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THE INFLUENCE OF LANDSCAPE STRUCTURE TO THE ACTIVITY OF BATS

Zuzana Haceková[2], Blanka Lehotská[1*], Jana Ružičková[2]
[1]Department of Landscape Ecology, 2Department of Environmental Ecology, Faculty of Natural Sciences, Comenius University, Bratislava, Slovak Republic
z.hacekova@gmail.com, lehotska@fns.uniba.sk, ruzickova@fns.uniba.sk

ABSTRACT: The presented paper discusses the issue of the bat community activity in the model area (SACMartinský les, SW part of the SlovakRepublic) and the impact of selected factors on it. Since we studied the foraging activity of bats, we focused on the bat habitat preference and ecological classification of bats in connection with foraging habitats. We also defined the current landscape structure, including the evaluation of the percentage of 22 elements identified in the studyarea. We describe the detailed attribute and the process of selecting specific sites where the bat-detectoring took place. Two criteria (age of forest stands and the number of tree cavities) have influenced this choice. The bat activity on 15 particular detecting points depending on the landscape structure was evaluated. The percentage of the landscape structure elements within the radius of 100 m from each monitoring site was evaluated too. In the selection of foraginghabitats, the presence of linear elements was of greater importance than old forest stands.

Keywords: landscape structure,Chiroptera, bat's activity, foraging habitats, SlovakRepublic

INTRODUCTION

The recent state of landscape is the result of natural processes and human activities, what conduce inter alia to landscape fragmentation. The process of biotopes fragmentation in Slovak Republic rise in conjunction with the settlement of the country and with agricultural and economic activities. Influence of natural habitat fragmentation to wildlife species increase with expansion of urban areas and network of roads. The impact of fragmentation is species specific. The fragments of forests in agricultural landscape become islands of suitable places for survive of wildlife. On the other hand human activities lead to more diversified landscape structure, what could be preferred by some species.

The purpose of the study was investigation of bats activity in relation to the landscape structure and localization of forest fragments in agricultural landscape.

The study area is situated in the southwest part of Slovak Republic on the Danube lowland (part Trnava loess upland) on the neighbourhood of Small Carpathian Mountains, between the towns Pezinok and Senec (Fig. 1), about 30 km far from the capital city of Bratislava. It consists of two forest fragments (Martinský les and Šenkvický háj woods, 145–212 m a. s. l.) surrounded by agricultural landscape and small village St. Martin, which is situated between the forests.

During 250 years the area of Martinský les and Šenkvický háj woods was reduced from 2,230 ha in 1747 to 980 ha and was divided into several forest fragments (Ružičková 2003). Martinský les wood and the southern part of Šenkvický háj wood represent Special Area of Conservation Martinský les. The total area of forest land is 899.61 ha. The forest management plan of Martinský les wood was approved by decision of the District forest office in Bratislava on 2008, April 28No. 77/2009 for the period 2009–2018.

The aims of the research were:

- to observe the flight activity of bats in the selected sites of forest fragments (Martinský les and Šenkvický háj woods) and in settled area (St. Martin village);
- to evaluate the habitat preferences of bats in the study area;
- according to the map of thecurrent landscape structure to evaluate the importance of landscape elements in relation to the flight activity of bats;
- to evaluate the influence of forest age structure on the flight activity of bats.

The research was carried out with support of the VEGA Grants No. 1/0334/08 Assessment of function and quality of biocorridors in the contact zone of Small Carpathian Mts. and Trnava upland and No. 1/1139/11 Changes of landscape connectivity in the contact zone of Small Carpathian Mts. and adjacent lowlands – CONNECA.

Correspondence: Blanka Lehotská, Department of Landscape Ecology, Comenius University Bratislava, Faculty of Natural Sciences, Mlynská dolina, 842 15 Bratislava, Slovak Republic, Tel. +421-2-60296582, Fax. +421-2-60296703, e-mail: lehotska@fns.uniba.sk
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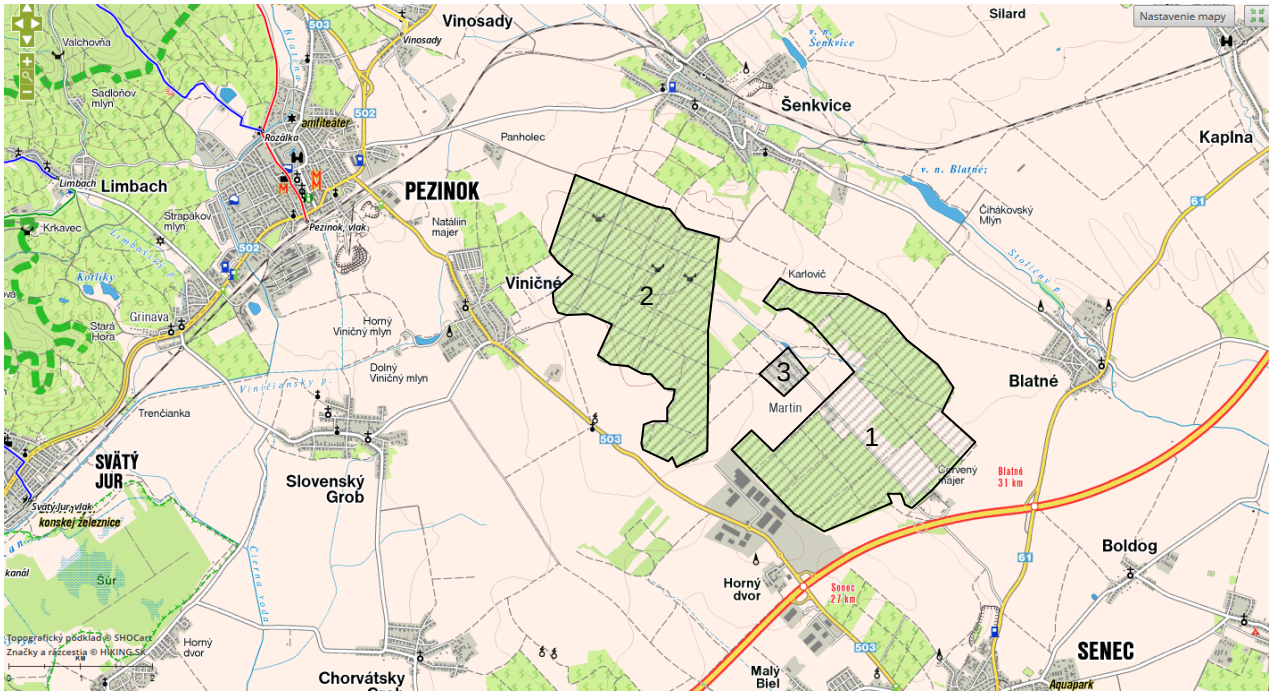

Fig 1 The study area – forest fragments Martinský les wood (No. 1), Šenkvický háj wood (No. 2) and St. Martin village (No. 3).

MATERIAL AND METHODS

The activity of bats was evaluated in three habitat types, altogether 15 detecting sites – forest interior (oak-turkey oak forest, 7 sites), ecotone zone (contact between forest and surrounded fields, 5 sites) and settled area (St. Martin village, 3 sites). Inside the forest complex the sites were selected according to the age of trees and the number of tree cavities. Also landscape structure was regarded by sites selection. The percentage of the landscape structure elements within the radius of 100 m from each monitoring site was evaluated on the basis of the current landscape structure (CLS) map and compared with bat activity on the detecting sites.

Methodologyby Pucherová (2007) was used in the creation of CLS map. Based on the databaseoutput quantitative characteristics of landscape structure elements (amountand percentage) were determined, the elements were classified according to the originality and functionality. Information necessary to elaborate maps of CLS were obtained by field research, supplemented by information from aerial photographs and orthophoto maps. The final map of CLS was created in MapInfo Professional 8.5 SCP program and subsequently converted into AutoCad. The studyarea has an area of 3,241.59 ha, directly situatedon two cadastral areas Senec and Veľké Šenkvice. Beyond the borders of the studyarea were determined roads, highway and railway track that surround it, reasons of convenience to the purposes of the research.

Preliminary fieldwork aimed at finding suitable tree cavities of tree hideouts was conducted in March and April 2009 before the spring's rollout of letters. Potential tree cavities were plotted in the map and marked by heavily erasable colour spray in field because of retrospective control of bat's population.

Bat-detectoring was the main field research method. It was carried out monthly between May and September 2009 always from the sunset till midnight in all selected sites. The length of the detection was 10 minutes on each site. Ultrasound detector Pettersson D-240 and recorder EU3C infinity M250 were used to determine the bat activity. The activity of all bats from the order Chiroptera was counted together from heterodyne mode record. Relative activity was used as a ratio between active seconds (seconds with echolocation records of bats) and the whole recording time. Software Audacity 1.3 was used for the isolation of active seconds from the rest parts of records. Time expansion mode was used for the species determination on single detecting sites and obtained records were subsequently analysed by BatSound Pro 3.3.1b. Bat-detectoring research was supplemented by netting in several detecting sites.

RESULTS AND DISCUSSION

The current landscape structure expresses the arrangement of landscape components, is defined by the currentstate and is valid until significant changes will occur. CLS determines internal and external relationships between landscape components, natural factors and human economic activity. The results of these relationships are landscape elements that can be grouped into several basic groups. Spatial representation of landscape elements is a reflection of land use (Pucherová, 2007).

In the study area the classification of current landscape structure was realised in 8 basic groups, in which 22 landscape elements were identified (Table 1, Fig. 2).

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Table 1.
Groups and CLS elements of the study area and its spread.

Landscape structure elements	Spread [ha]	Percentage [%]
Forest vegetation	**1,069.10**	**32.98**
Turkey oak-sessile oak forest (clear-cut)	24.96	0.77
Turkey oak-sessile oak forest (age 5–39 years)	141.34	4.36
Turkey oak-sessile oak forest (age 40–79 years)	356.58	11.00
Turkey oak-sessile oak forest (age 80–120 years)	538.44	16.61
Turkey oak-sessile oak forest (more than 120 years)	7.78	0.24
Non-forest vegetation	**152.69**	**4.71**
Forest nursery	3.89	0.12
Planar non-forest woody vegetation (NFWV)	91.42	2.82
Linear non-forest woody vegetation (NFWV)	46.36	1.43
Alley	11.02	0.34
Grassland elements	**55.43**	**1.71**
Meadows and pastures	55.43	1.71
Agricultural landelements	**1,290.84**	**39.82**
Arable land	976.72	30.13
Vineyards	314.12	9.69
Water elements	**2.27**	**0.07**
Watercourse	0.32	0.01
Water bodies	1.95	0.06
Settlement elements	**486.15**	**15.00**
Rural type houses	485.60	14.98
Cemetery	0.55	0.02
Industrial and technical elements	**125.46**	**3.87**
Built-up area	25.29	0.78
Industrial area	85.26	2.63
Controlled landfill	14.91	0.46
Transport elements	**59.65**	**1.84**
Roads	28.85	0.89
Highway	20.75	0.64
Railway	10.05	0.31
Sum	**3,241.59**	**100%**

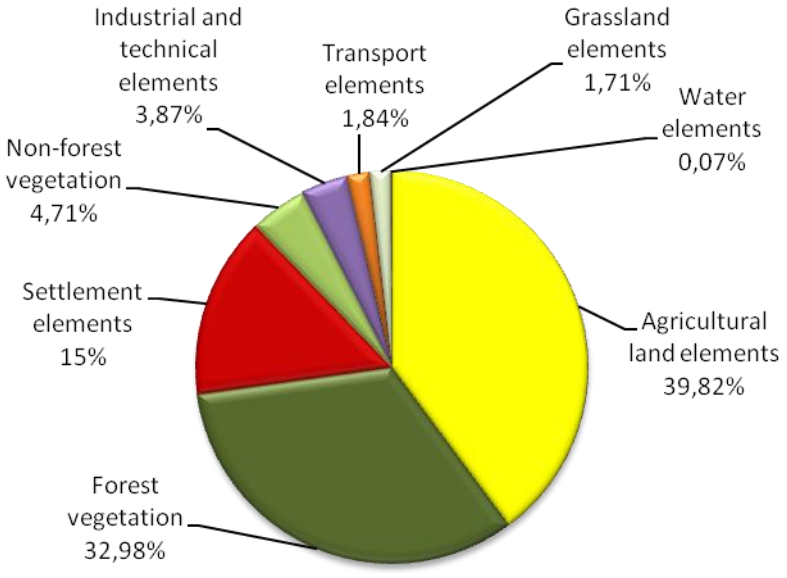

Fig. 2 The percentage of groups of CLS elements in the study area

The forest vegetation wasdivided according to age into five categories as follows:

- Forest A – Turkey oak-sessile oak forest (clear-cut) – the youngest forest stands to 5 years,
- Forest B – Turkey oak-sessile oak forest (age 5–39 years),
- Forest C – Turkey oak-sessile oak forest (age 40–79 years),
- Forest D – Turkey oak-sessile oak forest (age 80–120 years),
- Forest E – Turkey oak-sessile oak forest (more than 120 years).

Monitored sites were situated in the forest interior (A1–A7),ecotone zone (B1–B5) and settled area (C1–C3). The percentage of the CLS elements in the surrounding of detecting sitesis illustrated in the Fig. 3.

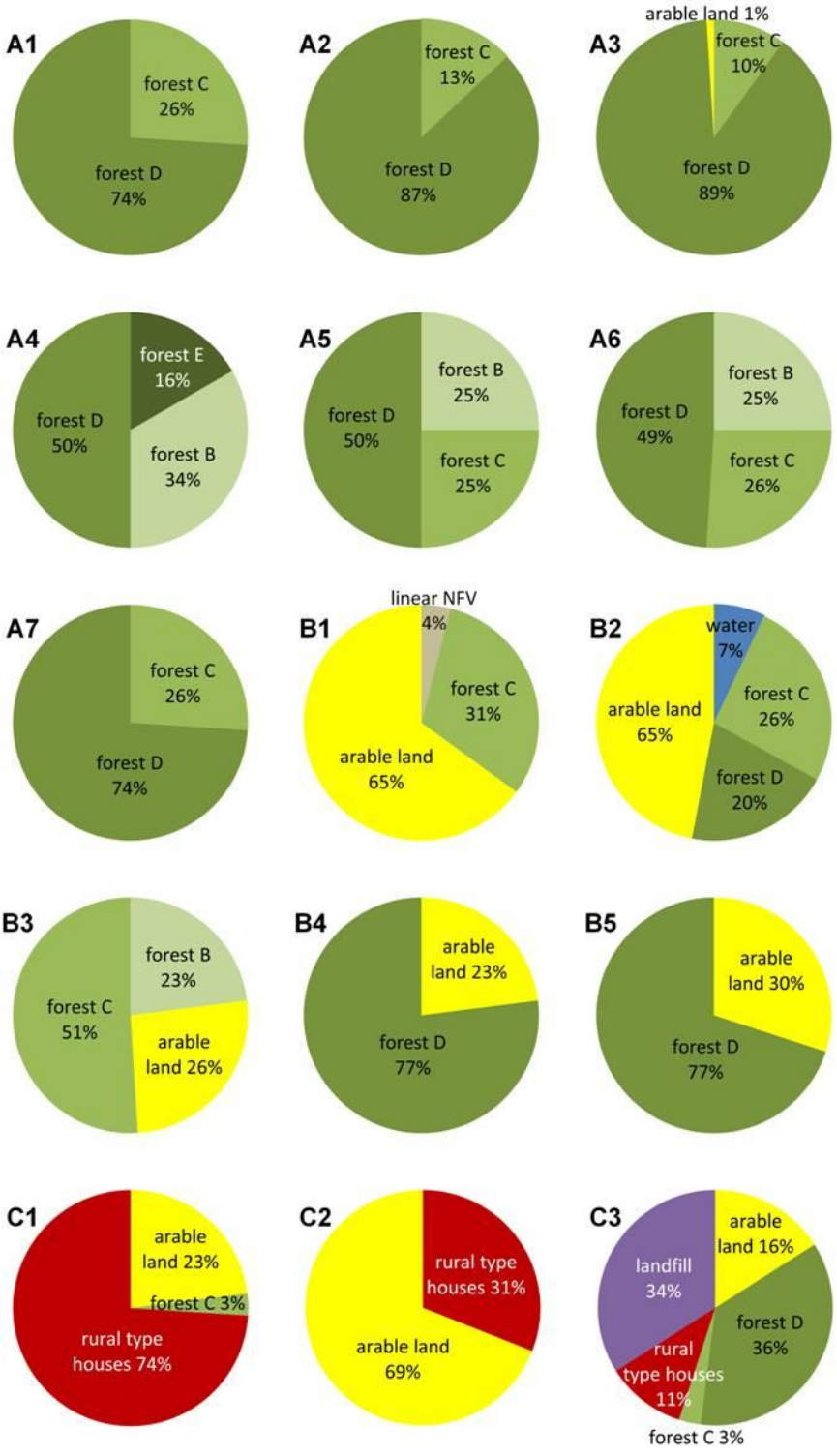

Fig. 3 The percentage of CLS elements in the surrounding of detecting sites

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Survey of recorded bat species

In total, there were recorded 9 species of bats in the study area. Out of them, 8 species (*Myotis myotis*, *Myotis emarginatus*, *Myotis mystacinus/brandtii*, *Myotis daubentonii*, *Nyctalus noctula*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*, *Pipistrellus nathusii*) were recorded by bat-detectoring and 2 species (*Myotis daubentonii*, *Plecotus austriacus*) by netting. The highest number of species was determined within the forest complex. Three species (*Nyctalus noctula*, *Eptesicus serotinus*, *Pipistrellus pipistrellus*) were observed in all three types of investigated habitats (Table 2).

Table 2.
Species abundance in investigated habitats

SPECIES	HABITAT		
	FOREST INTERIOR	ECOTONE ZONE	SETTLED AREA
Myotis myotis	+	–	–
Myotis emarginatus	+	–	–
Myotis mystacinus/brandtii	+	–	–
Myotis daubentonii	–	–	+
Nyctalus noctula	+	+	+
Eptesicus serotinus	+	+	+
Pipistrellus pipistrellus	+	+	+
Pipistrellus nathusii	+	–	+

The influence of habitat preferences to the bat activity

All the studied habitats were used by bats, but their activity was different (Fig. 4). The forest interior is by many authors (e. g. De Jong, 1994; Krusic et al., 1996; Wunder, Carey, 1996; Hogberg et al., 2002; Loeb, O'Keefe, 2006) considered to be less popular foraging habitat in comparison to peripheral habitats, open areas or forest paths. The results of our research correspond to this claim, because the lowest measured average activity (15%) was recorded just inside the forest fragments. This result may be associated with high vegetation density in the interior forest, which conduces to increased energy demands of flight. Similar results were reached also by Norberg, Rayner (1987).

The highest average activity of bats was observed at the edges of forests, in ecotone zone (33%). The activities in this habitat ranged from 16 to 60%, with a peak month of August. Ecotones in this area were created as a result of fragmentation and represent suitable foraging conditions for various bat species. Several authors recorded the great activity in this type of habitat (Grindal, Brigham, 1999; Kusch et al., 2004). In accordance with the results of Kusch et al. (2004), our research confirmed the preference of ecotone zone of the forest from its interior (Fig. 5).

Approximately one-third lower average activity of bats (24%) than in ecotone zones was measured in the settled area with a range from 3.83 to 37.44 % and a maximum in June. The reason for the generally positive impact of settled areas on the bat activity is a great abundance of prey and offer of roosts (Kunz, Fenton, 2003). The relatively high activity of bats in the settled area was probably influenced by the presence of street lighting and many solitary (mostly fruit) trees around detecting points. These places are attractive to insects, and this habitat may represent a positive change in foraging offer.

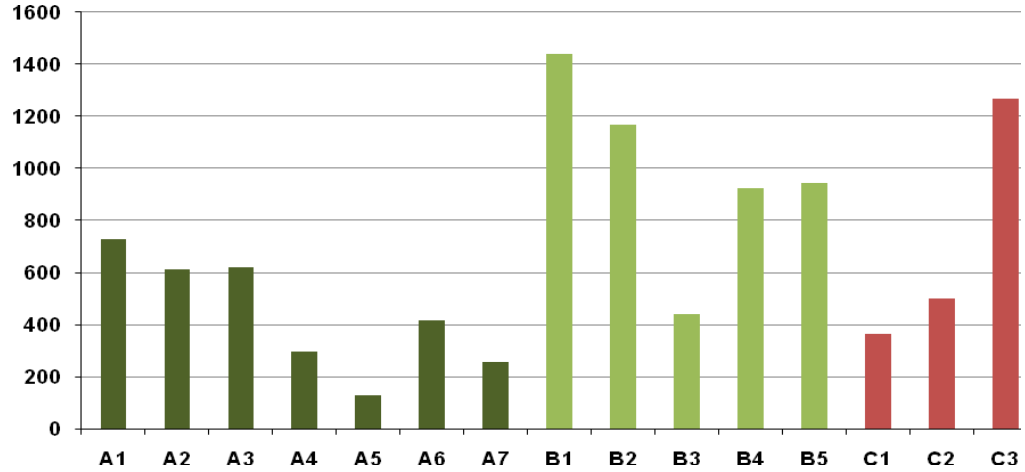

Fig. 4 The amount of active seconds recorded on single sites in the forest interior (A1–A7), ecotone zone (B1–B5) and in the settled area (C1–C3)

The influence of landscape structure to the bat activity

By the comparing the percentage of different landscape elements in the surrounding of the detecting sites and the activity of bats in these sites, we concluded that the presence of linear elements in the landscape is the most important criterion for selecting a suitable foraging place for bats. To some extend this result was expected, given the results of the research of the other authors. For instance Limpens and Kapteyn (1991) concluded that elements of linear vegetation are more popular due to the fact that they provide protection from predators, wind and serve for orientation. The highest bat activity was recorded during our research in the points B1, B2 and C3, around which exist many different elements of landscape structure. At these sites the bats had a high foraging supply of insects; in the point B1 due to the uncultivated field and linear vegetation, in the point B2 in consequence of the small nearby wetland and small adjacent field and in the point C1 due to high landscape elements diversity – forest, field, settled area with street lightingand controlled landfill.

The influence of forest age structure to the bat activity

The gained results show that the age structure of forests has a positive effect on the activity of bats, but it was not the primary criterion in choosing of foraging habitats. Considering our native bat species can be seen as food opportunists, if occurred around the place with a higher abundance and availability of insects, it was preferred more than old forest. To the same conclusion came also Kunz and Fenton (2003), who also considered age of forest as an important but not paramount.

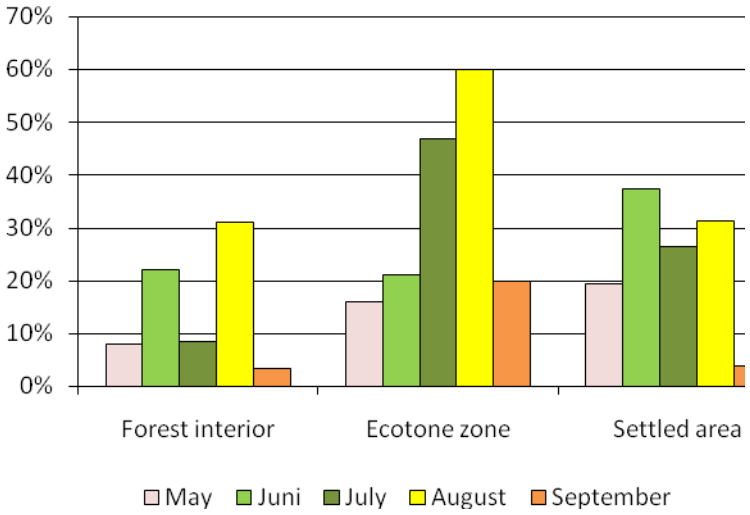

Fig. 5 The relative activity of bats in the selected habitat types during the period May till September 2009

CONCLUSIONS

Based on the results obtained by the method of bat-detectoring on the 15 detecting sites in three habitat types: forest interior, ecotone zone and settled area we found that the bats most used habitat was ecotone of forest stands. In this type of habitat was recorded an average activity 33% of the total recording time. Approximately one-third lower average activity (24%) was monitored in the settled areas. Forest interior was the least used type of habitat (15%).

The percentage of the landscape structure elements within the radius of 100 m from each monitoring site was evaluated on the basis of the CLS map. Subsequently, each monitoring site was evaluated separately. Based on the results of the measured active seconds in relation to these data, we concluded that the most important factor for the hunting bats is the presence of line elements in the landscape. The research also confirmed that bats avoid open country in flyover to the favourite foraging site. We classified the forest stands according to their age in the five categories. The data of the measured activities were confronted with the criterion of age and we found that mostly the foraging bat's activity was positively correlated with the age of the surrounding forest (the higher the age, the higher activity). But overall the presence of older trees is not priority criterion for bats in the selection of foraging sites. After comparing of the measured activity with the presence of tree cavities near the detecting sites we didn't clearly confirmed bat activity dependence on the number of potential hiding places in the surrounding stands.

Through the analyses of the recorded ultrasound calls of bats we identified the presence of eight species of bats (*Myotis myotis, Myotis emarginatus, Myotis mystacinus/brandtii, Myotis daubentonii, Nyctalus noctula, Eptesicus serotinus, Pipistrellus pipistrellus* and *Pipistrellus nathusii*).In the forest interior was determined the highest number of species. Three species (*Nyctalus noctula, Eptesicus serotinus, Pipistrellus pipistrellus*) wererecorded in all three types of monitored habitats.

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Based on the results, we point out the need of the linear landscape elements maintenance, especially in the intensively farmed land, which is essential as foraging habitat of bat community.Into the bargain forest interior habitat seems to be important as shelter habitat for various bat's species.

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