need for hunting. Our knowledge of the needs and habits of individual species is increasing all the time and we are now in a position to be able to offer some advice about the conservation and management of bats' feeding areas.

This guidance, which draws on the latest scientific information, should help foresters, farmers and other land-managers to take the needs of bats into account during their operations and so make a positive contribution to the conservation of these threatened animals. It should also help regulatory authorities ensure that agriculture and forestry regulations and support schemes are designed in such a way as to ensure the conservation of these protected species. As this guidance is intended to cover the whole of the EUROBATS area, supplementing it with national guidance is encouraged. National or regional guidelines can better take local farming and forestry practices into account and ensure that the guidance is locally relevant.

2. Why conserve and manage bat habitats

The need to conserve bats as an important component of biodiversity is widely recognized and bats are now legally protected by every EUROBATS Party and Range State. Although it has taken time to change, many countries can now report more favourable public attitudes to bats, though some problems remain. In many European countries, for example all EU Member States, the bats' roosts are also protected, though this protection rarely extends much beyond the roost and its immediate vicinity.

As major predators of insects and other invertebrates, the health of our bat populations is a good indicator of the health of our countryside; fewer flying insects means fewer bats. Their value as an indicator of biodiversity is already recognised in the UK and they may soon be adopted as an indicator at the EU level, based on the prototype Pan-European bat indicator (Haysom *et al.* 2013).

Bats use a wide variety of habitats, both natural and managed, to hunt in, though some are clearly more important than others. As bats can be found almost everywhere, strictly protecting all their foraging habitats, which could include both farmland and villages, is not a practical option in most cases, though bats do benefit from the protection of habitats for other reasons, such as National Parks. If bats are to survive as an important component of biodiversity, other mechanisms must be used to ensure that the habitats they use for hunting and the linkages they use to move across the countryside are maintained in good condition.

3. What is an important feeding area or commuting route?

Though bats use many different types of biotopes with varying degree of human impact, some key aspects are common for important feeding areas: foraging areas around and near maternity roosts are of priority, the areas should offer a rich supply of prey insects to ensure the survival of bats, and the landscape structure should favour the movements of bats. The foraging areas should also be connected with the roosts so that bats can access the areas without having to cross large open areas.

Foraging habitats near maternity colonies are of great importance, as the energy demand of pregnant and lactating females is high. Good nutritional state of the female enhances the fetal development and later the growth of young. In many species, females from a maternity colony forage within one kilometres distance from the roost, meaning that the areas close to the roost are the first priority for habitat management. However, also female bats may travel distances of several kilometres to forage but data on the distances travelled is not easy to obtain.

Studies on habitat preferences have mainly been conducted using radio tracking, as this technique allows constant monitoring of the bat and therefore quite precise data on the bat's habitat choice. Also acoustic monitoring with bat detectors gives information on bat activity at certain spots or along a route. These methods differ however in the resulting data type, costs and labour demands. Detailed descriptions of different methods for studying bat habitat preferences can be found for example in Kunz & Parsons 2009. The species accounts in this guidance document summarize the results of studies for each species, including the habitat selection, distances travelled between the roost and the

feeding areas. Radiotracking studies have been prioritized in the literature search but also information from studies using bat detectors and other methods has been included.

As bat species differ in their choice of feeding areas, there should be good knowledge of the species inhabiting the area. Conservation and management of important feeding areas and commuting routes should be based on adequate information and therefore any land use project likely to affect bats, their roosts and feeding environment should include a bat survey and analysis of the projects' potential effects on bats. Depending on the probability of bats inhabiting the area and the effects of the development or management action, surveys of different scale need to be carried out. Good practice guidelines on bat surveys are available e.g. in Bat Conservation Trust's publication (Bat Conservation Trust 2012). Any development near known bat roosts should be preceded by a bat survey. The aim of a bat survey is to find out the species occurring in the area and their roost sites, foraging areas and commuting routes from roosts to these areas.

Results from different monitoring schemes for bats can also provide valuable information for management and conservation of bat habitats. Since the output of monitoring programmes usually draws from a larger dataset consisting of long period of observations, they might have more power in describing the bat populations of certain areas than surveys, which are based on one field season only.

Value of an area for bats may be estimated using species composition – rare or sensitive species being more valuable than common and/or generalists – and numbers of individuals feeding or roosting in the area.

As bats orientate and locate their prey with the means of echolocation, the structure of the landscape can either facilitate the moving of bats or make it very demanding or dangerous to them. Bats with strong, low frequency echolocation pulses use open space when moving or hunting whereas species with lower intensity calls rely on acoustical cues of the landscape. This means they usually follow structures such as hedgerows and other tree lines, fences or edges of forest patches. For these species linear and other landscape structures are an important part of their habitat without which they can't commute from the roost to the foraging area. Loss of small-scale landscape structures related to the major changes of rural landscapes in recent decades as well as forestry practices favouring large, open clear-cuts affect bat species which use linear landscape elements and prefer fine-scaled environment.

Several bat species are known to migrate from their summer areas to other sites to hibernate. As these species fly great distances (up to circa 1900 km in Europe) they need either to stop for fuelling at suitable areas en route or feed during their flight. Whether they do one or the other is still to be answered by studies on bat migration ecology and physiology. In any case, feeding areas along migration routes also need to be taken into consideration which poses challenges to surveys.

Generally, bats and specially females favour biotopes with high insect production, such as woodlands near water bodies of different sizes, broadleaved forests, parks and orchards. Many bat species however use a variety of feeding habitats, some species being more specialized in certain biotopes. Habitats favoured by different European bat species are summarized in table 1.

Table 1. Summary habitats of important for bat species

Habitat **Species** (common name?)	**Deciduous forest**	**Coniferous forests**	**Riparian, water bodies**	**Parks**	**Cultural landscape**	**Edges of habitats**	**Pastures**	**Orchards**	**Villages, other "lightly built" areas**	**Notes**	**Linear elements used?**
Rousettus aegyptiacus								++		generalist, also gardens	no; uses vision
Taphozous nudiventris										deserts, semideserts	?
Rhinolophus blasii	++									open "savanna-like"	hedges
Rhinolophus euryale	++		++			+					yes
Rhinolophus ferrumequinum	++		+	++			+	++			yes
Rhinolophus hipposideros	++	+	++		+		+				yes
Rhinolophus mehelyi	++		++							olive groves	yes, rivers important
Barbastella barbastellus	++					+					forest corridors and edges
Eptesicus nilssonii	+	+	++	+		+			+	generalist	no
Eptesicus serotinus	+						++		+	uses open areas	uses hedgerows
Hypsugo savii	+		+	+						wide range of habitats	can use hedgerows
Myotis alcathoe	+		++								streams etc
Myotis bechsteinii	++									lots of dead wood, structured forest	no?
Myotis blythii							+			dense grasslands	yes, hedges etc
Myotis brandtii	+		++								
Myotis capaccinii	++		++							large rivers etc.	large rivers etc.may follow water courses
Myotis dasycneme			+++							water bodies, marshlands	canals, tree lines
Myotis daubentonii			+++								rivers, tree lines
Myotis emarginatus	+		++							cow sheds, stables	yes
Myotis myotis	++									mown meadows	?

Habitat **Species** (common name?)	**Deciduous forest**	**Coniferous forests**	**Riparian, water bodies**	**Parks**	**Cultural landscape**	**Edges of habitats**	**Pastures**	**Orchards**	**Villages, other "lightly built" areas**	**Notes**	**Linear elements used?**
Myotis mystacinus		?					++				yes
Myotis nattereri	++	+	++					+			yes
Myotis punicus				++			+++	+		mainly open habitats	yes?
Nyctalus lasiopterus	+	+?	+++							all kinds of wetlands, above but not inside forests	yes
Nyctalus leisleri	++	++	++				+	+		forest roads and clearings, canopy, open sky	no
Nyctalus noctula	+		+				++			open habitats	no
Otonycteris hemprichii			++								no
Pipistrellus hanaki	++		+							also chestnut groves	?
Pipistrellus kuhlii			++						++	low-intensity agricultural areas	not much, crossess open areas
Pipistrellus nathusii	++		++							wetlands important	yes
Pipistrellus pipistrellus			++	+					+	very flexible. Also gardens, built areas	yes, but also crosses open areas
Pipistrellus pygmaeus	+?		++							more narrow habitat selection than *P. pipistrellus*	yes
Plecotus auritus	++	++		+	+					also gardens	yes
Plecotus austriacus	++	++		+	+						yes
Plecotus kolombatovici											
Plecotus macrobullaris							++?			alpine and subalpine grasslands	yes?
Plecotus sardus	+									no studies, these habitats near roosts	?
Vespertilio murinus	++		++							water bodies	no
Miniopterus schreibersii	++		+					+			yes
Tadarida teniotis	+	+						+		generalist	no

4. How to protect important feeding habitats?

The quality of habitats for bats can be enhanced in many ways. As a general guideline, maintenance and creation of small scale structures is encouraged and creation of large open areas should be avoided. Many bats favour linear structures, edges and other elements that they can follow in the landscape, and the roosts and feeding habitats should be connected with these elements if there are no wide corridors of suitable habitat between roosts and foraging sites.

Changes in the landscape structure, including fragmentation and loss of important habitats, loss of natural or semi-natural patchiness, monotonous structure of managed areas (agricultural etc.) may affect bats. It should be noted that some management practices may create feeding areas but destroy roosts, for example forestry practices where old trees are removed but only small open areas created. Therefore bats, as any other part of biota, benefit of a strategy for the whole landscape. More information on management practices favouring bats is also given in the Habitat management for bats by Joint Nature Conservation Committee (Entwistle *et al.* 2001). In some cases, international co-operation may be needed to conserve important bat habitats across national boundaries.

4.1. Forestry practices

Many of the European bat species use forests for roosting and foraging. Different types of roosts are available in woodlands, depending on the age and structure of the forest stand. Woodpecker holes and cavities as well as hollow branches are easier to spot for a surveyor, but roosts under loose bark are more difficult to notice. As bats tend to use several roosts during summer, there should be several trees with cavities in each forest hectare to sustain a network of roosts.

Besides of roosts, forests offer important feeding opportunities for bats. Bats often prefer foraging in forests with semi-open structure. Typically very young forests or patches of dense sapling stage are not utilized; also monocultures are not optimal foraging habitats. Bats rather forage in mature forests with small open patches created by fallen trees or small scale forestry management actions. Also narrow paths, streams and other small open structures in the landscape provide good feeding areas and commuting routes from the roosts for bats.

As bat species differ in their morphology and echolocation call characteristics, they also use different foraging strategies often referred to as gleaning, aerial hawking and perch hunting. These strategies affect the habitat selection of the bats – aerial hawkers typically exploit the open areas in forests or above the canopy whereas gleaners rely more on the more densely vegetated parts of the forests or areas near the canopy.

In many situations the openings produced by forestry cuttings are far too large for bats to cross. Multi-aged stands and small cut areas would better ensure the survival of bats in the forest area. Connectivity between forest areas should also be taken into consideration, as the forest patches with no interconnecting tree lines remaining after clear cuts might be

too isolated and therefore impossible for bats to utilize. Tree lines or groups of trees can be used to interlink the patches.

More guidance on bat-friendly forestry is given in the EUROBATS Bats and forestry leaflet, Bats in forests brochure and Woodland management guidelines (references).

4.2. Water bodies, wetlands, river valleys

Stagnant or slow running sweet waters are of high importance to a number of insectivorous bat species within the Agreement area, perhaps most notably to *Myotis capaccinii*, *Myotis dasycneme* and *Myotis daubentonii*. These spend significant time trawling for insects at low height over the water surface. *Nyctalus* species also frequently hunt over water, although at higher height. Insect rich habitats such as water bodies and associated woodlands and tree stands may be of particular importance to lactating females, as demonstrated in a study of *Vespertilio murinus* (Safi *et al*. 2007). Many other species utilize tree stands along water ways and riverine forests, as evident in the species accounts. Desert dwelling species such as *Otonycteris hemprichii* may be particularly dependent on whatever water sources that exist within their home range and the associated vegetation for hunting.

The quality of the water may be of significance, as bat hunting activity along stretches of rivers polluted by sewage outputs was less than along cleaner stretches (Vaughan *et al*. 1997). The kind and extend of vegetation edge may also be of importance. The existence of an open, vegetation free water body is obvious for the low height trawling *Myotis* species. There is a need for better understanding of these elements in the ecology of many species.

4.3. Bats in agricultural landscape

The value of farmland in the broadest sense as foraging habitat for bats depends on the amount of green veining/openness, and the insect density, which in turn is influenced by management. Orchards or olive groves can be of great value to many species, very open pastures or crop fields may only be of value on certain moments in the year.

Unfortunately, little is known of the effects of adapted farm management on bats, and studies are ambiguous. Some studies show little or even a negative effect of adapted management, others show a positive one. In the UK, insect density and bat activity were compared among 18 farms with an agro-environment scheme (AES) and 18 without one (Fuentes-Montemayor et al., 2011). The AES consisted of field edge management, development of species-rich pastures and water edge management. Insect densities and bat activity turned out to be significantly lower on AES farms. The study did show an effect of landscape surrounding the farms, and concluded that AES scheme should take landscape scale into account. MacDonald *et al*. (2012) compared bat activity between AES and regular pastures and found a nonsignificant elevation of bat activity on AES parcels. Wickramasinghe *et al*. (2003) compared organic and conventional farms, finding more bat activity and more foraging activity on biological farms. Pocock & Jennings (2008) studied effects of intensification of management (pastures and cereal field on bats, among other species groups. Bats only reacted to decreases in hedgerows. The study showed

that spatial composition of the farm in the wider landscpae is very important in changing farm management.

Other relevant research focusses on the landschape scale, and then especially on linear features in the agricultural landscapes. Frey-Ehrenbold *et al*. (2013) showed that numbers and number of species higher were around lineair landscape features than in open agricultural landscapes, and that more animals were present in parcels that were “tied into” the network of linear features. Boughly *et al*. (2012) show that inclusion of tree and hedgerow management in AES schemes will increase the activity of *Pipistrellus pipistrellus* in particular: succesfull schemes depend on tree density (more is better) and distances to woodlands.

4.4. Urban areas, parks

To be included

- see the new publication by BCT

4.5. Linear elements and routes to roost

To be included

4.6. Strategic legal tools

Farming and forestry remain crucial for land use and the management of natural resources in the EU's rural areas, and as a platform for economic diversification in rural communities.

The European Agricultural Guidance and Guarantee Fund (EAGGF), set up by Regulation No 25 of 1962 on the financing of the common agricultural policy (as last amended by Regulation (EEC) No 728/70) consumes a large part of the general budget of the European Union.

Through the Rural Development Programme, it supports rural development and the improvement of agricultural structures, such as the Agri-environmental measures and the optimal utilisation of forests.

Agri-environmental Schemes reward farmers for environmentally-sensitive land management. The agri-environment schemes are considered crucial in relation to biodiversity and sustainability.

Some examples that can be undertaken by Member states in favour of bat critical feeding areas:

– Agri-environmental schemes: management of unimproved grassland, of ponds, of hedges; conservation of permanent pastures along rivers or permanent grassland along forests

– Optimal utilisation of forests: conservation of broadleaved forest edges; conservation of old trees and cavity trees in private and public forests

The paying agencies make payments to beneficiaries in accordance with the Community rules.

The **conditionality** of these payments to farmers' compliance with basic environmental and animal welfare standards ("cross-compliance") strenghten the impact of the PAC. Farmers may have their direct payment reduced, or in extreme cases, completely cancelled, if they do not respect a set of Good Agricultural and Environmental Conditions (GAEC) and Statutory Management Requirements which are linked to 18 EU Directives and Regulations relating among others to the Habitat Directive.

Some examples of GAEC that can be chosen by Member states in favour of bat critical feeding areas: conservation of topographic elements such as hedges, isolated trees, ponds, public rights of way.

- examples (***to be included***)

LIFE is the EU's financial instrument supporting environmental and nature conservation projects throughout the EU, as well as in some candidate, acceding and neighbouring countries. Since 1992, LIFE has co-financed some 3115 projects, contributing approximately €2 billion to the protection of the environment.

Some examples of Life projects in favour of bat critical feeding areas:

CHIROFRSUD : The project aimed to study the diet and foraging habitats of the three species concerned by the project and to inform the elaboration of management recommendations for the foraging habitats favourable to the bats.

CHIROMED: Life project in south-eastern France focusing on *Rhinolophus ferrumequinum* and *Myotis emarginatus* with some actions to improve foraging habitats (plantation of hedgerows linking roosts to foraging habitats, enhancement of good practices in the use of anti-parasitic drugs for livestock, operational mitigation to stop/reduce bat mortality on some dangerous road sections). http://www.lifechiromed.fr/resultats.php?lang=fr

Other tools can enhance the efficiency of cross-border cooperation in the field of rural development (**Interreg, Instrument for Pre-Accession Assistance**). It may also concern the protection of the bat fauna.

4.7. Summary of actions favouring and harming bats

Though bat species differ in their habitat preferences, there are some actions that typically favour all bat species. Similarly, some management practices are usually harmful for bats. Table 2 gives a summarizy of these actions.

Table 2.

Action	**Positive impact**	**Negative impact**	**Remarks**	**Mitigation measures**
building new areas of settlement		x	Depending on the intensity of building	
road construction		x		green bridges
forest management: clear cutting		x		saving treelines
forest management: small patch cutting	x			
removing dead trees		x		alternative roosts provided
removing trees with cavities		x		alternative roosts provided
use of pesticides		x		
use of herbicides		x		
creation of new hedgerows	x			
expansion/creation of field margins and dikes	x			
creation and maintenance of ponds	x			

5. Examples of successful habitat management cases

As resources are limited, evidence based conservation would be an optimal way of ensuring the favourable future of species. Well reported cases of successful habitat management for bats can help in the planning of conservation and management by providing important background knowledge and best practices. However, there are not

many reported cases available where the outcomes of the actions have been monitored. Few cases are reported here.

Case studies

Habitat management for the Greater horseshoe bat *Rhinolophus ferrumequinum*

The greater horseshoe bat *Rhinolophus ferrumequinum* has a restricted distribution in England, with a small number of widely spaced and isolated populations. It is believed to have undergone a significant population crash and reduction in range in the first half of the 20th century and most of the remaining populations are quite small and fragile. The species was one of the first to be protected by specific wildlife legislation in 1975.

Up till the 1990s, conservation action for the species focused largely on identifying and securing the remaining maternity and hibernation sites, many of which were threatened by neglect, decay or inappropriate development of various sorts. The majority of significant roosts, both maternity and hibernation, are now well-protected and managed.

Once the majority of the roosts had been secured, attention turned to the other major resource needed by the bats – foraging areas with appropriate food resources. To make progress with this conservation work, several important pieces of information were needed:

- How far from the roosts the bats flew on their nightly foraging trips;
- Which habitats they hunted over and whether they followed linear landscape features when commuting;
- What insect prey they preferred at different times of the year.

Attention initially focused on the maternity roosts, as these contain the largest concentrations of bats with the highest energy demands, though some work has also been done on foraging habits around hibernation sites.

Development of habitat management recommendations

Initial information about the foraging habits of the species came from research work, particularly that carried out by Gareth Jones and his colleagues at Bristol University (Jones & Morton, 1992; Jones et al., 1995). Radio-tracking provided data on the foraging habits of the bats, including the differences between adults and juveniles. Key findings for a habitat management project were:

- For the maternity roosts studied, most foraging activity was within 3-4km of the roost. Juveniles initially foraged within 1km of the roost before later extending their foraging range.
- The most important foraging habitats were cattle-grazed pasture and mixed deciduous woodland. Juveniles were very dependent on pasture while they learnt to hunt.
- Bats commuted along linear features, particularly hedgelines, and foraged at the interface between grazed pasture and woodland.

This work on foraging behaviour was then supplemented by detailed dietary analyses (Ransome, 1996, 1997), to determine the key prey items for both adults and juveniles while occupying the maternity sites. From these data, and a knowledge of the ecology of the prey species, critical feeding habitats could be identified, leading to detailed habitat and landscape management recommendations.

Pasture

- Retain existing grazed permanent pasture and create further areas of botanically diverse pasture to promote high densities of insect prey. Ideally, 50% of the land within a 4km radius around each maternity roost should be pasture.
- Maintain pasture as small fields separated by substantial hedges containing larger trees; minimise insecticide use against cutworms, wireworms and leatherjackets to avoid disrupting insect life cycles.
- Grazing regimes should be sympathetic to insect food production and keep pasture in good condition. Annual stocking rates for unimproved pasture should average about 0.5 cattle or 4 sheep per hectare but could be increased to 1 to 3 cattle (5 to 16 sheep) per hectare for short periods, providing this does not damage the pasture. These higher stocking densities should be maintained within 1 km of maternity roosts during July and August, with stock rotated between fields rather than ranched throughout the farm to help control parasites.
- Manage stock without the use of wormers based on Avermectin compounds (eg. Ivermectin) as such chemicals remain active in the dung, preventing colonisation by dung beetles.

Hedges

- Maintain all hedges, managing them to create tall, bushy structures, ideally with a broad base of between 3 and 6 metres to provide sheltered flight paths for bats. Leave mature trees and encourage young saplings to grow on into hedgerow trees to provide shelter and feeding perches.
- Create new hedgerows and tree lines across large open areas of permanent pasture, linking with existing hedges and woodland blocks to improve the network of flight paths and increase the area of pasture available to foraging bats. New hedges should be broad (3 - 6m across) with an average height of 3m. Hedgerow trees should be dotted along the length of the hedge.
- Leave uncultivated arable field margins adjacent to hedgerows to provide insect food for the bats.

Woodland, parkland and old orchards

- Retain existing mature ancient semi-natural deciduous woodland and create further blocks of deciduous woodland, shelter belts or small woods adjacent to grazed pasture. Ideally, up to about 40% of the land within a 4km radius of each maternity roost should be deciduous woodland to support good populations of moths and provide sheltered areas for foraging bats. Areas of high conservation value, such as unimproved grassland, should not be converted to woodland.
- Woodlands should contain grassy rides and glades, managed without insecticides. Glades should be at least 10 to 15 metres across to promote use by foraging bats. Coppice coupes should be small, to provide the maximum woodland edge habitat.
- Promote the development of a parkland landscape by planting additional standard trees in pasture areas (but do not plant trees or shrubs on unimproved or semi-improved pasture without seeking conservation advice). Newly planted trees should be adequately guarded against stock damage and managed to grow well developed crowns.
- Large old trees ('veteran trees') are particularly valuable to a wide range of wildlife, including bats. Try to retain these wherever possible, seeking specialist advice where necessary.
- Old orchards, with rows of mature fruit trees over a grazed understorey, can be valuable hunting areas for bats, provided insecticide use is restricted.

Marshy and aquatic habitats

- Retain existing and create new areas of marshy and aquatic habitats, such as ponds, to support good populations of craneflies and other insects. Again, avoid areas of high conservation value for creating ponds.

Delivery of habitat and landscape improvements

The main way in which habitat improvements on a large scale can be delivered is through government and EU-funded agri-environment schemes. These voluntary schemes support farmers in delivering environmental benefits, usually through long-term agreements with annual payments. Most schemes are targeted at particular areas or habitat types and involve applicants selecting from a series of options to deliver a farm-specific package of environmental benefits.

During the course of the work, two agri-environmental schemes were available. The higher-level tier of ESS is comparable to CSS and is the main one of interest.

Scheme	**Period available**	**Characteristics**
Countryside Stewardship (CSS)	1991-2005	Competitive scheme targeted at high nature conservation value land. Many

		options and combinations of options.
Environmental Stewardship (ESS)	2005-	Two-level scheme. Entry level, available to all, provides low-cost modest environmental benefits. Higher level, competitive and targeted, provides greater environmental benefits at higher cost.

By 1998, sufficient information was available from the research work to identify options

available in Countryside Stewardship that would deliver benefits for Greater horseshoe bats and a project officer was appointed to take the work forwards. A leaflet was produced summarising the conservation requirements of the Greater horseshoe bat, with a more detailed supplement available for landowners interested in committing to a CSS agreement. The role of the project officer was to improve the understanding of the needs of the bats within the target area and identify and visit farmers with land in the roost sustenance zone (within 4km of the roost) and persuade them to enter stewardship agreements with options that would benefit the bats.

Between 1998 and 2003, when the project ended, the project officers visited and provided advice to 163 landowners managing approximately 13211 hectares of land in bat foraging areas around key maternity and hibernation roost sites in Devon, Cornwall and Somerset. After some negotiations, 46 of these farms, covering 4191 hectares, entered Countryside Stewardship Scheme agreements. In addition, extensive support was given to partner organisations to improve their management advice and agreements for the bats, resulting in a further 31 bat-related management agreements covering approximately 2345 hectares.

Options used within the agreements included the following:

• improving important foraging areas by reverting arable land to grazed grassland

• management of permanent pasture and hay meadows with targeted grazing regimes to ensure plentiful supplies of key prey species for the bats

• creation of wide grassy arable field margins alongside hedgerows and woodland edges

• maintenance and improvement of bat commuting routes through the restoration of hedgerows (laying, coppicing and replanting gaps) and new planting of hedge boundaries, parkland trees and tree lines.

Through the work of the project, 80 kilometres of hedgerow located within the roost sustenance zones was designated for replanting or restoring under the CSS. In addition, nearly 400 hectares of grassland was brought under specialised management for the bats.

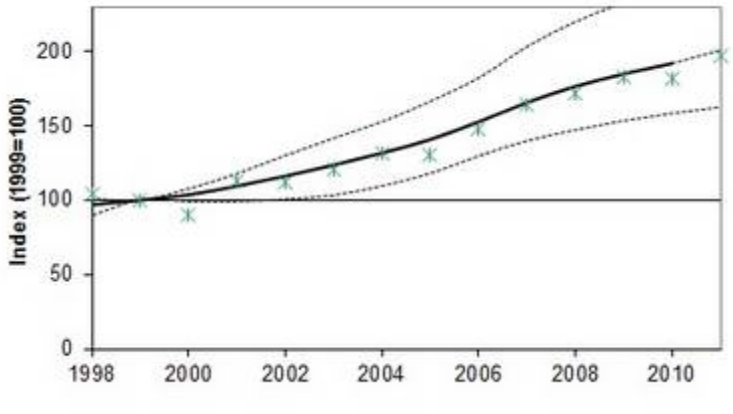
The project has provided management advice, and assisted with CSS applications, on a number of organic, in-conversion or extensively managed farms. An example is Riverford Farm which is an organic dairy enterprise operating in South Devon within the Buckfastleigh roost sustenance zone. They entered the CSS, following advice from English Nature, with specific measures to benefit the bats. During 2001, a marketing initiative was developed with Riverford Farm, whereby they

featured information about the bats and English Nature on their milk cartons. The simple message on the carton was used to inform consumers about the link between extensive agriculture and the provision of insect prey for the bats. Approximately 7000 cartons a week are sold across south-west England and in Hampshire and London. This initiative brought the Greater horseshoe bat project and English Nature to a new audience both within, and beyond, the project target area at no cost.

Since 2005, when Environmental Stewardship was introduced, work to deliver environmental benefits in the roost sustenance zones has been incorporated into the work of the scheme advisors, rather than requiring a dedicated project officer. As CSS agreements reach the end of their life (usually 10 years), farmers will be offered new ESS Higher level agreements to continue delivering environmental benefits for the bats. By 2008 almost 9000 hectares of land in the target areas was in an agri-environment scheme agreement.

Measuring success

The ultimate measure of success for this land management work is an improvement in the status of the Greater horseshoe bat. Colony counts from the National Bat Monitoring Programme, run by the Bat Conservation Trust, show that the species is currently increasing in numbers. The population index is currently 101% above the 1999 base year value, equivalent to an annual increase of 5.97% and this **upward trend is significant**.



Unfortunately, it is not currently possible to determine whether colonies where habitat restoration work has been focussed are increasing faster than other colonies because of small sample sizes and the fact that all colonies have benefitted to varying extents from agri-environment schemes.

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Case Study of Habitat Enhancement for Greater Horseshoe Bats

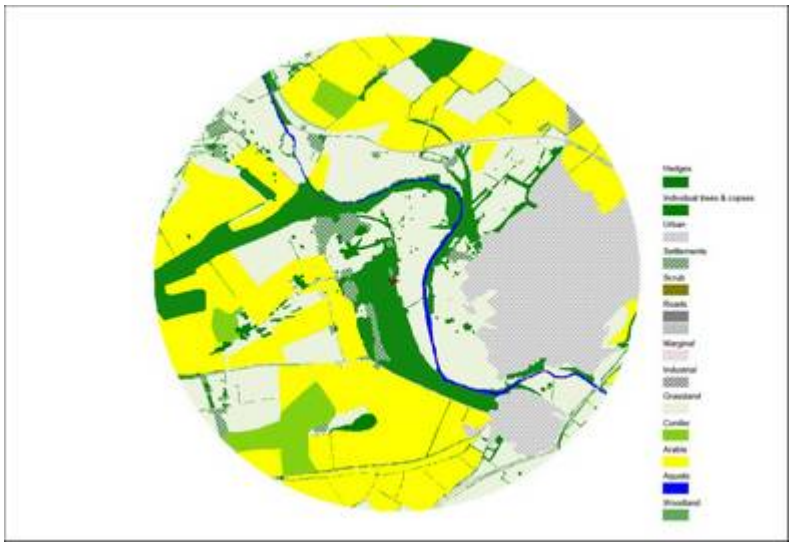
Background

This project was based around a maternity colony of greater horseshoe bats in Dorset, south-west England. Discovered in the 1950s, the colony occupied a large disused building on the edge of the flood plain of the River Stour and at the time was one of a handful of roosts for this species known in the UK. In 1994 the building was purchased by The Vincent Wildlife Trust and established as a nature reserve for the bats. In the following years considerable work was undertaken to enhance the building for the bats and by 2002 the colony had grown from about 60 to some 140 animals. With the building in good condition, it was recognised that the foraging habitat surrounding the roost was equally important and this was something that had to be addressed; especially as the landscape features were considered to be less than optimal.

Assessing the habitat

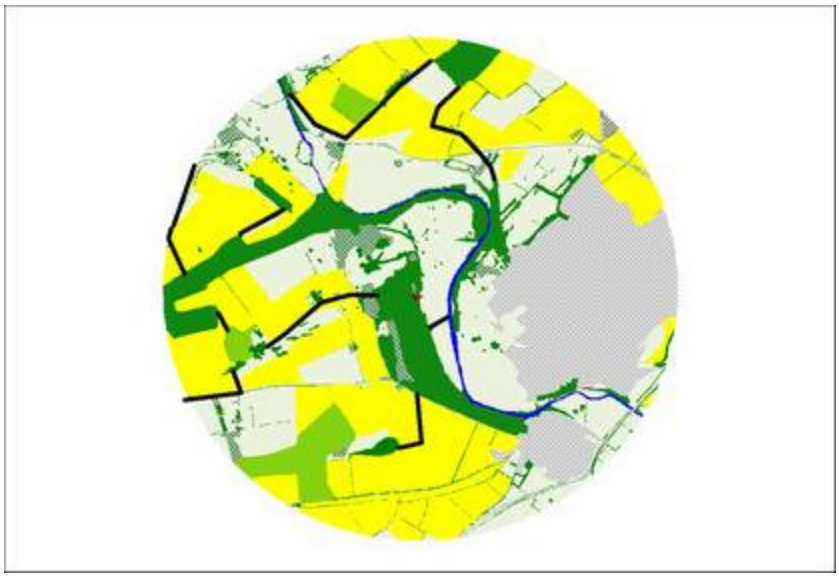
Although it was recognised that ideally work should be undertaken at a 4 kilometre radius of the roost, for a detailed assessment this area prove too large and it was decided that greatest impact could be had working closer to the roost. Consequently it was decided to target work within 2 kilometres of the roost. Within this area the habitat was mapped onto a Geographical Information System with habitat data being collected using aerial photographs and field-based surveys. The intention being to identify the location of preferred foraging habitats in relation to the roost and to assess how well these areas were connected to the roost by suitable landscape features.

Figure 1. Habitat mapped in a two kilometre radius of the roost.



The majority of the habitat surround the roost consisted of large arable fields, many of which had been enlarged by removing the traditional hedgerows. These accounted for 30% of land area within a two kilometre radius of the roost. Grassland, much of which had been improved, accounted for 27% and woodland 19%. To the east of the roost is a provisional town occupied 14% of the available land area. The habitat in the floodplain with its riparian woodland and grazed pasture provided the most obvious local foraging areas. However, potential foraging areas to the west and north of the reserve were effectively isolated from the bats by large open arable fields that had been fenced rather than having hedgerows. To reduce the degree of habitat fragmentation in the landscape surrounding the roost nine areas were identified as requiring habitat enhancement work. This work included the planning of new hedgerows, gapping up of existing hedgerows that had become derelict and the planting of a tree line.

Figure 2. Areas identified for re-instatement of hedgerows shown in black.



Local land owners were approached for permission to carry out the work and in some cases compensation was agreed with them to off-set the loss of agricultural land. During early 2003 some 2 kilometres of new habitat features were planted around the roost.

Figure 3. New hedgerow being planted.

Figure 4. Planting completed on a new hedgerow

Conclusion

In the ten years since the habitat enhancement scheme the numbers of bats using the roost has increased to 230 animals. The hedgerows have matured and been allowed to grow bushy. Radio-telemetry studies during 2009 and 2010 of the bats have shown that they are now commuting along some of the new hederows and accessing foraging areas that would previously required them flying across open landscape.

Figure 5. The effect of planting a dark corridoor leading from the roost

Case Study of Habitat Enhancement for western barbastelle

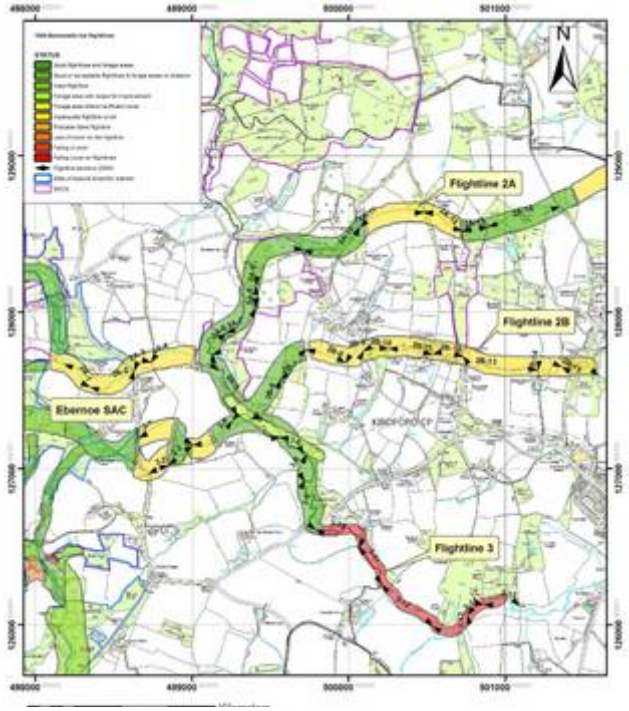
Background

The West Weald is an area of south-east England in the counties of West Sussex and Hampshire, characterised by undulating landscape containing a mixture of farmsteads, ancient woodland and heathland. It is an important area of the UK for the woodland bat species, including the western barbastelle. A colony of this species was discovered in an extensive area of ancient woodland in 1997 and a subsequent radio-telemetry study of the colony was conducted over 1998/9. In addition to identifying and characterising roost trees and foraging areas, the study highlighted the importance of linear vegetative landscape features with a 5 kilometre radius of the woodland. These served as commuting route for the colony enabling them to remain under cover on route to their foraging areas.

Assessing the habitat

Field surveys were undertaken of the commuting routes used by the barbastelles to assess the condition of the linear features and determine whether there was a need undertake habitat enhancement work.

Fig. 1 Main Flightlines from the woodland identified in 1998 and a condition assessment



An initial planting scheme was undertaken to improve the quality of the habitat where the condition assessment had indicated it was unsatisfactory. This involved fencing in areas that may be subject to stock damage and either allowing natural regeneration or planting up the enclosures with native species. These provided the bats with broad corridors to fly along at dusk.

Figure 2. One of the enclosures set aside for nature regeneration

Figure 3. An area with new planting to strengthen the hedgerow and make the corridor broader.

Following the initial radio-telemetry study the colony was monitored for ten years through an extensive ringing project and colony counts using infra-red video equipment; during this period the colony size doubled.

6. Guidance on habitat management for individual bat species

- *references to be checked*
- *some species texts need updating, new literature available and partly collated already*

Egyptian fruit bat (*Rousettus aegyptiacus*)

Feeding habitats and areas

The Egyptian fruit bat is known as a generalist frugivore feeding on almost all fleshy fruits (Izhaki *et al*. 1995; Korine *et al*. 1996; Korine *et al*. 1998; Korine *et al*. 1999), from natural as well as manmade orchards and gardens. Although it feeds mainly on fruit it is also known to also feed on leaves and insects (Barclay *et al*. 2006).

Flight distance to the feeding area is dependent on landscape structure, with observations of foraging flights as far as 25 km from the roost. No difference has been found between males and females, although Korine *et al*. (1994) have shown a significant difference between the sexes in cave departure order.

Tsoar *et al.* (2011) found that the foraging site constituted a relatively small area with a median convex hull of 0.052 km^2 per bat. Bats usually forage between trees that are close to each other, up to a kilometer away from the roost, although on rare occasions, larger distances of up to 10 km have been recorded.

In Israel, fruit bats showed a clear preference to foraging near human settlements; mean distance to nearest settlement center was found to be 795 ± 490m with a clear statistical significance to foraging nearby settlements (Tsoar *et al*. 2011).

Critical feeding areas

Because the Egyptian fruit bat is a generalist feeder utilizing both natural and cultivated fruits trees (e.g. Del Vaglio *et al.* 2011), it has a wide feeding area.

The main threats to the Egyptian fruit bat are from direct killing by humans (Korine *et al*. 1999) and from secondary poisoning due to pesticide use in agricultural orchards.

The lack of traditional diverse orchards, minimizing the year long availability of fruit for the bats seems to be one of the main limiting factors for the population growth.

Commuting routes

High resolution GPS tracking as well as standard telemetry tracking have shown that the bats fly high, fast and straight commuting flight to their feeding area. Bats do not seem to be using linear elements of the landscape but rather long range visual cues.

GPS tracked fruit bats (N=10) exhibited long (14,491 ± 4,160m), straight (straightness index: 0.95 ± 0.04) and fast (33.4 ± 3.1km/hr) continuous commuting flight in relatively high altitudes above ground level (130.7 ± 50.3m) upon departing from their roost after sunset and while flying back from the foraging site to the roost before sunrise (Tsoar *et al*. 2011).

Conservation and management of critical feeding areas

- Minimize pesticide spray on fruit.
- Ensure fruit availability year round. Consider planting orchards of fruit trees fruiting at times when other fruit availability is low, and during pregnancy and lactation when energetic demands are highest on the female (Korine *et al*. 2004).

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Naked-rumped tomb bat (*Taphozous nudiventris*)

Feeding habitats and areas

Feeding areas and habits of the Naked-rumped tomb bat are nearly unknown. They hunt at a considerable height and over a fairly straight and constant trajectory. The species is said to be often associated with large water bodies (Bates *et al.* 2008). Information on diet comes mainly from Turkey (Whitaker & Karataş 2009) where the main prey are Scarabaeidae in June, but Advani (1980) reported huge seasonal variations in Rajasthan They forage on the cotton worm *Spodoptera littoralis* in July-August in Egypt (Madkour 1977). .)

Critical feeding areas

Unknown.

Commuting routes

Naked-rumped tomb bats display swift, strong and usually high flight, they are thought to travel considerable distances from their roost when hunting (Harrison & Bates 1991).

Conservation and management of critical feeding areas

No recommendations can be made due to lack of information on the species' feeding habitats.

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Blasius's horseshoe bat (*Rhinolophus blasii*)

Feeding habitats and areas

Blasius's horseshoe bat is the rarest and least studied of the European rhinolophids. It is found in karstic areas of south-east Europe, in landscapes characterised by a small scale patchwork of shrub and open areas. It hunts in scrub, low growing broadleaf forests and along linear features such as hedgerows. These foraging areas are thought to be within 10 km of their day roosts. In common with other European rhinolophids, Blasius's horseshoe bat extremely agile in flight and adapted for hunting close to vegetation. The limited radio-telemetry studies of this species that have been conducted found it hunting around vegetation between 0.5–5 m above the ground (Dietz *et. al*. 2007). Experimental studies in flight cages prove it can also take prey from the ground (Siemers & Ivanova, 2004). The main prey for this species are moths, which make up over 95% of its diet in the Balkans (Dietz *et al*. 2007) and Jordan (Benda *et al*. 2010).

Comment [t1]: Dietz. et al. refer to their own data

Comment [t2]: In the English edition it says that two individual were tracked and reference is made to own data.

Critical feeding areas

Mosaic landscapes of shrubby vegetation, broadleaved woodland and hedgerows.

Commuting routes

Blasius's horseshoe bat commutes along hedgerows and other linear landscape features.

Conservation and management of critical feeding areas

The maintenance of a patchwork landscape of open areas and vegetative cover is critical for this species. Landscape connectivity is important as this bat species is not known to fly in open areas. The role of open areas is probably the generation of its insect prey, with the ecotones within the landscape concentrating prey abundance. The use of agricultural pesticides should be avoided in the areas surrounding known roosts.

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Mediterranean horseshoe bat (*Rhinolophus euryale*)

Feeding habitats and areas

Mediterranean horseshoe bats typically hunt in structurally heterogeneous broadleaved woodlands and forests as well as riparian vegetation (Russo *et al*. 2002, Siemers & Ivanova 2004, Russo *et al.* 2005, Némoz & Brisorgueil 2008), where they often feed on small moths (Goiti *et al*. 2004, Benda *et al.* 2006, 2010, Whitaker & Karataş 2009) – but other prey may seasonally become important (Goiti *et al*. 2004, Mikova *et al.* 2013). They seem well adapted to foraging in mosaic landscapes, such as those made of woodland patches interspersed with olive groves (Russo *et al*. 2002), or edge habitats such as hedgerows and woodland edges (Goiti *et al*. 2003, 2008, Barataud *et al.* 2009). Although plantations of broadleaved trees, native and exotic (e.g. Eucalyptus), may be used for foraging (Aihartza *et al.* 2003, Russo *et al*. 2005), those of conifers are typically avoided (Russo *et al*. 2002), but their edges can also be selected (Barataud *et al.* 2009).

Foraging distances vary largely according to productivity of available habitats, sex, age class and reproductive season. Lactating females have been found to move more than non-lactating ones to reach their foraging sites. In optimal landscapes of Southern Italy, distances up to 5 km are recorded during lactation, with a mean distance of 2.2 km (Russo *et al*. 2002). Longer maximum distances of ca. 9 km have been measured in the Iberian peninsula (Russo *et al*. 2005; Goiti *et al*. 2006), and more recently in France (15.6 km, Némoz *et al.* 2008). Males have been found to move less to reach foraging areas (mean 1.9 km; Goiti *et al*. 2006), but this may be due to more frequent roost switching which may increase proximity to favoured feeding habitat. No significant difference between sexes has been found in a previous study (Goiti *et al.* 2003). Newly volant juveniles flew on average 2.6 km from the roost (Goiti *et al*. 2006), then females forage at longer distances (Némoz *et al.* 2008).

Critical feeding areas

Broadleaved woodland, mosaic landscapes of woody vegetation, riparian vegetation.

Commuting routes

Mediterranean horseshoe bats follow hedgerows and other natural linear landscape features (e.g. vegetation corridors, riparian vegetation) as commuting landmarks. They detour to avoid urban settlements and lit up areas.

Conservation and management of critical feeding areas

- Attention paid especially to management of areas within 5–10 km from nursing roosts.
- Avoid reforestation with conifers – prefer broadleaved species, particularly those native to the area.
- Avoid interruption of critical commuting routes by limiting growth of urban areas, roads and illumination.
- Favour traditional management of agricultural landscapes and avoid pesticide spreading by encouraging e.g. traditional or organic farming.

- Favouring landscape heterogeneity does not mean encouraging fragmentation! Habitat corridors, hedgerows, tree lines, stepping stones and in general a high landscape connectivity should be preserved.

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Greater horseshoe bat (*Rhinolophus ferrumequinum*)

Feeding habitats and areas

Greater horseshoe bats hunt in traditional natural landscapes around their maternity colonies. While in the UK the species seems to prefer to a large percentage cattle grazed pastures with hedgerows as feeding habitats (Duvergé & Jones 1994, Duvergé 1994, Ransome & Hutson 2000), the species shows in Central and Western Europe beside the use of extensive used green land a higher preference to broadleaved forest habitats and broadleaved forest edges, extensive orchards, hedges and riparian vegetation. Arable land is avoided. (ASHG 1994, Bontadina *et al.* 1995, Bontadina *et al.* 1997, Pir 1994, Pir *et al*. 2004, Boireau 2007, Dietz *et al.* 2013). Coleoptera, Lepidoptera, Hymenoptera and Diptera are the most selected preys in Europe (Jones 1990, Beck 1995, Vaughan 1997, Boireau 2007, Flanders & Jones 2009, Fabbri & Giacomoni 2010).

The mean foraging distances vary with the physiological reproductive status, the age and foraging strategy of the bats as with the seasons and weather conditions. Greater horseshoe bats may forage from the immediate surroundings of the colony up to a radius of 14 km radius around the maternity roost (Duvergé 1996). In the UK the mean hunting areas seem to be at a greater distance to the colony. In Central and Western Europe the mean foraging distances from the maternity roost was 1,8 km for juveniles and up to 4,5 km for lactating females (Pir *et al*. 2004), and 9.1 and 9.9 km for a pregnant and lactating female respectively (Boireau 2007).

In one night a female greater horseshoe bat can visit up to 2-11 different hunting areas (mean size 3–7ha) (Ransome & Hutson 2000, Bontadina 2002, Boireau 2007) using different hunting strategies. The presence of a great number of night roosts seems to be important in rhinolophoid bat species.

Critical feeding areas

Broadleaved woodland, broadleaved woodland edges, hedges, orchards, cattle grazed pasture, extensive meadows, scrubs and riparian vegetation.

Commuting routes

Greater horseshoe bats are using natural linear landscape features as hedges, tree rows, orchards, forest edges and forest tracks and riparian vegetation for commuting flight to their foraging areas. Streets are crossed at a low height of approximate 0,80–1m. Greater horseshoe bats prefer crossing streets and places with a closed tree canopy.

Conservation and management of critical feeding areas

- Special conservation management measures within urban areas of nursing colonies up to a radius of 1.8 km to enhance insect availability for juveniles.
- Conservation management measures (extensive cattle grazing …) within a radius of 4.5 km (up to 12km for the UK) to enhance insect availability for lactating females.

- Coniferous forests should be transformed in broadleaved habitats within the foraging areas of greater horseshoe bats.
- Preservation of broadleaved forest edges, orchards and hedges with hanging branches for perch hunting.
- Avoid interruption of critical commuting routes by limiting growth of urban areas and roads bypasses.
- Conveying the transformation of arable land in extensive pastures and meadows.
- Favour traditional management of agricultural landscapes and avoid pesticide spreading by encouraging e.g. traditional or organic farming.
- Favouring landscape with a high natural heterogeneity: habitat corridors, hedgerows, tree lines and other natural stepping stones and in general high landscape connectivity should be preserved.
- Avoid the use of ivermectin or similar products as antiparasitic drugs in cattle stock farming within the hunting areas to preserve the coprophageous fauna of dung.

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Lesser horseshoe bat (*Rhinolophus hipposideros*)

Foraging habitats and areas

The Lesser horseshoe bat is mainly a forest bat (Bontadina *et al*. 2002; Reiter 2004, Zahn *et al.* 2008, Reiter *et al.* 2013). It forages in all types of woodlands, even coniferous ones, with a clear preference for deciduous and riparian forests, pastures, along hedgerows and tree lines, and also along edges of pond and lakes when they are (not always) lined by vegetation (McAney & Fairley 1988, Jones & Rayner 1989, Barataud 1992, Schofield 1996) where they prey upon Lepidoptera, Diptera, Neuroptera (McAney & Fairley 1989, Beck *et al.* 1989, Artois *et al.* 1990, Godat *et al.* 1991, Beck 1995, Vaughan 1997, Motte 1998, Williams *et al.* 1998).

The mean foraging area of a colony of 50-100 individuals was estimated 12 km² (Roué & Barataud 1999); when the individual domain varies between 6.8 to 62.7 ha (mean 25.2 ha) in Bavaria for an activity centre between 2.8 and 8.2 ha (mean 5.3) (Zahn et al. 2008), which is nealy the same (0.4 – 22 ha, mean 6.3 ha) in Corsica (Beuneux *et al.* 2008).

The distance of foraging areas from the maternity roost varies with the size of the colony and the availability of suitable habitats from a few hundred meters up to 8 km (Schofield 1996; Beuneux *et al.* 2008) but it is usually between 1 and 2.5 km. A female can use up to 7 different foraging areas in three nights (Kolzhaider *et al.* 2002).

Critical feeding areas

Riparian woodlands, wooded ravines and a network of habitats with deciduous woods, interspersed with ponds or brooks, small pastures, scrubs and hedgerows. Especially forested areas within 2.5 km from the maternity roosts are important (Roué & Barataud 1999, Reiter *et al.* 2013).

Commuting routes

The Lesser horseshoe bat commutes always along linear features such as rivers, ravines, hedgerows and tree lines (Schofield 1996, Motte 1998). These features need to be linked to the roost (Motte & Libois 2002). It may cross lake up to 1.2 km (Zahn et al. 2008) and open land but only under cover of darkness. It is very sensitive to street lighting with no evidence of habituation (Stone et al. 2009).

Conservation and management of critical feeding areas

- Roosts must be connected to foraging habitats by linear protecting structures (hedges, tree lines). The conservation of these features or the plantation of new ones is necessary.
- Avoid fragmenting foraging habitats.
- To avoid cutting off commuting routes, unlit passages should be provided either over the road (green bridges) or under it (tunnel).
- Maintenance of a traditional land use (small pastures, extensive crops and orchards).

- Conserve night roosts (typically they are in buildings) near feeding areas (Knight & Jones 2009).

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Mehely's horseshoe bat (*Rhinolophus mehelyi*)

Feeding habitats and areas

Foraging habitats of Mehely's horseshoe bats include a variety of woodlands that differ structurally, from open savannah-like woodlands to dense broadleaved and riparian forests. Traditional olive groves and eucalyptus plantations may temporally be important foraging habitats (Rainho 2005, Russo *et al.* 2005, Salsamendi 2010, Rainho & Palmeirim 2013). Foraging activity seems closely related with habitat patches associated with water, sites where abundance of moths is higher – the main prey of Mehely's horseshoe bats (Rainho 2007, Rainho & Palmeirim 2011, Salsamendi *et al*. 2008, Salsamendi 2010, Salsamendi *et al.* 2013). Habitat suitability declines steadily with distance to roost (Rainho & Palmeirim 2011).

Foraging areas and foraging distances differ largely between individuals, probably according to the availability of profitable foraging habitats around roosting sites. Mean foraging distances during lactation vary from 3.3 km to 19.2 km (52% of animals forage at more than 10 km), requiring high energy costs of flight (Rainho 2011). Maximum individual foraging distances of 29 km have been recorded in southern Iberian Peninsula (Rainho 2005, 2011, Salsamendi 2010). Mean foraging areas range from 0.6 km^2 to 4.5 km^2 (Russo *et al*. 2005, Salsamendi 2010).

Critical feeding areas

Woodlands with diverse structural complexity and close to water bodies near nursing roosts should be strictly protected.

Commuting routes

Mehely's horseshoe bats commute mainly by following rivers and valleys, flying through or near to riparian vegetation, woodlands edges and tree lines.

Conservation and management of critical feeding areas

- Attention should be paid especially to management of areas within 12–15 km from nursing roosts.
- Promote landscape diversity favouring woodland types with diverse structural complexity.
- Promote the development of natural landscape linear elements as commuting routes to reach profitable foraging habitats.
- Preservation or construction of a net of small water bodies (e.g. wetlands) near nursing roosts should be contemplated in threatened populations.
- Avoid the use of pesticides and insecticides in foraging areas and encourage traditional land management.

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(Western) Barbastelle bat (*Barbastella barbastellus*)

Feeding habitats and areas

Feeding mainly on moths (Beck 1995, Rydell et al. 1996, Sierro & Arlettaz 1997, Vaughan 1997, Sierro 2003, Andreas et al. 2012), the barbastelle bat is quite flexible in terms of foraging preferences. Although forest remains a chief foraging habitat (Sierro and Arlettaz 1997; Sierro 1999), vegetation edges and mosaics as well as wetland are also frequently used (Russ 1999). It forages and commutes above canopy, ca 2-4 m above tree crowns (Sierro and Arlettaz 1997), but may also forage below it, along forest trails and roads, as well as in forest gaps (Roué & Barataud 1999, D. Russo, pers. obs.). Usually it avoids open woodland on stony outcrops and rocky slopes, human settlements and open habitats such as meadowland (Sierro and Arlettaz 1997; Sierro 1999).

A fast flying species, it may cover long distances in short times. In the UK, foraging sites have been recorded at maximum distances of over 25 km from roosting areas (Warren 2008, Girard-Claudon 2011, Zeale *et al.* 2012, Vernet *et al.* 2014). Even 4-week juveniles may fly 7 km from their roosts (Warren 2008). Individual home ranges recorded in Switzerland averaged 8.8 ha, but according to long commuting distances recorded elsewhere, home ranges were much wider in Germany: 125 to 2551 ha (median: 403 ha), with core areas (1-5 per individual) ranging from 5 to 285 ha (median: 67 ha) (Hillen *et al*. 2009), and even wider in southeastern France: 1220 ± 1600 ha (up to 8600 ha, Girard-Claudon 2011, Vernet *et al.* 2014).

Critical feeding areas

Richly structured forests, wooded riparian valleys.

Commuting routes

Although it may cross open areas, even in subalpine habitats, forest corridors and edges seem important as commuting landmarks.

Conservation and management of critical feeding areas

- Large areas of highly structured forest should be preserved.
- Unmanaged forest patches with numerous dead trees should be retained in forested landscapes or near wetlands to favour proximity between foraging and roosting quarters
- Tall riparian vegetation should be carefully preserved.
- Forest continuity should be favoured by promoting corridors connecting networks of important sites.
- Although the available information on distances travelled and home range size is far from sufficient, there is evidence that long distances are covered (up to 25 km in the UK), so management of foraging sites should take place within at least 10 km from main roosting areas or more.

- Preserve small ponds, cattle troughs and other water sources in forest, along its edges as well as in pastures bordered by woody vegetation: these are frequently used by barbastelles for drinking.

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Botta's serotine (*Eptesicus bottae*)

Foraging habitats and areas

Eptesicus bottae is a desert species which inhabits arid areas; its known distribution range comprises several isolated areas (Nader & Kock 1990b, Benda *et al*. 2006). Being a slow aerial hawker it hunts in the open air, along gorge edges, around streetlights and above water (Korine & Pinshow 2004). Hymenoptera, Lepidoptera and Coleoptera were reported to be the most important prey items in this species in Palestine (Feldman *et al*. 2000), whereas in Syria the most important were Coleoptera, Heteroptera and Auchenorrhyncha (Benda *et al.* 2006), and in Jordan two diets differed significantly, one similar to the data by Feldman *et al*. (2000), the second dominated by Heteroptera, Hymenoptera and Coleoptera (Benda *et al.* 2010). This species has probably high feeding flexibility. The most critical is availability of water, both artificial ponds etc. and natural water bodies, in the desert regions.

Critical feeding areas

Access to water.

Commuting routes

Not known.

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Isabelline Serotine Bat (*Eptesicus isabellinus*)

Feeding habitats and areas

On a large scale the isabelline serotine has a strong Mediterranean affinity, the main difference from the serotine bat is the occurrence in dryer habitats (Santos *et al.* 2014). In Andalusia colonies are located either in irrigated agriculture or in Mediterranean shrub landscape (Papadatou *et al.* 2011). They select areas with high relative humidity (e.g. river banks) as preferred hunting sites, most probably because of the highest availability of hard insects, such as Coleoptera and Hemiptera, which represent the largest proportion of its diet (Pérez-Jordá 1994). In Murcia they also show higher affinity for river streams, and secondary to matorrals, avoiding crops (Lisón *et al.* 2014). In central Tunisia *E. isabellinus* preferentially hunts in areas where water bodies (stream, water tank) are surrounded by vegetation (R. Dalhoumi, unpublished data).

E. isabellinus are typical air hunters, but can sometimes capture prey on "surfaces" (rocks, leaves ...) as they often fly near vegetation (including among trees) and bare rocks in Algeria (Gaisler & Kowalski 1986). Their diet seems relatively diverse, including a smaller proportion of Diptera and Dermaptera to Coleoptera, Hemiptera and Lepidoptera (F. Lisón, unpublished data).

Critical feeding areas

Wetlands offering a high production of insects, preferably with a lentic hydrolic system.

Commuting routes

Unknown

Conservation and management of critical feeding areas

- Support the abundance and diversity of its prey by ensuring the quality of aquatic environments.
- Protect, preserve and restore matorrals and wetlands.
- Realize more studies to know more about *Eptesicus isabellinus*' feeding habitat.

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Bénédicte Ferrer & Stéphane Aulagnier

Northern bat (*Eptesicus nilssonii*)

Feeding habitats and areas

Northern bats are highly flexible in their foraging behavior (e.g. Wermundsen & Siivonen 2008). Habitats include farmland as well as forest, where they fly in open spaces like forest glades and clear cuts, along forest edge and tree lines, and over water and along riverine tree stands; also in urban parks and suburban gardens. The densest populations occur where the foraging habitat is most diverse, such as in small farmland areas with deciduous woodlands, and near lakes (Rydell 1993) where they prey upon Diptera, mainly Chirnomidae and Tipulidae, Coleoptera, Ephemeroptera and Trichoptera (Rydell 1986a, 1989a, 1992a). The diet is totally different in Moravia, dominated by Lepidoptera, Heteroptera, Homoptera and Diptera, mainly Brachycera (Gajdošik & Gaisler 2004). Large open fields, pastures and young spruce plantations are avoided as feeding habitat (Rydell 1986a).

The flight path while hunting is typically straight or slightly curved at a height of 5–10 m, often at tree top height, but ranging from 2 to more than 50 m (Rydell 1993). Females often establish small (about 100 m^2) feeding territories in places where insects are abundant, for example along forest edge or around isolated trees in open farmland, which are used by the same individual night after night (Rydell 1986b, 1993). Females mostly hunt close to the colony (within 600 m), and utilize lakes and wetlands in particular. When insect density decreases they may shift to hunting sites up to 4–5 km from the colony. After weaning, they can fly probably more than 30 km to visit deciduous woodland and eutrophic lakes (de Jong 1994). Males can travel up to 70 km per night during exploring flights (Haupt *et al.* 2006). Also Frafjord (2013) observed a significant increase in the homeranges of female bats as the season progressed. In spring and late summer/autumn northern bats often hunt for insects near artificial light sources such as street lights (Rydell 1991, 1992b).

Critical feeding areas

Water bodies, beaver flowages, deciduous forest near water and other areas with high insect abundance within 5 km of colonies are important for lactating females, particularly in regions with otherwise low insect production such as the boreal coniferous forest (de Jong & Ahlén 1991, de Jong 1994, Nummi *et al.* 2011).

Commuting routes

Linear landscape elements are relatively unimportant, and northern bats often take the shortest route between hunting sites or between roosts and hunting sites (de Jong 1994).

Conservation and management of critical feeding areas

Attention should be paid especially to management of areas with high insect production within a distance of 5 km from maternity colonies.
Natural habitats of forest and grassland remain essential, at least in some part of the range.

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Serotine bat (*Eptesicus serotinus*)

Feeding habitats and areas

The serotine bat can be defined as an edge and open area specialist. It is well able to glean insects from vegetation or the ground, but the predominant foraging strategy is aerial hawking (Baagøe 2001). It usually forages close around trees (Kurtze 1991), particularly the canopy, often touching the vegetation. In open pasture it can fly close to the ground or up to 20 m, with sudden steep dives. The species often feeds along roads and around street lamps (Baagøe 2001), however they never used anthropogenic habitats in Ticino (Switzerland, Mattei-Roesli et al. 2008).

The distance to foraging sites can be as far as 5-7 km, but usually they spent around 90 % of their foraging time at distances smaller than 2 km from the maternity roost; A high percentage of traditional feeding sites is used by the colonies in subsequent years (Catto *et al*. 1996; Kervyn et al. 1997; Harbusch 2003; Kervyn 2001).

Faecal analyses of the serotine bat in different parts of its European distribution area showed that this bat forages predominantly on Coleoptera (e.g. *Aphodius,* Melolonthinae, *Necrophorus*), Lepidoptera, Diptera, Trichoptera, Hemiptera and Hymenoptera (Kurtze 1982; Labee & Voûte 1983; Robinson & Stebbings 1993; Catto *et al*. 1994; Beck 1995; Beck *et al.* 1995, Gerber *et al*. 1996; Vaughan 1997; Kervyn 2001; Gajdošik & Gaisler 2004; Kervin & Libois 2008, Zukal & Gajdošik 2012). In all studies, dung beetles (and other dung fauna) are of major importance to this and other bat species.

Serotine bats select their foraging habitats according to the absolute densities and variety of their preferred prey taxa. These main prey taxa are associated with semi-open and open habitats such as meadows and cattle pastures with tree groups, hedges or woodland edges (Harbusch, 2003).

Critical feeding areas

The most important feeding areas are those in a distance of up to 2 km around the maternity roost, since lactating females need abundant and preferred food at close distance. These are usually unimproved pastures with tree groups or hedgerows, as well as deciduous woodlands in a mosaic with grassland.

Commuting routes

The importance of commuting routes is not as high as it is for smaller species since the serotine bat is able to fly straight and in higher altitudes (up to 50 m) to the foraging grounds. However, linear landscape elements such as hedgerows are used when available as commuting route.

Conservation and management of critical feeding habitats

1. The conservation of unimproved, permanent and extensively used pasture in a radius of up to 2 km around the roost is vital for the survival of adults and juvenile serotine bats of

a maternity colony. Grassland management should best be organic, thus avoiding pesticide use.
2. Park-like landscape structures such as tree groups within grassland or extensively used orchards should be promoted to increase the sources of key insect prey taxa. The use of insecticides in orchard management should be discouraged.
3. Deciduous woodlands, especially those close to maternity colonies, should be conserved and promoted. Coniferous stands should be replaced by deciduous trees. Woodland borders adjacent to grassland should include a broad range of locally characteristic shrubs. Clearings within woodlands should be left to natural succession, thus enhancing the growth of flowering plants.
4. The use of avermectins on cattle on pasture close to the maternity roost should be restricted to early spring and autumn, when the animals are confined.
5. Local planning of green spaces within settlement areas should promote unbuilt areas, such as gardens, parks or fallow land.

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Savi's pipistrelle bat (*Hypsugo savii*)

Feeding habitats and areas

This generalist forager is associated with a wide range of landscapes and also markedly synanthropic. It may be observed feeding in many habitats, including riparian habitats, forest edges, farmland and urban settlements (Russo & Jones, 2003), also in mountainous areas over 1000 m a.s.l. In northern Italy it mainly uses water habitats (Toffoli 2007), and in southern Italy, it has been found to forage less in artificial conifer plantations (Russo and Jones, 2003), and hunts frequently around street lamps, especially those emitting white light which prove more attractive for insect prey. On Crete it forages mainly in oak forests and wetlands (rivers, lakes and ponds). It is also present in shrublands, up to 1800 m a.s.l. Its feeding activity during winter is minimal (Benda *et al*. 2008; Geogiakakis 2009). The main prey are Homoptera Heteroptera and Lepidoptera for Bauerova (*in* Horáček & Benda 2004), Lepidoptera, Diptera, Hymenoptera and Neuroptera for Beck (1995).

No information on distances travelled is available, but according to wing morphology foraging should mainly occur within a few km from the roosts.

Critical feeding areas

- None in particular, albeit riparian habitats, traditionally managed farmland and "green areas" in urban settlements such as parks and gardens may be especially important.
- On Crete, Oak forests, wooded wetlands and chestnut groves.

Commuting routes

As pipistrelle bats (Verboom & Huitema 1997), may follow hedgerows or commute along woodland edges, but frequently crosses open spaces.

Conservation and management of critical feeding areas

- Preservation of riparian habitats and low-intensity agriculture, promoting spatial and temporal heterogeneity.
- Reduction of pesticide spreading.
- Establishment and appropriate management of gardens and parks in built-up areas.
- Avoidance of reforestation with conifers, at least outside the ecological and biogeographical original areas of these trees e.g. along many Mediterranean coasts.

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Alcathoe whiskered bat (*Myotis alcathoe*)

Foraging habitats and areas

Alcathoe whiskered batis a recently discovered species (Helversen *et al*. 2001), so only fragmentary information is available. This species has probably a wide European distribution, but its occurrence is rather patched and restricted to suitable habitats (Niermann *et al*. 2007). It hunts in small valleys with deciduous trees and with flowing water (Helversen *et al*. 2001), among the trees or in clear spacing and unpaved roads in an old natural deciduous forests, around water bodies with patches of riparian vegetation surrounded by the forest, rather close to the vegetation. Depending on season, bats also forage in gardens and water streams in intravillan (Lučan *et al*. 2009, Lučan *et al*. unpubl.).

Small Diptera are the most important prey item along with spiders, caddis flies, small moths and neuropterans for Lučan *et al*. (2009), moths (mainly below 12 mm) and locally ants for Dank *et al.* (2010).

The farthest distance a male moved away from roost was 935 m for an activity area of 39 ha (Schorcht *et al.* 2009).

Critical feeding areas

Natural deciduous forests, patches of old woods with small water bodies.

Commuting routes

Linear landscape elements such as water streams and roads. Also, Alcathoe whiskered bats were found as traffic casualties (Řehák *et al*. 2008)**.**

Conservation and management of critical feeding areas

- Preservation of deciduous woodland in valleys.
- Riparian vegetation should be maintained as ecological corridors..

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Bechstein's bat (*Myotis bechsteinii*)

Feeding habitats and areas

Myotis bechsteinii prefers old open deciduous forests (Wolz 1992, Kerth *et al*. 2002, Lüttman *et al.* 2003). It has been found also in highly structured coniferous forests as the structure of the forest is more important than the tree species in the stand (Albrecht *et al*. 2002, Napal et al. 2010, Arrizabalaga-Escudero *et al.* 2014). It favours windthrow gaps as their great amount of dead wood and herbaceous plants allow the development of saproxylic insects which are numerous in its diet (Barataud *et al*. 2005). However the species mainly feed upon Diptera, mostly Tipulidae, Lepidoptera and Coleoptera (Taake 1992, Vaughan 1997, Wolz 1993a, b), and locally or seasonnaly Orthoptera (Andreas et al. 2012).
n areas with isolated woodlands, *Myotis bechsteinii* forages also in agricultural landscape providing that it finds a mosaïc of habitats: pastures, hedgerows, parks, old trees, old extensive orchards (Lüttman *et al*. 2003, Barataud *et al*. 2005, Schofield & Morris 2000). Younger woodlands with some older stands are also used, provided that they present a closed but clear canopy and an understorey with different vertical structures (Dietz & Pir 2009).

Foraging areas were estimated 17.5-20 ha by Wolz (1992), located within a radius of 200 m to 2 km around the roost, this later result was confirmed by Kerth *et al.* (2001) and Lüttman *et al*. (2003). In southeastern France the distance is longer (1.3 ± 0.9 km), up to 3.9 km, and domain larger (190 ± 150 ha, Girard-Claudon 2011, Vernet *et al*. 2014). Each individual uses several daily roosts, usually less than 1 km apart, but they can move up to 4.5 km (Schofield *et al.* 1997). The size of the activity area is greater in a fragmented woodland habitat than in a large block of forest (Schofield & Morris 2000, Kerth *et al*. 2001, 2002, Albrecht *et al*. 2002, Lüttman *et al.* 2003, Greenaway & Hill 2005, Napal *et al.* 2013). The smallest foraging areas (0.83 to 7.10 ha, mean: 3.41 ha) were recorded in the Upper Rhine valley in Germany, indicating a very high suitability of the study area (Brinkman et al. 2007).

Critical feeding areas

Large blocks of old deciduous and richly structured forests with clearings, windthrow gaps and a lot of dead wood are critical feeding areas for Bechstein's bat.

Commuting routes

Outside forests *Myotis bechsteinii* crosses open areas in direct flight.

Conservation and management of critical feeding areas

- Large areas of highly structured forest should be preserved.
- Unmanaged forest patches presenting numerous trees with cavities and windthrow gaps should be retained in forested landscapes.

- Clear cutting of large areas of high forest is to be avoided as *Myotis bechsteinii* has difficulties to adapt to major changes in its environment.
- Forest continuity should be favoured by promoting corridors connecting networks of important sites.
- Bat friendly management of woodlands within 2 km of the roosts is necessary.
- Spraying of pesticides in forests should be banned.

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Lesser mouse-eared bat (*Myotis blythii (oxygnathus)*)

Foraging habitats and areas

This species prefers dense steppe vegetation over sparse xeric grassland, unmown meadows, pastures, and avoids forests (Arlettaz 1995, 1999). *Myotis blythii* forages also in wet meadows which present more insects than pastures (Güttinger *et al.* 1998). It feeds mainly upon bush crickets (Arlettaz *et al.* 1993, 1997, Siemers *et al.* 2011), replaced by cockchafers in the spring as it can switch from traditional feeding habitats, 0.3 to 1.2 m high grass, to secondary (usually temporary) foraging grounds (Arlettaz 1996).

The mean size of foraging areas is 38.1 ± 11 ha.Lesser mouse-eared bat forages in high altitudes: mean altitude of foraging areas was 1012 ± 317 m, the highest being at 2000 m a.s.l. according to Arlettaz (1995).

The mean distance of foraging areas from the nursery roost is 3.8 ± 1.5 km (Arlettaz 1995) and the furthest feeding grounds observed were at the distance of 10.9 km (mean: 6.3 km, Güttinger *et al*. 1998) and 22 km (Groupe Chiroptères de Provence *pers. comm.*).

Comment [t3]: Dietz et al. also refer to an Interreg Project www.livingspacenetwork.bayern.de but this page is not working?

Critical feeding areas

Grasslands with sufficient vegetation to host a great variety of insects.

Commuting routes

Unknown.

Conservation and management of critical feeding areas

Management recommendations should focus on the fact that pastures should not be overgrazed, nor treated with pesticides. On dry grasslands, extensive grazing is recommended to avoid the development of encroaching woody vegetation.

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Brandt's bat (*Myotis brandtii*)

Feeding habitats and areas

The Brandt's bat feeds in woodlands and above and among stagnant water, rivers and streams (Taake, 1984; Racey, 1998; Meschede & Heller 2000; Dense & Rahmel 2002; Tupinier 2004) preying mainly upon Lepidoptera and Diptera (Taake 1992, Vaughan 1997). Coniferous forests were favoured over other forest types as well as over grassland and arable land in the study by Berge (2007). In the south of Europe, the species can only be found in mountainous woodlands. It is hardly ever found in urbanised habitats (Taake 1984, Tupinier 2004. In a study conducted in Finland, the primary feeding areas were spruce dominated, middle-aged forests or mature spruce mires, located at the average distance of 950 m from the roost (Vihervaara *et al.* 2008).

The species forages in areas from 1.5 km up to 10 km from its roost (Dense & Rahmel 2002). In Germany, radiotracked females used 2 to 13 different feeding areas (Meschede *et al*. 2000; Dense and Rahmlel 2002).

Critical feeding areas

Large blocks of old woods, at stagnant waters, riparian habitats, treelines, small woodlands and hedges.

Commuting routes

Ekman & De Jong (1996) showed that *M. brandtii* often was absent on isolated patches of woodland within an agricultural landscape, nor on islands in lakes, indicating that the species does not readily cross open areas like crop fields or lakes. Individuals use fixed routes along wood lanes, hedges, or woodland edges (Dense & Rahmel 2002).

Conservation and management of critical feeding areas

- Maintenance of corridors between roosts and foraging habitats.
- Conservation of woodlands and riparian zones in the vicinity of the roost.

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Long-fingered bat (*Myotis capaccinii*)

Feeding habitats and areas

This wetland specialist typically forages in riparian habitats and over lakes (Kalko 1990, Médard & Guibert 1990, Russo and Jones 2003, Almenar et al. 2009), preferring calm waters bordered by well-developed riparian vegetation and large (over 5m) inter-bank distances (Biscardi *et al*. 2007). Trawling bat, it forages low over water surface (17.5 ± 4.6 cm, Kalko 1990) from which catches its prey: Diptera (Chironomidae), Lepidoptera Trichoptera (Médard & Guibert 1992, Almenar *et al.* 2008), and even small fish (Aihartza *et al*. 2003, Aizpurua *et al.* 2013). The most suitable patches in terms of prey accessibility and detectability are selected (Almenar et al. 2013). Interestingly, it persists on some Mediterranean islands where surface water habitats are very rare. In at least one of such cases (Zakynthos) has been found to switch to forested foraging habitats (Davy *et al*. 2007).

In Central Italy, Biscardi *et al*. (2007) observed a mean distance from roost to foraging sites of 7.5 km, with a maximum of ca 21 km, and up to 22.7 km in Spain (Almenar et al. 2011). In Corsica, the mean distance between the maternity roost and foraging habitat was 19.7 km, and the maximum distance 31 km in straight line (54 km along the river, Rist *et al.* 2010). This distance varies according to the status of bats, during prebreeding and weaning periods they forage nearer the roost and tend to gather at stretches, during lactation they scatter along the river (Némoz & Brisorgueil 2008, Almenar *et al.* 2011). Foraging activity drops on very windy nights, so trees bordering water sites are also valuable to shelter feeding areas (Russo and Jones 2003).

Critical feeding areas

Riparian sites characterised by large inter-bank distances, clean, calm water and trees along both banks.

Commuting routes

Often follows water courses but may cross open areas.

Conservation and management of critical feeding areas

- Preserve or restore riparian vegetation, especially in the areas surrounding main cave roosts, but also over longer distances (> 20 km) from them, given the species' high mobility.
- Avoid deterioration of riparian ecosystems, including pollution, channelisation, dredging and damming.

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Pond bat (*Myotis dasycneme*)

Feeding habitats and areas

Pond bats use buildings, such as houses and churches, are predominantly as summer roosts. This species can fly up to 15 kilometres from their roost and even 25 kilometres during spring and autumn (Haarsma & Tuitert 2009). Although they are specialized in trawling insects from the water surface, they are quite flexible in terms of foraging habitat. The species is most abundant in habitats with a combination of lakes, a dense network of waterways, marshland and meadows. Although they are known to hunt mostly abose bigger water bodies and slow flowing rivers, in Holland, they have observed to be spending 25% of their night hunting above meadows (Haarsma *et al*., pers. comm.). During periods of extreme weather conditions, such as sudden rainfall and high wind speeds (>4 Bft) they have been observed hunting along hedgerows and in woodland.

Pond bats' diet is dominated by non-biting midges (Chironomidae - both imagines and pupae) and caddis flies (Trichoptera) (Ciechanowski & Zapart (2012), Kruger *et al.* (2014).

There is not much published data on radio tracking studies on pond bats available. In Poland feeding areas are located 2.2 - 4.8 km from the nursery roost (Kokurewicz & Furmankiewicz (in Ciechanowski *et al*. 2007), in Holland feeding areas are located on average 8 km from maternity roosts and 12 km from male roosts (Haarsma unpublished data). In Germany (Dense & Rahmel unpublished data) males and females are also known exhibit sexual segregation in size of home range. Pond bats prey mostly on small Dipterans such as Chironomids and Culicidae, but also moths and beetles (Britton *et al*. 1997; Sommer & Sommer 1997). The diet of pond bats differs significantly from Daubentons bats (Krueger unpublished data).

Critical feeding areas

Lakes, waterways and other water bodies but also marshland and to a lesser extent meadows form critical feeding areas. Habitats with high insect production, especially during spring and autumn are especially important for reproducing females and their offspring.

Commuting routes

Linear waterbodies, such as canals and rivers, as well as other linear elements such as tree lines and hedgerows are used as commuting routes (Verboom *et al*. 1999). If commuting routes cross unlit roads, pond bats tend to cross these fairly low (approximately 1 metre above the ground) which can cause traffic accidents.

Conservation and management of critical feeding areas

- Attention paid especially on management of water bodies in distance of ~ 0,5 kms from nursery roosts. Pond bats often display pre-swarming behaviour above water (social function).

- Attention paid especially on management of linear water bodies in distance of <6 kms from nursery roosts, as they form key habitat (both as commuting routes and as feeding habitat).
- Reduction of light levels near water bodies is important as pond bats are disturbed by the light itself (Kuiper *et al*. 2007) as well as by the reduced insect abundance on the water. High illumination levels are easily softened with tree lines along water bodies (Protection of such tree lines is also important).
- Water management in pond bat habitats should aim to conserve the edges of water bodies. A natural bank (gradual transient between land and water, if possible with reed vegetation) has a higher insect production then a steep bank. Further steps should be taken to prevent the accumulation of duckweeds (Lemnaceae) (continuous displacement of water, no drainage of polluted water into important water bodies).

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Daubenton's bat (*Myotis daubentonii*)

Feeding habitats and areas

Daubenton's bats forage mainly above water bodies of both flowing and stagnant water. Feeding areas are usually at a maximum distance of 2–5 kilometres from the roosts (Arnold *et al*. 1998, Dietz *et al*. 2006) – but may occasionally be as far as 10 kilometres away from the roost. Females tend to forage closer to their roost than males (Encarnação *et al*. 2005). Foraging areas of pregnant and lactating females are typically small while after weaning of the young also females use larger areas (Dietz *et al*. 2007). Females show high fidelity to good quality foraging areas (Kapfer *et al*. 2008) even though they might change the roost quite often.

Critical feeding areas

Ponds and other water bodies with high insect production near roosts are important especially for lactating females.

Commuting routes

Daubenton's bats use e.g. rivers and tree lines as commuting routes (Downs & Racey 2006).

Conservation and management of critical feeding areas

- Attention paid especially on management of areas in distance of ~ 2 kms from nursing roosts.
- Tree lines and other commuting routes saved.

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Geoffroy's bat (*Myotis emarginatus*)

Feeding habitats and areas

Geoffroy's bats are "flexible specialists" in terms of feeding preferences. May feed in forest habitats (Krull *et al*., 1991; Demel *et al*., 2004; Flaquer *et al*., 2008, Zahn *et al* 2010) as well traditionally managed farmland, olive groves (Flaquer *et al*., 2008) and riparian areas (Russo & Jones, 2003). In the north part of its range (Germany, Netherlands), it feeds in cow sheds and stables (Krull et al. 1991, Brinkmann et al., 2003, Zahn et al 2010, Dekker *et al*. 2010). Prey is either gleaned from substrate or caught on the wing. Adults forage further than juveniles (3.4 vs. 1.8 km; Flaquer et al., 2008), with maximum distances from roosts of over 6.5 km.

Critical feeding areas

Forests, traditional farmland and riparian habitats, stables.

Commuting routes

Prefer sheltered routes in forests; may cross urban settlements but major roads and open areas are avoided (Flaquer *et al*. 2008). In the north, it uses tree lanes to move from roosts to feeding areas (Brinkmann *et al.* 2001; Dekker *et al*. 2013).

Conservation and management of critical feeding areas

- Preserve richly structured woodland, traditionally farmed habitats with a high landscape heterogeneity, riparian vegetation and cattle stables.
- Favour connections between roosts and foraging areas by creating or preserving forest corridors, hedgerows, and tree lines.
- The species benefits from low-intensity agriculture, promoting spatial and temporal heterogeneity and reducing pesticide spreading.

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Greater mouse-eared bat (*Myotis myotis*)

Foraging habitats and areas

A ground gleaning bat which shows a preference for deciduous or mixed open woodlands with sparse or no understorey, grazed woods, olive groves; forages also above freshly cut meadows, harvested fields, intensive cultivated orchards, and avoids scrubs (Rainho 2011, Rainho & Palmeirim 2013). Found also above the illuminated area of street lamps (Barataud 1992).

Foraging areas at a maximum distance of 25 km from roost (Arlettaz in Roué & Barataud 1999) but usually 5–15 km (e.g. Rudolph *et al.* 2009). Size of foraging areas: min. 100–1 000 ha (mean size 350 ha in Portugal).

Critical feeding areas

Open deciduous woodlands with no vegetation on the ground are essential for the species.

Commuting routes

(Check if information in Drescher 2004)

Conservation and management of critical feeding areas

- No use of pesticides in agriculture and forestry within the home range of a nursery.
- Maintenance of corridors between roosts and foraging habitats.
- Conservation of woodlands with no understoreys in the vicinity of the roost.
- Maintenance of forest alleys clear of vegetation.

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Whiskered bat (*Myotis mystacinus*)

Feeding habitats and areas

There is not much radio tracking data on whiskered bat available. The whiskered bat forages in forests, also woodland edges and river banks are suitable habitats. More open areas such as parks and hedges might be used as well. It is said to be not as tightly linked to forests and bodies of water as Brandt's bat (Schrober & Grimmberger 1997). However, contrary to previous findinds, Buckley *et al.* (2013) report in their study in Ireland that the species used mostly mixed woodland and riparian habitats

Several feeding areas up to 2.8 kilometres from the roost can be used (Cordes 2004). Recent studies have indicated that the species clearly favored grassland over builtup areas, woodland and arable land (Berge 2007). In the study of Berge (2007), Whiskered bats typically have few feeding areas (1,25). Maximun foraging distance is 200 to 2300 m while the average is 812 m (Berge 2007).

- Taake 1984?

Critical feeding areas

Key foraging habitats are grassland (pastures etc, Berge 2007) and mixed woodland and riparian habitats (Buckely *et al.* 2013).

Commuting routes

In a study on echolocation behaviour it was observed that whiskered bats followed closely (distance under 7 meters) a hedgerow (Holderied *et al.* 2006) This suggests the importance of landscape elements that can provide acoustic "landmarks" to the species, such as hedgerows.

Small forest islands in and agricultural landscape may not be suitable for the species (Lesinski *et al.* 2007) as the species needs acoustic cues for orientation during commuting.

Conservation and management of critical feeding areas

- Management of grasslands.
- Save hedgerows in an area with radius of 2,3 km around the roost.

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Natterer's bat (*Myotis nattereri*)

Feeding habitats and areas

Natterer's bats typically hunt in a variety of habitats across Europe ranging from meadows, pasture, orchards, broadleaf woods to open conifer forest and riparian habitats (Arlettaz 1996; Siemers *et al.,* 1999; Siemers & Swift 2006; Smith & Racey 2008 Lundy et al., 2012). Natterer's bat is likely to select foraging areas which are rich in horizontal and vertical edges (Siemers *et al.* 1999). Foraging areas range between 128 and 580 ha (Fielder *et al*. 2004; Siemers *et al*. 1999; Smith and Racey 2008). Multiple partial foraging areas are used within this area (Smith and Racey 2008). The core of foraging grounds can be up to 4 km from roosts and individuals are faithful to core hunting areas, returning to these on consecutive nights (Siemers *et al.* 1999). Connecting habitats between the roost and core area are also utilised for foraging (Siemers *et al.* 1999).

Natterer's bats rely on a gleaning foraging strategy, preying on resting insects from the surface of vegetation using the tail membrane and/or feet to capture prey (Arlettaz 1996; Swift and Racey 2002). Diurnally active insects, insects which rarely fly, and non-flying arthropods are eaten (Gregor and Bauerova1987; Shiel *et al.*1991; Siemers and Swift 2006).

Critical feeding areas

Broadleaved riparian woodland, open conifer forest, orchards and grassland.

Commuting routes

Hedgerows and riparian vegetation are important, particularly in areas where the foraging habitats are fragmented. Open areas tend to be avoided.

Conservation and management of critical feeding areas

- Semi-natural broad-leaved woodland should be retained.
- Clear felling of large blocks of woodland should be avoided.
- Maintain diverse hedgerow structure in grassland areas for both roosting and commuting.
- Tree cover along river banks should be encouraged and protected.
- Minimum application of insecticides in orchards and grassland agricultural systems.

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Maghrebian mouse-eared bat (*Myotis punicus*)

Feeding habitats and areas

Corsican studies in 1999 when the species was still considered as being *M. myotis* (Beuneux 1999), already mentioned that its foraging habitat differed from foraging habitat of continental *M. myotis*, with a preference for pastures and grassland-wood ecotone and not forests (Beuneux 2002, 2004). Radio-tracking studies were carried out in 2009-2011 and 44 foraging grounds pertening to 9 different types of habitat were identified for 53 gestating or lactating females (Beuneux *et al.* 2014). They show that the preferred foraging grounds of *Myotis punicus* are open habitats with sparse vegetation: pastures (62%), mown hay meadows (9%), unmown grasslands (7%), but they also use orchards and vineyards. In Corsica the species has been observed searching for prey in slow flight at less than one meter from the ground, landing to catch it and taking off quickly. In Malta it hunts also on the ground or in flight, preying upon Orthoptera, Lepidoptera and Coleoptera (Borg 1998). In Corsica, it feeds mainly on Orthoptera, Coleoptera and Lepidoptera (Beuneux 2002), and occasionally on Homoptera (Arlettaz 1995).

Foraging areas vary from 1 to 25 ha (mean 8.1 ± 5,8 ha) and they represent less than 10% of the individual MCP. Mean distance of foraging areas from maternity roost were 3.6, 4.9 and 6.0 km for three colonies, with a maximum distance of 16.5 km in straight line (Beuneux *et al.* 2014).

Critical feeding areas

Open habitats with sparse vegetation

Commuting routes

In Corsica *Myotis punicus* crosses every day over a mountain pass at 1,450 m a.s.l.

Conservation and management of critical feeding areas

This opportunistic species foraging mainly in hay meadows and pastures, its conservation implies a global agricultural policy for the preservation of extensive sheep and cattle farming. And xeric grasslands turning into scrubland need also management.

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Greater noctule (*Nyctalus lasiopterus*)

Feeding habitats and areas

Aerial hawking bat that frequently forages above riverine areas and marshlands in southern Spain (Ibáñez *et a*l. 2004, 2009; Popa-Lisseanu 2007; Popa-Lisseanu *et al* 2009), and in oak woodlands in Portugal (Rainho 2007). Population roosting in urban parks in southern Spain could also use urban areas for foraging. However there is no observation of city light attraction on the species. Woodlands and open areas are not frequent foraging habitats for the species in southern Spain (Popa-Lisseanu 2007). In Corsica where the studied population consisted only of males, the foraging areas were mountaineous wooded areas, high ridges, coastal habitats destroyed by fire (previously woodlands), eucalyptus and citrus fruit plantations, and vegetable fields (Beuneux *et al.* 2010). In continental France, during radio-tracking studies aimed at locating the roosts of the species, some individuals have been watched foraging above pastures (Destre 2007), also close to rivers, above wet meadows and above the canopy of deciduous woods (Dubourg-Savage *et al*. 2013, 2014).In Hungary the species was mist-netted next to lakes, rivers and woodlands where it came down for drinking and probably foraging (Estók & Gombkötő 2007).

As *Nyctalus lasiopterus* switches diet in spring and autumn (Dondini & Vergari 2000, 2004; Ibáñez *et al*. 2001; Popa-Lisseanu *et al*. 2007; Lugon 2008; Smirnov & Vekhnik 2013) - (according to the availability of passerine preys) - mountain passes could also have an important role in some areas.

Due to the lack of roosts in the best feeding habitats, bats (including lactating females) regularly forage in southern Spain up to 40 km from the roost. An extraordinary distance of 92 km from the roost (Popa-Lisseanu et al. 2008) has also been recorded. In Corsica the mean distance of the foraging areas to the roosts can reach 25 km (Beuneux *et al.* 2010.

Critical feeding areas

Water bodies, wetlands, large river valleys, mountain woodlands and deciduous forests are therefore the most important areas to conserve for the species.

Commuting routes

Along river valleys (Popa-Lisseanu 2007, Popa-Lisseanu *et al*. 2009) and possibly along bird migration routes.

Conservation and management of critical feeding areas

- No intensive logging in forests inhabited by the species;
- conservation of aging tree stands;
- reforestation (if necessary) and nest boxes in the meantime;
- no spraying of the foraging areas with insecticides.
- no installation of wind turbines in the critical feeding areas and in migration corridors of birds.

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Leisler's bat (*Nyctalus leisleri*)

Feeding habitats and areas

Foraging behaviour depends on season, age, sex and geographical position of the site. In southern England Leisler's bats significantly preferred foraging in areas of woodland and along scrub-lined roads in Kent, but over pasture around Bristol. Urban and arable areas were avoided at both sites. Bat-detector transects showed a significant preference for bats to forage along woodland margins (Waters *et al*. 1999).

In Ireland two-thirds of the recorded foraging time was over pasture or drainage canals. Foraging over other habitats, particularly lake and conifer forest, was greatest in preparturition. Other habitats foraged included lights, estuary, stream, beach and dunes. Lights are relatively the most favored foraging sites (Shiel & Fairley 1998; Shiel *et al*. 1999).

In eastern Germany forages both in large woodland areas without preference for any forest types, and also in different open lanscapes and at waters, as well as in settlements (Schorcht 2002).

In south-western Germany most foraging activity was recorded at lakes and rivers near forests, along forest roads and above clearings (Harbush *et al*. 2002).

In Italy foraging activity of *N. lesleri* was recorded by acoustic surveys in all habitat types except coniferous plantations and arable areas (Russo&Jones 2003), in England most activity was related with rivers, lakes and improved pasture (Vaughan *et al*. 1997).

In Corsica 76% of Leisler's foraging areas are in cluttered environments (small forested valleys and inside woodlands), 21% semi-open habitats (wind-throw gaps in woods, orchards/pastures, xeric grasslands with shrubs) and 3% open habitat (pond) (Chalbos 2013).

Female and male home ranges in Germany were estimated at least in 6 and 1,5 km^2 correspondingly (Furmann *et al*. 2002), maximum distances of foraging flights could be over 17 km, but usually about 5 km from the roost (Shiel *et al*. 1999, Waters *et al*. 1999, Schorcht 2002).

Critical feeding areas

Water bodies, forest roads and clearings, pastures.

Commuting routes

In Ireland commuted directly to foraging sites at speeds often exceeding 40 kmh. (Shiel *et al*. 1999).

Conservation and management of critical feeding areas

A network of trees with woodpeckers holes concentrated in small areas are more favoured by Cosican Leisler's bats than trees with cavities dispersed over a wider area (Chalbos 2013). This has to be taken into account by forestry management plans.

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Noctule bat (*Nyctalus noctula*)

Feeding habitats and areas

Noctule bat uses different feeding habitats; open water bodies, woodlands, wetlands and riparian habitats, valley pastures, harvested fields and enlighted places in towns (Austria: Spitzenberger 2001, Czech Republic: Gaisler *et al*. 1979, Bartonička & Zukal 2003, Denmark: Baagøe 2001, Germany: Kronwitter 1988, Meschede & Heller 2000, Greece: Hanak *et al*. 2001, Rottmann *et al*. 2003, Italy: Russo&Jones 2003, Latvia: Rydell & Petersons 1998, Luxembourg: Harbusch *et al*. 2002, Poland: Rachwald 1992, Spain and Portugal: Benzal *et al*. 1991, Russia: Strelkov&Ilyin 1990, Switzerland: Stutz & Haffner 1989, Gebhard & Zingg 1995, The Netherlands: Limpens & Kapteyn 1991. The UK: Vaughan *et al*. 1997).

At feeding sites bats flew at 6.0 ± 2.1 m/s (Jones 1995). Foraging flights can easily go more than 10 km away from the roost site (Meschede & Heller 2000), up to 20 km maximum (Limpens *et al*. 1997, Heise 1989), but the main activity of a maternity colony in Germany was within a radius of about 2 km from the colony's roost (Schmidt 1988).

The minimum convex polygon (MCP) used by the colony in the UK was 62.75 km2 and mean individual bat MCP was 8.2 km2 . A comparison of relative habitat use, between lactating and non-lactating bats, demonstrated state-dependent differences in use and identified habitats important for foraging in reproducing bats. Broadleaved woodland and pasture were the highest ranked foraging habitats consistently preferred by noctule bats across both levels. Although there was little difference in foraging activity (e.g. nightly duration, median 115 min) or maximum distances travelled to foraging grounds (mean 4.23 km), non-lactating bats used less preferred marginal habitats (arable land and moorland) significantly more than lactating bats (Mackie, Racey, 2007).

Critical feeding areas

Woodlands and nearby water bodies, pastures and other open habitats.

Commuting routes

It seems that in most cases noctule bats fly directly from the roost to foraging areas.

Conservation and management of critical feeding areas

Conserve broadleaved woodland and surrounding pastures in cultural landscapes as these are important feeding areas for noctules (Mackie & Racey 2007). Practices reducing insect numbers and diversity should be avoided.

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Hemprich's long-eared bat (*Otonycteris hemprichii*)

Feeding habitats and areas

Hemprich's long-eared bats usually forage over rocky habitats with sparse herb vegetation (Horáček 1991), hovering close to the ground (Rybin *et al.* 1989, Arlettaz *et al.* 1995, Qumsiyeh 1996, Korine & Pinshow 2004), ca. 1 m on average in the early evening, or flying in large circles in height of 4-8 m later in the night (Horáček 1991). They also forage over small ponds in arid zones with many rock crevices (Harrison & Bates 1991, Bates & Harrison 1997), wadis and areas with springs vegetation, and even a garbage dump (Yom-Tov 1993, Fenton *et al.* 1999). Depending on the feeding areas, the diet could also vary seasonally (Fenton *et al.* 1999). Prey is taken from the ground (Arlettaz *et al.* 1995, Fenton *et al.* 1999) and also in flight (Horáček 1991). They include Tenebrionids, Blattoidea and Orthoptera (Horáček 1991), Scarabeidae (Whitaker *et al*. 1994), Solifugae, Acrididae, Scorpiones (Holderied *et al*. 2011), Araneae, Carabidae, Gryllidae, Tettigoniidae, Lepidopteran imagos and larvae, Staphyllinidae (Arlettaz *et al.* 1995), and also Chilopoda, Heteroptera, Hymenoptera and Diptera (Fenton *et al.* 1999).

When feeding areas are next to the roost (0.5-2 km) females have 3-4 bouts of foraging per night, and only one when the roost is 9 km far from these areas (Daniel *et al*. 2008), this pattern is altered by pregnancy and nursing (Daniel *et al.* 2010).

Critical feeding areas

In desert habitats the richest zones, mainly near water bodies, are the most favourable.

Commuting routes

Hemprich's long-eared bats seem to fly straight to foraging areas without fluttering or quick manœuvres over rocky habitats (Daniel *et al.* 2008).

Conservation and management of critical feeding areas

- Attention paid especially on maintenance of water bodies and herb vegetation.

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Pipistrellus hanaki

Pipistrellus hanaki was originally described from Cyrenaica, Libya (Benda *et al*. 2004). It was discovered very recently (Hulva *et al*. 2007) in Crete, which represents the only European territory inhabited by this species. Based on morphological and molecular differences from conspecifics from Libya, Benda *et al*. (2008) described the Cretan populations, as a separate subspecies, *P. h. creticus*.

Feeding habitats and areas

P. hanaki belongs to moderately abundant bat species in Crete and occurs in a wide range of altitudes, from the sea level up to over 1000 m a. s. l. (Benda *et al*. 2008). It has been trapped and recorded in a wide array of habitats, like shrublands, pine forests, olive groves and inhabited areas. Comparison of feeding habitat preferences with standardized recordings along transects showed that the species' optimum habitat type is mature mediterranean *Quercus* forests (mainly *Q. coccifera*, but also *Q. ilex* and *Q. macrolepis* which can be found in central and western Crete between 800 and 1200 m.a.s.l. (Geogiakakis P. 2009, Phd Thesis). *P. hanaki* is relatively abundant in wetlands (rivers, lakes and ponds) with rich vegetation, mainly *Platanus orientalis* and *Castanea sativa*. The species is active also in winter, although to a considerably lesser extent.

Nothing is known on the species roosting habits, apart from an old record of a specimen found on a wooden box outside a cottage.

Critical feeding areas

Oak forests, wooded wetlands and chestnut groves.

Commuting routes

Unknown.

Conservation and management of critical feeding areas

- Bat-friendly forest-practices
- Preservation of riparian habitats

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Kuhl's pipistrelle bat (*Pipistrellus kuhlii*)

Feeding habitats and areas

A very flexible species, associated with a wide range of landscapes and also markedly synanthropic. In practice, may be observed foraging in virtually all habitats below 1000 m a.s.l., including riparian habitats, forests, farmland and urban settlements (Russo & Jones 2003), whereas at higher elevations disappears (especially outside urban settlements), except on the southern side of the Pyrenees, and may be replaced by other, less thermophilous pipistrelle species. Forages frequently in urban areas around street lamps (Haffner & Stutz 1985/6; Russo & Jones 1999, Rainho 2007), especially near those emitting white light which proves more attractive for insect prey.

In Portugal, the species forages in a wide array of habitats, but its activity is greater in wetlands with many trees and oak woodlands (Rainho 2007). In Crete it is also common in olive groves and inhabited areas. Its abundance in shrublands is reduced, although this is the most common semi-natural habitat type on Crete (Benda *et al*. 2008; Geogiakakis P. 2009, Georgiakakis *et al*. 2010). Its feeding activity during winter is considerably reduced.

Critical feeding areas

- None in particular, albeit riparian habitats, traditionally managed farmland and "green areas" in urban settlements such as parks and gardens may be especially important.
- In Crete, wooded wetlands.

Commuting routes

As other pipistrelle bats (Verboom & Huitema 1997) may follow hedgerows or commute along woodland edges, but frequently crosses open spaces.

Conservation and management of critical feeding areas

- Preservation of riparian habitats and low-intensity agriculture, promoting spatial and temporal heterogeneity
- Reduction of pesticide spreading
- Establishment and appropriate management of gardens and parks in built-up areas

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Nathusius's pipistrelle bat (*Pipistrellus nathusii*)

Feeding habitats and areas (based on Boye & Dietz, 2005)

Nathusius's pipistrelle bat prefers rather lowland region with water bodies (ponds, lakes, river, wetlands), if they are not available, they forage in rich structured biotopes, e.g. along forest edges, tree-lines, roads, old-growth woodlands, sometimes over reeds, pastures or around lamps (Austria: Bauer & Wirth 1979, Spitzenberger 2001, Denmark: Baagoe 2001, Fennoscandia: de Jong 1993, Germany: Heise 1982, Dense 1991, Schmidt 1997, Arnold & Braun 2002, Schorcht *et al*. 2002, Greece: Pieper 1978, von Helversen & Weid 1990, Hanak *et al*. 2001, Italy: Spagnesi *et al*. 2000, Luxembourg: Harbusch *et al*. 2002, Poland: Ruprecht 1977, 1990, Jarzembowski *et al*. 1998, Russia: Chistyakov 2001, Spain and Portugal: Benzal *et al*. 1991, Flaquer *et al*. 2009, Switzerland: Gebhard 1995, The Netherlands: Limpens & Kapteyn 1991). In the Transcaucasia forages also in semi-desert landscapes (Rakhmatulina 2005).

Pipistrellus nathusii has a home range of 10-22 km^2 in summer (Schorcht *et al*. 2002). Certain foraging areas may be at a distance of 6.5 km from the roost site (Boye & Meyer-Cords 2004). The size of a foraging area is in eastern Germany 18 ha on average (Eichstadt 1995), in northern Germany four individual home ranges of femals from a maternity colony covered a total area of 5,8 km^2 (Schorcht *et al*. 2002). The common home range of a colony is approximatly 80 km^2 (Meschede & Heller 2000, Arnold & Braun 2002).

It is a typical aerial hawker, which hunt mainly Diptera in moderate distances from ground/water and vegetation (Kalko 1995), but it can also be a facultative gleaner (Pithartová 2007).

Critical feeding areas

The most important areas are natural wetlands and riparian habitats (Flaquer *et al*. 2009) and natural deciduous forest with established bat roosts.

Commuting routes

Nathusius's pipistrelle bat is a long distance migratory species in northeast-southwest direction (Petersons 2004, Hutterer *et al*. 2005). The importance of to guiding landscape structures, such as coastal lines, great rivers etc. is worth mentioned.

Depending on the habitat, the commuting flights from a roost to a foraging area are generally conected with linear landscape elements, e.g. streams, forest edges, hedges, tree-lines, roads or forest aisles, but they are also able to go across open fields (Arnold & Braun 2002).

Conservation and management of critical feeding areas

To be writen

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Common pipistrelle bat (*Pipistrellus pipistrellus*)

Feeding habitats and areas

The common pipistrelle is a very flexible species that can be found hunting in a wide range of landscapes: from urban centres to arable land and woodland, but will hunt close to woodlands or riparian areas if available (Eichstat & Bassus, 1995; Taake & Vierhaus, 2004; Nichols & Racey, 2006a; Davidson-Watts *et al*., 2006; Dietz *et al*., 2007). As the Common pipistrelle has its roosts in buildings, it will be mostly found close to human settlement. Poorer habitats, such as heather, pine wood, sand dune are poor habitats for the common pipistrelle (Kapteyn, 1996). In these habitats, it hunts in half open spaces, for example under the canopy of trees, or at water edges, usually no closer than 1 meter from vegetation. Frequently forages around street lamps (Haffner & Stutz, 1985; Russo & Jones, 1999), especially those emitting white light which proves more attractive for insect prey.

Critical feeding areas

None in particular, albeit riparian habitats, traditionally managed farmland and "green areas" in urban settlements such as parks and gardens are more important than others. Riparian areas and woodland edges are favoured (Taake & Vierhaus, 2004), but degraded riparian habitats (fewer trees, more uniform bank vegetation, etc.) have less bat activity than intact riparian habitats (Scott *et al*., 2009).

Distance between foraging areas and (maternity) roost can vary, but only females have been radio-tracked, and seem to forage round 1.5 km, and maximally 5 km, from the roost (Helmer 1987; Racey & Swift 1985; Simon *et al*. 2004; Davidson-Watts & Jones 2006; Nicholls & Racey 2006b).

Commuting routes

Uses hedgerows, tree lines or woodland edges (Verboom & Huitema 1997), but frequently crosses open spaces of up to a few hundred meters (Helmer, 1987).

Conservation and management of critical feeding areas

- Preservation of riparian habitats and low-intensity agriculture, promoting spatial and temporal heterogeneity
- Reduction of pesticide spreading
- Establishment and appropriate management of gardens and parks in built-up areas

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Soprano pipistrelle bat (*Pipistrellus pygmaeus*)

Feeding habitats and areas

Ecological differences between common pipistrelle (*Pipistrellus pipistrellus*) and soprano pipistrelle (*Pipistrellus pygmaeus*) have been studied only in recent years, following the recognition in the late 1990s of the latter as a distinct species (see, e.g., Barrat *et al*. 1997, ICZN 2003). Nevertheless, before species recognition there were some useful studies of what was then perceived as two phonic types of *P. pipistrellus*, with the 45 kHz phonic type corresponding to *P. pipistrellus* (*sensu stricto*) and the 55 kHz phonic type corresponding to *P. pygmaeus*.

Several studies in the British Isles (Vaughan *et al*. 1997, Russ & Montgomery 2002, Nicholls & Racey 2006) and in Central Europe (Dietz *et al*. 2007) have concluded that soprano pipistrelle utilizes a more narrow feeding niche than its close congener, with feeding mainly taking place over or near wetlands (rivers, canals, lake/reservoir margins, riparian woodland). This was also suggested by studies of diet based on faecal analysis of the two phonic types (Barlow 1997). Glendell & Vaughan (2002), however, found that soprano pipistrelles selected tree lines and semi-natural woodlands over aquatic habitats in landscape parks in England, and Russ & Montgomery (2002) found that not only wetlands but also deciduous woodland was significantly selected in Northern Ireland. Bartonička & Řehák (2004) found a particularly high flight activity over water during spring, and an increase in foraging activity in ecotones and forest glades later in the season in their study area in Moravia, Czech Republic, and non-aquatic Brachycera has been found to be part of the diet particularly in the second half of the year (Arnold *et al*. 2002 #NOT SEEN#). In Scandinavia, where the soprano pipistrelle is by far the most widespread and numerous of the two species, *P. pygmaeus* does not show the same strong association with wetland habitats but are also found feeding in openings in woodlands, along tree lines and forest edge, and in parks and gardens with stands of deciduous trees (Ahlén 2004, Baagøe 2007). Wetlands, however, also constitute important hunting habitats, perhaps particularly in areas with otherwise low insect production (Ahlén 2004). In Portugal, the species uses the same habitats as *Pipistrellus kuhlii* including water sites, oak woodlands and urban areas (Rainho 2007).

Comment [t4]: Please give the original references

In general, bat hunting activity along stretches of rivers polluted by sewage outputs is less than along cleaner stretches of river in Southeast England, but soprano pipistrelle activity was found to be less affected than that of common pipistrelle (Vaughan *et al*. 1997). In accordance with this, Barlow (1997) found that the 55 kHz phonic type (=soprano pipistrelle) in Britain mainly feed on pollution-tolerant prey associated with wetland habitats. Russ & Montgomery (2002) found that water bodies with no vegetation edge generally were avoided by bats in Northern Ireland.

Critical feeding areas

Oakeley & Jones (1998) reported water (especially water edge habitat with woodland or hedgerow on the banks) and continuous hedgerow with emergent trees as habitats occurring significant more than expected around maternity roosts of the 55 kHz phonic type. They suggest that conservation of continuous hedgerows and watercourses close to maternity roosts may be particularly important for the soprano pipistrelle. It would seem, from this and the other studies listed above, that water bodies, deciduous forest near water

and other areas with high insect abundance is likely to be important. The tendency of the soprano pipistrelle to establish rather large maternity colonies (e.g., Barrat *et al*. 1997, Dietz *et al*. 2007) implies that access to areas of high quality feeding habitat within reach of the colony is vital for the species. #Most foraging within 2 km of colonies?#

Commuting routes

Linear landscape elements are likely to be important for soprano pipistrelles, as it is for common pipistrelle, although relevant studies were done before recognition of the two as distinct species (e.g. Verboom & Huitema 1997).

Conservation and management of critical feeding areas

Attention need to be paid to management of

- wetlands and rich deciduous forest near maternity colonies (#within 2–3 km?#)
- linear landscape elements like hedgerows, tree lines and water courses near colonies
- bankside vegetation

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Brown long-eared bat (*Plecotus auritus)*

Feeding habitats and areas

The brown long-eared bat is a typical woodland bat. All over its range, its habitats are woody elements: deciduous forests with different ages of trees, less structured woodlands, forest edges, bushes and hedges, but also orchards, parks and gardens (Horácek 1975, Fuhrmann & Seitz 1992; Entwistle *et al*. 1996; Swift 1998, Woloszyn 2001; Kiefer & Boye 2004; Kyheröinen 2008). It uses both coniferous and deciduous woods.

Diet studies and tracking studies show that the brown long-eared bat forages most on sitting prey, such as spiders, moths, earwigs, etc. gleaning it from leaves, branches, of walls, but it also catches prey in flight (Swift 1998, Rydell 1989; Meineke 1991). It can hunt on moths that are attracted to street lights (Swift 1998).

Critical feeding areas

Important habitats are woodlands, or wooded habitats with more human-influence, such as orchards, wooded parks and gardens. The species hunts in feeding areas that are close to its roost: usually within 100 meters; not further than 3 kilometres (Furhman & Seitz 1992; Entwisle *et al*. 1996; Swift 1998, Kyheröinen 2008). If feeding areas cannot be reached directly from the roost, commuting routes are used.

Commuting routes

P. auritus avoids crossing open spaces (Swift, 1998). Indeed, Ekman & de Jong (1996) found that the species does not forage in patches of isolated woodland in open agricultural areas.

Hedgerows, tree lines and fences and river edges can be used as commuting routes between roosts and feeding sites (Barataud 1990; Entwistle 1996; Swift 1998; Kyheröinen 2008) when it cannot be reached directly from the roost, or where woodland is fragmented.

Conservation and management of critical feeding areas

Attention need to be paid to management of

- woodlands, orchards and gardens within range of 1.5 km from roosts
- structure linear landscape elements like hedgerows and tree lines in the case of areas with fragmented woodland

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Grey long-eared bat *(Plecotus austriacus*)

Feeding habitats and areas

The Grey long-eared bat is a species of mosaics landscapes of wooded and open areas and of villages. It is known to hunt above extensively managed arable lands, meadows and uncultivated fields, in open forests (especially old beech forests) and at forest edges and in more urbanised areas, such as wooded gardens, parks and building and sheds (Horacek 1975; Flückinger & Beck 1995; Swift 1998; Kiefer & Veith 1998; Boeckx 2005; Johannes Regelink pers. comm.). In Southern Europe, the species is also reported from open mountain slopes with dry bush vegetation, mountain woodland, steppe areas and villages (Gaisler & Hanak, 1964; Rottmann *et al*. 2003).

The species hunts its prey in flight more than *Plecotus auritus*, but it also gleans prey from leaves, walls, or the ground; prey are predominantly moths but also beetles and flies (Bauerova, 1982; Barataud, 1990; Swift, 1998; Meineke, 1991).

Critical feeding areas

Critical feeding areas are meadows and arable fields, open woodland, wooded slopes, mountain steppes, orchard, parks and gardens and villages.

The species hunts in feeding areas that are maximally 5.5 kilometres, but usually not further than 1.5 kilometres from its roosts (Kiefer & Veith, 1998; Flückinger & Beck 1995; Boeckx 2005; Regelink pers. commun).

Commuting routes

Linear landscape elements such as hedges, treelines, fences, banks and streams or even railway lines are used as commuting routes (Barataud, 1990; Swift, 1998).

Conservation and management of critical feeding areas

Attention need to be paid to management of

- woodlands, orchards and agricultural lands within range of 1.5 km from roosts
- linear landscape elements like hedgerows, tree lines etc., especially in the case of areas with fragmented woodland

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Alpine long-eared bat *(Plecotus macrobullaris*)

Feeding habitats and areas

All over Europe and the Near and Middle East, the recently discovered Alpine long-eared bat (Kiefer & Veith 2001), *Plecotus macrobullaris* has been mist-netted not only in mountain ranges but also down to the Mediterranean coast and a synthesis of its distribution was published in 2013 by Alberdi *et al*., showing an altitudinal range of 0-2800 m a.s.l. For details on distribution refer to the above mentioned reference.
The same author had previously studied the feeding habitats of this newly discovered species by using DNA mini-barcodes to identify prey remnants in its faeces (Alberdi *et al.* 2012). 97.8% of the species diet are moths. Foraging habitats were deduced from ecological habitats of identified prey, living mainly between 1500 and 2500 m a.s.l., i.e. mainly subalpine meadows, orophilous grasslands and alpine meadows. No forest prey species were identified in the faeces.

In France, only two females were radiotagged and one had been foraging in meadows, montane grasslands and open pine woods (Bérenger 2014).

In the coastal areas of the Adriatic Sea the species inhabits Mediterranean pubescent oak woods with hop-hornbeam and oriental hornbeam. These habitats cover the southern slopes of the coastal mountains from the sea level to 800 m a.s.l. *Plecotus macrobullaris* occurs up to elevations of 1550 to 1800 m a.s.l. to the subalpine belt consisting of beech or mountain pine scrub (Pavlinic. & Tvrtkovic 2004) ?

On Crete it has been located in five localities, from 46 to 1490 m a.s.l. (Benda et al. 2008) Three of these localities are caves above 1000m, but the species was trapped there in the autumn (late August to October), so it was probably preparing for hibernation, or swarming. These caves are surrounded by shrublands, with forests in a distance of 2 to 7 km. Another record comes from a mine surrounded by olive groves, while the species was also trapped in a park, inside the city of Irakleion, central Crete (2 parus females in late July, unpublished data).

Critical feeding areas

Grasslands at subalpine and alpine levels and rocky slopes

Commuting routes

No information as long as roosts and feeding areas have not been studied.

Conservation and management of critical feeding areas

At the altitude at which the species forages, the habitat is not really endangered and ski resorts infrastructures cannot be a problem as it hunts usually at one meter from the ground. However more research needs to be done on its foraging habitats outside mountain areas.

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Sardinian long-eared bat (*Plecotus sardus)*

According to Mauro MUCCEDA, no study on *Plecotus sardus* foraging habitats has ever been done for this endemic species.

Habitats around roosts: olive groves, cork oak (*Quercus suber*) and holm oak (*Quercus ilex*) woodlands (Dietz *et al*. 2007).

Parti-colored bat (*Vespertilio murinus*)

Feeding habitats and areas

Parti-coloured bats may be found hunting in a variety of landscapes, like over water, open agricultural areas, treeless steppes, meadows, riparian zones, forested areas and around human settlements (Rydell & Baagøe 1994, Baagøe 2001). A mosaic of habitat types appears to be important, and Hermanns *et al*. (2001) found that the surroundings of roosts always contained larger wetlands with slow flowing or standing waters and extensive forest areas in Mecklenburg-Vorpommern (northern Germany) and eastern Poland. As for most vespertilionids, sexes are segregated during the time when females congregate in maternity colonies in summer. In parti-coloured bat even fairly large (200+) all male colonies may be formed. Colonies are mostly situated in buildings (Rydell & Baagøe 1994, Baagøe 2001). While hunting it usually flies 20–40 m above the ground (Rydell & Baagøe 1994), but can also utilize insect abundances around artificial street lights (Rydell 1992a, Rydell & Racey 1995).

The most thorough studies of parti-coloured bat habitat use and foraging behaviour appears to be those of Jaberg *et al*. (1998), Jaberg & Blant (2003), Safi (2006) and Safi *et al*. (2007) in Switzerland. Jaberg *et al*. (1998) radio-tracked females from a breeding colony between May and July, and found that the bats were exclusively hunting above shallow water and natural shores of a large lake, and avoided other landscape types. Jaberg & Blant (2003) looked at the spatial distribution of known roosts (both maternity and male roosts) in relation to foraging habitats. Data on nocturnal roosts were acquired by radio-tracking of females. The thirty day roosts located were situated at an average of 1.06±0.69 km from the shore of a large lake. For night roosts, the bats mainly applied trees of a riparian forest within a few hundred meters from either the nursery or the foraging grounds.

Safi (2006) looked, among other aspects, closer at differences between maternity and male roosts. He found that males foraged throughout the night, without returning to the roost, in an average home range of 86 km^2. Females, on the other hand, frequently returned to the roost and had a much smaller average home range of 16 km^2. There were also differences in habitat use, with males using open agricultural landscape and forests, as well as rivers as main foraging areas, whereas females almost exclusively foraged above lakes. These differences were further highlighted by Safi *et al*. (2007).

Critical feeding areas

Water bodies are of high importance for females in the summer, while males are more flexible in their foraging habits. A landscape mosaic of water bodies/wetlands and deciduous forest near (usually within 2–3 km of) maternity colonies seem to be required (Jaberg *et al*. 1998, Hermanns *et al*. 2001, Jaberg & Blant 2003, Safi 2006).

Commuting routes

The relatively high-flying parti-coloured bat does not appear to be particularly affected by linear landscape elements, as it can be found hunting in open agricultural areas and treeless steppes (Rydell & Baagøe 1994).

This species is very often killed by wind turbines (Rodrigues coord. 2014). Attention must be paid to wind energy development on its commuting routes.

Conservation and management of critical feeding areas

Attention should be paid especially to management of areas with high insect production within a distance of at least 5 km from maternity colonies. Males may utilize foraging habitats up to 20.5 km from the roost (Safi 2006), but their opportunistic and variable hunting strategies may render them less vulnerable. Although both maternity and male day roosts are usually situated in buildings, forested areas near lakes are of importance to females for night roosting.

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Schreiber's bent-winged bat (*Miniopterus schreibersii*)

Feeding habitats and areas

Schreiber's bats forage mainly in deciduous woodlands and old-growth orchards (including olive groves), gardens, along hedgerows separating pastures and riverine forests and in urban areas (Barataud 1992, Lugon & Roué 1999, Russo & Jones 2003, Rainho 2007, Vincent 2007, Némoz & Brisorgueil 2008, Roué 2008, Rainho & Palmeirim 2011). In the Mediterranean area, they can use grasslands (Barataud 1994), and avoid arable lands and maquis (Russo & Jones 2003); however in Portugal they use farmland (olive and cereals), avoiding montado with denser tree cover (Rainho 2011, Rainho & Palmeirim 2013), favouring areas close to the roost (Rainho & Palmeirim 2011). In some populations pregnant and lactating females forage over white street-lamps (Némoz *et al.* 2007, Vincent 2007, Némoz & Brisorgueil 2008, Roué 2008, Rainho 2011, Vincent *et al.* 2011).

Feeding areas are commonly located in a radius of 30 km around the main roost in France (Roué 2008, Vincent *et al.* 2011) when 82% of females forage within 10 km around the colony in Portugal (Rainho 2011). Each female forages over 18.5 ha in Franche Comté (Roué 2008), 7.5 ha in the Rhône Valley (Vincent 2007), moving among good quality feeding patches during the night (3 patches in a 500 m radius up to 6 patches 4 km apart, Vincent 2007, Némoz & Brisorgueil 2008, Vincent *et al.* 2011). Females show fidelity to foraging areas over at least short periods, when juveniles change each night (Guillaume & Roué 2006, Némoz & Brisorgueil 2008). Lactating females forage farther than pregnant females, as their home range was 22318 ± 7141 ha vs 10837 ± 5399 ha in the Rhône Valley (Némoz *et al.* 2007, Vincent *et al.* 2011). The foraging area of maternity colonies was ca. 200 000 ha (Némoz & Brisorgueil 2008, Roué 2008, Vincent *et al.* 2011).

The diet relies on Lepidoptera in all seasons, varying among colonies from 76 to 95% of volume (Lugon & Roué 1999a, Presetnik 2002, 2005, Lugon 2006, Presetnik & Aulagnier 2013), Diptera, mainly Tipulidae in late summer) being the second main preys in France (Lugon & Roué 1999b, Roué 2002) *versus* Neuroptera in Slovenia (Presetnik 2002, 2005, Presetnik & Aulagnier 2013). This diet includes larvae of Lepidoptera and Aranaeidea; as well as taxa flying close to vegetation (Mycetophilidae, Tipulidae and Cyclorraphae) (Lugon & Roué 1999a).

Critical feeding areas

Deciduous woodlands, old-growth orchards, riverine forests as well as hedgerows with high Lepidoptera production are the main feeding areas over the range.

Commuting routes

Schreiber's bats use tree lines, woodland borders, forest paths, hedgerows and riverine forests as commuting routes, flying usually at an altitude of 5-10 m and at 2 m from the vegetation, however they can cross open spaces up to 300m closer to the ground (Constant 1957, Barataud 1992, Lugon & Roué 2002). In spite of their quick flight (50-54 km/h, Constant & Cannonge 1957) they are able to easily jump over obstacles, including linear infrastructures, providing some landscape preparation (Lugon & Roué 2002). They

preferably use rivers as landmarks (Serra-Cobo *et al.* 2000, Russo & Jones 2003), including when they are migrating (Serra-Cobo *et al.* 1998).

Conservation and management of critical feeding areas

- Management of areas within at least a radius of 30 km around the nursing roosts
- Tree lines, mixed deciduous woodlands and riverine forests saved, and even replanted
- Varying forest logging, conserving borders
- Insecticides prohibited in forests

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European free-tailed bat (*Tadarida teniotis*)

Feeding habitats and areas

The European free-tailed bat forages generally high above forested areas or high mountain passes. Opportunistic forager it will hunt where it finds swarms of insects and exploits therefore various habitats: stone pine and/or cork oak woodlands, mountain forests, orchards and annual crops, scrublands, lakes, illuminated urban areas (Arlettaz 1990). In Italy the species shows no preference for a habitat or another (Russo & Jones 2003), in Portugal it is the only species that shows lower activity over fresh-water habitats (Rainho 2007).

To find a suitable feeding habitat it can fly up to 36 km from the roost (Yavruyan & Safaryan, 1975) but the size of its feeding area is fairly small, about 102ha (Tiago Marques *et al*. 2004).

Critical feeding areas

All types of habitats providing that they are rich in insects.

Commuting routes

No evidence of clear commuting routes as the bats often change foraging areas, according to the abundance of insects.

Conservation and management of critical feeding areas

Prior to management recommendations, it is important to know the home range of the colonies and their habitat preferences as they may change according to geographical location, topography, and land-use types.

In the Mediterranean countries woodlands and scrublands are prone to forest fire and the use of land changes rapidly resulting in the disappearance of foraging habitats. Management of these areas is particularly important.

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7. Further reading

8. References

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