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Home Range and Habitat Use of Brown Bear in Bulgaria: the First Data Based on GPS-Telemetry

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Abstract: This is the first GPS-telemetry study based on four brown bears in Bulgaria revealing data about their home range and habitat use. The brown bear is frequently the cause of conflicts with humans. For better understanding of the species needs, investigations on the size of the home range and the habitat use are crucial. Our results showed that the home range of the Bulgarian brown bear was similar to those of bears on the Balkan Peninsula (65 km^2 for adult female and 212 km^2 for young male in dispersal). Brown bears preferred forest areas and shrubs. They avoided actively open terrains and human-influenced habitats. Size of the core area of bears is around 16% of the home-range size (based on kernel 50% contour).

Keywords: brown bear, GPS-telemetry, Minimum Convex Polygon, kernel, home range, habitat use

Introduction

The Bulgarian population of brown bear is one of the largest in Europe (Swenson *et al*. 2000). The main sub-populations in the country inhabit the middle and high forest belt in the Central Balkan Mts., Rila, Pirin and Western Rhodopes (Spiridonov, Spassov 1990, 1998, Spassov, Spiridonov 1999). According to the IUCN criteria, the species is endangered for the territory of Bulgaria (Spiridonov, Spassov 2011). The brown bear is listed in the Appendices II and III of the Bulgarian Biodiversity Act (2002). Moreover, it is strictly protected species according to Appendix II of the Bern Convention, also subject to Annexes II and IV of the Council Directive 92/43/EEC and Annex II of CITES. It is a subject of "Management Plan of the brown bear in Bulgaria" (2009), endorsed by the Ministry of Environment and Water (MOEW). As a large carnivorous species with limited home range the brown bear often causes conflicts with the local communities. In Bulgaria poaching appears to be the main way of dealing with this problem despite the high conservational status of the species. This determines the need of stronger and more comprehensible measures for the conservation of the species in the country, which will contribute to the well-being of the bear populations on the Balkan Peninsula.

Most of the studies on the brown bear from Bulgaria are based on direct observations of bears or signs of their activity (Ruskov, Markov 1974, Raichev 1989). A few recent studies use advanced analyses based on GIS habitat modelling and the impact of linear transport corridors on the movement of large carnivores (Zlatanova 2009, Kaphegyi *et al*. 2012).

The present study is based on GPS-telemetry and presents preliminary data on home range and habitat use of the brown bear in Bulgaria.

The aim of this study was to establish the home range and the degree of utilisation of habitats of four brown bears tracked with GPS-collars in different regions of Bulgaria.

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Materials and Methods

Study area

The study was conducted in Central Balkan Mts., West Rhodope Mts. and Vitosha Mts. It included areas between 800 and 1800 m a. s. l. covered with broadleaved (mainly beech) and coniferous forests, woodland fringes, scrubs, meadows and pastures, rock formations and river gorges.

The present study included data collected for four animals fitted with GPS-GSM collars (Vectronix, model GPS PRO Light-3) in 2007-2009 (Table 1). Three of the animals were trapped in Aldrich foot snares with bait and one young male – in poachers trap near Bistritsa Village, Vitosha Mountains.

All animals were examined medically and weighted. Biometry measures and dental status were taken alongside with blood sample and hair for genetic analysis. Age for each bear was determined according to the dental status, size and weight of the animal.

All animals were given code names based on the following algorithm: first two letters determine the region in which the bear was caught (CB – Central Balkan, WR – West Rhodope, VM – Vitosha Mountains, RM – Rila Mountains, etc.), the third and the forth letter present the sex (MB – male bear or FB – female bear), followed by a consecutive number of the bear of the same gender for the region.

GPS-coordinates were taken in a different pattern for the tracked period of every brown bear, varying from 10 minutes to 6 hours. Bears' locations at 06:00, 14:00 and 24:00 h of each day of the research period were used for the analysis. This was necessary because a lot of data of the GPS-collars were lost due to the lack of GPS coverage (10-25% for the different collars) and the inconsistency between the data from the different bear collars. To minimise the error the above mentioned sub-sampling was used.

The locations were analysed spatially with ArcGis Desktop 9.1 (ESRI) software. The habitat use by the bears was established as an absolute evaluation and as an index of selectivity. To establish the habitat type preferences of every individual the selectivity index of Jacobs (D) was used:

$$D = \frac{r - p}{r + p - 2rp}$$

where r is the ratio of the point locations for certain habitat type to all point locations, and p is the percentage of the available habitats (Jacobs 1974). Jacobs' selectivity index varies between -1 (total avoidance of a habitat type) through 0 (selection proportional to the frequency of occurrence) to 1 (maximum positive selection).

The habitat types of the presented vegetation in the researched areas were given according to the nomenclature of CORINE Land Cover 2006 (EEA 2006). The altitude of the individual locations was derived from a Digital Elevation Model (DEM) with a resolution of 40 m.

Minimum Convex Polygon (MCP) (Mohr 1947, Hayne 1949) and Arc GIS Desktop function kernel-density estimation (50% and 99% contours) were used to analyse the home-range size of the studied individuals; MCP and kernel 99% were used to calculate the total home-range size and kernel 50% to calculate the number and size of the core areas. The comparative analysis of home range of the studied individuals was based on kernel 99%. The MCP calculated home-range was used for comparison with other countries.

The main part of the analysis was based on data from a female bear (CBFB1) with the longest tracking period, monitored for 11 months. The data from the other three bears were used for comparison.

Results and Discussion

Understanding bear's ecology, preference to certain habitats and the home-range needs by a single individual play a crucial part of bear management.

Home-range and core area size

As a result of our study the home range of four

Table1. Individual information and study period of four brown bears tracked in the period 2007–2009 in different areas of Bulgaria

Individual	Sex	Age	Area	Number of locations	Number of tracking days	Tracking period
CBFB1	female	adult (3-4)	Central Balkan Mts.	930	310	22 September 2007 – 28 July 2008
CBMB1	male	subadult (2.5)	Central Balkan Mts.	69	23	3 November 2009 – 25 November 2009
VMMB1	male	juvenile (1.5)	Vitosha Mts.	273	91	30 April 2009 – 30 July 2009
WRFB1	female	subadult (2.5)	West Rhodope Mts.	51	17	15 November 2009 – 1 December 2009

bears was determined (Table 2).

MCP values for the home-range were smaller than kernel 99% estimates. Exception was observed only in VMMB1 and it was due to the specific shape of the bear's home range. MCP is largely used by many researchers (Mertzanis *et al*. 2005, Dahle *et al*. 2006, Kanellopoulos *et al*. 2006, Martin *et al*. 2008) but it gives a poor results if there are areas unsuitable for bears in the centre of the home range or the GPS-locations form a sickle- or kidney-like shape. In these cases home range is greatly overestimated in size, like the home-range of VMMB1 (Fig. 1). By our opinion, kernel home-range estimate gave better understanding of the true home range and habitat use.

The comparative home-range analysis of the studied individuals based on kernel 99% indicated that VMMB1 had the largest home range (212 km^2). This could be explained by the fact that VMMB1 was a young male. It was important that the animal was caught near the Bistrica Village (in very close proximity to the capital Sofia) and large parts of the habitats were close to areas with high human presence and disturbance. The tracking period (30 April 2009 – 30 July 2009) fell within the period of the year in which the natural food sources were scarce and mature animals were breeding. This was probably another reason for the long-distance travel of the animal and the shifts of its activity to more unsuitable areas. These results corresponded to the data obtained for a subadult male in Greece, with home range estimated to 206 km^2, MCP (Kanellopoulos *et al*. 2006). Some results from Scandinavia showed similar relation between home-range size, age and sex. According to Dahle *et al*. (2006) home-range size of philopatric subadult brown bears was larger in males than in females and it increased with increasing body size and decreased with increasing population density.

Table 2. Home-range size of four brown bears tracked in different regions in Bulgaria based on MCP and kernel (99% and 50%)

Individuals	MCP 100%, km^2	Kernel 99%, km^2	Kernel 50%, km^2
CBFB1	65.61	83.54	13.51
CBMB1	8.21	36.16	6.83
VMMB1	265.57	212.32	32.2
WRFB1	11.76	25.50	3.49

Smaller home range (84 km^2, kernel 99%; 66 km^2, MCP) was observed in CBFB1. It included the area of the Sokolna Strict Reserve in the Central

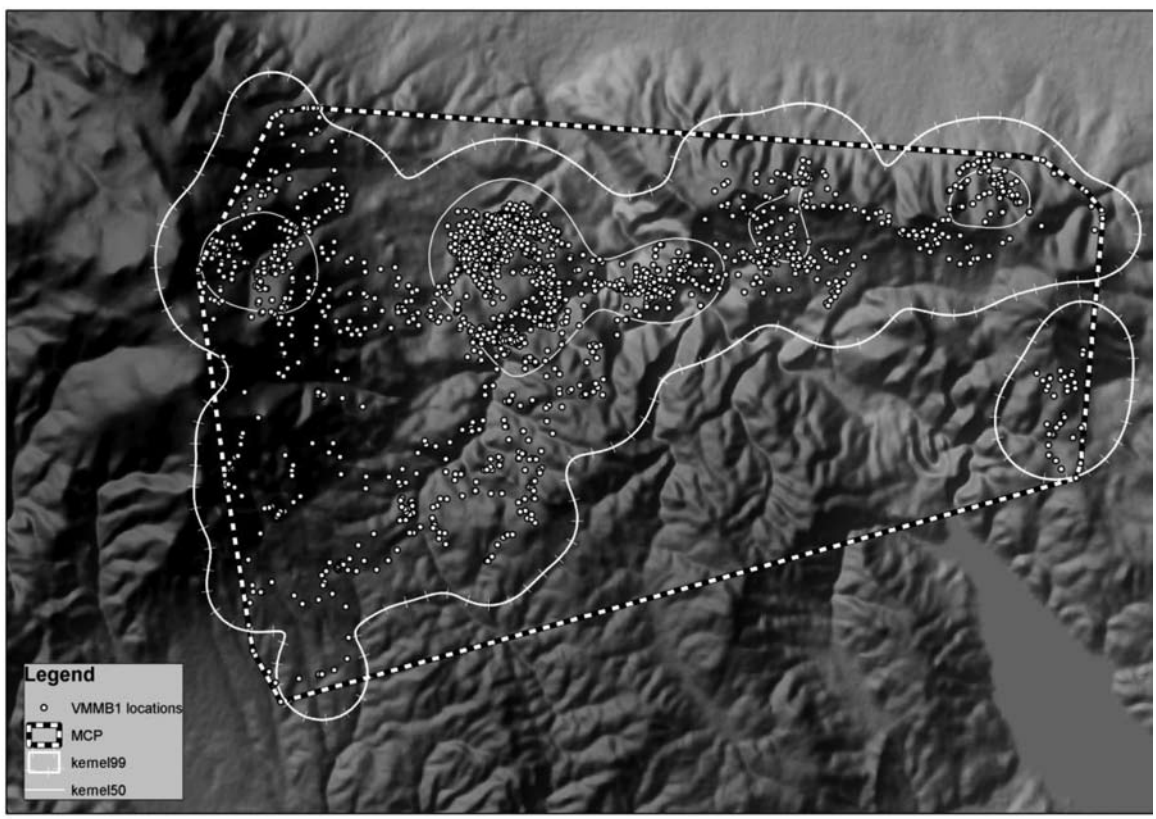

Fig. 1. Home range estimated on a base of MCP, kernel 99 and 50. The specific shape of the home range leads to overestimation of the size by the MCP-method

Balkan National Park and part of the Mazalat Game Breeding Station (GBS). The natural environment offered many suitable habitats for bears due to a combination of natural food resources, good opportunities for natural shelters and availability of artificial feeding of game in the GBS, which was also used by the bears. The described conditions could explain the relatively small home range. These data confirmed the results obtained for other Balkan countries. There was similarity in the size of the home range for bears in similar conditions – 58 km^2 reported for Croatia (Huber, Roth 1993) and 59 km^2 for Greece (Mertzanis *et al*. 2005) calculated using MCP.

The smallest home-range sizes had bears CBMB1 (36 km^2) in the Central Balkan and WRFB1 (26 km^2) in the Rhodope Mts., tracked in November. In this case the territory of the young male CBMB1 was greater than that of the female of the same age (WRFB1). From the literature it is well-known that males generally cover a larger area (Stoen *et al.* 2005a).

The core-area analysis (kernel 50% estimates) showed that CBFB1 had one distinct individual territory, which covers 16% of the total home range calculated using kernel 99%. The number of core areas of VMMB1 was four and the proportion of the core area compared to the kernel 99 estimate for the animal was 15%. WRFB1 had a core area size that represented 14% of the home range. For individual CBMB1 the core area (19% of the home range) was divided into three zones (Table 3).

Comparison showed that males were more likely to fragment their core area compared to females, which was confirmed by the literature (Blanchard, Knight 1991).

Habitat selectivity and use

GPS-telemetry data provided a good basis for assessing the habitat use. We used a GIS-based layout of a bear's GPS locations on a Corine land cover layer, within the home range of the studied brown bears (Fig. 2). The absolute habitat use presented the overall number of bear locations in the different habitats. Some authors used it to show bear's selection and use

Table 3. Core area number and size for the different individuals

Tracked individual	Number of core areas by kernel 50%	Size of largest core area (km^2)	Total size of all core areas (km^2)
CBFB1	1	14	14
VMMB1	4	21	32
CBMB1	3	5	7
WRFB1	1	3	3

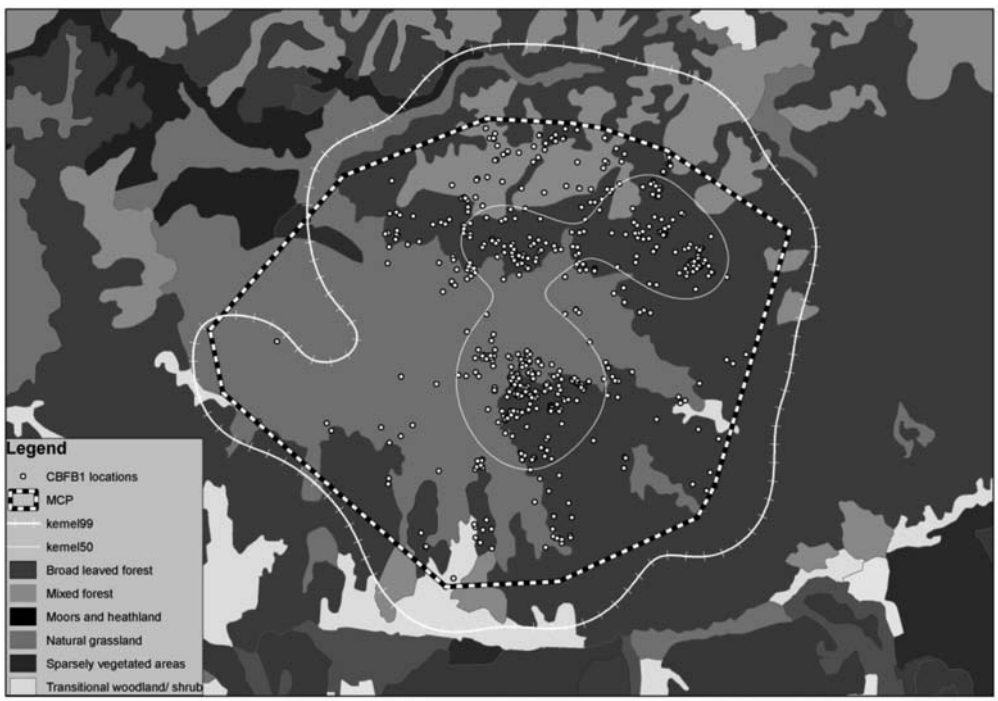

Fig. 2. Home-range size of CBFB1 on Corine land cover layer displaying different habitats

of habitats as an absolute value (Pop *et al*. 2012).

The forests were with highest coverage in all home-range areas. The territories of CBFB1 and CBMB1 were dominated by deciduous forests, followed by natural grasslands. Almost half of the locations of CBFB1 were in broad-leaved forests, similar percent in natural grasslands and only 1/10 mixed forests. Other three classes were with insignificant role (less than 2%; Fig. 3).

Only three classes were used by CBMB1. Broad leaved forests were most preferred, followed by natural grassland and transitional woodland/shrub.

Individual WRFB1 inhabited the region of Trigrad Village (Western Rhodopes), where the main forest class was conifers. This was in line with the distribution of most of the points. Three of the classes (land principally occupied by agriculture, with significant areas of natural vegetation; land occupied by agriculture*; natural grasslands and broad-leaved forests) share the same percentage of locations (around 10%). The other six classes had low absolute selection values (less than 5%).

Individual VMMB1 was captured and tracked in the vicinity of Sofia (including part of Vitosha Mt.), where a large number of heterogeneous habitat classes were present. Its most preferred habitat was the broad-leaved forests, followed by coniferous forests and land occupied by agriculture sharing around 1/10 of the overall number of locations. The rest of the available habitats were presented with small shares in the overall amount of locations but show great variety. They summed up to 15%.

Similar results based on fixed kernel estimate were reported by Pop *et al*. (2012) for Romania. They showed that on average around 75% of the bear's home range consisted of forest and shrubs, while 22% were agricultural fields and 3% were urban areas.

Selectivity index

Selectivity index provides precise comparison between number of locations in certain type of habitat and total area of that habitat in a brown bear home range. Small number of locations within a habitat with large size shows that the bear is avoiding it for some reason, while numerous locations in a small-sized habitat shows strong preference.

A comparison of the selectivity indices of CBFB1 and CBMB1 showed that both bears preferred deciduous forests, but in addition CBMB1 somewhat preferred the transitional woodland/shrub (Fig. 4). Preference for natural grasslands compared to absolute use of the habitat decreased significantly for both bears. Although both animals inhabited areas with low human presence (Mazalat Game Breeding Station and near by Sokolna Strict Reserve) they avoided exposure in the open grasslands. WRFB1 preferred coniferous forests, transitional woodland/shrub and to a lesser extent – broad-leaved forests. This distribution corresponded to the distribution of the main types of natural vegetation in the study area. Most of the opened habitat types like agricultural

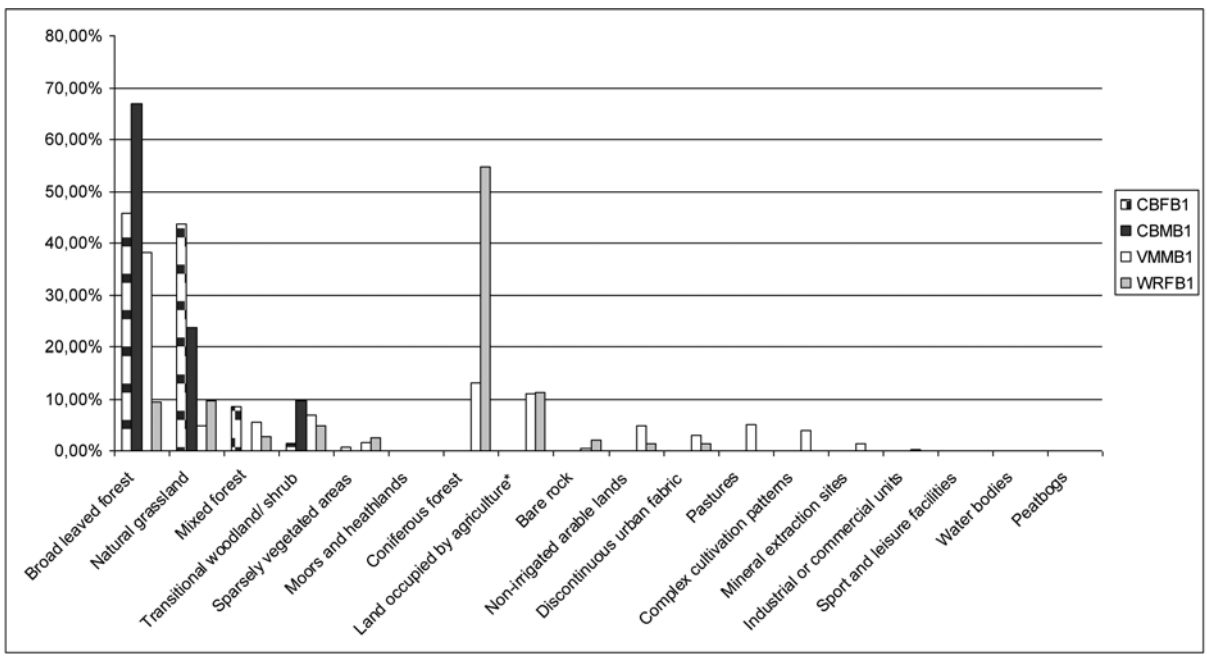

Fig. 3. Absolute habitat use according CORINE Land Cover 2006 for four brown bears tracked in different regions of Bulgaria based on kernel 99%

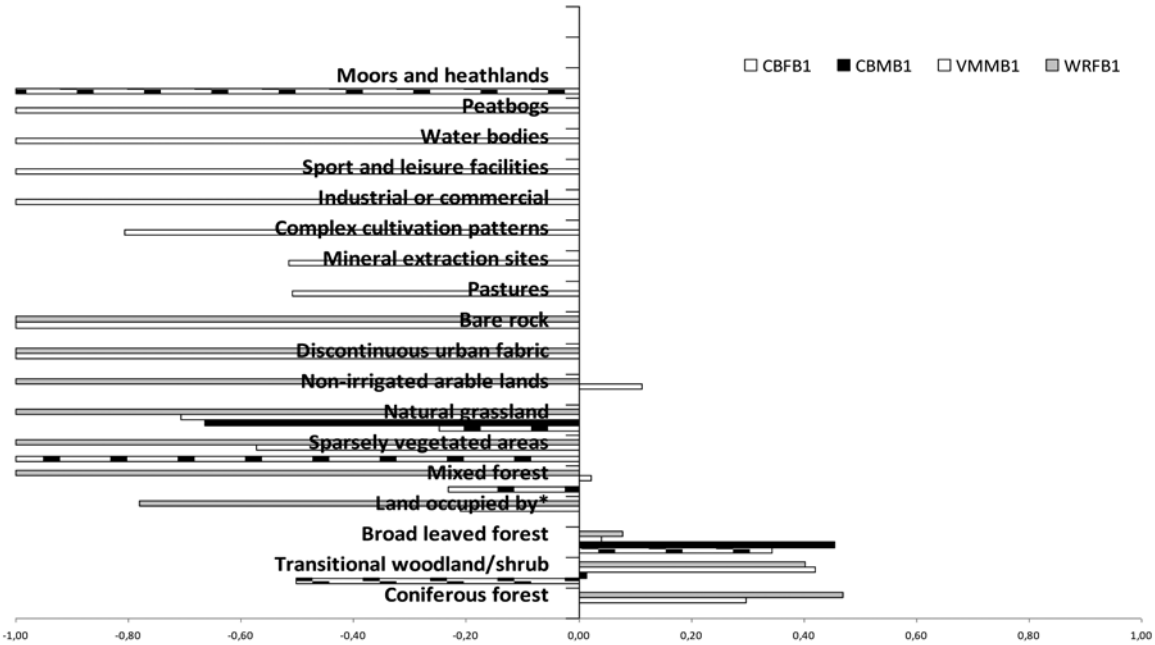

Fig. 4. Selectivity index according CORINE Land Cover 2006 for four brown bears tracked in different regions of Bulgaria based on kernel 99%

land , natural grassland and sparsely vegetated areas were avoided by the animal. Probably these habitats were used only for passing from one forested patch to another, occasional approach to a settlement (like Trigrad Village, West Rhodope Mountains where it was caught), etc.

Unlike the other three bears, which showed preferences to few habitat types (1÷3), VMMB1 preferred five: transitional woodland/shrub, coniferous forest, agricultural areas, deciduous and mixed forests. This could be explained with the presence of small patches of suitable habitats within the large human-influenced surroundings of the capital city of Sofia.

Our study confirmed the results of previous studies that habitats with great importance for the bears, which they actively select, were mainly forests and transitional woodland/shrub (Preatoni *et al*. 2005, Mertzanis *et al*. 2005, Moe *et al*. 2007, Pop *et al*. 2012). For all tracked bears forests represented the largest part of the territory used by the bears and at the same time were greatly preferred. On average around 61% of the home-range area consisted of forests (Standard Error of the Mean /SEM/ = 6%). Transitional woodland and shrub were very important for the bears and were generally actively preferred, although their average presence was around 6% (SEM = 28%) of the home-range. The significance of forests and transitional woodland/shrub could be attributed to the availability of food sources. Forests owing to their multi-storey and dense structure provided good cover and refuge conditions.

The preferred forest type depended on its availability in the natural vegetation cover in the study area, which was demonstrated also in other studies (Preatoni *et al*. 2005, Mertzanis *et al*. 2005, Moe *et al*. 2007, Pop *et al*. 2012).

Habitat types with significant contribution in the home-range of the studied individuals were the opened grasslands which included natural grasslands, pastures and sparsely vegetated areas. They summed up to an average of 22%. These opened habitats were used for quick passing between forest patches, used with caution close to the forest boundary or avoided by the bears even when there was low human presence, like in Sokolna strict reserve area, Central Balkan.

Conclusions

According to this study, kernel estimates gave better understanding of the true home range and habitat use of the bears compared to MCP.

The home range of males was larger than those of females. The core area was around 16% of the size of the home range and might not be related to the length of the tracking period. Therefore, the relation of the core area with the home-range size needs further investigation.

All studied individuals preferred forests and transitional woodland/shrub. Forested habitat used by bears represented the largest part of the home range and was around 61% (SEM=6%). This might not be related to the length of the tracking period and need further investigation. All other available habitats, especially when human-influenced, were avoided in varying degrees.

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