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FACTORS AFFECTING BROWN BEAR HABITUATION TO HUMANS: A GPS TELEMETRY STUDY

FINAL REPORT – summary for users

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Authors

Ljubljana, April 2012

This summary presents the main results of the research project entitled "Factors affecting brown bear habituation to humans: a GPS telemetry study" and key points of the management recommendations prepared on the basis of these results and other studies in Slovenia and abroad. Detailed management recommendations together with all results and their interpretation, a description of the methods used, and an extensive review of previous studies on human-bear conflicts and possible solutions can be found in the full version of the final report, which is available in the Slovenian language at www.medvedi.si.

INTRODUCTION AND RESEARCH GOALS

Large carnivores are characterized by their large body size and the large spatial requirements needed to satisfy their energetic needs. Consequently, in human-dominated landscapes, such as in Slovenia, large carnivores frequently come into contact with the people with whom they are forced to coexist. In such areas the management of large carnivores is a challenging and complex task. For species like the brown bear (*Ursus arctos*), which causes frequent property damage, competes with people for natural resources, and, in rare cases, even threatens human life, conservation in large part depends on the tolerance of people.

The will of local people to tolerate bears has a great deal to do with the behaviour of the bears with which they coexist. Often just a few negative experiences with a single animal can considerably deteriorate people's attitude towards bears. For this reason, it is important to have a good understanding of the behavioural characteristics of bears living in human-dominated landscapes and factors that affect this behaviour, especially factors affecting habituation to people. Understanding the causes of human-bear conflicts is the first and crucial step to their resolution. Only with a good understanding of the factors that affect the occurrence of conflicts is it possible to propose guidelines for sound management that will effectively prevent further conflicts. This is one of the main goals of this study and one of the priorities for future bear conservation.

Using GPS telemetry and field inspections of bear GPS locations, we were able to comprehensively study the space use of the Slovenian brown bear. We gave special attention to the factors that could be important for the occurrence of human-bear conflicts. We attempted to determine why, when, and how frequently bears approach human settlements and how this is affected by landscape characteristics (e.g. distance of a settlement to the nearest forest edge). We studied the effects of the presence of feeding sites and other intentional as well as unintentional anthropogenic food sources on the space use of bears. We also attempted to document individual differences in bear behaviour, e.g. can some of the bears in Slovenia be designated as "problem bears" or is the behaviour of different bears more or less similar? This question is especially relevant regarding the use of management removals as a conflict mitigation measure.

The results of this study were then used in combination with experiences from other countries to prepare guidelines and management recommendations for the effective prevention of human-bear conflicts in Slovenia.

DATA COLLECTION

BEAR CAPTURE

Between 13.10.2008 and 4.5.2009, we captured bears with the use of Aldrich snares and the free-ranging technique. An additional three bears were later captured coincidentally in other projects that intended to capture Eurasian lynx and wild boar. The bear capture plan was designed so that bears were equipped with GPS telemetry collars in all regions with a permanent bear presence and the number of collared bears in a given region corresponded to the relative bear densities in that region. Bears were captured throughout their distribution range in Slovenia, including areas with high and low rates of reported human-bear conflicts. Thus, we were able to obtain data from all combinations of areas with high and low conflict rates throughout the bear density gradient. This was important for the representativeness of the results and the statistical power of the analyses.

During this project we captured 26 bears in 20 localities. Twenty-one bears were equipped with telemetry collars (five were too young for collaring). Among these, nine were captured with the use of Aldrich snares (capture success rate of one bear per 17 nights) and 11 by the free-ranging technique (one bear per eight nights). One bear was captured in a box-trap for lynx and two in a box-trap for wild boar. Three bears were captured during intervention by the Slovenian Bear Emergency Team.

We additionally included telemetry data from 12 bears captured in previous studies, which took place in Slovenia between 2005 and 2008 and were carried out by the Forest Conservation and Wildlife Ecology Research Group at the Department of

Forestry and Renewable Forest Resources at the Biotechnical Faculty. Thus, a total of 33 bears were included in the analyses (Fig. 1).

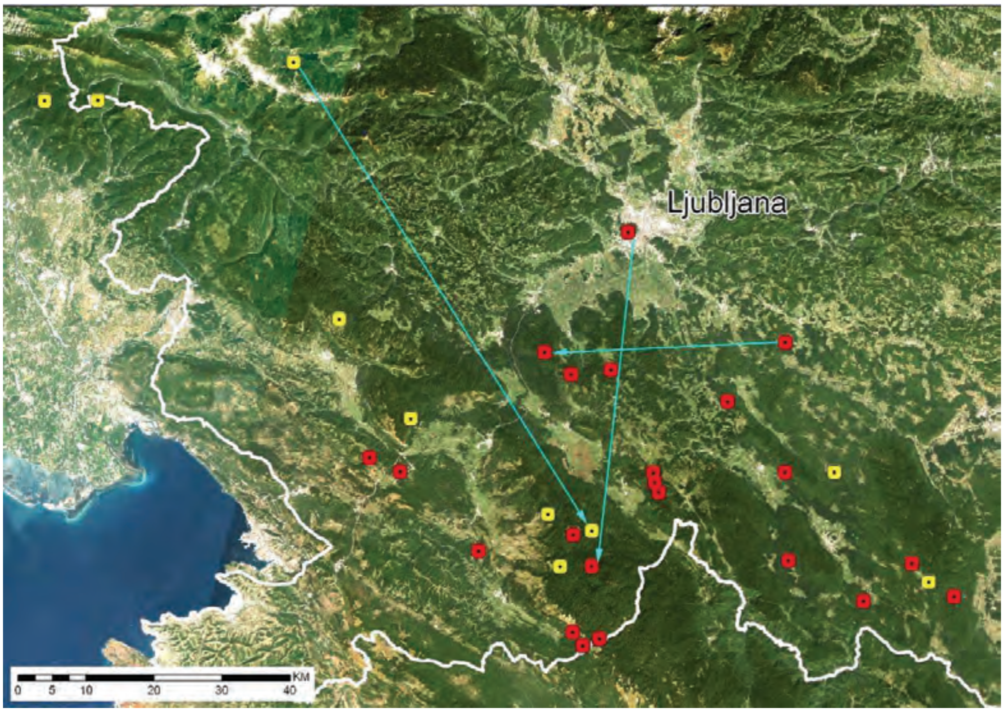

Figure 1: Locations where bears were captured in this project (red) and previous projects (yellow). Blue arrows represent translocations of collared bears carried out by the Slovenian Bear Emergency Team.

PROGRAMMING OF TELEMETRY COLLARS

Telemetry collars were scheduled to receive a GPS fix every hour (24 locations/day) continuously throughout the year. For some of the bears from previous projects, the interval between fix attempts was different for some of the time during monitoring. Four collars did not drop off after one year, as they were supposed to, and were re-scheduled afterwards to receive a GPS fix once every 23 hours. If there was no recorded activity for more than 24 hours, the collar sent a mortality signal indicating that the collar had dropped off or the animal had died. GPS data was regularly (4 times per day, if the GSM network was available) sent as text messages via the GSM network to a terminal at our office. Data on bear activity and temperatures was periodically (every 1-3 months) downloaded remotely in the field via VHF or UHF signal or directly from the collars after they were recovered.

CAPTURED BEARS

We monitored 14 females and 19 males. Eleven of the females were accompanied by offspring during at least part of the monitoring. One was not accompanied by cubs, and we were not able to confirm whether cubs were present for the other two. We monitored ten younger males (<4 years) and nine mature males (>4 years). The mean estimated age of the bears in this study was 6.6 years (median: 4.5 years; range 2.5-20 years). Sex and age structure was comparable with that of the bear population in Slovenia (excluding cubs, which we did not monitor), thus the bears in this study comprised a representative sample.

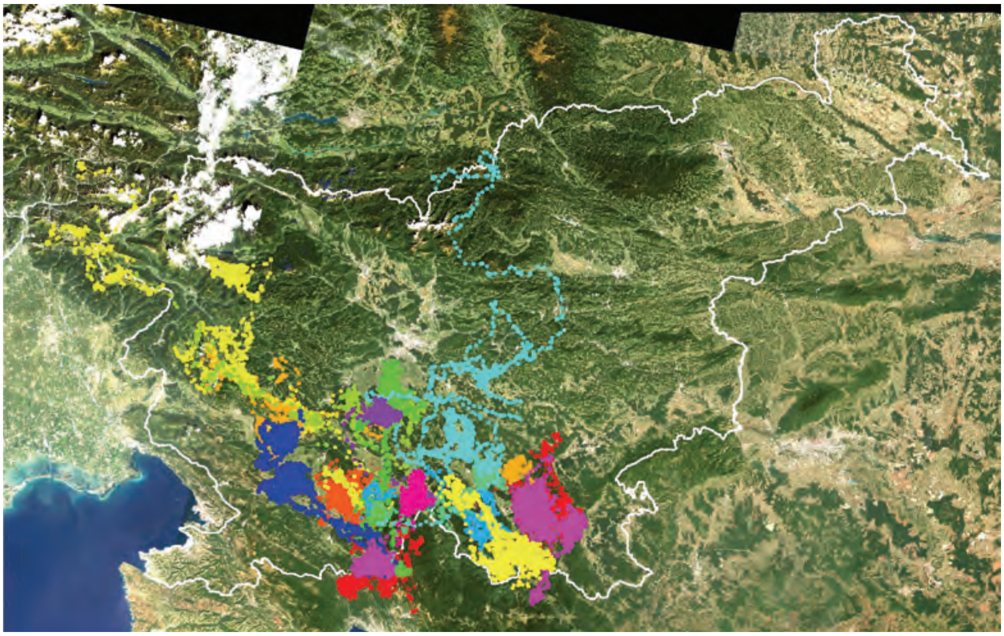

Figure 2: GPS locations obtained from 33 bears equipped with telemetry collars. Each collar corresponds to a different bear.

TELEMETRY DATA

Using telemetry we collected a total of 93,733 GPS locations of bears. Among them, 15,617 were collected in previous studies and 78,116 were collected in this project (Fig. 2). Mean GPS fix success rate was 74.6%. Because some of the collars were not recovered after they dropped off, we were able to obtain activity and temperature data for only 22 bears. In total we obtained 1,806,350 activity records and the same number of temperature records. Each bear was monitored for an average of 257 days (range 20-1040 days). The bears moved a total of 37,205 km during the monitoring period.

Using logical filters and visual control, we scanned all locations and removed those with obvious errors. An additional 10,950 locations were added to the original set to compensate for those that were missed because collars went into hibernation and recording stopped when a bear did not move for more than four hours. In such cases the new locations had the same coordinates as the last known location, which in all cases indicated the location of a resting bear. The total set was thus enlarged to 104,683 locations. Several factors can affect the GPS fix success rate, e.g. environmental characteristics, animal activity (and associated position of the GPS receiver), and the type of collar. We used logistic regression and GIS tools and applied inverse values of the estimated probabilities of GPS fix success to remove systematic errors and bias from recorded GPS locations. After bias was removed using this procedure, the dataset was decreased to approximately 85,000 GPS locations that were then used in all further analyses.

DATA COLLECTED DURING FIELD INSPECTIONS

In order to determine the microhabitat selection of bears, and the effects of anthropogenic food on bear habitat use in particular, we carried out field inspections at 450 of the GPS locations of monitored bears (several microhabitat characteristics that could not be gained from the GIS data were recorded, including the presence of different food sources, and cover availability). In the same area, we also randomly selected 450 control locations in which bears may or may not have been present and surveyed them with the same procedure as that used at bear locations. Both types of locations were selected inside the same GIS strata that were pre-determined with respect to three environmental factors indicating a certain level of habituation to people: distance to the nearest house, presence of forest cover, and distance to the nearest major road.

RESULTS

The large amount of data collected through telemetry of 33 bears and inspections of GPS locations in the field enabled us to carry out a detailed analysis of several aspects of the biology and ecology of brown bears in Slovenia, resulting in a better understanding of human-bear conflicts in this region.

BEAR MOVEMENT

Data on bear movement is useful for identifying the potential contact area between bears and people, for understanding human-bear conflicts, and consequently, for proposing suitable management recommendations. Mean distance that bears moved per hour was 248 m (range 0-9783 m). This corresponds to a mean daily movement distance of 5,975 m (sum of mean hour distances). Among monitored bears, the highest movement rate was observed for Rožnik, a young male that moved an average of 15 km per day (Fig. 3). In contrast, some of the other bears moved less than 1 km per day on average.

We observed two peaks in daily movement. The first occurred between 4 and 5 a.m., and the second was between 7 and 8 p.m. (both peaks were linked to light conditions, so the exact time changed somewhat between the seasons). Bears moved the least during midday (Fig. 4), most likely to avoid human contact (negative synchronization of their activity with activity periods of humans). Bear movement differed throughout the seasons. The highest movement rate was observed in June and the lowest in January. On average, males moved more (6.8 km/day) than females (3.5 km/day). The lowest movement rates were observed in females with cubs of the year: 199 m/h compared with 248 m/h, the average for all monitored bears. We also noticed higher movement rates among problematic bears; however, this could be partly explained by the fact that they were monitored after translocation.

BEAR ACTIVITY

Bears were active 35% of the time on average. Most bears were mainly active at night and at dusk, i.e. periods during which the probability of encountering humans was lowest. Support that this pattern is likely linked to human activity comes from data on bears that had lost their fear of humans (e.g. Rožnik). These bears were considerably more diurnal than other bears. Similar to movement rates, the two peaks in activity corresponded to sunrise (5 a.m. on average) and sunset (7 p.m. on average), with higher values for the evening peak in activity. The lowest activity was recorded at midday (1 p.m. on average). Bears were most active in spring and summer and least active in winter. We also noticed considerable differences among individual bears, e.g. the most active bear (male Bohinjc) was 19-times more active than the least active individual (female Živa). On average, males were 30% more active than females, which is mainly due to their higher activity in wintertime (shorter denning period).

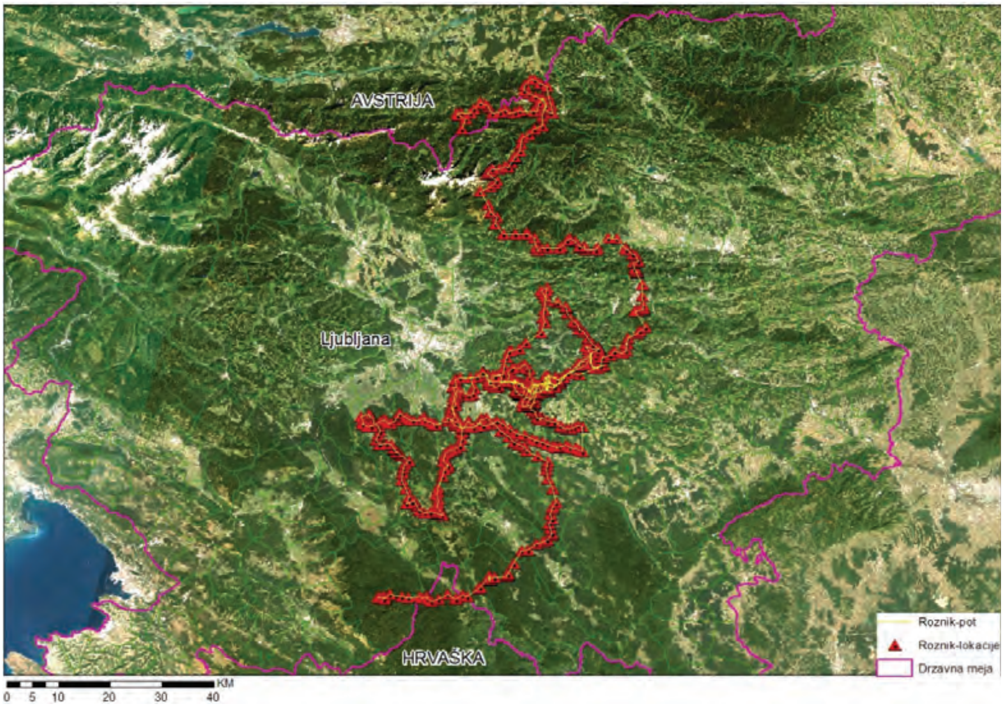

Figure 3: The movement of Rožnik, a male who covered 649 km during 1.5 months of monitoring, before being poached in Austria.

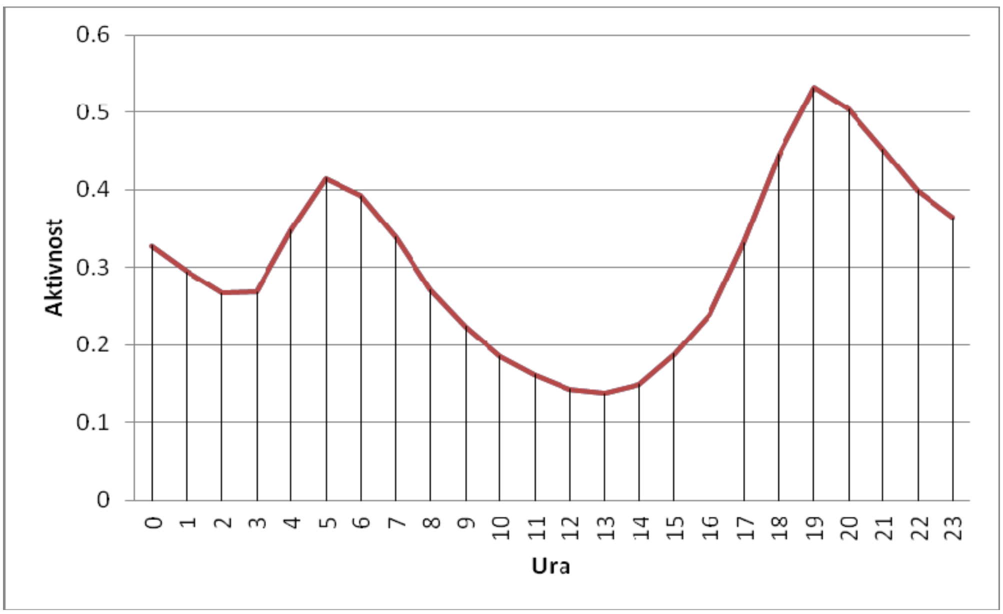

Figure 4: Changes in bear activity during the day.

HOME RANGE SIZE

The home range size of individual bears is a basic biological parameter that enables us to understand the life strategy of the species. It is also important for management because conflict mitigation measures vary considerably depending on whether home range size is relatively small compared to the size of available forest patches with no human settlements or whether each individual covers an area large enough to include areas with regular human presence – as was observed in our case.

Mean bear home range size in Slovenia was estimated at 350 km^2 (using the 100% minimal convex polygon method), which is comparable with the home range sizes of bears from other populations existing in similar environments. On average, male home range size was 4 times larger than that of females. The largest home range of 3,144 km^2 was observed for the male Rožnik. Our data indicated that from the perspective of a bear even the largest forest patches in Slovenia are relatively small (e.g., the largest Slovenian forest complex on the Snežnik plateau and Javnorniki covers approximately 500 km^2, which is even less than the home range of some bears). Therefore, it is not surprising that the home ranges of almost all monitored bears also included some human settlements. This is one of the key facts for bear management, as it shows that in Slovenia we do not have regions available where bears can live in isolation from people. Brown bears will survive in Slovenia only if people are willing (and understand how) to coexist with them.

Monthly home ranges (apart from winter) ranged from 37 km^2 in October to 84 km^2 in May on average. Home range size also depended on bear category (sex, age, reproduction status) and correlated negatively with local bear densities. Another important parameter was distance to the feeding site – in areas with a higher density of feeding sites, bears had smaller home ranges.

Almost half of all bears captured in Slovenia also crossed into Croatia. This indicates the importance of transboundary cooperation in brown bear management in this region. Large home range sizes and the long distances bears can travel in a relatively short period of time also show that careful consideration is needed when prescribing management removals of potential problem bears and with the interpretation of data from bear monitoring. Because individual bears can move a considerable distance in a short time, two kinds of problems can occur. First, the same bear can cause conflicts at locations that are far apart, which can lead to the wrong impression that several problem bears are present at the same time. A good example of this was Rožnik, a problem bear that caused conflicts in areas throughout Slovenia, including Kočevska, Bloke, Raktina, Grosuplje, Zasavje, Vransko, and Koroška. If this bear had not been equipped with a telemetry collar, the conclusion would likely have been that several problem bears were present at the same time. This could have led to the removal of several bears, most of which would not have been problem bears. Second, brown bears are not territorial and several individuals typically share the same area. At the same time, bears cover large areas in a short time (large monthly home ranges). It is therefore questionable whether the right bear is always removed when management removals are performed away from the location of the conflicts (e.g. at nearby feeding sites).

A good understanding of the factors that determine bear home range sizes and their seasonal movements is also crucial for the correct interpretation of monitoring data, especially when monitoring takes place in a relatively small area and local density measurements are extrapolated to a larger area. Locally and temporally abundant food resources can, during certain periods, attract a large number of bears from the wider area. As a consequence, local bear densities can increase dramatically in small area for a short time. When local observations are then generalized to the larger area, we can come to the erroneous conclusion that bear numbers suddenly increased enormously. Care is needed even when monitoring is performed at the national level, since a large part of the population is shared with Croatia and changes in bear densities in one country can occur due to the seasonal movements of bears across administrative borders.

USE OF FEEDING SITES BY BEARS

Artificial feeding of bears is a very controversial practice that is forbidden in many countries. However, in some countries it is intensively used for the purposes of hunting, eco-tourism, population monitoring, or conflict resolution. Despite a long tradition of bear feeding in several countries, including Slovenia, the positive and negative effects of this practice are poorly understood.

In our study, 6.8% of all bear locations were recorded on feeding sites. Feeding site use depended on several factors: the time of day, the individual bear, the month of the year, and bear category (age, sex, reproductive status). Bears visited feeding sites most frequently in the evening (peak was recorded at 9 p.m. with 16.5% of bear locations at feeding sites) and in April and least often during the day and in December. We noticed considerable differences between bears, with some bears present at feeding sites as little as 1% of the time and others up to 20%. Feeding sites were used most often by young males and least often by females with cubs of the year. On average, the first bears to arrive at feeding sites in the evening were females with cubs, followed by lone females and young males, while larger males tended to arrive the latest at night. This pattern is most likely a consequence of a combination of the avoidance of people and the presence of dominant bears – bears prefer to visit feeding sites at night, when people are less active, and subordinate bears (females and younger bears) visit feeding sites earlier to avoid dominant bears (large males). On average, an individual bear visited a feeding site on 11.8% of all nights. A single bear could visit up to six different feeding sites in a single night; however, bears typically visited only one feeding site per night. On average, bears visited 4.1 feeding sites per month and used 39% of the feeding sites within their home ranges (range: 8-63%).

When annual bear counting was taking place at permanent counting sites at selected feeding sites (three times per year, between 6 p.m. and midnight), individual bears visited at least one counting site on 9% of days (to increase sample size we included ±3 days to each count day). This represents a conservative estimate of the probability that a bear would be recorded during a given count day. To obtain a more accurate estimate (which would have probably been higher), it would have been necessary to increase the frequency of GPS fixes. This is because some of the bears stayed at a feeding site less than one hour and may not have been recorded. In contrast to the general use of feeding sites, counting sites were visited more frequently by females than by males during the monitoring period. This is most probably because males often visited feeding sites later at night, after monitoring finished (at midnight).

These results indicate that care is needed when interpreting monitoring data from bear counting at feeding sites, especially when attempting to estimate the absolute population size and the absolute proportions of different bear categories in the population. For example, such monitoring data can overestimate the proportion of females with cubs in the population. We therefore recommend that future data on bear counting at feeding sites should be used only for monitoring relative trends in the population size and structure over time and not for estimating absolute values at any given time.

Contrary to speculative opinion in Slovenia, comparison of data from the period when intensive diversionary feeding of bears with carrion was taking place with data from the period following this did not support the expectation that bears would in general prefer feeding sites with carrion to feeding sites where non-animal feed was available. We also did not detect any relationship between the use of feeding sites and problem bears at the level of individual bears, the month, or the week, thus it appears that feeding sites are not related to the occurrence of problem bears.

Our analysis of the effects of diversionary feeding showed that feeding sites have a strong influence on the space use of bears (e.g. Fig. 5). However, telemetry data indicated that diversionary feeding did not prevent bears from approaching human settlements. This is also supported by the fact that there are a high number of human-bear conflicts in Slovenia despite the very intensive feeding practices here. Analysis of data from the carrion feeding period also did not show any relationship between feeding with carrion and livestock depredation. It therefore seems that diversionary feeding is not effective as a conflict mitigation measure and may also have undesirable consequences.

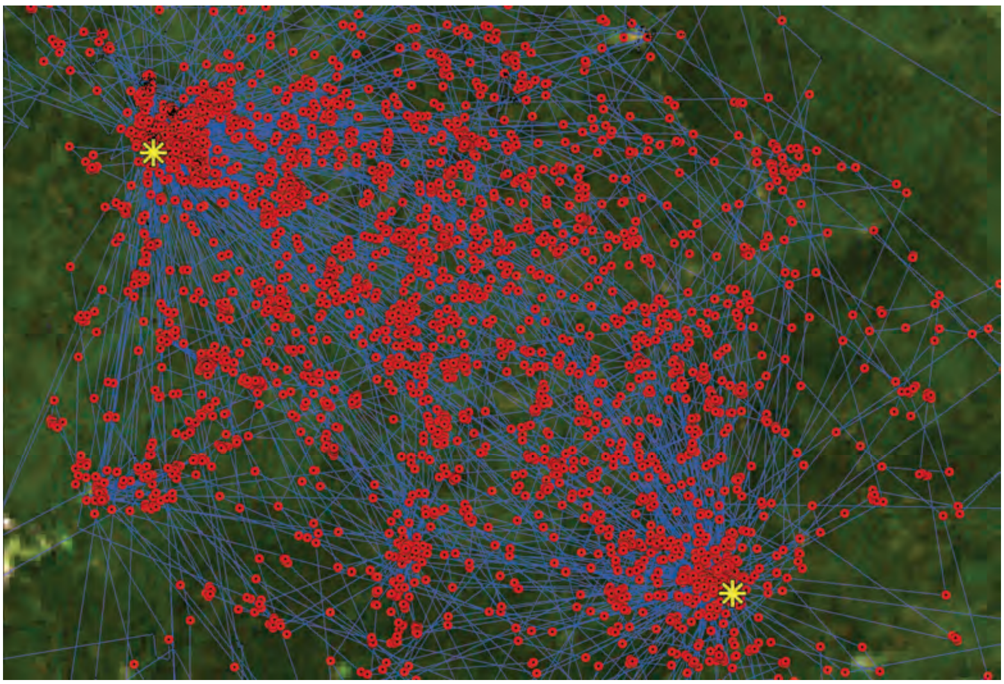

Figure 5: The presence of feeding sites can considerably change bear movement patterns. The figure shows such an example with locations of the female Pepca (red points), her movement (blue lines), and the locations of the two feeding sites in her home range (yellow asterisks).

BEARS APPROACHING HUMAN SETTLEMENTS

The majority of human-bear conflicts in Slovenia refer to bears approaching human settlements. Telemetry data enables us to gain a better understanding of the patterns associated with bears coming into contact with people. In general, we noticed that bears clearly avoided human settlements, as the space use of bears considerably increased with distance to the nearest house up to about 500 m. Bears approached houses most often around midnight (between 10 p.m. and 2 a.m.) and least often between 8 a.m. and 5 p.m. Therefore, bears also tried to avoid human contact when they approached settlements.

We observed large differences between individual bears. The majority of bears approached settlements very rarely or never, while a few individuals came within the vicinity of houses relatively frequently (Fig. 6). For example, the male Rožnik approached human settlements 12 times more often than other bears. When we compared telemetry data from Rožnik's collar with reports of human-bear conflicts, it became evident that during monitoring this single bear was the cause of 40% of all reported conflicts in Slovenia (and as much as 71% of all reported conflicts in April 2009). Our data clearly showed that in the Slovenian bear population just a few bears cause the majority of all human-bear conflicts and most of the other bears cause conflicts extremely rarely or never. We also observed that settlements were approached more often by bears that were at least partly habituated to human presence (e.g. male Rožnik and female Bora).

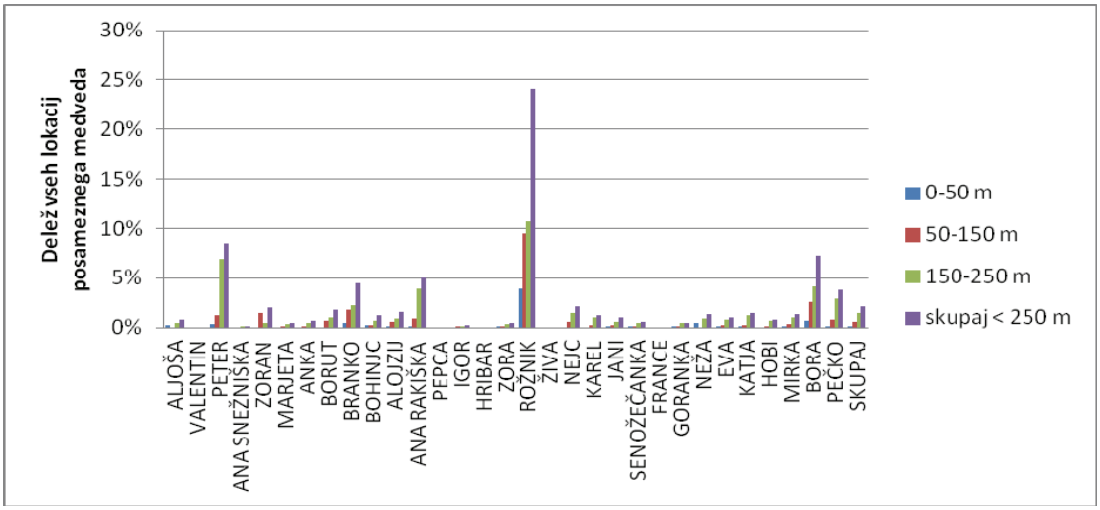

Figure 6: Proportion of GPS locations located at different intervals of distance to the nearest house for individual bears.

HABITAT MODEL FOR BROWN BEAR IN SLOVENIA

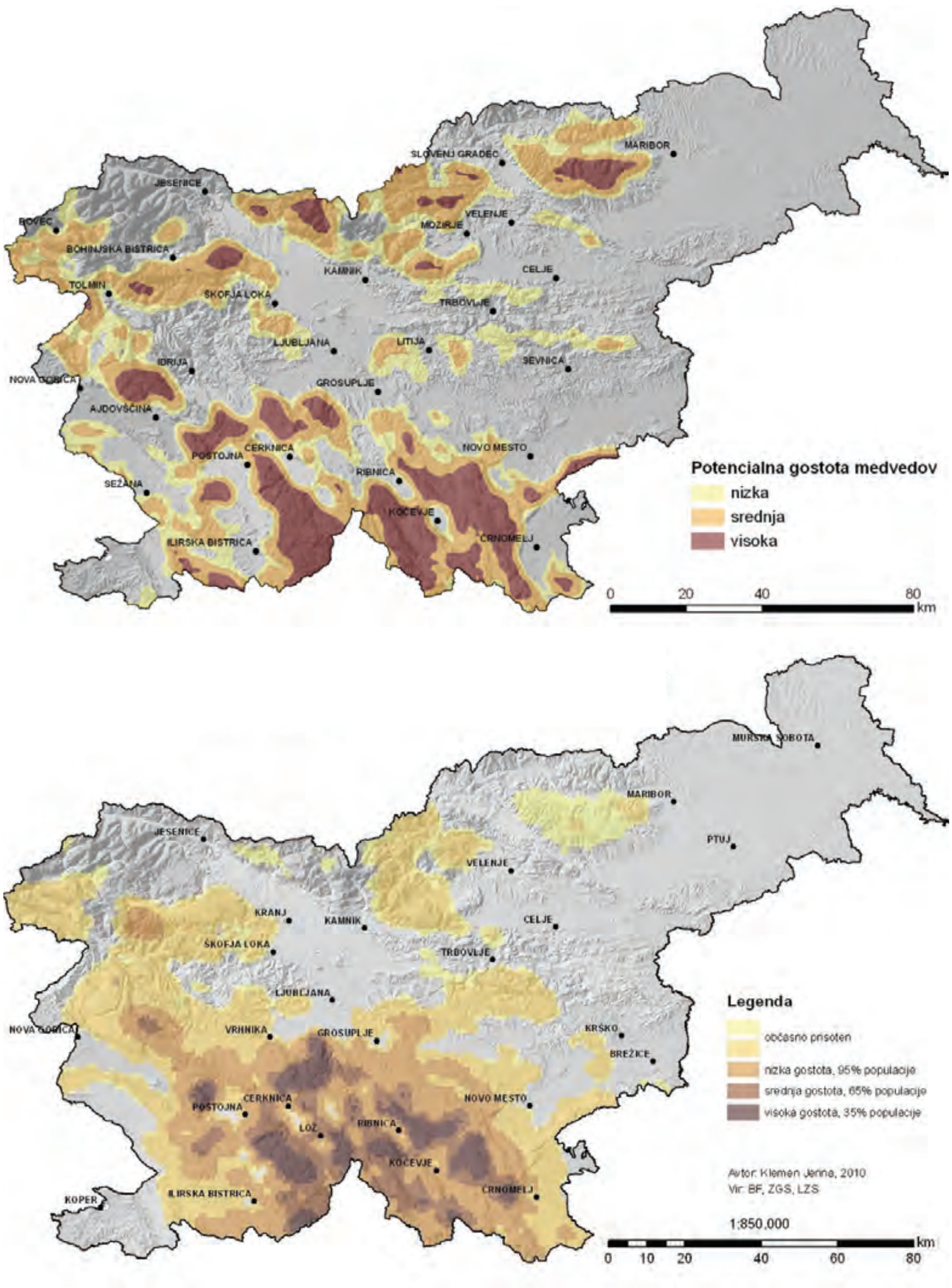

Figure 7: Habitat model – potential bear densities in Slovenia according to environmental factors (above) and current bear densities in Slovenia (below).

Habitat modelling was used to study environmental factors that affect the spatial distribution of bears and to identify and map areas that are suitable for bears based on these factors. Such maps can be used for predicting the future dynamics in the spatial distribution of the species. We used binary logistic regression and included several environmental factors that could influence habitat suitability, such as the amount and availability of food, cover availability, and human disturbance. The final model predicted that habitat suitability increases with greater forest cover on the larger scale, smaller distance to the nearest feeding site, greater distance to the nearest house, the presence of the forest at the location, smaller distance to the forest edge (from non-forest areas towards the forest), greater size of the forest patch, and greater distance to the closest main road. Comparison between potentially suitable bear habitat and the current bear range in Slovenia (Fig. 7) indicates that most of the suitable unoccupied areas are located in the northern part of the country (Pohorje, Karavanke, Kamnik-Savinja Alps, and Julian Alps).

EFFECTS OF ANTHROPOGENIC FOOD SOURCES ON BEAR PRESENCE

Studies from other countries indicate that anthropogenic food sources are among the most important causes of human-bear conflicts. We set out to determine the importance of such food sources for bears in Slovenia. The results from this section are based on field inspections of 450 GPS bear locations and 450 randomly selected control locations in the same areas. We found anthropogenic food sources in 37% of bear locations, significantly more than that found in the control locations. The largest difference between bear and control locations was observed in the presence of feeding sites and scattered garbage. Anthropogenic food sources found at bear locations outside feeding sites included carrion (slaughter remains), garbage bins, garbage dump sites, scattered garbage, compost, and food leftovers at picnic sites (Figs. 8 and 10).

Using logistic regression, we also tested whether bear presence is influenced by interactions between the presence of anthropogenic food and presence of forest, the presence of a main road, or the distance to a house. The model predicted that bear presence is more likely where anthropogenic food is present and that it is affected by the interaction between the presence of anthropogenic food and the distance to the nearest house. Analysis showed that in general bears avoid houses except in cases when there is accessible anthropogenic food near them. This is important for the preparation of management recommendations, as it has been shown that conflicts are often caused by the actions of people. Compared to other habitats, bears found more anthropogenic food near houses and outside the forest, while the effect of roads was negligible. Results show that the presence of accessible anthropogenic food sources in the vicinity of settlements is an important factor in bears approaching human settlements in Slovenia. This is in accordance with previous studies in other countries.

After a bear repeatedly acquires food near human settlements, it begins to make the connection between humans and anthropogenic food. Such "rewards" in the form of food further promote visits to human settlements, especially to those where food is often available. This can cause the bear to eventually lose its fear of people (bear becomes habituated to human presence). In the final stage, such a bear becomes a problem bear and begins approaching settlements during the daytime. This creates anxiety among the local people and leads to repeated conflicts.

Figure 8: An illegal garbage dump with slaughter remains (parts of a dead horse and wild boar) that attracted Goranka, a female bear and her cub, to the vicinity of a village at the foot of Mt. Nanos for several days (see also map on Fig. 9).

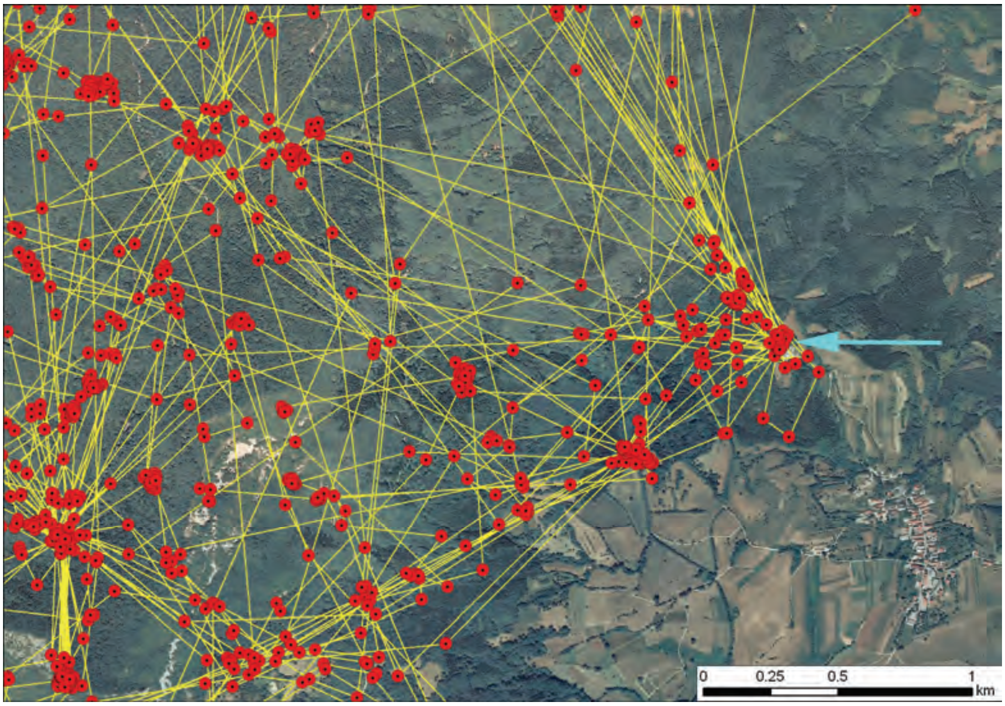

Figure 9: GPS locations of female Goranka at the foot of Mt. Nanos. The blue arrow indicates the location of the illegal garbage dump with slaughter remains near one of the villages (see Fig. 8). The yellow lines connect consecutive locations.

Figure 10: Food waste on compost behind a house that was regularly visited be the female Bora.

MANAGEMENT RECOMMENDATIONS

The successful management and prevention of human-bear conflicts is a necessary condition for the coexistence of local people and brown bears. Many years of experience with bear management in Slovenia has enabled us to successfully manage the bear population size. The removal of individual bears will likely remain an important management measure, especially when dealing with problem bears. However, bear removals alone will not be enough to effectively decrease the current large number of human-bear conflicts to an acceptable level.

Another measure that has been used to prevent conflicts is diversionary feeding, including feeding with carrion. Although studies on the effects of bear feeding are still on-going, preliminary results suggest that this measure is not effective for human-bear conflict mitigation. Supporting this is the large number of conflicts that take place every year in Slovenia despite intensive feeding practices. Therefore, new, more effective conflict mitigation measures, which have already proved successful in other countries, will have to be used in the future in order to decrease the number of conflicts.

After reviewing reports on human-bear conflicts throughout the world, examining experiences with different conflict mitigation measures, and analyzing the results of this study, it is clear that the cause of the majority of conflicts is the availability of easily accessible sources of anthropogenic food in the vicinity of human settlements. Consequently, preventing access to anthropogenic food, especially near human settlements, is the key management measure to effectively reduce the number of human-bear conflicts and is one that is being used in several other countries with bear populations.

Based on the results of this study and experiences from other countries, we have prepared a set of recommendations for priority management measures, which could, in our opinion, considerably improve human-bear conflict resolution in Slovenia:

1) replace existing garbage bins with bear-proof garbage containers at conflict hotspots

2) carry out swift and harsh prosecution of those who illegally dump animal slaughter remains in the vicinity of human settlements

3) protect compost, bee-hives, small livestock, orchards, and other food sources that attract bears to settlements with the use of an electric fence of appropriate size and

electric charge during periods when these food sources are attractive to bears (e.g. during the fruiting season)

4) promote the raising of cattle and horses instead of small livestock (sheep and goats) in the brown bear core area if environmental factors allow for such a transition

5) prohibit people from feeding bears (including cubs) directly and threaten harsh prosecution for offenders

6) design and implement a broad educational campaign for local people in the bear distribution range regarding the appropriate behaviour of people for the prevention of human-bear conflicts with a clear message about the importance of preventing bear access to anthropogenic food sources.

In addition to these new conflict mitigation measures for Slovenia, we recommend the continued removal of problem bears that show clear habituation to human presence.

As Dr. Miha Adamič said: "The most important tool for the prevention of human-bear conflicts is our knowledge." We now have a good understanding of bears in Slovenia. The next step is to apply this knowledge in the field. In some foreign countries managers began using effective measures to prevent bear access to anthropogenic food sources only after several lethal attacks on humans had already occurred. In Slovenia, we hope we will learn from others' mistakes rather than our own.