Action Plan for the Conservation of All Bat Species in the European Union
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- *Pipistrellus pipistrellus* – L. Spanneut (Ecosphère)

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INTRODUCTION

There are 45 species of bats in the European Union. They occur in a wide range of habitats, including forests and agricultural land. Populations have been in serious decline throughout Western Europe, particularly in the second half of the twentieth century. Strict protection, accompanied by investments in their conservation, has stabilised the populations of a number of species recently. But, overall, bats remain vulnerable to habitat change and roost disturbance in several EU Member States. In addition, there are still persistent misunderstandings and prejudices arising from ignorance about bats and their habits. As a result of these impacts, many species are threatened; some have even become extinct in a number of countries.

From an ecological perspective, bats are a good ecological indicator as they are sensitive to very slight changes in their environment. Such responses can be useful in revealing habitat fragmentation, ecosystem stress or changing habitat use, resulting, for instance, from the intensification of agriculture or forestry as well as from various other human activities.

This EU Multi-Species Action Plan (SAP) covers all bat species occurring in the EU. Its aim is to support the development of national or local action plans and implementation of conservation measures[1]. In particular, it aims to:

- Provide baseline data on the status of the species in the EU;
- Provide scientifically-based recommendations to promote and support their conservation;
- Establish priorities in bat species conservation;
- Provide a common framework for a wide range of stakeholders.

The SAP has been prepared and in consultation with EUROBATS and nominated experts from all EU countries following an extensive review of existing literature up until 2015. In the course of the preparation of the document several meetings and consultations with bat experts were held in order to analyse the threats facing the species, develop a conservation strategy and identify the most important actions.

The SAP provides a summary of the ecology, distribution, status and threats of the bat species in the EU and offers a series of recommended targets and actions for their conservation to guide Member States in the choice of conservation efforts at national, regional or local level.

[1] EU Species Action Plans are not of a binding nature; species action plans are drafted and implemented at the discretion of each MS.

1 - BAT SPECIES AND THEIR NATURAL HISTORY

1.1 - European Bat species and their IUCN Red list status

There are 45 species of bat in the European Union, belonging to 5 families and 12 genera. Their conservation status in Europe and the EU (25 Member States at the time) was published by International Union for the Conservation of Nature (IUCN) in 2007[2]. This is summarised in table 1.

Table 1 – European species and their conservation status

IUCN red list categories:

- *EN: Endangered – Very high risk of extinction in the wild;*
- *VU: Vulnerable – High risk of extinction in the wild;*
- *NT: Near Threatened – Likely to become threatened in the near future;*
- *LC: Least Concern – Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category;*
- *DD: Data Deficient – Inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status;*
- *N/A: not assessed.*

SPECIES		**IUCN Red list status**			**HD[3] Annex IV**	**HD Annex II**
		World	**Europe**	**EU 25 terrestrial**		
Rhinolophidae (Horseshoe bats)						
Blasius's horseshoe bat	*Rhinolophus blasii*	LC	VU	DD	x	x
Mediterranean horseshoe bat	*Rhinolophus euryale*	NT	VU	VU	x	x
Greater horseshoe bat	*Rhinolophus ferrumequinum*	LC	NT	NT	x	x
Lesser horseshoe bat	*Rhinolophus hipposideros*	LC	NT	NT	x	x
Mehely's horseshoe bat	*Rhinolophus mehelyi*	VU	VU	VU	x	x
Vespertilionidae (Evening bats)						
Western Barbastelle bat	*Barbastella barbastellus*	NT	VU	VU	x	x
Botta's Serotine	*Eptesicus bottae*	LC	N/A	N/A	x	
Northern bat	*Eptesicus nilssonii*	LC	LC	LC	x	
Isabelline Serotine bat	*Eptesicus isabellinus*	LC	N/A	N/A	x	
Common Serotine	*Eptesicus serotinus*	LC	LC	LC	x	
Savi's pipistrelle	*Hypsugo savii*	LC	LC	LC	x	
Alcathoe whiskered bat	*Myotis alcathoe*	DD	DD	DD	x	
Steppe whiskered bat	*Myotis aurascens*	LC	LC	LC	x	
Bechstein's bat	*Myotis bechsteinii*	NT	VU	VU	x	x

[2] www.iucnredlist.org

[3] Annexes of the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. 1992 (Consolidated version 1. 1. 2007). http://ec.europa.eu/environment/nature/legislation/habitatsdirective

SPECIES		IUCN Red list status			HD[3] Annex IV	HD Annex II
		World	Europe	EU 25 terrestrial		
Lesser mouse-eared bat	*Myotis blythii*	LC	NT	NT	x	x
Brandt's bat	*Myotis brandtii*	LC	LC	LC	x	
Long-fingered bat	*Myotis capaccinii*	VU	VU	VU	x	x
Pond bat	*Myotis dasycneme*	NT	NT	NT	x	x
Daubenton's bat	*Myotis daubentonii*	LC	LC	LC	x	
Escalerai bat	*Myotis escalerai*[4]	N/A	N/A	N/A	x	
Geoffroy's bat	*Myotis emarginatus*	LC	LC	LC	x	x
Greater mouse-eared bat	*Myotis myotis*	LC	LC	LC	x	x
Whiskered bat	*Myotis mystacinus*	LC	LC	LC	x	
Natterer's bat	*Myotis nattereri*	LC	LC	LC	x	
Maghreb mouse-eared bat	*Myotis punicus*	NT	NT	NT	x	
Azorean bat	*Nyctalus azoreum*	EN	EN	EN	x	
Greater noctule bat	*Nyctalus lasiopterus*	NT	DD	DD	x	
Leisler's bat	*Nyctalus leisleri*	LC	LC	LC	x	
Common noctule	*Nyctalus noctula*	LC	LC	LC	x	
Kuhl's pipistrelle	*Pipistrellus kuhlii*	LC	LC	LC	x	
Hanaki's Dwarf Bat	*Pipistrellus hanaki*	DD	N/A	N/A	x	
Madeira pipistrelle	*Pipistrellus maderensis*	EN	EN	EN	x	
Nathusius's pipistrelle	*Pipistrellus nathusii*	LC	LC	LC	x	
Common pipistrelle	*Pipistrellus pipistrellus*	LC	LC	LC	x	
Pygmy pipistrelle	*Pipistrellus pygmaeus*	LC	LC	LC	x	
Brown long-eared bat	*Plecotus auritus*	LC	LC	LC	x	
Grey long-eared bat	*Plecotus austriacus*	LC	LC	LC	x	
Kolombatovic's Long-eared bat	*Plecotus kolombatovici*	LC	NT	NT	x	
Mountain long-eared bat	*Plecotus macrobullaris*	LC	NT	VU	x	
Sardinian long-eared bat	*Plecotus sardus*	VU	VU	VU	x	
Tenerife long-eared bat	*Plecotus teneriffae*	EN	EN	EN	x	
Parti-coloured bat	*Vespertilio murinus*	LC	LC	LC	x	
Miniopteridae						
Schreiber's bat	*Miniopterus schreibersii*	NT	NT	NT	x	x
Molossidae (Free-tailed bats)						
European free-tailed bat	*Tadarida teniotis*	LC	LC	LC	x	
Pteropodidae						
Egyptian fruit bat	*Rousettus aegyptiacus*	LC	N/A (EN?)	N/A (EN?)	x	x

[4] Formerly in *Myotis nattereri.*

1.2 - Natural history of bats

1.2.1 - Evolution and Biogeography

1.2.1.1 - Evolution

The earliest existing bat fossils are around 50 million years old and are very similar to the species of bats that exist today (2). However, genetic analyses indicate that bats evolved already more than 65 million years ago. The origins of fruit bats and relatives of horseshoe bats are different from that of other insect–eating bats.

1.2.1.2 - Biogeography

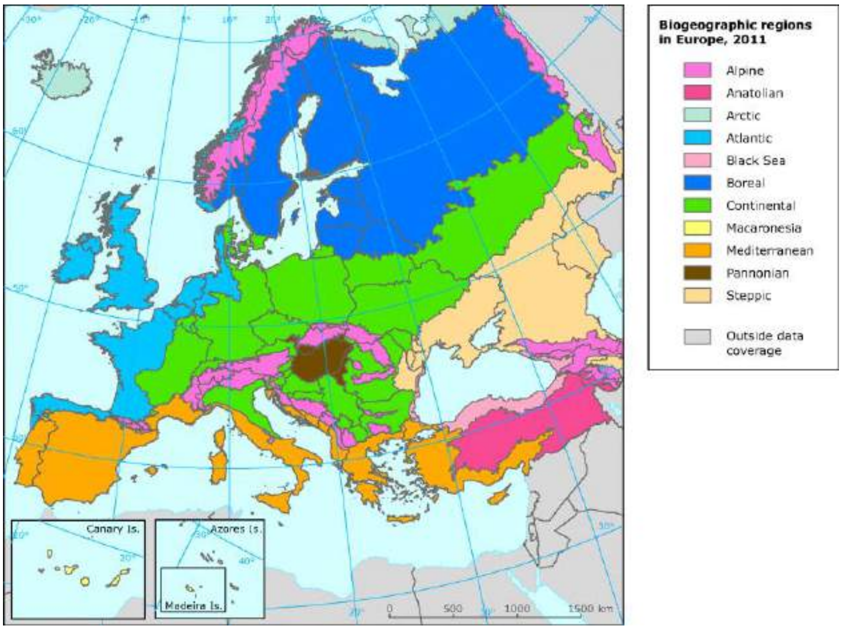
The ability to fly enables bats to colonise large parts of the world. They are found in most terrestrial habitats, except in colder parts of the northern and southern hemispheres beyond the limit of tree growth or on some oceanic islands. The number of species increases towards that equator because of the greater abundance and variety of food sources here than in temperate regions. Bats constitute the second most diverse mammal group in Europe (1). Three environmental characteristics (latitude, area and temperature) influence bat species richness in Europe. These attributes act cumulatively (2).

1.2.1.3 - Endemism

Each species is restricted in its range due to the ecological niche it has filled, which is governed by food supplies, temperature and roosting site availability. Some species have an extensive range, particularly those on large land masses. Other species, by contrast, have very small ranges. When they become geographically isolated over a very long period of time, bats evolve into new species – this is called endemism. Endemic species are especially likely to develop in biologically isolated areas such as islands. The endemic insular bat species of Europe are the Tenerife long-eared bat (*Pl. teneriffae*), the Sardinian long-eared bat (*Pl. sardus*), the Madeira's pipistrelle (*P. maderensis*) and the Azorean bat (*N. azoreum*).

1.2.1.4 - EU Biogeographical regions

European bat species have a widespread distribution in Europe (3), covering all the major biogeographical regions from the warmer Mediterranean to the colder Boreal and Alpine regions as shown in map 1.



Map 1 - Biogeographic regions in Europe

Using statistical analysis, the following plot was produced for 28 European bat species in which the three biogeographic groups can be distinguished (4). Four species are grouped in the Boreal biogeographic region, 10 in the Temperate Humid Zone and 14 in the Mediterranean Zone (Fig. 1).

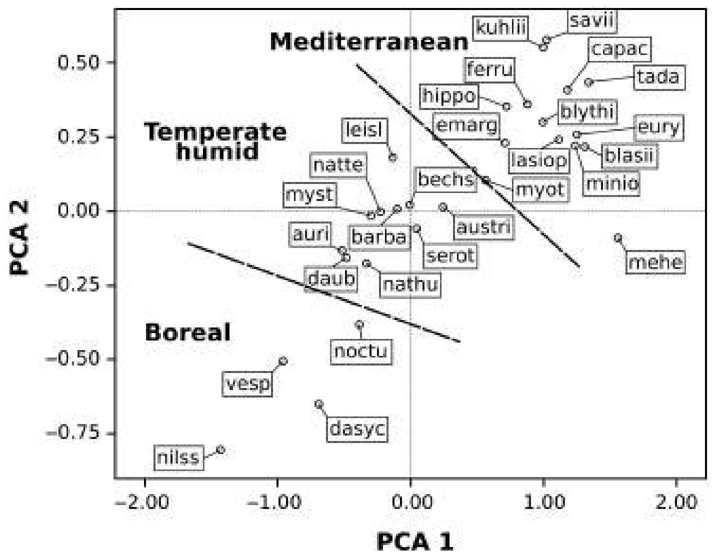


Figure 1 - Principal Components Analysis plot of the 28 bat species using three climatic variables (from (5)). The dashed lines separate each biogeographic group

Furthermore, there is a north-south gradient with the number of species increasing southward (see Fig. 2 below).

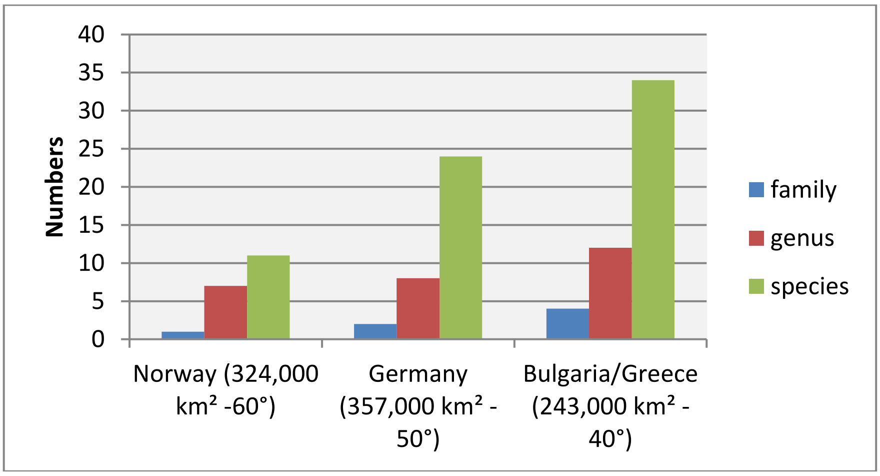


Figure 2 - Numbers of families, genera and species of European bats from north to south (from (8)).

1.2.1.5 - Influence of climate change

Biogeographic patterns exert a great influence on the species' response to climate change, affecting, for instance, their range and population changes (4). Bat species associated with colder climates are most likely to be affected by current climate change prediction scenarios, than Mediterranean and Temperate groups, which may be more tolerant. However, the projections can vary considerably under different climate change scenarios (4).

1.2.2 - Life cycle

1.2.2.1 - General description

In winter, the cold weather limits the amount of food available for insectivorous bats. As a consequence, in order to save energy, bats hibernate over a long period (many weeks) and cool their body temperature down to approximately the temperature of the surrounding air. They also slow down their heart-beat and their breathing.

In spring, their body temperature increases as the ambient temperature rises so that they are once again able to fly and hunt for prey. While building up their reserves, they explore new areas and new roosting sites. The embryos of females that mated the previous autumn also start to develop.

In summer, pregnant females gather together to give birth in maternity roosts – these are warm, hidden, sheltered places. A female usually produces a single baby a year, but a few species, such as the ones belonging to the genera *Nyctalus*, *Pipistrellus* and *Eptesicus,* can occasionally produce twins. Females spend several weeks weaning their babies which are born around June and July. The juveniles may be able to fly at the age of one month. By the end of summer, the young are almost independent. Males are usually not very active at this time of the year, apart from feeding and exploring sites.

At the end of summer, maternity colonies begin to move and split into smaller groups. Males become more active and start courting females. Some roosts, mainly caves, are used for social gatherings called 'swarming sites' where up to a thousand bats may interact and mate. By winter, the bats have settled into suitable hibernation sites where they stay during the cold months either individually or in small groups or in aggregations of up to several thousand.

This is a general description (5). A closer examination of individual species will show a number of variations to this basic pattern. For instance, some species may not hibernate in warmer winters and a number of bats may be active during warm spells.

1.2.2.2 - Roosts

Bats do not make nests but instead roost in a wide range of habitats, including above ground structures like buildings, bridges, trees, or in underground sites like caves, tunnels, mines, cellars. They often change site from one period of the year to another according to changing weather and temperature patterns and in order to get closer to areas rich in prey.

Being warm-blooded animals they need to keep warm when they are resting or asleep during their active period (March to November in general), although a number of individuals may go into torpor for several weeks due to bad weather. During winter, they need to find sheltered places with the right conditions in terms of humidity and temperature so that they can safely hibernate over several months (5).

Depending on their functionality, the different types of roosts can be classified as follow:

A Hibernation roosts

Like many other mammals, the lack of food in winter forces bats to hide for safety when hibernating because they are not capable of reacting to any form of danger (disturbance or predation) that may come in from outdoors. Each species has its own requirements or habits, thus bats can be found in caves, mines, rock crevices, buildings but also in trees in winter.

B MATERNITY ROOSTS

These roosts are made up of breeding and rearing female bats. Being together in large numbers helps to keep the young warm and safe. These maternity wards or nurseries can contain many hundreds of females with their babies. Each species has its own requirements or habits, thus pregnant bats can be found in caves, mines, rock crevices and buildings or in trees. Males usually roost elsewhere (transitional roosts); with some noticeable exceptions among species from the genera *Plecotus* and *Rhinolophus* or *M. schreibersii*, *M. myotis*.

C SWARMING SITES

These sites are roosts where a great number of bats gather in late summer for social interactions that are not fully understood. Swarming sites are 'hot spots' for gene flow among populations as mating is known to take place. In addition, swarming may help to renew information about suitable hibernacula (10). These roosts are usually found in caves, mines, tunnels or buildings, but also in deep forest areas.

D TRANSITIONAL ROOSTS

These are all the other types of roosts where bats do not stay for long. They may be used as an alternative for a better, but disturbed, roost or as a stopover while migrating or dispersing.

Table 2 – The different roost types for the European bats
Acronym: A: attics and other roofing spaces; B: buildings; C: caves and other underground sites (mines, bunkers); I: infrastructures (bridges, tunnels); T: trees; R: rock crevices or fissures; (A, B, C, I, T or R): means possible but not typical

SPECIES	Hibernation	Maternity	Transitional	Swarming
Rhinolophus blasii	C	C	C	
Rhinolophus euryale	C	C, A, (B), (I)	C, A, (B)	
Rhinolophus ferrumequinum	C	C, A, B	C, A, B	
Rhinolophus hipposideros	C	C, A, B, I	C, A, B, I, (T)	
Rhinolophus mehelyi	C	C	C	
Barbastella barbastellus	C, R, I, (T)	T, B, (R)	T, B, R	C, I
Eptesicus bottae	R, B, (I)	B, R ?, (T)	B, R, I, (T)	
Eptesicus nilssonii	C, B, (R), (I)	B, (T), A	B, I, (T)	C
Eptesicus isabellinus	?	?	?	
Eptesicus serotinus	B, I, (C)	B, A, I, (T)	B, (R), (T)	C
Hypsugo savii	R, C	R, B	R, T, B, (I)	R, C
Myotis alcathoe	C, (T?)	T	T, C	T, C
Myotis aurascens	C	R, I	R	R, C
Myotis bechsteinii	C, (T)	T, (B)	T	C
Myotis blythii	C	C, A, (I), (B)	C, A, I, (B)	C, I
Myotis brandtii	C, I	T, B	T, B	C, B, R
Myotis capaccinii	C, (B)	C	C, (I), (R)	C
Myotis dasycneme	C	B, A, (T)	B, T, C	B, C
Myotis daubentonii	C, I, (T)	I, T, C, B	I, T, B	C, I
Myotis escalerai	C	T, B, C	T, B, C	C, B
Myotis emarginatus	C	B, A, C, I	B, A, C, T, I	B, A, C
Myotis myotis	C, R	C, A, I, (B)	C, A, B, T, R	C, A
Myotis mystacinus	C	T, B, I	C, B, T	C, B
Myotis nattereri	C	T, B, (C), (I)	T, B, R, I, C	C, R
Myotis punicus	C	C, B,(I)	C, B, A, I	C, B, I
Nyctalus azoreum	?	?	?	
Nyctalus lasiopterus	T, R	T, (B)	T, R, I	

SPECIES	Hibernation	Maternity	Transitional	Swarming
Nyctalus leisleri	T, R	T, (B)	T, R, I	
Nyctalus noctula	T, R, B, (C)	T, B	T, R, I, B	
Pipistrellus hanaki	B, R, C	T, B	T	C
Pipistrellus kuhlii	B, R, (C)	B	B, T, R	B, C
Pipistrellus maderensis	B, R	B, A, R	B, A, R, I, T	B, A, R
Pipistrellus nathusii	T, R, (C)	T, B	T, B, R, I	T, B, R
Pipistrellus pipistrellus	B, C, I, (T)	B, T, A	B, T, A	B, A, C
Pipistrellus pygmaeus	B, T, C, I, (R)	T, B, A	B, T, A, I	B, A, C
Plecotus auritus	B, (C), (T)	T, B, A	B, T, A, I	C, B, R, I
Plecotus austriacus	B, (C)	B, A, (C)	B, A, I	C, I
Plecotus kolombatovici	C, R	B, A, I	R, B, C	
Plecotus macrobullaris	C, B	B, A	B, A	
Plecotus sardus	C, R, I	B, C	B, I, R	
Plecotus teneriffae	C, R	C, B, (R)	C, R, B	
Vespertilio murinus	R, B, I, (T)	B, A, R, (T)	B, R, (T)	C
Miniopterus schreibersii	C	C, (A)	C, I, (B)	C, I, (B)
Tadarida teniotis	R, I	R, I, B	R, I, B, (T)	
Rousettus aegyptiacus	C	C, B, T	C, B, T	

1.2.3 - Diet, dispersal and migration

Bats use various natural or man-made features, such as rivers, hedges, walls and bridges, to aid navigation and commute to their principal foraging areas in search of prey.

1.2.3.1 - Diet

A Prey items and their availability

In Europe, bats eat flies, moths, beetles, other insects and spiders (except *N. lasiopterus* which could also hunt small birds, fructivorous *R. aegyptiacus* and *M. capaccinii* which can catch small fish). Each species is relatively specialised in the type of insects it forages. For instance, moths make up the bulk of the diet of *M. schreibersii* (6) throughout the year while *E. serotinus* and *E. nilssonii* may hunt various types of swarming insects belonging to the Coleoptera, Lepidoptera, Hymenoptera and Heteroptera orders (7).

B Hunting strategies

In Europe, bats forage mostly at night, presumably in order to reduce competition with insectivorous birds and avoid predation. They emit calls in the dark and listen to the echoes that return from objects in their vicinity to avoid collisions and to catch insects. This capability is called echolocation or active sonar. Bats are not blind, they can also see (5).

Each species has developed its own strategy to avoid competition with other species, but they are all able to adapt to the ever-changing environment. Most species hunt in the air space from 0 to 30 m above the ground level. Some species may fly and hunt at higher altitudes, especially those from the *Nyctalus* genus. *M. daubentonii and M. dasycneme* are known to skim over the water surface of rivers and lakes, while *T. teniotis*, the noctules, the serotines and parti-coloured bats fly fast and high in the sky, staying well clear of obstacles. Other species, such as *M. bechsteinii*, favour deciduous woodland to glean insects from the leaves of trees, and *M. myotis* and *M. blythii* that prefer to forage over pastures, meadows and freshly harvested fields to catch beetles and grasshoppers off the ground (8).

A single bat, especially a lactating female, may forage in up to 20 different areas at night. This varies greatly between species: some species forage close to their roosts, like the Bechstein's, pipistrelles and long-eared bats while others, like *M. schreibersii* and *T. teniotis,* do not hesitate to fly up to 25-30 km away to forage.

C ROLE IN THE ECOSYSTEM

Although there are few studies on the degree to which bats impact on insect populations, in some regions they have been found to be highly effective in controlling agricultural pests, which can be economically beneficial to farmers[5] (9; 10; 11). *R. aegyptiacus* also serves as a pollinator and seed disperser for many plants that are important to humans.

Bat populations have the potential to be robust natural indicators of the health of our environment (12; 13). This is because bats are very sensitive to pressures such as climate change, agricultural intensification, pesticides, land-use changes. They can also complement other taxonomic indicators by providing information on the night-time environment.

1.2.3.2 - Dispersal and Migration

A POPULATION DYNAMICS

Bats live a relatively long time. There are records of individuals reaching 20 and even over 40 years of age (14). Most species tend to have K-selected traits[6] ie a long life expectancy and fewer offspring that often require extensive parental care.

Females generally gather with other females to give birth but they may not be able to do this every year for a variety of reasons, and so it will live instead with closely related individuals, mostly females. A male may be part of a particular group over winter but is more solitary in summer. A single bat may live in a variety of groups or families during its whole lifespan (5). A typical situation is the gathering of a large number of individuals coming from the same local population for hibernation in winter. These individuals will then split into smaller groups in spring. Females and males live separately until autumn when they mate (8).

Variations also occur: many tree-dwelling species such as *M. bechsteinii* have very few exchanges between colonies. Studies of the mitochondrial DNA of several maternity colonies revealed little genetic variability within each colony but strong genetic segregation between colonies (15). In general, bats seem to have a typical population dynamic because the mortality rate is constant, and independent of the age of adult individuals (7). A long lifespan is essential for the population to remain stable because of the small number of bats that reach sexual maturity and successfully rear a youngster every year.

Bats have no major natural predators since they are mostly active at night. Some are caught by opportunistic birds of prey (kestrel, sparrowhawk, owls) or mustelids (beech marten, weasel and stoat), but it is more often the domestic cat that has a significant impact on bat populations (16).

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[5] E.g.: a two-year study on the diet of one individual of *Plecotus austriacus* at Mdina (Malta) resulted in 23 different species of moths, some of which are known to be pests on agricultural products (157).

[6] In ecology, the r/K selection theory relates to the selection of combinations of traits in an organism that trade off between quantity and quality of offspring. The terminology was coined by the ecologists Robert MacArthur and E. O. Wilson based on their work on island biogeography (162).

Table 3 - Different population parameters for 5 species from Central Europe (from (7)).

	Nyctalus noctula	*Pipistrellus pipistrellus*	*Pipistrellus nathusii*	*Myotis myotis*	*Myotis mystacinus*
Adult mortality (per annum)	0,44	0,31 - 0,37	0,32 - 0,34	0,21 - 0,24	0,19
Average life expectancy (in years)	1,7	2,1-2,6	2,4-2,7	3,6 - 4,2	4,6
Average recorded age for individuals at least 1-year old (in years)	2,2 - 2,3	2,7 - 2,9	2,6 - 2,9	3,9 - 4,0	4,5
Maximal recorded age (years)	12	16	14	25	23
Nativity rate required for maintain the population (per annum)	1,5 - 1,6	0,9 - 1,2	0,9 - 1,05	0,54 - 0,64	0,48

B MIGRATORY SPECIES

Many European species of bats migrate long distances. Some are known to migrate over more than 1,000 km, e.g. all *Nyctalus* species and *P. nathusii*.

The terminology that describes the observed migrating behaviour of bats is not yet entirely consistent. Fleming & Eby (2003) in (17) defined migration as a seasonal, usually two-way, movement from one place or habitat to another to avoid unfavourable climatic conditions and/or to seek more favourable energetic conditions. In 2005 the German Federal Agency for Nature Conservation compiled an overview of data on bat migration in Europe (17).

Dispersal usually involves movement away from an animal's place of birth – but this is not always the case (18). Because it is often difficult to distinguish between dispersal and migration, three categories of spatial behaviour in bats have been provisionally adopted – long distance, regional and sedentary. These are shown in Table 4. Available data indicates that most of the long-distance migratory bats move in a northeast-southwest direction, while regional migrants move in a typical star-like pattern.

Population dynamics are slightly different for migratory species: females are faithful to their place of birth in north-eastern Europe while males select their mating roosts close to migratory routes that connect summer breeding areas with hibernation roosts in southern Europe (7).

Migration is still understudied for bats and much less understood than for example for birds. It is technically challenging to study but advances in science and technology should lead to major advances in our understanding in the future.

Table 4 – Spatial behaviour of European bat species (from (17)).
"(x)": means possible but not typical.

SPECIES	Long-distance (> 100 km)	Regional (10-100 km)	Sedentary (<10 km)
Rhinolophus blasii			x
Rhinolophus euryale		(x)	x
Rhinolophus ferrumequinum		(x)	x
Rhinolophus hipposideros		(x)	x
Rhinolophus mehelyi		(x)	x
Barbastella barbastellus		(x)	x
Eptesicus bottae			
Eptesicus nilssonii		x	
Eptesicus isabellinus		(x)	x
Eptesicus serotinus		(x)	x
Hypsugo savii	(x)	x	
Myotis alcathoe			x
Myotis aurascens			x?
Myotis bechsteinii			x
Myotis blythii		x	
Myotis brandtii		x	
Myotis capaccinii		x	
Myotis dasycneme		x	
Myotis daubentonii		x	
Myotis escalerai			
Myotis emarginatus		(x)	x
Myotis myotis		x	
Myotis mystacinus		x	
Myotis nattereri		(x)	x
Myotis punicus		x	(x)
Nyctalus azoreum		x	
Nyctalus lasiopterus	x?	x	x
Nyctalus leisleri	X		
Nyctalus noctula	X		
Pipistrellus hanaki			x?
Pipistrellus kuhlii		(x)	x
Pipistrellus maderensis			x
Pipistrellus nathusii	X		
Pipistrellus pipistrellus	x?	x	
Pipistrellus pygmaeus	X	x	
Plecotus auritus			x
Plecotus austriacus			x
Plecotus kolombatovici			x
Plecotus macrobullaris			x
Plecotus sardus			x
Plecotus teneriffae			x
Vespertilio murinus	X	(x)	(x)
Miniopterus schreibersii	(x)	x	
Tadarida teniotis			x
Rousettus aegyptiacus			x

2 - BAT CONSERVATION IN EUROPE

2.1 - Conservation through the Habitats Directive and EU policies

The Birds Directive (BD)[7] and Habitats Directive (HD)[8] are the cornerstones of the EU's biodiversity policy (19). They enable all 28 EU Member States (MS) to work together within a common legislative framework to conserve Europe's most endangered and valuable species and habitats across their entire natural range within the EU, irrespective of political or administrative borders.

The overall objective of the HD is to maintain and restore natural habitats and species of wild fauna and flora of Community interest to a favourable conservation status. The directive does not cover every species of plant and animal in Europe. Instead, it focuses on a sub-set of around 2,000 (out of ca 100,000 or more species present in Europe) that are in need of protection to prevent their extinction.

All European bat species found are covered by the Habitats Directive:

- **14 bat species** are included in **Annex II** of the HD, and hence require the designation of core sites for their protection (Special Areas for Conservation) and the establishment and implementation of conservation measures aiming at maintaining or restoring the species at a favourable status;
- **All bat species** are included in **Annex IV** of the HD. They benefit from species protection provisions *across their entire natural range* and therefore also outside protected sites. The degradation or destruction of breeding sites or resting places is prohibited all over Europe (apart from the implementation of the derogation system foreseen by article 16 of the HD).

The directive requires that Member States do more than simply prevent the further deterioration of the listed species. They must also undertake positive conservation measures to ensure their populations are maintained and restored to a ***favourable conservation status*** throughout their natural range within the EU.

Favourable conservation status can be described as a situation where a species is prospering (extent/population) and has good prospects to do so in future as well. The fact that a species is not threatened (i.e. not faced by a direct extinction risk) does not necessarily mean that it is in a favourable conservation status. The target of the directive is defined in positive terms, oriented towards a favourable situation, which needs to be defined, reached and maintained. It is therefore much more than just avoiding extinction.

2.1.1 - The Natura 2000 network and site protection provisions

A central element of the EU nature directives is that they require Member States to designate Natura 2000 sites for selected species and habitat types listed in the two directives. Stretching over 18 % of the EU's land area and almost 9 % of its marine territory, the Natura 2000 network is the largest coordinated network of protected areas in the world. It contains around more then 27 500 terrestrial sites covering 1322630 km² (figures for 2018[9]), and more than 700 new sites including many caves (>

[7] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds (http://ec.europa.eu/environment/nature/legislation/birdsdirective)

[8] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (http://ec.europa.eu/environment/nature/legislation/habitatsdirective)

[9] https://www.eea.europa.eu/data-and-maps/dashboards/natura-2000-barometer

170) which were designated more recently in Croatia. Around a third of the sites designated under the HD harbour bat populations. If foraging areas and commuting routes are also taken into consideration, the number of sites harbouring bat species is even greater.

Table 5 - Data from the Natura 2000 database (end of 2014, excluding Population category D)

Bat species included in the Annex II of the Habitats Directive		**Number of sites designated for the species at the end of 2014**
Blasius's horseshoe bat	*Rhinolophus blasii*	105
Mediterranean horseshoe bat	*Rhinolophus euryale*	694
Greater horseshoe bat	*Rhinolophus ferrumequinum*	2007
Lesser horseshoe bat	*Rhinolophus hipposideros*	2070
Mehely's horseshoe bat	*Rhinolophus mehelyi*	186
Western Barbastelle bat	*Barbastella barbastellus*	1493
Bechstein's bat	*Myotis bechsteinii*	1287
Lesser mouse-eared bat	*Myotis blythii*	789
Long-fingered bat	*Myotis capaccinii*	352
Pond bat	*Myotis dasycneme*	429
Geoffroy's bat	*Myotis emarginatus*	1136
Greater mouse-eared bat	*Myotis myotis*	2963
Schreiber's bat	*Miniopterus schreibersii*	857
Egyptian fruit bat	*Rousettus aegyptiacus*	26

Natura 2000 sites must be managed and protected in accordance with the provisions of Article 6 of the HD. The first two paragraphs of Article 6 require Member States to:

- Establish the necessary conservation measures which correspond to the ecological requirements of the relevant bat species on the sites (Article 6.1);
- Prevent any damaging activities that could significantly disturb the relevant bat species or deteriorate their habitats (Article 6.2).

For each Natura 2000 site Member States are required to develop site level **conservation objectives**. As a minimum, the conservation objective will be to maintain the conservation condition of bat species for which it was designated and not to allow this to deteriorate further. However, as the overall objective of the directive is orientated towards reaching a favourable conservation status, more ambitious conservation objectives may be needed at individual site level. **Natura 2000 management plans,** where they exist, usually outline the conservation objectives for the protected features occurring in the site and the measures needed to achieve these objectives.

Whereas Article 6(1) and 6(2) of the HD concern the day-to-day management and conservation of Natura 2000 sites, Articles 6(3) and 6(4) lay down the procedure to be followed when planning new developments that might have an adverse effect on a Natura 2000 site. In essence, Articles 6(3) requires that any plan or project that is likely to have significant negative effect on a Natura 2000 site (irrespective of whether it is within or outside the site) undergoes **an 'Appropriate Assessment'** in view of the site's conservation objectives.

Depending on the findings of the appropriate assessment, the competent authority can either agree to the plan or project as it stands if it has ascertained that the project will not adversely affect the integrity of the site. Alternatively, depending on the extent of the potential impacts, the competent authority may require:

- ➢ the plan or project to be redesigned to prevent adverse effects on the Natura 2000 site;
- ➢ mitigation measures to be introduced to remove the negative effects foreseen;

- alternative less-damaging solutions to be explored instead.

In exceptional circumstances, a project may still be approved in spite of having an adverse effect on the integrity of one or more Natura 2000 sites provided the conditions and procedural safeguards laid down in the HD are respected (Article 6(4)). Thus, if it can be demonstrated that there is an absence of alternatives and the plan or project is considered to be necessary for ***imperative reasons of overriding public interest,*** the project may still be approved provided adequate compensation measures are put in place to ensure that the overall coherence of the Natura 2000 network is protected.

2.1.2 - Species protection provisions

In addition to protecting core sites through the Natura 2000 network, the HD also requires Member States to establish a general system of protection for species listed in the Annex IV of the HD (i.e. including all bat species). These provisions apply both within and outside protected sites.

The exact terms are laid down in article 12 of the HD[10]. They require Member States to prohibit:
- the deliberate disturbance, capture and killing of species during breeding, rearing, hibernation and migration;
- the deterioration or destruction of their breeding sites or resting places;

As some of the protected bat species are vulnerable to hindrances in between their distant summer and winter roosting sites, these provisions must be taken into account when considering building traffic infrastructures or wind farms (if roosting sites or resting places around).

Derogations are possible under article 16 of the HD in exceptional circumstances. However, the case of "*accidental killing*" has to be clarified (article 12.4). In view of the impact of roads and wind farms on bats (see below), it is difficult to determine whether the article 16 derogation system has to be applied or if the article 12.4 should be used. Referring to the latter, Member States should establish a system to monitor the incidental capture and killing of the bat species listed in Annex IV. In the light of the reviewed available information, Member States should promote further research work or conservation measures to ensure that incidental capture and killing do not have a significant adverse impact on the species concerned. As of 2016, these monitoring systems are absent in most of the Member States.

2.1.3 - EU biodiversity strategy

In May 2011, the European Commission adopted a strategy to halt the loss of biodiversity and improve the state of Europe's species, habitats, ecosystems and the services they provide over the next decade. The EU Biodiversity strategy to 2020 includes a vision for 2050 and a 2020 headline target.

Two specific targets will directly benefit to bat populations:
- The full implementation of the EU nature conservation legislation (Actions: complete the establishment of the Natura 2000 Network and ensure its good management; ensure adequate financing of Natura 2000 sites; increase stakeholder awareness and involvement and improve enforcement ; improve and streamline monitoring and reporting);
- More sustainable agriculture and forestry (Actions: enhance direct payments for environmental public goods in the EU Common Agricultural Policy; better target Rural Development to biodiversity conservation; conserve Europe's agricultural genetic diversity; encourage forest holders to protect and enhance forest biodiversity; integrate biodiversity measures in forest management plans).

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[10] See the guidance document on the strict protection of animal species of Community interest under the Habitats Directive: http://ec.europa.eu/environment/nature/conservation/species/guidance/index_en.htm

2.1.4 - Green infrastructure

In May 2013, the European Commission published a new Strategy to promote the use of Green Infrastructure across Europe (20). Green Infrastructure is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. The new Strategy calls for Green Infrastructure to be fully integrated into policies, and to become a standard part of spatial planning and territorial development.

The Natura 2000 Network forms the backbone of Europe's Green Infrastructure which will help reduce the fragmentation of the ecosystems, improve connectivity between sites in the Natura 2000 Network and thus help achieve the objectives of Article 10 of the HD. In addition to designating core sites under the Natura 2000 Network, Article 10 of the HD also encourages Member States to improve the ecological coherence of the network across the broader countryside by maintaining and, where appropriate, developing features of the landscape which are of major importance for wild fauna and flora, such as wildlife corridors or stepping stones which can be used during migration and dispersal.

Bats are very good indicators of an effective Green Infrastructure because they tend to move regularly between their roosts and their foraging areas (up to 40 km away for some species (21)). Landscape features such as hedges, rivers and cliffs are i particularly well used by commuting bats.

2.2 - UNEP/EUROBATS

The Convention on the Conservation of Migratory Species of Wild Animals (also known as CMS or Bonn Convention[11]) aims to conserve terrestrial, aquatic and avian migratory species throughout their range. It is an intergovernmental treaty concluded under the aegis of the United Nations Environment Programme (UNEP). As the only global convention specialising in the conservation of migratory species, their habitats and migration routes, CMS complements and co-operates with a number of other international organisations, NGOs and partners in the media as well as in the corporate sector.

Migratory species threatened with extinction are listed in the Appendix I to the Convention whereas migratory species that need or would significantly benefit from international co-operation are listed in the Appendix II. All European bats are mentioned in the Appendix II (apart from *R. aegyptiacus* which is nevertheless taken into consideration by EUROBATS – see below). The Convention encourages Range States to conclude global or regional Agreements. The Agreements may range from legally binding treaties (called Agreements) to less formal instruments, such as Memoranda of Understanding, and can be adapted to the requirements of particular regions.

Map 2 - Parties and Range States of the UNEP/EUROBATS

[11] www.cms.int/index.html

In December 1991, an Agreement was concluded on the Conservation of Populations of European Bats (EUROBATS[12]). The Agreement aims to protect all European bat species[13] - whether migratory or not - through legislation, education, conservation measures and international co-operation. As of January 2016, 36 of 63 Range States are Parties to this Agreement, which entered into force on 16th January 1994. In the EU, Austria, Greece and Spain have not joined but contribute to the common work which is described in Annex 1. EUROBATS has also developed a Conservation and Management Plan, which is the key instrument for the implementation of the Agreement (see also Annex I).

2.3 - NGOs and BatLife Europe

NGOs' expertise and activities represent a substantial contribution to the successful implementation of the EUROBATS Agreement and to bat conservation. Bats benefit in particular from voluntary monitoring and data collection work as well as efforts to raise public awareness. In 2010, Bat Conservation Trust (BCT) UK united with 5 other NGOs[14] to found BatLife Europe. BatLife Europe currently has 33 partner NGOs in 30 countries and a part time secretariat based in London.

BatLife Europe aims to conserve bats and their habitats and provide a stronger international voice for bat conservation in Europe by:

- Facilitating international communication and knowledge sharing
- Identifying European conservation priorities
- Developing pan-European projects
- Fundraising for international projects
- Developing best practice guidelines
- Assisting in capacity building
- Providing support and technical advice for EUROBATS initiatives
- Coordinating action in relation to special threats
- Collecting / managing data
- Assisting national bodies in developing / implementing national conservation plans /strategies
- Giving international status to national NGOs
- Providing international support for national matters of concern

BatLife Europe is active within the EUROBATS Agreement and has been a partner in the development of a pan European bat indicator (see 3.1.4).

2.4 - Bat Action Plans

Many Member States have monitoring programmes or site management plans that include objectives and measures for conserving bats (e.g. for Natura 2000 sites) [15]. In addition, specific "Species Action Plans" or Conservation or Restoration Plans for species have been established in a number of Member States at a national and/or regional level. Some specific examples are presented below.

2.4.1 - National Action Plans

[12] www.eurobats.org

[13] www.eurobats.org/about_eurobats/protected_bat_species

[14] The Dutch Mammal Society (DMS), Nature and Biodiversity Conservation Union (NABU), Romanian Bat Protection Association (RBPA), StiftungFledermaus and the French Society for Study of Mammals and their Protection (SFEPM).

[15] http://www.eurobats.org/official_documents/national_reports

- Bat conservation action plans were included in the new Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of **Croatia** in 2008, especially with regard to wind farms.
- **Estonia** has adopted an Action Plan for the protection of bats. The first plan[16] covered the period 2005-2009. This plan identified the main threats and important actions to improve the conservation status of bats. An updated plan is currently under preparation.
- In **France**, the first restoration plan was implemented from 1999 to 2004 by the French Society for the Mammals Study and Protection (SFEPM). A second National Action Plan has been implemented by the Federation of the French Wildlife trusts (FCEN) under the auspices of the French Ministry of Environment and with the support of new legislation. This national action plan 2009-2013 involved numerous NGOs, local administrations and public bodies. The 26 actions covered all aspects needed for bat conservation including those related to the protection and monitoring of roosts, forestry, transport infrastructures, wind energy, population monitoring of all bat species, bat workers networking and raising public awareness. Since 2016, the third national plan (2016-2025) is under implementation. In line with the previous plan, it is made of 10 actions addressing the main treats to the bats.
- In **Germany,** a Species Action Plan for the Lesser Horseshoe Bat was drafted in 2013.
- In **Hungary**, the Ministry of the Environment and Water has adopted a Species Protection Plan for *N. lasiopterus*.
- An "All-**Ireland** Species Action Plan – Bats" was published in 2008[17]. This Action Plan targets the maintenance of populations of all bat species in Ireland and of their present range. It suggests a number of actions to be carried out in the interest of bat conservation by the lead agencies (NPWS, EHS, BCIreland, etc.). It also summarises all current actions being carried out in favour of bats in Ireland.
- In **Lithuania**, a Ministerial order approved the project "*Preparation of Action Plans for Protection of Rare Species and Action Plans for the Control of Invasive Species*". This project includes three conservation plans for *M. dasycneme, P. nathusii* and *Pl. auritus*. Further plans are foreseen for other species.
- In **Luxembourg**, a five-year nature protection plan was established for bats in May 2007 by the Ministry of Environment. The following three species are currently in the national nature protection plan and have been benefiting from a species action plan since 2009[18]: *B. barbastellus*, *M. emarginatus* and *R. ferrumequinum*. Management targets are listed for each of these species, mostly related to the conservation and restoration of habitats.
- In **Portugal**, a conservation plan for cave-dwelling species was published in 1992 (22).
- In **Sweden,** an action plan entitled **"***Conservation and management of the bat fauna in Sweden - Action plan for implementation of the EUROBATS agreement*" was adopted in 2006 to implement the EUROBATS agreement. Species-specific recovery plans are also being developed. There is an action plan for *B. barbastellus* in implementation. Other action plans are likely to follow, probably for *M. bechsteinii* and *M. dasycneme*.
- In the **UK**, *B. barbastellus*, *M. bechsteinii, P. pygmaeus, Pl. auritus, N. noctula, R. ferrumequinum and R. hipposideros* benefit from Species Action Plans updated in December 2010 by the Joint Nature Conservation Committee (JNCC)[19]. This was done for priority species in the framework of the UK Biodiversity Action Plan.

2.4.2 - Other regional action plans

[16] http://envir.ee/498230

[17] www.npws.ie/publications/speciesactionplans/2008_Bat_SAP.pdf

[18] www.environnement.public.lu/conserv_nature/dossiers/Plans_d_actions/Plans_d_actions/index.html

[19] http://jncc.defra.gov.uk/page-5170

- In **Belgium**, a LIFE+ project "*Bat action, Action plan for three threatened bat species in Flanders*"[20] was implemented for the period 2006-2010. It provided a major driving force for all kind of initiatives relating to bat conservation and bat management in Flanders (**Belgium**): land acquisition, management plan, census, awareness campaigns. It included three targeted bat species (*M. bechsteinii, M. dasycneme, M. emarginatus*) and aimed to achieve a substantial increase in the numbers of bats. A species action plan is also implemented for *R. hipposideros* in the Walloon region for the relictual maternity colonies.
- In **Germany,** there are numerous bat actions planned at regional level. In Bayern (and in Berlin), local species-assistance programmes for bats have been built to implement conservation measures on threatened species[21]. In Thuringia and Bavaria, there are Coordination agencies for bat conservation (since 1996) that support and develop bat conservation programmes.
- In **Netherlands**, an action plan for bats was launched in 2006 by the province of Noord-Brabant, which is still currently running.
- In **Romania**, the Life+ Project "*Bat Conservation in Pădurea Craiului, Bihor and Trascău Mountains*" started in 2009 by the regional Environmental Protection Agency of Bihor. This project plans to implement conservation actions for bats on 16 Natura 2000 sites and to draw up management plans for 7 bat species (*M. myotis, M. blythii, M. bechsteinii, B. barbastellus, R. ferrumequinum, R. hipposideros, M. schreibersii*).
- In **Spain,** two specific Action Plans are in place in the Autonomic region "Comunitat Valenciana on M. capaccini and R. mehelyi respectively. Plus an Action Plan specific on M.myotis and M. blythii in Asturias[22] and another Action Plan on R. mehelyi and R.euryale[23] and on M. bechsteinii[24] for the region of Extremadura.

2.4.3 - Action Plans for the conservation of bats in Europe

- An Action Plan for the conservation of *R. ferrumequinum*, was prepared by R.D. Ransome and Anthony M. Hutson in 1999 (under the Bern Convention for the Council of Europe) (23);
- The Action Plan for the Conservation of *M. dasycneme* in Europe was prepared by Herman Limpens, Peter Lina and Anthony Hutson in 1999 (Council of Europe) (24).
- The Action Plan for Microchiropteran Bats was compiled by Anthony M. Hutson, Simon P. Mickleburgh, and Paul A. Racey (IUCN/SSC Chiroptera Specialist Group) in 2001 (25).

2.5 - EUROBATS co-funded projects

Many actions are being implemented for bat conservation by local NGOs with the support of local administrations and sponsors. Although it is not possible to list them all, some of EUROBATS supported projects are listed below to illustrate needs and possibilities. The EUROBATS Project Initiative (EPI) was launched in August 2008 to provide appropriate funding for small to medium sized bat conservation projects (costs of up to 10,000 €). The following criteria are taken into account when

[20] www.natuurenbos.be/~/media/Files/Projecten/BatAction/laymans%20report.pdf

[21] www.lfu.bayern.de/natur/artenhilfsprogramme_zoologie/fledermaeuse/index.htm

[22] https://sede.asturias.es/bopa/2002/12/26/20021226.pdf

[23] http://doe.gobex.es/pdfs/doe/2009/1360o/09050364.pdf

[24] http://doe.gobex.es/pdfs/doe/2009/1360o/09050365.pdf

assessing EPI applications (details of each project are presented in the complementary information volume):

- Predictable impact on bat conservation, in particular the enhancement of implementation of the Conservation and Management Plan of the Agreement and other EUROBATS Resolutions, national conservation targets,
- Degree of transboundary character,
- Contribution to the promotion of international cooperation between Parties and Range States,
- The ability to provide innovative information and experience that can be shared with other Parties and Range States,
- Contribution to the education and motivation of young bat workers,
- Focus on threatened species defined by EUROBATS Resolutions or the European Mammal Assessment,
- Envisioned outcomes for public awareness like publications, guidelines or follow-up programmes, educational outreach.

Various projects (n = 20) dedicated to bat conservation have also been funded through the various European Funding streams, especially the EU LIFE Programme[25]. These are listed in the background document accompanying this document.

[25] Also through Interreg or Leader programmes

3 - SURVEILLANCE AND KNOWLEDGE ASSESSMENT

3.1 - Introduction

Good quality data is essential for understanding the conservation requirements of the different bat species. Member States must also report every six years on the conservation status of bat species within the EU under Article 17 of the Habitats Directive.

Population surveying and monitoring is a key item of the EUROBATS Conservation and Management Plan. It focuses on developing common and transboundary approaches. There is a will, through pan-European observation frameworks, to identify national and European population trends, to better understand local and regional migrations or to refine data for representative key species.

The use of non-invasive methods is preferred and, in this respect, two key guidelines were prepared by EUROBATS to reinforce ethical approaches in field studies:

- Guidelines for the Issue of Permits for the Capture and Study of Captured Wild Bats were issued in 2003[26] with some slight amendments made later on.
- Guidelines on Ethics for Research and Field work practices were issued in 2010[27].

3.2 - Population survey`

As stated in EUROBATS Publication series No5, surveillance is defined as population surveys (range, abundance) over time, while monitoring is related to a defined target involving species but also other factors surveillance.

3.2.1 - Surveillance methods

The EUROBATS Publication series No5 published in 2010 "***Guidelines for Surveillance and Monitoring of European Bats***" recommends best practices to detect changes in distribution, range and abundance and provide longterm population trends. The guidelines concentrate on the standardised methods required to produce indices of population change.

3.2.1.1 - Roosts counts

Surveillance activities are facilitated by the gregarious character of bats. Maternity and hibernation roosts are particularly useful for surveying numerous species. Counts of emerging bats or counts inside the roosts can be used for maternity roosts. At hibernation sites, the relationships between the number of bats seen and the number of bats present is not always clear because of numerous cracks and crevices in which bats may be hidden from view. The EUROBATS publication No. 2 cites the example of a German cave in which about 300 individuals were visible when about 15,000 were present when counted with infrared detection.

Other summer or transitional roosts are also interesting but interpretation of data, especially quantitative, is more difficult when there are regular changes of roosts. It is much more difficult to count forest species, unless it concerns individuals in bat boxes (e.g. *P. nathusii*) that are dedicated surveillance programmes.

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26 www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/MoP4_Res.6_Issue_of_Permits.pdf

27 www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/MoP6_Record_Annex8_Res_6_5_Ethics.pdf

In a greater urban area, there are many types of buildings (e. g. prefabricated houses) that harbour gaps, cracks, vents and crevices where some species of bats can roost. In some countries these structures represent important hibernation sites of *N. noctula*. Because of the inaccessibility of these roost sites, it is only possible to broadly estimate the number of individuals in cavities. Nevertheless, observing bats flying out their roost sites at each suitable building before they start to hibernate seems to be an effective method.

In late summer/autumn, swarming sites seem to play a key role in the yearly cycle of bats (this may be related to mating, assessing hibernation sites, or training their young). Swarming sites attract thousands of individuals, and may sometimes double up as roosting sites.

3.2.1.2 - Away from roosts counts

Away from roosts, bat detectors or Automatic Recording Devices (ARDs) can be used. Walked surveys with handheld bat detectors, using line-transects and/or point-counts are utilised to monitor variations in species composition and activity between the years. They are also used to study bat foraging areas or to identify commuting routes. Bat detector transects along roads using moving vehicles can provide statistically robust conclusions on population trends of common species along roadsides. Such a project is implemented at national level in France. It involved the monitoring of 146 road sections in 2008[28] through a partnership between scientists and volunteers.

Remote automated recording could become a more important monitoring tool in the future considering the huge progress made in recent years with this technology and with the development of classification tools[29]. New devices become available every year and some studies are now using batteries of ARDs. There are even new approaches concerning algorithms to use automatic data to mitigate specific impacts as in the wind farms projects (26).

The capture of bats is not recommended for the purpose of surveillance unless less invasive bat detectors, ARDs and roosts counts methods are not adapted (e.g. to confirm reproductive status or for radio tagging projects). A good example may be provided by *M. bechsteinii* or *M. alcathoe* for which radio-tracking is generally needed to locate roosts. In addition, monitoring scheme for some countries include mist netting as the only applicable method for some bat species.

The EUROBATS Publication series No. 5 also addresses long term surveillance with different scales of stratification relevant to surveillance obligations under the HD. However, this is not suitable for use in short term survey as Environmental Impact Assessment[30] (EIA) or Appropriate Assessment (Article 6.3). To illustrate this issue, completeness in terms of species diversity is difficult to reach: e.g. a study based on 257 hours of listening with bat detector in forests habitats (27) has shown that the exhaustiveness, in terms of number of bat species, was only rating at 65 % after 45 min. Therefore, data analysis and its transcription of impacts from EIAs is sometimes difficult to interpret both before the project authorisation and after during BACI[31] protocols.

3.2.2 - Data analysis and compilation for roosts

Because of the fidelity to roosts and the gregarious nature of bats at roost sites, there is considerable benefit in compiling data from roost counts to monitor trends of their populations in Europe. In 2010,

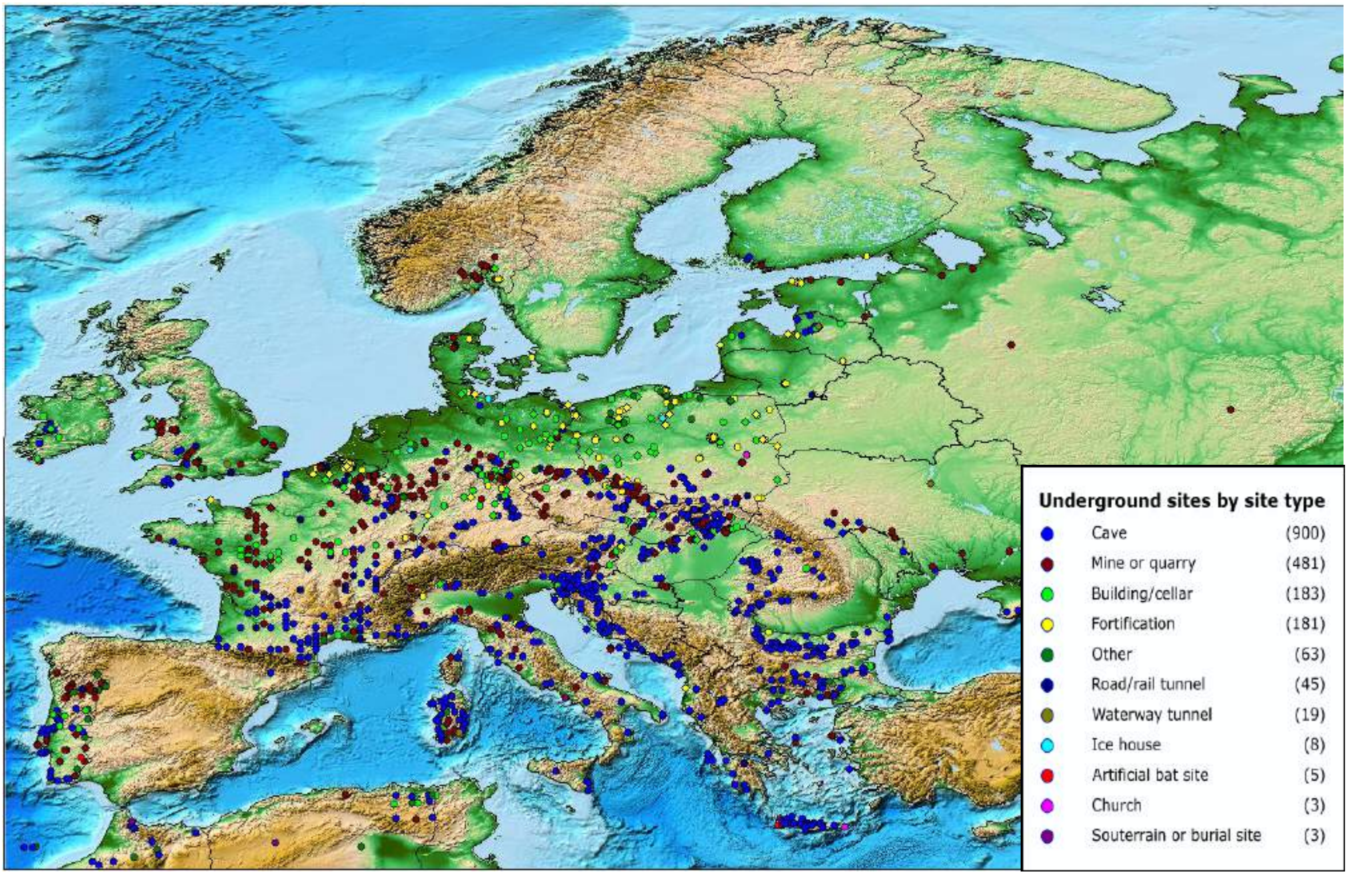
[28] http://vigienature.mnhn.fr/chauves-souris

[29] As iBatsID, a free online tool developed by a network of European research worker, using ensembles of artificial neural networks to classify time-expanded recordings of bat echolocation calls from 34 European bat species https://sites.google.com/site/ibatsresources/iBatsID

[30] Note that guidelines for consideration of bats in wind farm projects are provided in the EUROBATS Publication Series N° 6

[31] Before After Control Impact

EUROBATS collated a list of 1,487 internationally important underground sites for bats identified by Parties and non-party Range States (1,402 for the EU)[32]. The list of sites is accessible through the EUROBATS website. The latest update (2015) brings the number of enlisted sites to more than 1,900. It would be useful to analyse whether such sites are included within the Natura 2000 network (in the knowledge that some sites are may be important for Annex IV species only).



Map 3 - Underground sites important for bats in Europe as identified by EUROBATS Parties and Range States (2015)

3.2.3 - Daily and seasonal movements – migration

The EUROBATS Conservation and Management Plan recommends to collect data on local and commuting movements among bat populations and identify long distance migration routes. International protection measures for bats are most important for those species that migrate furthest across Europe, crossing national boundaries. Possible dangers caused by barriers on the migratory routes of various species can then be identified and addressed. Furthermore, understanding migration is also important for understanding the potential spread of infections that can be harmful to bats and also to humans.

Today, the use of modern methods (e.g. genetics and isotope analysis) should supplement classical methods (e.g. banding) to identify long distance migration routes which cross national frontiers (28).A EUROBATS IWG[33] is currently tasked with the collection of data on species migrations within the range of the Agreement.

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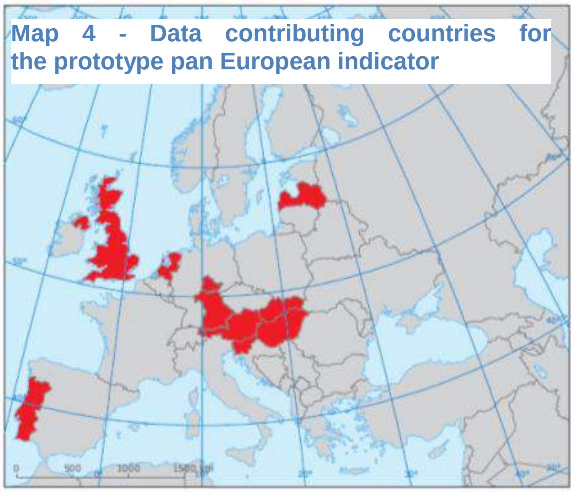
[32] http://www.eurobats.org/activities/intersessional_working_groups/underground_sites

[33] Intersessional Working Groups, see 7.2

3.2.4 - Prototype pan European indicator

To improve the coordination and streamlining of international biodiversity-related indicators, in line with the recommendation of the Streamlining European Biodiversity Indicators (SEBI) 2010 process, the EUROBATS IWG on Monitoring and Indicators is aiming to develop a bat indicator to summarize population trends at European scale. A first step towards this goal, which involves developing a prototype indicator using hibernation data, has recently been made possible through work commissioned by the European Environmental Agency (EEA) in 2011. This work has been published in the EEA technical report series[34] in early 2014.


Map 4 - Data contributing countries for the prototype pan European indicator

The Bat Conservation Trust, the Dutch Mammal Society and Statistics Netherland led the work and established cooperation among 10 hibernation surveillance programmes in 9 countries. The data contributing countries (see map 4) were UK, Netherlands, Bavaria and Thuringia (Germany), Austria, Hungary, Slovenia, Slovakia, Portugal and Latvia. The contributing hibernation surveillance schemes cover 6000 sites, 6 bio-geographic regions, 27 species and time series ranging from 6 to 26 years.

The **prototype** hibernating bat indicator, covering the period 1993-2011, incorporates data on 16 species from 10 schemes spread over 9 countries. Overall, the species included in the prototype indicator appear to have increased by 43% at hibernation sites between 1993-2011, with a relatively stable trend since 2003. However, due to the **preliminary nature** of this prototype indicator, the early conclusion that bats have increased at hibernation sites should be **interpreted with caution** until the indicator can be expanded to cover a more representative range of European countries and species, and elements of the methodology to do with how sibling species are amalgamated be further refined. One species, *Pl. austriacus,* shows a significant decline.

Figure 3 - The prototype European bat hibernating indicator (From (29))

[34] www.eea.europa.eu/publications/european-bat-population-trends-2013

Table 6 – Slope, error of slope and number of sites where the species occurred; trend of species and of the combined prototype European hibernating bat indicator

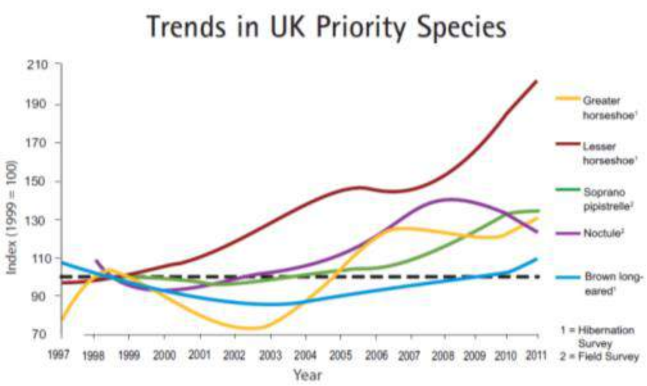
Species	Slope	Standard slope error	Number of sites	Trend classification
European hibernating bat indicator	**1.02**	(a) -		Increase
Rhinolophus euryale (Blasius, 1853)	1.08	0.03	37	Moderate increase
Rhinolophus ferrumequinum (Schreber, 1774)	1.04	0.01	272	Moderate increase
Rhinolophus hipposideros (Bechstein, 1800)	1.06	0.01	619	Moderate increase
Barbastella barbastellus (Schreber, 1774)	1.04	0.01	973	Moderate increase
Eptesicus nilssonii (Keyserling and Blasius, 1839)	1.03	0.02	309	Uncertain
Eptesicus serotinus (Schreber, 1774)	1.02	0.01	201	Stable
Myotis bechsteinii (Kuhl, 1817)	0.96	0.04	500	Uncertain
Myotis dasycneme (Boie, 1825)	1.00	0.01	230	Stable
Myotis daubentonii (Kuhl, 1817)	1.02	0.00	2 125	Moderate increase
Myotis emarginatus (Geoffroy, 1806)	1.08	0.02	111	Moderate increase
Myotis mystacinus/brandtii (Kuhl, 1879; Eversmann, 1845)	1.06	0.00	1 506	Strong increase
Myotis nattereri (Kuhl, 1817)	1.05	0.01	2 066	Moderate increase
Myotis myotis/(blythii) oxygnathus (Monticelli 1885)	1.02	0.00	1 748	Moderate increase
Plecotus auritus (Linnaeus, 1758)	0.99	0.01	3 655	Stable
Plecotus austriacus (Fischer, 1829)	0.91	0.03	399	Moderate decline
Miniopterus schreibersii (Kuhl, 1817)	1.00	0.01	44	Stable

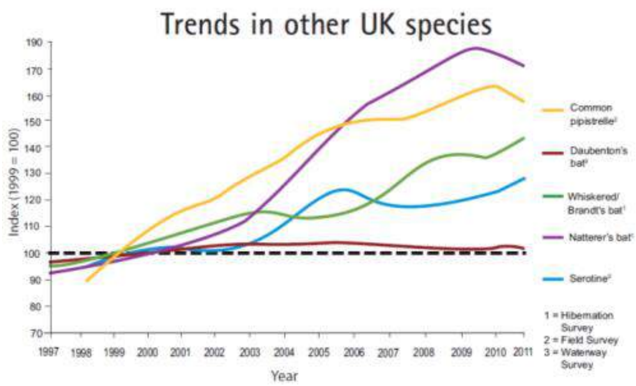
Note: (a) Trendspotter analyses differ from those of TRIM and do not result in standard errors of a slope.

The plan is to expand and update the indicator to incorporate data from at least 15 and ideally over 20 European countries and to develop an additional trend line using data from maternity roosts. The working group would also like to develop a data sharing structure for census data to calculate pan-European and regional trends (which could be managed by BatLife Europe). This would also require specific funding.

National Bat Monitoring Programme in UK

Since 1996 more than 3,500 volunteers have taken part in surveys coordinated by Bat Conservation Trust (BCT) at over 6,800 roost or field sites around the UK. The data collected has already indicated population changes in some species but surveying needs to continue for many more years in order to ascertain whether these are long-term trends or simply short-term fluctuations. The figure below illustrates some of the results.





3.2.5 - Autecological studies for priority species

In the framework of transboundary approaches implemented by EUROBATS, a working group on autecological studies has defined three priority species in 2004 (*R. euryale*, *M. capaccinii* and *M. schreibersii*). A first state of the art was set up in 2006 and a more comprehensive one was prepared in 2010. In 2014, a new list of 10 priority species was identified and adopted by EUROBATS. This list includes *R. blasii, E. isabellinus, Pl. kolombatovici, Pl. sardus, Pl. teneriffae, N. azoreum, N. lasiopterus, P. hanaki, P. maderensis* and *M. Escalerai*

Gzeneral studies to be supported include:

- Studying population structure, including metapopulation structuring and dispersal (flight paths when commuting from the roost to the foraging areas and when moving between seasonal roosts).
- Investigating roost choice according to the microclimate of roosts (temperature, humidity) through the seasons;

3.2.6 - Bat rescue and rehabilitation

Data collected by bat rehabilitators can provide important information. The level of bat rehabilitation varies ranging from countries with no rehabilitation centres to those with well established operating networks. The number of bats received for bat rehabilitation per year differs from country to country and is influenced by different factors (the severity of winters, location of the country, availability of contacts of bat carers, the regularity of accidents of demolishing roosts, etc.). However, this number may reach considerable values (> 3000 individuals per country / year).

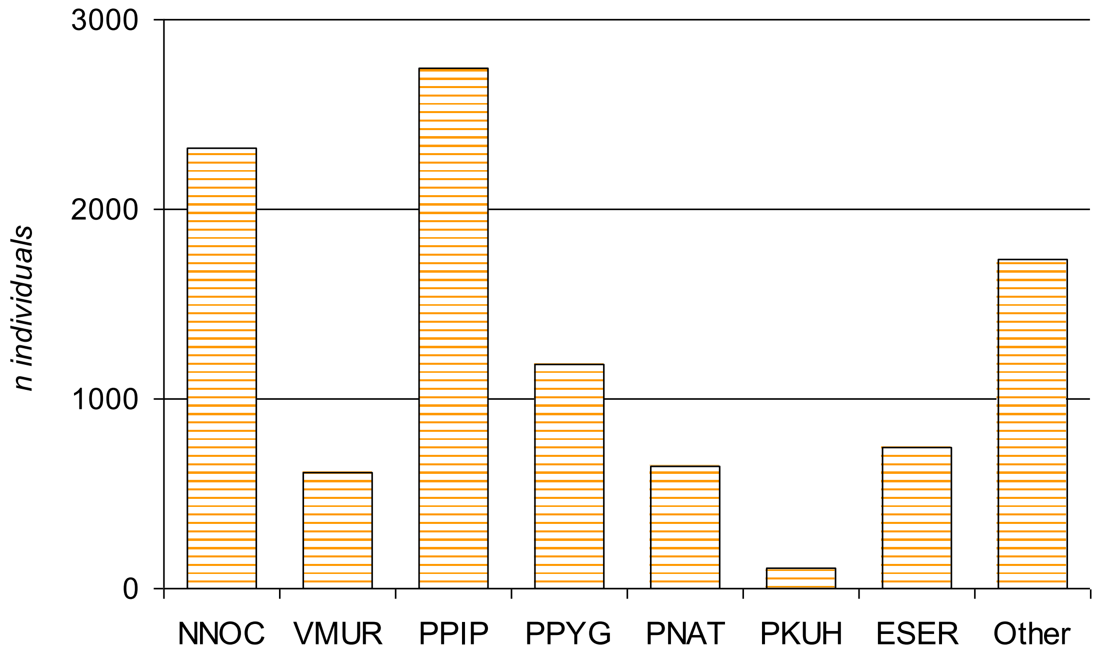


Figure 4: Rough estimations of bats being rescued and rehabilitated per year in 25 European countries.

Species acronyms: NNOC – *N. noctula*, VMUR – *V. murinus*, PPIP – *P. pipistrellus*, PPYG – *P. pygmaeus*, PNAT – *P. nathusii*, PKUH – *P. kuhlii*, ESER – *E. serotinus.* Category "Other" includes: *R. ferrumequinum*, *M. mystacinus/brandtii, M. daubentonii, Pl. auritus*, *Pl. austriacus*, *B. barbastellus*, *P. maderensis*, *H. savii*, *N. leisleri, E. nillsonii*, *T. teniotis*[35]

[32] http://www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/Inf.MoP7_.47-ReportIWGBatRescueRehab.pdf

The most common species for rehabilitation are: *P. pipistrellus (16 countries), N. noctula (14 countries)*, *P. pygmaeus (12 countries)*, *P. nathusii (14 countries)*, *P. kuhlii (8 countries)*, *E. serotinus (12 countries) and V. murinus (15 countries)*. These species roost very often in buildings and form maternity colonies or aggregations during hibernation, and are often discovered during reconstruction and insulation works. However, at least 11 more species are also being rehabilitated.

Adoption of standardized protocols in bat rehabilitation centres, which include also a description of places for ringing, enable exchange of information with specialists which focus on mitigation of building reconstruction (e.g. specific cases where roosts should be or was damaged), forestry (tree felling) or disease risk (e.g. transboundary projects for rabies surveillance) and facilitate cooperation among particular countries, especially if available online.

Establishment and support of effective bat rescue rehabilitation systems in countries should be encouraged, as well as capacity building and training in order to raise the standards of bat rescue and rehabilitation. In countries with well-developed bat rescue and rehabilitation network collaboration between bat rehabilitators and bat scientists for the purposes of data collection, other scientific research and exchange of knowledge should be emphasized.

3.3 - Reporting under Article 17 of the Habitats Directive (2007-2012): outcomes

Under Article 17 of the Habitats Directive, Member States must submit a report to the European Commission every 6 years following an agreed format. The ‘Article 17’ report provides an assessment of conservation status of the habitats and species targeted by the directive. The assessment is made based on information on status and trends of species populations or habitats, and on information on main pressures and threats. The following data has been extracted from the reports for the period 2007-2012 (it excludes Croatia which joined in 2013). This concerns 42 of the 45 species present in the EU (three species were not included in the reports: *E. isabellinus*, *M. escalerai, P. hanaki*).

The analysis was prepared per “trinomial”: A trinomial is one species assessment in one Biogeographical Area for one Member State (sp/BA/MS). A total of 1.110 trinomials have a status at the end of 2012, including:

- 266 with an unknown status (24 %, this is rather high)
- 285 with a favourable conservation status only (25, 7%)
- 431 with a status unfavourable-inadequate (38, 9%)
- 127 with a status unfavourable-bad (11, 5 %)

New Article 17 report for the period 2013 – 2019 will be available at the beginning of 2020 on the EC website[36]

[36] http://ec.europa.eu/environment/nature/knowledge/rep_habitats/index_en.htm

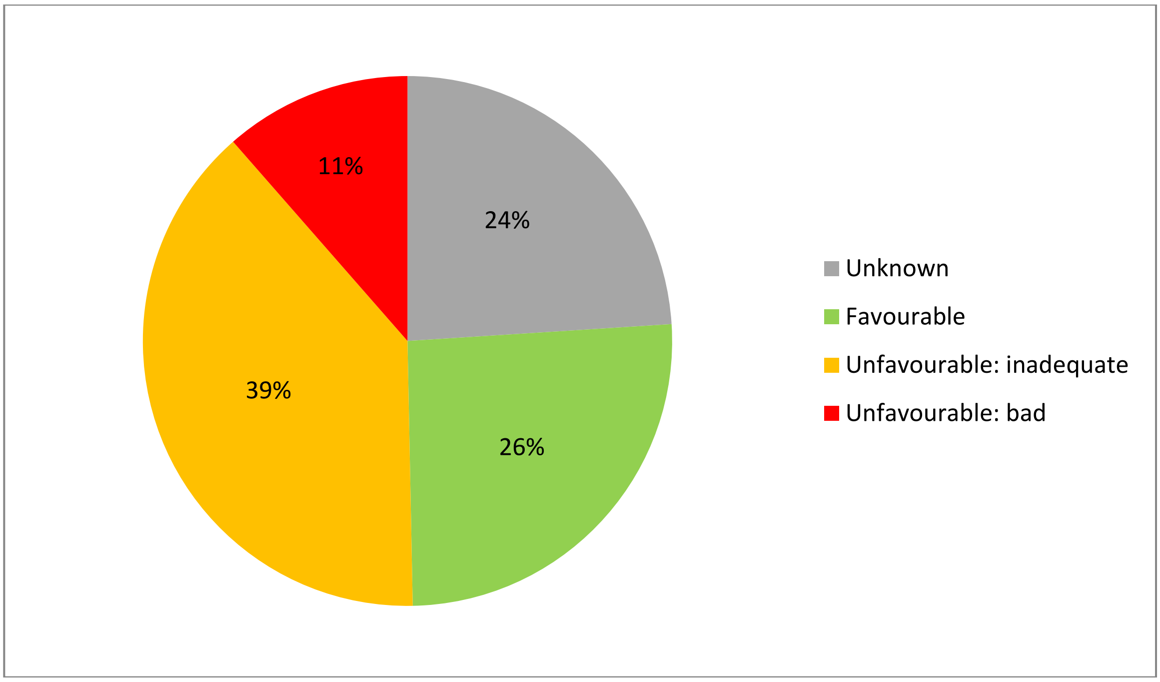


Figure 5 – Bat conservation status in the EU
(Source: http://bd.eionet.europa.eu/article17/reports2012/species/report/, 27 Member states and 1.110 sp/BA/MS assessed)

For this data set, 883 BA/MS/sp are comparable between 2006 and 2012;

- The situation was unknown in 2006 and has been assessed in 2012 for 177 sp/BA/MS (including 46 species with a stable or improving situation and 30 with a decreasing situation) However the situation is still unknown for 184 sp/BA/MS.
- On the 522 other cases:
  - The situation was stable for 82 sp/BA/MS;
  - The situation has improved for 44 sp/BA/MS;
  - The situation was worse for 116 sp/BA/MS (including 48 currently in bad status);
  - The evolution in unclear for the last 280 sp/BA/MS ;

Another approach, at the EU level, is presented in Tables 7 and 8.The situation seems to be better in the Pannonic and the Black sea biogeographical regions and worse in the Steppic, Macaronesian, Continental and Mediterranean ones.

Table 7 – Conservation status per biogeographical region.

Conservation status per biogeographical region	ALP	ATL	BLS	BOR	CON	MAC	MED	PAN	STE
Unknown (XX)	29.4%	13.8%	6.9%	13.3%	8.8%	11.1%	24.3%	10.7%	5.6%
Favourable (FV)	8.8%	20.7%	34.5%	26.7%	14.7%	11.1%	0.0%	35.7%	0.0%
Unfavourable-inadequate (U1)	55.9%	44.8%	58.6%	33.3%	76.5%	66.7%	54.1%	46.4%	94.4%
Unfavourable-bad (U2)	5.9%	20.7%	0.0%	26.7%	0.0%	11.1%	21.6%	7.1%	0.0%
Unfavourable : (U1 + U2)	61.8%	65.5%	58.6%	60.0%	76.5%	77.8%	75.7%	53.6%	94.4%

Abbreviations: ALP- Alpine; ATL- Atlantic; BLS- Black Sea; BOR- Boreal; CON- Continental; MAC- Macaronesian; MED- Mediterranean; PAN- Pannonic; STE- Steppic.

Table 8 – Conservation status per species and biogeographical region.

Species	ALP	ATL	BLS	BOR	CON	MAC	MED	PAN	STE
Barbastella barbastellus	U1	U2	U1	U2	U1	U1	U1	U1	-
Eptesicus bottae	-	-	-	-	-	-	XX	-	-
Eptesicus nilssonii	U1	XX	-	FV	U1	-	-	XX	-
Eptesicus serotinus	U1	U1	U1	U1	U1	-	U1	FV	U1
Hypsugo savii	FV	U1	FV	-	FV	U1	U1	FV	XX
Miniopterus schreibersii	U2	U2	FV	-	U1	-	U2	U2	U1
Myotis alcathoe	XX	XX	XX	-	XX	-	U1	U1	-
Myotis aurascens	FV	-	U1	-	U1	-	XX	-	-
Myotis bechsteinii	U1	U1	U1	-	U1	-	U2	U1	-
Myotis blythii	U1	U2	FV	-	U1	-	U2	U1	U1
Myotis brandtii	XX	U2	-	XX	U1	-	XX	U1	-
Myotis capaccinii	U1	-	U1	-	U1	-	U2	-	U1
Myotis dasycneme	XX	U1	-	U1	U1	-	-	U1	-
Myotis daubentonii	FV	FV	U1	FV	FV	-	U1	XX	U1
Myotis emarginatus	U1	U1	U1	-	U1	-	U1	FV	U1
Myotis myotis	U1	U1	FV	-	U1	-	U1	U1	-
Myotis mystacinus	U1	FV	U1	U2	U1	-	XX	U1	-
Myotis nattereri	U1	U1	U1	U2	U1	-	U1	U1	-
Myotis punicus	-	-	-	-	-	-	U2	-	-
Nyctalus azoreum	-	-	-	-	-	U1	-	-	-
Nyctalus lasiopterus	XX	XX	U1	-	XX	-	XX	U2	-
Nyctalus leisleri	U1	FV	U1	XX	U1	U1	U1	U1	U1
Nyctalus noctula	U2	U1	U1	FV	U1	-	U2	FV	U1
Pipistrellus kuhlii	U1	FV	U1	-	FV	FV	U1	FV	U1
Pipistrellus maderensis	-	-	-	-	-	U1	-	-	-
Pipistrellus nathusii	XX	XX	U1	U1	U1	-	U1	FV	U1
Pipistrellus pipistrellus	XX	FV	FV	U1	FV	-	U1	FV	U1
Pipistrellus pygmaeus	U1	FV	FV	FV	U1	-	U1	FV	-
Plecotus auritus	U1	U1	U1	U1	U1	-	U1	U1	U1
Plecotus austriacus	XX	U1	U1	-	U1	XX	U1	U1	U1
Plecotus kolombatovici	-	-	-	-	-	-	XX	-	-
Plecotus macrobullaris	XX	-	-	-	U1	-	XX	-	-
Plecotus sardus	-	-	-	-	-	-	U1	-	-
Plecotus teneriffae	-	-	-	-	-	U2	-	-	-
Rhinolophus blasii	U1	-	FV	-	U1	-	XX	-	-
Rhinolophus euryale	U1	U2	FV	-	U1	-	U1	FV	-
Rhinolophus ferrumequinum	U1	U1	FV	-	U1	-	U2	U1	U1
Rhinolophus hipposideros	U1	U1	FV	-	U1	-	U1	FV	U1
Rhinolophus mehelyi	U1	-	U1	-	U1	-	U2	-	U1
Rousettus aegyptiacus	-	-	-	-	-	-	U1	-	-
Tadarida teniotis	XX	U1	-	-	FV	U1	U1	-	-
Vespertilio murinus	XX	U2	XX	U2	XX	-	XX	XX	U1

Abbreviations: ALP- Alpine; ATL- Atlantic; BLS- Black Sea; BOR- Boreal; CON- Continental; MAC- Macaronesian; MED- Mediterranean; PAN- Pannonic; STE- Steppic.

Main conclusions are that a lot of unknown situations still occur (with 3 species without any data – *E. isabellinus, M. escalerai and P. hanaki*). Concerning Endangered species from the IUCN red lists:

- In the Macaronesian biogeographical region, the situation has been improved for *N. azoreum* and *P. maderensis* (essentially a change in assessment methodology) but is still unclear for *Pl. teneriffae* ;
- In Cyprus, more accurate data reveals an unfavourable-inadequate status for *R. aegyptiacus*.

3.4 - Gaps in biological knowledge

Bats are difficult to study because of their nocturnal behaviour, their inaudibility,, hidden roost sites, lack of quantitative data, and vulnerability to disturbance.
However, good knowledge on bat ecology is needed to address priorities and improve their conservation management. As in any action plan, filling the gaps in knowledge is a priority not only for biological and ecological aspects but also to assess the pressure of human activities.

- **Population ecology:**
  - ✓ The knowledge on regional meta-population is poor, even in countries with a long tradition on studying bats.

- **Behaviour:**
  - ✓ Several hypotheses have been produced to explain the gathering or swarming behaviour seen in late summer and autumn near cave or mine entrances. More research is required to fully explain the reasons of such phenomena (extension and importance in Southern Europe should be assessed).

Species knowledge:

- ✓ There is a strong lack of biological knowledge for the following species: *M. escalerai*, *M. aurascens*, *N. azoreum*, *N. lasiopterus, Pl. kolombatovici, Pl. macrobullaris*.
- ✓ Knowledge on cryptic species (e.g. from *Pipistrellus*, *Myotis genera*)
- ✓ Why does *N. noctula* have a high nativity and mortality rate compared to the other species of similar size (7) ?
- ✓ Natural wintering roost sites of *N. noctula*: population wintering in the structures of buildings (panel houses) in comparison with population wintering in natural roost sites (tree or rock cavities);
- ✓ For *P. nathusii*, there is an urgent need of systematic studies about winter habitats of bats in coastal and mainland France, Italy, Slovenia, Croatia and other Balkan countries.

- **Migration:**
  - ✓ Migration mechanisms are still not well known and can have conservation implications (e.g. use of landscape features as spatial references, other environmental factors, memory or Earth magnetic field...);
  - ✓ Precise assessment of migration routes, including possible movements between Africa and Southern Europe ;
  - ✓ Lack of knowledge on migration pattern of *P. pipistrellus*, *P. pygmaeus* and *V. murinus* in north-eastern part of species ranges ;
  - ✓ In spite of the study of *P. nathusii* migration routes launched in 1998 by EUROBATS, migration is still not well understood. However, recent studies have provided evidence, that in some locations, *P. nathusii* migration is very intensive and temporally concentrated (30). Recently, new wind farms have been sited and planned in this coastal region without any intensive migration survey. There is also evidence that some species can migrate over distances greater than expected (e.g. *E. nilssonii*).
  - ✓ Do bats in the UK migrate?
  - ✓ Is there a migration over the Alps (because the number of wind farms in the area is increasing)?

- **Bats conservation:**
  - ✓ Impact of mortality due to human projects (wind farms, roads, insulation of buildings) on local bat population;
  - ✓ Role of mitigation and compensation schemes and artificial roosts in population dynamics;
  - ✓ Effects of pesticides/biocides on bat survival / fitness (agricultural, forest and buildings);
  - ✓ Agriculture: impact of endectocides and farming practices.
  - ✓ Impact of building insulation on various kinds of bat roosts.

- **Bats and forestry:**
  - ✓ Assessment of direct mortality in bats due to forestry operations;
  - ✓ Evaluation on the density of “suitable” trees (e.g. dead trees for *B. barbastellus*) to be left in order to sustain populations of forest species to provide foresters with appropriate guidelines to be put into practice rather than qualitative indications or “rules of thumb”;
  - ✓ Effects of forest fragmentation on movement / gene flow of forest bat species.
  - ✓ Loss of food resource and foraging habitats as an effect of wetland drainage for forestry purpose.

4 - THREATS AND CONSERVATION ISSUES

European bats are threat from a range of pressures, including in particular:
- The loss and degradation of roosts and disturbance at roost sites;
- Habitat loss (commuting routes and foraging areas) and fragmentation;
- Mortality of individuals;
- Prejudices against bats and misunderstandings arising from ignorance.

4.1 - Loss and disturbance of roosts

The loss of roosts, by destruction or disturbance, has a significant impact on local populations. As explained by the Bat Conservation Trust: "*Where there are limited alternative roosting opportunities locally, loss of a roost site would result in bats moving away perhaps to a site that is less suitable. In other cases there may be no suitable roosting sites nearby."* Damage will be higher for maternity roosts as the "*loss of one maternity roost site may result in all the breeding females from an area being unable to rear young in that year, and possibly future years if there are no suitable alternative roosts nearby*" (31).

There are three main categories of roosts :
- Underground sites: the word "*underground site*" is frequently reduced to natural caves. However all man-made structures that mimic the environmental conditions found in caves also belong to this category (32) such as abandoned mines, catacombs, tunnels, cellars, military installations and fortifications (war bunkers. …);
- Above ground sites: generally man-made structures such as bridges, castles, churches, houses, flats, stables and cowsheds, barns or even artificial roost sites built for bats. Crevices in cliffs are also used;
- Tree roosts: cavities in trees and under the flaking barks, cracks or even bat boxes in forests.

4.1.1 - Underground sites

This includes all man-made structures that mimic the environmental conditions that can be found in natural caves. Usually, underground roost sites are buffered against rapid changes in humidity and temperature (32). Bats are very sensitive to these aspects and any modifications in airflow may alter the site's value for bats. Because caves are durable structures, a single site may be used by several generations. Bats are generally faithful to their underground roosts provided the conditions within them remain stable.

A list of internationally important underground sites for bats was produced by EUROBATS experts in 2015 (> 1,900 sites). 78 % are composed of caves, mines, quarries or tunnels. The conservation of underground sites is often done through legal protection and/or site management. Preliminary guidance for restrictions within sites is provided in the EUROBATS Publication Series No. 2 with examples of site grading and conservation code (32).

4.1.1.1 - Issues

The two main issues to be considered for underground site management are:
- Ecological modifications of cave features;
- Excessive disturbance at underground sites;

A ECOLOGICAL MODIFICATIONS OF CAVE FEATURES

Many caves or subterranean sites have become unusable for bats because they have been damaged, transformed, or closed for security reasons. Gates or grills can also modify airflows by increasing the inner temperature or humidity, compelling bats to abandon the site (32; 33; 34; 35). A grill can also become an obstacle for some species such as *M. schreibersii* (36; 32) or, in breeding season for *R. euryale, R. mehelyi, M. myotis, M. blythii* (32). Fences used to protect their underground roosts should therefore be carefully designed.

The EUROBATS Publication Series No. 2 provides guidelines and numerous case studies concerning physical protection of underground sites

B EXCESSIVE DISTURBANCE

Significant disturbance can trigger abandonment or mortality (32; 33; 37). Many people may visit caves: speleologists, tourists and recreationists, or local people where they may dump waste, light fires or intentionally kill bats (e.g. using them as paintball target (38). EUROBATS highlights the fact that the increasing use of a growing number of sites as outdoor leisure centres, adventure holiday groups and for unregulated tourism is a cause for concern as members of such parties generally have a poor understanding of the impact of humans on these sites.

Excessive disturbance was seen, for instance, in the Devetashka cave in Bulgaria, which is one of the most important bat caves in Europe. In 2011, after the filming of the movie “Expendables 2”, the bat population in the cave fell by a quarter (8,000 bats hibernating compared to 30,000 the year before). Numerous bats came out of hibernation much earlier than usual and died as a result. A bridge has also been built since. It provides easy access to the cave entrance, attracting even more visitors (39).

Furthermore, mining state companies regularly apply for a total closure (by demolition or filling of entrance sections) of old abandoned mines (e. g. in Slovakia) following legislation on protection of mineral resources and public security.

4.1.1.2 - Bat-friendly management of artificial underground sites

To take part in an appropriate management of underground sites, local authorities have to be made aware of bat requirements (raising awareness). The priority is to develop and support strict protection of the sites of international importance within the Natura 2000 network and to include other sites of international importance lacking in this EU network.

Habitat conservation measures can only be implemented if bat requirements in underground roosts are correctly taken into consideration as in the examples below. The EUROBATS Publication Series n°2 provides further examples of site management (32).

There are thousands of military installations from the 20th century scattered across the EU: war bunkers, pillboxes and blockhouses, fortified buildings etc.. These can offer a network of artificial sites for bats. One of the first LIFE projects dedicated to bats was the “*Transboundary program for the protection of bats in Western Central Europe*” (LIFE95 NAT/D/000045). Implemented in Belgium, Germany, France, Luxembourg, the project secured a total of 143 sites all of which were subsequently made safe for bats (bat-doors, grills and other devices).

In Germany, around 22.000 bunkers were built between 1936 and 1940 to form the Western Wall. After the war, most of the fortifications were blown up by the occupying powers, and were then largely forgotten. These bunker systems have evolved over the decades into valuable bat habitats amid a densely populated and intensively cultivated landscape. At least 10 species of bats have been found here including *M. dasycneme*, *M. myotis*, *Pipistrellus spp*., and *E. serotinus*. The NGO Bund is committed to preserving the remaining underground sites and further improving the ecological bat network along this Western Wall strip[37].

In Poland, an extensive subterranean system of defences, often referred to as the Miedzyrzecz fortifications (Ostwall), was built by German troops from 1933 to 1945[38]. Today, sections of this underground bunker complex, often called Nietoperek, serve as some of the most important winter

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[37] www.gruenerwallimwesten.de

[38] http://polandpoland.com/nietoperek_bats.html

hibernation roosts in Europe for at least 12 species of bats. The total number of bats present is almost impossible to ascertain because the entire system cannot be thoroughly surveyed. However, most researchers agree that the number of hibernating bats is between 20,000 and 30,000. Species, such as the *B. barbastellus* and *M. myotis*, arrive from as far away as Western Germany, the Czech Republic and throughout Poland in October each year.

In the UK, local NGOs are converting pillboxes from the World War II into bat hibernacula, achieving good results for *Pl. auritus* or *M. nattereri*. Gun ports have been bricked up, leaving just a single small entrance for bats to fly through. A steel door is fitted to each pillbox and secured with a padlock to prevent disturbance.

There are many mining areas in Slovakia with thousands of old mines providing ideal underground roost sites (e. g. maternity colonies of *R. euryale* or *M. schreibersii*). Their protection is assured through cooperation with the Mineral Mines State Company. Protective walls[39] have been constructed around dangerous entrances to the old mines, which eliminates the threat of unauthorised entries or accidents whilst retaining access for the bats.

More recently, artificial underground site have been built especially for bats as part of a mitigation or biodiversity offsetting scheme. This was done in the context of the construction of large reservoirs in north-east Portugal where two artificial galleries were built in 1995 and 2005 for the benefit of *M. myotis*, *R. mehelyi* and *M. schreibersii*. More recently, a motorway company has built two artificial concrete bat shelters along the motorway A89 in France, in the framework of a partnership with a local NGO (see also 4.1.2 on overground sites). Time will tell whether these mitigation projects are effective. Also, it is unlikely that these artificial underground roosts can shelter as many bats as natural caves.

4.1.2 - Roosts in buildings

Man-made above ground structures which are regularly used by bats across Europe include bridges, castles, churches, houses, blocks of flats, stables and cowsheds, barns or even artificial bat roosts. These roosts can be used all year round. In late spring, bats may occupy roosts in attics to take advantage of the heat. Breeding females in particular seek warm roosts to minimise the energy used in maintaining a high body temperature during pregnancy and lactation. In winter, most species have been recorded hibernating in voids of buildings such as inside cavity walls, in crevices around window frames, under ridge tiles and in cooler areas with stable temperatures such as cellars and basements.

A higher percentage of bat species rely on roosts in buildings in northern European countries, than in southern countries (40). A survey carried out by EUROBATS has shown that in Europe, for their roosts:

- At least 33 species depend on castles and fortifications;
- At least 32 species depend on church, buildings and houses;
- 27 species depend on stables;
- 23 species depend on bridges.

However, there is a true diversity within Europe, which may be related to differences in constructions. Furthermore, some species such as *R. hipposideros* show a great variability in their roost selection across Europe (40): churches are highly important in Austria, Slovenia and Slovakia and are of medium importance in Hungary, Czech Republic, Germany and France.

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39 www.netopiere.sk/aktuality/2013/10/15/Grafity_v_lesoch_Revuckej_vrchoviny_upozornuju_na_vyskyt_netopiero

4.1.2.1 - Issues

A PROBLEMS CAUSED BY BATS ROOSTING IN BUILDINGS

On occasion, bat roosts in buildings can cause problems in buildings (40):

- A serious smell of bats or the noise from the roost can disturb people;
- Droppings, over a protracted period of time, may cause pitting, long-term staining and etching on porous materials such as painted wall surfaces, wooden monuments and stone sculptures;
- Bat urine (which is 70% urea) is chemically aggressive. It can cause spotting and etching of wooden, metal and painted surfaces;

The presence of protected species also needs to be taken into account when planning building restoration works such as remedial timber treatment or reroofing.

B POISONING BY TIMBER TREATMENT DURING RENOVATION OF BUILDINGS

Bats are very sensitive to chemicals because of their long lifespan and low reproductive rate. Due to their large naked wings, bats are more sensitive to chemical sprays and dusts than other mammals. Species roosting in roofs can, for instance, be exposed to products for treating window frames. They could also ingest these chemicals by licking their wing membranes and their fur or by grooming other members of the colony. Some substances can also be transmitted to the foetus during lactation.

A recent study (41) compiled data on different toxics substances. Three mains types of chemical substances are used to treat wood:

- Chlorinates (organochlorine pesticides, DDT, dieldrine, lindane, chlordane): cause severe and chronic poisoning. They can also affect reproduction and fertility. These substances can increase bat metabolism, and can induce death by precocious exhaustion of fat reserves. Because chlorinates are stocked in fat, they can be mobilised to the brain during hibernation, or they can be transmitted by lactation to juveniles. These substances are persistent in the environment, and studies show that recent bat corpses sometimes contain a high level of toxic substances that have been forbidden for more than 40 years.
- Pyrethrinoide pesticides (cypermetrine and permethrine): are less toxic for mammals but can still affect reproduction (more abnormal spermatozoids, decrease of weight of juveniles at birth, increase of prenatal death, delay of growth…). Although potentially lethal it seems that they don't have any noticeable effects in doses of normal use.
- Metals and metalloids (TBTO, boron salt and zinc): products are concentrated in different organs. The accumulation rate depends on species, age and sex of animals. They can also be transferred to juveniles through the placenta and during lactation. Some scientists have noticed a significant mortality with TBTO use, but not with boron salt or zinc salt (42) (41).

Many of these chemicals are no longer permitted for use because of the hazard to human health.

Wood treatment should take place at a time when bats are absent. In most situations this recommendation is fairly straightforward. Certain species, however, may roost in buildings all year round and there is no ideal solution for such cases (40). The local bat conservation organisation may provide some help.

Tree species that require little timber treatment include sweet chestnut, oak, arch, Douglas pine. A number of fungicides and insecticides available on the market have been granted the European Ecolabel[40] due to their less toxic chemical composition (43).

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40 http://ec.europa.eu/environment/ecolabel/index_en.htm

C BUILDING INSULATION

All types of buildings may be colonized by a number of bat species, since they provide different roosting opportunities (e.g. attics, crevice between panels, cavities under the roof, air ducts, roof and wall covering, etc.). Damage to bat roosts or even the bats themselves may be caused while insulating a building. Another problem relates to breathable roofing membranes (BRMs). Although originally designed for use as part of a continuous breathable/airtight barrier, they are also used in conventional buildings. Research undertaken by the University of Reading (UK)[41], indicates that most of these membranes are detrimental to bats.

The issue is widespread across Europe:

- In the Czech Republic, Slovak Republic, Poland, Hungary and Slovenia, the situation is similar and insulation of block of flats, office buildings, private houses, hospitals, etc. increased markedly in the last four years. Besides private and local supports, countries ask for EU grants, which do not include necessity of bat-friendly solutions prior or during insulation;
- In Slovakia and Poland, the worst examples come from apartment blocks being upgraded, especially by insulation of accessible roof voids often occupied by swifts and bats. Financial support for this insulation has been received from the EU through the program "Jessica";
- In the Netherlands, a workshop on urban bat ecology (2013) had highlighted many problems with post-construction insulation of wall cavities;

The problem can be minimized by a proper pre-insulation work surveys and mitigation measures during and/or after the insulation works, as well as by raising awareness of the problem among stakeholders.
The implementation of directive 2010/31 on the energy performance of buildings should be done in conformity with other legislation, such as the Habitats Directive. It is therefore important that, at least in the case of publicly-funded renovation or restructuration projects, bat colonies are monitored systematically and mitigating measures for the bats are implemented.

Case study: Bats enclosed in their roost during insulation works, Czech Republic

Hundreds of dead bats were found by workers of Czech Bat Conservation Trust during the control of an insulated building in Lovosice in April 2011. Bats died because the under-roof cavities, where they roosted, was blocked off by a metal grill during insulation works on block of flats. The case was investigated by the Czech Environmental Inspectorate.

The bats also occur in fissures among panels and are threatened by isolation layers of polystyrene. These cases could be solved e.g. by installation of special bat boxes, which have openings in both front and back sides enabling bats to enter their original roost.

[41] http://www.bats.org.uk/data/files/Entanglement_StaceyWaring.pdf

4.1.2.2 - Renovation works and mitigation measures

There are many examples throughout Europe to show how adverse impacts on bats can be avoided during building works. Indeed, conditions for bats in a building can often be enhanced through careful planning. Equally, it has been shown that if bat expertise is used from the early planning stages of a restoration project, and a flexible approach is taken to the scheduling of the works, the bats can be satisfactorily accommodated throughout the project at little or no additional cost and without compromising the aims of the works.

Table 9 - Optimal period for carrying out works

Bat usage of site	Optimal period for carrying out works (some variation between species, and geographical regions)
Maternity	1 October – 1 April
Summer (not a proven maternity site)	1 September – 1 May
Hibernation	1 May – 1 October
Mating / swarming	1 November – 1 August

A BUILDINGS OF CULTURAL HERITAGE

UNESCO's Convention on the Protection of the World Cultural and Natural Heritage[42], recognises the need for protecting both natural and built heritage elements[43]. However, conflicts can arise between these two objectives when restoration/renovation works are planned that will have impacts on bats, or when bats cause damage or disturbance to a building (40). Stakeholders from both sides need to cooperate to find appropriate technical solutions.

Many cultural heritage buildings tend to be illuminated at night. This has a potential impact on certain species such as *Rhinolophus* and *Myotis spp*. Lighting can prevent the assemblage of bat colonies or compromise their foraging activities (44). Some public buildings, particularly churches, have been closed to avoid colonisation by pigeons. If the belfries are fenced by wire netting it also prevents access for bats which can become trapped inside and die.

Case study: Ratková Church, Slovakia (40)

The loft of the Lutheran church in the village of Ratková, Slovakia, is occupied in summer by a nursery colony of *M. myotis* and *M. blythii*. The colony was discovered in 1992 and is the biggest colony of this type known in Slovakia, with up to 5,000 individuals present. A layer of bat guano had accumulated below the colony over the years; in some places thicker than 1 m. The weight of the guano was about 10 tonnes, giving rise to concerns about the ceiling of the church.

[42] Further information on this agreement can be found at http://portal.unesco.org/culture/en/ev.php-URL_ID=8453&URL_DO=DO_TOPIC&URL_SECTION=201.html

[43] Only for buildings nominated for both these natural and cultural heritage values

On 3 - 4 December 2004, the loft of the church was cleaned with the help of the employees of the Muránska Planina National Park and Slovak Bat Conservation Society (SON) members. The guano was bagged and distributed among the local community as a fertiliser. The colony continues to thrive and the ceiling of the church is no longer threatened with collapse. See SON website for further details of this work: http://www.netopiere.sk/aktuality/2004/12/03/cistenie-kostola-v-ratkovej.

Case study: Grad na Goričkem, Slovenia (40).

Grad na Goričkem lies in north-eastern Slovenia, close to Austria and Hungary. It is a historically important castle dating from the middle ages. When plans were developed to transform the castle into a visitor centre for cross-border landscape parks, it provided an opportunity to improve the roosting habitat of the castle's bats. Bats were first discovered in the castle in 1999. Intensive research followed on the composition of the bat fauna, seasonal dynamics of species and the microclimates of the areas being used by bats. Volunteer involvement was also important in developing an understanding of the importance of the building for bats.
Conservation work was then undertaken to protect the bats from disturbance. Funding was provided by the State and also through an INTERREG IIIA project (Conservation of amphibians and bats in the Alpine & Adriatic region).

Ten bat species (one third of all Slovenian species) were found to use the site; the cellars provide hibernation sites for *R. hipposideros*, *M. myotis*, *B. barbastellus* and even occasionally for *M. bechsteinii*. *M. myotis* use the cellars as mating quarters as well. Up to 100 *M. schreibersii* have been recorded in the castle, making it one of the biggest known roosts for this species in the north-western part of the Pannonian basin. *R. hipposideros* also forms a small nursery group in the attic of the castle. As underground habitats are generally rare in the region, the cellars are thought to be an important swarming site for bats in the wider area.
The building works required the complete demolition and reconstruction of parts of the castle used by bats. On the basis of the research, mitigation measures were recommended during the renovation, including the designation of a part of the cellars as a bat roost. Extensive discussion took place between nature conservation and cultural heritage officers to agree on the position and size of a new entrance for bats (Figure 16). Follow up monitoring is now required to ensure that the conservation measures are effective, but it seems that the conservation efforts to date have been successful. For further details of this work see (45).

A specific issue with some older buildings is the existence of lead based paints on girders or other metal structures. Bats can be poisoned by ingesting flakes of this paint during grooming. Such a situation arose in the Château de Trévarez in north-west France which contained a nursery roost of 300 *R. ferrumequinum*. Lead and pentachlorophenol poisoning caused a high juvenile mortality at the site. In this case the best solution was to build a new roost for the bats (46).

B BARNS AND ATTICS

As detailed in EUROBATS Publication Series No. 4 (40), old barns play a locally important role as roosts for some bat species and provide their own challenges when it comes to accommodating bats during renovation or restoration works. A study in the UK has shown that many old timber-framed barns, some dating back several centuries, are now being converted into dwellings. Briggs (47; 48) found that the vast majority (77%) of converted barns have not maintained their bat species. She looked at how bats could best be accommodated in these conversions and provides details of mitigation measures that should be built into future barn conversion designs (Species specific design, light pollution, timing of the works...). The same issue exist for attics that are transformed into rooms in old houses (49).

C BRIDGES

Bridges are known to be of particular importance for at least 23 species of bats across Europe (40). For example, 30% of the 328 inspected bridges in Austria were used by bats (50). A survey of 200 known bridge roosts of *M. daubentonii* in Ireland showed that 75% were occupied by 1-5 bats and 5% held 20 or more bats (51). Individual bats will use crevices as small as 50 mm deep and 12 mm wide, but larger groups require bigger, deeper roosting sites. Large, concrete motorway bridges with big interiors can provide shelters for many bats (e.g. one of the biggest known maternity roosts of *R. hipposideros* in Austria is found in such a bridge). In Southern Spain, there are also modern bridges, which support colonies of several thousand *P. pygmaeus* or hundreds of *E. isabellinus*

Old bridges, often made of stone, are subject to different types of disturbance and require different forms of maintenance or restoration works (redo joints, roughcast...). Crevices-dwelling species are very concerned by this issue. Some guidance documents provide helpful advice on how to accommodate bats in both old and new structures[44]. Again, careful timing of the works is a determining factor as well as preserving individual roosting spaces wherever possible.

D MODERN BUILDINGS

All types of modern buildings (houses, flats, offices…) may be colonized by a number of species of bats, since they provide roosting opportunities which are becoming harder to find in more natural habitats. These modern buildings are often subject to renovation, reroofing, thermal insulation in the attic or elsewhere, or even demolition works at shorter periods than the buildings of cultural value. Simon et al. (52) provide detailed information on the construction of artificial roosts within buildings. Mitchell-Jones (53) and Schofield (54) provide extensive advice on the design and construction of roosts in dwellings. For other practical examples of mitigation measures and alternative roosts see Reiter & Zahn (55).

Case study: Morcegário, Portugal (40)

In 2000, bats were discovered during the environmental impact study for the destruction of a 15-storey building in Portugal. Up to 100 *T. teniotis* and some *E. serotinus* and *P. pygmaeus* were hiding in crevices below concrete plates covering the walls. Detailed monitoring showed that bats were present in all seasons and favoured walls with higher sun exposure. Bats were present at various heights, but were most abundant above 21 m, where temperatures were warmest. 75% of the bats were found inside crevices less than 3 cm wide.

The developer built a new roost in 2003, 150 m from the original. It was designed to replicate the original building, although it is only 12 m high. In order to ensure that the thermal characteristics of the crevices were replicated the concrete plates of the original building were re-used. Follow-up monitoring confirmed that the thermal behaviour of the new roost was quite similar to the original one. To encourage colonization of the new roost, 50 bats were captured and released there when it was finished. The old building was knocked down in 2005. In 2006, 22 *T. teniotis*, 12 *E. serotinus* and 4 *P pygmaeus* were recorded in the new roost. In 2007, the maximum numbers seen were 11 *T. teniotis*, 11 *E. serotinus* and 7 *P. pygmaeus*. Monitoring of the new roost is continuing.

Old and new Tadarida roosts, Portugal. © M. Carapuço © J. Palmeirim

[44] See the leaflet produced by SFEPM that can be downloaded from www.sfepm.org/NuitChauveSouris/images2/Savoirplus/plaqponts.pdf.

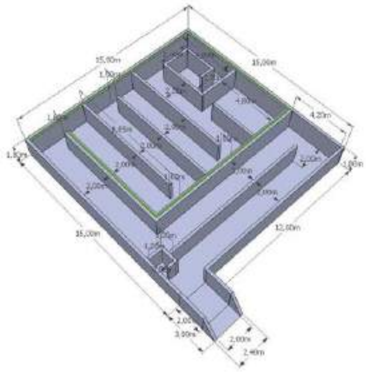
Case study: Prefabricated panel houses and blocks of flats, Slovakia

While planning the thermal insulation of a series of block of flats, the investor asked for an expert‘s view on the occurrence of protected species. This appraisal became a part of the project documentation. In the statement the expert proposed a number of protective measures during the construction works (e.g. evacuation of bats from rifts between panels) and listed a series of potential compensation measures for the loss of roosts as a consequence of the insulation of the building. This can be done in different ways – e.g. keeping used roosts or installing artificial bat houses on the building façade or directly into the insulation)[45]. These works are covered by the investor (or after agreement by the construction company).

- Photos © D. Lobbova

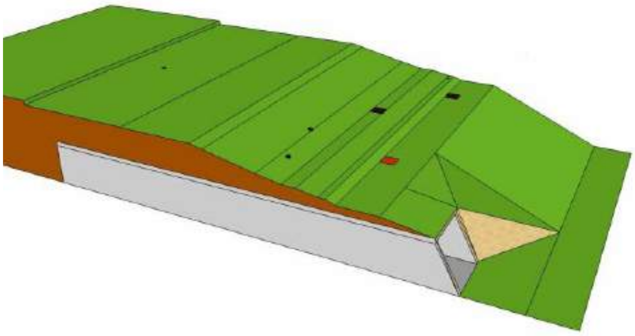
E ARTIFICIAL BAT HOUSES AS MITIGATION OR COMPENSATION MEASURES

Creation of new roosts – bat bricks or boxes - can be incorporated into bridges and buildings to replace lost crevices. This kind of measure can be used in the framework of a compensation scheme or biodiversity offset projects. Some private or public bodies are building bat boxes for gardens, walls etc.. and numerous NGOs or commercial catalogues are selling this equipment. However this is mainly proposed for some species (e.g. *Pipistrellus*) and transitional roosts. In the Nordic countries, bat boxes can usually not be used for compensation purposes of climatic reasons. In some cases, artificial large bat houses are now proposed[46]. Such large bat houses have been proposed in some Environmental Impact Assessment studies as compensation measures (56). Artificial bat houses imitating caves have also been proposed, for instance in a neighbouring forest as in the figure below.



[45] www.bat-man.sk/netopiere/eshop/1-1-Budky-pre-netopiere/1-2-Polystyrenove

[46] www.batmanagement.com/Ordering/condos/batcondo.html



Different views of a proposed artificial roost in the forest of Belles-Forêts (France). This project is being undertaken since 2012 by a public French company in the railway sector (RFF) in the framework of a compensation scheme (views extracted from the call for tender for the building operation published in 2012).

Case study: Man-made bat houses in Navarra (Spain)

In Navarra (Spain) three disused fish-farm buildings where about 300 adult bats of four species (*R. hipposideros, R. ferrumequinum, M. emarginatus* and *P. pipistrellus*) were breeding, were removed in 2013 to restore the place. To compensate the loss of these shelters, in 2014 two man-made bat-houses, specifically designed for bat colonies, were established with three wooden bat-boxes on the walls. Bats quickly occupied both of them in June 2015, although all the *M. emarginatus* left the shelter in July after a heat stroke, and five young bats of this species and another of *R. ferrumequinum* were found dead. By the end of 2015, the bat houses were thermally insulated by a raised roof and insulating paint. In 2016 both bat-houses were again occupied and the colonies then normally bred. In addition, the same year the number of adults approximately doubled the bats observed in previous years, reaching 417 *M. emarginatus*, 93 *R. ferrumequinum*, 44 *R. hipposideros* and 32 *P. pipistrellus*. Maximum temperatures recorded inside one bat-house in 2016 were significantly lower than those of 2015 and the period with temperatures above 30C° was reduced by 69 %. This experiment shows an effective and affordable alternative to keep bat colonies by man-made shelters, which can be applied when current shelters are in danger. However, it is necessary to take into account the possible overheating of the roosts in Mediterranean areas, so it is recommended to insulate them and if possible, to place them in shaded areas.

Big bat-house where *R. ferrumequinum* and *M. emarginatus* breed. One of the wooden bat-boxes can be seen on the wall.

Colony of *R. ferrumequinum* and *M. emarginatus* hanging from the ceiling of the big bat-house. Most of *R. ferrumequinum* are scattered, while *M. emarginatus* are placed on the edge of the wooden boards that cover part of the ceiling.

4.1.3 - Tree roosts

Trees are often used by bats as roosts with some species specialising in forest habitats (e.g. *M. bechsteinii*). They can use lots of different cavities: cracks, woodpecker tree holes, etc. Nevertheless, they prefer old indigenous trees or forests with large trunks and dead or broken trees. They also prefer a cavity high up in the trunk, with a thin opening and tree cavities which are close to each other. Aged or ancient forests with enough dead wood are more often used by bats (57; 58). Also, orchards and isolated trees in hedges or in urban areas may also offer good roosting opportunities. Habitat requirements for each tree-dwelling species are detailed in (59; 60; 61) – see also 4.2.3

In the town of Strasbourg (France), seven old plane trees were felled in January 2013 for a new urban development project. The second most numerous tree-dwelling colony of *N. noctula* in Europe was discovered in one of them: 488 animals were found hibernating in the big cavity. Unfortunately, 24 died on the day of the felling; the other 464 were cared for by a local NGO and released in March-April. These releases were screened with an infrared camera and several individuals were radio-tracked. Thanks to this tracking four other tree roosts were discovered within 1.8 to 14 km. All of these roosts were found in big trees more than 100 years old (62; 63; 64).

Roosts can be preserved during forestry operations by conserving standing dead trees, as well as old and big trees and trees with holes (around 7-10 roosting trees per ha are recommended (60)). Clusters of old trees are particularly valuable. In Germany, several Landers have recommended, as good practice, the conservation of at least 3 (Hesse, Thuringia) and up to 10 (Bavaria, Berlin, Saarland, Schleswig-Holstein) old trees per ha (61). The importance of tree-dwelling bats in the countryside with isolated trees and hedges is not well known because these roosts are very difficult to find and studies are scarce. However, bats would benefit from the next CAP reform as some areas of ecological interest will have to be conserved within the farmers' estate.

Logging in areas with high potential for roosting bats should be carried out outside of the breeding (mid-May to the end of July, or August in northern countries) and hibernating (December to March inclusively) seasons.

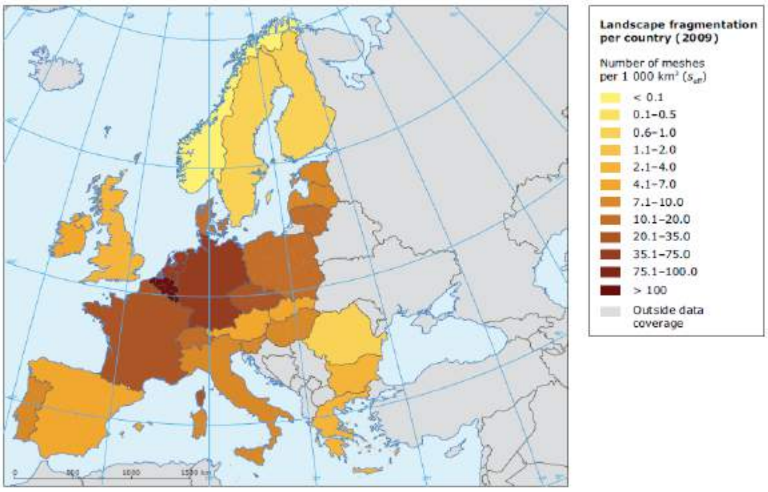
The conservation value of bat boxes (for certain forest species) is limited to areas without old trees, where natural bat roosts are missing. In such areas bat boxes can be helpful for bats to survive until trees become old enough to have holes and crevices. However, bat boxes should only be used if it is ensured that somebody cares for them for many years. Bat boxes should not be used for conservation or compensation purposes in old-growth forests and core areas of nature reserves or national parks (59).

4.2 - Commuting and foraging in fragmented landscapes

4.2.1 - Land planning and fragmentation

Commuting routes play a key role in the conservation of bat populations as foraging areas are sometimes far away from roosting sites. Bats are thus very sensitive to the fragmentation of the landscape from both infrastructure and the reduction of habitat diversity. Landscape fragmentation may increase the risk of local extinction as isolated populations are more vulnerable to natural threats such as weather conditions, fire or disease[47].

In 2011, the European Environment Agency, in association with the Swiss Federal Office for the Environment (FOEN), published a report specifically addressing the issue of landscape fragmentation in Europe (65). As can be seen from the map, highly fragmented regions are located in Belgium, the Netherlands, Denmark, Germany, France, Poland and the Czech Republic.



Map 5 - Landscape fragmentation per country in 2009. Source: (65)

Note: Landscape fragmentation was calculated using fragmentation geometry FG-B2.

High fragmentation mostly occurs in the vicinity of large urban areas and along major transportation corridors. Many new transportation infrastructure projects have been planned after 2009, in particular in Eastern Europe. As a consequence, landscape fragmentation of landscapes is still on the increase. The fast pace of road development exceeds by far our understanding of its effects on the environment and biodiversity, which makes appropriate adaptive management very difficult. Effects may appear years after the construction of new transportation infrastructure due to the long response times of wildlife populations (65).

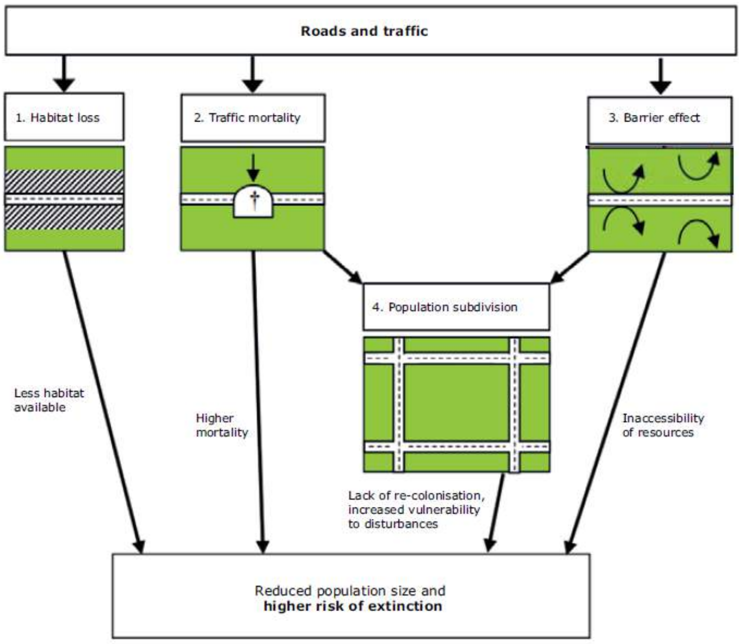


Figure 6 - The four main effects of transportation infrastructure on wildlife populations.
***Source: from Jaeger et al., 2005b in* (65).**

While single alterations are easily visible and assessed as 'not significant', their cumulative effects over longer periods of time are much more difficult to observe. Thus, single landscape alterations are easily marginalised and their cumulative impacts underestimated. This has been called the 'pitfall of

[47] A EUROBATS IWG is currently working on guidelines for the conservation and management of critical feeding areas and commuting routes

marginalisation'. Only after several decades can the full extent of the alterations and the resulting degradation of the landscape be properly evaluated (65)).

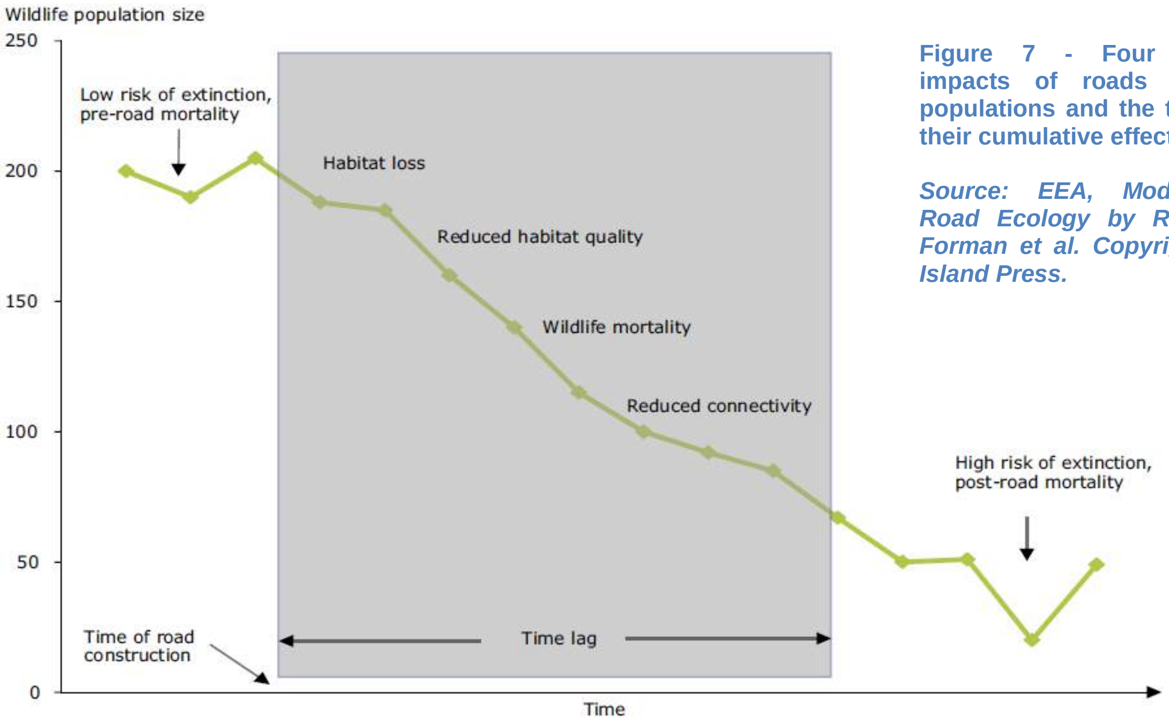


Figure 7 - Four ecological impacts of roads on animal populations and the time lag for their cumulative effect.

Source: EEA, Modified after Road Ecology by Richard T.T. Forman et al. Copyright © 2003 Island Press.

The 2011 report of the EEA on landscape fragmentation in Europe made the following recommendations with regard to biodiversity that are also relevant for bats:

- "We recommend drawing up guiding concepts for the landscapes in Europe that include the identification of regionally and nationally important unfragmented areas and priority areas for defragmentation. To make these guiding concepts more tangible, it is desirable to adopt appropriate benchmarks or targets for the degree of landscape fragmentation. For example, the German government and the German Conference of Environmental Ministers claimed as an important goal a 'trend reversal in landscape fragmentation and urban sprawl' in Germany (Bundesminister des Innern, 1985; LANA, 1995). To achieve this goal, the German Advisory Council on the Environment (SRU) (1994: 128; 253) recommended the development and implementation of limits and orientation values for changes in landscape structure over time. Waterstraat et al. (1996) recommended the protection of large unfragmented low-traffic areas in Germany. More recently, the German Federal Environment Agency suggested that region-specific limits to control landscape fragmentation should be introduced (Penn-Bressel, 2005)".
- "Appropriate objectives and measures should be elaborated that are made binding for European and national offices and should state what measures should be taken and where and how they should be implemented, in connection with ongoing EU initiatives for a green infrastructure[48]. A process of Europe-wide documentation and coordination is recommended to produce an overview of measures at the European level and to enable regional strengths and shortcomings to be recognised more easily. This work could build on the achievements of the previous EU COST 341 Action (Luell et al., 2003) and the Infra Eco Network Europe (IENE) (http://www.iene.info)".
- "Further research should also address the question of how current transportation systems can be improved to keep landscapes unfragmented. The identification of thresholds of landscape fragmentation is a particularly important task.

[48] http://ec.europa.eu/environment/nature/ecosystems/

4.2.2 - Agricultural practices

Apart from using hedgerows as commuting routes, bats regularly forage in fields and meadows, especially around the on edges between meadows or crop fields and wooded areas or water courses. Pastures may play a key role as a foraging habitat for a number of species (*E. serotinus*, *R. ferrumequinum, R. hipposideros, M. myotis, M. blythii ., M.nattereri, Pl. austriacus*). Removal of hedgerows, loss of foraging areas (meadows, ponds) and the increased use of pesticides all impact bat populations. Agricultural intensification is suspected to be a major cause of the decline in many European bat populations (13).

4.2.2.1 - Changes in farming practices

After World War II, an increase in the size of fields, mechanisation, as well as the loss of traditional crop rotations has led to major losses in semi-natural habitats. Yet, these are essential for maintaining connectivity within the landscape (66; 67). Intensification leads to the degradation of hedgerows, draining of pastures, ponds and other wetlands, loss of crop rotation, conversion of pastures to arable land and conversion of woodland to farmland, all of which has had an impact on bats. (68) These changes also lead to a decrease in non-crop habitats such as hedgerows, groves, field margins, unmown grass strips, ponds and orchards, which are essential habitats for bats (flight paths, foraging sites, insect source) (13; 69). Moreover, a number of bats are likely to have suffered from destruction of roost sites in groves and hedgerows.

The European Grassland Butterfly Indicator 1990-2011 (70) illustrates the influence these changes have on one of the bats key sources of food. 17 butterfly species were assessed including 7 widespread and 10 specialist species. 8 species have declined in Europe, 2 have remained stable, 1 has increased and for 6 species the situation is uncertain. The main causes of this decline are agricultural intensification leading to uniform grasslands, and land abandonment. Linear landscape elements are of prime importance for bats and provide them with protection against wind, but also more foraging habitats with higher prey densities than in open areas.

In a recent Swiss study (67), bat activity was 1.4–2.8 times higher around landscape elements compared to open and unstructured control areas. This study corroborates previous findings that open habitats seem to be less attractive to bats for foraging, apart for cattle grazed pastures (71). The shape of landscape elements (linear vs. patchy) is much less crucial for bats than the area covered. The authors highlight the importance of connectivity for bat communities in farmland-dominated landscapes and claim that fragmentation is a major threat to bat populations. Another recent study from the UK (72) has demonstrated that the effect of boundary loss on most bats was very strong in both crops and grasslands, but larger species of bat (*Nyctalus*/*Eptesicus* spp., mostly identified as *N. noctula*) showed no sensitivity to boundary loss.

From 2000 to 2006, 22 % of semi-natural habitats loss was due to the conversion from natural land to farmland (73). Common Agriculture Policy (CAP) instruments have been created in order to slow down this trend. It includes the concept of eco-conditionality, which establishes a number of conditions under which farmers can get direct payments from CAP's first pillar (74). In order to qualify farmers must fulfil good agricultural and environmental conditions (GAEC), which includes the implementation of field margins, the maintenance of set-aside and/or cultivated land, grassland management and the upkeep of landscape features (hedges, ditches, woodland edges, etc.) (75). Important habitat features can also be restored through agri-environment schemes which compensate farmers for the loss of income or extra work due to measures they take to improve biodiversity.

4.2.2.2 - Pesticides and chemicals

The use of pesticides and chemicals is also an important threat to bats. It reduces food supply by eliminating insects and can poison birds and mammals that feed on them (68). Pesticides can also accumulate in insects which can lead to lethal levels in bats (76). Endectocides (avermectins and milbemycins) are drugs used on livestock to control parasites (77). Ivermectin is an antihelminthic from the avermectin family, which is massively used (it was the most sold veterinary drug in 1996) (78). Many coprophagous invertebrates are negatively affected by avermectins or other antihelminthics coming from livestock dung (Beynon, 2012; Vickery et al, 2001 in (79)). These drugs can kill adult insects or larvae, impair reproduction of these insects, delay their development or cause malformations. In Europe, such antiparasitic drugs are used for livestock in at least 16 range states. The bat species most likely to be affected by the resulting lack of food are *Rhinolophus* spp., *E. serotinus*, *Nyctalus* spp., *M. myotis, M. blythii*, *M. punicus* and some *Pipistrellus* spp.

A recent German study (80) found that by following the toxicity-exposure ratio approaches of the current pesticide risk assessment, no acute dietary risk was found for all recorded bat species. However, a potential reproductive risk for bat species that include foliage-dwelling arthropods in their diet was indicated. The results emphasize the importance of adequately evaluating the risks of pesticides to bats, which, compared to other mammals, are potentially more sensitive due to their ecological traits.

Contrary to agriculture intensification, organic farming excludes the use of chemicals (synthetic fertilizers, pesticides, growth regulators and livestock feed additives). Organic farmland habitats have a higher quality and higher overall insect abundance, and key insect families important to bats are more common on organic farms than on conventional farms. As a consequence, bats seem to prefer organic farms over conventional farms for both foraging and general activities (13).

4.2.3 - Forestry practices

4.2.3.1 - Forests - Key habitats

Bats seek out particular features in forests, such as ponds or streams, clearings or forest edges, where insects tend to be most abundant. The species for which forest habitats are vital, for both roosting and foraging, include two Annex II species (*M. bechsteinii* and *B. barbastellus*), and several Annex IV species (e.g. *P nathusii, M nattereri, M brandtii*…). However, forests are also key habitats for *Nyctalus* spp., *Pl. auritus* and *M. daubentonii*, and provide favoured foraging areas for e.g. *M. myotis, M. emarginatus*, *E. nilssonii*, *V. murinus* and *Rhinolophus* spp.

More research is needed to better understand their ecological requirements of bats in view of promoting a more sensitive forestry management. There are links between management options and the related use of forest by bats such as partial thinning of the canopy which increases the light intensity and thus promote undergrowth which is good for gleaning species like *M. bechsteinii and Pl. auritus*. On the contrary, the development of dense canopy eventually increases open space between trees which is the preferred foraging habitat of *M. myotis*.

4.2.3.2 - Forestry issues

Overall in Europe, most of the forested areas are managed for commercial purposes with limited consideration for the protection of bats. The main issues are the following (61; 60):

- Cutting trees during the hibernating season (winter), and thinning in summer (breeding season);
- The age of the trees are limited to its optimum in terms of quality of wood (80 years for the spruce and 120 years for the beech), hence there is usually a low number of trees with bat roosting opportunities (cavities, cracks, holes, spaces underneath loos bark, etc.;
- An increase in coniferous plantations and other exotic species (e.g. the Douglas pine tree and the Japanese larch tree), which are unfavourable to most of bats;
- The impoverishment in insect diversity due to a limited number of tree species present in forest (monoculture) causes decreases in prey availability for bats;
- The sudden loss of foraging areas used for years when clear-cut harvesting on large areas;
- The use of pesticides which also reduces prey availability and possibly affect the bats themselves;
- The fragmentation of large forested areas split into smaller plots bordered with tracks and roads, and disturbance and mortality caused by the vehicle traffic at night;
- Classic harvesting techniques can be harmful to surrounding trees, while modern techniques using cranes allow to avoid damaging valuable trees for roosting bats;

- Structural and functional relationships between unmanaged and managed stands with the forest (they might act as sources and sinks in metapopulational dynamics respectively (81)).

4.2.3.3 - Reducing the impacts of forestry practices

A EUROBATS Working Group was launched in 2004 and a leaflet with good practice guidance for bat-friendly forestry in Europe, “Bats and Forestry”, was published in 2004[49]. Apart from the landscape planning advices related to fragmentation and corridors, 11 good practices for forestry operations were proposed:

- Preserve and increase roosting sites by conserving standing dead trees, old and big trees and trees with holes in all forestry operations (logging, thinning and cleaning). Groups of old trees are particularly valuable;
- Wherever possible try to increase variation in tree species and forest structure. Use native species wherever possible;
- Conserve deciduous trees in coniferous forests. Deciduous trees produce food and roosting sites;
- Increase food production for bats by conserving important habitats: wet forests, riparian habitats, gaps and forest edge zones;
- Limit the use of pesticides in forests;
- Avoid drainage of forest land. Creating new small wetlands and ponds within the forest benefits the bats. Flooding and storms can create dead trees and a variable forest structure;
- Semi-open pastures are sometimes important habitats. Nowadays grazing is often abandoned and these areas are allowed to re-grow or are planted with trees. It is important to conserve some areas with semi-open structure and high abundance of flowering plants. Do not cover the whole landscape with monoculture plantations;
- Grazing and browsing by cattle or other large herbivores creates a variable semi-open forest which is a good foraging habitat for bats. However, too much grazing can remove the whole under storey;
- Avoid creating large clear-cuts;
- Identify the next generation of trees for bats and leave these during harvesting;
- Avoid cutting through any trees close to holes; there may be bats roosting inside.

The public body in charge of nature conservation in England (previously English Nature, now Natural England) has also published several guidance documents on the good practice management of woodlands for bats (59), including one specifically targeted on Bechstein’s bat and the Barbastelle bat (82). Another technical guide on this topic was also published by the Conservatoire des Espaces Naturels Rhône-Alpes[50] from France (83).

Excerpt from Natural England’s booklet on “*Woodland management advice for Bechstein’s bat and barbastelle bat*” (82)**.**

“[…] In dedicated plantation woodlands, Bechstein’s bat colonies may exist for periods but they are neither stable nor sustainable in the longer term with current commercial woodland practice. Colonies rely heavily on semi-mature or mature canopy to forage in and a continuous supply of suitable roost trees into the distant future. This requires linked canopy cover with under storey over an area of about 50 hectares with further areas going into canopy decline and others not yet in canopy closure or in sapling stage. The current trend in forestry practice towards a wider remit of wildlife and recreation as well as timber production gives some scope for management practice to improve matters. A forestry timber extraction policy that follows the slow removal of prime individual trees on a continuous basis, rather than clear fell, will avoid sudden crashes in colony population sizes by maintaining adequate canopy cover for foraging.

[49] www.eurobats.org/publications/eurobats_leaflets

[50] www.cen-rhonealpes.fr/index.php/editiontech

Improvements in plantation management should include:

1. Creating non-intervention strips along all watercourses within the woodlands. This should include all the small floodplains and steep banks along the woodland streams.
2. Harvesting hardwood trees in plantations only when unavoidable and then by selected felling only, done on a slow continuing basis cutting only the best sound mature timber at appropriate times of the year.
3. Monitoring stands of trees used as nest sites by woodpeckers and leaving these stands as non-intervention until their natural decay.
4. Creating a series of suitable areas within which Green Woodpeckers can forage for ants. These areas should be over and above the woodland area required by the bats to forage in.
5. Ensuring, by new planting if necessary, that all hardwood blocks in nursery colony areas have deciduous woodland connections.
6. Leaving not only hollow trees but the immediate stand of trees around them together with the under storey during any felling operations

4.2.4 - Light pollution

Light pollution is also thought negatively influence some bat species[51]. These include for instance:

- (In)direct effects on maternity colonies, hibernation sites and roosts;
- Effects on commuting routes e.g. barrier function of lit roads
- Interaction with feeding activity, including prey distribution and intra-bat species competition;
- Higher risk of prey to the predator by illuminated roost sites.

Few species (*P. pipistrellus, P. pygmaeus, P. kuhlii, H. savii, Eptesicus spp., Plecotus spp.* and *Nyctalus spp.*) seem to take advantage of the aggregation of insects around UV light sources. On the other hand, observations of repeated predation on bats by diurnal raptors in urban areas (roosts present in blocks of flats) were made in Slovakia (Kadlečík J., pers. comm.). Street lights for instance enables the common kestrel to prey on bats at night.

Observations of predation of illuminated maternity roosts have been recorded several times in Estonia. Tawny owls seem to specialize in catching swarming bats around illuminated areas near the entrance to a maternity colony (*M. dasycneme, P. nathusii*). Subsequent visits to the site found that the colony had moved to another safer roost (Leivits M., pers. comm.). Possible longer term effects were also speculated in an Italian study (84): street light in Italy may have acted as an evolutionary pressure on cranial size of *P. kuhlii*, which has increased since 1940's-1950s presumably to catch larger prey concentrated near street lamps.

The Bat Conservation Trust hosted the European Symposium on Artificial Light and Wildlife on 20-21 March 2014)[52]. The symposium aimed to bring together the lighting industry (manufacturers, installers, designers and planners), local authorities, ecological consultants and academics, to share the current state of scientific knowledge and highlight gaps and solutions, introduce the UK audience to the research and practices occurring elsewhere in Europe. The presentations from this symposium are now available to download from the BCT website.

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[51] www.eurobats.org/sites/default/files/documents/pdf/Advisory_Committee/AC13_Doc_13_IWGLightPollutionReport.pdf

[52] http://www.bats.org.uk/pages/artificial_light_and_wildlife_symposium_determining_solutions_for_practitioners.html

4.3 - Infrastructures and mortality

4.3.1 - Traffic infrastructures

Linear infrastructures (particularly roads, motorways, railways) have different impacts on bat populations, both during construction and operation use. These are generally negative; however some infrastructure may have a role as commuting routes (canals, bridges).

4.3.1.1 - Issues

A HABITAT DESTRUCTION BY TRAFFIC INFRASTRUCTURES

The construction phase may lead to the destruction of roosts (buildings, caves or tree-dwelling). In this case, there is a strong adverse impact if these roosts are maternity or hibernation roosts (e.g. *N. noctula*). The impact is less adverse for transitional roosts if precautions are taken to avoid mortality of individuals. Roosts destruction can also occur when a bridge is reshaped, widened or maintained (reinforcement, joints), as roosting animals can become trapped (85). The construction phase will also induce destruction of habitats which can be used by bats for foraging. In addition to the land take for the infrastructure itself, works require additional areas for compound sites and temporary storage areas, building engines circulation ways. It may represent a large area which becomes unfavourable for bats (85).

For instance, a motorway may block around 3 ha per kilometre. The pollution of wet zones, via the run off waters loaded in hydrocarbons and heavy metals, can also induce a decrease of insect abundance and hence a loss of interest for foraging (85).

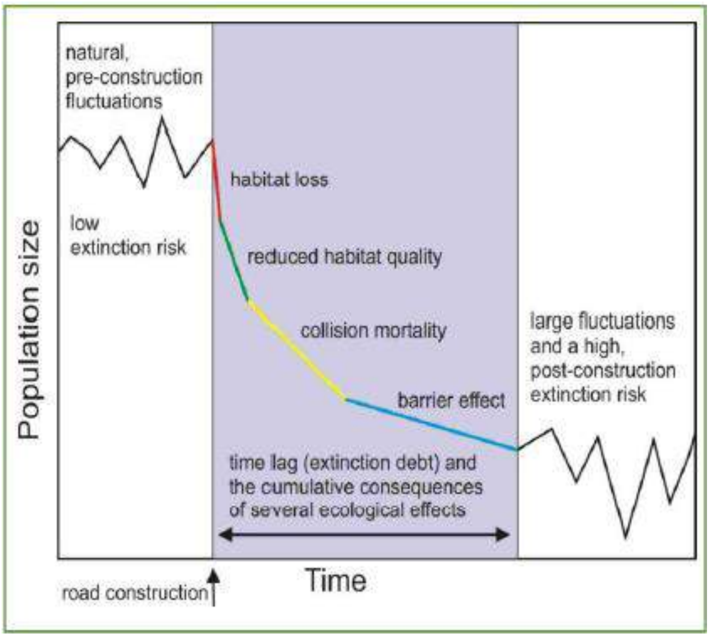

Figure 8 - The multiple causes of bat population reduction by roads and the delayed response (extinction debt). Adapted from (86)

B HABITAT FRAGMENTATION BY TRAFFIC INFRASTRUCTURES

New linear infrastructures can intercept flyways and make them unusable by bats. Older infrastructures have the same effect but bats may have found new strategies for using local territories. Every type of flyway can be concerned: hedgerows, forests edges, rivers, forests canopy or alley, tree alignments. Zurcher *et al*. (87) explained that 60 % of bats turn back when crossing a road if a vehicle arrives. However some species can cross roads more easily than others, depending on their ecology: *Nyctalus* species generally fly high and are less dependent from landscape features. This is not the case for other species as *Rhinolophus* or *Plecotus spp.* (88; 89; 90).

A study by Kerth *et al* (89) demonstrated that motorways can restrict habitat accessibility for bats but the effect seems to depend on the species' foraging ecology and wing morphology. Motorways seem to have stronger barrier effects on bats that forage close to surfaces than on bats that forage in open space. Using radio-telemetry, mist netting, and mark-recapture data the authors investigated the effects of a motorway with heavy traffic on the habitat use of two threatened forest-living bats. They have compared *B. barbastellus*, which forage in open space, to *M. bechsteinii*, which glean prey from the vegetation. Five of six radio-tracked barbastelle bats crossed the motorway during foraging and roost switching, flying through underpasses and directly over the motorway. In contrast, only three of 34 radio-tracked Bechstein's bats crossed the motorway during foraging, all three using an underpass. Bechstein's bats, unlike barbastelle bats, never crossed the motorway during roost switching.

C BAT MORTALITY

Some studies show that all kind of species are concerned by collision with traffic (91; 92; 88; 93; 94; 95) although not to the same extent. The following table illustrate this issue with some results gathered during monitoring surveys carried out along roads.

Table 10 - Case studies of bat mortality due to traffic

References	Country	Context	Mortality
Bickmore 2003 (96)	Wales	A477 and A487 in 2001 and 2002	16 carcasses (10 in 2001 and 6 in 2002 on the A487 - nothing on the A477).
Choquène, 2006 (93)	France	7 Km of a 2 x 2 lanes in 1997	30 carcasses - 3 species.
		27 Km of the RN27 (2 x 2 lanes)	87 carcasses in 3 years (31 in 1997; 42 in 1998 and 14 in 1999) - 9 species.
		Few Km of a 2 x 2 lanes	12 carcasses in 4 consecutive days in August.
Capo *et al.*, 2006 (94)	France	On a 2 x 2 lanes near a hibernacula	104 carcasses (17 in 1998; 41 in 1999; 23 in 2001 and 23 in 2002). Mortality peak in May and August-September.
Graisler *et al.* 2009 (91)	Czech Republic	Two roads R5204 (3.5 Km) and R5205 (4.5 Km)	119 carcasses in 2007 - 11-12 species. Mortality peak in July-August and September-October.
Lesinski, 2008 (92)	Poland	1 Km of highway (2 x 2 lanes)	52 carcasses in 2.5 years (2 in 2004; 28 in 2005 and 19 in 2006).
Lesinski, 2007 (88)	Poland	8 Km of a 2 x 2 lanes - 1994-2000	112 carcasses - 11 species. Mortality peak in August-September. Different mortality peaks according to the species.
Lesinski *et al.*, 2011 (95)	Poland	16.6 km of a 2 x 1 lanes in the National Park Kampinos in 2008 and 2009	61 carcasses - 7 species. 2 mortality peaks: July-August and October.

Lesinski (88) specified that young-of-the-year seems more sensitive to accidental killing than adults. Some differences appear also depending on the surrounding landscape structures (92; 95; 91) which can lead bats to the road. He noticed that there are more carcasses at junctions between road and forest edges or with tree-lined alleys (88; 92). The rate of casualties depends on the landscape surrounding the road (95).

Different studies report three mortality peaks during the year:

- At the end of hibernation (96), when adults need to intensively forage in order to build up energy supplies;
- At the end of summer, when young-of-the-year begin to fly and are in dispersal phase (95; 88),
- September to October, when bat populations are at their peak numbers, seeking to mate and to build up fat reserves for hibernation (95).

Poisoning by pollution may have an impact on bats through food chains (85) via the run-off waters from roads which are contaminated with hydrocarbons and heavy metals. However, this requires more research.

D DISTURBANCE

Noises, vibration and light pollution during the construction of the infrastructure can induce disturbance of bat populations when roosts are located near a building site and can trigger the desertion of these roosts (96). Disturbance can also occur on flyways: bats tend to avoid construction areas, especially because of work lights (97), which can subsequently isolate some of their habitats. It had been shown that bats, even those that are able to hunt around street lights, avoid lights when commuting along flyways.

Berthinussen & Altringham (98) have shown a clear avoidance of major roads by bats: the bats activity and the number of species are three times more important 1,600 m away from the road than at its direct edges. Schaub *et al*. (99) observed foraging behaviour of *M. myotis* in different compartment (three noisy, one silent). It appeared that there was a clear noise effect through the time spent in each compartment. Noise affects the hunting success of bats and so they tend to avoid noisy compartments. This experience shows that bats tend to desert foraging areas close to important source of noises, like major roads.

4.3.1.2 - Mitigation measures for traffic infrastructures

A CURRENT KNOWLEDGE

Different studies show that bats can cross a road or a railway using sheltered passages. The use of tunnels as flyways, when they are not too far from the original flyways, has already been demonstrated (100). Better ways to mitigate fragmentation by different sheltered passages have been compiled recently (90). Results showed that bats use more frequently underpasses and river bridges than overpasses (regularly proposed for bigger mammals like deer). In this study, 93.6 % of bats were crossing via underpasses and 98 % via river bridges whilst only 50 % were using overpasses. They have also noticed that underpasses and river bridges are not so efficient if bats can stay in higher canopy as the height of the road verge tends to induce bat to increase the height of their flight.

In another study (101), it was demonstrated that if an underpass allows bats to cross without changing their direction or their flight height, they are the ones preferably used (96 % of crossings); remaining cases concerned direct crossing over the road. They have also seen that gantries seem to be ineffective. The height of underpasses is a key feature for bat crossing whilst the length seems to be a non-significant element (102). Several reviews and reports have been drafted, in which solutions and good practices have been compiled and summarized (96; 97; 85).

In any case, bats need to be able to fly across such infrastructures to commute to foraging territories and roosting sites in order to maintain their local populations. Three examples of innovative projects are presented below.

Innovative palliative measures for the A7 motorway (Spain)

The motorway A7 in Alcoi (Spain) was recently constructed next to an important bat shelter. Different mitigation strategies were assessed. A sector of the motorway was entirely covered with a net of 20 cm of aperture size to avoid bat collisions. The preliminary results showed that the net can effectively block access to the road. The net is combined with overpasses and underpasses. The preliminary results showed that underpasses are preferred to overpasses by commuting bats.

Photo 1 - Detail of the net that covers the A7 in the vicinity of the bat shelter (© Miguel Angel Monsalve)

Photo 2 - Overpass details (© J. Juste)

Innovative bat bridge for the A89 motorway (France)

In southern France, an innovative approach is currently being tested on new motorways. However, data are still missing in order to assess the effective use of these group-specific overpasses by bats. On the A89, the overpass is a part of a comprehensive project including the erection of artificial galleries, the monitoring of tree roosting, the development of specific bat roosts in the structures. The overpass itself was an experimental project with a specific structure being also safe in terms of security, easy to manage, and attractive for both bats and the human eye!

Photo 3 – Bat bridge of the A89 in France (© ASF)

Innovative bat crossings above the S3-expressway junction with the A3 motorway in Poland

The efficiency of bat flight guiding on wildlife crossings depends on many factors e.g. biometric parameters of trees, road surface level declination in comparison with surrounding terrain level at the crossing area, location of clearings in the vicinity of crossings. The wildlife crossings analyzed on the S3 expressway junction in Poland (103) is accepted by bats, however its functionality should be improved both by implementing technical modifications - increasing width of gates, decreasing of road surface level in comparison with terrain level and by implementing biotic modifications (properly introduced tree compositions and ecotone zones of tree stands).

Photo 4 - The view of gateway and the guiding trees and net

A GOOD PRACTICES AND EXPERIMENTAL PROJECTS

In **Ireland**, the National Roads Authority (NRA) has established guidelines and procedures that focus on the impacts on bats during the construction of new national road schemes[53]. These can also be adopted for road realignment and bridge maintenance programmes.

In **Germany**, Guidelines were produced from research works in Saxony[54]

A EUROBATS Working Group was launched a few years ago to look into methods to minimise the impact of roads and other infrastructures. Its objectives include:

- the collection and review of the different studies, scientific literature and impact assessment reports available on bat mortality, habitat fragmentation relating to roads, railways, etc;
- the collection and review of technical documents on the approach to road building and landscape management which seek to minimise impacts when constructing new infrastructures; and
- the production of general guidelines to raise awareness on the impact of traffic infrastructures on bats and provide some advice for assessing mortality, fragmentation of habitats and others impacts on bats.

[53] www.nra.ie/environment

[54] http://www.verkehr.sachsen.de/download/verkehr/bq_SMWA_Querungshilfen_WEB.pdf

4.3.2 - Wind energy development

The EU is committed to promoting the use of alternative energy sources as outlined in Directive 2009/28EC on the promotion of the use of energy from renewable sources. "*Guidelines for consideration of bats in wind farm projects*" for assessing potential impacts of wind farms on bats was adopted by EUROBATS in 2006. However, knowledge is rapidly increasing on this issue and new measures to reduce the impacts are being proposed. Therefore, the guidelines were updated in 2014 with new data from recent literature and published (104).

4.3.2.1 - Issues

While many studies have long since shown the impact of wind turbines on birds, mortalities of bats have only really been properly documented since 1996. Two causes of bat deaths have been documented: collision with blades and barotraumas caused by rapid air pressure reduction near moving turbine blades (105; 106; 107).

Today, monitoring studies of bat mortality at wind energy facilities are required in many EU countries. Several monitoring methods continue to be developed in Europe and mortality rates can be corrected by tests which determine the search efficiency, the predation rate and the surface correction. Data processing can cause statistical difficulties because mortality rates are expressed with or without the use of bias correction. Moreover, results are very variable depending on the calculation methods used to remove bias (sometimes with differences of several tens). Also bat mortality is very different depending on the site and habitat type. The following table summarizes a number of bat fatalities identified during various European studies (for comprehensive data see (104)).

Table 11 – Number of bats fatalities identified for various European windfarm studies

References	Country	Context	Mortality results	Bats killed/ turbine/year	
				Unadjusted numbers	***Corrected numbers***
ABIES, 2009 (108)	France	28 turbines - 4,5 months	30 fatalities	-	1,07
AVES Environnement, 2009 (109)	France	9 turbines -1 year	103 fatalities	11,44	79,3
Behr O. & Helversen O., 2005 (110)	Germany	4 turbines - 1 year	31 fatalities	7,75	31,5
Brinkmann R., 2004 (111)	Germany	16 turbines - 1 year	40 fatalities	2,5	20,9
		8 turbines -1 year	10 fatalities	1,25	11,8
Georgiakakis P. et al., 2012 (112)	Greece	88 turbines -1 year	181 fatalities	2,08	-

Data on bat fatalities at wind turbines in Europe have been compiled since 2002 by Tobias Dürr from the Ornithological Station of the State Office for Environment, Health and Consumer Protection of the Land Brandenburg, Germany[55]. Most of the data come from Germany, Spain, France and Portugal. The figures are dependent of the data providers and do not stem from standardized studies. The most impacted species belong to genera *Pipistrellus*, *Nyctalus* and *Eptesicus.*

Recently, direct and indirect monitoring techniques have been developed, as well as methods for estimating and mitigating mortality based on the acoustic activity and statistical models. Nevertheless, numbers of bat carcasses found by surveyors has been shown to be systematically less than the actual mortality since many biases are involved in the methodology (113). Many questions remain unanswered, e.g. do collisions occur fortuitously or do wind turbines attract bats. Recent studies suggest that some bats, at least from the genus *Nyctalus*, can be attracted to wind turbines (114). Yet

[55] Die Staatliche Vogelschutzwarte des Landesamtes für Umwelt, Gesundheit und Verbraucherschutz Brandenburg (www.lugv.brandenburg.de/cms/detail.php/bb1.c.312579.de)

several characteristics of the wind turbine influence the mortality of bats like the diameter of the rotor, the size of the tower, the ground clearance and the blade tip speed which can exceed 300 km/h. Studies show that bat activity at turbines increases with net energy production (115). Other parameters increasing bat mortality like meteorological, seasonal and time of the day have been demonstrated (116).

Voigt et. al. (115) states that presumably more than 250 000 bats are killed annually due to interactions only with German wind turbines, and the total losses may account for more than two million killed bats over the last 10 years only in Germany. Surveys revealed that about 10–12 bats are killed annually at each wind turbine in Germany where no mitigation measures have been implemented (26).

This issue is now considered key for bat conservation in Europe (115). It is therefore important that Impact assessments and monitoring are standardized to include bat surveys and mitigation measures are systematically implemented where appropriate on any new wind farm developments.

4.3.2.1 - Mitigation measures

Minimizing fatalities is critically important to both bat conservation and public acceptance of wind-energy development. Currently, multifactorially-modeled blade feathering and increase of cut-in wind speeds offer an ecologically sound and economically feasible strategy for reducing bat fatalities at wind energy facilities and should be implemented broadly (104). Curtailment, the act of cutting-out the generator from the grid when bat activity is high, has demonstrated effective reductions of bat fatalities (117; 118). Techniques using automated systems based on models incorporating variables in addition to wind speed (time of night, bat activity) and meteorological data have been developed (119). When risky periods for bats (high bat activity) are detected, turbines are stopped automatically.

Easier methods like increasing cut-in speed and feathering blades by slowing rotor speed up to the turbine manufacturer's cut-in speed yields substantial reductions in fatality of bats. The cut-in speed is the wind speed at which the generator is connected to the grid and producing electricity. The manufacturer's set cut-in speed for most contemporary turbines is between 3.0 and 4.0 m/s. The principle of this measure to reduce the risk of bat mortality is increasing the cut-in speed. The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed.

The turbines are set to remain almost completely stopped until the increased cut-in speed is reached over an average number of minutes (usually 5-10 min). Several studies have shown that raising turbine cut-in speeds from the manufactured speed by 1.5-3.0 m/s results in significant reductions in bat fatalities compared to normally operating turbines. Most have shown a 50 % reduction in mortality of bats when the cut-in speed was delayed by 1.5 m/s. Generally, it can be stated that bat activity is decreasing only at wind speeds higher than 6 m/s (115).

At wind speeds below operational cut-in speeds, turbines are generally "freewheeling". Even though turbines are not producing any electricity while freewheeling, they still may rotate at high speeds that are lethal to bats. Thus, altering turbine operations to eliminate blade movement at or below normal cut-in speed also may reduce bat fatalities without raising cut-in speeds. Normally operating turbine blades are angled perpendicular to the wind at all times.
The feathering is adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation. The advantage of the feathering turbine blades is that it could be implemented at many facilities with those turbine models that have SCADA systems capable of relatively easy programming.

More recently, studies have tested the effectiveness of ultrasonic acoustic deterrent for reducing bat fatalities at wind energy facilities (120). They proved that the emission of ultrasonic broadband can affect the behaviour of bats directly by discouraging them to approach the sound source, or indirectly by reducing the hunting time spent near the turbine because insects are repulsed by ultrasounds.

However, this mitigation measure has some limitations. Deterrence by ultrasound is limited by distance (efficiency up to 15 meters) and weather conditions like humidity. Further, effectiveness is different between bat species. Future studies must also evaluate cost-effectiveness of deterrents in relation to curtailment strategies to allow a cost-benefit analysis and mitigating bat fatalities.

Case study: Estimating bat (and bird) mortality occurring at wind energy turbines from covariates and carcass searches using mixture models (121)

Two approaches have been employed to assess collision rates: carcass searches and surveys of animals prone to collisions with wind turbines. The authors combined carcass search data with animal density indices in a mixture model to investigate collision rates. In a simulation study, they showed that the collision rates estimated by their model were at least as precise as conventional estimates based solely on carcass search data. Furthermore, if certain conditions are met, the model can be used to predict the collision rate from density indices alone, without data from carcass searches. This can reduce the time and effort required to estimate collision rates.

They applied the model to bat carcass search data obtained at 30 wind turbines in 15 wind facilities in Germany. They used acoustic bat activity and wind speed as predictors for the collision rate. The model estimates correlated well with conventional estimators. Their model can thus be used to predict the average collision rate. It enables an analysis of the effect of parameters such as rotor diameter or turbine type on the collision rate. The model can also be used in turbine-specific curtailment algorithms that predict the collision rate and reduce this rate with a minimal loss of energy production.

year	number of turbines (I)	number of nights	number of recordings	number of carcasses found	average carcass detection probability	Average wind speed in m/s (SD)
2007	12	473	2187	22	0.58	5.2 (1.9)
2008	18	1225	16263	35	0.61	5.5 (1.8)

doi:10.1371/journal.pone.0067997.t001

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Regarding the micro-wind turbines for local energy production, they may also potentially have significant impacts on bats if they are erected in close proximity to a roost or commuting route of these animals. A British study[56] carried out in 2010 on 20 different sites located in Scotland and England showed that bat activity (dominated by *P. pipistrellus*) was 50 % lower near the micro-win turbine (1-5 m) compared to bat activity recorded at a further distance (20-25 m).

A guidance document[57] on this issue has been published in May 2010 by the Malta Environment and Planning Authority. This document includes considerations of related impacts to bats and their mitigation.

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56 Park K., University of Stirling. "*Integrating applied ecology & planning policy: the case of micro-turbines & wildlife conservation*" (Presentation at a conference on Renewable Energy and Biodiversity Impacts, 7-8 November 2012, Cardiff).

57 "*Planning Guidance for Micro-Wind Turbines*" (www.mepa.org.mt/file.aspx?f=4983)

4.4 - Infectious diseases

4.4.1 - Infections affecting bats

Many different infectious agents have been found in bats (reviewed in (122)). However few have been shown to seriously affect bat health or to be effectively transmitted from bats to humans.

4.4.1.1 - White-nose syndrome

White-nose syndrome (WNS) is a disease affecting hibernating bats. A newly cold adapted soil fungus, *Pseudogymnoascus destructans* (*Pd*) previously known as *Geomyces destructans* (123), has been demonstrated to cause this disease which was first documented in New York in the winter of 2006-2007. Named for the white fungus that appears on the muzzle and other body parts of hibernating bats, WNS is associated with extensive mortality of bats in eastern North America: in some hibernacula, 90 to 100 % of bats have died. Bats with WNS exhibit uncharacteristic behaviour during cold winter months, including flying outside in the day and clustering near the entrances of hibernacula58.

In response to WNS in North America, researchers in Europe initiated a surveillance effort during the winter of 2008–09 for WNS-like fungal infections among hibernating populations of bats. *Pd* in Europe was previously reported in a single hibernating bat which was sampled in Périgueux (France) during March 2009 (124). Despite laboratory confirmation that bats obtained in Germany, Switzerland, Austria and Hungary were colonised by *Pd,* deaths were not observed at collection sites. Although the mechanism(s) by which hibernating bats died because of infection with *Pd* in North America is not yet fully understood. Bat species in Europe may exhibit greater resistance or respond differently to infection by this fungus than their counterparts in North America.

A more recent study seems to demonstrate that altered torpor-arousal cycles underlie mortality from WNS and provide direct evidence that *Pd* is a novel pathogen to North America from Europe (i.e. accidental introduction by tourists visiting caves) (125). A resolution "*Guidelines for the Prevention, Detection and Control of lethal fungal Infections in Bats*" was adopted by the Parties of EUROBATS[59] to encourage monitoring of this issue and to raise awareness on this subject (NGOs, operators of tourist caves in Europe, laboratories).

4.4.1.2 - Mass mortality on *M. schreibersii* - Lloviu virus as putative cause

In 2002, mass mortality on several populations of *M. schreibersii* was observed. It started in May in France and moving south to end on the southern Iberian Peninsula in July. France, Spain and Portugal were affected by the event (126). Other bat species sharing roosts with *M. schreibersii* were not affected. Subsequent investigation revealed interstitial pneumonia as the cause of the death.

High loads of a new filovirus related to Ebola and Marburg viruses called the Lloviu virus was found in several organs of the affected bats including lungs. The Lloviu virus has been described as a new genus (Cuevavirus) within the family Filoviridae. Intensive search of the virus in affected populations of *M. schreibersii*, as well as in many other bat species from Spain has not succeeded on detecting the virus again. Consequently, the origin of the virus remains unknown. According to the extreme pathogenicity observed and to the absence of the virus in other populations of *M. schreibersii* than the ones affected by this particular mass-mortality event, punctual cross species from an unknown source resulting in a self-limited outbreak without further adaptation to the new host remains as the most likely hypothesis.

[58] http://whitenosesyndrome.org/about-white-nose-syndrome

[59] www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/MoP6_Record_Annex9_Res_6_6_GuidelinesFungalInfections.pdf

4.4.1.3 - Other infectious agents

In Europe, research is predominantly focused on viruses, but first indications of bat-pathogenic bacteria isolated from deceased bats in Germany and Great Britain has been found (127; 128; 129; 130).

Bats attacked by cats are likely to succumb to bacterial infection even if non-fatal injuries were present since various bacteria can be transmitted via bites. This relation has been proven for *Pasteurella multocida* infections in European bat species (128; 127; 131). On the other hand, bats already debilitated by disease are more vulnerable. Consequently, bats may also act as vectors for zoonotic pathogens, as domestic cats could pass these infectious agents on to humans. Such cross-species transmission events from bats to domestic animals are well documented (132; 133).

Ectoparasites (mites, fleas, and ticks) and endoparasits (helminth parasites and different protozoan) can also affect bats.

Impact of diseases and infectious agents on bats in Germany (134)**.**

Alongside trauma-associated mortality and undefined mortality cases, disease represented one third of mortality causes in 486 investigated bats of 19 European Vespertilionidae species. By comparing pathology and bacteriology results, the authors were able to detect 22 different bacterial species (families *Pasteurellaceae*, *Enterobacteriaceae*, *Steptococcaceae*) that were clearly associated with disease in bats. There was a strong association between cat predation and bacterial infections in bats as almost one half of bats (44 %) caught by cats were affected by bacterial disease.

Ectoparasites were noted in 14 % of bats. Microscopic examination of organ tissues revealed endoparasitic infection in 29 % of investigated bats, involving different protozoan (families *Eimeriidae* and *Sarcocystidae*) and helminth parasites (trematodes, cestodes, and nematodes). Helminthes were predominantly found in the gastro-intestinal tract of the bats, while in some animals, granulomatous organ lesions were associated with larval migration of nematode species. Large bats like *N. noctula*, *E. serotinus* and *V. murinus* revealed higher endoparasite prevalence compared to individuals of medium-sized or small Vespertilionidae species. At least 12 % of all bats had died due to bacterial, viral and parasitic infections. They also found clear seasonal and individual variations in disease prevalence and infection rates, indicating an increased susceptibility to infectious agents in female bats and juveniles during the maternity season.

4.4.2 - Negative public opinion of bats as carriers of viruses

Negative public opinion on potential health risks associated with bats may influence bat conservation (individual killing, roosts destruction and others).

4.4.2.1 - Rabies

The occurrence of Lyssaviruses (European Bat Lyssaviruses or EBLVs) in certain European bat species has been confirmed in several Member States. These viruses have an extremely rare incidence in humans or other non-bat wild and domestic mammals; and none of these viruses seems to be a threat to bat populations. EBLVs might be under-reported as prevalence is routinely reported only in countries that have a regular surveillance programme.

Bat rabies reporting is historically based on passive surveillance made on bats in circumstances like dead, injury or diseases. These circumstances facilitate contact with humans. Consequently, anthropic species and their associated viruses are overrepresented while bat species restricted to the wilderness are underrepresented and their associated viruses are rarely detected or even remain unknown.

A resolution was adopted by EUROBATS in 2006[60] and included recommendations such as:

- Establishment of national bat rabies surveillance network in close collaboration with bat specialists,
- Supporting education efforts that reflect the best scientific advice available regarding the human health risks associated with bat rabies,
- Supporting efforts to avoid overreaction to incidental bat bite exposures and to develop policies for determining the fate of bats involved in contact incidents with humans (and domestic animals such as cats);
- Ensuring that reasonable advice on precautions to avoid infection is available and implemented, including for the maintenance of colonies in buildings where rabies-positive bats have been recorded.

Protocols based on recommendations of the EU Med-Vet-Net working group (*Rabies Bulletin Europe*, 2005(4): 3.1) were also proposed.

4.4.2.2 - Other viruses

Viruses relevant for human health have been found in bats. However, only some have proven to have a relevant role in public health. Several s studies have recently implicated bats as sources of important RNA viruses of humans and livestock (122; 135; 136), including:

- coronaviruses (CoVs, human pneumonia, severe acute respiratory syndrome as SARS virus and the recently described MERS virus (137));
- filoviruses (viral hemoragic fever as Ebola and Marburg viruses (138));
- henipaviruses causing severe respiratory disease as hendra virus or severe encephalitis as Nipah virus, which are naturally harboured by Pteropid fruit bats in Asia and perhaps Africa (no current occurrence in the EU); and
- orthoreoviruses (diarrhea) (139; 140; 141)

It has been shown that bats harbour a great diversity of viruses of families such as Rhabdoviridae, Coronaviridae, Paramyxoviridae or Astroviridae that are considered as putative ancestors of members of these families infecting other mammals, including humans. However, a recent study found that bat hepadanvisuses may have been ancestral sources of primate hepadnaviruses including the Hepatitis B virus (142). DNA viruses, including herpesviruses and adenoviruses (AdVs), have also been detected in bats, although with less clear implications regarding the role of bats as sources of infection for other mammals (143; 144; 136).

Most bat viruses transmitted to humans are carried by tropical fruit bats (filoviruses, henipaviruses) with no current emergence in the EU. But the predominant hosts of mammalian CoVs, including those related to the agent of Severe Acute Respiratory Syndrome (SARS), are insectivorous bats that are not restricted to tropical climates (145). The presence of SARS-related CoV in Europe has recently been demonstrated (136). Coronaviruses related with the Middle East Respiratory Syndrome (MERS) has been also found in Europe recently (146).

Knowledge is currently lacking on the ecology of bat-borne viruses in bat reservoirs (136). However, the Food and Agriculture Organisation of the United Nations has published in 2011 a document investigating the role of bats in emerging zoonoses worldwide (147). The advance of molecular tools and increased scientific activities in this field is likely to uncover many more new bat viruses in the near future. Bat populations are more and more under stress, foraging and behavioural patterns are altered, niches expand, and livestock and humans come into closer contact than ever. The involvement of veterinarians and other wildlife specialists has highlighted the role that they can play in the surveillance, control and prevention of emerging zoonoses.

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60 www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/MoP5_Record_Annex5_Res5_2_bat_rabies.pdf

4.5 - Misunderstandings and myths

4.5.1 - Ignorance

Because they are active only at night and difficult to observe and understand, bats are often misunderstood and persecuted. A good description of our historical ignorance on bats was made by Arthur & Lemaire in 2009 (148) and is briefly summarised below. Bats were firstly described as a viviparous bird, according to Pliny the Elder (23-79) and then as a flying mouse by Albertus Magnus (1200-1280). Several myths built up around bats which led people to fear them and to try to eradicate them. They were considered as vampires sucking blood from sleeping animals. They were suspected to transmit scabies and to tangle into hair. Individuals were captured and nailed to doors or plunged into molten lead (8).

From the 19th century on, this perception has changed gradually thanks to naturalist observations and the wish to take out any negative popular belief on bats. Bats were considered as mammals for the first time in the second 18th century by Linnaeus (8). At the end of 19th century, they were finally described as auxiliaries to agriculture by feeding on pest insects and started to be protected. However, since pesticides are used to control pest insects, the bats' role in crop protection is not promoted (148). Some prejudices against bats remain today. Bats are still believed by some to be dirty rodents full of germs, or even ugly “little monsters”. Intentional damages or destructions still occur as bats are sometimes unwanted in buildings because of the noise they make and their bad smell (148).

4.5.2 - Educational programs

Stakeholders, local authorities, land owners, building owners, farmers, foresters and other land users are key players in the conservation of bats. It is important to provide them with all relevant information concerning the species ecology and the required management of their habitat. It is also important to provide information to the general public and to improve the public’s relation with bats. The following initiatives have been show to play a key role raising interest and awareness for bats.

- Local bat groups

Many local bat groups run events at night or during the day to raise public awareness on the issues that bats face nowadays. Nationwide NGOs assist them through the provision of communication material.

- European/International bat night

The Bat Night, which is organised by EUROBATS, takes place every year since 1997 in more than 30 countries on the last weekend of August[61]. Nature conservation agencies and NGOs from across Europe pass on information to the public about the way bats live and their needs with presentations, exhibitions and bat walks, often offering the opportunity to listen to bat sounds with the support of ultrasound technology. From 2012, it was renamed the “International Bat Night” in order to be in phase with similar events taking place in other continents.

- Year of the bats in 2011-12

In 2011-12, The Convention on Migratory Species (CMS) and EUROBATS celebrated the Year of the Bat. It attracted the attention of the media and thus numerous members of the general public were invited to join in at a local event near where they live. It also helped in increasing data gathered by amateur naturalists with the aim of publishing regional distribution maps.

- the 'Bat of the Year' project

Batlife is supporting the 'Bat of the Year' project in which a bat is annually chosen since 2015 to promote conservation and education efforts across Europe.

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[61] www.eurobats.org/international_bat_night

5 - A FRAMEWORK FOR ACTION

5.1 - Vision and overall goal

In the 2011 EC Communication "Our life insurance, our natural capital: an EU biodiversity strategy to 2020" (COM 244 final), the target 1 specifies:

"To halt the deterioration in the status of all species and habitats covered by EU nature legislation and achieve a significant and measurable improvement in their status so that, by 2020, compared to current assessments: (i) 100% more habitat assessments and 50% more species assessments under the Habitats Directive show an improved conservation status".

In reference to this policy the overall goal of this EU bat species Action Plan is:

To halt the deterioration of the conservation status of all EU bat species

The objective of this action plan is:

To achieve a significant and measurable improvement in bat conservation status, so that 50% more species assessments under the HD show an improved conservation status by 2020 compared to current "inadequate" or "bad" assessments.

According to the 'Article 17' report for the period 2007-2012, on a set of 1.110 assessments[62] there are currently 558 with an "inadequate" or "bad" level. To achieve the above objective there needs to be an improvement in more or less 280 assessments".

5.2 - Targets

The targets of this BAP are defined on the basis of the issues identified in the first part of this report.

n°	Issues	Targets
1	Old or local or only limited number of single species action plans in 16 MS and lack of action plans in 12 other MS (see 2.4) does not offer a good framework for bat conservation.	Multi/single bat species action plans developed and put into implementation in all the EU Member States
2	Improve proper implementation of the Habitat Directive	Designation of a sufficient number of SACs with conservation objectives related to bat correctly addressed and the necessary measures implemented within the SACs. Improve the implementation of the species protection requirements (art 12 of the Habitats directive), especially for bats species in unfavorable conservation status
3	Gaps in the biological knowledge (see 3.4)	Knowledge improved for the identified gaps
4	Lack of capacity or common approach to assess bats population trends and defining conservation status	Capacity building sufficiently developed with common approaches to assess population trends and bat's conservation statutes

[62] An assessment = a species in a single Biogeographical Area within a single Member State

n°	Issues	Targets
5	Decline of bat underground roosts due to the lack of knowledge and involvement of local authorities and private landowners to correctly protect these roosts	Decline of bat underground roosts stopped within Natura 2000 sites and the Eurobats Important Underground Sites.
6	Lack of knowledge and involvement of local authorities and private landowners to correctly protect above ground roosts	A European approach introduced in order to align the European building insulation schemes with bat conservation requirements
7	Lack of knowledge and involvement of local authorities and private landowners to correctly protect above ground roosts	Technical solutions for bat conservation implemented in all key above ground roosts especially within Natura 2000 sites
8	Poor quality or complete lack of assessment of the impact of infrastructure development projects (building renovation, roads, railways, wind farms, etc.) on bat species in the EIA/AA	Quality of bat studies in the framework of AAs and EIAs improved
9	Large mortality caused by wind farms due to the lack of mitigation measures to reduce risks	Mitigation measures applied in all new wind farm projects and old wind farms revised within Natura 2000 sites
10	Large mortality along roads that are built without consideration of local bat issues	A brochure on mitigation measures for road projects is published and a system to monitor road killing is developed in at least 14 MS
11	Fragmentation through transportation infrastructures, disappearance of hedgerows or habitat degradation is affecting commuting roads and bat key habitats	Any initiative to reduce fragmentation of EU landscape is supported and a bat indicator is developed to measure fragmentation
12	Forest are key habitats for bats but forest management does not take enough into consideration bat needs	A common scheme/strategy is developed between EUROBATS, Forest Europe and EC to better integrate bat conservation within forest management policies/practices
13	Bad use of endectocides (antihelminthics) lead to insects mortality and reduce preys of some bat species	Define the best protocol possible concerning the use of antihelminthics
14	Conservation objectives hindered by a negative opinion against bats related to the risk of transmission of rabies and viruses to human and domestic animals	Public health, environmental authorities and practitioners correctly informed on risks associated with viruses carried by bats and prevention measures are put in place.
15	Fears due to misunderstandings and lack of knowledge on the life of bats	Increased public awareness and trainings and information for key stakeholders on action for bat protection

5.4 - Actions

Legends for the time scale in the tables below:

- ➢ ***Ongoing***: *currently being implemented and should continue,*
- ➢ ***Immediate***: *action should be completed in 1 year;*
- ➢ ***Short:*** *action completed in 3 years (2019 – 2021);*
- ➢ ***Medium***: *completed in 6 years (2019 - 2024);*
- ➢ ***Long***: *completed in more than 6 years;*

Legend for priorities in tables below:

- ➢ ***Priorities***: *high, moderate, low*

Target 1: Multi/single bat species action plans developed and put into implementation in all the EU Member States						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
1.1	Distribute this EU Action Plan and promote its implementation among all EU MS.	EU level	high	immediate	European Commission, (EUROBATS, Batlife Europe)	Done beginning of 2019
1.2	Prepare and implement National (Regional) multi/single-bats action plan	All MS	high	medium	National authorities, Conservation agencies, NGOs	Number of MS where such action plans have been adopted
1.3	Identify all appropriate EU funding resources for the activities outlined in the Action Plan, ensuring that all relevant organizations, institutions and individuals are aware of such opportunities	All MS	moderate	short	European Commission, National authorities	Already done for Natura 2000 Done before 2019 for Annex IV species
1.4	Assess the current EU multi-bats action plan in 6 years	EU level	high	long	European Commission (EUROBATS)	Done before June 2024

Target 2: sufficient number of SACs with conservation objectives related to bat correctly addressed and the necessary measures implemented						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
2.1	Define Favourable Reference Values (FRVs) for all bat species of community interest	All	high	medium	European Commission National authorities, Conservation agencies, Research institutions	A report published before 2022
2.2	Assess and aggregate site-level conservation objectives and measures for all bat species of community interest	All	high	medium	European Commission National authorities, Conservation agencies	A report published before 2022
2.3	Launch conservation programmes on the Endangered species that are not in a favourable status in the EC: *N. azoreum, P. maderensis,Pl. teneriffae, Pl. sardus, R.aegyptiacus...*	CY, PT, IT, ES	high	medium	National authorities, EUROBATS, Conservation agencies, Research institutions, NGOs	Number of species with actions undertaken

Target 3: Knowledge improved for the identified gaps (see also other targets)						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
3.1	Promote research on regional meta-population and autecological studies for *R. blasii, E. isabellinus, Pl. kolombatovici, Pl. sardus, Pl. teneriffae, N. azoreum, N. lasiopterus, P. hanaki, P. maderensis and M. Escalerai*	All MS	high	medium	National authorities, Conservation agencies, Research institutions, EUROBATS, NGOs	Number of publications/reports concerning these issues
3.2	Promote research and gather knowledge on migration mechanisms and precise assessment of migration routes, including possible movements between Africa and Europe	All MS	moderate	medium	National authorities, Conservation agencies, Research institutions, EUROBATS, NGOs	Number of publications/reports concerning these issues
3.3.	Promote research on cryptic species (*Pipistrellus, Myotis*, etc.)	All MS	low	medium	National authorities, Conservation agencies, Research institutions, EUROBATS, NGOs	Number of publications/reports concerning these issues
3.4	Promote research on effects of pesticides/biocides on bat survival / fitness	All MS	high	medium	National authorities, Conservation agencies, Research institutions, EUROBATS, NGOs	Number of publications/reports concerning these issues
3.5	Gather knowledge on the role of compensation schemes and artificial roosts in population dynamics;	All MS	moderate	medium	National authorities, Conservation agencies, Research institutions, EUROBATS, NGOs	Number of publications/reports concerning these issues

Target 4: Capacity building sufficiently developed with common approaches to assess population trends and bat's conservation statutes						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
4.1	In the framework of article 17 reports, define a common understanding for reference value concerning bats and appreciation of pressure from human activities	all MS	high	medium	European Commission, EEA, national authorities, Conservation agencies	A report published
4.2	Development of pan European bat population indicator based on existing data (hibernacula counts, statistical package TRIM used for national trends, combination by a central statistical team to create pan European trends). Extend the approach to maternity roosts.	More than 15 MS	high	short	EEA, EUROBATS, Batlife Europe, Conservation agencies, NGO's	A new report published by EEA before 2020
4.3	Develop capacity building for monitoring in countries which do not currently have national monitoring schemes.	To be determined	high	medium	National authorities, Batlife Europe, NGOs	Number of new countries participating in European bat population indicators

Target 5: Decline of bat underground roosts stopped within Natura 2000 sites and the Eurobats Important Underground Sites						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
5.1	Review and update the list of EUROBATS important underground sites for bats and the criteria for assessing them.	all MS	high	medium	EUROBATS, national authorities, Conservation agencies, NGOs	A list published before 2022
5.2	Ensure that all the underground sites of international importance are protected (and within the Natura 2000 network where Annex II species are present).	EU level	high	immediate	European Commission, EUROBATS, national authorities	An assessment carried out before the end of 2020
5.3	Ensure that all underground sites within the Natura 2000 network have proper physical protection and are safe from excessive disturbance.	all MS	high	medium	National authorities, Conservation agencies, NGOs	Assessment done within the next article 17 reports (2021)
5.4	Define a strategy to protect underground sites at the national/regional level in relation with the needs of species to be in a favourable conservation status.	all MS	high	medium	National authorities, Conservation agencies, NGOs	Chapter included within the National/Regional action plans
5.5	Ensure implementation of compensation measures in case of destruction of roosting sites in order to maintain the species conservation status.	all MS	moderate	medium	National authorities, Conservation agencies, research institutions, NGOs	Assessment based on national derogation reports and/or article 6.4 schemes

Target 6: A European approach introduced in order to align the European building insulation schemes with bat conservation requirements						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
6.1	DG Environment to liaise with other European Commission departments encouraging insulation, to make sure the needs of protected species are taken into account (e.g. programme Jessica)	EU level	high	short	European Commission	Key contacts identified and a meeting organised
6.2	Ensure EU and national policies promoting building insulation (in new and existing buildings) include the need to survey for the presence of bats and take account of their needs by including space for bat roosts	All MS	high	medium	Conservation agencies, NGOs, site managers, land owners and users	An assessment conducted for 2021
6.3	Launch an EU campaign on bat conservation within building insulation programmes	EU level	high	short	EUROBATS, Batlife Europe	A brochure published before 2019

Target 7: Technical solutions for bat conservation implemented in all key overground roosts especially within Natura 2000 sites						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
7.1	Ensure appropriate management on all Natura 2000 overground roosting sites with regular bat occurrence	all MS	high	medium	National authorities, Conservation agencies, NGOs, owners	Assessment done within the next article 17 reports (2020)
7.2	Ensure appropriate management on all other overground roosting sites with regular bat occurrence for priority species (to be determined nationally)	all MS	moderate	medium	National authorities, Conservation agencies, NGOs, owners	An assessment conducted for 2021
7.3	Define the best protocol possible concerning timber treatment during renovation of buildings, compile guidance documents already produced in a single web page with a summary on good practices	EU level	high	short	EUROBATS, Batlife Europe, European Commission	A web page produced at the end of 2019
7.4	Management of problems caused by bats in cultural heritage roosting sites: compile guidance documents already produced in single web page with a summary on good practices.	EU level	high	short	EUROBATS, Batlife Europe, European Commission	A web page produced at the end of 2020
7.5	Bridge restoration: compile guidance documents already produced in a single web page with a summary on good practices.	EU level	moderate	short	EUROBATS, Batlife Europe, European Commission	A web page produced at the end of 2019
7.6	Biodiversity offset by building bat houses: compile and assess “experimental” designs in view of producing guidelines.	All MS	moderate	short	EUROBATS, Batlife Europe, conservation agencies, NGOs	Guidelines published at the end of 2019
7.7	Define the best protocol possible concerning precaution in tree cutting in rural and urban areas, compile guidance documents already produced in a single web page with a summary on good practices.	All MS	moderate	short	Conservation agencies, NGOs	A web page produced at the end of 2019

Target 8 : Increased quality of bat studies in the framework of AAs, or EIAs or reporting under article 16 HD improved						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
8.1	Update/Supplement relevant EC guidance documents where appropriate on Natura 2000 to include bats conservation issues (especially mitigation measures).	EU level	high	short	European Commission	New EC guidance published before 2019
8.2	Develop guidelines for assessing impacts of roads on bat population	All MS	high	medium	EUROBATS, National authorities, Conservation agencies, NGOs	A report published for 2021
8.3	Develop guidelines for AAs (HD Art.6.3) for projects such as sky beamers or installation of any kind of large spotlights	All MS	moderate	medium	National authorities, Conservation agencies	A brochure or a web page published for 2021

Target 9 : Mitigation measures applied in all new wind farm projects and old wind farms revised within Natura 2000 sites						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
9.1	Organise a technical seminar on the impacts of wind farms on bats	All MS	high	short	Batlife Europe, National authorities, Conservation agencies, NGOs	A seminar organised before end of 2019 and a report published for 2020
9.2	Develop guidelines for the design of new wind turbines taking into consideration the ecological requirements of bat populations (mitigation measures)	EU level	high	medium	European commission, EUROBATS, Batlife Europe	Guidelines published or a web page produced at the end of 2020
9.3	Promote research on the impact of mortality due to wind farms on local bat meta-populations or European cross-border populations	All MS	moderate	long	EEA, Batlife Europe, Conservation agencies, Research institutions	Number of publications/reports concerning this issue
9.4	Produce a pilot register/data base to collect mortality cases (HD, art 12.4)	EU level	high	medium	EEA, National authorities, Conservation agencies, NGOs	A report published by EEA before 2021

Target 10 : A brochure on mitigation measures for road projects is published and a system to monitor road killing is developed in at least 14 MS						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
10.1	Organise a technical seminar on the impacts of roads on bats and develop guidelines for assessing impacts of roads on bat populations	All MS	high	short	Batlife Europe, National authorities, Conservation agencies, NGOs	A seminar organised before 2020 and a report published for 2020
10.2	Produce technical guidance/best practice to help local authorities and stakeholders to minimise negative impacts during the planning and construction phases of new transportation infrastructures.	All MS	high	medium	European Commission, EUROBATS, Batlife europe	Guidelines published or a web page produced at the end of 2021
10.3	Address the question of how current transport network can be improved to enhance the ecological coherence of the Natura 2000 network in relation with HD art.10. This includes works on the infrastructure transparency for bats (underpass and overpass, mitigation to reduce mortality) and actions to restore connectivity across existing infrastructures systems (by building tunnels and wildlife bridges) on the basis of national priorities.	All MS	moderate	medium	National authorities, Conservation agencies, NGOs	Assessment done within the next article 17 reports (2021)
10.4	Produce a pilot register/data base to collect mortality cases (HD, art 12.4)	EU level	high	medium	European Commission, EEA, Topic centre	A report published by EEA before 2021
10.5	Promote research supported by EU or national support on the impact of mortality due to roads on local bat meta-populations or European cross-border populations	All MS	moderate	long	EEA, Batlife Europe, Conservation agencies, Research institutions	Number of publications/reports concerning this issue

Target 11: Initiatives to reduce fragmentation of EU landscape is supported and a bat indicator is developed to measure fragmentation						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
11.1	Support the recommendation made by EEA on landscape fragmentation in Europe: *"[...] We recommend drawing up guiding concepts for the landscapes in Europe (together with the MS) that include the identification of regionally and nationally important unfragmented areas and priority areas for defragmentation. To make these guiding concepts more tangible, it is desirable to adopt appropriate benchmarks or targets for the degree of landscape fragmentation. [...]".* *"[...] Appropriate objectives and measures should be elaborated that are made binding for European and national offices and should state what measures should be taken and where and how they should be implemented, in connection with ongoing EU initiatives for a green infrastructure. A process of Europe-wide documentation and coordination is recommended to produce an overview of measures at the European level and to enable regional strengths and shortcomings to be recognised more easily. [...]".*	EU level	high	immediate	European commission	A support given by Habitats Committee
11.2	To enhance the ecological coherence of the Natura 2000 network in relation with HD art.10, improve connectivity between bat populations by creating line corridors and stepping stones with appropriate habitat and its management, especially in areas with fragmented populations (e.g. connection of forest fragments with hedgerows and tree lines)	all MS	high	medium-long	National authorities, Conservation agencies, NGOs	Assessment done within the next article 17 reports (2021)

Target 12 : a common scheme/strategy is developed between EUROBATS, Forest Europe and EC to better integrate bat conservation within forest management policies/practices						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
12.1	Collect and promote best practice on bat conservation measures in forest management	EU level	moderate	medium	Batlife Europe, EUROBATS	Guidance document published on forest management and bat conservation
12.2	Promote research work on the relationship between bat communities and forest types in the next research and innovation programmes supported by the EU: Assessment of direct mortality in bats due to forestry operations, evaluation on the density of "suitable" trees (e.g. dead trees) to be left in order to sustain populations of forest species, effects of forest fragmentation on dispersal / gene flow of forest bat species.	All MS	moderate	long	European Commission, EEA, Batlife Europe, Conservation agencies, Research institutions	Number of publications/reports concerning this issue
12.3	In relation with the new EARDF or LIFE funding possibilities, promote and implement agreements with forest owners regarding forest management in key Natura 2000 sites for vulnerable tree-roosting bats.	All MS	moderate	medium	National and regional authorities, NGOs	Number of projects co-financed
12.4	Encourage MS to promote training and awareness for forest managers and forest workers. Encourage MS to develop and put into implementation national guidance relevant to their bat communities, forest ecosystems and forest management practices.	All MS	moderate	medium	National/regional conservation and forest authorities, conservation agencies, NGOs	An assessment conducted for 2021
12.5	Produce European technical guidance to help local forests authorities and stakeholders to combine forest management with bat conservation in intensively managed forests or in key bat forest habitats	EU level	high	medium	EUROBATS, Batlife Europe	Guidelines published or a web page produced at the end of 2021

Target 13: Define the best protocol possible concerning the use of antihelminthics						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
13.1	Define the best protocol possible concerning the use of antihelminthics, compile guidance documents already produced in a single web page with a summary on good practices	EU level	high	short	European Commission, EUROBATS, Batlife Europe	A web page produced at the end of 2019

Target 14: Public health, environmental authorities and conservation NGOs correctly informed on risks associated with viruses carried by bats						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
14.1	Support public awareness with regards to human health risks associated with bat rabies and support efforts to avoid overreaction to incidental bat bite exposures and to develop policies for determining the fate of bats involved in contact incidents with humans (and domestic animals such as cats).	All MS	moderate	medium	EUROBATS, National authorities, Conservation agencies, NGOs	An assessment conducted for 2021
14.2	Ensure that the bat conservation and speleological societies are aware of the threat associated with the fungal infection known as White Nose Syndrome in North America and encourage liaison between them. Encourage surveillance for the presence of fungal infections in bats. Identify laboratories with facilities to identify skin fungi and refer any such fungi found on bats for identification.	All MS	moderate	medium	National authorities, Conservation agencies, Research institutions, NGOs	An assessment conducted for 2021
14.3	Ensure that reasonable advice on precautions to avoid infection is available and implemented (e.g., rabies compulsory vaccination for people regularly handling bats) including for the maintenance of colonies in buildings where rabies-positive bats have been recorded.	All MS	moderate	medium	National authorities, Conservation agencies, Research institutions, NGOs	An assessment conducted for 2021

Target 15: Increased public awareness and trainings and information for key stakeholders on action for bat protection						
No.	**Action**	**MS**	**Priority**	**Time scale**	**Responsible organizations**	**Indicator**
15.1	Continue the event “International Bat Night” on an annual basis	All MS	moderate	Ongoing	EUROBATS, NGOs	See EUROBATS
15.2	Draft and publish on the web a list of FAQ concerning solutions to problems arising from the discovery of colonies in private properties (public: owners)	All MS	high	Medium	Conservation agencies, NGOs	An assessment conducted for 2021
15.3	Training workshops, informative seminars, factsheets, etc., to involve volunteers into conservation work (e.g. monitoring of colonies, acoustic monitoring…).	All MS	moderate	long	Batlife Europe, NGOs	An assessment conducted for 2021
15.4	Development of guidelines for bat rescue centres (captivity): value and effectiveness of bat rehabilitation and care in captivity.	All MS	moderate	medium	EUROBATS, Batlife Europe, Conservation agencies, NGOs	Guidelines published by Batlife Europe for 2021

ANNEX: WORKING WITHIN THE FRAMEWORK OF EUROBATS

Meeting of Parties (MoP) and Secretariat

Since the first one in 1995, there are periodic Meetings of Parties (MoP) to this Agreement (in average every 3 years). This is the key governance place for any matter related to the Agreement. In 1995, during its first session, the MoP took the following key decisions:

- Establishment of a permanent **Secretariat** in Bonn in collocation with the CMS Secretariat ;
- Establishment of an **Advisory Committee,** which may establish working Groups, to provide expert advice and information to the Parties and the Secretariat;
- Adoption of priorities for Bat Conservation through the first **Conservation and Management Plan**.
- Proposal of guidelines for **national report** to the Parties;

Furthermore, since 2006 a **Standing Committee** was established to act on behalf of the MoP mainly with administrative matters, finance and representation. The core functioning of the Agreement remains the same today but, as described below, the Conservation and Management plan is amended during the MoP.

The EUROBATS **Secretariat's** particular tasks are to:

- exchange information and co-ordinate international research and monitoring initiatives;
- arrange the Meetings of the Parties and the Advisory and Standing Committee meetings;
- stimulate proposals for improving the effectiveness of the Agreement, and attract more countries to participate in and join the Agreement;
- stimulate public awareness of the threats to European bat species and what can be done at all levels to prevent their numbers dwindling further.

Advisory Committee and Intersessional Working Groups (IWG)

To advice the Parties and prepare technical resolutions for the MOP and the revision of the Conservation and Management Plan, there are regular (annual) meetings of the Advisory Committee. The work is prepared with working groups which organise meeting more or less regularly depending on the subjects. Even if they meet quite often during institutional meetings, they are named intersessional working groups (IWG).

Currently there are 17 IWG[63] working on different bat conservation issues.

1. Conservation of Key Underground Sites
2. Bat Conservation and Sustainable Forest Management
3. Monitoring and Indicators
4. Monitoring of Daily and Seasonal Movements of Bats
5. Autecological Studies for Priority Species
6. Wind Turbines and Bat Populations
7. Light Pollution
8. Conservation and Management of Critical Feeding Areas and Commuting Routes
9. Man-made Purpose-built Bat Roosts
10. Impact of Roads and other Traffic Infrastructures on Bats
11. Communication, Bat Conservation and Public Health
12. Bat Rescue and Rehabilitation
13. Bats and Building Insulation
14. Education
15. *Quality of Assessments and Experience and Skills of Experts*
16. Overground roosts for bats
17. EUROBATS Projects Initiative (EPI) projects' assessment group

[63] http://www.eurobats.org/activities/intersessional_working_groups

***Ad hoc* Working Groups:**

1. Geographical Scope of the Agreement
2. Amendment of the Annex of the Agreement
3. EPI Project Assessment Working Group

The minutes and resolutions taken during the annual Advisory Meeting and documents produced by the IWGs are published on the EUROBATS website (www.eurobats.org) and on an extranet platform for members of the working groups. This published material was a key source for the preparation of this EU Action Plan and relevant information is presented in the corresponding chapters.

Conservation and Management Plan

The fundamental obligations of the Agreement are described in its article III. To help apply article III and set up priorities, a **Conservation and Management Plan** is endorsed by the Parties during the MoP. Some **resolutions** concerning conservation issues and priorities are also voted during the MoP to be integrated in the Conservation and Management Plan. MoP after MoP, the Conservation and Management Plan is updated and makes reference to past endorsed resolutions. It may also make reference to other official papers as those prepared by the Advisory committee. The **current Conservation and Management Plan** was adopted in October 2018 for the period 2019-2022[64]. Apart from institutional matters, it encompasses 7 main topics:

- Legal Requirements (1 items)
- Population survey and Monitoring (27 items)
- Roosts (10 items)
- Habitats (7 items)
- Promoting Public Awareness of Bats and their Conservation and Providing advice (4 items)
- Incest decline (5 items)
- International cooperation (2 items)
- Diseases (3 items)
- EUROBATS Projects Initiative (EPI) (3 items)
- Climate change (4 items)

Details of the outcome of each IWG can be consulted on the EUROBATS workspace website[65]. Each Party has a duty to provide regularly updated **National Reports** on the implementation of the Agreement. A number of non-party Range States also provide EUROBATS with a national report.

In relation to the Conservation and Management Plan or to the work undertaken by the Advisory Committee and the IWGs, EUROBATS has already published several key documents dealing with various aspects of bat conservation[66].

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64 http://www.eurobats.org/sites/default/files/documents/pdf/Meeting_of_Parties/MoP8.Resolution%208.11%20Implemenatation%20of%20the%20Conservation%20and%20Management%20Plan.pdf

65 http://workspace.eurobats.org/node/257

66 http://www.eurobats.org/publications/eurobats_publication_series

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