Technical Guide No. 5

Elements of area conservation management

LIFE+ CHIRO MED Program
2010–2014

Intergrated conservation and management
of two bat species
The Greater Horseshoe Bat and Geoffroy's Bat
in the Mediterranean region of France

LIFE+ CHIRO MED

is a Life*+ "Nature and Biodiversity*"
Dedicated specially to two species of bats :

The Greater Horseshoe Bat and Geoffroy's Bat

Cover photo : Opus Species.

Contents

Bats, mammals that testify to the state of the biodiversity

From their position in the food chain, bats are good indicators of the ecological status of natural habitats.They are in effect directly impacted by the alteration of the ecosystems* in which they live. They are the flag bearing species* whose conservation involves many issues where man has a role to play.
In the course of the XXth century the numbers of the 34 species identified on French metropolitan territory has vastly declined. Their rapid regression has aroused, for the last few decades, an interest from naturalists and scientists who seek to better understand the problems which weigh against them. The improvement in knowledge of these problems, as well as that of the biology of the ecology of bats, allowed them to propose methods to protect them. These methods are put in place on a case by case basis or within the framework of larger programs (The Regional Action Plan in favour of bats) and for the last few years has given positive and encouraging results and reinforces the continuation of scientific and technical research.

A strong concentration of the species in the south of France

Metropolitan France houses 34 of the 41 bat species present in Europe, of which a third are threatened or near threatened[1] because of the change in their environment. The Mediterranean, the Rhone Valley and the Alps have the highest diversity.For example, the regions of Provence-Alpes-Côte d'Azur and Languedoc-Roussillon Coast are home to 30 species.But these regions also have the highest proportion of threatened species at national level. The responsibility for these regions in terms of conservation is paramount.

Services rendered* to man, and unsuspectedly, from bats

- **An economic and health issue :** All species of European bats are insectivores. They eat tons of insects during the night including some pests of cultures[2]. They therefore play a natural and free regulating role in the control of insect populations and thus contribute to reducing the purchase and use of pesticides. A study Science has been able to estimate the economy of the U.S. agriculture could reach 53 billion dollars[3].

- **A natural fertilizer :** Bat guano is a powerful natural fertilizer because of its high nutrient content.

- **Recent scientific research into future medical issues :** The special morphology and physiology of bats are studied in many fields of medical research into new technologies for the exploration of body by imaging, and are providing solutions on viral outbreaks and cancers[4].

[1] According to the International Union for Conservation of Nature (IUCN) and the National Museum of Natural History (NMNH). 2009.
[2] Jay M., Boreau de Roncé C., Ricard J.-M., Garcin A., Mandrin J.-F., Lavigne C., Bouvier J.-C., Tupinier Y. & S. Puechmaille. 2012. Biodiversité fonctionnelle en verger de pommier : Les chauves-souris consomment-elles des ravageurs ? *Infos CTIFL*, 286 : 28-34.
[3] Boyles J. G., Cryan P. M., McCracken G. F. & T. H. Kunz. 2011. Economic importance of bats in agriculture, *Science*, vol. 332 (6025) : 41-42.
[4] Zhang G. *et al.* 2013. Comparative analysis of bats genomes provides insight into the evolution of flight and immunity. *Science*, 339 (6118) : 456-460.

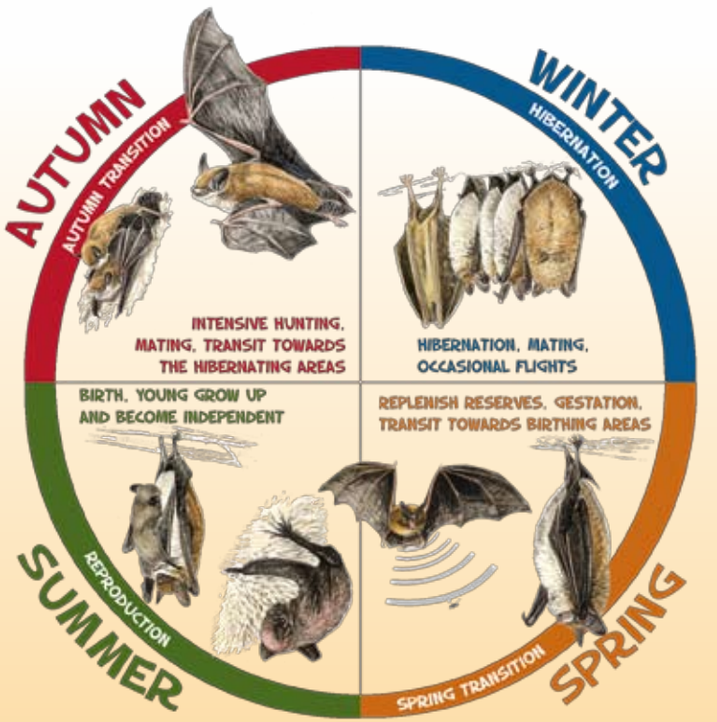
All bats are protected by law by means of :

- **International law,** by the Bonn Convention and the Berne Convention signed in 1979 and ratified by France in 1990. And by the agreement "EUROBATS*", created in 1991 and ratified by 31 countries, which commits signatory states to implement a concerted protection of the populations of bats from the European continent.

- **European Union law,** by Annex IV of the "Fauna-Flora-Habitat" Directive* (92/43/EEC) of 21 May 1992 dictates that all species of bat need of strict protection. Twelve species in France are listed in Annex II of the Directive, which lists species of community interest whose conservation requires the designation of Special Zones of Conservation (SZCs). Thus, bat populations, including their roosts and their habitats* were included in the designation of sites of the European Natura 2000 network.

- **French national law,** by Article L.411-1 of the Environmental Code and the Ministerial Decree of 23 April 2007 (Official Journal of 10/05/2007) which establishes the list of terrestrial mammals protected throughout the country and the terms of their protection. The new law now protects all species of bats currently present in metropolitan area by name, as well as the protection of breeding sites and resting places of the species, necessary for the proper performance of their life cycles.

A very specific life cycle



THE GREATER HORSESHOE BAT

The Greater Horseshoe Bat (*Rhinolophus ferrumequinum*) is the largest Horseshoe Bat in Europe. The main feature of this species is the morphology of his nose, decorated with a leaf-shaped horseshoe essential for echolocation.

Longevity : 15 to 30 years
Size : about 7 cm
Wingspan : 33 to 40 cm
Weight : 15 to 34 g
Coat : brown, more or less a type of red (dorsal) and grey-white to yellowish-white (ventral)
Ultrasound : between 79 and 84 kHz (Frequency Constant)

Reproduction : Females reach sexual maturity at 2-3 years. Their mating, in autumn, is accompanied by a winter sperm storage in females. Ovulation occurs when the sunny days return. Then their gestation lasts between 6 and 8 weeks, with a maximum of 10 weeks when spring is particularly unfavorable. From mid-June to late July, they give birth to one young per year which learns to fly at between 19 and 30 days, and is autonomous at 45 days.

Movement / Migration : A sedentary species, the Greater Horseshoe Bat rarely moves more than 100 km between breeding roosts* and hibernating roosts* passing through one or more transit roosts* (known maximum distance of travel 320 km).

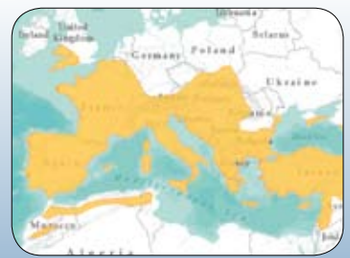

T. Stoecklé

Roosts : In summer, females settle in small groups in warm cavities (21-30°C) and often in buildings(barns, attics, hot cellars, roofs of churches, bunkers...) abandoned, maintained, or new, to give birth and raise their young until emancipation. Males generally pass summer alone.
In winter, the species hibernates from around October-November to April in natural or artificial underground cavities (mines, quarries, caves or cellars) which possess total darkness, a temperature between 5°C and 12°C, humidity at saturation, light ventilation absolute tranquility. These bats hang by the feet (typical of Rhinolophidae).

Hunting Grounds : Essentially wooded (riverine woodland, deciduous forest) and pastureland's surrounded by hedges. Hedgerows are very important for their resources of prey on one hand and also especially as travel corridors on the other (*see* Technical Guide No. 5 "Elements of area conservation management").

Diet : In general, the species feeds on dung beetles (beetles and dung beetles) and nocturnal Lepidoptera, but can also consume Orthoptera (grasshoppers, crickets), Trichoptera, flies, spiders, etc. (*see* Technical Guide No. 5 "Elements of area conservation management").

Distribution : Populations have much reduced in the northwest of Europe during the last century, sometimes completely disappeared (Belgium, Netherlands, Malta) **The epicenter of the European** distribution is in the **Mediterranean basin**.



Map source : IUCN (International Union for Conservation of Nature) 2008.
Rhinolophus ferrumequinum. In : IUCN 2013. IUCN Red List of Threatened Species.

GEOFFROY'S BAT

Geoffroy's Bat (*Myotis emarginatus*) is medium in size with a distinct indentation, almost at right angles to the outer edge of his brown ear. His coat has a dense woolly appearance, red on the back, lighter on the belly (not much contrast).

Longevity : up to 18 years
Size : about 4-5 cm
Ears of medium size : from 1.4 to 1.7 cm
Wingspan : 22 to 24.5 cm
Weight : 6 to 15 g
Tragus* : sharp and does not reach the top of the notch in the ear
Ultrasound : begins at 140 kHz and ends to 38 kHz (Frequency Modulated Steep)

Reproduction : Mating take place in autumn. The females store sperm until spring. Ovulation occurs when the warm days return, and birth of one single young per year takes place between mid-June and late July, after 50 - 60 days of gestation. The youngster is capab e of flying at the age of 4 weeks.

Movement / Migration : A largely sedentary species. The distances between summer roosts and winter roosts is generally less than 40 km (maximum known movement : 105 km).

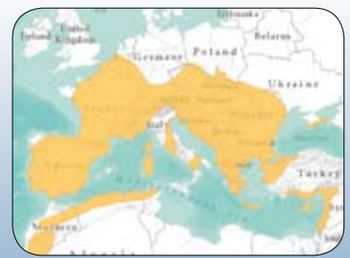

B. Morazé

Roosts : The breeding roosts are mainly attics or lofts but can be barns, caves, or bunkers as in the Camargue, temperate (23-27°C). Females congregate in swarms of 50 to 600 individuals. Males generally pass summer alone. In winter, the species hibernates in caves, quarries, mines and large caverns which have total darkness, a relative humidity close to saturation, temperature below 12°C and almost no ventilation.

Hunting Grounds : Mainly forest or wooded areas, deciduous or mixed. However this species also exploits parks and gardens, large isolated trees or small patches of vegetation, stables, pastures, groves, areas above rivers and also, in the Mediterranean, traditional olive groves, coniferous forests and orchards (*see* technical Guide No. 5 "Elements of area conservation management").

Diet : Very specialized, it is composed mainly of spiders, harvestmen and flies, supplemented by Coleoptera, Hemiptera and Neuroptera. In the Camargue there is a local particularity as it is composed mainly of spiders and Odonata, an abundant food resource in the area (*see* Technical Guide No. 5 "Elements of area conservation management").

Distribution : The species shows a very heterogeneous distribution over its entire range. In France there are strong disparities depending on the region. **The south of France** has a low population in winter but a **high population in summer**.

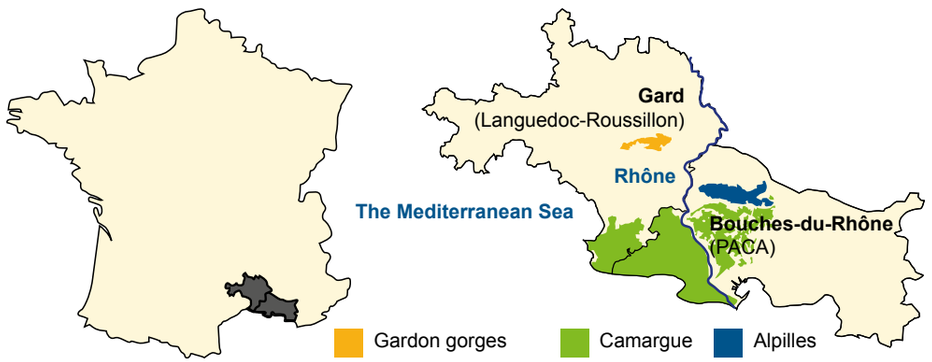


Map source : IUCN (International Union for Conservation of Nature) 2008.
Myotis emarginatus. In : IUCN 2013. IUCN Red List of Threatened Species.

THE EUROPEAN LIFE+ CHIRO MED PROGRAM (2010 – 2014)

The LIFE+ CHIRO MED program (www.lifechiromed.fr) focuses on the conservation and integrated management of two species of bats, the Greater Horseshoe Bat and Geoffroy's Bat, in the French Mediterranean region. The objective of the program is to understand and to preserve each required biological compartment necessary for the annual cycle of local populations of the two targeted species. The strong anthropisation of targeted territories and interactions between the species and humans necessitates an implementation of concerted actions, most importantly close to human activities.

The program focuses on three geographic areas, the **Camargue**, the **Alpilles** and the **Gardon gorges**, and eight sites of community interest, called CIS. In effect in the French Mediterranean region, the main populations of the two species targeted by the program are concentrated in these three territories. In winter, these species hibernate in the cavities of the Gardon gorges and the Alpilles, while in summer they come to feed and reproduce in the Camargue.



The program allows, through 29 actions, to unite technical competence and territorial jurisdictions to overcome the **five major threats to these species :**

- *Threat 1* : the loss and alteration of hibernation and breeding roosts.
- *Threat 2* : the loss and alteration of habitats used as feeding sites (hunting grounds) and travel corridors.
- *Threat 3* : dwindling food resources related to the use of pesticides and modification of agro-pastoral practices.
- *Threat 4* : road deaths.
- *Threat 5* : an ignorance of bats which generates unintended destruction.

To address these threats to the two target species also means protection a large number of other species and their habitats. These are referred to as "umbrella species".

CONSERVATORY MANAGEMENT

Understand the use of areas to preserve them

The conservation of bats requires the consideration of multiple intervening factors throughout their life cycle*, which deeply connects their biological needs to their environment. Their remarkable ability to move about, and the constant constraints on their energy means there is a need **to identify the "key" elements or factors** to better understand their lifestyle, and prioritise the protective measures to be implemented to preserve them. Since 1999, two National Action Plans for the protection of bats, broken down into regional Action Plans, have structured **a global approach with multiple criteria's towards the protection of bats in France**. Many of the actions of LIFE+ CHIRO MED are included in the objectives of the Action Plans and permit the establishment of a management which is local and in the context of the area.

The acquisition of local knowledge is a prerequisite for the definition of conservation measures. Recently, the techniques for the study of bats has allowed a better definition of the status and needs of a population. Geoffroy's Bat and the Greater Horseshoe Bat have been studied in Europe for several years, but their biological characteristics in the Mediterranean region are little known. This guide provides **a methodology and concrete measures for the management of areas in a way that is favourable for both species**, in the context of the Mediterranean, through the example of the Camargue-Crau-Alpilles-Gardon sector (CCAG).

For each of the two species studied in this program, a management approach is proposed from the scientific knowledge acquired in vital areas*, roosts, hunting grounds, the use of corridors and food resources. This knowledge is derived from the bibliography or studies carried out under the LIFE+ CHIRO MED program. Conservatory management should integrate the determining biological and anthropogenic factors which maintain the populations of the target species.

Ultimately, it is up to local managers of natural and economic areas, such as parks and syndicates, to prioritise their policy and management actions to maintain the Man-Nature balance that today, many species depend directly on. It is therefore the real choices made by these managers that will determine the future presence or absence of sensitive species. The results of the Life+ CHIRO MED program provide the tangible elements that managers can use to feed their decisions and take concrete actions.

Objectives of the LIFE+ Chiro Med program

The LIFE+ Chiro Med enabled the implementation of various protective actions in a sector which is made up of the Camargue area, the Crau, the Alpilles and the Gardon. Several actions were aimed at understanding the use of this area by the two species throughout their vital life cycle, especially the roosts that were used in summer and winter, hunting areas, and their movement from place to place.

Table 1 : The actions of the LIFE+ Chiro Med program related to the management of areas.

Area of Action	Goals	Related Actions
Roosts	Understand the use of roosts over the summer and winter periods.	A3
	Use the knowledge gained to improve the searches for roosts.	A3 A4
Habitats / Resources	Identify and locate preferential hunting grounds.	A5 A7
	Know the nature of prey and associated habitats.	A8
Corridors	Locate and characterize the corridors used for movement.	A5
	Restore corridors and improve the functionality of the network.	C4
Global approach	Suggest a holistic diagnosis of an area for the Greater Horseshoe Bat and Geoffroy's Bat.	A7

Conservation of bats : What is the home range ?

Targeting conservation measures and defining useful actions involves knowing the needs of the species, in space and time. If the complete study of a species within its vital domain is long and complex, it is possible to look at a fraction of this cycle, to obtain representative results for the species in the context of a given landscape. For bats, reproduction is the period of maximum activity and is best suited to field studies. Indeed, pregnancy and lactation result in significant energy expenditure and females actively hunt in the spring and summer to meet their needs, and those of their young. They cover a large area at this time and leave their **breeding colony*** daily to hunt in areas rich in insects.

The radius of action of individuals around the breeding colony, called the **summer home range***, leads to the identification of their needs in terms of shelter in specific environments for that period. The summer home range is the space required for the completion of the cycle of reproduction and is therefore considered as a priority area for conservation. In the Camargue, studies have led to the definition of this area (*see* Table 2).

Estimate the home range of a breeding colony

Home ranges of males during parturition and all individuals outside the period of reproduction must be added to that of the breeding females to define the home range of a given population. However, they can not currently be determined without a significant investment and do not represent the same crucial issue as that of groups of breeding females. Thus, to simplify and define our management approach, **the home range studied (*see* Figure 1) and referred to in this guide is one of a group of females and their young in the heart of a given colony,** during a period of birth and care of the young. The first step was to reference the studies previously carried out on the species and pull out information that was useful and applicable to the area concerned. However, bats adapt to a local context and an in situ study is often essential to collect original and reliable information. Monitoring of individuals by **telemetry*** (A5) can locate their hunting grounds and **corridors***, to find new roosts and measure their radius of action. From the locations of individuals, we can map the summer home range of the colony, called the **MCP*** (Minimum Convex Polygon). This method uses point technology : miniature radio transmitters are placed on the backs of animals, and a system for receiving and tracking is used to follow them through the night. Study sites are generally breeding colonies in summer because the females are very active. Males are rarely included as they move very little during this period. Studies show that following ten individuals for 10 to 15 consecutive nights gives representative results. Handling and marking bats requires ministerial authorisation.

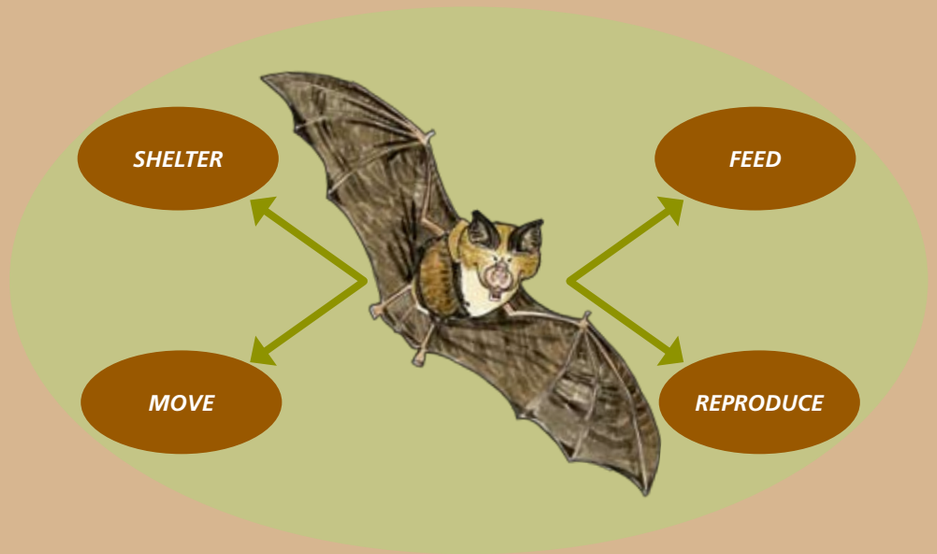


Figure 1 : *The home range should allow a population to survive and reproduce, fulfilling its primary functions year after year. This is the area, as a whole, to be considered in terms of the conservation of individuals in a population of a species, or a group of related populations.*

Table 2 : The radius of actions of adults and young Greater Horseshoe Bats and Geoffroy's Bats measured in the Camargue, around their breeding colony.

Radius of action	Greater Horseshoe Bat *ADULT*	Greater Horseshoe Bat *IMMATURE*	Geoffroy's Bat *ADULT*	Geoffroy's Bat *IMMATUR*
Average	4,8 à 5,3 km	3 km	4,2 à 5 km	3 à 6 km
Maximal	21 km	9,5 km	11 km	8 km

The young, active in late summer and less effective at hunting and flying, are dependent on a favourable environments, rich in prey, near the colony. It is important to take into account their range of action because their requirements may be different from those of adults. This is a fundamental given to implement efficient management around a colony.

If parturition is a critical period for the dynamics of a population, **the entire life cycle should be considered in envisaging their long-term maintenance**. Males move very little in summer, but they have an extended home range in autumn as they migrate towards other populations at mating time, thus ensuring genetic mixing. In winter, males and females return to hibernate at underground sites. All the hunting grounds and the roosts used throughout the year are known as the **annual home range***. It is estimated that the **radius of a breeding colony of Greater Horseshoe Bats is on average 60 km** (maximum known is 500 km) and **20 km for Geoffroy's Bat** (maximum known is 126 km, Hutterer *et al*. 2005). Across an administrative region, these radius's of action cover a large territory and home ranges of populations overlap, which implies that management conducted locally can have beneficial effects on neighbouring populations (*see* Figure 2). In the CCAG sector, movements of 80 km between winter and summer roosts are known of by the Grezter Horseshoe Bat (former colony of Aigues-Mortes from which some individuals hibernated at Saint-Hippolyte-du-Fort).

The LIFE+ Chiro Med in numbers

Two mixed breeding colonies (Greater Horseshoe Bat and Geoffroy's Bat) were monitored, 60 nights of telemetry divided into 4 sessions over two years, 34 Greater Horseshoe Bats and 25 Geoffroy's Bats were studied, many observers participated making a total of 600 man-nights. Transmitters used varied from 0.5 g to 0.7 g (Biotrack Ltd, UK and Titley Scientific, AU) depending on the weight of the individual.

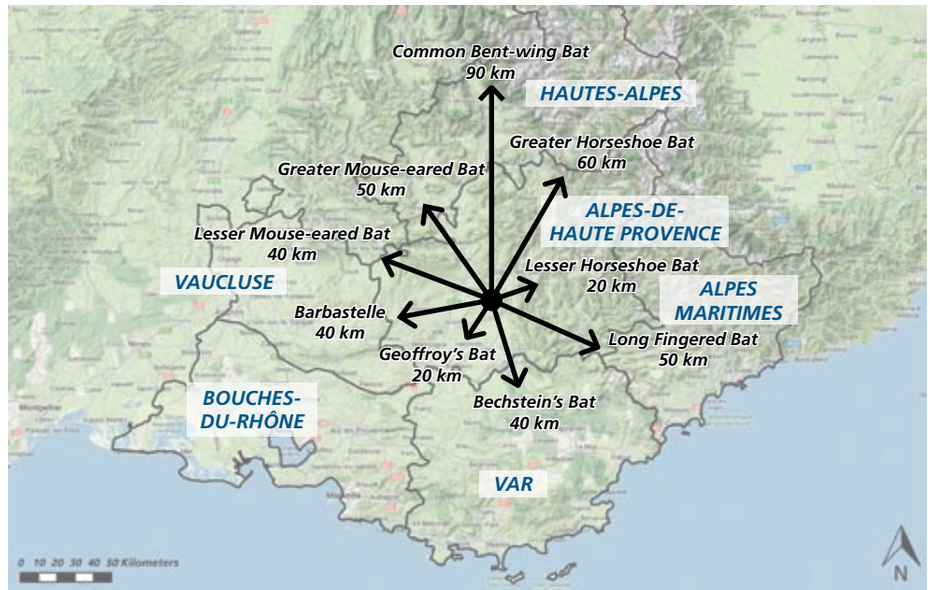


Figure 2 : *Theoretical radius of annual home ranges around a breeding colony of some species of bat in the PACA region*

MANAGEMENT APPROACHES

Two home ranges enables two levels of conservation for the Greater Horseshoe Bat and Geoffroy's Bat in the sector Camargue- Crau-Alpilles-Gardon :

- In the short term, to support breeding colonies of both species, the minimum spatial scale for the design and implementation of measures is a 5 km radius around the colonies, focusing on an area of enhanced protection of 3 km for the young.
- In a broader perspective, to maintain the population of a colony in the long term, the minimum scale to cover an annual home range is a 60 km radius, targeting the transit and hibernation roosts and landscape structures used for displacement.

A network of roosts indispensable for various functions

Bats obey variable physiological constraints that lead them to use several types of shelters, called **roosts** (*see* Table 3 and Technical Guide No. 3 "Developing roosts suitable for breeding"). Under the protection of species and their habitats (Ministerial Decree of April 23, 2007), these roosts are named by type of habitat for the species, such as : **"Breeding Site" (BS)** or **"Rest Area" (RA)** :

Table 3 : Description of different types of roosts used by bats.

Type of roost	Functions	Periods of occupancy
Breeding roost (BS)	Home to the breeding colony, mostly female adults and young of both sexes. This is the area where they go through gestation, parturition and lactation until the emancipation of the young.	DAYTIME (adults and young). NIGHT TIME (the young and some adults). Middle of spring to late summer .
Satellite roost (BS related to the main colony)	Shelters some individuals, often pregnant females,and sometimes the young. Near the favourable hunting grounds and the mother colony, it is occasionally used to reduce the journey to the breeding roost.	DAYTIME Mid spring to late summer NIGHT TIME sometimes the young
Resting Roost (RA)	Shelters of a highly variable nature designed for rest, digestion and grooming of both sexes between hunting during the night or during the day. Often located close to hunting grounds .	DAYTIME AND NIGHT TIME Spring-summer : in hunting season.
« Swarming » or mating roost (BS)	Roost where individuals of both sexes gather for mating. It is in these roosts that the gene transfer takes place. The Greater Horseshoe Bat does not seem to follow this behaviour for mating.	NIGHT TIME Autumn and early winter, during the night.
Spring transit roost (BS)	Gestation, rest before gathering in the breeding colony.	DAYTIME Spring.
Transit roost (RA)	Shelters individuals in transit outside the breeding and hibernation seasons. From a few individuals to several hundred, often in lethargy.	DAYTIME Autumn and spring.
Hibernation roost (RA)	Shelters individuals in lethargy during the winter by providing calm and coolness. A few individuals to hundreds.	DAYTIME and NIGHT TIME winter

The presence of all these roosts is essential to maintain the local population of bats. Studies in the UK show that the optimal network of roosts around a breeding colony of Greater Horseshoe Bats consists of : several satellites roosts, rest and transit roosts within 4 km, several hibernation and transit roosts within 60 km and at least one dedicated breeding roost within 95 km (Ransome & Hutson 2000). The Camargue context seems to confirm these results with several satellites or reproduction roosts within 5 km, and hibernation roosts in a radius of 60 km. No breeding roost is known of to this day.

Roosts and population dynamics

The assessment of the **genetic diversity of some major colonies** can give good picture of the health and the history of the population. The results of action A3 show that the Camargue breeding population has high genetic diversity and could be regarded as a "reservoir" for the populations from the surrounding area. Thus, this data on the diversity helps to both **prioritise emergency actions for the on the weaker colonies** (the Greater Horseshoe Bats in the Alpes-de-Haute-Provence, little diversification) and to implement **actions of reinforcement for the fastest growing populations, enabling the support of nearby regional populations by emigration** (the Greater Horseshoe Bat in the Camargue, very diverse).

In the home range studied, to know where the roosts are and to understand their network and their functions allows for the prioritisation of the shelters necessary to the species (*see* Figure 3). In the Camargue, we today know of a breeding point located on the delta, surrounded by a wreath of potential hibernation roosts. **Maintaining the integrity of this network of various roosts, adapted and accessible is a key goal for the conservation of populations.**

Opus Species

Find roosts and establish their function

A good knowledge of the roosts in an area requires specific research. One methods is to conduct surveys of buildings and natural and artificial cavities in collaboration with local stakeholders (A4) : the owners, operators, managers... When roosts are identified, there are several methods to understand their functions and their inter- connections.

The presence of individuals, or evidence of presence (guano, insect remains) and the period of occupancy provide initial information on the use of and frequentation of the roost by bats (*see* Table 3) .

Telemetry (A5) can be used to track individuals (*see* photo 1) who sometimes use several roosts and even several breeding colonies. This method is very effective in the underground environment is limited in duration (15 days of battery life) but it does **lead to the discovery of many roosts**. Individual banding associated with a protocol **Capture- Mark-Recapture*** (CMR), was formerly used to track individuals in their network of roosts but it causes lesions, particularly in Greater Horseshoe Bats, and today is not recommended.

Photo 1 : *observer and reception equipment when monitoring via telemetry.*

Recently, advances in genetics allows for the creation of a virtual CMR protocol, **identifying animals by their DNA** which is contained in their droppings (A3). Guano collected from a breeding roost permits the genetic identification of individuals who go there regularly (*see* Figure 4), thus creating a **genetic signature*** of the colony. Thereafter, droppings collected in a new roost are analysed. This unknown DNA can then be compared to a previously identified signature and the relationship between the two roosts can be established.

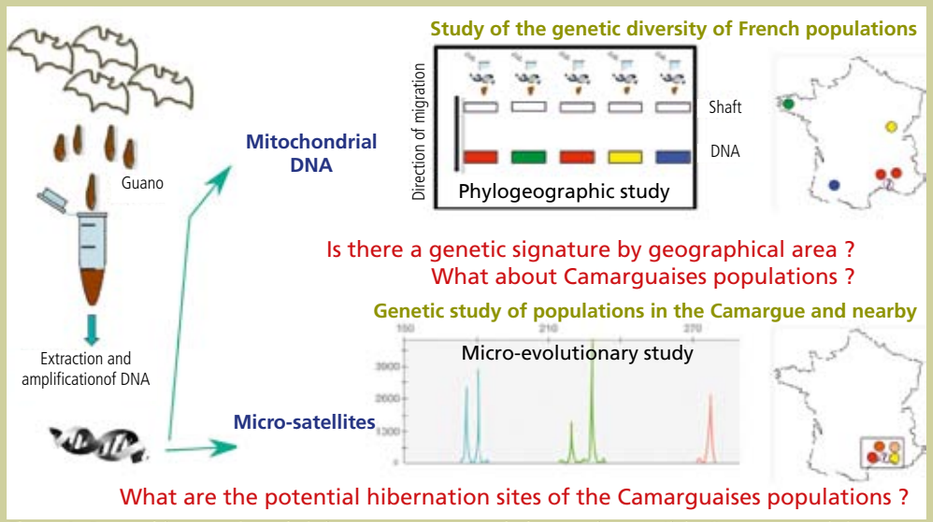


Figure 4 : ***Protocol for genetic analysis from guano to research the use of roosts.*** *If the Camargue populations are old and structured, then the breeding roosts may have their own genetic signature.*

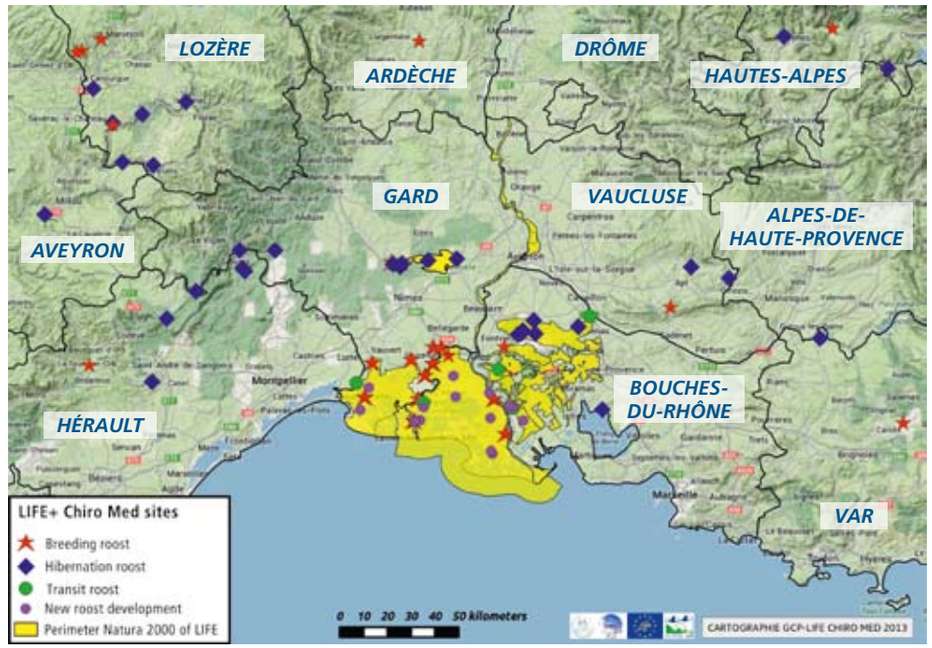


Figure 3 : *Network of roosts used by populations of Greater Horseshoe Bat : Example of system Camargue-Crau-Alpilles-Gardon.*

The LIFE+ Chiro Med in numbers

In 2005, no breeding colony of either of the two species was known of in the Camargue area. In three seasons of study (surveys and especially telemetry) 7 breeding colonies have been identified totalling more than 700 Greater Horseshoe Bats and 1 200 Geoffroy's Bats.

It is estimated that 50 sets of droppings were analysed by species to genetically characterise one breeding colony of about 300 individuals. During the program, 56 roosts of all types were sampled and 975 sets of droppings were analysed. The cost of the analysis currently amounts to 13€ per dejection (study carried out by the laboratory IMBE of the University of Aix-Marseille, team : Evolution - Genome - Environment, Dr. Caroline Costedoat).

MANAGEMENT APPROACHES

- Area survey (A4). Collection of evidence and identification of roosts in use or potentially used, and evaluation of their functions.
- Search for roosts by telemetry near a known colony (A5). It is wise to focus on a mobile species that use numerous roosts (*eg.* Geoffroy's Bat) in the period during which the colonies begin to spread, namely the end of the summer.
- Secure the identified roosts (A1) with managers or owners for monitoring and protection. Regular monitoring is an indispensable action since buildings change rapidly : in 3 years, 5 out of 7 colonies have disappeared or deteriorated sharply (renovations of buildings, disturbance of the animals). An agreement with an owner or manager is a first step towards sustainable conservation.
- Integration of roosts over the entire life cycle by reflective management (A3). Systematic harvesting of guano in different roosts has been used to establish genetic links between them, and thus to identify the network. In the Camargue-Crau-Alpilles-Gardon sector, analysis of guano have linked breeding colonies from the Camargue to hibernation sites located in the Alpilles and the Cevennes.
- Possible work to improve the conditions of the roost and its quality to attract bats (C1 and see Technical Guide No 3 "Developing roosts suitable for breeding"). It is important to anticipate the future, and the possible degradation of occupied breeding roosts, to maintain the network.
- Creation of new roosts available for Greater Horseshoe Bats and Geoffroy's Bats (C2 and see Technical Guide No 3 "Developing roosts suitable for breeding") to improve the network of roosts. It is important to predict the possible disappearance of favourable roosts and create in advance substitution roosts. However, the occupied roosts are by definition more favourable to the species , and should therefore be kept in priority.

LOCAL CONTEXT OF THE PROGRAM

Good quality and available resources

Environments

In periods of high physiological activity, bats face constraints in terms of energy such as the availability of insect prey which can affect, in a few months, their reproduction and survival. Opportunistic insectivores or specialists, they know their environment and know in which areas to find their **food resources**.

The Camargue-Crau-Alpilles-Gardon sector has a wide variety of environments including a part which is halophilic. From this range, **the environments most exploited for hunting by one or the other of two species** (*see* Table 4) **were identified using telemetry** (A5) for two colonies, namely G01 and G03, and mapping of land use. A first analysis comparing available environments to those used allows us to highlight favourable environments.

Table 4 : Favourable environments in the Camargue for either of the two species of bat.

Habitat	Description
	**Riparian forest** Woodlands of white poplars, white willow, ash, alder.
	**Grassland environment** Open or semi-open meadows, grazing for cattle and horses.
	**Wetlands** Freshwater environments herbaceous vegetation, often grazed (cattle and horses).
	**Orchards** Apricots, quinces, cherries, plums, almonds.

The results show, consistent with previous studies, the environments most attractive to bats in the study area. However, **the telemetry data can be used in an optimum fashion with high resolution maps**, and to procure finer results on the environments exploited.

The identification of preferential hunting grounds requires a good prior knowledge of the environments present on the territory. **A recent mapping of the habitat, on a fine scale** and which covers all the study area is an **indispensable tool**. Under LIFE+ Chiro Med, the Joint Association for the Protection and Management of the Camargue Gardoise (SMCG) coordinated the development, by the expert Alisé Geomatics, a map of this type (*see* Figure 5) to a scale of 1/2500 as well as a database of hedges (linear) and isolated trees (single element) (A5), from orthophotos and field visits (*see* photo 2).

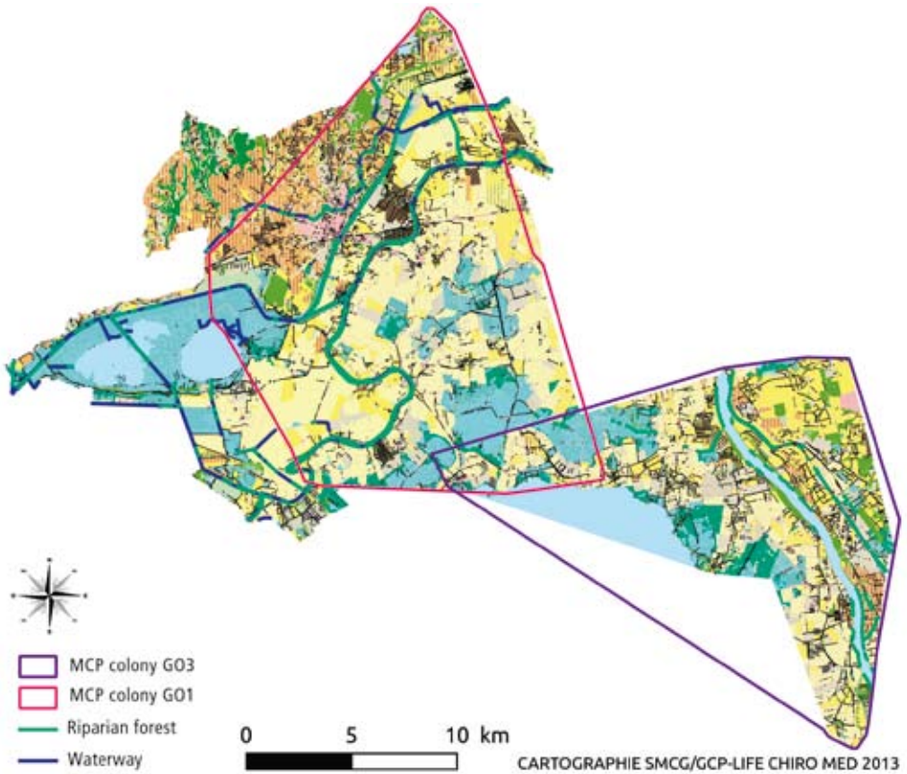


Figure 5 : *Mapping of habitats to a scale of 1/2500. The zones to be mapped are defined by the MCP of the two colonies and are sometimes extended beyond this when potentially supportive environments are present.*

Analyses of hunting sites and conclusions on supportive environments for both species have been refined in the framework of action A7, and are presented in the chapter entitled "Global Approach" in this guide.

Photo 2 : *Photo-identification of vegetation by infrared photography (left), field visits with laptop equipped with mapping software, to verify identifications made using photos and to identify non-visible elements in photographs (right).*

Food resources

In addition to its nature, the **quality of the habitat as a "producer of food resources"** should be taken into account. Knowledge of the diet of local populations of bats, combined with an understanding of human activities, permit's the evaluation and improvement in the availability and quality of these resources. For example, it appears that a lowering in the consumption of insects in the meadows in late summer for the individuals of colony G03 reflected a decline in **productivity of these environments in the prey on offer**, which was probably due to the summer drought. In addition, individuals from this colony used twice the number of hunting sites than colony G01, which does not seem an optimal strategy given the cost in terms of energy of travel in flight. These observations can be explained by a need for bats from G03 to increase their search for various food sources in an environment less rich in insects.

In the Camargue-Crau-Alpilles-Gardon sector, Greater Horseshoe Bats feed primarily on prey associated with woodlands (Lepidoptera, Diptera) or grassland habitats (Hemiptera, Hymenoptera, Coleoptera), including dung eating species. Geoffroy's Bat feeds on arthropods associated with dense vegetation, woody or not (Spiders, Diptera) or wet (Odonata). Detailed results are available in the specific activity reports (*see* technical report A8).

Another example illustrates the need for a concluding diagnostic of the existing environment. Greater Horseshoe bats eat 5 to 10% of the dung insects in the Camargue (A8.1), which is a little lower than in other regions of France and Europe (7 to 27% in Brittany). This can on one hand be explained by the **strong entomological diversity in the Mediterranean**, offering a greater range of potential prey compared to other regions further north. On the other hand this observation also raises questions about local practices in cattle and horse breeding, which may have had a recent impact on populations of dung insects in the Camargue (anti parasitic treatments recently given to many cattle in the Camargue). This hypothesis was the motivation behind an action by the LIFE+ Chiro Med program to **assess the reality of the presence of insects associated** with this activity (A8.2, *see* Technical Guide No. 2 "Management of bovine parasites and wildlife coprophagia").

The example of Geoffroy's Bat in the Camargue also illustrates the importance of understanding populations at a local level. Indeed, we found 13% of their diet was Odonata (dragonflies and damselflies), which had never been shown before (*see* Technical Report A8).

The LIFE+ Chiro Med in numbers

Acquisition of a magnifying binocular 1,800€ and the creation of a reference collection of local insects ; 64 collections of guano organized in 16 trips between June 2010 and September 2011 and 960 sets of droppings analyzed for macro-remains of insects. The Barcoding, capable of genetically determine species, genus or family of insects in the guano, has not been tested.

MANAGEMENT APPROACHES

- Identify areas used for hunting and localize these environments across the home range using suitable tools and methods (telemetry, mapping, etc.).
- Assess the quality of the environment in terms of the production of food resources and identify threats that exist (high pressure of degradation) : trapping insects, identification of human activities and the presence of potential pollutants (pesticides , insecticides for example).
- Assess the availability of environments and resources. Know the distances to the colony, highlight the real possibilities of access to food resources.
- Put in place sustainable protection for the resource habitats which are particularly fragile or rare (Prefectural Order for the Protection of Biotope, nature reserves, or other protective measures, physical or regulatory).
- Encourage local stakeholders, users and managers of spaces to conserve environments that are favourable for bats, and to use sustainable practices in the human activities identified (contracting, catering, entertainment, communication).

How to facilitate displacement and re-establish continuities ?

Bats use a variety of linear landscape elements when they move about. **Ensuring protection against predation, weather, and also serving as a reservoir of food, borders and hedges are essential** to the ecological functionality of the territory. Across the summer home range, we talk about biological corridors : they are often made up of linear woodland (hedges, borders, trees in alignment). On a broader scale, such as the annual home range, these are the macro elements of the landscape such as strings of forest or wooded valleys that maintain ecological continuity between winter and summer regions.

The optimal configuration of **an efficient network of corridors consists of a liaison between a breeding colony, all the land used for hunting, and annex roosts** (for transit, resting, mating). The presence of this network is essential within 2-3 km of the colony. In addition, the corridors adjacent to the colony (within 500 m) are essential because they guide individuals to favourable habitats and they especially protect the young when they are learning to fly. When the network is degraded, it can be improved by a process of restoration, enclosures or plantations. Indeed, a default corridor can lead bats to make significant detours (several kilometers), or to approach the ground which can be deadly when crossing roads (*see* Technical Guide No. 1 "Systems to help with the crossing of roads").

Identify the corridors

Detailed mapping can help you identify and make a diagnosis, around a breeding colony, all the corridors that need to be maintained or improved to ensure the functionality of the home range. Locating and assessing the quality of corridors should be a constant concern in various studies (telemetry, inventories).

Identified passages do not all have the same importance and an assessment of the frequency and the type of transition is essential. Visual identification methods can then be used (imaging), and ultrasound recorders to qualify and quantify the activity of bats. These techniques have been implemented for actions related to the crossing of roads by LIFE+ Chiro Med (A6, C3, E5, *see* Technical Guides No. 1 "Systems to help with the crossing of roads" and No. 6 "Imaging techniques in the service of conservation").

Other landscape elements associated with urbanisation hinder the movement of bats (linear infrastructure, towns...). A vision of the territories through the green and blue networks (TVB - www.trameverteetbleue.fr) as well as the black network often raises awareness of the impact of discontinuities on the populations and to reconcile anthropogenic development with the preservation of functional ecosystems (*see* Technical Guide No. 1 "Systems to help with the crossing of roads".

The LIFE+ Chiro Med in numbers

Over 20 km of hedgerows have been planted under LIFE+ Chiro Med (C4, *see* Photo 3) over the whole of the Crau-Camargue-Alpilles-Gardon territory. Species which were local and adapted to the climate were favoured. A technical guide summarizes the species chosen for these plantations, the practices implemented and their cost (Vigot 2010).

***Photo 3 :** Hedge plantation realised by the LIFE+ Chiro Med program at various sites, prioritizing areas near highlighted breeding colonies and hunting grounds.*

MANAGEMENT APPROACHES

- Make a diagnosis of the network of corridors and the continuities on the territory at different levels (*see* Technical Guide No. 1 "Systems to help with the crossing of roads").
- Maintain as a priority a good quality and functional network in a 3 km radius around the colonies, with particular attention and effort made for the first 500 meters.
- Improve the efficiency of the network of hedgerows and linear woodland by plantations (C4) or specific amenities to help with crossing discontinuities (C3 and *see* Technical Guide No 1. "Systems to help with the crossing of roads").
- Protect the existing network and anticipate degradation in advance when there are urban development projects.

The approach to the management of a territory in order to protect bats requires the taking into account many parameters, which need to be included in an effective, realistic and applicable plan made in context with the locality. Current techniques and software tools allow for the collection and cross checking of various information from the field, and to process it to extract the **"key" elements involved in observed biological phenomena**. Figure 6 shows a flow chartdescribing the overall approach. Action A7 of LIFE+ Chiro Med aims to establish a procedure combining statistical tools and Geographic Information Systems (GIS), called a "landscaping model", which aims to guide a manager in his choices concerning the management of a species. The example of the Greater Horseshoe Bat and Geoffroy's Bat helped build and test this procedure.

The two colonies studied by telemetry, G01 (west of the delta, along the Petit Rhône) and G03 (east of the delta, along the Grand Rhône), were made subject to the model which integrates mapping of the area.

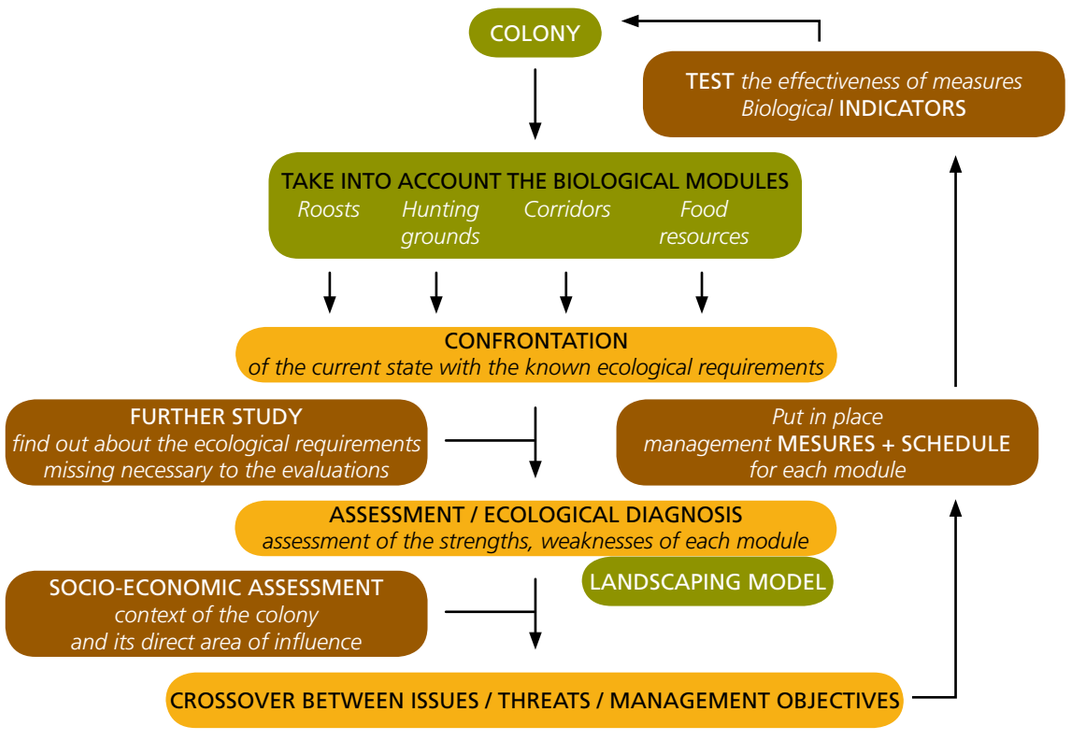


Figure 6 : ***Global Approach to managing a territory in order to protect bats.*** *The first step consists of a compilation of knowledge on the 4 modules of the biological cycle of the species. An ecological analysis can then be performed with the help of a landscaping model (Action A7). Enriching knowledge in a local context, this diagnosis allows you to define objectives and management measures. Finally, it is important to plan for follow up testing of these measures through monitoring of the colony, as well as looking for areas for improvement.*

The dual benefit of this tool is the added ability to prioritise conservation measures and reduce the in situ studies which are needed to feed the model with proven data. The research into the ecological requirements of the species is often fragmented by habitat type or resources to facilitate analysis (*see* Figure 7). The landscaping model meanwhile takes into account the different variables simultaneously and thus their possible interactions, **allowing the most important factors to be highlighted**.

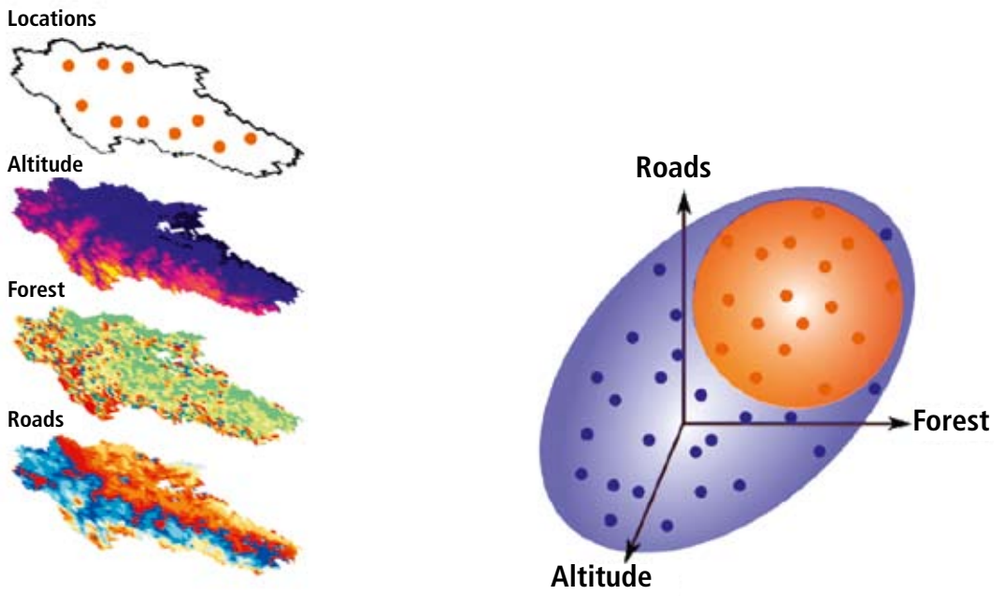


Figure 7 : *The landscaping model can take into account all the physical variables to determine accurately the potential ecological niche of species (orange area) within the home range (blue area) and prioritize the role of these variables in the conservation of these species.*

The key elements in the Carmargue

At the end of the analysis, the variables that best explain the distribution of the two species can be considered the most important levers for their conservation. These variables in the complex geographic of Crau-Camargue-Alpilles-Gardon are listed in Table 5. For each of them, an explanation of their role is given from knowledge of the biological needs of each species. The effect of these variables can sometimes be different from one colony to another.

Table 5 : List of variables that best explain the distribution of hunting sites of the Greater Horseshoe Bat and Geoffroy's Bat around the two colonies studied. +++ : Much sought after element, ++ : sought after element, + : important element whose involvement is unclear. The percentages (%) indicating the proportion of the surface of a habitat in relation to the surface of the MCP for each colony. The symbols ¤ ¤ and ¤ represent the explanatory variables and are included in the paragraphs that follow the table below.

Variables of interest	*Greater Horseshoe Bat*	*Geoffroy's Bat*	Differences inter-colony
Riparian woodland ¤ ¤	+++ Hunting ground productive in Lepidoptera and dung insects, often present in uncontinuous lines in the Camargue and used as a corridor.	+++ Hunting ground productive in Lepidoptera, Spiders, Diptera and dung insects, often present in continuous lines and used as a corridor. Highly sought after.	Little, this habitat is very little represented (< 1%) around the two colonies, yet very sought after by both species studied, especially for the G03 colony.
Distance to the colony ¤ ¤	+++ The hunting sites close by are very often selected.	++ The hunting sites close by seem to be selected but the distance seems to be less of a constraint than for the Greater Horseshoe Bats.	Yes, the distance to the colony determines the choice of hunting sites for both colonies. More especially for the G01 colony.
Dense deciduous woods ¤ ¤	+++ Hunting ground productive in Lepidoptera and dung insects, sometimes pasture so rich in dung insects.	+++ Hunting ground productive in Lepidoptera, spiders and dung insects, sometimes pasture so rich in dung insects.	Little, this habitat is distributed similarly around the 2 colonies (< 5%) and it is very sought after by both species, a little more for G03 .
Sparse deciduous woods ¤ ¤	++ Ground rich in various insects.	+ Ground rich in various insects	Yes , both species select this habitat more especially G01, and very little for G03.
Semi- open grasslands ¤	++ Herbaceous pastures rich in dung insects, Diptera and Hemiptera, Hymenoptera.	++ Herbaceous pastures rich in dung insects, Diptera and Spiders, Odonata Anisoptera (*Sympetrum sp.*).	Yes, this habitat is 10 times less represented around the colony G03. Geoffroy's Bat from colony G01 seek this habitat more actively. Greater Horseshoe Bats show no differences between colonies.
Orchards and vines ¤	+ Area rich in various insects, linked to wooded and grassy areas, and often grazing pasture.	+ Area rich in various insects, linked to wooded and grassy areas, and often grazing pasture.	Yes, for Greater Horseshoe Bats only. Those from G01 select this habitat. Habitat well represented (> 5%).
Parks and gardens ¤	+ Area rich in various insects, linked to areas of trees and grass.	++ Area rich in various insects, linked to areas of trees and grass.	Yes, Geoffroy's Bat from the colony G03 select this habitat, but not those from the colony G01.

Undeveloped areas

Analysis suggests that certain types of habitat are mainly avoided. Interpretations are not always obvious at this stage of analysis, and may reflect gaps in quantity or availability of resources in these habitats, or individual habits. Thus, **the following areas are mainly avoided** :

- **Reed beds** by both species of colony G03. However Greater Horseshoe bats of colony G01 seem to exploit reed beds a little.

- **Roads** by individuals of colony G03. There seems to be some attraction to roads by the colony G01. It is possible that the roads, which release during the night the heat that has built up during the day, attracts insects and thus bats, it is also possible that the result is biased. A first bias may be due to the location of the roads, often close to riparian woodlands. These are very popular, many bats actually hunt "in the proximity" of roads. The second bias is methodological, monitoring teams use the roads to approach the bats during activity, hunting grounds further from roads are therefore less detectable.

- **Field crops** (rice, vegetables, cereals, maize) for all individuals.

Uncertain variables **(?)**

Furthermore certain areas show no clear trend in their frequentation by the two species studied. Additional analysis will be carried out to support the hypothesis.

- **Open grasslands** are selected a little by all individuals of both species. This positive habitat selection is certainly linked to pasture but could be constrained by a lack of barriers against the steady winds in the Camargue.

- The variable "**Distance to villages**" seems to have a significant effect, mainly attractive, especially for the Greater Horseshoe Bats from the two colonies. It has not been shown in earlier studies that individuals of both species look for these urban areas for hunting. This result is perhaps biased by local data telemetry carried out near to inhabited areas (especially with Saint-Gilles, *see* figure 8). More detailed analysis is needed.

- The **salt flats** do not appear to be actively selected but are involved in part in the explanation of the distribution of Geoffroy's Bat when hunting. These environments, often pasture, could be a source of dung insects but there are strong constraints linked to this habitat which explain their low offer of prey to hunters of large insects such as Greater Horseshoe Bats (periodic flooding, high salinity and soil compaction are not favourable to large insects on the ground). Only Geoffroy's Bat, hunter of Diptera and spiders can find sufficient prey (Diptera in dung and spiders in the shrubs of the salt flats).

- **Water courses** are selected by both species of the two colonies. However, this environment is closely linked to riparian woodland, located by definition along water courses. It is therefore likely the strong attraction exerted by the water actually concerns the riparian woodland, heavily used for hunting and travel in the Camargue. Field observations (Saint-Gilles) also confirm that the agricultural canals without trees along the edge are rarely used by animals that are hunting or in transit, unlike the riparian woodland near the Petit Rhône.

If the **edges of woodlands** are attractive to all individuals, **hedges** (linear, woody less than 10 m wide) seem rather to be avoided or not selected for hunting. This result has the appearance of being somewhat surprising for the species who use linear borders for their displacement, such as Greater Horseshoe Bats. However, analysis was applied to a sample of targeted locations in hunting grounds, the tracking signals from moving bats disappeared. It is thus not inconsistent that, on one hand hedges are not selected for hunting, and on the other they are fundamental for the transit of individuals as was directly observed during the program. Thorough research is necessary to clarify these assumptions.

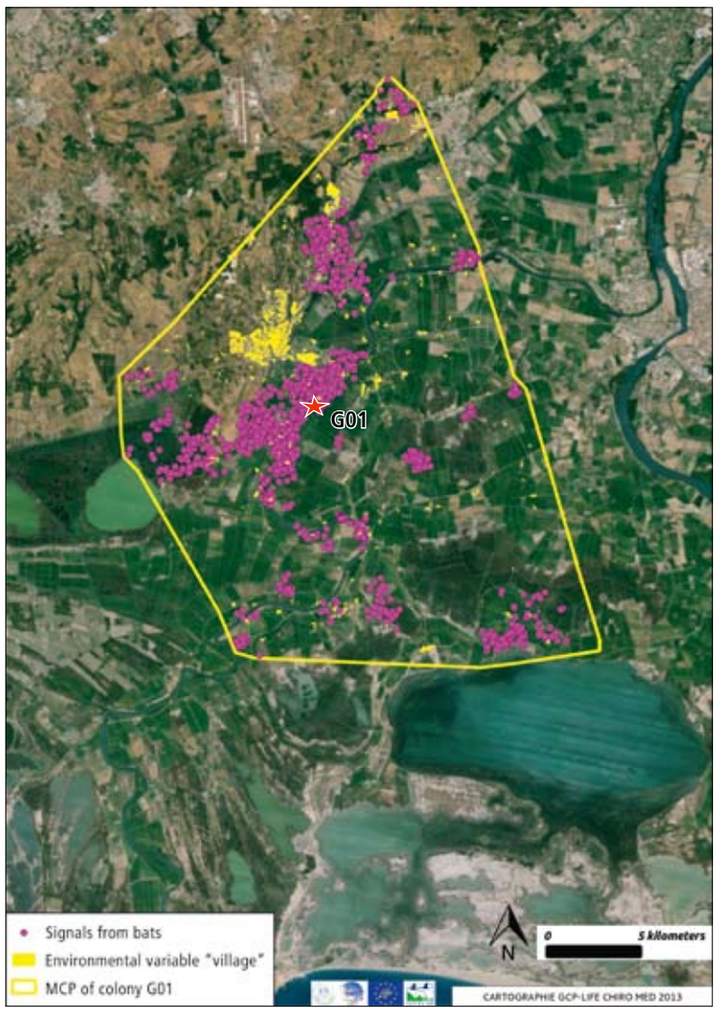


Figure 8 : *Example of the EV "Villages", this variable is distributed unevenly and in a large framework, near colony G01.*

Conclusion

The analysis of environmental variables by the landscaping model can highlight 3 main types of factors :

- **Elements that are essential to a species** : this is the case, for example, of woodland habitats such as riparian woodlands and dense deciduous woodlands that are specifically sought out by both species of the two colonies, even if these environments are sparsely present. The importance of these environments has also been demonstrated by the traditional univariate analysis (A5). In addition, 12 known colonies in the Camargue area situate themselves on average 231 m (0-650 m) from woodland. This effect is even more striking in the delta where 7 known colonies are located within 200m of the riparian woodland of the Grand or Petit Rhône (*see* Figure 9).

- **Elements that are indispensable but more or less sought out locally** : for example, the network of hedges and borders is more intense around G01, and individuals of both species select this habitat. This difference between the two colonies is indicative of an adaptation to the context of the landscape, bats use firstly supportive environments that are present and accessible.

- **Elements** that influence the choice of hunting sites by both species, but **the action is difficult to assess at this stage of the analysis (?)** : these are variables such as proportions of orchards, vineyards, distance to roads or villages. More detailed analysis of these environments is needed to support interpretations.

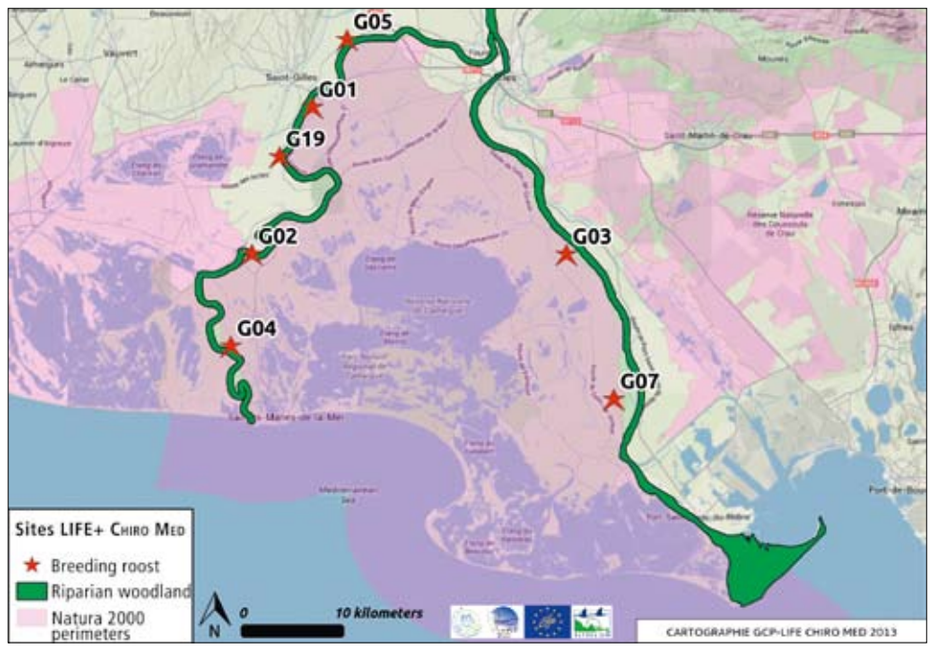


Figure 9 : *Location of the 7 known colonies in the Camargue delta. They are all located within 200 m of the riparian woodland (shown in green).*

Favourable environments in the Camargue

From the key elements highlighted, you can create maps showing the favourable habitats for each species around the colonies (*see* Figure 10). These maps are used to locate the most favourable areas for species and to implement priority actions there. The study area remains the choice of the project manager depending on the context. In this case, the study areas are constituted of the areas connecting the placements of each species for each colony (**MCP**).

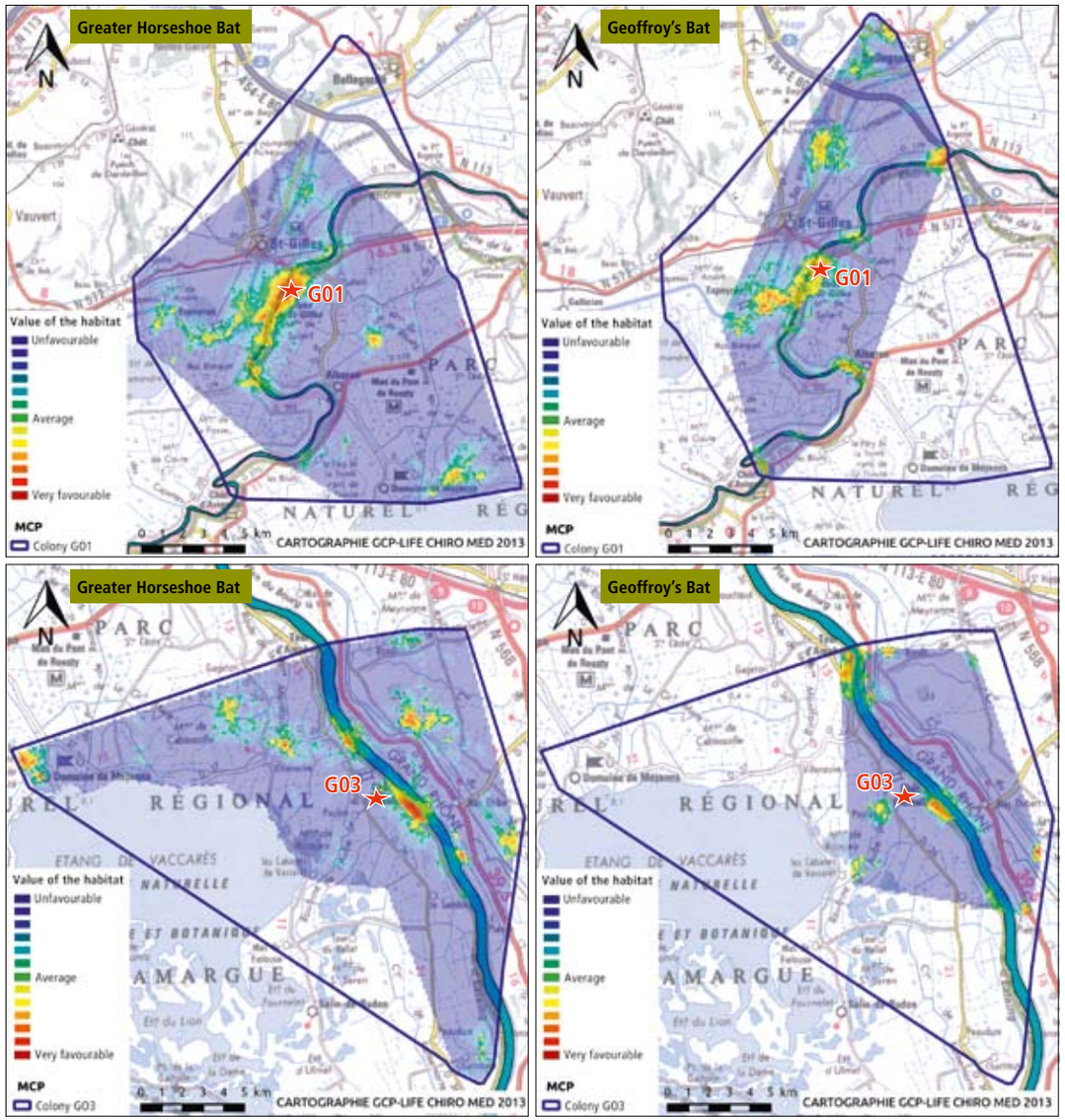


Figure 10 : *Favourable environments around the colony G01 and G03 for the Greater Horseshoe Bat and Geoffroy's Bat (Azam 2012).*

CONCLUSION

Managing an area in favour of the conservation of these emblematic species is complex work, involving the consideration of many factors, such as the biological requirements species, the environment, and the state of their conservation, human activities practiced in the area concerned and any future plans for development work. The manager should be familiar with the area, anticipate how it is going to evolve and plan their actions accordingly. Generally, in the context of expansion of human activities at the expense of natural environments, consultation with local stakeholders and the promotion of good practices prove an effective strategy for the conservation of biodiversity and is complementary to the enclosure of zones to be protected.

The range of techniques and knowledge allows the manager to choose the best tools that enable him to respond to problematic issues and to convince local stakeholders in the area of a shared project. The tools can be adapted in order to take a comprehensive approach to recovery and preservation of natural environments and biodiversity, combining the conservation of iconic species with that of ordinary nature.

Understanding life is a constant challenge, constrained by constantly changing environments, organisms, and the complexity of their multiple interactions. If wanting to imprison the living in simplistic patterns is a utopia, to search for the elements on which to act in priority, to support and encourage the populations of a fragile species, is a realistic and necessary goal for managers involved.

GLOSSARY

Annual home range : geographical area that permits a species to survive by performing its primary functions, such as feeding, sheltering, reproducing and moving. For bats, this area includes roosts for all functions, the hunting ground, the corridors and landscape continuities.

Bar coding : genetic technique which allows you to characterize an individual, population or species from specific DNA sequences contained in a mitochondrial gene (the Cytochrome oxidase). We make the analogy between these sequences and a "bar code".

Biodiversity : refers to the diversity of living things. This diversity is expressed and plays a role in all organizational levels of life : diversity of species, diversity in a species, between individuals at any given moment, ecological diversity, the associations of species in a given environment. (source : National Biodiversity Strategy 2011-2020).
Variability among living organisms of all origins : terrestrial, marine and other aquatic ecosystems among others, and the complex ecology of which they are part ; including diversity within species, between species and of ecosystems (source : Convention on Biological Diversity).
Diversity of living organisms, which is assessed by considering the diversity of species, that of genes of each species , as well as the organization and distribution of ecosystems. Maintaining biodiversity is an essential component of sustainable development. (source : vocabulary of the Environment published in the Official Journal of 12 April 2009)..

Breeding colony: groups of individual bats consisting essentially of adult females and young of both sexes. The colony thus gathers during summer to benefit from the increased temperature of a group to complete gestation, parturition, care of the young and their emancipation.

Breeding Roosts : from June to September, females gather in birthing colonies and give birth to their single young of the year (from mid- June to late July). Sites occupied by these colonies are characterized by a high temperature, the absence of air flow, the absence of disturbance and abundant food nearby. The most favourable sites are roofs and attics, barns, stables, cracks in trees, warm caves...

Capture- Mark-Recapture (CMR) : the method used in ecology to estimate the size of a animal population. A portion of the population is captured, labelled (by colours, rings, etc.) and released. Subsequently, another part is captured and the number of individuals marked in the sample is counted. The number of marked individuals in the second sample being proportional to the number of marked individuals in the population, an estimate of the size of the total population can be obtained by dividing the number of individuals marked by the proportion of marked individuals in the second sample.

Corridors : functional zones of passage which assure connections between natural areas, providing species with favourable conditions for their displacement and the performance of their lifecycle. They are usually made up of vegetal formations, mainly trees and water courses, and even paths.

Ecosystem : functional ecological unit formed by the biotope and biocenosis, in constant interaction. (source : vocabulary of the Environment published in the Official Journal on 4/02 /2010).

EUROATS : this agreement has the aim of protecting 36 species of bats identified in Europe, through legislation, education and conservation, as well as international cooperation between the signatory countries and other European governments. The signatories to the Eurobats Agreement committed to a common goal: the conservation of the European populations of bats.

Genetic Signature : specific combination of genes allowing the characterization of an individual, population, species, etc.. In the studies of the LIFE+ Chiro Med, genetic signatures at the level of breeding colonies were able to show evidence clearly.

Habitats Directive Fauna and Flora (Directive 92/43/EEC of 21 May 1992) : a regulation made by the European Union to maintain the biological diversity of the Member States by conservation of natural areas and species of fauna and flora of Community interest. The Natura 2000 network brings together these sites of community interest consisting of Special Conservation Zones defined by the Habitats Directive, and Special Protection Zones as defined by the Birds Directive (Directive 79/409/EEC of 2 April 1979). Annex II the DH list of species whose conservation requires the designation of Special Conservation Zones.

Habitat, Priority Habitat : place where the species and its immediate environment are both abiotic and biotic. (source : Dictionnaire encyclopédique de l'écologie et des Sciences de l'Environnement - François Ramade).
A natural or semi-natural habitat is an environment that meets the physical and biological conditions necessary for the existence of a species or group of animals or plants. (source : Natura 2000).
The habitat of a species is in the midst of the life of a species (breeding area, feeding zone, hunting area, etc.). It may include several natural habitats. (source : Natura 2000).
A priority natural habitat within the meaning of Directive 92/43/EEC, is a type of habitat in danger of disappearance, present in the territory of the European Member States to which the Treaty applies, the conservation of which the Community has particular responsibility for given the importance of the natural range within this territory. Types of priority natural habitat are listed in Annex I to the Directive.

Hibernation Roosts : bats hibernate in natural or artificial cavities, such as caves, mines, tunnels, basements, old quarries, cracks, holes in trees... These roosts offer them total darkness, absolute tranquillity, a cool stable temperature which protects them from frost, light ventilation, and humidity generally close to saturation to avoid their wings drying out.

Hygrometry : measurement of humidity. Relative Humidity, RH denoted, which is the percentage of the maximum value of humidity in the air at a specific temperature.

MCP : literally "Minimal Convex Polygon", the polygon obtained by connecting all external locations obtained during telemetry monitoring of individuals in a colony. It is the summer home range of individuals, *ie.* the space they pass through during a given period.

Services rendered by ecosystems or eco-systemics : these are the direct or indirect benefits that man derives from nature; they include the provision of services (food, water, timber, fibre, etc.), regulating services (climate, floods, disease, wastes, pollination, etc.), self-maintenance services (soil formation, photosynthesis, nutrient recycling) and cultural services (recreation, aesthetic, spiritual).

Species : basic taxonomic unit in the classification of the living world. A species consists of all individuals belonging to breeding populations who exchange freely their gene pool but, in contrast, do not breed with individuals constituting of populations of neighbouring taxa belonging to the same population. (source : Dictionnaire encyclopédique de l'écologie et des Sciences de l'Environnement - François Ramade).
Priority Species : a species of community interest at risk and the preservation of which EU has a particular responsibility for, given the importance of part of its natural range within the European territory of the Member States. Priority species of community interest are listed in Annex II of the Fauna-Flora-Habitat Directive 92/43/EEC.

Summer home range: Geographical area that allows bats to fulfil their functions of reproduction, feeding, shelter and movement during the period of reproduction, *ie.* between April and September.

Telemetry : study technique also called "radio tracking" used to monitor animals from a distance. For this, individuals are equipped with VHF transmitters that emit a signal of limited duration (ten days for bats) and teams of observers provided with an adapted receiving system regularly track the position of individuals, known as localisation. This technique can locate the hunting grounds and passages of transit of the individuals followed.

The Financial Instrument for the Environmen (LIFE+) : the LIFE+ program funds projects that contribute to the development and implementation of environmental policy and law. This particular program facilitates the integration of environmental concerns into other policies and, more generally, contributes to durable development.

Tragus : projecting appendage inside the ear.

Transit Roosts : these are shelters occupied by bats more or less temporarily in spring and autumn. They are quite varied (sheds, barns...), but their conditions are not conducive to reproduction. Their role is still unknown, they often provide a stopping point between winter and summer roosts, and house a large variety of numbers.

Vital cycle (= life cycle) : succession of phenomena constituting the life stages of a animal or plant species. The life cycle of bats is detailed on page 3.

BIBLIOGRAPHY

Azam C. 2012. Caractérisation des habitats potentiels de chasse du Grand Rhinolophe *Rhinolophus ferrumequinum* et du Murin à oreilles échancrées *Myotis emarginatus*. Mémoire de Master, Univeristé Montpellier II, Montpellier, FR, 89 p.

Azam C., Lyx D., Brochier C., Fonderflick J. & D. Quekenborn. 2013. *ACTION A7 : Tutoriel pour l'élaboration d'un modèle paysager*. Rapport final d'action LIFE+ Chiro Med, 40 p.

Bertin L. 2012. Étude du régime alimentaire de deux espèces de Chiroptères en Camargue : Le Grand Rhinolophe et le Murin à oreilles échancrées. Rapport de PTS GPN, Nogent-sur-Vernisson, FR, 50 p.

Corse E., Costedoat C., Chappaz R., Pech N., Martin J.-F. & A. Gilles. 2010. A PCR-based method for diet analysis in freshwater organisms using 18SrDNA barcoding on faeces. *Molecular Ecology Resources*, 10 (1) : 96-108.

Costedoat C. 2013. *Action A3-2013 : synthèse finale du mode d'utilisation du réseau de gîtes par les Chiroptères*. Rapport final d'action LIFE+ Chiro Med, 23 p.

Dawson D. A., Rossiter S. J., Jones G. & C. G. Faulkes. 2004. Microsatellite loci for the greater horseshoe bat, *Rhinolophus ferrumequinum* (Rhinolophidae, Chiroptera) and their crossutility in 17 other bat species. *Molecular Ecology Notes*, 4 : 96-100.

Durand H. 2011. *Rapport production – Données occupation du sol et haies – LIFE+ Chiro Med 2011*. Rapport final d'action LIFE+ Chiro Med, Alisé Géomatique, Saint-Jean-de-Védas, FR, 60 p.

Fonderflick J., Azam C., Lyx D., Brochier C. & D. Quekenborn. *Sous presse*. Approche méthodologique pour caractériser et prédire la distribution des terrains de chasse des Chiroptères : l'exemple du Grand Rhinolophe *Rhinolophus ferrumequinum* en Camargue. *Symbioses*.

Heude S. 2011. *Étude des terrains de chasse de deux espèce de Chauve-souris en période de reproduction Rhinolophus ferrumequinum et Myotis emarginatus en Camargue*. Mémoire d'ingénieur, Agrosup, Dijon, FR, 79 p.

Hutterer R., Ivanova T., Meyer-Cords C. & L. Rodrigues. 2005. *Bat Migrations in Europe : A Review of Banding Data and literature*. Federal Agency for Nature Conservation. Naturschutz und Biologische Vielfalt, Bonn, DE, 28, 176 p.

Lyx D. 2011. *Élaboration d'un modèle paysager prédictif de la distribution des territoires de chasse du Grand Rhinolophe et du Murin a oreilles échancrées en Camargue*. Mémoire de Master, Université Joseph Fourier, Grenoble, FR, 93 p.

Marchetti E. 2011. *Assurer la protection et préserver l'habitat naturel du Grand Rhinolophe et du Murin à oreilles échancrées sur la commune d'Arles (13).* Rapport de stage, BTSA Gestion et Protection de la Nature, Angers, FR, 50 p.

Pereira-Dias S. 2011. *Caractérisation des terrains de chasse du Grand Rhinolophe et du Murin à oreilles échancrées dans le cadre du programme LIFE+ Chiro Med*. Mémoire de Licence, Université Franche-Comté, Besancon, FR, 25 p.

Petit F. 2012. *Structure génétique des populations reproductrices de Rhinolophus ferrumequinum en Camargue et mise en évidence de leurs aires d'hibernation*. Rapport Licence, Université Aix-Marseille, Aix-en-Provence, FR, 32 p.

Poitevin F., Olivier A., Bayle P. & O. Scher. 2010. *Mammifères de Camargue.* Éditions Regard du Vivant, Marseille, France & Éditions Parc naturel régional de Camargue, Arles, FR, 232 p.

Puechmaille S. J., Ar Gouilh M., Piyapan P., Yokubol M., Mie Mie K., Bates P. J., Satasook C., Nwe T., Hla Bu S. S., Mackie I. J., Petit E. J. & E. C. Teeling. 2011. The evolution of sensory divergence in the context of limited gene flow in the bumblebee bat. *Nature Communications*, 2 : 573.

Puechmaille S. J., Mathy,G. & E. J. Petit. 2007. Good DNA from bat droppings. *Acta Chiropterologica* 9 (1) : 269–276.

Quekenborn D. 2013. *Action A5-2012 : synthèse finale des suivis par télémétrie des colonies G01 et G03*. Rapport final d'action LIFE+ Chiro Med, 22 p.

Quekenborn D. 2013. *Action A8-2013 : synthèse finale du régime alimentaire du Grand Rhinolophe et du Murin à oreilles échancrées en Camargue*. Rapport final d'action LIFE+ Chiro Med, 25 p.

Quekenborn D., Cosson E., Stoecklé T., Albalat F. & S. Fourasté. 2012. *Vie et déboires des colonies de reproduction : le cas du Grand Rhinolophe en Camargue.* 35ième Colloque de Mammalogie du 19 au 21 octobre 2012, Arles, FR, *poster.*

Ransome R. D. & A. M. Hutson. 2000. Action plan for the conservation of the greater horseshoe bat in Europe (*Rhinolophus ferrumequinum*). *Nature and environnement* (Council of Europe Publishing), 19 : 56 p.

Raymond A. 2011. *Étude du régime alimentaire de Rhinolophus ferrumequinum et Myotis emarginatus sur deux sites du Parc Naturel de Camargue.* Rapport de fin d'études d'ingénieur, ENSA, Toulouse, FR, 68 p.

Schofield H. W. 2008. *The lesser horseshoe bat : Conservation handbook*. Publication of The Vincent Wildlife Trust, Ledbury, UK, 78 p.

Servant C. 2011. *Les habitats de chasse du Grand Rhinolophe (Rhinolophus ferrumequinum) et du Murin à oreilles échancrées (Myotis emarginatus) en Camargue (action aA5*). Rapport de stage, École Nationale d'Ingénieurs des Travaux Agricoles, Bordeaux, FR, 35 p.

Vigot M. 2010. *Étude préalable à la création d'un réseau de haies Programme LIFE+ Chiro Med - Cahier technique de plantation.* Rapport de stage, École Nationale d'Ingénieurs en Travaux Agricoles, Bordeaux, FR, 28 p.

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Opus species *(photos tableau n° 4)*

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This collection was created by the LIFE+ Chiro Med program
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and results of actions undertaken
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