
Keywords: 7SI/Alps/Brown bear/coexistence/colonization/condition/cooperation/home range/landscape/LIFE/Malme/management/population/spatial/strategy/telemetry/trapping/Ursus arctos

Abstract: The Slovenian bear population is of high international interest because of its importance as a source for the natural colonization of the Alps and as a future link between the dinaric and the alpine bear population. In addition, life conditions of bears in Slovenia are very similar to those in the other alpine countries and management strategies developed there will be of high relevance elsewhere. The objectives of the present study were to: (1) initiate cooperation concerning brown bear between Austria and Slovenia; (2) monitor movements and spatial requirements of brown bears in a cultivated landscape; (3) evaluate the impact of the Ljubljana-Postojna highway on brown bear movements; (4) work out future research needs and research focus to help understand the limitations and potentials of bear-people coexistence in a cultivated landscape.
Final Report
SLOVENIAN BEAR TELEMETRY PROJECT 1993 - 1995

Petra Kaczensky, Felix Knauer, Marko Jonozovic, Thomas Huber, Miha Adamic and Hartmut Gossow

MAY 1995

1 Institut für Wildbiologie und Jagdwirtschaft (IWJ) der Universität für Bodenkultur in Wien, Peter Jordan Str. 76, A-1190 Wien, Prof. Dr. Hartmut Gossow
2 Wildbiologische Gesellschaft München e.V. (WGM), Linderhof 2, D-84288 Ettal, Prof. Dr. Wolfgang Schröder
3 Slowenischer Jagdverband (SL), Zupanciceva 9, SLO-61000 Ljubljana, Dipl. Ing. Blaz Krase
4 University of Ljubljana: Biotechnical Faculty at the Department of Forestry, Vecna Pot 83, SLO-61111 Ljubljana, Prof. Dr. Miha Adamic
Final Report
SLOVENIAN BEAR TELEMETRY PROJECT 1993 - 1995

1. Introduction

The Slovenian bear population is of high international interest because of its importance as a source for the natural recolonization of the Alps and as a future link between the dinaric and the alpine bear population (ADAMIC 1994). In addition life conditions of bears in Slovenia are very similar to those in the other alpine countries and management strategies developed there will be of high relevance elsewhere.

The fairly high population density of bears in Slovenia and adjacent Croatia (around 700 bears at a density of 7 bears per 100 km²; HUBER 1990) enhances bear dispersal northward into the Alps. Single bears are known to travel into Austria and northeastern Italy. Dispersal corridors still exist but are threatened by road building and land development. Traffic axes like highways, istrestates and railways may fragment an otherwise continuous environment due to: high mortality, avoidance and/or its border effect (SERVHEEN AND HUBER 1993, KACZENSKY ET AL. SUBMITTED).

Between 1972 and 1994 nine bears have been killed on the Ljubljana-Postojna highway, seven within the last four years (JOVOZOVIC IN PREP). This highway cuts right through the most important migration corridor for bears towards the Alps (ADAMIC 1994). Presently an extension of this highway is under construction and will again cut through prime bear habitat. Technical solutions like viaducts, animal passages (green-bridge) and electric fencing are discussed but little data on the efficiency of these measures or the behavior of bears coming in contact with highways is available (PAQUET PERS. COM, KACZENSKY ET AL. SUBMITTED).

On the other hand attitude towards the large predators has changed and in several places habitat suitability has greatly increased due to reforestation, high numbers of wild ungulates and the abandonment of animal husbandry. Today bears are allowed to return into the Alps and other parts of their former range through natural recolonization, restocking and reintroduction (SCHRÖDER 1992). The economic development of the source countries and the return of bears into suitable but fairly densely settled areas makes it necessary to understand the impact of human land use practices on bears. Without this base line data it will be impossible to develop management strategies for long term survival of bears in cultivated landscapes.

The objectives of the study were:

1. initiate cooperation concerning brown bear between Austria and Slovenia
2. monitor movements and spatial requirements of brown bears in a cultivated landscape
3. evaluate the impact of the Ljubljana-Postojna highway on brown bear movements
4. work out future research needs and research focus to help understand the limitations and potentials of bear—people coexistence in a cultivated landscape
2. Funding / Acknowledgments

Funding was provided by the Austrian Ministry of Science (Projekt zur Kooperationsanbahnung Luchs/Bär Kärnten/Slovenien), Slovenian Hunters Association, Munich Wildlife Society, University of Munich and the Brevins Memorial Foundation (IBA). We also want to thank all the many people that helped to make this project possible, especially: Blaz Krize for support and organization, the military base on Ljubljanski Vrh for monitoring our trap transmitters, the hunters of the hunting clubs: Ljubljanski Vrh, Rezeq, Hotezalica, Logatec, Krkevovje, Brezovica and Rakija for letting us trap on their territory and for providing bait and many bear information. Special thanks also to the pilot Thomas Meze from the Aeroclub Postojna, Gregor Bolcina, Alexis Zrimec, Rosi Kugler and Ilka Reinhard for their help with telemetry.

3. Study area

The study area is located 20 km SW of Ljubljana, the capital of Slovenia and covers an area of about 2,000 km² (Fig. 1). It is on the main corridor which still allows bears from the Dinara Mountains disperse towards the Alps. Even though the area is not very densely populated (~ 80-90 inhabitants/km²), human impact on that brown bear population is high:

1. some areas of the forests are heavily used for recreation by people from Ljubljana
2. the Ljubljana-Postojna highway cuts through the western portion of the study area - since the construction in 1972 nine bears have been hit by vehicles.
3. forests are exploited by selective cutting, for which a high density of forest roads is necessary (20m/ha) - human access to these roads is unrestricted.
4. bears are fed on permanent feeding places (corn and/or meat) in spring and fall for hunting purpose.

Concerning hunting management the study area is at the northeastern edge of the so-called "bear core area" (Fig.5) which was established in 1966. Within this bear core area bears are fed and hunted on a quota system. Hunting is allowed only at bait stations and open season lasts from 1. October to 30. April. In all of Slovenia about 40 bears are shot annually out of an estimated population of 300 - 400, the population trend still being positive. Outside the "bear core area" there was no closed season for bears until recently. In 1991 this policy was reversed - the Slovene Hunters Association agreed on completely protecting the bears outside the core area to allow for an increased dispersal of bears into the Alps (SIMONIC 1994).

Geologically the study area is part of the Dinara Mountain Range, stretching from Slovenia over Croatia and Bosnia into Macedonia. The relief shows typical karst phenomena, dolines, caves and shallow soils. Elevations range from 300m to 1500m. Annual precipitation is 1500mm, snow cover lasts for 50-70 days and annual temperature averages 7-8°C. Bear habitat consists of mixed, uneven aged forests. The dominant tree species are beech (Fagus sylvatica) and fir (Abies alba), intermingled with varying amounts of spruce (Picea abies), maple (Acer pseudoplatanus) and elm (Ulmus spec.).
4. Methods

Capture

We caught bears using Aldrich foot snares (JONKEL 1992) at established bait sites. These sites are normally used for hunting and have been in place for many years. Usually bait was provided by the local hunters and consisted of meat (game and domestic animals) and/or corn. During the first and second capture season we prepared small sand beds on bear trails and in front of traps to monitor bear activity and check for possible avoidance of traps and/or detect non-target animals that sprang snares without getting caught.

To minimize time bears were snared, traps were permanently surveyed using trap transmitters (Wagener, Germany). To allow a maximum of safety, trap sides were selected to provide access by car (for night handling) and to be within the range that signals of trap transmitters could be picked up from the field station or from a military base which is located on one of the high peaks within the study area. Trap transmitters were monitored every hour during daylight and every 30 min. at night.

We tranquilized bears using a CO₂ pressure gun (Telinject, Austria) with Zoletil 100 (Vitabc, France), a mixture of tiletamine and zolazepam. We took standard body measurements, pulled a premolar for aging (Matson’s Lab, USA) and fitted bears with radiocollars (Telonics, USA; Televilt, Sweden) and colored ear tags (“Prima-Flex”, Germany) in both ears.

Radiotracking

Radiotracking was done almost exclusively from the ground using triangulation or homing in (WHITE AND GAPROTT 1990). Depending on topography, distance and activity of the bear, we classified the accuracy of the locations as: 1ha, 1/4km², 1km² or more than 1 km². Only one location per day and bear with an accuracy of at least 1km² was accepted for data analysis. Habitat parameters were only protocolled for 1ha locations and for 1/4km² locations, when the habitat was seen to be continuous.

For calculating annual total ranges we used the 100% minimum convex polygon. We refer to annual home ranges as minimum convex polygons excluding excursions. Excursions were defined as single, long distance trips more than 5 km out of the area of usual presence.

Bears were considered resident, if they used the same or greatly overlapping areas in adjacent years. When monitoring of a bear was only possible for one season it had to come back to the vicinity of its capture site to be considered resident. Bears not showing these patterns and/or continuing to move in a certain direction were considered dispersers.

No systematic effort was conducted to find den beds due to financial and personal restraints. The beds found were protocolled: type of bed, topography, elevation, distance to civilization, canopy closure, coverage, forest composition. A visibility index
was calculated measuring the distance a bright colored plastic ball (0.75m diameter) was visible in all four directions of the compass. All scats collected near day beds of collared bears were visually checked for the presence and amount of corn. The percentual amount was determined by comparing scats with reference pictures of corn / mud mixtures of known percentages.

**Highway crossings**

Minimum number of highway crossings of collared bears was gained from the number and timing of locations on both sides of the highway.

To monitor the overall frequency of bear crossings via bridges and tunnels, we used sandbeds on three bridges and in three tunnels on a ten kilometer stretch of the Ljubljana-Postojna highway. In August 1993 and June 1994 we checked sandbeds a minimum of once a day, removing all tracks with a rake.

With financial support of IBA (Brevins memorial foundation) and in cooperation with Video Rapp, WCM and F. Kaczensky a remote camera system was developed for future monitoring of bridges and tunnels. Inexpensive 35mm cameras with internal flash and databack were connected with two infrared sensor and can be programmed with a timer. Cameras were locked in metal boxes and will be fixed to the tunnels and bridges.
5. Results

From 1993 - 1995 four capture seasons with a total of 1,033 trapnights resulted in the capture of 17 bears (13 different individuals, 4 recaptures). No non-target animals were captured but tracks on sand beds indicated triggering of traps by foxes, dogs, roe deer, wild boar and people. All bears were caught at night.


<table>
<thead>
<tr>
<th>month</th>
<th>trap nights</th>
<th>bears trapped</th>
<th>trap nights per bear</th>
<th>spring traps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>31</td>
<td>2</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>175</td>
<td>1</td>
<td>175</td>
<td>4</td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td>152</td>
<td>3</td>
<td>51</td>
<td>9</td>
</tr>
<tr>
<td>April</td>
<td>178</td>
<td>5</td>
<td>36</td>
<td>5</td>
</tr>
<tr>
<td>October</td>
<td>90</td>
<td>0</td>
<td>-----</td>
<td>1</td>
</tr>
<tr>
<td>November</td>
<td>62</td>
<td>2</td>
<td>31</td>
<td>6</td>
</tr>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td>345</td>
<td>4</td>
<td>36</td>
<td>15</td>
</tr>
<tr>
<td>total</td>
<td>1,033</td>
<td>17</td>
<td>60</td>
<td>40</td>
</tr>
</tbody>
</table>

The 17 captures were on the territory of four different hunting clubs, each covering an area of about 40 km². Of the thirteen different bears four were females (3 adults, 1 subadult), and nine were males (2 adults and 7 subadults) (Tab. 2). All bears captured were in perfect physical conditions and no capture related injuries occurred. Weights ranged between 35-42 kg for yearlings (n=5) and for animals older than one year between 74-120 kg for females (n=4) and between 80-162 kg for males (n=6).
### Tab. 2: Bears captured from 1993 - 1994.

<table>
<thead>
<tr>
<th>Date</th>
<th>Bear name</th>
<th>Sex</th>
<th>Weight (kg)</th>
<th>Age (a)</th>
<th>Hunting club</th>
<th>Collar</th>
</tr>
</thead>
<tbody>
<tr>
<td>26.04.93</td>
<td>M1 Yogi</td>
<td>m</td>
<td>36</td>
<td>1</td>
<td>Ljubljanski Vrh</td>
<td>no</td>
</tr>
<tr>
<td>28.04.93</td>
<td>M2 Krabas</td>
<td>m</td>
<td>42</td>
<td>1</td>
<td>Ljubljanski Vrh</td>
<td>no</td>
</tr>
<tr>
<td>04.05.93</td>
<td>F1 Jana</td>
<td>f</td>
<td>40</td>
<td>1</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>07.11.94</td>
<td>Jana</td>
<td>-</td>
<td>120</td>
<td>2</td>
<td>Kretovce</td>
<td>-</td>
</tr>
<tr>
<td>24.03.94</td>
<td>F2 Melka</td>
<td>i</td>
<td>85</td>
<td>13-14</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>31.03.94</td>
<td>Melka</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>25.03.94</td>
<td>M3 Clio</td>
<td>m</td>
<td>35</td>
<td>1</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>07.04.94</td>
<td>Clio</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Catek</td>
<td>-</td>
</tr>
<tr>
<td>28.03.94</td>
<td>M4 Janko</td>
<td>m</td>
<td>118</td>
<td>2-3</td>
<td>Hotedrlica</td>
<td>yes</td>
</tr>
<tr>
<td>31.03.94</td>
<td>M5 Luka</td>
<td>m</td>
<td>35</td>
<td>1</td>
<td>Catek</td>
<td>no</td>
</tr>
<tr>
<td>07.04.94</td>
<td>M6 Misko</td>
<td>m</td>
<td>155</td>
<td>adult</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>18.04.95</td>
<td>Misko</td>
<td>m</td>
<td>160</td>
<td>adult</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>23.04.94</td>
<td>F3 Anshka</td>
<td>f</td>
<td>73</td>
<td>4</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
<tr>
<td>16.11.94</td>
<td>M7 Jure</td>
<td>m</td>
<td>154</td>
<td>subadult</td>
<td>Hotedrlica</td>
<td>yes</td>
</tr>
<tr>
<td>05.04.95</td>
<td>M8 Urosh</td>
<td>m</td>
<td>80-100</td>
<td>adult</td>
<td>Catek</td>
<td>yes</td>
</tr>
<tr>
<td>16.04.95</td>
<td>M9 Milan</td>
<td>m</td>
<td>110</td>
<td>subadult</td>
<td>Catek</td>
<td>yes</td>
</tr>
<tr>
<td>23.04.95</td>
<td>F4 Maja</td>
<td>f</td>
<td>101</td>
<td>adult</td>
<td>Ljubljanski Vrh</td>
<td>yes</td>
</tr>
</tbody>
</table>

### Break away

For most bears the monitoring period was restricted because of premature breakage of the break away device. The first 5 collars had break aways made of 18 loops of 1.0 mm iron wire. Two came off prematurely: one after 6 month (F2) and one after 7 month (M6). One got embedded in the fat of the neck due to abnormal growth of the bear F1 and was still on when the bear was recaptured 18 month after collaring. One is still on the bear for more than 12 month (F3). The fate of M4 and his collar is unknown because of dispersal into Croatia. Yearling males with the exception of M3, were not collared because of their potential for very rapid growth. M3, received a small collar (Taletivi) with an extremely wear, break away device (9 loops of 0.5 mm iron wire) - it fell off after 2 1/2 month.

All bears caught after spring 1994 received cotton spacers for break aways, on subadults spacers were cut to speed up breakage. The collar of M7 was found unscrewed 4 1/2 month after collaring, the break away not showing any signs of wear. The collar of M9 was found only two weeks after capture - the break away ripped apart. The collars of M8, M6, F3 and F4 are still on and will hopefully last for the expected 18 to 24 month (SER/HEEN PERS. COMM.).
Home Ranges

Of a total of 512 locations, 442 had an estimated error polygon of less than 1 km² and were used for home range analysis (for bears with less than 10 fixes no range was calculated). Home range size was 56 and 67 km² for the two adult females F2 and F3 and 177 km² for an adult male during a six month period in 1994. The yearling male M3 covered 30 km² during a three month period in 1994, and the yearling female F1 covered 57 km² and 143 km² during a 6 month period in 1993 and 1994, respectively. The adult male M2, captured during the 1995 spring trapping season already covered 42 km² after one month of monitoring. The subadult male M4 first stayed near the capture site but then quickly dispersed into Croatia. The subadult male M7 collared in fall 1994 covered an area of 51 km² during the remaining three weeks before denning. The subadult M9 lost his collar after only two weeks of monitoring (Tab 3).

Tab. 3: Annual total ranges and home ranges (excluding excursions) of collared bears and highway crossings 1993 - 1995.

<table>
<thead>
<tr>
<th>bear</th>
<th>time monitored</th>
<th>locations</th>
<th>total range</th>
<th>home range</th>
<th>loc. near hwg</th>
<th>highway crossings</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>04.05.93 - 28.10.93¹</td>
<td>49</td>
<td>57</td>
<td>57</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>24.03.94 - 07.11.94²</td>
<td>60</td>
<td>143</td>
<td>143</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F2</td>
<td>24.03.94 - 26.09.94³</td>
<td>67</td>
<td>56</td>
<td>56</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>M3</td>
<td>25.03.94 - 31.05.94⁴</td>
<td>39</td>
<td>30</td>
<td>30</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>M4</td>
<td>28.03.94 - 26.11.94¹</td>
<td>6</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>M7</td>
<td>16.11.94 - 27.03.95⁵</td>
<td>10</td>
<td>51</td>
<td>51</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>M9</td>
<td>16.04.95 - 02.05.95³</td>
<td>5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>M6</td>
<td>07.04.94 - 20.11.94⁶</td>
<td>81</td>
<td>418</td>
<td>177</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>18.04.95 - ongoing</td>
<td>4</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>M5</td>
<td>05.04.95 - ongoing</td>
<td>13</td>
<td>42</td>
<td>42</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>F3</td>
<td>23.04.94 - ongoing</td>
<td>111</td>
<td>98</td>
<td>67</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>F4</td>
<td>23.04.95 - ongoing</td>
<td>5</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>442</td>
<td>--</td>
<td>--</td>
<td>58</td>
<td>5</td>
</tr>
</tbody>
</table>

¹ bear not found any more, ² killed, ³ collar lost, ⁴ hwg = highway

Ranges of bears overlapped greatly, regardless of age and sex (Fig. 2). The core trapping area (Ljubljanski Vrh, Borovica, Rakvek and Logatec) of about 120 km² is frequented by at least two resident males (M6, M8), three resident females (F2, F3, F4) plus their offspring (yearlings and cubs of the year) and an unknown number of subadults like F9.
Influence of the highway on bear movements

Adult bears

Data from the 1994 field season shows that for the adult bears (F2, F3 and M5) the highway represented part of their western home range boundary (Fig. 3). All three bears came close, 23 out of 183 locations (14%) were less than 1 km from the highway, but only M5 crossed. This happened twice during one excursion of eight days during the mating season. For the bears captured during the spring 1995 capture season not enough data is available yet.

Subadult bears

In 1993 the yearling female F1 crossed the highway in mid May and then lived very close to it until October. Twenty-three (47%) locations during this time were less than 1 km from the highway, but she never crossed. By the end of October she was back on the east side, then we lost radio contact. In the begin of November F1 was seen several times at a feeding station back on the west side. We believe she crossed for the third time shortly after the last location in October and then dened on the west side. In spring we found a fresh winter den near the last sighting in November and near where we picked up the first radio signals in March 1994. In 1994 F1 did not cross the highway again and seemed to settle in an area somewhat west of her 1993 den site (Fig. 4).

For the subadult males not much information is available. The yearling male M3 lost his radiocollar after only 2 1/2 month of monitoring the end of May. During this time he came within less than 1 km of the highway eight times (23%), but never crossed. The subadult male M4 was never located close (all locations > 1 km away) to the highway, but it is not impossible that he came close or even crossed the highway when he dispersed into Croatia (Fig. 2). Monitoring time of M7 and M9 was to short for interpretation.

Crossings by unmarked bears

Five crossings by unmarked bears via two tunnels were detected with the help of sandbars during a two month period. No bear tracks were found on the bridges. In addition one bear was observed attempting to cross by climbing over the fence and two others were killed: one subadult male in June 1994 on the highway about 200m away from a viaduct and an other one in October 1994 on a railway bridge above the highway.

One prototype of the automatic cameras was tested at the lynx telemetry project in February 1995. The camera was set up on a forest road for four nights and produced pictures of two bears, one badger and one wolf. In a second trial we installed the camera at a kill of two colored lynx and received at total of 32 pictures of the female lynx, their two yearlings and the collared male. Little adaptations were still necessary, but otherwise the system proved to work well. We will start monitoring animal crossings with 10 cameras at the Ljubeljana-Postoje highway in July 1995.
Reproduction and mortality

Some data on reproduction could be gained from four collared females (F1-F4) and one collared male (M6).

Telemetry data suggests that mating season starts end of April and lasts till mid June. In 1994 the adult male M6 was located together with F3 from 26.4. - 13.5.94, together with F2 on the 1.6.94 and from 12.6 - 20.6.94 he went on an excursion out of his usual range. In 1995 he was together with F4 on the 27. and 28.4.95.

F1 was first collared as a yearling. Autopsy of the reproductive tract 18 month later revealed the presence of corpora lutea, meaning she would have come into estrus for the first time at age three, possibly producing cubs for the first time at age four [VIDOVEC PERS. COMM.].

For the adult female F2, cementum annuli analysis of F1 suggested that she produced cubs for the first time at age four and then had litters at age 6,8,10 and 12 (Matson’s Lab.).

F3 was caught at the beginning of the mating season in 1994 at age four. No signs of cub presence could be seen. In addition only three days later she was located together with the adult male M6 with whom she stayed for 18 days. The early den entrance and late den emergence suggests that she is accompanied by cubs for the first time in 1995 - at age five.

Heavy tooth, wear and ripple condition (milk but minimal wear) of F4 suggest that she is an older female that just recently separated from yearling cubs.

Three marked bears are known to have died: F1 was destroyed on 7.11.94 because of an, embedded collar, M2 was legally shot on 28.10.94 and M7 was illegally killed shortly after den emergence in March 1995. His collar was found on 23.3.95 23 km from the den site on the steep slope of the mountain Nanos. The security screws were opened on one side and we believe the collar was thrown over the edge.

Denning and day beds

Only three bears could be monitored through the denning season. In 1993 telemetry contact with F2 was lost before denning, but information from local hunters allowed us to estimate denning time. We probably even found her den. F1 was seen by several hunters on a feeding place and in a nearby delline seven times from July to September 1993 with the last sighting on 10.11.93. After receiving these information we picked up her signal near that feeding place 23.3.94. When she left the area we searched in the vicinity of the feeding place and found a fresh winter den in a nearby delline (the same she was seen in).

For F3 denning lasted almost six month from 31.10.94 - 27.4.95 (n=30). The den was located in the steep slopes of Borovnica Canyon.
M7 entered the den on 7.12.94 and stayed at least till 3.2.95 (2 months, n=5). The den was located high up in the steep and very rocky slopes of Bela Canyon. After the begin of February no signals were picked up any more and snow greatly hindered searching effort. Finally the end of March the collar was found.

In 1993 at 9 out of 21.1 ha locations of F1 bear signs could be found. Besides tracks we found 18 scats and 8 day beds. The daybeds were in the NW part of F1's 1993 range and therefore close to the highway (Fig.4). Five daybeds were in a large clind in which F1 stayed for a minimum of 9 days/night, one was in a spruce plantation and two were in a mixed forest stand.

During the 1994 and the begin of the 1995 field season not much time could be spend on searching for day beds. Only 8 beds were investigated: 1 was in a spruce plantations, 5 in one clind and 2 in mixed forest stands (of these 1 was on a very steep slope).

Cover and activity

For 155 1ha and 1/4km² location one or all of the following parameters were protocols: forest type, topography, altitude and exposition (Fig.5). A use/availability analysis was not possible because habitat data of the whole study area has not been mapped, yet.

Telemetry effort was almost exclusively restricted to day time. Bears often seemed to be active but mostly without changing their location. Single observations suggest that large distances might be traveled mainly at night.

Feeding stations

Within the core trapping area on the east side of the highway we know of 17 feeding stations on a 10 x 10 km² plot (Fig.6, almost 2 per 10 km²). With such a high density bear use of feeding stations is difficult to quantify with daily locations because bears are always within easy reach of a feeding station. Sometimes bear use of feeding stations was obvious because bears were located nearby for extended periods of time and/or actual feeding was observed by the field team or local hunters (Tab.4).

Of the 33 scat found 6 contained corn and at least one contained meat from domestic animals (rabbit hair).

Growth rates of young bears were rather high. Within 18 month two yearlings increased their weight from 40 to 120 kg (F1) and from 42 to 99 kg (M2), respectively. Three subadult males between 2-3 years old already weighted 110 kg (M8) and 118 kg (M4) in spring and 154 kg (M7) in fall.
Tab.4: Periods when it was obivous that bears were at feeding stations.

<table>
<thead>
<tr>
<th>bear</th>
<th>month / year</th>
<th>minimum days present</th>
<th>prove of presence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>F1 May</td>
<td>~ 8</td>
<td>observation, location</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>2</td>
<td>observation, location</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>2</td>
<td>observation, location</td>
</tr>
<tr>
<td></td>
<td>August</td>
<td>4</td>
<td>observation, location</td>
</tr>
<tr>
<td></td>
<td>September</td>
<td>2</td>
<td>observation</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>1</td>
<td>observation</td>
</tr>
<tr>
<td>1994</td>
<td>F1 November</td>
<td>5</td>
<td>observation, location</td>
</tr>
<tr>
<td>M3</td>
<td>April</td>
<td>7</td>
<td>observation, location</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>2</td>
<td>observation, location</td>
</tr>
<tr>
<td>M6</td>
<td>October</td>
<td>1</td>
<td>observation</td>
</tr>
<tr>
<td></td>
<td>November</td>
<td>3</td>
<td>location, observation, collar found</td>
</tr>
<tr>
<td>1995</td>
<td>F3 May</td>
<td>8</td>
<td>location</td>
</tr>
</tbody>
</table>

Dispersal

Whereas the adult bears stayed within a defined area during monitoring time, two collared subadults dispersed. The male M4 moved a minimum of 55 km (capture site to most distant point) South to Ciecija Mountains in Croatia (Fig.7). Unfortunately the border and the unstable political situation in Croatia hindered continuous monitoring. Radio contact was lost in July, three month after capture. In August we received the last information on that bear - somebody had seen it, in the area of Ucka mountain, 15 km away from the last location.

For the female F1 the annual ranges in 1993 and 1994 were quite different, the only overlap being the der. site Fig.4. The geographic means of the 1992 and 1994 range were about 22 km apart and the most distant points of the two annual ranges were about 45 km apart. In comparison the most distant points for the three adults were only around 15 km for F2 and F3 and 20 km for M6.

For two other subadult bears not enough data is available to decide whether or not they dispersed. The yearling male M2 which was ear tagged in 1993 was legally shot 18 month later about 23 km from the capture site (Fig.7). The subadult male M9 lost his collar after only two weeks. Within these two weeks he first moved 25 km southeast of
his capture site, then, came back half way and lost the collar. No information were available on the fate of M1, M3 and M5.

6. Discussion

Methods

For a more detailed study on behavior and requirements of bears in a cultivated landscape most technical problems were solved. Capture success and technique proved to be adequately successful and safe.

The main drawback were the problems we had with the unreliability of break aways. The case of F1, who tripled her weight within 13 month, showed that yearlings of either sex may grow at an extremely fast rate. Selective recaptures of subadults are possible but can not be guaranteed due to dispersal, collar failure or just bad luck. We therefore feel that the risk to collar yearlings is too high. On the other hand a lot of information is lost by not monitoring this age class and with the next yearings caught we will test the possibility of hair transmitters (transmitters glued to the fur). Because aging in the field is not very accurate and growth rate and pattern may greatly vary between individual bears we will go on using break aways on all collars, regardless of sex and estimated age. We feel that the risk to cause lifelong neck irritation is greater than to have collars fall off prematurely. Our experiences and data collected by GARSHELIS AND MCLAUGHLIN (in prep.) will help us to find the most suitable device - an important prerequisite for other studies as well.

Telemetry in the rugged, rocky terrain of the Dinaric mountains proved to be very time consuming. Locations by triangulation, are not very accurate because of multiple reflections. On the other hand the dense net of forest roads often allowed us to surround the bear and accurately pinpoint its location. Still, microscale habitat data is difficult to obtain without searching for signs of bear presence after the bear left. For any preference/avoidance analysis a detailed habitat mapping on a GIS base is needed.

Spatial requirements

A comparison of ranges sizes from different studies is difficult to interpret because home range size greatly depends on definition (exclusion of excursions and outliers), resident versus dispersing animals, sampling frequency and number of locations. But the dimension of the size of home ranges/total range of czechoslovakian bears in Slovenia was within the range reported from telemetry studies in Gorski Kotar and Plitvice, Croatia (HUBER AND ROTH 1993) and from, the Italian Alps (ROTH 1983) but it was much smaller than the range of three bears reintroduced into the Austrian Alps (RAUER UND KRAUS 1993) or for bears in Scandinavia (BJÄRVALL ET AL. 1992).

Small ranges and the high bear density in the bear core area of Slovenia might be the result from the combination of a productive habitat (moderate temperature, mixed uneven aged forests) and intensive feeding of bears (Fig.6). The situation for bears in Croatia is similar. In the Italian Alps the habitat also seems very productive and the two
collapsed bears which were followed for at least four months both had access to the only bear feeding place in the area. Fast growth of young bears, early maturity and a high reproduction (about 19% of the estimated population size is harvested every year but the population is still expanding) further supports that carrying capacity for bears in Slovenia is high.

In spite of the high bear density bears are rarely seen by locals (only hunters see bears fairly regularly at feeding places). Many locals were surprised to learn that we followed bears not far from their homes. In addition to the shy behavior, bears only rarely cause damage. Within the core study area there are only few cattle and sheep but it is an important area for forest honey production. In summer time density of mobile bee houses is high and none is protected by electric fence. To our knowledge in 1994 there has not been any case of livestock depredation and only one bee house was destroyed (probably by M6).

No special care is taken to store garbage bear proved (many open garbage pits, easily accessible garbage cans, slaughterhouse remains near to villages) but there does not seem to be many problems with food conditioned bears. Bears that came to houses or approached people have been reported but were fairly rare - and normally are shot (Križ pers. comm.). Bears in Slovenia might heavily depend on food provided at feeding stations and they may be habituated to the smell and the sight of people - but habituation seems restricted to certain locations, only.

Bears are actually surprisingly rarely seen because the area is heavily frequented by people (recreationalists from Ljubljana, mushroom pickers, forestry workers etc.) and the dense net of forest roads is accessible to everyone. These rare sightings of bears can only be achieved when bears actively avoid people. For this to be successful, bears would have to hide in inaccessible areas, areas of dense cover and/or be mostly nocturnal. In Croatia bears seemed to select areas of dense cover for denning and bedding (CICNAK and RUSS 1990) and our first data also suggest that steep canyons, large dunes and sparse plantations might be important habitat parameters (fig.5).

Impact of the Ljubljana-Postojna highway

We are well aware of the fact, that our telemetry data were restricted to a small number of animals and a relatively short monitoring period. In addition, sandbeds did not provide quantitative data on crossing frequency of bears due to varying impacts by traffic, weather, and people. But these methodical shortcomings only made us underestimate the number of successful bear crossings. If during these 17 months of radiotracking and two months of sandbed monitoring we registered 10 successful bear crossings, it means that more bears successfully cross than get killed. The highway is not an absolute barrier. On the other hand, the home range boundaries and movement patterns of the adult bears clearly show, that the highway is at least a relative barrier (fig.3). None of the bears had a home range with areas on both sides, crossing regularly back and forth.

To resident bears the highway presented a barrier which they rarely crossed. They did not seem to avoid being close to it: many locations are less than 1 km away from the
highway, one time we even found a day bed of F1 only 15m from the highway. This is in contrast to findings from North America where grizzly bears show avoidance of heavily frequented roads (MCLELLAN AND SHACKLETON 1988). In contrast to North America, bears in Slovenia are shot only at established bait stations. Bear hunting while walking on the road or from a car is prohibited and might be a reason why bears do not mind being close to roads and cars. In addition a highway is a very constant and calculable source of disturbance, cars do not stop and people rarely hike next to a highway.

The radiomarked bears that crossed the highway were a dispersing yearling female (Fig.4) and a male (Fig.3) during the mating season. These dispersers are important for the recolonization of suitable habitat and for the gene flow between subpopulations. Long distance movements of adult males during the mating season give them access to additional females and also enhances gene flow between subpopulations. If a barrier still allows enough potential breeders to cross, the gene flow between the populations on both sides is secured (ALLENDORF AND LEARY 1986). The Ljubljana-Postojna highway does not yet threaten the continuity of the Slovenian bear population: actual losses are small (9 bears in 22 years), probably all bears killed were males (JONOSOVIC IN PREP.) and there are enough bears crossing successfully.

The situation is quite different if there is few bears and many or fairly impermeable barriers, a situation found in the Pyrenees (SERVEEHN AND HUBER 1993) or the Alps. In a fragmented landscape like the Alps bears will only be able to live in form of a metapopulation, a system of more or less isolated subpopulations, interconnected by dispersed corridors (GILPIN 1987). In such a setting single dispersers will be more valuable then in a continuous population. In the near future Slovenia will also have more highways (see KACZENSKY ET AL. SUBMITTED) and a denser infrastructure. Bear habitat will become more fragmented and the bear population more vulnerable.

For planned highways in bear country it will be necessary to map important bear corridors and to plan structure or “green bridges” at these locations. For already existing highways in actual or potential bear habitat critical points will have to be evaluated from knowledge on bear habitat requirements, present and historical dispersed data and landscape features (HOBBS ET AL. 1990). At important linkage points “green bridges” will have to be build. In addition it will be necessary to stop bears from climbing over the regular wildlife fences. Only providing attractive crossings will not be enough. The last bear accident on the Ljubljana-Postojna highway again showed this. The bear tried to cross over the highway only 200m away from a nectar (300m long, mainly forest cover). Electric fencing might prove a cheap and effective method not only to stop bears from breaking into beekeves, but also to stop them from climbing over highway fences. Care has to be taken not to stop bears from crossing the highway at all - no more dead bears can also mean no more crossing bears.
Dispersal

The dispersal data of P1 and M4 is in accordance with data from hunting/accident statistics from Slovenia (ADAMIC, JDNOZOVIC UNPUBL.) and Austria which already suggests that it is predominantly subadult males that disperse longer distances. Subadult males also seem to be the most likely to get into trouble: e.g. in 1994 two male bears were shot in Austria, one in self defense (180 kg, 5 years old) and one because of livestock predation (100 kg, 2 years old). Data from Norway (SWENSON AND WABAKKEN PERS. COMM.) and North America (AUNE AND KASWORM 1989) also supports this. For a natural recolonization by bears like it is taking place in the eastern Alps this might mean that long before there will be a stable bear population there will be a period with few, mainly male bears but a high potential for damage. For prognoses regarding the expansion of bear populations into new areas, more data on patterns (sex and age classes), timing and possible distances of dispersal in a cultural landscape are needed.

As already mentioned in the introduction the Slovenian bear population is the source for the natural recolonization of the Alps and it will be a future link between the dinaric and the alpine bear population. The corridor function of Slovenia for dispersal north into the Alps and south along the Dinaric range is still working as the increased number of bears showing up in the eastern Alps and dispersal of colored bears from Slovenia into Croatia (M4) and vice versa [HUBER PERS. COMM.] shows.

The Slovenian bear population should be seen as the northernmost part of a continuous bear population stretching from Bosnia over Croatia into Slovenia numbering about 1600-2000 animals all together (before the war, HUBER 1990). Just seen by itself the Slovenian bear population (estimated size: 300-400 bears), even though it is very vital and expanding, is rather small for long term conservation. To avoid inbreeding and to allow for the full range of adaptability to changing environment an effective population size of 500 breeding individuals has been suggested [SOULE 1987]. For bears this probably means an actual population size of more than 1000 individuals [KNAUER 1993]. Therefore bear management can not be done on a national level alone - only cooperation of the countries sharing the same population will allow for long term conservation.
Future perspectives

Working on highly mobile, long living, potentially dangerous and politically "brisant" animals like bear means that you have to invest a lot before you get really started and produce good results. Stopping the project now, after we became familiar with the bears, solved most of the technical problems, built up the infrastructure necessary and established good contacts with the locals would mean stopping a project right when it gets into its most productive stage. There is still a lot to be learnt about bears and without a detailed understanding of bears living in a cultivated landscape most European population will vanish sooner or later.

From the results and the experiences gained during the course of this two year study we feel that future research should be especially focused on the following:

1. evaluate the influence of human land use on the activity, movements and habitat use patterns of individual bears
2. identify structures acting as barriers, evaluating their impact and testing measures to reduce the barrier effect
3. examine dispersal/expansion patterns of a bears population in a cultivated landscape

7. Literature


Fig. 1: Study area in relation to bear core area, bear migration corridor and Ljubljana-Postojna highway.
Fig. 2: Location of the home ranges of all collared bears 1993 - 1995.
Fig. 3: Home ranges and excursions of three adult bears relative to the Ljubljana-Postojna highway in 1994.
Fig. 4: Annual home ranges of the subadult female F1 in 1993 and 1994 relative to the Ljubljana-Postojna highway.