This Guideline is created within the project "Sustainable bats conservation in the cross-border area" (Bats Conserve), funded under a cross-border cooperation program INTERREG V-A "Greece – Bulgaria 2014 – 2020".

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Guideline for the Conservation of Bats in Agricultural Lands

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Sofia, 2019

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EDITOR: Elena Georgieva

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Content

Introduction

This guideline has been prepared as part of the implementation of a contract for "Performing specialized activities under a project “Sustainable bats conservation in the cross-border area” (BatsConserve), funded under a cross-border cooperation program INTERREG V-A “Greece - Bulgaria 2014 – 2020”.

The guideline has been developed from Consortium Bat-Map, with a lead partner OPIMOS and partners “Gap Consult” LTD and “Bul Pro Consulting” LTD.

Its development also takes into account the results of modern research and concepts for the conservation of bats in agroecosystems of Europe. The main methodological guidelines for monitoring are presented as well as the legal framework for the protection of bats with an emphasis on the Bulgarian legislation.

During the 20th century, abundance of bat populations in Europe decreases significantly due to a combination of factors, including the loss of foraging habitats and the quality of the food resource. The bat roosts are protected from the Biodiversity act, but their foraging habitats are not. This makes them susceptible to different changes in the land use. Bulgaria ranks 7th place in the EU on the share of land suitable for agriculture. They occupy 32% of the territory of the country, so it is important to understand how the negative impact of agriculture on the foraging areas of bats can be reduced.

As a result of intensification of the agricultural sector, in many European countries there has been a decrease in biodiversity over the last 50 years as a consequence of the massive removal of single old trees, entire forest massifs and last but not least, the massive use of insecticides.

Agro-landscapes traditionally are combining mosaics from different arable land and semi-natural environment. These landscapes have maintained relatively high biodiversity despite human-induced changes.

All bats, dwelling the agroecosystems in Europe or using them in some period of their life cycle, are insectivorous mammals with predominantly nocturnal activity. Many of them are capable to catch and eat insects for one night equal of their body weight. For example, one bat with average size from genus *Myotis* can eat more than 1000 insects with the size of mosquito per night. One of the most important ecosystem services provided by bats is the abundance control and prevention of massive growth of insect-pests, a problem that requires investing enormous financial resources in agriculture. For example, over 90% of butterfly species are pests, and because they have mostly night activity, their main enemies who are controlling their massive growth are bats. Recent researches in USA, proves a fundamental role of bats in maintaining environmental balance and their economic matter in agriculture and forestry. Just another research proves that colony of only 300 Greater mouse-eared bats (*Myotis myotis/blythii*) yearly eats about 550 kilos of insects. The current researches of the European bat's diet, shows that they feed with huge number of moths, plant pests. Those pests are essential part of the food of 22 species, including *Rhinolophus spp., Myotis brandtii, M. bechsteinii, Nyctalus leisleri, N. noctula, Eptesicus serotinus, Hypsugo savii, Barbastella barbastellus,* and *Plecotus spp*. Among the eaten moths, we can point species, which are especially dangerous pests in agriculture and forestry and they are well-known to agronomists: *Agrotis exclamationis, A. ipsilon, A. segetum, Autographa gamma, Chilo suppressalis, Chrysodeixis chalcites, Cydia pomonella, Galleria mellonella, Heliothis peltigera, Hepialus humuli, Mamestra brassicae, Naenia typica, Noctua fimbriata, N. pronuba, Odonestis pruni, Phlogophora meticulosa, Spodoptera exigua, S. littoralis, Xestia c-nigrum*. A number of studies in the

USA, Canada and Germany have funded studies proving that areas with extensive agriculture and mosaic crop distribution have richer fauna and are significantly less injured than extensive farmlands and monocultures and extremely poor and small number of bat fauna.

Extensive monocultures blocks are with extremely poor bat fauna

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Bats eat billions of insect pests. A proof of this is the huge piles of guano in some Bulgarian caves

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Bats are estimated to save the USA economy from 3,7 billion to 5,3 billion dollars per year, by reducing the costs for insecticides. The economic benefits of bats for the conservation of farmlands from pests and the urgent need to implement measures to protect the endangered bat community in many European countries are obvious.

Modern knowledge of the ecology of bats in agricultural lands is based on the identification of key habitats for their conservation.

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1. General information about the bat species and their habitats

Bats are one of the most widely distributed mammals on the Earth. They can be found almost everywhere except for the Antarctic. There are about 1110 species, all over the world, divided into two sub-orders: insectivorous (*Microchiroptera*) and frugivorous (fruit-eating) bats (*Megachiroptera*). Insectivorous (over 930 species) can be found almost everywhere on land and they are an important natural regulator of insect populations, which are their main food. Frugivorous (around 180 species) live in the tropics and feed mainly on fruits and seeds. They play a significant part in pollination and spreading seeds.

Species diversity of bats is the highest in tropical regions and decreases on north. Bulgaria has a uniquely high diversity of bats. Of the 35 species present in Europe, 33 species are known to inhabit Bulgaria. Among the reasons for this high diversity are the country's transitional geographic location, its mosaic of habitats which start at sea level and reach an altitude of over 2900 m, the continued existence of wild nature in many parts of the country, extensive farming activities in the mountains and semi-mountainous regions, the presence of over 5400 caves and the high diversity and abundance of insects. The greater bat diversity can be found in the belt between 100 and 400 m altitude, where relatively small areas are inhabited by 17-20 species.

The earlies bat fossils have been found in deposits dating back 55 million years. Their direct ancestors were ancient insect-eating mammals who possibly had gliding or even flying abilities. While the shape of the body and limbs of all other animals has constantly evolved, the most interesting thing with

bats is that the modern species is almost the same as their fossil forms. The body structure and anatomy of bats is very similar to that of other mammals. The main differences are in the length and proportions of the forelimbs and the presence of a wing membrane. Though that eyes are not the main organ of orientation and foraging, all species have eyes of different size and can see surprisingly well in the dark. The first finger (thumb) ends with a small nail, which helps the bat to move on the ground. The wingspan of Bulgarian species reaches up to 46 cm and their weight varies between 5 and 55 g. The Giant noctule (*Nyctalus lasiopterus*) is the largest, and the smallest one is the Soprano pipistrelle (*Pipistrellus pygmaeus*). Some species have elongated wings (*Miniopterus schreibersii, Nyctalus noctula* etc.), which make them faster and agile flyers, capable of covering great distances without effort. Other species have broad and short wings, which give a slower, fluttering flight. The ears of all bats (except for the horseshoe bats) have a fleshy projection called tragus, the function of which is not fully understood. The body is covered with thick and soft fur which protects the body from the cold during times of rest and when flying through cold air.

The bats that are found in continental part of Europe, belong to the big evolutionary branch *Microchiroptera*, or real bats. Those are insectivorous mammals, adapted for active and continuous flight. Their wings represent a flight membrane between the elongated fingers of the forelimbs, hindlimbs and the tail. Those are small mammals, as the smallest species weight is only 4-5 g. The length of the body is usually between 5 and 8 cm and rarely is over 10 cm. All of them are night active. The main instrument for orientation in the surrounding environment is echolocation. This unique biosonar allows to the bats to fly infinitely in complete darkness and to find their prey, mostly flying insects, without a problem. Apart from determining the distance to their preys and obstacles, bats use ultrasounds also to communicate with each other. The duration of these calls varies

from a few milliseconds to a few hundred. Usually their frequency range cannot be heard from the humans, because it is over 20 kHz. Only for some of the species those calls are with frequency from 9 to 20 kHz and they can be heard from humans. Even though inaudible for our hearing, the power of those sounds of bats in ultrasonic area is big – they "scream" with power of 50 till over 100 dB. Depending of the specific features in the biology of the species, emitted sounds can be often strongly frequency modulated or to be referred to the so-called quasiconstant. The energy of the sound can be concentrated in different frequencies – from 11 – 14 KHz at Free-tailed bat, until over 100 KHz at some Horseshoe bats. There is direct connection between surrounding environment, the remoteness of surrounding object and how often they make sounds. In practice the sound serves as orientation, the more "open" the less is the needed information about the surrounding objects. In a "complex" environment, made up from diverse objects and at shorter distances, bats need more detailed information to be able to navigate themselves. Because of that reason, when the bats fly in "outdoor" they emit calls more rarely, than flight in varied environment and closer objects, they emit sound more often. Of this rule there is the connection between ecology of bats and how often they emit their sounds. Species that hunts high over the vegetation and other terrestrial objects, emits more rarely sounds than those who feeding around the tree crowns or under forest canopy, which make sound more often.

Except the frequency, with which they make the calls, the habitats are reflected also to that if the sounds are loud or quiet (amount of energy, focused in the sound). Through that way in complex area with more objects, the sounds can be quiet, because there is no need to travel far. The bats that inhabit such areas do not emit loud sounds – "not screaming", which can cost them a lot of energy. Bats who inhabit open spaces, must invest much energy to - literally to "scream", to reach faraway distance and to allows them to find their distant prays also to

orient themselves better in open spaces. The third volume of the sound, which is affected from the habitat is the frequency. Since the high- frequencies sounds have more detailed information, the ideal option would be for all bat species to emit such sounds. Unfortunately, those sounds are absorbed from the air much more than those with low frequency. Through that way, species who inhabit open areas cannon navigate themselves and locate their victims, which is located on a greater distance. That is why such species emit sounds with lower frequency, which can travel far into space, without being absorbed. It is exactly opposite for species, which inhabit complex habitats with multiple objects around them. They emit high-frequency sounds, which allows to them to get detailed picture for the surrounding area.

For one night, the bat can emit about 400 000 separate echo calls, which together with the fly is very energy intensive and it requires a rapid recovery of energy losses. Bats have extremely developed anatomical devices, that affect both the structures of the outer and inner ear, as well as the nostrils and the characteristic nasal formations in the horseshoe bats that allow them to capture and analyze the ultrasounds and their echoes. Their brain is also specialized – part of the cerebral cortex, which is for processing information from the sounds is much more developed than in other mammals, as well as the vocal and auditory centers.

Except the echolocation, bats have others specific features, which distinguish them from all others mammals with similar size. They give birth to one pup per year, but only some species to two. To compensate for this low fertility rate in the evolution, their life expectancy has reached an average of 7 – 10 years, with recordings of about 30 years. In most species the mating period is in the end of summer and beginning of autumn, and the reproductive process is during spring.

Even thought that bats are flying mammals who can move on large areas, they are strictly attached to a certain type of

roosts – hollows, caves, rock crevices, different man-made structures, such as attics, basements etc. Often, they form colonies in those roosts which can be consisting of several individuals to tens of thousands. Depending on the year lifecycle roosts must have strictly defined characteristics such as humidity, temperature, volume, etc. During the summer maternal colonies are formed, most often gather female individual from extensive nearby territories. Male species during that period are more often isolated in other roosts. Males, especially during autumn when is the mating period, emit character social calls, with which they "mark" their territory. Typical is the attachment to certain roosts that have been used for decades and hundreds of years. Winter roosts also have specific strictly defined characteristics for each species. Some of the bats form mixed colonies consisting several species. For example, those are the colonies of Long-fingered bat (*Myotis capaccinii*) and Common bent wing bat (*Miniopterus schreibersii*). Changing of the roosts during the year also makes seasonal migrations – bats can migrate in addition to distances of several tens of kilometers and much more than thousands of kilometers, moving mainly from Northern to Southern Europe and back. Those distinctions in the bat's biology make them extremely sensitive and vulnerable to direct human interference and to global environmental changes. The condition of their populations is very good indicator of environmental trends and anthropogenic pressure. During winter they are usually in lethargy (hibernation) in colonies or individually in roosts, where the temperature does not drop below o°C and the humidity is appropriate.

Every species chooses roosts by matching his features. Sometimes bats can wake up during winter for short periods of time when they can move to the limits of the roosts, and more rarely to change it. Coming out of hibernation is long process, which requires a lot of energy. That is why the disturbance from person, most often in caves, can be dangerous for part of the population, because during winter the troubled individuals

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Hibernating Greater mouse-eared bat (Myotis myotis), filled with droplets of condensed moisture

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cannot recover energetically and they can die. It is also very dangerous, the impacts immediately after the young ones are born, if they get off from their mothers and fall. In the time of nursing, mothers also need more energy, and that is why they hunt closer to the roost. On the other hand, the specialization of the species to certain groups of insects as their food, determines their demands on the qualities of the hunting territory. Bats are choosing territories which are rich in insects, such as forests, slopes, wet meadows, above water bodies and often around street lighting in urban areas is also a preferred hunting area, as light can attract a huge number of insects. Hunting competition is often avoided, because different species in some territories go out for hunting at different time, feed on different insect sizes or hunt on different heights. The election of the flight can be also different. For example, the Common noctule (*Nyctalus noctula*) flies till 100 m height, while the smaller spe-

cies from geniuses *Pipistrellus и Myotis* and most often fly on 5 – 10 meters height.

The landscape is important for the orientation of bats during 24-hour foraging flights and during long distances seasonal (spring and autumn) migrations. Most often for orientation are used landmarks that are linear landscape elements such as paths in the forests, river valleys and more. Each change of the landscape such as forest harvesting, new roads, new lighted artificial area, can have a negative impact on the populations.

Bats can be generally grouped into four main categories, according to their environment preferences:

- **Cave-dwellers** – breed and hibernate exclusively in caves or other underground roosts. They are found mainly in karstic, volcanic or sea caves. The size of colonies can reach between 100–10 000 individuals in the summer and between 50 till 100 000 individuals in the winter.

Mixed cave colony from several species horseshoe bats (Rhinolophidae)

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• **Forest-dwellers** – breed mainly in hollows, crevices and under the bark of trees; some of these species spend the winter in caves. They can be found in broad-leaved, deciduous, mixed and more rarely coniferous forests which offer roosts and a supply of food. The number of individuals roosting in the hollows is around 10 to 50, with colonies well distributed throughout a large area.

Hollows in old growth trees provides roost for many bat species

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• **Wetlands** – due to their high biological potential and rich biodiversity wetlands provide one of the most important foraging habitats for nearly all bat species. They are important during the summer months when thousands of bats hunt above the water surface and become an important part of the regional food chains. Most species that depend on water areas live in proximity around those areas. They occupy tree hollows, residential or industrial buildings, caves and other nearby roosts.

Wetlands are a preferred foraging habitat for bats

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- **Synanthropic** – live almost in man-made roosts such as attics, basements, shafts, chimneys, ventilation facilities etc., throughout their entire life cycle. They can be found everywhere in villages, towns and other urbanized areas. The colonies of some species vary from 5 to 20 individuals and of others from 50 to 1000 individuals.

Depending on the season, bats inhabit different types of roosts:

During the winter all bats inhabit roosts with a permanent temperature of between 2° to 10°C. Such conditions are most often found in water caves and flooded mine galleries and, occasionally in the attics and basements of residential buildings.

During the spring and autumn bats can be found in different roosts with a variable or constant temperature (e.g. abandoned or inhabited residential or industrial buildings, underground bunkers, galleries, discharge and ventilation shafts, pipes, chimneys, hollow posts, small and large caves, rock crevices, etc.).

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Synanthropic species often settle in attics and basements of abandoned houses

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Breeding colony of Lesser horseshoe bat (Rhinolophus hipposideros) in house attic

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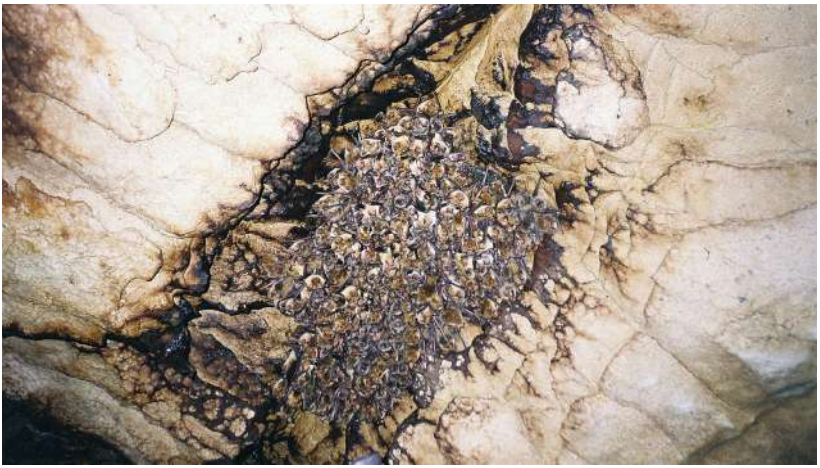

Hibernating numerous mixed colonies in "Parnitsite" cave, Bulgaria

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Colony of Greater horseshoe bat (Rhinolophus ferrumequinum), inhabiting the ventilation shaft of a mine

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During the summer bats prefer roosts with a higher temperature and this is where they breed. Species which form larger colonies congregate in caves with larger entrances so that in the evening hundreds or even thousands, of bats can fly in or out simultaneously.

During summer bats often inhabit abandoned bunkers

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2. Ecological features and requirement of the species

The characteristics of the bat species presented below are based on both author's own researches and extensive literature. The following works are used: Popov et al. (2007), Popov, Sedefchev (2003), Peshec et al. (2004), Petrov (2008), Benda et al. (2003), Grimmberger (1991), Papadatou et al. (2008), Ivanova (1998), Ivanova, Guerguieva (2005), Pandurska, Beshkov (1998a, b), Pandurska (1997, 2000, 2002), Pandourski (2004), Pandourski, Popov (2008) etc.

Lesser horseshoe bat (*Rhinolophus hipposideros*). Identifying mark is the horseshoe-shaped part of the nose leaf. The base of its fur is light grey in color and on the ventral side is even brighter. Flight membranes are red-brown in color. It has body length from 3,8 to 4,5 cm. Wingspan 18-25 cm and a mass of around 6-10 g. Often flying is relatively slow, but it's also agile, flying within 2 - 5 meters above the ground. When hunting they are close to its roosts (usually around 5 km) around forests outskirts, bushes, river sides, overgrown with greenery, above the water and also around rocks and karst regions. Can be found at the lower and middle altitudes. In Bulgaria during summer can be found in attics and other man-made structures, and spends his winter in shafts and caves. The summer colonies (usually in buildings) are mostly consisting of female individuals. They appear throughout April and fall out apart throughout August. They give birth around begging of July. The small ones can already fly after around 3-4 weeks. Summer habitats can be various - buildings (basements, attic), caves, artificial galleries, rock piles etc. Lesser horseshoe bats hibernate from October until April into caves or artificial underground galleries. They

prefer insides parts where the temperature is around 5 - 9 degrees. When hibernate they prefer to hang in close proximity to others until 50 cm. Summer and winter roosts are usually no more than 15 km apart. It is considered for globally threatened species. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Lesser horseshoe bat (Rhinolophus hipposideros)

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Greater horseshoe bat (*Rhinolophus ferrumequinum*). The largest Bulgarian horseshoe bat. Its fur is reddish-brown on the dorsal side and cream on the ventral. Wing membranes and ears are light grey-brown The ears are large and very mobile and also they do not have a tragus in the ear, they have only broad skin on the underside (antitragus). It can be found in the whole country, except the highest parts of the mountains. Oc-

cupies a variety of habitats, from pastures to rare forests, close to karsts areas and other rock regions and also water bodies. Greater horseshoe bat emerges soon after sunset, and sometimes the hunting continues all night. They can be active even during the cold nights. Its flying is made up of slow, fluttering travel similarly like a butterfly. Normally between – 0,5-3 meters (sometimes and above the trees) above the ground. During night is getting around 10 till tens of kilometers away from the roosts. They feed predominantly on beetles and moths and other range of other big flying insects. He is a social species. During the summer they live in shallow caves, rocks regions, under roofs, desolated buildings, artificial galleries. Sometimes those desolated buildings are close to caves and they use them as roosts through foul weather conditions. Summer colonies are too loudly, especially young ones when they need to be fed. Usually, they are using temporary night roosts, where they can rest during hunting and to feed with the caught insects. Hibernation is in caves, mines or artificial galleries – from October-November till April, and they prefer temperatures in the range 7-11°C. Often they can awake and change the roosts. Sometimes during winter if the weather conditions are softer, they can feed around the entrance of the cave. Travel distance between winter and summer roosts often do not exceed 50 kilometers, but there is recorded distance of 100 kilometers. Most mattings take place in the fall and the spring. A bats pregnancy lasts between 10 -11 weeks. Females form large nursery roosts during May – June, often to several hundred bats. (from 200 species rarely till 600). Youngs are born in June – mid July and they are raised by their mother. Usually they bear a single blindly young or rarely twins. Young ones can open their eyes and at their third or fourth week they can fly and after six to eight weeks they can leave the roosts and live separately. Mating colonies are falling apart at the end of August – beginning of September. They gave birth for the first time to the 3rd year and some individuals - to the 9th year. Not every year females participate in reproduction.

Males becomes sexually mature at their two years. A bat can live approximately 30 years. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Greater horseshoe bat (Rhinolophus ferrumequinum)

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Mediterranean horseshoe bat (*Rhinolophus euryale*). Medium-sized horseshoe bat. In Bulgaria is common type species. With light grey base and the dorsal side is grey-brown color. Sometimes a slight reddish tinge, while the ventral side is yellow-white and the boundary between ventral and dorsal color is indistinct. The horseshoe and snout of the bat are light brown, and the ears and wing membranes are light grey. The species is nasal emitting, with an upper saddle process pointed and slightly curved downward. The lower saddle process is rounded when viewed from below, and is noticably shorter than the upper saddle process. The wings of the bat are broad. When it hangs, the body is not

completely enveloped by the membranes, even during hibernation. Usually this species is living in the forests or karst regions. The summer reproduction colonies are made after the mid of May. Females give birth after the mid of June till the mid of July. Maternity roosts often contain from 100 till 600 individuals. They are much more social than lesser and greater horseshoe bat. Sometimes they formed independent colonies in caves from 50 – 300 individuals. They also often roost together with other bat species. During winter is occur in mixed colonies mostly with Blasius's and Mehely's horseshoe bat, less often with Greater horseshoe bat. Usually they settled up to more warmer parts (10-13°C) in the caves. In Bulgaria they migrate between summer and winter roosts up to 10 till 60 km. The longest registered movements do not exceed 140 km. There are missing specific information about the composition of their food, but probably small insects (flies, mosquitoes, moths). In Bulgaria are registered breeding colonies that often contains from a few dozen up to 2000 individuals. In cave in North Bulgaria is registered a record breeding colony of this species that is counting 20 000 individuals. Most births in this genus occur in the end of June – beginning of July. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Blasius's horseshoe bat (*Rhinolophus blasii*). Medium sized horseshoe bat. The length of the body is around 4,6 till more than 6 cm. Although a typical inhabitant of karsts underground roosts, hunting areas of the species are associated with forest areas. In roosts are commonly found with two other horseshoe bats species, Mediterranean horseshoe bat (*Rhinolophus euryale*) and Mehely's horseshoe bat (*Rhinolophus mehelyi*), as the three species can form colonies reaching several thousand individuals. This bat eats mainly nocturnal moths, but its nutritional biology is still not under-researched. He is uses echolocation sound for orientation, with constant-frequency from around 95,5 – 96 KHz. Species give birth in breeding colonies in the end of June and the begging of July. It hibernates in

Small colony of Mediterranean horseshoe bat (Rhinolophus euryale)

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karsts caves, with average temperature 12°C. It is comparatively sedentary species, does not perform long-distance migrations, but only those between summer and winter roosts. The presence of karst cave-roosts of the species among the farmland's massifs of southeast Europe, defines these territories as a part of its hunting habitat.

Greater mouse-eared bat (*Myotis myotis*). It is comparatively large bat species. The length of the body is around 6,5 till over 8 cm. The species is found mostly in Eastern Europe and Mediterranean. One of the most common species found in karst regions. This bat is forming mixed colonies with Lesser mouse-eared myotis (*Myotis blythii*). The hunting area is often in deciduous woodlands and mixed sets and parks and their outskirts at an altitude of about a hundred meters till 800 – 900

m. The hunting area of the bat can reach 70-80 km². He feeds with large even non-flying beetles, discovering them by the sounds that they are making. The food includes and other invertebrates, such as spiders, flies, butterflies etc. They have selectively eating as it prefers large insects over than 5 mm, but if there is abundance of small ones, it can also eat with them. It breeds in natural karst, volcanic caves and less often in buildings and other artificial roosts. Females give birth from the end of May till the first part of June. It hibernates individually or forms large colonies, who can reach till several thousand individuals. It is migrating between summer and winter roosts, travelling up to 100 km. Avoids urban territories and his natural enemies are night birds of prey. The presence of karst caveroosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Lesser mouse-eared myotis (*Myotis blythii*). Species similar to the Greater mouse eared bat, but smaller. On the dorsal side the fur is soft lighter brown, ventral – light grey. The weight is around 15 and 30 g. It is a common species, spread mainly in lower parts in the country. They typically roost in areas with roughest terrain such as hills, rocks, steep river side etc., karts areas with rare forests, bushes, parks, cities. Avoids extensive steppe areas. Behavior: it is hunting its victims by hovering in the air or often landing on the ground to capture insects. It is mainly found in caves all over the year. It forms big summer and winter colonies. Winter colonies are formed by females and male species. It hibernates in winter roosts with a relatively constant temperature of 3 till 12-15°C. The species is an occasional migrant, with average movements 60-70 km, and up to recorded around 600 km. This species feeds with larger insects – moths, beetles, grasshoppers. During the spring and summer, female ones are forming large colonies – up to a few thousand species, in which they are having population (in the end of May – beginning of June) and they raise their small ones there. They can start to fly on age of 30-35 days. The permanent teeth erupt on the 45th day,

and after 50th day they can live separately. Maximum life expectancy of those bats is around 30 years.

According to some database from genetics analysis both twins' species can hybridize, which can affect with under 5 % of the population in Bulgaria. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Lesser mouse-eared myotis (Myotis blythii)

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Daubenton's bat (*Myotis daubentonii*). Daubenton's bat is medium-sized. The length of its body is from 4.5 to 5.5 cm. It has brown dorsal fur and pale brown or silver-gray. Its snout is with red-brown color. This species is with relatively small ears. It is rare species on the Balkan Peninsula. It is found in high mountains areas – on 2500 m in Pirin mountain, Bulgaria. Roosts are typically in woodland flats and hilly mountains landscapes. It can be also found around water bodies, rivers, lakes

etc. The flight is with rush moves, usually above some meters from the ground, more often above water. When it is catching insects, they can use the interfemoral membrane, till they are flying. Feeding with smaller insects (flies, butterflies, mosquitos) can happen during flight, but the larger ones it has to be on the ground. Summer roosts can be in tree hollows or in buildings and other artificial structures. They will hibernate in rock crevices as well as in caves. Seasonal movements between winter and summer roosts are mostly within a distance till 100 km. Mating occurs in autumn till the following spring. Females gather in maternity colonies of 20 – 50 bats during May. They typically consist of a single pup, and they are able to fly by 4 till 6 weeks after they are born. They can reach 20 years old, but it is recorded case of 40 years old. It is connected with water bodies among the farmlands (rivers, lakes, dams).

Geoffroy's bat (*Myotis emarginatus*). Middle-sized bat. The body-length is over 4 cm and reaches 5,3 cm. It can be easily recognized by its rust color on the dorsal fur and tricolored hairs – gray at the base, yellowish and brownish to the end. Prefers karst areas, where is concentrated on the lower altitudes – around 100 – 300 m. Its roosts are usually in nature caves, having known colonies of several thousand individuals. Often forms mixed colonies with horseshoe bats. Reproduction is in warm roosts, as in Bulgaria is registered, colony in abandoned bunker with temperature 34°C. It is foraging in regions with bushes and tree vegetation. Hunting activity can be also attached with water bodies, but if prefers crown of the trees, where its preys are spiders, flies and not so often butterflies. It can fly for two hours without stopping. Breeding period is in the end of summer and during May the nursery colonies are formed, which can be with sever hundred individuals. They give birth to one pup during June and till one month the juveniles can fly. There is life expectancy till 20 years. This species is also a sedentary and does not make any long distances migration, but the fact that in Bulgaria no winter colonies have been found

shows that they are possible. They are victim of night birds of prey. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Geoffroy's bat (Myotis emarginatus)

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Long-fingered bat (Myotis capaccinii). Middle-sized bat from genus *Myotis*. His snout and dorsal side are dark and on the ventral side is bright, almost white. The sizes of the body are between 4,5 and 5 cm. Its range includes Mediterranean parts of Europe, in the Balkans reaches to Romania. It is attached to the karst regions, where finds roosts in caves. Often lives together with Schreiber's bent-winged bat (*Miniopterus schreibersii*). The territory of Bulgaria hosts a substantial part of the population of a species – during summer there are registered over 20 000 species, and winter colonies consists over 45 000 species. Except in forests, he also hunts above water surfaces. His diet consists insects,

flies, etc. Its echolocation sounds are highly frequency modulated with maximum energy around 45 KHz. Little is known about this species reproductive cycle. Births occur in the end of May – June, with only one pup born. It hibernates as forming multiple dense colonies in caves. It makes seasonal migrations between summer and winter roosts. The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Long-fingered bat (Myotis capaccinii) often forms mixed colonies with other species from genus Myotis and Schreiber's bent-winged bat (Miniopterus schreibersii)

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Brown big-eared bat (*Plecotus auritus*). Medium sized bat, with length from 3.7 till 5 cm. The dorsal fur is long and usually brown or grey-brown, grading to cream grey on the ventral side. Ears are very long, and merged at the core. In Europe can be seen even till the Polar circle, but on the Balkans is rare

and it is specific for the higher mountain areas. It prefers medium mountain zone with forest lands. It has short wings for slow flight, by making "silent" echolocation noises. They are catching smaller insects in free flight and bigger ones when landing on the ground. Those bats mate in autumn. Mating colonies are usually composed of 10 – 20 females and single ones male species. During summer mainly occupies tree hollows, but it can also be found in buildings. They hibernate in caves or undergrounds of buildings on temperature till 5°C. They do not fly long migration distances and even the range between summer and winter roosts is just a few kilometers.

Grey big-eared bat (*Plecotus austriacus*). Medium size bat, it is morphology like Brown long-eared bat. The body length is from 4 till 5,5 cm. On the ventral side the fur color is white, but the hairs have a dark basis. It can be found mainly in regions from the sea level till around 1400 m altitude. It prefers lower places with steppe character, but is also found to hunt in dry forests diluted habitats. It has slow flight and maneuver. Usually is catching flying insects (butterflies are dominating). Summer roosts are more often in hollows and attics on buildings. They hibernate in caves, mine galleries and basements at temperature from 2 to 6 degrees. It is attached to his roosts and it does not achieve long distances migrations. Mating is during autumn in the summer roosts. Nursery colonies can number of ten individuals. There is only one pup born. Maximum life expectancy is 14 years, but the average, between 5 and 10 years. They are preys of night birds.

Greater noctule bat (*Nyctalus lasiopterus*). The largest European bat. Length of the body can go above 10 cm. The fur is brown through along its entire length. Especially rare species in his area, but with large abundance in Span and Greece. Almost half of the famous localities in Bulgaria are in Strandzha mountain, characteristic with rich forest vegetation. Extremely attached to large forests. There is only data for its summer roosts – tree hollows, while the winter ones are not studied. It is established that this bat eats as well large insects (beetles, butterflies)

as small ones. Interesting fact is that this is the only European bat that attacks small Passeriformes birds during autumn migration. It collects its prey from different surfaces, including from the ground. Maternity colonies are formed in the end of spring in hollows. Migration data for the species is very limited. Natural enemies are predatory night birds. Rarely uses arable land as part of hunting habitats.

Lesser noctule (*Nyctalus leisleri*). Middle-sized bat, but is the smallest in the genus. The length of the body is from 4,8 till more than 6 cm. The dorsal side is dark brown and the ventral is lighter grey-brown. The hair is darker at the base. The ears are short and wide. Mostly this bat can be found in forest regions under 800 m altitude. Its real abundance is underestimated because they fly in open space and rarely can be captured. In Greece is also found for lowland regions. Preferences of the species are for dry and warm extensive forest habitats. It can be adapted also in urban areas, more often is found in bigger cities. Inhabits hollows and buildings. It has been found also in bat houses. It flies away for hunting 10 minutes after dusk and it flies on groups. This system of hunting is involved with order to confuse them prays which are close to their roosts. During warmer summer days those species have two peaks of activity – exactly after dusk and morning before dawn. While foraging it can cover territory of more than 10 km^2. It is moving away around 4 – 5 km from the daily roost, as it prefers forests outskirts, riverside trees, tree lines around roads etc. It feeds mainly with small flies and rarer with beetles, butterflies, aquatic insects etc. Echolocation sound are composed of both a frequency-modulated component and a quasiconstant frequency domain with maximum energy around 24 – 25 KHz. Mating is at the end of summer and autumn. Males choose individual roosts, where they may acquire 6-7 females. Maternity colonies are formed during April, as females give birth to one pup during June. The nursery process continues 6 weeks. The life expectancy is around 8-9 years. Hibernates usually in hol-

lows, buildings and rarer in rock crevices. This species is migratory, but his migration paths between summer and winter roosts are less studied. They have become enemies of owls. Although primarily associated with forest ecosystems, they can occur in open farmlands during seasonal migrations.

Noctule bat (*Nyctalus noctula*). Large bat. The body length is from 6 till 8 cm. The coat is yellow-brown or red-brown. The snout and ears are dark brown. A typical species on the Balkan Peninsula, closely related to deciduous forests. It can be found even more rare in high-mountain areas. It flies away from its roosts right after dusk, but it was observed and during the day, especially during autumn migrations. The flight is fast on height above 10 meters. It hunts above open spaces, tree passes, above the tree crown. It captures and eat its prey during flight. Males and females live separately during summer. Inhabits hollows, rock crevices and structures, rare occupies crevices semilight broad cave parts (for example Devetashka cave and "Dushnika" in Bulgaria). Hibernates in colonies, as the species are tightly pressed together, sometimes counting over 1000. Migratory species even on distances than more 1000 km. In Bulgaria has been found Noctule bat, ringed, past more than 1600 km in straight line. Mating period is a prolonged period from August till October, but sometimes and during spring. In that period one male species live with 4-5 females in a separate hollow. The pregnancy is with duration from 6 till 8 weeks and nursing lasts 4-6 weeks. There registered is life expectancy from 12 years. They can become victims of predatory night birds. Although primarily associated with forest ecosystems, they can occur in open farmlands during seasonal migrations.

Common pipistrelle (*Pipistrellus pipistrellus*). Small bat species. With a body length from 3,3 till 4,8 cm. The color of the fur on the dorsal side is changeable even in the population – from black-brown till yellow-brown. The snout, ears and flight membranes are dark grey or brown. The wings are narrow. Wide spread on the Balkans. Inhabits different landscapes including forests. It

has high flying activity, recorded even in young and dry coniferous forests in Eastern Rhodopes. It has fast and agile flight; it hunts even when there is a sharp cold. His diet is primarily small insects – flies, mosquitos, moths. It is a "social" species, moves and hunts on groups from several individuals. Emits specific social sounds in the audible range of human sound. Stays active till late autumn. Breeding colonies are from several tens to one hundred individuals. It finds roosts in hollows, under the tree bark, in crevices, in buildings, under tiles and others. It hibernates individually or on small groups, often in hollows. It makes migrations ranging from several tens of kilometers to several hundred. Copulation is during autumn and rarer during spring. Males takes individual territories where that are defended from the others by specific sounds. Pregnancy continues form 4 till 6 weeks, depending on climate features in the region. Births occur from the begging of June till the middle of July. The newborns are with body mass around 1 g, but after three weeks they reach development that allows for an independent flight. They live mainly around 4 years. They can become victims of predator night birds – such as owls. It is often hunting in open arable lands.

Soprano pipistrelle (*Pipistrellus pygmaeus*). A duplicate of the Common pipistrelle with very similar biology and appearance. As opposed to Common pipistrelle, this bat hunts more often above water surfaces. It is easy to recognize by the sounds that those bats make with most energy at 55 KHz. It is often hunting in open arable lands.

Nathusius' pipistrelle (*Pipistrellus nathusii*). Small bat, but bigger than Common pipistrelle. The fur on the dorsal side is brown, ventral side is grey-brown. The snout, ears and the flight membrane are dark brown to black. The body length is from 4.6 till 5.5 cm. During winter period he is not so common in Bulgaria and Greece, but during spring migration they are extremely numerous in regions with water bodies. He can find roosts in hollows of deciduous and mixed forests. Sometimes those bats can gather mixed colonies with other species, that use similar roosts. The flight is fast on height of 5 – 15 meters, its

diet consists small flying insects – flies, mosquitos, moths. As in Northeast Europe does not have enough places for hibernation, he undertakes long-distance migration of more than 1000 km, as the major migration routes become the big river streams or system of coastal freshwaters and brackish wetlands of Black and Aegean sea. Before the breeding period which is during autumn, males appear to use a distinctive call to attract females to those mating roosts. The pregnancy is about 6 till 8 weeks, and females give birth during June. They have become victims of predatory night birds. It is often hunting in open arable lands. During autumn migration it can be registered with high abundance in open farmlands.

Kuhl's pipistrelle (*Pipistrellus kuhlii*). One of the most common and multiple species in the Mediterranean region of Palearctic. Inhabits mostly plains, regions around coasts, river valleys, but also in urban areas or outskirts. It feeds with flying insects. His hunting area is above forests, in parks between the trees, between buildings, around street lamps. During the day this bat inhabits narrow crevices in trees or buildings. He is strongly attached to urban areas, because he shows one of the highest levels of synanthropic among the other bat species in Europe. It is often found in olives groves in southern Europe.

Savi's pipistrelle (*Hypsugo savii*). Small bat, similar to Common pipistrelle, but a little bit bigger. The fur is long, on the dorsal side is dark brown till yellow-brown, often with lighter at the tips, the ventral side is pale yellow or light grey. The boundary between dorsal and ventral sides is stripe. The snout, ears and membranes are dark brown. The tail emerges out of the membrane. They occupy rocks and karst regions, pastures and valleys, woodlands and cultivated areas. Out of breeding period they can be found in towns and cities. It flies slowly in correct paths. Hunts over water bodies, around top of the trees, high in karst regions and edges of open areas. Summer roosts are in rock crevices or on buildings, tree hollows. During summer females' colonies (including the young ones) contain

from 15-20 till 50-70 individuals. Often hibernates individualy in more protected places such as narrow tree hollows, buildings, rocks crevices. Migration is suspected, there are registered flights more than 250 kilometers. Feeds on small flying insects. Breeding is during August – September. There are born usually 1 or 2 small ones in July. Often found above arable lands, close to karst and rock massifs, which are part of its hunting habitat.

Serotine bat (*Eptesicus serotinus*). Large bat species. The body length is from 6 till 8 cm. The dorsal fur is dark brown and on the ventral yellow-brown. The snout, ears and flying membrane are dark brown till black. The ears are short and wide and the wings are also wide. Large spread bat in the lower parts of the Balkans. It can be found in the mountains till around 1600 meters. Inhabits different terrains – forests, rocks and karsts regions, urban area. It flies slowly on height of 6 – 10 meters. During May, the female forms breeding colonies from hundred individuals. During summer, male species lives severally or on small groups. During winter occupies crevices in rocks or in buildings. It feeds with large flying insects. The copulation is during the autumn, rare during spring. The pregnancy is from 6 to 8 weeks and the small ones are born during the second half of June. Nursing is around 2 months. The life expectancy can reach 20 years. Often hunts in open arable lands.

Schreiber's bent-winged bat (*Miniopterus schreibersii*). Middle-sized bat with body length from 5 till 6,7 cm. It is easy to recognize by its short snout and small, almost hidden ears. He has grey color and on the ventral side is lighter. The wings are long and pointed. Typical species for southern Europe. Extremely numerous and it can form colonies of many thousands of individuals. It is common inhabitant of cave regions, but it hunts in forest territories. Usually they leave the daily roost massively and together in large groups. It is extremely good flier and its speed can reach 50 km/h. It hunts high above the tree crowns and it can go away for several dozens of km per one night in searching for appropriate hunting area. Echolocation sounds are slightly

variable and with the higher energy in the range of 50 – 52 KHz. Copulation is in the end of summer and autumn and there can be latent pregnancy and the fertilization of the ovum can happen during spring. Breeding colonies are formed during May and the pups are born in June – beginning of July. Often among the female there are also male individuals as their part of the colony is being able to reach 45 %. Hibernates only in caves on temperature around 7°C. The individual territory of the species is several thousand square kilometers with only single species are spread over long distances. Migrations are seasonal, local on distance till 150 km. Victim of night birds of prey (owls). The presence of karst cave-roosts of the species among the farmland's massifs of Europe, defines these territories as a part of its hunting habitat.

Schreiber's bent-winged bat (Miniopterus schreibersii)

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Particoloured bat (*Vespertilio murinus*). This bat is medium-sized. Body length is from 4,8 till 6,4 cm. Its fur color

is black and the hair tips are silver. It has grey-white ventral side. The snout, ears and flight membrane are red-brown. A common species, reaching 60 degrees north latitude. It is a migratory species, it prefers mountainous forests habitats, but it can be found also in urban areas and cultural landscapes. Often hibernates in buildings (attics, crevices, etc.) as the migration's roads are from the mountains, where are the summer roosts towards the settlements. During autumn emits characteristic social sounds in the audible sound range (around 17 – 18 KHz), which allows its recognition. It feeds mainly with flying moths. There are registered long-distances migration more than 1000 km from North to Southern Europe. Copulation is during autumn or spring. Usually, female give birth to two pups in the end of June. In contrast to other species, the female grows her own juveniles not in a group. They may become a victim of owls. Often found above arable lands during seasonal migrations.

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3. Common approach

The conservation approach of bats in agro-ecosystems is based on integrated approach to environmental quality protection, both directly on arable lands and adjacent natural and semi-natural roosts and habitats, taking into account the basic habitat requirements:

- **Presence of appropriate roosts**. Natural roost for species hunting in agroecosystems is the adjacent forests. Those are first hollows in old growth trees, as well as crevices and spaces under the bark. For some species there is a need for a frequent change of the roost during the year lifecycle, because of the need to avoid predators, infestation of the roost or finding new one with a suitable seasonal temperature. In the composition of bats above open arable areas can also participate and cave-dwellers species, in case there are natural caves or abandoned mine galleries near or directly in the forest massif. In that case the numerous colonial species also take part in the regulation of insect pests. Also important are man-made buildings, including abandoned buildings, bridges, etc., populated by number of species of the genus: *Myotis, Nyctalus, Pipistrellus* etc.
- **Existence of favorable hunting areas.** Different species use specific sections of the arable areas during hunting, depending on the dominating composition of insects in them. To avoid competition, they have distributed the vertical area as part of the species hunts high above the tree crowns while others use airspace close to the ground or capture their prey directly from the leaves and other surfaces.
- **Availability of drinking water sources**. This is a significant limiting factor in some dry regions mostly in southern Europe. The potential of the territory as a bat habitat can be substantially increased by the creation of artificial ponds.

Natural roost of bats, hunting in agro-ecosystems, are the caves

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Artificial ponds in arable areas are essential for bats

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4. Institutional framework

All bats found in Europe are subjects of protection as under international conventions and agreements and under national laws specific to each country of Europe. Analysis of this legislative and institutional framework can be found in management for assessing the environmental impact and assessment regarding bats (Petrov, 2008). A number of legislative documents determine the terms, conditions and requirements under which to perform various types of coordination regimes for investment plans in order to protect the bats as endangered group of animals. For almost all types are required to be performed some form of coordination with different state institutions. For example, for Bulgaria it is the Ministry of Environment and Water's regional divisions (RIEW).

INTERNATIONAL LEGISLATION ON THE CONSERVATION OF SPECIES AND HABITATS

1. Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)

Ratified on 25.01.1991 (Promulgated, State Gazette 13/1991). Special attention is given to endangered and vulnerable species, including endangered and vulnerable migratory species specified in appendices The Countries undertake to promote education and disseminate general information concerning the need to conserve species of wild flora and fauna and their habitats. Each Country shall take appropriate and necessary legislative and administrative measures to ensure the conservation of the habitats of the wild flora and fauna species, especially those

specified in Appendices I and II, and the conservation of endangered natural habitats The Countries undertake to give special attention to the protection of areas that are of importance for the migratory species specified in Appendices II and III and which are appropriately situated in relation to migration routes, as wintering, staging, feeding, breeding or moulting areas.

Appendix II – Strictly protected fauna species
All bat species except *Pipistrellus pipistrellus*
Appendix III – Migratory species *Pipistrellus pipistrellus*

2. The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention)

Ratified on 23.07.1999. The Countries acknowledge the importance of migratory species being conserved and of Range States agreeing to take action to this whenever possible and appropriate, paying special attention to migratory species the conservation status of which is unfavourable, and taking individually or in co-operation appropriate and necessary steps to conserve such species and their habitat.

In particular, the Countries:

a) should promote, co-operate in and support research relating to migratory species;

b) endeavour to provide immediate protection for migratory species included in Appendix I;

c) endeavour to conclude Agreements covering the conservation and management of migratory species included in Appendix II.

All European bat species are included in Appendix II.

3. The Agreement on the Conservation of Populations of European bAts - Eurobats

As migratory species, the Agreement was set up under the auspices of the Bonn Convention and stipulates that each coun-

try shall adopt and enforce such legislative and administrative measures as may be necessary for the purpose of maintaining a favourable conservation status of all species by prohibiting the deliberate capture, keeping or killing of bats, identifying the areas of importance in terms of bat reproduction and wintering, promoting research programmes on the protection and management of bats, taking into account the potential effect of pesticides on bats and making additional endeavours to save the bat populations designated as threatened.

Fundamental obligations:

1. Each country shall prohibit the deliberate capture, keeping or killing of bats except under permit from its competent authority.

2. Countries shall identify those sites within its own area of jurisdiction which are important for the conservation status, including for the roost and protection of bats. It shall, taking into account as necessary economic and social considerations, protect such sites from damage or disturbance. In addition, each country shall endeavour to identify and protect important feeding areas for bats from damage or disturbance.

3. When deciding which habitats to protect for general conservation purposes each country shall give due weight to habitats that are important for bats.

4. Each country shall take appropriate measures to promote the conservation of bats and shall promote public awareness of the importance of bat conservation.

5. Each country shall assign to an appropriate body responsibility for the provision of advice on bat conservation and management within its territory particularly with regard to bats in buildings. Countries shall exchange information on their experiences in this matter

6. Each country shall take such additional action as it considers necessary to safeguard populations of bats which it identifies as being subject to threat and shall report under Article VI on the action taken.

7. Each country shall, as appropriate, promote research programs relating to the conservation and management of bats. Countries shall consult each other on such research programs, and shall endeavor to co-ordinate such research and conservation programs.

8. Each country shall, wherever appropriate, consider the potential effects of pesticides on bats, when assessing pesticides for use, and shall endeavor to replace timber treatment chemicals which are highly toxic to bats with safer alternatives.

The provisions of this Agreement in no way affect the right of Countries to take stricter measures concerning the conservation of bats.

In this national implementation is planned:

1. Each country shall adopt and enforce such legislation and administrative measures as may be necessary for the purpose of giving effect to this Agreement.

4. Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora (the Habitats Directive)

The main purpose of this Directive is to „ enable the natural habitat types and the species" habitats concerned to be maintained or, where appropriate, restored at
a favourable conservation status in their natural range ".

Article 2 includes 13 bats species: *Rhinolophus blasii, Rh. euryale, Rh. ferrumequinum, Rh. hipposideros, Rh. mehelyi, Barbastella barbastellus, Miniopterus schreibersii, Myotis bechsteinii, M. blythii, M. capaccinii, M. dasycneme, M. emarginatus* and *M. myotis*.

The member countries are obliged to guarantee adequate protection of these species and their habitats particularly within the ecological network of NATURA 2000 sites. Upon discovery of the presence of any of these species, the assessment of the status of their populations in the examined territory must be particularly thorough. For all species listed in Annex 2 standard

forms have been worked out with specific criteria to determine if the species enjoys a favourable conservation status. Achieving such a status is the major purpose of the Directive and all the ensuing obligations for our country to guarantee adequate protection for bat roosts and foraging habitats

NATIONAL LEGISLATION FOR CONSERVATION OF SPECIES AND THEIR HABITATS

National environmental legislation of Bulgaria is in line with EU-wide directives, setting priorities, guidelines and regimes for the conservation of bats and their habitats.

1. Biodiversity Act

This act regulates the relations between the countries, municipalities and legal and physical persons in terms of the conservation and sustainable use of the biological diversity of the Republic of Bulgaria. **Under this act all bat species in the country are proclaimed strictly protected.**

2. Forestry Act

This law regulates the public relations related to the protection, management and use of the forest territories in the Republic of Bulgaria, in order to ensure multifunctional and sustainable management of forest ecosystems. The preparation and adoption of forest management plans is a key stage of forest management in Bulgaria.

3. Protected Areas Act

This act defines and categorises the protected territories within Bulgaria, the procedures for their establishment and provides for the implementation of their management plans. Around **40%** of the caves known to be host to large colonies of

roosting bats in **Bulgaria are included in the protected territories**. Some of these important bat caves have the status of natural landmarks. In the majority of the cases the protected are also includes adjacent territory (forests or land).

NATIONAL BIODIVERSITY MONITORING SYSTEM (NBMS) is a complex mechanism for monitoring and reporting on changes in the biological diversity of Bulgaria in the long run. This is achieved through a system for assessment and analysis of the impacts on biodiversity, its state and the measures that need to be undertaken to prevent its loss. The NBMS is the basic instrument for assisting decision-makers in protecting and conserving Bulgaria's biodiversity at a national level and to provide information to as many other users as possible. The monitoring focuses on species of different biological groups and selected types of habitats. The information is gathered regionally and summarized nationally. Regional databases are kept in the RIEW and the departments of national parks.

With high monitoring priorities are:

- Schreiber's long-fingered bat (*Miniopterus schreibersii)*
- Bechtein's bat (*Myotis bechsteinii)*
- Lesser mouse-eared bat (*Myotis blythii)*
- Long-fingered bat (*Myotis capaccinii)*
- Geoffroy's bat (*Myotis emarginatus)*
- Greater mouse-eared bat (*Myotis myotis)*
- Blasius's horseshoe bat (*Rhinolophus blasii)*
- Mediterranean horseshoe bat (*Rhinolophus euryale)*
- Greater horseshoe bat *(Rhinolophus ferrumequinum)*

All the listed bat species are monitored by expert teams, who visit underground habitats such as caves, disused mine galleries and bunkers, which are known to have been inhabited in recent years by hibernating or breeding bat colonies. The list of monitoring sites corresponds with the caves and galleries included in the document „Important Bat Underground Habitats in Bulgaria" (IVANOVA, 2005). The document was drafted in

compliance with Resolution 4.3 MoP4 („Guidelines for the protection and management of important underground bat habitats“) and represents is the official Bulgarian position (through MOEW) for the EUROBATS Convention. This national report evaluates all the important underground habitats (92 in total) in terms of the number of species and the seasonal character of the habitat, their number, protection status and level of importance (regional, national or European/world). Fifty-two caves and galleries are considered to be highly important on a national and European level.

5. Threats

The main threats to bats in agro-ecosystems arise both directly from human activities (intensive, mechanized agriculture using insecticides) and from activities in adjacent areas providing roosts for the species:

- **Loss of roosts** – exists mainly in loggings, when old trees with hollows and crevices are being destroyed. Especially negative consequences can occur in extensive forest fires and less often due to natural landslides and erosion processes.
- **Change of natural characteristics/deterioration of habitats** – most often agricultural activities change the quality of hunting habitats of bats. The main factor for deterioration of the quality of agricultural lands is the use of insecticides and as a consequence the reduction not only of the abundance of insects-pests but also of others important for foraging of bat groups. Often, this impact is not limited to the treated area but also affects adjacent territories from importance to bats, for example forest massifs, karst regions where maternal colonies are formed. In keeping with best practice, the extent of this threat can be substantially reduced and, in some cases, it may even have a positive effect on the bat community, expanding available hunting areas.
- **Fragmentation** – it is possible to occur in the area of certain species in case of permanent change of the purpose of large territories and their transformation into territories with other land use. Most often this happens when new agricultural lands are used for the cost of forest territories.
- **Extermination of individuals** – excessive use of insecticides in agriculture can be a cause of both direct mortality in individuals and their prolonged use accompanied by accumulation in the food chain. Excessive farming chemicals can also

Farmlands are replacing the natural habitats of bats

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damage adjacent territories used by bat populations during different periods of their life cycle – hibernation, breeding and migration. It is possible mortality of bats in case of harvesting old trees during the breeding season (May-July, depending on the geographical location and the altitude). It is possible to destroy maternal colonies of dozens of individuals in hollows and crevices of old trees. This threat exists both in natural forest habitats and in some old orchards.

- **Disturbance of species composition of the bats** – it is possible to use insecticides in the arable areas as well as in the case of forest logging in large adjacent areas as the populations of rare and fewer numbers of species are the most vulnerable. Afforestation with invasive species and the replacement of deciduous forests with coniferous, more productive from an economic

point of view are also factors for species composition change.

- **Disturbance** – most often this threat is related to agricultural activities during the breeding season, with the use of mechanized equipment and concomitant noise can drive bats away of their roosts.

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6. Types of impacts

Regardless of the specific character of the impacts on bat species in agro-ecosystems, resulting from both natural factors and as a result of human interference, a common scale for their degree is often used for the assessment of these impacts. In the next table there are criteria for assessment, as well scale of impacts and evaluation scale for those criteria:

Table 1.

Matrix for assessment degree of impacts

Assessment	CRITERIA	LEVEL OF THE IMPACT
0	The activity has no impact	No impact – **0**
1	The activity has low negative impact	Low impact, which can be avoided without special activities, except compliance with best practices in forest exploitation – **from 1 to 3**
2	The activity can affect temporary with negative impacts	
3	The activity can affect in short-term period with negative impacts	
4	The activity can have secondary negative impacts	Moderate value of impact, which is not necessary to be reported with other factors and to be recommended measures about mitigation or eliminating – **from 4 till 6**
5	The activity can cause cumulative negative impacts	
6	The activity can cause synergistic impacts	
7	The activity can cause secondary, cumulative, synergistic negative impacts. The impact can be eliminated by mitigating or compensatory measures.	Significantly impact, which is necessary to be eliminated by choosing alternatives or implementation of mitigating or compensatory measures – **from 7 till 9**

Assessment	CRITERIA	LEVEL OF THE IMPACT
8	The activity can cause secondary, cumulative, synergistic negative impacts. The impact can be eliminated by mitigating or compensatory measures.	
9	The activity can cause significant, mid-term or long-term constant negative impacts. The impact can be eliminated by mitigating or compensatory measures.	
10	The activity can cause significant and constantly/irreversible negative impact. The impact cannot be eliminated by mitigating or compensatory measures.	Significantly impact, which cannot be eliminated by implementation of mitigating or compensatory measures - **10**

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7. Character of the impacts

Emerging impacts on the bat species found in agro-ecosystems might be short-term in period and reversible or long-term, irreversible.

About the short-term and reversible impacts those can be disturbance in the roosts or temporarily expelling the bat species. The bigger part of the impacts in farmland practice refer to long-term and irreversible impacts and those are: loss of roosts as a result of logging of old-growth trees with hollows and during the digestion of new agricultural areas, change of the natural ecological characteristics of sensitive habitats such as foraging areas and bio corridors, change in the structure of the assemblage, fragmentation and interruption of migration roads, mortality of individuals in the roosts, breaking of genetic flow between populations in the range of the species.

Some of the intensive farming practices have a negative effect not only on the overall biodiversity but also with a direct impact over the bats. For example, the change in crop rotation can significantly affect the species composition of insects or to lead to changes in their abundance, which also affects the composition of the insectivorous bat community. Bats are also indirectly affected by the use of anthelmintic preparations for farmed animals.

8. Risk Assessment

For the assessment on the risk over the bats from the activities in farmlands it is proposed to observed modified algorithm of consecutive activities developed by Pandourski and integrated in the methodical management of Petrov (2008):

STEP 1. Collection and analysis of available information

A. What is the available information on the species composition of bats in the region of the activities to be carried out?

B. What is the existing information on the habitats and the functional features of the terrain, which are relevant for bats?

C. What is the existing information on the structure defining elements of the characteristics of ecosystems?

D. What is the data about previous experience in implementing similar projects?

Guidelines: When looking for existing information on the habitats and the functional features of the terrain, that are relevant to bats, the expert must focus on areas with an abundance of insects, existing roosts, known flight corridors and linear landscape elements such as roads, forest clearings and flowing rivers with well-developed vegetation along the banks, etc. Information on potential bat migration routes can be drawn from documented migratory routes of birds.

Sources of information: Reports and available information kept in the NATURA 2000 database, management plans of protected areas and sites, topographic maps at the 1:20000 or 1:50000 scale, aerial photographs, preliminary surveys of the region, vegetation maps, published hydrological reference books, meteorological bulletins, scientific articles, Internet and others.

This stage needs to include at least one site visit and

survey of the region where the activities are planned.

For the field visit you must have a good topographic map on which the planned project is clearly shown, the main types of habitats should be marked and landscape elements. This is essential preliminary evaluation of any possible conflicts.

STEP 2. Preliminary evaluation of the need for additional studies to establish the level of risk and the potential impact of the activity

A. Evaluation how up to date the information collected in Step 1 is. Analysis of Step 1 (*A+B+C+D*).

B. Which bat species can one potentially expect to find in the affected area?

C. What is the possible function of landscape elements in the different periods of the life cycle of bats?

D. Identify potential conflicts which might result from the activities and have a direct negative impact on individual bats, bat populations or the functional landscape elements that relate to bats.

Guidelines: Compare the results of the bibliographic references, consultations performed and field visit. Assess the main functions of the identified habitats on bats and their possible flight corridors. Mark all the available data on the map. Check the points where these overlap – these are the conflict zones. Grade their level of significance. Each piece of available information must be critically evaluated in terms of its topicality, i.e. if the data collected correspond to the existing conditions within the affected are, if abrupt and lasting changes in the ecological characteristics have occurred since the data was collected and if any subsequent changes in the structure of the bat community may have occurred.

The conclusive evaluation on the level of significance of conflicts – must be with consultation with a bat expert. This saves time and money, not only for the developers, but also for the monitoring institutions. Additional fields studies must be planned for all identified priority conflicts.

STEP 3. Developing and carrying out studies on bats and the related functional elements of the environment

A. To define appropriate methods of study.

B. To determine a suitable representative period to conduct the study.

C. To establish the intensity of the study depending on the specificity of sites and the study season.

D. To conduct the field studies and gather up-to-date information and interpret the collected information. Analysis of Step 1 (*A*+*B*+*C*) and Step 2 (*B*+*C*).

Guidelines: The appropriate methods for field studies should be selected on the basis of the type and specificity of the affected ecosystems and the characteristics of the potentially most vulnerable bat species. The main purpose of the assessment process during this period is to obtain missing information on bats and their habitats within the region of the activity. Mark the new results on a map and use them as the basis for the next step in the research. The duration of field research is mostly determined by a one-year life cycle between two breeding periods.

The periods of bat activity which are subject to assessment are as follow:

- Breeding period (from late May to late July);
- Period of active communication between the summer roosts (June- August);
- Activity of local populations (May-September);
- Dispersal of colonies and the start of the autumn migration (August-September);
- Autumn migrations and swarming behaviour at some roosts (September-October);
- Hibernation (December-March);
- Spring migration (March-April).

The additional research would provide information on:

- The complete species composition;

- The characteristics of landscape elements of significance for bats;
- The presence, number and exact locality of the roosts;
- The presence and location of flight corridors and the species which use them;
- The presence and location of foraging habitats and the relative density and activity of the species that use them.

Mandatory: if the activity is planned to be implemented within the boundaries of a NATURA 2000 site at least 4-6 field studies must be carried out for each square kilometre of affected area. For the projects outside NATURA 2000 sites 2-3 field studies must be performed for each 1-5 square kilometres of affected areas.

STEP 4. Final assessment of the impact of the activities and measures to prevent, mitigate and offsetting the risk

A. To present the conservation status of the established species under the national and international legislations.

B. To determine the species at risk from the activities and particularly the potential danger of destruction of individuals and colonies.

C. To locate the habitats and roosts and to access the main risk factors during the different stages of implementing the project.

D. To work out recommendations to reduce the negative impact of the realisation of activities and purpose alternative solutions for mitigation and compensation.

Guidelines: The analysis of the result of Steps 1+2+3 and the information for the planned activities will identify the conflict zones of greatest importance for the bat communities within the region of the planned activities. Conflict analyses must be submitted for all stages.

The final report must contain basic information and recommendations for decision making that relate to the different stages of the realization so as to prevent, reduce and/or com-

pensate for the negative impact on the environment and on bats in particular. Alternative solutions are necessarily proposed.

The final assessment report must contain and some of the following specific components:

- Assessment of the impact on migration routes (destruction and disconnection of communication corridors);
- Assessment of loses of foraging habitats (sites with a great abundance of insects, attracting native species);
- Assessment of the cumulative effect.

The assessment must contain a well-argued case as to whether the risks posed are acceptable. The risk must be evaluated as UNACCEPTABLE if it affects a population level.

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9. Cumulative effect

For the species in agro-ecosystems, cumulative effects are those which in combination with agricultural practices can lead to an increase of the impact over the populations. These activities can be implemented both directly in agro-ecosystems and in adjacent areas of importance for bats at different stages of their life cycle. Table 2 presents the main factors of impact with a cumulative effect.

Table 2.

Main cumulative impact factors

Activity	Positive impact	Negative impact	Character of the impact
Development of renewable energy sources, including wind turbines		X	Death of bat individuals. Disturbance and interruption of bat's bio corridors. Take away the hunting area.
Construction works and building maintenance		X	Taken the habitat. Disturbance and expulsion of individuals.
Roads development		X	Possible mortality of individuals as a result of wade. Habitat removal and declining of the natural ecosystem qualities due to air pollution and adjacent territories.
Forestry activities, including clearcutting		X	Bats mortality in the roosts. Destruction of roosts. Extinction of individuals with possible changes and in the structure of populations.

Activity	Positive impact	Negative impact	Character of the impact
Clear forests from dead trees		X	Bats mortality. Destruction of roosts
Using of pesticides and insecticides		X	Deterioration of natural ecosystems qualities and reduction of capacity for feeding of bats. Changes in the structure of bat populations.
Creation and maintenance of new water bodies	X		Enriching the species composition of the bat community and increasing its abundance. Improving the quality of hunting habitat.
Creation and maintenance of new riverside forests	X		Enriching the species composition of the bat community and increasing its abundance. Improving the quality of hunting habitat.
Conservation of old, abandoned buildings	X		Roost conservation for many European bat species.

Both European legislation and that of each individual European country require an impact assessment of each new investment proposal also for bats in the agroecosystems.

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10. Assessment of sensitive areas

As particularly sensitive areas in the agroecosystems that are important in the bats' lifecycle, we can consider migratory roads and their foraging habitats near small ponds and wetlands. The conservation of these habitats and their maintenance in natural ecological condition are an important part of the overall strategy for preserving biodiversity and maintaining favorable conservation status of bat populations. Out of the roosts, bats require appropriate hunting habitats, as well as suitable flying corridors for movement during 24-hour and seasonal migrations. Fragmented territories without the presence of binding elements such as preserved tree rows are with low importance for bats.

Water sources are also of importance, as they are both sources of drinking and important hunting grounds. The standing and slowly flowing ponds are of great importance for all European bats and especially for Long-fingered bat (*Myotis capaccinii),* Daubenton's myotis (*Myotis daubentonii*) and species from genus *Nyctalus*, who spend considerable time in hunting insects above the water surface. These high insects' habitats, including the adjacent wetlands are vital for nursing females, who often form breeding colonies in nearby coastal tree vegetation.

In dry Mediterranean habitats, water bodies are vital to all bats that inhabit them. Maintaining the quality of surface waters is key to maintaining a favorable conservation status of the populations of many bat species. Further environmental research is needed to better understand the role of these landscape elements in ecosystems and their relevance to species.

The river valleys also play role of migratory corridors for bats

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11. Limiting factors

Globally, habitat loss, degradation and fragmentation of ecosystems are identified as one of the most important factors for biodiversity loss. This global process of impoverishment of flora and fauna continues in Europe, where the landscape has been heavily influenced by economic activity over the centuries. Bats as an essential element of ecosystems are also subject to specific factors leading to reduction in their abundance. Bats as taking high sections of food chain, they are especially sensitive to the environment changes and as a slow-breeding species is difficult to recover after population crises.

There are evidences that the abundance of bats in the roosts decreases depending on farming practices.

Each species has its habitats and landscape preferences in its hunting territory: open spaces - *Eptesicus serotinus*, *Hypsugo savii*, *Nyctalus noctula*, *Pipistrellus nathusii*; outskirts of forests - *Pipistrellus kuhlii*, *Pipistrellus pipistrellus*, *Pipistrellus kuhlii/nathusii*, tree enclosed (closed) habitats – low-flying *Myotis* (LF), hight-flying *Myotis* (HF), *Plecotus sp*.

Differences can be related to the ecological niches of different species and their different foraging behavior. Some species from genus *Myotis* have broad wings and are adapted to feed in dense vegetation where they capture fixed prey and emit echolocation sounds with modulated frequency. *Nyctalus noctula* and *Pipistrellus nathusii* have a dive fast flight because of their long, narrow wings, as they capture their preys in open spaces (Dietz et al., 2009).

The research of Toffoli (2016) presents list of species and overall number of registrations per habitat type (table 3).

The diversity of vegetation in ecosystems is a precondition for the existence of a rich bat community

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Table 3.

List of species and total number of registrations depending on habitat type

Species	Hedge sparse trees	Tree stripe	Open space	Total
Eptesicus serotinus	18 (0.65%)	-	-	18 (0.31%)
Hypsugo savii	164 (5.92%)	382 (15.24%)	71 (13.92%)	617 (10.67%)
Myotis (LF)	6 (0.22%)	-	-	6 (0.10%)
Myotis (HF)	144 (5.20%)	192 (7.66%)	12 (2.35%)	348 (6.02%)
Nyctalus noctula	92 (3.32%)	44 (1.76%)	39 (7.65%)	175 (3.03%)

Species	Hedge sparse trees	Tree stripe	Open space	Total
Pipistrellus kuhlii	680 (24.57%)	744 (29.69%)	66 (12.94%)	1490 (25.76%)
Pipistrellus kuhlii/nathusii	1240 (44.80%)	1116 (44.53%)	239 (46.86%)	2595 (44.87%)
Pipistrellus nathusii	376 (13.58%)	28 (1.12%)	77 (15.10%)	481 (8.32%)
Pipistrellus pipistrellus	40 (1.45%)	-	6 (1.18%)	46 (0.80%)
Plecotus sp	8 (0.29%)	-	-	8 (0.14%)
Total	2768 (100.00%)	2506 (100.00%)	510 (100.00%)	5784 (100.00

Differences in bat activity along linear forest structures of varying height and species composition must also be highlighted as compared to open field areas in agricultural lands. Most species have been recorded along linear tree structures, which is also confirmed by studies of flying and foraging activities, which many times exceed those compared to open spaces. This phenomenon intensifies in stripes of rare trees, for all species observed, as well as individuals.

Species with highest activity recorded around high linear tree structures in some southern regions of Europe is *Pipistrellus kuhlii* (Russo & Jones, 2003).

The existence of linear tree structures is of particular importance to bats because it provides more protection from predators and meteorological influences. In addition, there is a tendency for the insect abundance around the linear tree strips to be larger as a function of increasing the height of the tree species (Lewis, 1969). Tree vegetation with higher heights can also provide additional micro-habitat, such as old trees and deadwood, increasing the abundance of invertebrates.

12. Conservation measures and recommendations

Linear tree and bush structures and forest outskirts play a key role in the conservation of biodiversity in agroecosystems. They are a key factor in maintaining heterogeneity landscape structure, while providing adequate roosts for breeding, roost and food resources for many wild species, including those with declining abundance.

Bats are a very varied group with species-specific preferences. It is particularly important from a conservation point of view to emphasize the need for proper management of farmlands and especially the preservation or creation of linear elements of the landscape in the context of the conservation for bats. This is expected from the agro-environmental measures of EU's agricultural policy. Many species can benefit from the creation of tree stripes with bush undergrowth or groups of trees in agrosystems. This will facilitate their use from species which feed in wooden (closed) habitats such as those belonging to genus Plecotus and Myotis, as well as foraging on the edges of forests, suitable for the Soprano pipistrelle (Pipistrellus pygmaeus). For all species it is especially important to protect different waterways or water bodies, such as lakes and pools. The presence of trees in arable lands provides a number of advantages for overall conservation of biodiversity. The abundance/presence of different species of birds, mammals and other animals is directly related to the presence of tree vegetation (Walker et al., 2005; Michel et al., 2007), even with proven negative impacts on species strongly attached to open spaces. (DEFRA, 2010).

Considering the specificities in the biology of the species, the following recommendations can be made in the planning of

agricultural practice, accompanied by plans, programs and other projects with cumulative impact:

- creating and maintaining local connected habitats. When arable lands are created and amalgamated to the greatest extend possible to preserve or restore trees strips, field protection belts and hedges. This will improve or create new habitats. It is recommended the protective belts and hedges to have over 10% of the gaps.
- creating grass buffers for arable blocks. The grass buffer strips around the arable land are specific refuges. It has been proven that are increasing insect and other invertebrate animals. It is advisable that their width varies from 2 to 6 m.
- creating floristically enriched headlands with local blooming species and agricultural legumes (bean plants) providing pollen and nectar habitats that increase insect foraging resources.
- particular attention should be paid to the activities envisaged within a radius of 1 to 10 km from established maternity colonies.
- maintenance and resumption of linear structures connecting roosts and hunting territories (rows of trees and other vegetation).
- fostering traditional extensive land use.
- avoiding the use of pesticides and insecticides in hunting areas of bats.
- avoiding afforestation with invasive tree species.
- avoiding afforestation with coniferous vegetations in place of deciduous natural forests.
- avoiding interruption of important seasonal migration routes when urban areas are expanded and new road sections.
- conservation of existing high landscape ecosystem heterogeneity: flight corridors, tree rows and other vegetation providing habitat connectivity.
- conservation of surface water quality and natural state of coastal vegetation.

Shelter belts are important linear elements of the landscape

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- implementation of measures to reduce the eutrophication of water bodies.
- conservation of natural vegetation around the entrances of karst and volcanic caves, mine galleries and other underground habitats.
- promoting extensive pasture farming in areas with a dry climate where steppe and open grasslands are threatened from bushes.
- non-deployment of wind generators in hunting areas of bats.
- planning mitigation measures and programs during the operation of wind parks to generate electricity.

13. Good practices

In the developed from Working group to Agreement on the Conservation of populations of European bats (EUROBATS) Action plan 2018 – 2024, 11 good practices for conservation of bats were proposed:

1. Preserve and increase roosting sites by conserving standing dead trees, old and big trees and trees with hollows in all forestry operations (logging, thinning etc.). Groups of old trees are particularly valuable;

2. Whenever possible try to increase variation in tree species and forest structure. Use native species wherever possible;

3. Conserve deciduous trees in coniferous forests. Deciduous trees produce food and roosting sites;

4. Increase food production for bats by conserving important habitats: wet forests, riparian habitats, forest pass etc.;

5. Limit the use of pesticides in forests;

6. 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, often favorable for the bats;

7. Semi-open pastures are sometimes important habitats. Nowadays grazing is often abandoned and these areas can regrow 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;

8. Grazing and browsing by cattle or other large herbivores creates a variable semi-open forest which is a good foraging habitat for bats.;

9. Avoid creating large clear-cuts;

10. Identify the next generation of trees for bats and leave these during harvesting;

11. Avoid cutting through any trees close to hollows, there may be bats roosting inside.

A relatively successful practice for improving the conservation status of bats in Europe and North America is the installation of bat houses. Practices in different countries and geographic areas show varying degrees of success – from uninhabitable of the houses till 3 – 100 % success of settlement. Essential to success is the orientation of the houses and their exposure to sunlight. As a rule, greater success is achieved in industrial, intensively managed forests than in natural old forests. This fact can easily be explained by the existence of numerous natural roosts in old growth forests. The success of settlements is also greater in coniferous plantations. The result may vary depending on the design of the houses, including their size, number of compartments and the ability to maintain a certain temperature. An experimental staging in Costa Rica has led to a 100 percent success in settling in houses resembling the natural hollows in the area. In the UK in an area with placed bat boxes the bat community has doubled in size for a period of 10 years. A recurring study in coniferous forest in Suffolk, UK, found that the total population of Brown big-eared bat (*Plecotus auritus*), inhabit in the bat houses has doubled during this period of 72 to 140 bats. Observations carried out from 1985 to 2005 in UK forest habitats found that the success of bats settling was 8,7 % (occupied houses 5986 by 68715). Settlement is more successful in summer (10 %), than in winter (2 %). Again, a study in the UK (Wareham region) of 360 square km in a mixed forest found 1662 bats of three species inhabited in over 500 houses (976 Brown big-eared bat – *Plecotus auritus*, 355 Common pipistrelle – *Pipistrellus pipistrellus* and 286 Natterer's bat – *Myotis nattereri*).

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14. Management and monitoring

Generally recognized policy of the countries of the European Union is the combination of agricultural practices with environmental protection and biodiversity. Agro-environment schemes (AES), by providing financial incentives for farmers for the restoration and improvement of natural habitats in agricultural lands as well as for the protection of biodiversity and the cultural value of the territories, are already mandatory in the EU and common to Europe. There are a few schemes specifically targeting bats – famous example for that is the project affecting Greater horseshoe bat (*Rhinolophus ferrumequinum)* in southwest England between 1998 and 2003. Although many of the measures in this project that have been prescribed for other species or wildlife in general will likely help to conserve bats and invertebrates as their major nutritional resources. The example includes the recovery of hedgerows, planting trees and local forests, limiting the sediment and organic matter in natural water sources, creating artificial ponds, maintaining and restoring old orchards, reducing the moisture content of fertilizers and pesticides, and changing the harvesting regimes or grazing, to increase the structural and species diversity of pastures.

The debate on how successful Agro-environmental schemes (AES) are in favour of wildlife populations, as they are received with different results for species. In Scotland were surveyed 18 pairs of farms to evaluate the effects of specific AES management prescriptions on density of moths and activity of bats. A study has shown that the landscape in the vicinity of the farms influences the activity of the bats. Of particular importance is the management of forest areas in farmlands. There is some evidence that organic farming benefits from the presence

of bats, although it is not certain whether this is due to the lack of pesticides or the availability of more favorable habitats for bats. There is a higher species variety of bats in organic farming than in intensive practice.

The monitoring of the bat species in agro-ecosystems has to answer a number of questions whose answers would identify the main negative impacts on them and the measures that need to be put into farming practice as short as the long terms.

Methods for monitoring:

- **Field visits and direct counts**

The expert should visit the study site (cave, gallery, karst region, residential, industrial buildings, etc.) and carefully look for bats and possible bat roosts within that habitat. The species present at the site can be determined by observation from a distance or by catching a few individuals, taking measurements and releasing them. For a precise assessment is necessary to visit as many places as necessary within study region that might provide potential bat roosts. Potential roosts should be carefully examined for the presence of bat guano or owls' pellets, that frequently contain bones from bats that inhabit the region. Sections of the roads that cross the region must be also examined since bats are often killed by night traffic.

Advantages. This is the easiest and a relatively low-cost method for assessment of species composition, abundance and the function of the various bat habitats.

Limitations. A single visit to some roosts before or after the breeding or hibernation season may show no signs of bats living there at all. For this reason, it is necessary that the visits are carried out during periods when the bats are likely to inhabit the studied site. Such periods are form May 15th to August 1st and from December 1st to March 1st. Information on the number of individuals in the winter and summer colonies can vary due to experts' level of experience in counting bats in large

numbers. Digital photographs can be a very good way for archiving and substantiating the estimates.

- **Mist-nets and traps for bats** for establishment of species composition: The nets should be set above rivers, streams, ponds, forest clearings, not asphalt roads. To ensure some catches, it is deferable that the total length of the stretched nets in the forests is more than 50 m. When there is a cave entrance, a rock niche or a stream in the forest, the chances of catching more species are higher. Mist-nets for bats are made of a very thin polyester fibre. Some nets designed for catching small birds can also be used for catching bats. The nest should be set at the entrance of caves, galleries, bunkers, above rivers and streams, in forest clearing or above pathways.

The trap for bats on narrow entrances (harp trap) consists of one or two rectangular aluminum frames each coiled with a fishing line. The bats are stopped by the fishing lines and fall into the bag. This trap is used to catch bats emerging from small entrances where mist-nets cannot be properly set. The funnel trap consists of a cone shaped plastic tube, rings connected with a fishing line and guiding tunnel with nylon „trunk". The trap is usually set at tree holes/hollows, bats are deflected into the tube and through the tunnel into the cloth bag.

Advantages. These are the most reliable methods for catching bats when there is no direct access to them and cannot observe their colonies in order to count their number and species composition.

Limitations. These setting and positioning of nets and bat traps at the right places require previous experience to obtain the optimum results. Whenever a large colony is involved it is necessary to have assistants who can quickly release the caught specimens.

Recommendations. Depending on the place and the number of field assistants one or several nets should be set before sundown. In forests more than one net must be set in order to increase the capture success. During catching the experts

Tuttle Trap placed under bridge

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stay close to the net/trap and the captures bats must be promptly identified, examined and released. Bats can be kept in soft, cloth bags for a short period until they have been carefully examined.

- **Radiotelemetry:** by radiotelemetry can be established with the precision where bats are feeding, where they are going to reach their hunting areas, rest sites and in which hollows they live. Radiotracking (radiotelemetry) is an indirect method for studying behaviour of animals, including bats. Three are the main requires for the realization of this research:

– **Transmitter** – this emits constant signals within the 149.XXX or 151.XXX MHz range. In ideal conditions, it can be "heard" of 5–7 km, and from hilly regions under 2 km.

– **Receiver** – digital or analogue. The new models are highly sensitive, lighter and easier to use.

– **Directional antenna** – longer antennae ensure a better signal. This method enables a researcher to know at any time where the bat is when it is with the transmitter. Its weight is up to mac 10% of bat's weight, usually some 0,50–0,70 g. Normally

the bat is radio-tracked for 4–7 days and over this period it becomes clear where exactly its foraging ranges, resting sites and migration corridors, etc. The information accumulated during the radio tracking surveys is the best source of behavioral data, which can provide a basic foundation for the management and protection of bats in a given habitat. The method is widely used when the habitat is too complex to establish how bats use the different territories and can help clarify the most appropriate measures for their management. Telemetry is of undoubted value in helping to depict/analyze the exact home ranges of bats, which is particularly useful when new protected territories are declared.

Advantages. It is the only method for collecting rich information on the exact roosts of bats, their activities, foraging biology, hunting territories and individual behavior in a short period.

Limitations. The high value of micro transmitters and the need to be ordered a few months in advance. The tracking team needs at least two researchers. A GPS receiver can also be used to allow accurate mapping of the home range.

Recommendations: Ideally the researcher will have a digital interactive map (e.g. Google Earth) on which the data from the GPS point tracking can be plotted.

– Telemetry is one of the few methods which can show exactly where a bat or a colony live in regions with no caves, what flight paths use for their local movements, the size and the type of foraging territories (e.g. becomes whether the bats hunt in an old forest, above shrubs, in wetlands or above farming areas), how much time they spend hunting and resting.

– Radiotelemetry should only be used for well-organized and authorized projects where essential data cannot be acquired with less intrusive methods.

- **Ultrasound detection (detectors for bats)**: This is an increasingly accessible, non-invasive method. It is based on the computer analysis of the emitted bat specific echoes and social sounds. Allows to consider the relative flying activity of the specified species, the places of greatest importance such as

hunting areas, gathering points for individuals, the main 24-hour and seasonal migration corridors. Punctual (or transect) detection is the main technique for monitoring bats in open territories such as wetlands, forest and steppe areas of Dobrodzha or in the alpine habitats of the high mountains. This is the most reliable method for monitoring bats which can be repeated following the same tracks.

Ultrasound detector for bats with recording device

© R. Mecheva

During field research there are two main approaches used:

Stationary observations – the place of recording should be selected to allow for maximum information on the bat species composition. For punctual recordings, usually are used places "for gathering" from bats – such as water bodies, flight corridors. For the results of a variety of habitats to be subjected to statistical analysis, it is desirable that the point records to be conducted with the same duration. Typically, recordings of 15-20 minutes in a point are considered representative. If the surveyed area is homogeneous but with a large area the point re-

cords should be carried out on evenly spaced points throughout the area.

Transect method – records are used to run on predetermined or designated routes. Applied in the study of linear objects or in habitats with a large area, but with approximately uniform characteristics of the environment. It is important to consider the coordinates and time at the beginning of the recording to allow georeferencing of registered sounds as different point on the route. The disadvantage of the method is that the recording quality can be decay, as a result of additional noise emitted by the movement (on foot or by car).

Combined method – the movement is done on a transect, as there are taken "sound samples" at certain distance or time intervals.

Record time. It is recommended that recordings start 20 minutes to half an hour before dusk. When conducting bioacoustics monitoring, it is important to record not only at dusk but also throughout the night, as different bat species are active in different parts of the night. For example, in most species of bats, there is a second peak in activity early in the morning before dawn.

Collecting other data. In addition to conduction the record, it is also important to collect data on the habitat and behavior of the bats. For example, if the recording is done near an open water mirror, surveillance with spotlight for bat behavior, coloring and flight can help us with species determination, which will make the sound analysis even more precise. The exact geographic location of the recorded notes is relevant in the subsequent environmental analysis. For assessment of the impacts of environmental factors on flight activity, it is also important to collect data on air temperature, humidity, strength and direction of wind, cloudiness, etc. It is desirable that these data to be recorded some field notebook.

Acoustic monitoring as a method for research of bats – possibilities and limitations of the method

As noted, acoustic identification is an important method for establishing bats when direct observation or capturing cannot be accomplished. On practice in many cases, it is the only method that can be used to determine the species composition of bats in a given habitat. It has other advantages such as:

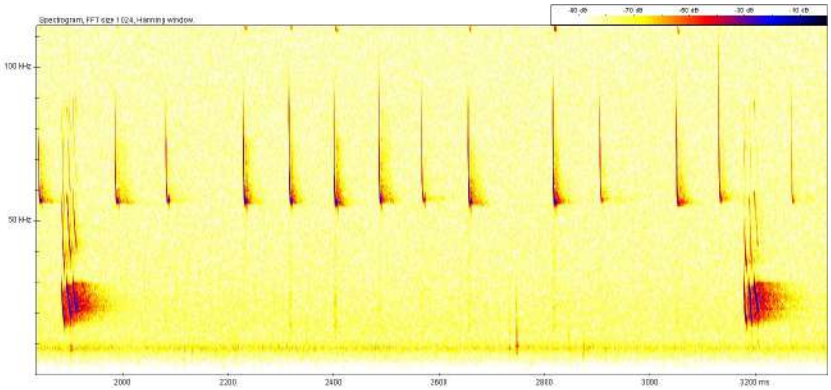
– - non-invasive study method;

– - a comparatively affordable method;

– - capabilities to automatically identify certain types;

– - allows for the establishment of species composition and for observations on behavior – food, social, other;

– - in some cases the differentiation of species is easier on their sounds than on morphological features (e.g. *Pipistrellus pipistrellus*/*Pipistrellus pygmaeus*).



Sonogram of echolocations and social sounds emitted from Soprano pipistrelle (Pipstrellus pygmaeus)

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However, the method has its limitations, arising from the following circumstances:

– identical or very similar echolocation sounds emitted by

bats;

– great variability of the sounds generated by the different conditions (habitats, including bat flying, the distance from surrounding objects, age, hunting strategy, social between other bats etc.);

– less sensitivity of the method to some groups – *Rhinolophus* („narrow" targeted sounds that can only be captured if they are projected against the microphone), *Plecotus* (quiet sounds);

– technical limitations associated with the range of microphones;

– greater labor intensity associated with the individual analysis of individual sounds of a large amount of data;

– need for knowledge and expertise on sound physics, echolocation in bats and their behavioral ecology;

– significant subjectivism in the definition of sounds, based on the different personal experiences and qualities of the experts.

The fact that technical constraints are overwhelming and the volume of invested work can be refined; the main limitation remains the fact that not all bats have type specifics or other characteristics of the sound.

The table below presents a list of bat species or groups of them in Bulgaria, which can be distinguished by their sounds. The presented confidence in the analysis is result of many years of practical experience of the researchers. Combined with direct observations of flying bats, detailed knowledge of existing roosts and environmental characteristics, in some cases this reliability can be almost 100 percent. The presence of social sounds can also increase the accuracy of determining the bat species in the studied habitat.

Table 4

Groups and bat species in Bulgaria, which can be distinguished by the sounds they make

Groups and bat species	Degree of reliability of determination of groups and bat species only by echolocation sounds
Family *Rhinolophidae* – Horseshoe bats	100 %
Family *Vespertilionidae* – Vesper bats	95 %
Family *Molossidae* – Free-tailed bats	95 %
Genus *Plecotus*	90 %
Genus *Myotis*	90 %
Rhinolophus hipposideros – Lesser horseshoe bat	70 %
Rhinolophus ferrumequinum – Greater horseshoe bat	95 %
Rhinolophus euryale – Mediterranean horseshoe bat	70 %
Nyctalus noctula – Noctule	80 %
Nyctalus lasiopterus – Giant noctule	90 %
Nyctalus leisleri – Lesser noctule	60 %
Pipistrellus pipistrellus – Common pipistrelle	95 %
Pipistrellus pygmaeus – Soprano pipistrelle	95 %
Pipistrellus nathusii – Nathusius's pipistrelle	90 %
Pipistrellus kuhlii – Kuhl's pipistrelle	70 %
Hypsugo savii – Savi's pipistrelle	80 %
Eptesicus serotinus – Serotine bat	90 %
Eptesicus nilssonii – Northern bat	90 %
Vespertilio murinus – Particoloured bat	50 %
Tadarida teniotis – European free-tailed bat	95 %

The definition of some species among which the following are facilitated by the presence of social sounds*: Pipistrellus pipistrellus* – Common pipistrelle, *Pipistrellus pygmaeus* – Soprano pipistrelle, *Pipistrellus nathusii* – Nathusius's pipistrelle, *Pipistrellus kuhlii* – Kuhl's pipistrelle, *Vespertilio murinus* – Particoloured bat, *Nyctalus noctula – Common noctule*. Some of the species occurring in Bulgaria can be distinguished relatively easily because the echosounds they emit are with specific frequencies. For example, the European free-tailed bat (*Tadarida teniotis*) most often emit sounds in a range of 11 – 14 kHz, which are usually clearly distinguishable from those of other species. It is possible to be wrong with Giant noctule (*Nyctalus lasiopterus*), which is very rare in Bulgaria and can emit low frequency souns 16 kHz.

In cases where species cannot be expressly defined by their sound, they can also be reduced to "acoustic groups". This information is also valuable and after subsequent field studies it is possible to specify exactly which species has been encountered in the given habitat. For example some sounds can be defined as sounds types as: *M. schreibersii/P. pipistrellus, Myotis myotis/blythii, Rh. mehelyi/euryale, Rh. mehelyi/euryale/hipposideros, P. kuhlii/P. nathusii, P. kuhlii/P. nathusii/H. savii, N. leisleri/N. noctula/V. murinus, N. leisleri/N. noctula/V. murinus/E. serotinus, N. leisleri/N. noctula, M. schreibersii/P. pygmaeus.*

Bats however do not emit sounds with the same constant frequency. They vary considerably depending on various factors such as – the surrounding environment, the distance of the subjects, hunting strategy and many others. This makes the sounds too "variable" in which sounds of two different types may look alike or similar, making it impossible to determine sounds.

Basic guidelines for the analysis of bats' sounds

– the sonogram analysis can be done with different software, according to the needs and capabilities of the analysis and

the analyzer;

– conduction sonogram analyzes requires an extraordinary investment of time and knowledge to inspect the specifics of sounds of each type;

– the sounds of the bats are greatly influenced by the environment – its character and its distance from the objects, which further complicates the analysis and is the cause of significant variability even in the sounds of the same species;

– there is a significant degree of subjectivity in the sonogram analysis. For this reason, the results of each analyzer should be verified by specialists, until enough experience that can guarantee the reliability of the data.

Ultrasound analysis as element of monitoring researcher for the aim of environmental assessment

Bulgarian environmental legislation requires that all investment projects to be compliant with the subject and objectives of Natura 2000 protected sites, as well as minimizing any negative impacts from their realization on biodiversity, including on bats. Widespread use for environmental assessment purposes is the method of bats ultrasound registration and analysis in order to gather enough data to implement adequate conservation measures for this mammal group. It is extremely important that the method is non-invasive and in practice does not even disturb the animals. Where direct observations on bats are impossible (e.g. in large agricultural areas, over water bodies, etc.) the use of ultrasound detectors is indispensable. Methodological guidelines for conduction similar monitoring studies are given by (Petrov, 2008), as well as with the guidelines of Agreement on the Conservation of European populations on bats (EUROBATS). In accordance with the requirements of the above guides, the results obtained should answer the following questions:

– What is the species composition of bats;

– Are there places with increased activity of bats;

– Are there clearly identified migration corridors;
– Will a barrier effect arise for migratory species of bats;
– Assessment on the risk from bat fatalities;
– Degree of fragmentation of habitats used from bats;
– Assessment of potential investment projects on bat species, subject to conservation in Natura 200 network of national protected area and national conservation legislation.

Recommendations

Even a simple detector is enough to register whether bats are flying over the region being assessed. Detectors can therefore be used to indicate whether there is value in mist-netting at certain places, where they were "heard" a lot of the bats flying. An expert who has carried out an initial field bat detector survey must decide if a more experienced specialist is needed to identify the exact species in the region. Detectors are expensive devices but they can help in identifying the "exact" places and thus save a lot of search effort, particularly when vast open areas/region need to be surveyed.

- **Genetic and molecular methods**

Some of the bat species found in Bulgaria and Europe are hard and sometimes even impossible to identify precisely under field conditions. The only way for exact determination of the cryptic species requires a genetic and molecular analysis of a small piece of tissue (most often taken from the wing membrane) collected from the animal.

Advantages. This method is appropriate when the assessment needs to be accurate in terms of species identification of bats which inhabit certain roost or a habitat.

Limitations. The method is very expensive way to identify individuals or species, especially when a larger number of samples must be processed.

Examples for monitoring and good practices

Agriculture and forest management remain crucial for land use and the management of natural resources in rural areas of the EU and as a platform for economic diversification in rural communities. The European Agricultural guarantee fund, established by Regulation № 25 from 1962 on the financing of the common agricultural policy (CAP, last amended by Regulation (EEC) № 728/70), consumes a large part of the general budget of the European Union. The Rural Development program supports and improves rural development and improves agricultural structures. One useful example is agro-ecological measures. Agri-environment schemes are considered key in relation to biodiversity conservation. Examples can be given which to be identified by the member countries in the areas critical to bats:

– Agri-environment schemes: management of undeveloped pastures, lakes, hedges, preservation of permanent pastures along rivers or along forests;

– optimal use of forests: protection of old growth trees in private and public forests.

Ultrasound bat biodiversity can be used as an indicator of changes in the environment, as bats are present in most areas of world, inhabiting a variety of habitats and playing a key role in ecosystem services (regulation of insect abundance, pollinating of higher plants and spreading of their seeds). Because of those bat species characteristics are the basis of the iBats global biomonitoring project. A wide range of algorithm-based applications allow the automatic determination of species. The project started out in 2006 in Great Britain as partnership between Zoological Society of London and Bat Conservation Trust. The main aim is to provide regional and as well national networks of monitoring programs to establish global changes in bat species. Bulgaria has an important role in the implementation of the program's objectives, as the project started in 2007. Monitoring method is based on 40 km of road transects, starting 30-45 minutes after sunset in the period of peak seasonal activity for bats –

July – August. The chosen speed from 25 km/h is to minimize the chances of a bat being encountered more than once on the transect. There is also used registration of sounds with the help of TE- detector (Tranquility Transect, Courtpan Design Ltd, UK), the exact geographic coordinates are also marketed at any time. The program is widely using volunteers. From surveys carried out in 2006 – 2008, using Maximum Entropy Modelling (MaxEnt), to predict habitat suitability over large regions of Europe. For the purpose are used 15 ecological and climatic parameters. The program iBats is a standardized and innovative method for assessing ultrasound bat biodiversity in reference with the upcoming global changes of the environment.

According to the Bulgarian environmental legislation, the construction of wind turbines should have surveys on bats in the project territory.

Windfarm in arable lands in Northeastern Bulgaria (Dobrudzha)

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Because of that requirement during the period of 2010 – 2015 year on the territory of Bulgaria dozens of field surveys have been carried out in a variety of landscapes – ranging from the mountainous forests to the flat coastal areas. During 2010 the monitoring study was carried out in a mountainous area representing a massif with the highest peak "Yordanov peak" (altitude 1073 m), part of the southern slopes of Stara Planina, west of the town of Sliven (Pandourski, unpublished data). The region is a combination of open meadow ridge parts and old deciduous forests, represented mainly by beech. The main method was the registration and analysis of bat's ultrasounds, performed point and route. The monitoring points were selected in order to cover the available habitats represented in the area of the proposed wind energy park such as: meadows, shrubs, woodlands, eco-zone of open-air forest ecosystems, coppice forest areas and open spaces. The species composition of the bats and their night activity was recorded within the operating wind energy park. During the study 16 species of bats were identified. Due to the specificity of the bat's ultrasound method, some of the sonograms obtained were not identified by considering the pairs of probable ultrasound species with a similar frequency and characteristic of the recorded echolocation sounds. Those are Noctule (*Nyctalus noctula*) and Lesser noctule (*Nyctalus leisleri*), Greater (*Myotis myotis*) and Lesser mouse-eared myotis (*Myotis blythi*) and Brown and Grey long-eared bats (*Plecotus auritus/austriacus*). Since the studied area is part of the range of the above-mentioned species, their presence in the area is considered.

The seasonal dynamics of occurrence and registration of individual species within the Investment offer is presented in the table below:

Table 5
Seasonal dynamics of bat species

Species	Period of spring migration (April 2010)	Breeding period (June 2010)	Period of displacement of colonies (August 2010)	Period of active autumn migrations (October 2010)
Greater horseshoe bat *(Rhinolophus ferrumequinum)*	+			+
Mediterranean horseshoe bat *(Rhinolophus euryale)*			+	
Greater mouse-eared bat *(Myotis myotis)*			+	+
Lesser mouse-eared myotis *(Myotis blythii)*			+	+
Schreiber's bent-winged bat *(Miniopterus schreibersii)*	+		+	+
Nathusius's pipistrelle *(Pipistrellus nathusii)*	+	+	+	+
Common pipistrelle *(Pipistrellus pipistrellus)*	+	+	+	+
Western barbastelle *(Barbastella barbastellus)*				+
Long-fingered *bat* (*Myotis capaccinii)*	+		+	

Species	Period of spring migration (April 2010)	Breeding period (June 2010)	Period of displacement of colonies (August 2010)	Period of active autumn migrations (October 2010)
Particoloured bat *(Vespertilio murinus)*				+
Grey long-eared bat *(Plecotus austriacus)*				+
Brown big-eared bat (*Plecotus auritus)*				+
Savi's pipistrelle *(Hypsugo savii)*		+	+	
Serotine bat (*Eptesicus serotinus)*	+		+	+
Noctule *(Nyctalus noctula)*		+		+
Lesser noctule *(Nyctalus leisleri)*				+
Total species	**6**	**4**	**9**	**13**

The obtained data clearly show the uneven seasonal distribution of the species composition in the territory affected by the implementation of the Investment proposal. Registered species during different seasons range from 4 (during breeding period) to 13 (during the autumn migration period). The poorest is the composition of the bats during the breeding period, when only 4 species are found. The species composition in the autumn is enriched with migratory species of the genus *Nyctalus* and *Vespertilio*. Increased activity and presence during this period are due both to relatively rare forest species as well as to typical cave-dwellers horseshoe and vesper bats.

Probably registered Serotine bat (*Eptesicus serotinus*) and Common pipistrelle (*Pipistrellus pipistrellus*) are part of local

populations. Two species from genus *Pipistrellus* (common and nathusius's bats) are present in the area throughout the monitoring period, as the Nathusius's bat is more numerous and higher activity compared with other species.

The following migratory forest and cave-dwellers species have been identified, performing long flights over hundreds of kilometers: Common pipistrelle (*Pipistrellus pipistrellus*), Noctule (*Nyctalus noctula*), Lesser noctule (*Nyctalus leisleri*), Particoloured bat (*Vespertilio murinus*) and Schreiber's bent-winged bat (*Miniopterus schreibersii).*

During the monitoring period a comparatively rich bat community was registered and the different species are presented here in varying degrees. As very rare we can consider the following species: Mediterranean horseshoe bat (*Rhinolophus euryale*), Western barbastelle *(Barbastella barbastellus),* Grey long-eared bat (*Plecotus austriacus*) and Brown big-eared bat *(Plecotus auritus).* Except for the Mediterranean horseshoe bat, the other species are mainly forest-dwellers.

Species found during transects are represented only by single individuals. Considering the sensitivity of the ultrasound detector used during transects, the density of bats per unit are over the individual periods is as follows:

– Spring migration: 18.5 individuals/km^2;
– Breeding period: 23.8 individuals/km^2;

The activity and species composition of bats during the summer and autumn periods respectively were recorded by points surveillance, as the relative activity of the registered species being represented on the following two diagrams:

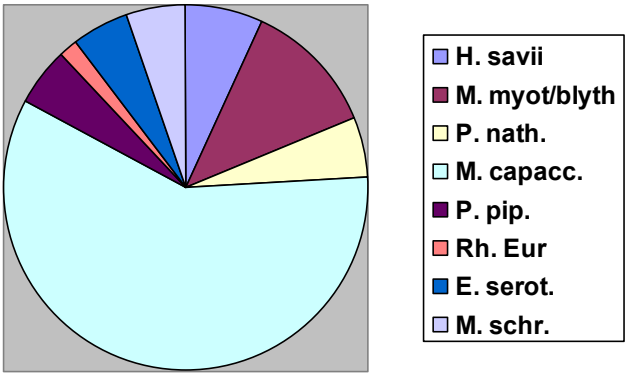

Figure 1. Relative abundance of registered bat species during the summer period. The species are named in the legend by their shortened names

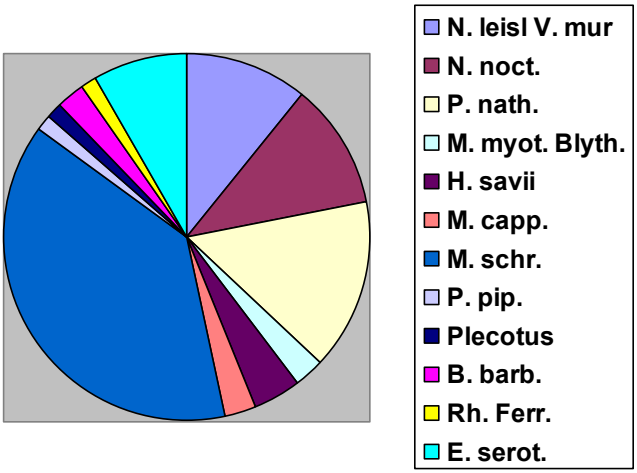

Figure 2. Relative abundance of registered bat species during autumn period. The species are named in the legend by their shortened names

In both periods, clearly dominate both cave-dwellers species (*Myotis capaccinii* during summer and migratory Common bent-wing bat – *Miniopterus schreibersi* during autumn).

Species found have the following habitats distribution in the area of the design wind farm:

Table 6

Distribution of species by habitats

Species	Type of habitat
Greater horseshoe bat *(Rhinolophus ferrumequinum)*	Open grass and shrub spaces
Mediterranean horseshoe bat (*Rhinolophus euryale*)	Open grass and shrub spaces
Greater mouse-eared bat (*Myotis myotis*)	Above the water surface on the dam
Lesser mouse-eared bat *(Myotis blythii)*	Above the water surface on the dam
Schreiber's long-fingered bat (*Miniopterus schreibersii)*	Open grass and shrub spaces, above the water surface. In the borders of the existing wind farm
Nathusius' pipistrelle *(Pipistrellus nathusii)*	Open grass and shrub spaces, above water surface. Ridge parts of the massive
Common pipistrelle (*Pipistrellus pipistrellus*)	Open grass and shrub spaces, above water surfaces. Ridge parts of the massive. In the borders of the existing wind farm.
Western barbastelle *(Barbastella barbastellus)*	Ecotone zone forest – meadow.
Long-fingered bat (*Myotis capaccinii*)	Extremely above the water surface of the dam
Particoloured bat (*Vespertilio murinis*)	Over open terrains.
Grey long-eared bat (*Plecotus austriacus*)	Forest clearings.
Brown long-eared bat *(Plecotus auritus)*	Forest clearings.

Species	Type of habitat
Savi's pipistrelle *(Hypsugo savii)*	Open grass and shrub spaces
Serotine bat *(Eptesicus serotinus)*	Open grass and shrub spaces
Noctule (*Nyctalus noctula*)	Open grass and shrub spaces. Ridge parts of the massive. In the borders of the existing wind farm.
Lesser noctule (*Nyctalus leisleri*)	Open grass and shrub spaces. Ridge parts of the massive. In the borders of the existing wind farm.

The analysis of the bats in the surveyed territory shows that their distribution and species composition are directly dependent on the availability of appropriate roosts in the forest and foraging territories, such as open grass lands, forest clearings and ponds, as well as the variety of underground karst roosts in the neighboring mountain slopes – Kotlenska, Tvurdishka and Sliven mountain. Based on the results, specific measures have been proposed to the investor to reduce the impact on bats aimed at protecting the forest species and their habitats, as well as preventing fragmentation of the habitat by interrupting migration routes.

A specific practice in Bulgarian forestry industry is the creation and maintenance of field belts in Dobrudzha. These belts represent forest deciduous plantations arranged in rows to protect crops from strong and cold northeastern winds. These constant winds cause a high investment interest in the construction of wind energy parks. Under Bulgarian legislation those projects are subject to an assessment of compatibility with the Natura 2000, along with a one-year bird and bird study.

In this connection a lot of studies have been carried out on the bats in the Dobrudzha area, such as those considered as local species and using for roosts old trees in the field belts as well as those present in the territory during migration.

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The contents of this publication are sole responsibility of project partners and can in no way be taken to reflect the views of the European Union, the participating countries, the Managing Authority and the Joint Secretariat.

Noctule bat (Nyctalus noctula), inhabited hollow in old growth tree during autumn migration period in Dobrudzha, Bulgaria

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A similar study was conducted in 2018 in a territory intended to build a wind energy park (Pandourski, unpublished data). It is part of a vast arable agricultural area, standing west of the Black Sea coast, at an altitude 70 – 100 m, and does not affect habitats with natural vegetation. Immediately to the west it borders on dry land and open areas with steppe and bush vegetation, which is part of BG0000130 «Kraymorska Dobrudzha" site. At different distance from the project sites of the wind turbines, there are 14 forest protection belts. The current analysis of the species composition, richness, rarity and vulnerability of the Bulgarian bats' fauna (Popov, 2018), shows that the territory is in an area with low species diversity, a low degree of rarity and an average degree of vulnerability of the community. The species present refer mainly to common and widespread

taxons of the country. Total stationary auditions with ultrasound detectors lasting every 10 to 45 minutes were performed at 19 points, five of which were visited several times, respectively during May, June, August and September. The total length of car transects with automatic recordings of the echolocation sounds of the bats is 72 km and 438 m. The total duration of the automatic recordings made on the transects is 15 hours, 36 minutes and 15 seconds. By month, the distance is distributed as follows:

- April: 21 km and 538 m;
- May: 20 km and 500 m;
- June: 30 km and400 m;
- July: 36 km and800 m;
- August: 46 km and 500 m;
- September: 10 km and 300 m;
- October: 27 km and 500 m.

The differences in the distance traveled during the individual months are due to the partial obstruction of the routes due to the precipitations that have fallen and formation of sections with deep puddles and muddy areas, not impassable for a car.

According to requirements of Resolution 4.7 of EUROBATS, and in order to assess the potential impact of the Investment intent on species of bats, objects of conservation in adjacent Protected sites Natura 2000, as part of their wider area, one-off studies in BG0002061 „Balchik", BG0000154 „Durankulak" and BG0000130 „Kraimorska Dobrudzha" sites. A total of ten bat species were identified in the territory of the planned wind energy park, all of them are from family of Vesper bats (Vespertilionidae):

1. Common pipistrelle (*Pipistrellus pipistrellus*);
2. Soprano pipistrelle (*Pipistrellus pygmaeus*);
3. Nathusius's pipistrelle (*Pipistrellus nathusii*);
4. Savi's pipistrelle (*Hypsugo savii*);
5. Schreiber's bent-winged bat (*Miniopterus schreibersii*);
6. Serotine bat (*Eptesicus serotinus*);
7. Noctule (*Nyctalus noctula*);

8. Lesser noctule (*Nyctalus leisleri*);
9. Particoloured bat (*Vespertilio murinus*);
10. Mouse-eared bat (*Myotis* sp. 45 KHz phonetic type).

The only representative of horseshoe bats is Greater horseshoe bat (*Rhinolophus ferrumequinum*), was established with three individuals in rocky monasteries in adjacent territory. All types were recorded in a direct flight with single flyers. In just one case was recorded a social sound activity of Noctule (*Nyctalus noctula*) near a steppe habitat and the end of a forest belt. The exception is the Durankulak Lake, which is an important hunting area focusing on the activity of bats even during the unfavorable early-spring weather conditions in 2018. The species found have a clear dispersion distribution in the territory of the planned wind energy park and there is no clear connection with certain landscape elements. Increased hunting activity of fewer groups or single individuals was observed at the intersection of forest protection belts or above the water surface of temporarily formed large spills and puddles after rainy days in May. Population density is extremely low: during June only 9 individuals were registered in the 30,4 km transect, or one individual at 3,38 km, and in May at a transection length of 20,5 km – only three individuals or an individual of 6,83 km. Relatively high flying activity was observed in August (average 1 individual at 800 meters) No bats was recorded in April due to the adverse weather conditions during this spring season of 2018 – low night temperatures, frequent rainfall, extensive arable areas without vegetation, representing a very unfavorable hunting area with minimum insect volume. In October, bats activity was also not recorded in the surveyed territory. Similarly, practically absent bats were also observed in adjacent steppe habitats, where during the observation period we found only one individual of Savi's pipistrelle (*Hypsugo savii*). The bats species found have an expressed time distribution over the life cycle periods. The dynamics of the species is presented in a table 7.

Table 7

Seasonal dynamic of species composition of bats during 2018

Species	Period of spring migration (April 2018)	End of spring migration and begging of breeding period (May)	Breeding period (June 2018)	Summer period (July, August)	Autumn migration period (September, October)
Common pipistrelle (*Pipistrellus pipistrellus*)	-	-	+(3 individual registrations of species with 11 echolocation sounds)	-	-
Soprano pipistrelle *(Pipistrellus pygmaeus)*	-	-	-	+ (3 registered with 9 sounds)	+ (2 registrations with 6 sounds)
Nathusius's pipistrelle *(Pipistrellus nathusii)*	-	+(4 individual registration of species with 38 echolocation sounds)	-	+ (20 registrations with 57 sounds)	+ (7 registrations with 196 sounds)
Savi's pipistrelle *(Hypsugo savii)*	-	-	-	+ (11 registrations with 34 sounds)	+ (1 registration with 2 sounds)
Myotis sp. **45 KHz**	-	+ (24 individual registrations of species with 284 echolocation sounds)	-	+ (4 registrations with 14 sounds)	-
Noctule (*Nyctalus noctula*)	-	-	+ (9 individual registrations of species with 35 echolocation sounds)	+ (16 registrations with 44 sounds)	+ (16 registrations with 327 sounds)

Species	Period of spring migration (April 2018)	End of spring migration and begging of breeding period (May)	Breeding period (June 2018)	Summer period (July, August)	Autumn migration period (September, October)
Lesser noctule *(Nyctalus leisleri)*	-	-	-	+ (5 registrations with 15 sounds)	-
Particoloured bat *(Vespertilio murinus)*	-	-	-	+ (5 registrations with 15 sounds)	-
Schreiber's bent-winged bat *(Miniopterus schreibersii)*	-	-	-	+ (3 registrations with 10 sounds)	-
Serotine bat *(Eptesicus serotinus)*	-	+ (2 individual registrations of species with 16 echolocation sounds)	+ (1 registration with 2 echolocation sounds)	+ (8 registrations with 69 sounds)	-
TOTAL SPECIES	0	3	3	9	4

As noted above, no bat was found in April over the territory under investigation. The activity of the bats in the area of the northern Bulgarian part of the Dobrudzha coast was concentrated not far from the most favorable hunting areas, such as coastal lakes. This was confirmed by our field trials in the Durankulak Lake area, where five bat species were registered on April 19th, whereas the same night in the territory of the projected wind energy park and despite the efforts with the same

equipment, no bats were found. The main reason for this fact is the unfavorable meteorological conditions during this period and the need for energy-saving behavior of individuals leading to the concentration of activity directly in favorable hunting areas. In May the most numerous was Mouse-eared bat (*Myotis* sp.), as its increased hunting activity was recorded near a temporary spill among some vegetation. During June a dispersed migration of Noctule (*Nyctalus noctula*) almost all the studied area, but unrelated to certain landscape elements. Very poor activity of the other two species during this month was observed at the site of intersection of several forest protection belts.

For the period of spring migration and the beginning of the breeding period, only 43 individual registrations were recorded (compared to 30 for the same period in 2011), with no social sounds recorded in any case. Except for hunting activity of *Myotis* sp. above the temporary water surface, all other registrations are echolocation sounds of flying bats not held at the observation site. The absence of flight activity in the initial 45 minutes till 1 hour after the astronomical sunset during all observation days proves the absence of roosts in the investment territory. It is also observed a deterioration in the potential conditions for hunting of forest and migratory species of bats as a result of the harvesting of old trees in part of the protection belts that existed in 2011.

During the summer period (July - August) was found a pronounced dispersion of bat species. There are no specific sites of gathering of individuals, with the highest species composition – seven species. Minor territorial affection can be set for Soprano pipistrelle (*Pipistrellus pygmaeus*) in the northern part of the project territory not far from Neikovo village and for Savi's pipistrelle (*Hypsugo savii*), whose registrations are in the southern part of the territory.

With the fall of the autumn migration period (September – October), the species richness of bats significantly decreased – from 4 species in September to lack of activity at the end of Oc-

tober. During this time the distribution of the registered activity is dispersed without marked places of gathering. The low density of the assemblage proves that the wind farm territory is not part of a significant migratory seasonal corridor, but rather the presence of individuals is of an accidental. During autumn period, the are surveyed is a poorly fitting hunting area with very low insect abundance since it is largely devoid of vegetation after harvest and early autumn plowing.

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