Co-existence of brown bears and men in Slovenia

Dissertation

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1. Preface *(6PP)*

PREFACE

1. Structure of this thesis

This thesis consists of five rather independent papers that cover different aspects of the coexistence of brown bears and man in the multi-use landscape of Slovenia. The rational behind structuring the thesis in five papers was that I cover a wide array of different disciplines, for which I used very different methodical approaches. The different parts of my thesis are hold together by a general introduction and a general discussion. I chose to write the thesis in English to allow a wider distribution to a broad scientific audience. Furthermore, I chose the paper structure and the English language to facilitate subsequent publications in peer reviewed scientific journals.

In the chapter *preface* I give an overview of the structure and organization of the bear research project “Project Medved” in Slovenia, which was the frame for this thesis. This chapter closes with general acknowledgements.

In the chapter *general Introduction* I provide an overview on the general nature of the problem, give a first overview about the relevant literature and introduce the five different issues addressed in my thesis. I briefly describe the methods used to address each issue as well as the essence of each paper. The chapter closes with the list of references.

In the chapter *study area* I give a detailed description of the area where most of our research activities took place and provide some basic information on bear distribution and management in Slovenia.

The *result* chapter of my thesis is composed of five papers, each following the structure: abstract, introduction, study area & methods, results, discussion, management implications, acknowledgements and list of references. To avoid unnecessary redundancy the part study area was only supplemented if additional information beyond those given in the chapter *study area* were needed. In addition funding was not repeated in the specific acknowledgements.

The first paper deals with trapping, immobilization and radiomarking of brown bears in Slovenia, which was the prerequisite to collect data on free-ranging bears.

The second paper is on activity patterns of brown bears in Slovenia and Croatia. It deals with the temporal segregation of bears and men in the Dinaric mountain range.

The third paper is on habitat use of brown bears in the muli-use landscape of Slovenia. It focuses on the disturbance potential of human infrastructure and human activity on bear habitat use in Slovenia.

The forth paper is on the impact of the Ljubljana-Razdrto highway. It deals with the mortality risk and the barrier effect of high speed traffic axis on the bear population in Slovenia.

The fifth paper examines people's attitudes towards bears and bear management, their knowledge and their personal experiences with the species in two areas with different bear history in Slovenia.

Following the five papers in the chapter *general discussion* I relate our findings to findings from other studies and derive general management implications from it.

In the chapter *summary* the I briefly summarize the main findings of all five papers.

2. Organization of "Project Medved"[1]

Project initiation

Working on large, long living, far ranging and cryptic, forest dwelling mammals is time and cost intensive. In addition, large carnivore like the brown bear (*Ursus arctos*) are of high public and political interest. Working on such a high priority species requires a long term commitment in respect to time and money – often a difficult task for one research institute alone. In 1991 a meeting on brown bears was held in Ossiach in the Province of Carinthia in Austria. On this meeting the idea for a cross border cooperation between Austria and Slovenia was born by professor Hartmut Gossow, Institute of Wildlife Biology and Game Management (IWJ) at the Agricultural University of Vienna, Austria and professor Miha Adamic, Forest Faculty at the Biotechnical Institute of the University of Ljubljana, Slovenia. A proposal concerning bear and lynx (*Lynx lynx*) research in Carinthia and Slovenia was prepared and subsequently accepted by the Austrian Federal Ministry of Science & Research, as part of the Support Program for Slovenia.

Project partners

In 1992 the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna and the Forest Faculty at the Biotechnical Institute of the University of Ljubljana became cooperation partners. First activities were focused on lynx in Carinthia, but in spring 1993 work on brown bears was started in Slovenia. The two research institutes were joined by a third partner, the Slovenia Hunters Association (SLD) represented by Dipl. Ing. Blaz Krze. The SLD was especially responsible for logistic support and the cooperation with the local hunting clubs. Shortly thereafter a German Institute, the Munich Wildlife Society, represented by professor Wolfgang Schröder, became the forth partner, providing additional experiences and funds. The four Institutes continued to cooperate from 1993 through 1997, after which the Biotechnical Institute dropped out of the cooperation treaty. From 1998-2000 the project was continued by the three remaining institutions.

[1] "Project Medved" was the official name of the common research project. Medved is the Slovenian word for bear.

Project goals

The aims of this long term cooperation study were to investigate the coexistence of brown bears and man in a densely settled area. It focused on the following main topics:

(1) the influence of human land use on the activity, movements and habitat use of individual bears

(2) the impact of the highway Ljubljana-Razdrto as a barrier and a mortality factors for bears

(3) dispersal and expansion patterns of a bear population in a relatively densely settled landscape

(4) attitudes towards and the knowledge about bears and bear management of the local population in Slovenia

Realization of project goals

Field work in Slovenia was conducted from spring 1993 until winter 1998 and I was the principal investigator. While I worked full-time on the project from 1993-2000, Felix Knauer from Munich Wildlife Society worked half-time and in the initial phase Thomas Huber from the Institute of Wildlife Biology and Game Management worked part time on the project. From the beginning we always had a Slovenian field assistant, that helped with field work, organization and especially with bridging the language gap. People that work for us were: in 1993 Gregor Bolcina, from 1994-1996 Marko Jonozovic, in 1997 Matjaz Prosen and in 1998 Mateja Blazic. We were additionally helped by numerous volunteers coming from Slovenia, Austria and Germany, but also from as far as Newfoundland.

Special aspects of topic (1) and (2) were covered by five diploma thesis (Diplomarbeiten) (Bürglin 1995, Jonozovic 1995, Wagner 1998, Große 1999 and Petram 1999), while topic (3) is covered by a Ph.D. thesis of Felix Knauer (Knauer 2000 in prep.)(general appendix 1). The focus of my thesis is on point (1), (2) and (4).

Role of co-authors

As the project leader of “Project Medved” I have defined the research goals, soliciting input from co-authors, where appropriate. All data analysis of this dissertation as well as all writing of manuscripts were done by myself.

3. Acknowledgements

Funding

In the initial phase funding came from the Austrian Federal Ministry of Science & Research (project: G.Z. 30.435/-23/92). Additional money was provided in form of grant money for the main investigator Petra Kaczensky from the Forest Faculty at the Ludwig-Maximilian University in Munich, Germany. Further funds came from EURONATURE, the Slovenian Hunters Association and the Brevins Memorial Foundation of the International Bear Association (IBA). The latter financed the use of automatic cameras to monitor wildlife use of highway underpasses and bridges.

In the second phase the majority of the funds were provided by the Austrian Science Foundation (FWF, project: P 11529-BIO) and to a lesser degree by the Donors Association for the Promotion of Science and Humanities in Germany. Additional money was provided by the Large Carnivore Initiative for Europe (LCIE) for human dimension work.

A big thank you to...

This work would not have been possible without the help of numerous dedicated people that supported me during the ups and downs of this long lasting project. There are more specific acknowledgements for each chapter, trying to list all people that helped with the different types of work, while here I will just list very general acknowledgments.

I would like to thank Hartmut Gossow and Miha Adamic for initiating this project, Blaz Krze for helping with all the organizational problems and Wolfgang Schröder for accepting me as his Ph.D. student. I would also like to thank them for their supervision, their confidence and their cooperation. It was not always easy, but it worked!

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For all his support and the many interesting discussions I would like to thank Chris Walzer of the Salzburg Zoo. For many discussions and support of the project I am also greatly indebted to Djuro Huber, Georg Rauer, Ivan Kos and Jon Swenson. A big thank you also to Thomas Rödl for corrections and discussions on earlier drafts of this thesis and for his support in the final stage of this work.

Last but not least, I would like to thank all the students, volunteers and hunters for their help and support, the bears for being very cooperative and Tony Hamilton for infecting me with his love for bears and giving me the chance to learn "bear work" with black- and grizzly bears in British Columbia.

2. General Introduction *(15PP)*

GENERAL INTRODUCTION

For a long time, Wildlife management has been viewed as the art of making the land produce wildlife and the task of wildlife management included research, its application, and its articulation to the public (Peek 1986). While in the past decades the focus of wildlife management was on natural resource management largely motivated by an utilitarian ethic, it has changed to ecosystem management motivated by ecological considerations and with a special focus on the preservation of biodiversity (Knight 1996). In Europe, wildlife management is challenged by the heterogeneity of the natural, political and cultural landscape (Schröder 1998). In addition, there is no true wilderness any more and wildlife has to share the landscape with a high-density human population and cope with human land use and infrastructure.

In such a situation, the protection and recovery of large carnivores like lynx (*Lynx lynx*), wolf (*Canis lupus*) and brown bear (*Ursus arctos*) is especially difficult as these species have large spatial requirements and involve a great potential for conflicts because they inflict damage to livestock, compete with hunters for wild ungulates and - in the case of the bear - may even inflict human injury or death. Despite these problems most European countries signed international treaties for the protection of large carnivores (e.g. Bern Convention, CITES regulation and the Flora, Fauna Habitat Guidelines of the European Union), and some even re-introduced lynx and brown bears (Breitenmoser and Breitenmoser-Würsten 1990, Rauer 1995, Quenette 1999).

While in Western and Southern Europe only small populations of large carnivores survived, large and contiguous populations can still be found in Eastern Europe. In the past, national borders and language barriers greatly hindered the transfer of knowledge and management was seen largely as a national affair. In recent years the rapid political changes in the former communist countries of Central and Eastern Europe have opened up new perspectives for research and management. By now, large carnivore populations and the related management problems are increasingly seen on a population level, and international cooperation has become a necessity (Boitani 1998, Breitenmoser et al. 1998, Swenson et al. 1998).

Brown bears in Slovenia

In Slovenia, a high-density bear population lives in close coexistence with people and seems to cope well with human land use. Human activities within the bear range are numerous, e.g. hunting (Simonic 1994), forestry operations (Zavod za Gozdove 1999) and recreational use (Jersic 1992) of the forest. Life conditions of bears in Slovenia are similar to those in other present and potential bear areas in central and southern Europe. Thus, strategies developed in Slovenia will be highly relevant for bear management elsewhere. So far, few data on activity patterns and habitat use of bears in densely populated multi-use landscapes are available.

Slovenia is located at the transition between the Dinaric Mountain Range in the south and the Alps in the north. Its bear population is of high international interest, because presently it is the only source for a natural re-colonization of the Alps (Adamic 1994a). Single bears are known to travel from Slovenia into Austria (Rauer 1995) and northeastern Italy (Gutleb et al. 1999). Dispersal corridors still exist but are potentially threatened by road construction and land development. So far, the Ljubljana-Razdrto highway is the only high speed, high volume traffic axis that cuts through prime bear habitat (Adamic 1994b, Kaczensky et al. 1996). Technical solutions like viaducts, animal passes (green-bridges) and electric fencing are discussed as mitigation measures for the existing highway as well as for new constructions (Bürglin 1995). However, very few data are available on the influence of the highways on bear movements and mortality rate.

To allow a natural recovery of bears in the Alps, Slovenia adjusted its bear management accordingly and since 1992 bears are allowed to expand northward (Simonic 1994). Bears are consequently reappearing in the pre-alpine and alpine regions where bear presence had been previously suppressed, and the human population has lost the old traditions, e.g. in livestock herding techniques, of co-existing with large carnivores (Breitenmoser 1998). In the absence of large predators, extensive sheep farming has become widespread in the Slovenian Alps and has been supported by a subsidy system in the past few years to adjust Slovenian agriculture to European Union common agricultural policy (CAP, Savelli et al. 1998). The reappearance of bears has resulted in increasing depredation problems and triggered intense and controversial discussions among the various interest groups and bear managers (Adamic 1996, Adamic 1997). However, the future of the brown bear in Europe, especially in intensively used areas like the Alps, will largely depend on the acceptance by local people. It is the human dimension in wildlife management that still remains a major challenge for the success of carnivore conservation in Europe.

In my thesis I address four main aspects of the co-existence of brown bears and men in Slovenia. My goals were:

(1) to assess the influence of human land use on the activity pattern (chapter 4.2.) and habitat use (chapter 4.3.) of individual bears

(2) to evaluate whether the Ljubljana-Razdrto highway impedes bear movements, and to assess the importance of transportation-related mortality compared to other sources of mortality in the bear population (chapter 4.4.)

(3) to examine people's attitudes towards bears and bear management, their knowledge and personal experiences with the species, to compare results from two different study areas: in a low conflict, but high bear density area in Notranski and in the high conflict, low bear density area in the Alps (chapter 4.5.)

1. Scientific and management questions asked

Chapter 4.1: Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia

Wildlife research on brown bears (*Ursus arctos*) and other shy, nocturnal or forest dwelling animals with large ranges has improved enormously with the help of radiotelemetry (White and Garrott 1990). Yet, a disadvantage is the need to trap (The wildlife society 1990, Jonkel 1993), immobilize (Gibeau and Paquet 1991, Hatapla and Wiesner 1982) and radiotag (Garshelis and McLaughlin 1998) the study animals which beholds a certain risk for the animals and capture team (Sheldon in prep.). The European Flora Fauna Habitat (FFH) guidelines and the Bern Convention, as well as national legislation in several countries (e.g. Austria, Germany) have great reservations concerning the use of snares, which are considered to be non-selective traps (Hinterleitner and Völk 1996).

Much information and experience is available from bear studies in North America, but some of the techniques are inappropriate or unacceptable for the small bear populations in southern and central Europe, because: (1) the loss of a single bear in a small population can make a big difference for the future of this population, especially if it is a female (Naves et al. 1999), (2) public acceptance of bear losses is very low, (3) public safety is a major concern as most bear areas are also heavily frequented by people. The experiences with trapping and immobilization of bears in Europe are limited (Gentile et al. 1996, Huber et al. 1996, Huber et al. 1997, Camarra et al. 1998, Walzer 1997), making the exchange of experiences among European bear researchers even more important and a chance to learn from the mistakes of others and improve the safety standards.

Chapter 4.2: Activity pattern of brown bears in Slovenia and Croatia

The activity pattern of animals is determined by internal and external factors. Light and temperature act as external synchronizers for endogenous activity pattern (Nielsen 1983), while the availability of resources, competition, predation (Geffen and MacDonald 1993), or disturbance (Liddle 1997) may alter the genetically fixed and physiologically regulated circadian rhythm.

Under natural conditions brown bears seem to be predominantly diurnal. In North America, however, diurnal activity levels vary with the intensity of interference by humans. In areas with low intensity of human utilization, bears are largely diurnal, while in areas with high intensity of human utilization or during periods of frequent human access, bears shift to nocturnal behavior (Gunther 1990, MacHutchon et al. 1998, Olson et al. 1998).

In Europe true wilderness areas do not exist and bears generally have to cope with a high intensity of human utilization (Schröder 1998, EUROPARC and IUCN 2000). The few studies that investigated brown bear activity in Europe, demonstrated a predominantly nocturnal and shy behavior (Roth 1980, Roth and Huber 1986, Clevenger et al. 1990, Wabakken and Maartmann 1994, Rauer and Gutleb 1997). This shift in the natural activity patterns is often regarded to have negative consequences for the individual and to be a sign of a high stress level (Roth 1980). However, high reproductive rates in several European brown bear populations (Saether et al. 1998) suggest no negative consequences on the population level. Contrary, forcing bears into a nocturnal behavior seems an important prerequisite for a low-conflict coexistence of bears and people in the multi-use landscapes of Europe. Only few information are yet available on how nocturnal activity is maintained in a bear population.

Chapter 4.3: Habitat use of bears in a multi-use landscape in Slovenia

Human population growth, the intensification of agriculture and urbanization have greatly altered the landscapes all over the world. This has resulted in habitat loss or degradation (Peyton 1994, Liu et al. 1999, Forman 2000) as well as habitat fragmentation (Grau 1998, Meyer et al. 1998, Dobson et al. 1999) for many wildlife species. All three effects have consequences on the population level, reducing overall carrying capacity and influencing the structure and dynamics of animal populations. Formerly contiguous populations may become divided in several subpopulations.

Depending on the dispersal ability of the species and the spatial arrangement of the habitat patches, subpopulation may still be connected by dispersal, thus forming a metapopulation (Hanski 1991, Moilanen and Hanski 1998). Beyond a critical level of fragmentation, subpopulations become isolated and the probability of population extinction greatly increases (Wilcox and Murphy 1985, With and King 1999). The impact of habitat loss, degradation and fragmentation on wildlife populations is highly scale and species dependent (Keitt et al. 1997, With and King 1999).

Large carnivores have large home ranges in the magnitude of several 10 to 1000 km² (Jackson and Ahlborn 1988, Breitenmoser et al. 1993, Amstrup et al. 2000) and thus are especially prone to be affected by human land use. Even when protected, human caused deaths might constitute the most important mortality factor and in such a situation, human infrastructures, like roads, which facilitate human access, may greatly increase the mortality risk (Gibeau and Herrero 1998, Mladenoff and Sickley 1998, Gibeau 2000). Furthermore, human infrastructure and human activity can have a high disturbance potential, resulting in frequent flight reactions or overall displacement of a species (e.g. Dyke et al. 1986, McLellan and Shackelton 1989, Liddle 1997, Linnell et al. 2000). This will result in a large deviance between potential habitat effectiveness (relative probability of using landscape features in the absence of human activity) and realized habitat effectiveness (using landscape features in the presence of human activity, Mace et al. 1999). In Europe, bears have to cope with multiple human land use practices and human infrastructure. Although there is great concern about the impact of human infrastructure and habitat fragmentation on habitat use of bears, few empirical data are available.

Chapter 4.4: The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia

The negative effects of roads and railroads on the biotic integrity of ecosytems has become a major issue in conservation biology (e.g. Bennett 1991, Bekker 1998, Van der Grift 1999, Trombulak and Frissel 2000). Besides the mortality risk, habitat and the resulting habitat fragmentation has become a focal topic for wildlife mangers in Europe and North America alike (e.g. Foster 1992, Van der Zee et al. 1992, Ruediger 1998, Hubbard et al. 2000). The negative effects of traffic axes on bears have been reported as: (1) direct mortality due to bear-traffic collisions (Boscagli 1987, Frikovic et al. 1987, Wooding and Brady 1987), (2) habitat fragmentation due to the barrier or filter effect of high speed, high volume traffic axis (Gibeau and Herrero 1998, Servheen et al. 1998, Gibeau 2000) and (3) habitat loss due to noise and increased human use along roadsides (McLellan and Shackleton 1988, Forman 2000).

Fencing in combination with mitigation measures like green bridges (Pfister et al. 1997) or wildlife underpasses (Wooding 1993, Clevenger and Waltho 2000) have proven effective under certain circumstances and for certain wildlife species. But constructions are expensive and to be effective, they have to be designed species-specific and located in an optimal position (Servheen et al. 1998). Despite high conservation priority, very little is known about the impact of traffic axes on bear movements and mortality rates in Europe.

Chapter 4.5: The brown bear – a highly valued controversial species in Slovenia

Even though it has been acknowledged for a long time that wildlife management largely means the management of people (Thomas 2000), until recently it had been a discipline based mainly on biology. But with the general public becoming more knowledgeable and engaged in issues of natural resources, it becomes crucial to integrate the human dimension into the decision-making process (Bright and Manfredo 1995). Bath (1996), defined human dimension research as "the understanding and documenting of public attitudes that can help wildlife managers better market their decisions, minimize public controversy and minimize delay in implementation of management plans, programs and policies".

The rational behind focusing on people's attitude is the assumption that by knowing somebody's attitude it is possible to predict the person's behavior, referred to as the attitude-behavior consistency (Ajzen 1993). Socio-demographic characteristics such as age, sex, profession, urban versus rural lifestyle, place of residence in relation to large carnivore distribution, as well as the knowledge and fear component were found to be critical factors influencing attitude and acceptance of a controversial wildlife species in previous research (Bath 1991, Hook and Robinson 1982, Kellert 1994). In Europe the importance of human dimension research for carnivore conservation was only recently acknowledged (e.g. Bjerke and O. Reitan 1994, Cicnjak and Huber 1995, Korenjak 1995, Baumgartner 1998, Hunziker et al. 1998, Kvaalen 1998, Caluori 1999, Ueberschär 2000, Szinovatz and Bath 2000 in press, Szinovatz and Gossow in prep., Zimmermann et al. 2000 in prep.). However, in the multi-use landscapes of Europe, the future of large carnivores will foremost depend on the acceptance by the local people and not only on the availability of suitable habitat. In Slovenia the present bear management is challenged by an increase in bear-human conflicts. Without information on the attitudes and knowledge of the involved public it will be difficult to find compromises and develop a widely acceptable management strategy.

2. Methods used

Bears in Europe are shy, forest dwelling and have large home ranges. In order to gain information on activity patterns, habitat use and dispersal, it was necessary to follow bears on a regular basis which was possible only employing radiotelemetry. We describe our experiences with trapping, chemical restraint and radiotagging of 25 different bears during 31 capture events in Slovenia from 1993-1998. A special focus is on safety considerations for trapping, tranquilizing and radiotagging of bears, but also on how to minimize the risk for the capture team and for local people frequenting the trapping area (see chapter 4.1.).

We monitored activity patterns of radiomarked bears via time sampling in three different multi-use study areas in Slovenia and Croatia from 1982-1998. This resulted in 18.948 activity samples (about 4000 hours) of 16 different bears. With logistic regression models, we first evaluated the influence of age class (yearling, subadult, adult), sex, weather conditions, time of the day, and date on activity patterns. Then we compared diurnal and nocturnal activity levels between individual bears and checked for influences of sunset and sunrise on the activity levels. In a final step we compared the diel activity patterns of individual bears using a cluster analysis approach (see chapter 4.2.).

We analyzed the habitat use of 17 different bears monitored between 1993 and 1998 by merging 1.698 day to day locations with habitat data in a Geographic Information System (GIS). We investigated bear-habitat relationships on two different scales and with three different approaches. On the level of third-order habitat selection we: (1) compared distances to selected habitat features between bear locations and random points and (2) compared availability and use of different distance zones from selected habitat features using compositional analysis statistics. On the level of second-order habitat selection we compared the density of habitat parameters within different sized range estimates (see chapter 4.3.).

To more specifically assess the impact of the Ljubljana-Razdrto highway we analyzed daily movements and the spatial arrangement of the home ranges of 15 individual bears that lived within 10 km of this traffic axis. In addition we analyzed highway mortality data and related it to the known bear mortality in all of Slovenia. We employed a GIS and a habitat model to relate mortality data to the characteristics of the highway and the surrounding habitat (see chapter 4.4.).

To address the human dimension of the bear-man co-existence in Slovenia we used a questionnaire survey, personally distributing 1629 questionnaires in two different study areas: in a low conflict, but high bear density area in Notranski (NOT) and in the high conflict, low bear density area in the Alps (ALP). The questions were designed to examine the attitudes of locals, hunters and pupils towards bears and the related management, their knowledge about and their personal experience with the species. After quality control a total of 1519 questionnaires were used for analysis. Questions were grouped to calculate four different scores as estimates of: (1) general attitude towards bears, (2) attitude towards the usefulness/harmfulness of bears, (3) attitude towards a further increase in bear numbers, and (4) general knowledge about bears. In a second step, using a stepwise multiple regression model, we determined these variables that best predicted score values. In a final step, we analyzed single questions to assessed peoples' knowledge about and support of the present bear management and point out information gaps (see chapter 4.5.).

3. Resumé

Managers have to be aware that there is a certain risk involved when trapping and handling bears. However, given adequate safety considerations, trapping bears at bait sites with Aldrich snares is a safe, highly selective and sufficiently effective method to capture brown bears on forested range.

Activity monitoring showed that age class and time of the day were the most important variables predicting activity or inactivity. In general, yearlings were more active during the day and had a less distinct difference between daytime and nighttime activity levels than in older bears. We conclude that nocturnal behavior is learnt through own negative experiences with humans, giving space for much individual variation. As a consequence, a certain level of disturbance is probably necessary to conserve this behavioral trait in fully protected bear populations.

Bears were limited in their movements to forest cover, but showed only a weak avoidance of human infrastructure, resulting in a small deviance of the realized- and potential habitat effectiveness and we believe that the disturbance potential is overestimated in most bear habitat models. In a landscape with a high forest cover and a low degree of forest fragmentation and given that illegal killing is a minor problem, the disturbance and displacement potential of human infrastructure seems low. In our opinion a greater risk stems from attractive food sources near human infrastructure that might result in bears becoming food conditioned.

Even though the vicinity of the Ljubljana-Razdrto highway was not avoided by bears it does act as a filter for bear movements and together with the parallel railway poses a significant mortality risk. Due to the high bear density, traffic axes constitute no immediate threat to the bear population. However, mitigation measures would be desirable and also help other wildlife. We suggest to test the efficiency of different measures for bears and other wildlife along this 30km stretch of highway, as empirical data is much needed.

Concerning the human dimension, we did not find the expected difference in the attitude of people in the bear core area as compared to the outer area. Overall attitude towards bears was very positive for all three target groups, but respondents indicated a low support for a further increase in bear population numbers. Fear and damage related topics were the most important factors predicting attitude, while knowledge level, place of residence and socio-demographic factors only played a minor role. Respondents had a high interest in the bear issue and were mostly concerned about population numbers and the distribution range of bears. Bear managers should develop a PR strategy focusing on these topics.

4. Reference List

Adamic, M. 1994a. Evaluation of possibilities for natural spreading of brown bear (*Ursus arctos* L.) towards the Alps, directions of main. Braunbär in den Ländern Alpen - Adria, Tagungsbericht, p:131-158. Ljubljana, Slovenia.

———. 1994b. Highways and free-living wild animals - inevitable conflicts and possible alleviation of their effects. Gozd, 52:426-433. (in Slovenian with English abstract)

———. 1996. An expanding brown bear population in Slovenia: current management problems. Journal of Wildlife Research, 1(3):297-300.

———. 1997. The expanding brown bear population of Slovenia: a chance for bear recovery in the southeastern Alps. International Conference on Bear Research and Management, 9(2):25-29.

Ajzen, I. 1993. Attitude theory and the attitude-behavior relation. In: D. Krebs and P. Schmidt (editors). New directions in attitude measurement, p:41-57, Walter de Gruyter, Berlin and New York.

Amstrup, S. C., G. M. Durner, I. Stirling, N. J. Lunn, and Messier F. 2000. Movements and distribution of polar bears in the Beaufort Sea. Canadian Journal of Zoology. 78(6):948-966.

Bath, A. J. 1991. Identification and documentation of public attitudes toward wolf reintroduction in Yellowstone National Park. In: J.D. Varley, and W. Brewster (editors). Wolves for Yellowstone? A report to the United States Congress, Volume III, Research and Analysis. National Park Service, Yellowstone National Park, Wyoming.

———. 1996. Human dimensions in wildlife resource management in Nova Scotia. Report for: Nova Scotia Dept. Natural Resources, Wildlife Division, 82pp.

Baumgartner, H.-J. 1998. Public involvement in the lynx project in the North-Western Swiss Alps. KORA Report, 3:13-14. Bern, Switzerland.

Bekker, H. G. J. 1998. Habitat fragmentation and infrastructure in the Netherlands and Europe. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation, p: 151-165. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Bennett, A. F. 1991. Roads, roadsides and wildlife conservation: a review. In: D.A. Saunders and R.J. Hobbs (editors). Nature Conservation 2: The role of corridors, p: 99-117. Surrey Beatty & Sons PTY Limited, Chipping Norton, Australia.

Bjerke, T. and O. Reitan. 1994. Attitudes towards wolves in a rural part of Hedmark, Norway. NINA Oppdragsmelding, 263:1-37.

Boitani. L. 1998. An action plan for the conservation of the wolf in Europe. Large Carnivore Initiative for Europe. Draft. WWF International, Gland, Switzerland.

Boscagli, G. 1987. Brown bear mortality in central Italy from 1970 to 1984. International Conference of Bear Research and Management, 7:97-98.

Breitenmoser, U. and C. Breitenmoser-Würsten. 1990. Status, conservation need and re-introduction of the lynx *Lynx lynx* in Europe. Council of Europe, 42pp.

———. P. Kaczensky, M. Dötterer, C. Breitenmoser-Würsten, S. Capt, F. Bernhart, and M. Liberek. 1993. Spatial organization and recruitment of lynx (*Lynx lynx*) in a re-introduced population in the Swiss Jura Mountains. Journal of Zoology, London, 231:449-464.

———. 1998. Large predators in the Alps: the fall and rise of man's competitors. Biological Conservation, 83:279-289.

———. C. Breitenmoser-Würsten, H. Okarma, T. Kaphegyi, U. Kaphegyi-Wallmann, and U. M. Müller. 1998. Action plan for the conservation of the Eurasian lynx (*Lynx lynx*) in Europe. Large Carnivore Initiative for Europe. Draft. WWF International, Gland, Switzerland.

Bright, A. D. and M. J. Manfredo. 1995. The quality of attitudinal information regarding natural resource issues: the role of attitude strength, importance. Society and natural resources, 8:399-414.

Bürglin, R. 1995. Planung von Grünbrücken an der Autobahn Ljubljana-Razdrto (Slowenien) unter besonderer Berücksichtigung des Braunbären. Diploma thesis at the University of Munich, 79pp. (in German)

Caluori, U. 1999. Füchse in der Stadt - missliebige und geliebte Nachbarn. Report of the WSL, Zürich, Switzerland, 57pp. (in German)

Camarra, J. J., P. Y. Quenette, A. Arquillere, L. Chayron, P. Cluzel, E. Dubarry, D. Dubreuil, and J. Troietto. 1998. Capture et reequipement radio-telemetrique d´un ours brun. Bulletin mensuel de l'Office National de la Chasse, 234:17-24.

Cicnjak, L. and D. Huber. 1995. Public attitudes towards brown bears in Croatia. International Conference on Bear Research and Management in Grenoble, French Ministry of Environment, France. (abstract only)

Clevenger, A. P., F. J. Purroy, and M. R. Pelton. 1990. Movement and activity patterns of a European brown bear in the Cantabrian Mountains, Spain. International Conference on Bear Research and Management, 8:205-211.

———. and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology, 14(1):17-56.

Dobson, A., K. Ralls, M. Foster, M. E. Soule, D. Simberloff, D. Doak, J. A. Estes, L. S. Mills, D. Mattson, R. Dirzo, H. Arita, S. Ryan, A. N. Norse, R. F. Noss, and D.

Johns. 1999. Corridors: Reconnecting fragmented landscapes. In: M.E. Soul, and J. Terborgh (editors). Continental Conservation, p:129-170, Island Press, Washington, D.C.

Dyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. 1986. Reaction of Mountain Lions to Logging and Human Activity. Journal of Wildlife Management, 50(1):95-102.

EUROPARC and IUCN. 2000. Guidelines for protected area management categories - interpretation and application of the protected area management categories in Europe. EUROPARC and WCPA, Grafenau, Germany.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology, 14(1):31-35.

Foster, M. L. 1992. Effects of highways on bobcat survival and movement patterns in SW Florida. Florida Scientist, 55:33.

Frikovic, A., R. L. Ruff, L. Cicnjak, and D. Huber. 1987. Brown bear mortality during 1946-85 in Gorski Kotar, Yugoslavia. International Conference on Bear Research and Management, 7:87-92.

Garshelis, D. L. and C. R. McLaughlin. 1998. Review and evaluation of breakaway devices for bear radiocollars. Ursus, 10:459-465.

Geffen, E. and D. W. MacDonald. 1993. Activity and movement patterns of Blanford's foxes. Journal of Mammalogy, 74(2):455-463.

Gentile, L., H. Roth, G. Boscagli, and F. Mari. 1996. Immobilizzazione chimica di orsi bruni (*Ursus arctos marsicanus* e *Ursus arctos*) nel Parco Nazionale d´Abruzzo. Suppl. Ric. Biol. Selvaggina XXIV:399-414.

Gibeau, M. L. and P. C. Paquet. 1991. Evaluation of TELAZOL for Immobilization of Black Bears. Wildlife Society Bulletin, 19:400-402.

———. and S. Herrero. 1998. Roads, rails and grizzly bears in the Bow River Valley, Alberta. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. p: 104-108. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

———. 2000. A conservation biology approach to management of grizzly bears in Banff National Park, Alberta. Ph.D. dissertation. Resources and the Environment Program, University of Calgary, Alberta, Canada. http://www.canadianrockies.net/Grizzly/pubs_and_papers.htm).

Grau, S. 1998. Überblich über Arbeiten zur Landschaftszerschneidung sowie zu unzerschnittenen Räumen in der Bundes-, Landes- und Regionalplanung Deutschlands. Natur und Landschaft, 73(10):427-434. (in German)

Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican valley, Yellowstone National Park. International Conference on Bear Research and Management, 8:73-78.

Gutleb, B, M. Adamic, A. Brugnoli, P. de Martin, C. Groff, P. Molinari, M. Scussat, and G. Tormen. 1999. Recent changes in the distribution of the brown bear (*Ursus arctos*) in the southeastern Alps. 12th International Conference of bear research and management, book of abstracts, 26.

Hanski, I. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society, 42:3-16.

Hatapla, H. H. and H. Wiesner. 1982. Die Praxis der Wildtierimmobilisation. Paul Parey Verlag Hamburg – Berlin, Germany. (in German)

Hinterleitner, R. and F. Völk. 1996. Bär & Recht in Österreich. Report, Arbeitsgemeinschaft Braunbär Life. Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria. (in German)

Hook, R. A. and W. L. Robinson. 1982. Attitudes of Michigan Citizens toward predators. In: L.N. Carbyn, S.H. Fritt, and D.R. Seip (editors). Ecology and conservation of wolves in a changing world, p:3-12. Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta, Canada.

Hubbard, M. W., B. J. Danielson, and R. A. Schmitz. 2000. Factors influencing the location of deer-vehicle accidents in Iowa. Journal of Wildlife Management, 64(3):707-713.

Huber, D., J. Kusak, and B. Radisic. 1996. Analysis of efficiency in live-capture of European brown bears. Journal of Wildlife Research, 1(2):162-166.

———. J. Kusak, Z. Zvorc, and R. B. Rafaj. 1997. Effects of sex, age, capturing method, and season on serum chemistry values of brown bears in Croatia. Journal of Wildlife Diseases, 33(4):790-794.

Hunziker, M., E. Egli, and A. Wallmer. 1998. Return of predators: Reasons for existence or lack of public acceptance. KORA Report, 3:25-30. Bern, Switzerland,

Jackson, R. and G. Ahlborn. 1988. A radio-telemetry study of the snow leopard *(Panthera unica*) in west Nepal. Tigerpaper, 15(2):1-14.

Jersic, M. 1992. Tourism in Slovenia. In: M. Pak, M. O. Adamic (editors). Slovenia, geographic aspects of a new independent Europeasn nation. 27th International Geographical Congress at Washington 1992, p: 65-76. The Association of the Geographical Societies of Slovenia, Ljubljana, Slovenia.

Jonkel, J. J. 1993. A manual for handling bears for managers and researchers. United state department of the interior, U.S. Fish and Wildlife Service, USA, 175pp.

Kaczensky, P., F. Knauer, T. Huber, M. Jonozovic, and M. Adamic. 1996. The Ljubljana-Postojna highway - a deadly barrier for brown bears in Slovenia? Journal Wildlife Research, 1(3):263-267.

Keitt, T., D. L. Urban, and B. T. Milne. 1997. Detecting critical scales in fragmented landscapes. Conservation ecology, 4:1-20.

Kellert, S. R. 1994. Public attitudes toward bears and their conservation. International Conference on Bear Research and Management, 9:43-50.

Knight, R. L. 1996. Aldo Leopold, the land ethic, and ecosytem management. Journal of Wildlife Management, 60(3):471-474.

Korenjak, A. 1995. Man and large predators in Austria and Slovenia. Graduation thesis at the Biotechnical Faculty of the University of Ljubljana, Slovenia, 71pp.

Kvaalen, I. 1998. Acceptance of lynx by sheep farmers - a sociological comparison. Council of Europe Publishing, 59-64, Straßbourg Cedex.

Liddle, M. 1997. A classification of disturbance to animals. In: M. Liddle. Recreation ecology, p: 347-442. Chapman and Hall, University Press, Cambridge, Great Britain.

Linnell, J. D., J. E. Swenson, R. Andersen, P. Barbu, and B. Barnes. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin., 28(2):400-413.

Liu, J., Z. Ouyang, W. W. Taylor, R. Groop, Y. Tan, and H. Zhang. 1999. A framework for evaluating the effects of human factors on wildlife habitat: the case of the giant pandas. Conservation Biology, 13(6):1360-1370.

Mace, R. D., J. S. Waller, T. L. Manley, K. Ake, and W. T. Wittinger. 1999. Landscape evaluation of grizzly bear habitat in western Montana. Conservation Biology, 13(2):367-377.

MacHutchon, A. G., S. Himmer, H. Davis, and M. Gallagher. 1998. Temporal and spatial activity patterns among coastal bear populations. Ursus, 10:539-546.

McLellan, B. N. and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: Effects of roads an behavior, habitat use and demography. Journal of Applied Ecology, 25:451-460.

———. and D. M. Shackelton. 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin, 17:269-274.

Meyer, J. S., L. L. Irwin, and M. S. Boyce. 1998. Influence of habitat abundance and fragmentation on northern spotted owls in western Oregon. Wildlife Monographs, 139:51pp.

Mladenoff, D. J. and T. A. Sickley. 1998. Assessing potential gray wolf restoration in the northeastern united states: A spatial prediction of favorable habitat and potential population levels. Journal of Wildlife Management, 62(1):1-10.

Moilanen, A. and I. Hanski. 1998. Metapopulation dynamics: effects of habitat quality and landscape structure. Ecology, 79(7):2503-2515.

Naves, J., A. Fernandez, F. Carcia-Marin, and M. Delibes. 1999. Brown bear death related to capture myopathy and clostridium chauveoi toxaemia (Somiedo Natural Park, Spain). 12th International Conference of bear research and management, book of abstracts, p:36.

Nielsen, E. T. 1983. Relation of behavioral activity rhythms to the changes of day and night. A revision of views. Behavior, 89:147-173.

Olson, T. L., R. C. Squibb, and B. K. Gilbert. 1998. Brown bear diurnal activity and human use: a comparison of two salmon streams. Ursus, 10:547-555.

Peek, J. M. 1986. A review of wildlife management. Prentice-Hall International, 486pp.

Peyton, B. 1994. Conservation in the developing world: ideas on how to proceed. International Conference on Bear Research and Management, 9(1):115-127.

Pfister, H. P., V. Keller, H. Reck, and B. Georgii. 1997. Bio-ökologische Wirksamkeit von Grünbrücken über Verkehrswege. Final report of the research project 02.143R91L. Vogelwarte Sempach, Switzerland.

Quenette, P. Y. 1999. Reintroduction of three brown bears in the central Pyrenees: Scientific results. Report of DIREN Midi-Pyrénées, France. 53pp.

Rauer, G. 1995. Stürmische Heimkehr - der Braunbär in Österreich. Stapfia 37:251-254. (in German)

———. and B. Gutleb. 1997. Der Braunbär in Österreich. Umweltbundesamt, Monographie 88. Federal Environment Agency, Vienna, Austria. 64pp. (in German)

Roth, H. 1980. Diel activity of a remnant population of European brown bears. International Conference on Bear Research and Management, 5:223-229.

———. and D. Huber. 1986. Diel activity of brown bears in Plitvice Lakes National Park, Yuguslavia. International Conference on Bear Research and Management, 6:177-181.

Ruediger, B. 1998. Rare carnivores and highways - moving into the 21st century. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation, p: 10-14. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Saether, B. E., S. Engen, J. E. Swenson, O. Bakke, and F. Sandegren. 1998. Assessing the viability of Scandinavian brown bear, *Ursus arctos*, populations: the effect of uncertain parameter. Oikos, 83:403-406.

Savelli, B. G., F. Antonelli, and L. Boitani. 1998. The impact of livestock support on carnivore conservation. Istituto Ecologia Applicata, Rome, Italy, 163pp.

Schröder, W. 1998. Challanges to wildlife management and conservation in Europe. Wildlife Society Bulletin, 26(4):921-926.

Servheen, C., J. S. Waller, and W. F. Kasworm. 1998. Fragmentation effects of high speed highways on grizzly bear populations shared between the United States and Canada. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation, p: 97-103. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Sheldon, D. 2000 in prep. Injuries and mortalities associated with bear research and management. Questionnaire survey conducted by the International Bear Association.

Simonic, A. 1994. The legal protection of the brown bear in Slovene territory-past and present, and some suggestions for the. Braunbär in den Ländern Alpen-Adria, Tagungsbericht. 43-75. Ljubljana, Slovenia.

Swenson, J. E., N. Gerstl, B Dahle, and A. Zedrosser. 1998. An Action Plan for the Conservation of the Brown Bears in Europe. Large Carnivore Initiative. Draft. WWF International, Gland, Switzerland.

Szinovatz, V. and A. Bath. 2000 in press. Norwegian attitudes toward and knowledge about brown bears and their management. Ursus, 11:00-00.

Szinovatz, V. and H. Gossow. 2000 in prep. Die Akzeptanz des Braunbären in Österreich - Eine Langzeitstudie. (in German with English abstract)

The Wildlife Society. 1990. Traps, Trapping, and furbearer management: a review. The Wildlife Society, technical review 90-1, 31.

Thomas, J. W. 2000. From managing a deer herd to moving a mountain - one pilgrim's progress. Journal of Wildlife Management, 64(1):1-10.

Trombulak, S. C. and C. A. Frissel. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology, 14(1):18-30.

Ueberschär, A. 2000. Die umstrittene Rückkehr des Wolfes in die französischen Meeralpen - Möglichkeiten zur Akzeptanzsicherung aus der Sicht der Schäfer im Nationalpark Mercantour. Diplomat thesis at the Technical University of Munich, 60pp. (in German)

Van der Grift, E. A. 1999. Mammals and railroads: Impacts and management implications. Lutra, 42(1):77-98.

Van der Zee, F. F., C. J. F. Ter Braak, R. C. van Apeldoorn, and J. Vink. 1992. Landscape change as a possible cause of the badger *Meles meles* L. decline in The Netherlands. Biological Conservation, 61:17-22.

Wabakken, P. and E. Maartmann. 1994. Sluttrapport for bjorn - sauprosjektet i Hedmark 1990-93. NINA forskningsrapport, 58: 41pp. (in Norwegian with English abstract)

Walzer, C. 1997. Beitrag zur Braunbär – Narkose und Fang im Zoo und in der freien Wildbahn. Tagungsbericht 17. Arbeitstagung der Zootierärzte im deutsch-sprachigen Raum. pp. 29 - 31. (in German)

White, G. C. and R. A. Garrott. 1990. Analysis of Wildlife Radiotracking Data. Academic Press, Inc., Harcourt Brace Jovanovich, Publishers, San Diego, New York, Boston, London, Sydney, Tokyo, Toronto, 383pp.

Wilcox, B. C. and D. D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist, 125:879-887.

With, K. A. and A. W. King. 1999. Extinction threshold for species in fractal landscapes. Conservation Biology, 13(2):314-326.

Wooding, J. B. and J. R. Brady. 1987. Black bear roadkills in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 41:438-442.

———. 1993. Evaluation of a new wildlife underpass on S.R. 46 in Lake County, Florida. Draft Study Narrative.

Zavod za Gozdove. 1999. Slovenian Forests and Forestry. Broschure 23pp. Ljubljana, Slovenia.

Zimmermann, B., P. Wabakken, and M. Dötterer. 2000 in prep. Human-carnivore interactions in Norway: How does the re-appearance of large carnivores affect people's attitude.

3. General study area *(7PP)*

General Study area

1. Location

Slovenia is located at the connection of the Dinaric mountain range and the Alpine arch (Fig.1). The bear population in Slovenia is estimated at about 300-500 bears and is of high international importance as it is the only source for a natural re-colonization of the Alps.

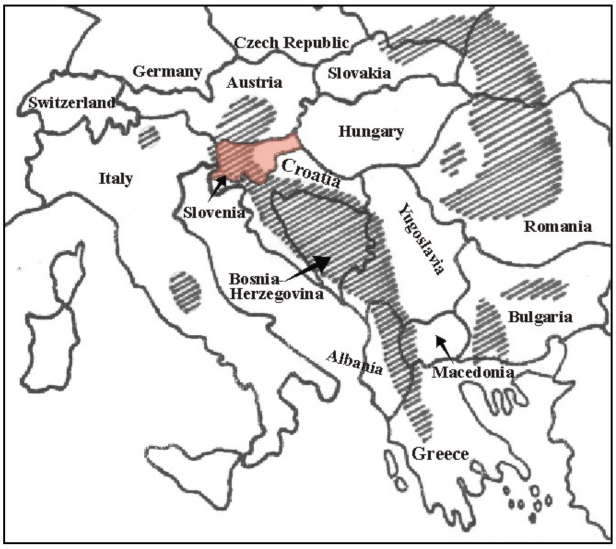

Fig.1: The bear population in Slovenia is the northern tip of a continuos bear population stretching along the Dinaric mountain range, numbering about 2800 bears (Servheen 1998).

Our core study area was located in the southern part of Slovenia, 20 km southwest of the capital Ljubljana (Fig.2). It covered an area of about 1.500 km² and was chosen for the following reasons:

(1) it lies on the main corridor which still allows bears from the Dinaric mountain range to disperse into the Alps

(2) the area is rather densely populated and human impact on that brown bear population is high, e.g. the area is used for recreation, forestry and hunting

(3) the highway Ljubljana-Razdrto dissects the study area and in 1992 several bears were hit by vehicles, raising great concern about the impact of the highway on the bear population

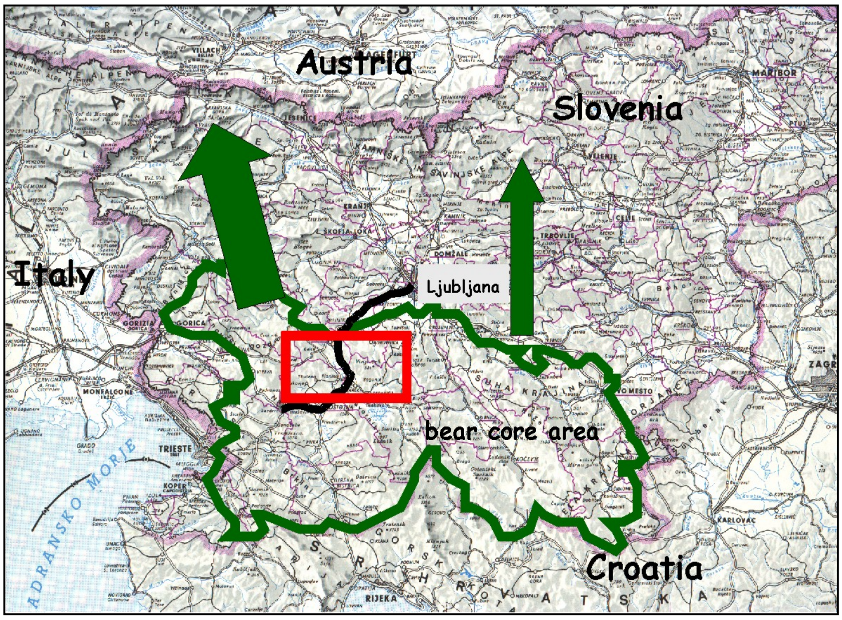

Fig.2: Location of the core study area in Slovenia (red square), relative to the “bear corridors” into the Alps (green arrows). The green area is the 5200km² bear core area, the black line is the highway Ljubljana-Razdrto.

2. Geology and climate

Our study area is located in the High Karst area, popularly known as Notranjska. The area is part of the Ljubljanica drainage basin, that drains into the Danube river. The karstic rocks are limestones and dolomites, mostly of the Mesozoic age (Sustersic 1996). The relief shows typical karst phenomena, dolines, steep canyons, caves (Fig.3) and shallow soils. Surface water is rare as water run-off is largely underground. Periodical lakes, poljes (Fig.3) and rivers that submerge after short distances are typical landscape features. Elevations range from 300m at Ljubljansko Barje south of Ljubljana to 1200m on top of the mountain Javornik near Cerknica.

The climate is characterized by influences from the Alps, the Mediterranean sea and the Pannonian basin. Annual precipitation averages 1500mm, and annual temperature averages 7-8°C, (range of average daily minimum and maximum temperatures from minus 20°C to plus 32°C). On average 110 days per year have daily minimum temperatures below freezing point and 30-40 days a daily maximum above 25°C. Snow cover lasts from 20-30 days at 500m altitude to several months at higher elevations (Republic of Slovenia 1997). Main vegetation period is about six month, at 700m lasting from late April to late October (Tab.1).

Tab. 1: Phenological data for Rovte (705m sea level) 1993-1998.

species		phenological phase	1993	1994	1995	1996	1997	1998
Snowdrop	*Galanthus nivalis*	first flowers	09.02	10.02	15.02	18.03	20.02	19.02
Coltsfoot	*Tussilago farfara*	first flowers	16.03	04.03	14.03	27.03	28.02	20.02
Saffron	*Crocus neapolitanus*	first flowers	16.03	07.03	24.03	30.03	24.02	27.02
Dandelion	*Taraxacum officinale*	first flowers	15.04	07.04	24.04	06.05	05.04	23.03
Golden daisy	*Leucanthemum ircutianum*	first flowers	20.05	09.05	25.05	29.05	15.05	12.05
Autumn crocus	*Colchicum avtomnale*	first flowers	01.09	27.09	16.09	18.09	22.09	18.09
Beech	*Fagus sylvatica*	first leafs	26.04	15.04	22.04	23.04	22.04	22.04
		beech mast	--	--	--	--	--	--
		leafs turn yellow	20.10	25.10	07.10	04.10	10.10	10.10
		leafs fall off	09.11	12.11	10.11	21.10	28.10	28.10
Elder	*Sambucus nigra*	first leafs	20.04	21.04	20.04	23.04	05.05	10.04
		first flowers	31.05	27.05	05.06	05.06	05.06	30.05
		generally blooming	05.06	28.05	15.06	10.06	12.06	04.06
		first ripe fruits	10.08	13.08	10.08	16.08	12.08	18.08
Hazel	*Corylus avellana*	first flowers	14.02	26.01	20.02	27.03	--	09.02
		generally blooming	02.03	05.02	28.02	09.04	05.03	18.02
		first ripe fruits	20.08	26.08	12.09	29.08	30.08	--

3. Forestry

Bear habitat consists of mixed, uneven aged forests. The most common forest type in our study area (*Abieto-Fagetum-Dinaricum*) is dominated by beech (*Fagus silvatica*) and fir (*Abies alba*) - intermingled with varying amounts of spruce (*Picea abies*), maple (*Acer pseudoplatanus*) and elm (*Ulmus spec.*) (Fig.3). Coniferous species contribute to about 40-60% of all trees in the study area (Zavod za Gozdove 1999). Forest coverage in all of Slovenia has steadily increased from 36% in 1875 to 55% in 1997. Within the study area forest cover was higher, averaging 70%.

Forest has been largely re-privatized over the last years and upon completion of this process, 80% of all forest land will be owned privately. Most of the private forest estates are small, with a country-wide average area of 3 ha. In our study area the average size of forest estates is between 3-5 ha (Zavod za Gozdove 1999). The forest is intensively managed, but all forest operations happen under the supervision of the State Forest Service (Zavod za Gozdove). Only selective cutting practice (single tree extraction) is allowed, while clear cutting is prohibited (Republic of Slovenia 1995). Spruce trees were planted in wind- and snowbreaks some 10-20 years ago, but this is not allowed any more. In our study area about 7% of the forest consisted of spruce plantations. Due to the selective cutting practice, forest road density is high, averaging about 1,5-2,0 km roads per km² of forest (15-20m/ha).

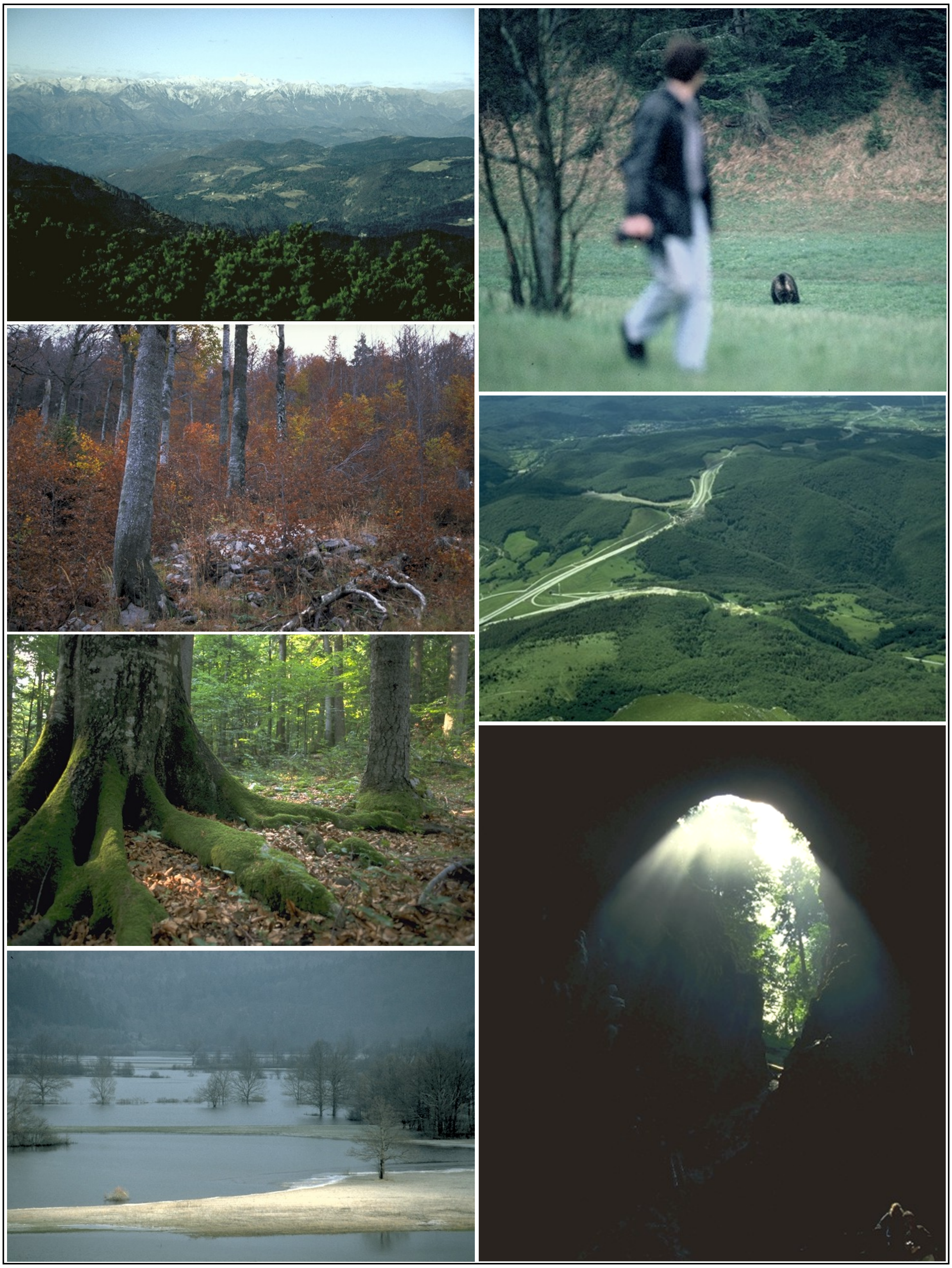

Fig. 3: From top left to bottom right: Bear corridor into the Alps, close coexistence of bears and people, mixed stands of beech and fir dominate the forest, highway Ljubljana-Razdrto, Planisko Polje and one of the frequently found caves.

4. Human population

Human population density averages 42 inhabitants per km², but is highly variable within the study area (Fig.4). On average 5% of the study area are covered by villages and the density of paved roads averages 0,42 km/km² in total and 0,25 km/km² outside of settlements.

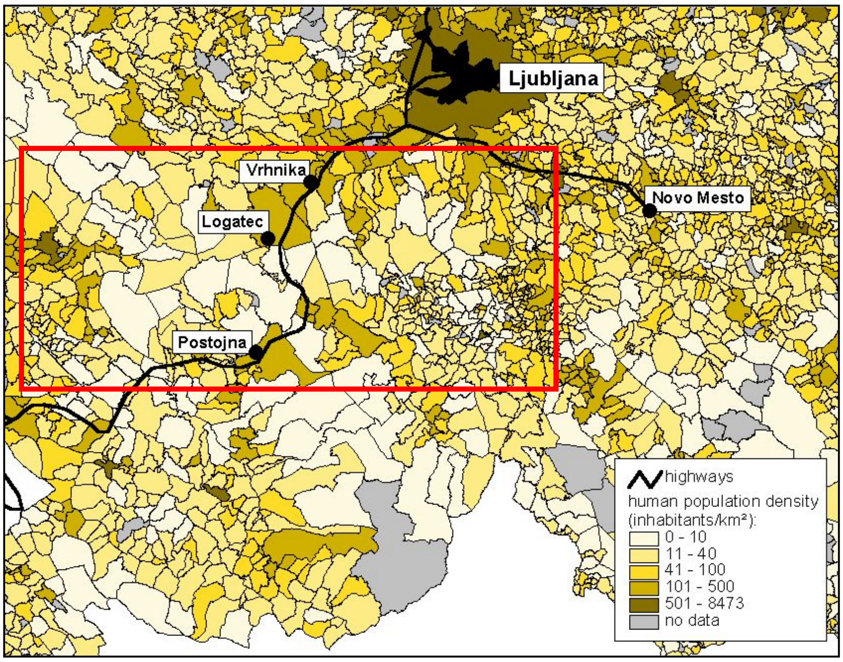

Fig.4: Human population density within our study area (red square) and the surroundings.

5. Hunting management

In 1966 bear management in Slovenia was structured according to different zones (Kaczensky 1996). Within a 3500 km² low conflict core area (low human population density, few small livestock) in the southern part of the country hunting was regulated, following a quota system within an open season from 1 October to 31 April. In the outer areas bears could be killed unlimited and year-round (Simonic 1994). To allow for an increased dispersal of bears into the Alps this management has been changed in 1991. All bears in the outer area are now fully protected. Special permissions to shoot problem individuals may be granted by the Ministry of Agriculture. In 1995 an extension of the bear core area was accepted and today it covers about 5200 km².

The present population is estimated at 300-500 bears. The average yearly hunting quota is around 40 bears, or 10% of the estimated bear population size (Adamic 1997). Bear population estimates are based on simultaneous counts at bear feeding sites and by determining the overall bear range (Adamic 1996). The yearly bear harvest is divided into three size groups: < 100 kg, 100-150 kg and > 150 kg. To allow for older animals in the population, the majority of permissions is issued for the two smaller size classes. Females with cubs are strictly protected - but cubs alone may be shot. Hunters are only allowed to shoot bears at established feeding sites and from elevated hides. It is attempted to shoot problem bears preferably during the hunting season and within the hunting quota. Outside the hunting season and for the outer area a special permit from the Ministry of Forestry and Agriculture is required.

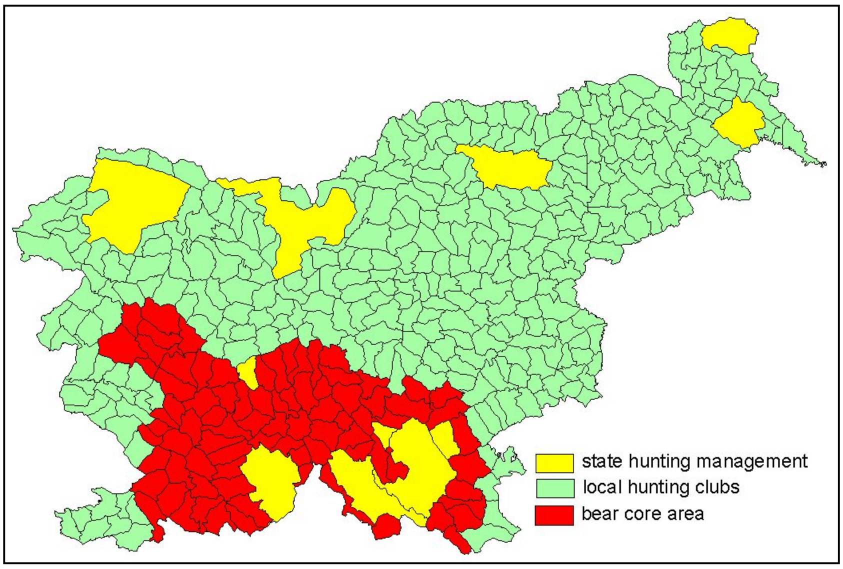

Fig.5: In Slovenia hunting rights are independent of private property. At present the Slovenian territory is divided in 425 hunting units averaging 4000-5000 ha each. Most of these hunting units are managed by local hunting clubs. The remaining (yellow) large hunting units are under state management, the small units under the Slovenian Hunters Association.

The overall hunting quota is determined by the Ministry of Agriculture and Forestry in accordance with the Ministry of Environment and Physical Planning. An advisory committee for wildlife was established at the Ministry of Agriculture in September 1999. This commission consists of five members assigned by the Ministry of Environment and five by the ministry of Agriculture - all are well experienced in wildlife issues. The commission suggests the regular hunting quota and the quota for the removal of problematic individuals of large carnivores.

Within the core area a supplementary feeding program was initiated in 1986, with a minimum of one feeding site required every 60 km² (Simonic 1994). These feeding sites are supplied mainly during spring and autumn with carcasses or corn. Feeding sites are expected to restrain bears within the core area, reduce the potential for possible bear-human conflicts, and allow for annual census and selective harvest. In addition to the feeding places required for bears there is additional feeding places for wild ungulates provided with corn, apple pulp or fruits. In our study area the total density of wildlife feeding sites is about 0,40 per km² and we estimated the amount of supplemented food at about 33 kg of meat and 70 kg of corn per 100 ha. In the fall there additionally may be up to 100 kg of fruits (mainly apples, plumes and pears) per 100 ha (Lovskih Organizacij Slovenije 1998).

6. Other mammalian wildlife species

Other large and medium sized predators present on our study area are wolves (*Canis lupus*), reintroduced Eurasian lynx (*Lynx lynx*), Eurasian wild cat (*Felis sylvestris*), red fox (*vulpes vulpes*), badger (*Meles meles*) and the occasional golden jackal (*Canis aureus*). The ungulate population consisted of red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), chamois (*Rupicapra rupicapra*) and wild boar (*Sus scrofa*). The annual harvest for the hunting year 1997/98 in our study area was about 0.2 red deer/100 ha, 1,1 roe deer/100 ha, 0,01 chamois/100 ha and 0,1 wild boar/100 ha (Lovskih Organizacij Slovenije 1998).

7. Reference List

Adamic, M. 1996. Decision making in the conservation management of problem wildlife species in Slovenia, based on the knowledge gained through current research projects. Gozd, 54:297-306. (in Slovenian with English abstract)

———. 1997. The analysis of the key sources of mortality of the brown bear (*Ursus arctos* L.) in Slovenia in the last 6 years. Zbornik gozdarstva lesarstva, 53:5-28. (in Slovenian with English abstract)

Kaczensky, P. 1996. Large Carnivore - Livestock Conflicts in Europe. Report of the Munich Wildlife Society, Germany.

Lovskih Organizacij Slovenije. 1998. Statisticni Podatki za leto 1997/98. Statistical Yearbook 1998 of the Slovenian Hunters Association. Slovenian Hunters Association, Ljubljana, Slovenia. (in Slovenian)

Republic of Slovenia. 1995. Forstgesetz. Ministry of Agriculture, Forestry and Nutrition, Ljubljana, Slovenia. 50pp. (in German)

———. 1997. Statistical Yearbook 1997. Statistical Yearbook 1997, Issue 36, Statistical Office of the Republic of Slovenia, Ljubljana, Slovenia.

Simonic, A. 1994. The legal protection of the brown bear in Slovene territory-past and present, and some suggestions for the. In: Braunbär in den Ländern Alpen-Adria, Tagungsbericht, p:43-75. Ljubljana, Slovenia.

Servheen, C., S. Herrero, and B. Peyton. 1998. Conservation action plan for the world bears. IUCN, Gland, Switzerland.

Sustersic, F. 1996. Poljes and caves of Notraska. Acta Carsologica, XXV:251-289.

Zavod za Gozdove. 1999. Forests and forestry in Slovenia. Brochure 23pp. Zavod za Gozdove, Ljubljana, Slovenia.

4. Results

4.1. Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia. *Petra Kaczensky, Felix Knauer, Marko Jonozovic, Chris Walzer and Thomas Huber (18+1pp)*

Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia

Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia

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Abstract

Wildlife research on brown bears (*Ursus arctos*) and other shy, nocturnal or forest dwelling animals with large ranges has improved enormously with the help of radiotelemetry. A major drawback is the fact that bears have to be trapped, immobilized and radiotagged which beholds a certain risk for the bears and people involved. Especially in the small and threatened bear populations of central and southern Europe accidents that may injure or kill a bear within the course of these procedures are a major concern to bear conservationists and animal rights groups.

Much information and experience is available from bear work in North America, but some of the techniques do not seem to be appropriate or acceptable for the small bear populations in southern and central Europe, because: (1) the loss of a single bear in a small population can make a big difference for the future of this population, especially if it is a female, (2) public acceptance for bear losses is very low, (3) public safety is a major concern as most bear areas are also heavily frequented by people.

The experiences with capturing bears in Europe are rather limited, making the exchange of experiences among European bear researchers even more important - a chance to learn from the mistakes of others and improve the overall safety standards. In the following we describe our experiences with trapping, chemical restraint and radiotagging of 25 different bears during 31 capture events in the course of a research project in Slovenia from 1993-1998. A special focus is on safety considerations for trapping, tranquilizing and radiotagging of bear, but also on how to minimize the risk for the capture team and local people frequenting the trapping area.

Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia

1. Introduction

Wildlife research on brown bears (*Ursus arctos*) and other shy, nocturnal or forest dwelling animals with large ranges has improved enormously with the help of radiotelemetry. A major drawback is the fact that bears have to be trapped, immobilized and radiotagged which beholds a certain risk for the bears and people involved (Jonkel 1993). Especially in the small and threatened bear populations of central and southern Europe accidents that may injure or kill a bear within the course of these procedures are a major concern to bear conservationists and animal rights groups. The European Flora Fauna Habitat (FFH) guidelines and the Bern Convention, as well as national legislation in several countries (e.g. Austria, Germany) have great reservations against the use of snares, as they are considered non-selective traps (Hinterleitner and Völk 1996).

Contrary to North America, experience with live trapping of bears was rather limited in Europe before the 1990s (3 bears 1972-77 in Trentino, Italy (Roth 1983); 26 bears 1981-91 in Croatia (Huber and Roth 1993), 1 bear 1985-87 in Cantabria, Spain (Clevenger et al. 1990); 40 bears 1984-89 in Scandinavia (Wabakken et al. 1990). However these techniques have become more and more important for research and management in the past years. The Scandinavian brown bear project has handled bears more than 755 times (A. Soderberg, pers. comm.). New research projects using telemetry have started in central Italy (Gentile et al. 1996), Greece (Mertzanis 1999), Spain (Fernandez et al. 1999), Romania (A. Mertens per. comm.) and Finland (I. Kojola per. comm.). Radiotelemetry has also become an important tool for monitoring reintroduced and/or problematic bears in Austria (Zedrosser et al. 1999), the French Pyrenees (Camarra et al. 1998) and northern Italy (E. Dupre pers. comm.).

There have been a few cases in Europe, where brown bears were lost due to trapping or chemical restraint (2 bears captured in Slovenia for the reintroduction in Austria - Rauer and Kraus 1993; 2 bear in Croatia – D. Huber pers. comm., and 10 bears in Scandinavia - A. Söderberg pers. comm.) or suffered neck injuries from ingrown collars (1 bear in Scandinavia - P. Wabakken pers. comm., 1 bear in Croatia - D. Huber pers. comm.). The most recent accident, an adult male bear from the small population in the Cantabrian mountains, that apparently died of capture related myopathy in 1998 (Naves et al. 1999) created a significant amount of anti-telemetry emotions in Spain. But it also triggered scientific discussions concerning acceptable risks and basic safety standards for trapping bears. As a consequence, the International Bear Association (IBA) initiated a world wide questionnaire survey on injuries and mortalities associated with bear research and management (D. Sheldon in prep.).

All individual bear research teams have their capture protocols, based on their own and rather restricted experience of trapping bears in Europe and/or from experience gained in North America (Jonkel 1993). Unfortunately some of the techniques from North America do not seem to be appropriate or acceptable for the small bear populations in southern and central Europe. This is due to the fact that: (1) the loss of a single bear in a small population can make a big difference for the future of this population, especially if it is a female, (2) public acceptance for bear losses is very low, (3) public safety is a major concern as most bear areas are also heavily frequented by people, who may accidentally or purposely disturb trap sites and run the risk of getting injured by traps or trapped bears.

We therefore feel that the exchange of experience among European bear researchers is very important - a chance to learn from the mistakes of others and improve the overall safety standards. In the following we describe our experience with trapping, chemical restraint and radiotagging of 25 different bears during 31 capture events in the course of a research project in Slovenia from 1993-1998.

2. Methods

2.1. Capture

With two exceptions all bears were caught using Aldrich foot snares (Jonkel 1993) at established bait sites. These sites are used for hunting and have been in place for many years. Usually bait was provided by the local hunters and consisted of meat (carcasses or slaughtering remains of domestic animals) and/or corn and fruits. During the spring 1993 and 1994 capture season we prepared small sand beds on bear trails and in front of traps to monitor bear activity, check for possible trap avoidance and detect non-target animals that sprung snares without getting caught.

Our capture seasons were restricted to the spring and fall and had to be coordinated with the local hunters and their hunting interests. No trap site was used for hunting and live trapping simultaneously and in hunting areas where hunters wished to shoot a bear, we normally had to wait until the bear was shot. Our spring trapping season started after most of the snow had melted until the beginning to middle of May, while the fall trapping season lasted from October to the beginning of the first heavy snowfalls.

To minimize the time bears were snared we used an alarm system by surveying snares with trap transmitters (Wagener, Germany). These transmitters were monitored every hour during daylight and every 30 minutes at night. All traps were visited every morning to check for sprung traps and to back up the alarm system. We visited trap sites immediately after the alarm signal was triggered, regardless of weather or light conditions. For safety reasons, we only selected trap sites that were accessible by car and could be reached within an hour from the field station. These safety requirements considerably restricted our possible trap site locations. In total we used 18 different trap sites in 10 hunting areas. We never had more than 7 trap sites activated simultaneously. Every trap site was equipped with 2 to 6 snares at the same time to enhance the chance to capture the accompanying female in cases where a cub or yearling of a family group was caught. To avoid catching non-target animals and small cubs we taped the snare loop so that it could not close completely. To avoid catching red-deer we fixed horizontal poles above the traps at bait sites with corn and fruits or near known deer trails.

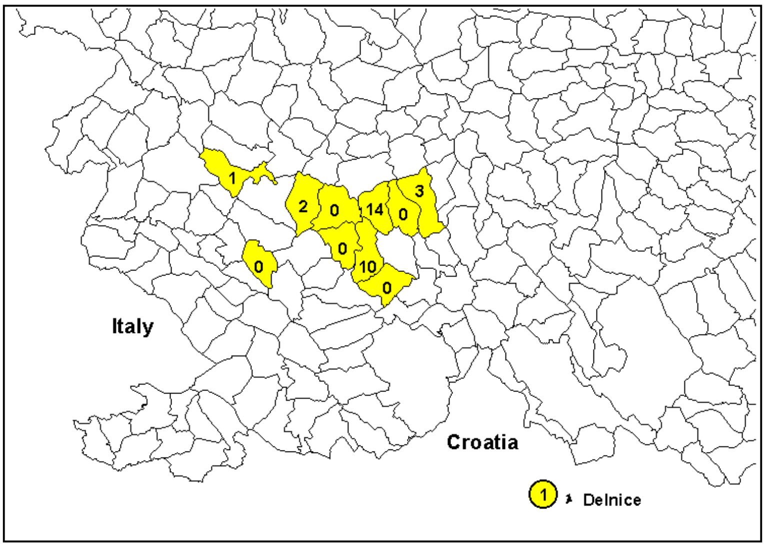

Fig.1: Hunting districts used for trapping (yellow) and numbers of bears trapped.

2.2. Immobilization

We immobilized bears using a combination of Tiletamin and Zolazepam (Zoletil 100 Virbac, France). Additional combinations used were a 1:1 mixture of Ketamine (Ketamidor®) and Xylazine (Rompun) and a mixture of Tiletamin and Zolazepam and Medetomidine (Dormitor). For the latter combination we used Antipamezol (Antisedan) as antidote for Medetomidine and/or Flumazenil (Anexate) as an antidote for Zolazepam (Tab.4). Drugs were administered by a CO_2 dart gun (Telinject, Austria) and air pressure activated 3,5ml darts (Telinject, Austria) with barbed 45mm needles in spring and 60mm needles in fall. Shooting distance normally did not exceed 10 m, but two bears were free-range immobilized without snaring, one on close range and one at a distance of 65m. We took standard body measurements, hair and blood samples for possible genetic and serological analysis, pulled a premolar (PM1) for aging (Matson´s Lab, USA) and fitted bears with colored ear tags (Prima-Flex, Germany) for permanent identification in both ears.

2.3. Radiomarking

Bears were categorized as adults ($\geq$ 4 years), subadults (2-3 years), yearlings (1 year) and cubs of the year (coys) according to tooth wear, presence/absence of cubs, size of testis or nipples and body measurements (see appendix Tab.1). Due to the possible rapid growth in body size, only adult or subadult bears with more than 70 kg were fitted with radiocollars weighing 200 and 500 grams, respectively (MOD-400 and MOD-600 Telonics, USA). In addition we used breakaway devices on all collars, either 18 loops of 1mm iron wire, a system developed by H. Roth and D. Huber in Croatia (pers. communication 1993), or cotton spacers (cotton webbing links with grommets spaced to fit hardware, Hellgren et al. 1988). For subadult bears we further notched cotton spacers on one or both edges, to allow for a more rapid break off. Starting in 1996, yearling bears and coys were fitted with eartag transmitters weighing 42 and 29 grams, respectively (EL-2(42) and EL-2(29) Holohil, Canada) or hair mount transmitters weighing 90 grams (MOD-225, Telonics, USA). Before 1995 two yearling bears were fitted with radiocollars (MOD-600 Telonics, USA; Televilt, Sweden), while three were released without any radiotags (Tab.1).

Fig. 2: Different transmitters and breakaway devices used on bears in Slovenia:

Upper left: Radiocollar (Telonics MOD-600) with wire loop breakaway. The upper collar was lost by ANCKA94 after 14 month. The lower collar shows the unbroken wire breakaway device and the cotton spacer used from 1995 on.

Lower right: The two types of breakaway devices used. On the left side is the wire loop construction with 19 loops of 1mm iron wire. On the right side a cotton spacer notched on one side.

Upper right: The two types of eartag transmitters used. The oval shaped EL-2(42) weights 42g and the round EL-2(29) 29g.

Lower left: Yearling bear (NEJC) with EL-2(29) eartag transmitter attached to the left ear. The transmitter stayed on the bear for at least 12 month.

Tab. 1: Traps, radiotags and breakaway devices used on bears captured between 1993-98.

date	**bear**	**sex**	**age**	**radio tag**	**type**	**breakaway**	**lifespan (months)**
1993							
26.04.93	*YOGI*	male	1	non	----	----	----
28.04.93	*KRABAT*	male	1	non	----	----	----
04.05.93	*JANA*	female	1	collar	MOD-600	19 loops of 1mm iron	≥ 18 (embedded in the neck)
1994							
24.03.94	*METKA*	female	13-14	collar	MOD-600	19 loops of 1mm iron	6 (broken)
25.03.94	*CLIO*	male	1	collar	Televilt	9 loops of 0.5 mm iron wire	2 (broken)
28.03.94	*JANKO*	male	2-3	collar	MOD-600	19 loops of 1mm iron	≥ 3 (bear disappeared)
31.03.94	*LUKA*	male	1	non	----	----	----
01.04.94	*METKA*	*recapture*		----	----	----	----
07.04.94	*CLIO*	***recapture***		----	----	----	----
07.04.94	*MISHKO*	male	2-3	collar	MOD-600	19 loops of 1mm iron	7½ (broken)
22.04.94	*ANCKA94*	female	4	collar	MOD-600	19 loops of 1mm iron	14 (broken)
07.11.94	*JANA*	recapture		----	----	----	
16.11.94	*JURE*	male	2	collar	MOD-600	cotton spacer with 1 cut	≥ 4 (bear poached)
1995							
05.04.95	*UROSH*	male	1-2	collar	MOD-400	cotton spacer with 2 cuts	2 (broken)
15.04.95	*MILAN*	male	3	collar	MOD-400	cotton spacer with 2 cuts	½ (broken)
19.04.95	*MISHKO*[1]	*recapture*		collar	MOD-600	cotton spacer	7 (broken)
23.04.95	*MAJA*	female	7	collar	MOD-600	cotton spacer	26 (broken)
1996							
05.10.96	*VERA*	female	coy	eartag	EL-2(42)	----	7 (hole in ear)
18.10.96	*LUCIA*	female	1	collar	MOD-400	cotton spacer	≥ 12 (bear killed)
31.10.96	*VINKO*	male	coy	eartag	EL-2(42)	----	7 (lost)
1997							
28.03.97	*SRECKO*	male	3	collar eartag	MOD-400 EL-2(42)	cotton spacer with 2 cuts ----	7 (broken) ? eartag broken
21.04.97	*VANJA*	female	1	eartag	EL-2(42)	----	4 (lost)
03.05.97	*DUSAN*	male	1	eartag	EL-2(42)	----	2½ (lost)
09.05.97	*VERA*[1]	*recapture*		hair mount	MOD-225	----	1 (shed with fur)
1998							
18.03.98	*JOZE*	male	1	eartag	EL-2(29)	----	1½ (unscrewed)
23.03.98	*NEJC*	male	1	eartag	EL-2(29)	----	≥ 12 (battery expired)
06.04.98	*POLONA*	female	5	collar	MOD-400	cotton spacer	≥ 18 (battery expired)
07.04.98	*KLEMEN*	male	3	collar eartag	MOD-400 EL-2(29)	cotton spacer with 1 cut ----	6 (broken) ? (eartag broken or lost)
10.04.98	*ANCKA98*[2]	*recapture*		collar	MOD-400	cotton spacer	≥ 18 (battery expired)
14.04.98	*IVAN*	male	2	collar	MOD-600	cotton spacer	≥ ½ (slipped over head)
31.08.98	*DINKO*	male	2	collar	MOD-600	5 loops of 2mm iron wire	≥ 3½ (bear lost)

[1] recapture, but collar lost in-between [2] recapture, but due to loss of eartags unclear identity

3. Results

3.1. Capture

A total of 4041 trap-nights resulted in 29 captures of 25 different bears. Six bears were captured two times, no bear was captured three or more times. One adult female (*ANCKA98*) with scars from previous eartags and a pulled PM1 was recaptured in 1998, but due to the loss of the eartags we could not identify her without doubt and she was treated like an independent individual for analysis. All bears were captured at night, ranging from early dusk to late dawn (Fig.2). Trap-nights per bear averaged 139, but were highly variable from season to season and increased from 1993 to 1998.

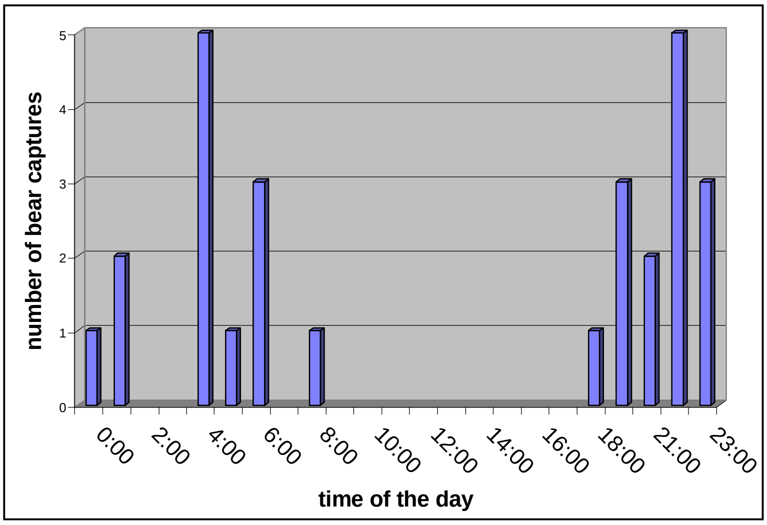

Fig. 3: Timing of bear captures 1993-1998.

season	trapnights / bear	bears trapped	sprung traps	non-target species
spring 1993	69	3	4	0
spring 1994	41	8	14	0
fall 1994	76	2	7	0
spring 1995	86	4	15	0
fall 1996	229	3	26	1 deer, 1 boar
spring 1997	266	4	40	1 boar
spring 1998	251	5	73	0
total	***139***	***29***	***161***	***3***

Tab. 2: Trapping effort and success during 7 trapping seasons 1993-98.

Traps were triggered by non-target animals and "sneaky" bears in 161 cases (4%). Non-target animals included in order of decreasing importance wild boar (*Sus scrofa*), deer (*Capreolus capreolus* and *Cervus elaphus*), foxes (*Vulpes vulpes*) and dogs, humans and unknown species. Non-target animals were caught three times: one young wild boar of about 30 kg, one wild boar of 60 kg and one adult female red deer. The wild boars were successfully released, the younger one uninjured and the older one with bruises on the leg. The red deer had fallen and apparently injured the nerves that innervate the front legs. It had no fractures and only slight bruises but was unable to move both front legs and therefore had to be shot.

We did not precisely document our efforts to free-range immobilize bears, but we spent numerous nights in elevated hides at bait sites. We got to see bears on four occasions: twice the bear was spooked before we got a chance to shoot, once it was too dark to shoot and once we managed to free-range tranquilize a yearling female. The bear was shot with a CO_2 gun (Daninject, Austria) and a black powder charge triggered dart (Pneudart, USA) on a distance of 65 m from an elevated hide. Visibility was good because of full moon and snow cover on the ground. Even though the bears bodyweight was greatly overestimated and therefore overdosed (about 3 times the required dosage, see Tab.4), it was able to run for more than 500 m.

The other bear that was free range immobilized was a handicapped bear that had gotten its head stuck in a plastic oil container. The bear was on the Croatian side of the Slovenian-Croatian border and was shot on close range by Prof. Dr. Djuro Huber from the Veterinary Faculty in Zagreb, Croatia. Because the bear was unable to see it remained on the spot were it was shot.

Fig. 3: Bear DINKO, shortly before being free-range tranquilized. The animal was stuck in a plastic oil container.

In total we captured 25 different individuals. The sex composition was 17 males and 8 females and the age composition 7 adults, 10 subadults and 11 yearlings. Of the 11 yearlings captured only one (*LUKA*) was together with his mother (*METKA*), in all other cases yearlings were already separated from the mother or the mother was not detected during the restraint and handling procedure. In the one case where the mother remained with the cub, she did not leave when we approached for the first time at night and appeared ready to attack the car. We therefore waited until daylight, by which time the female was trapped in another snare.

Even though we never trapped a female with coys, in two cases we caught coys; both times in the fall 1996. In 1 case the mother, a radiomarked female (*MAJA*) with three coys stayed with her two snared coys and we were unable to chase her away with the car at night. In the morning when we made an attempt to immobilize the cubs from the car, one managed to free itself and the female run off with the two free coys, leaving the third (*VERA*) behind. After successful handling and radiomarking it took the coy 2 days to reunite with the family group. In the second case (*VINKO*) we could not see a female nearby, but for safety reasons waited till daylight before we immobilized the coy. A few weeks later, tracks in the snow showed that *VINKO* was together with a larger bear, most likely his mother.

Two additional bears (*METKA* first capture and *KLEMEN*) were possibly snared for an extended period (>1-2 hours) due to a failure of the trap transmitter alarm system. Despite these complications, only two captured bears suffered minor capture related injuries: a subadult male (*JURE*) pulled a premolar (PM2) tooth and a coy (*VERA*) broke a front claw. Almost all bears were in good or very good body condition and the weights ranged from a minimum of 25 kg for a female coy in fall to 162 kg for an adult male in spring (Tab. 4).

3.2. Immobilization

26 bears were exclusively drugged with Zoletil using an average concentration of 12,6 mg per kg body weight (range: 5,0 – 37,3; median: 10,15; see: Tab.4). There was no significant difference in the mean concentration administered between the age groups adults (n=6), subadults (n=7) and yearlings + coys (n=13), (Kruskal Wallis, p=0,499), nor between males (n=16) and females (n=10) (U-test, p=0,623) or spring (n=21) and fall (n=5) (U-test, p=0,138). The 4 bears that were drugged with a combination of Zoletil and Medetomidine were all overestimated and therefore got equally high Zoletil® dosages (mean: 10,7; range: 5,4-16,3) like bears that were drugged with Zoletil alone (Tab.2).

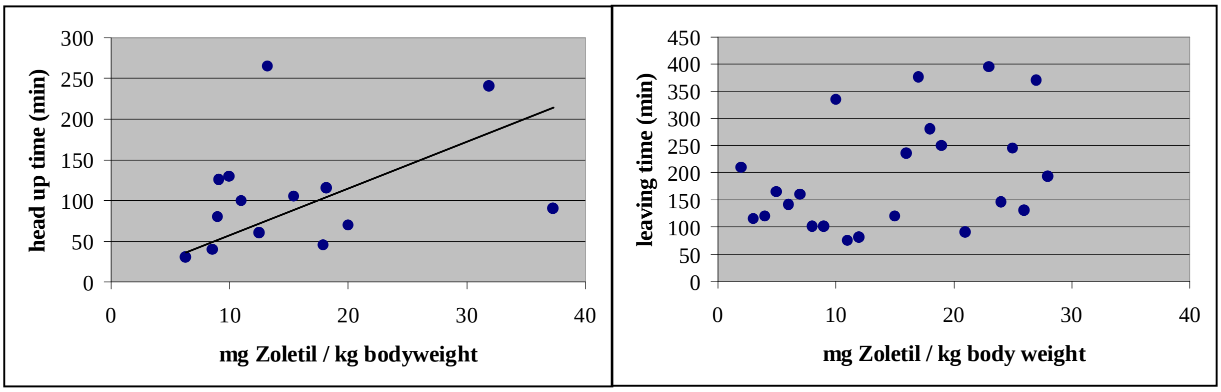

Fig. 5: For pure Zoletil the head up time was positively correlated with the dosage, but explained only a small portion of the overall variation (r^2=0.178, p=0.036). Leaving time was even more variable and was not correlated with dosage (r^2=0.124, p=0.108) - several bears seemed to slept at the trap site, rather than go away immediately after waking up.

With a high enough initial dosage, all bears were in lateral recumbency within 2-5 minutes. The head up time varied from 30 min to 4 hours with Zoletil (Tab.4). There was no significant reduction in the head up time when using Zoletil in combination with Medetomidine and the antidotes Antipamezol and/or Flumazenil (U-test, α=0,095), but the sample size was very small and bears dosed too high with Tiletamine/Zolazepam (Tab.4). However an increase in the respiratory rate and depth were noted 10 minutes after the intramuscular antidote application.

Fig. 6: Bears were immobilized with an average concentration of 12.6 mg Telazol /kg body weight. Lateral recumbency occurred within 2-5min, the mean head up time was 87 minutes and bears on average left the trap site after 193 minutes.

We monitored body temperature and respiration rate at irregular intervals during the handling process and often the data were not written down, especially when considered normal. No bears seemed to suffer from overheating, as body temperatures stayed below 40°C. In one case the body temperature of a soaking wet bear (*JURE*) started to drop below 35°C. We immediately stopped handling, covered the animal with a blanket and injected the antidote Flumazenil®. Thereafter the body temperature slowly rose. No other handling related complications arose during any of the captures.

Tab.4: Bears trapped and immobilized in Slovenia 1992-1998.

bear	date	time	sex	age	weight (kg)	stress factors / trapping situation	Zoletil	other drug	antidot	temp (^oC)	head up	leaving	comments
								average estimate applied (mg/kg)			time (min)		
YOGI	26.04.93	0:00	male	1	36	normal	7,2	----	----	nm	75	210	left immediately
KRABAT	28.04.93	5:50	male	1	42	normal	6,1	----	----	39,0	55	115	left immediately
JANA	04.05.93	22:00	female	1	40	normal	5,0	----	----	nm	70	120	left immediately
METKA	24.03.94	8:00	female	13-14	85	> 1 hour trapped	7,1	----	----	39,5	70	165	left immediately
CLIO	25.03.94	21:15	male	1	35	normal	6,9	----	----	nm	50	140	left immediately
JANKO	28.03.94	22:30	male	2-3	118	normal	7,1	----	----	nm	70	160	left immediately
LUKA	31.03.94	22:30	male	1	~35	> 1 hour trapped	8,6	----	----	nm	60	100	left immediately
METKA	01.04.94	7:00	female	13-14	~85	> 1 hour trapped yearling in trap	17,4	----	----	nm	70	100	left immediately
MISHKO	07.04.94	23:30	male	2-3	155	normal	13,3	----	----	nm	65	335	fell asleep
CLIO	07.04.94	8:15	male	1	~35	normal	6,3	----	----	nm	30	75	left immediately
ANCKA94	22.04.94	22:40	female	4	73	normal	10,5	----	----	39,0	65	80	left immediately
JANA	07.11.94	18:30	female	2	120	severe neck injury	11,3	----	----	nm	nm	nm	nm
JURE	16.11.94	19:00	male	2	154	problems with drugging bear extreamly fat	37,3	----	----	39,8	90	<510	fell asleep
UROSH	05.04.95	4:00	male	1-2	~80	rather thin	6,3	----	----	nm	30	120	left immediately
MILAN	15.04.95	22:00	male	3	110	normal	18,2	----	----	38,8	115	235	left immediately
MISHKO	19.04.95	4:15	male	3-4	162	normal	15,4	----	----	nm	105	375	chased away
MAJA	23.04.95	4:00	female	7	101	normal	10,0	----	----	38,5	130	280	left immediately
VERA	05.10.96	04:00	female	COY	25	> 1 hour trapped trapped mother with siblings around	20	----	----	37,5	70	250	fell asleep
LUCIA	18.10.96	19:30	female	1	80	normal	11,0	----	----	nm	100	nm	nm
VINKO	31.10.96	5:30	male	0	35	> 1 hour trapped	8,6	----	----	38,0	40	90	left immediately
SRECKO	28.03.97	0:55	male	3	120	normal	12,5	----		nm	60	nm	fell asleep
VANJA	21.04.97	20:45	female	1	40	free range traquilized	16,3	0,075 Medetomidin	0,375 Antipamezol 0,0125 Flumazenil	36,1	180	280	left immediately
DUSAN	03.05.97	22:00	male	1	38	normal	13,2	----	0,0132 Flumazenil	39,0	265	395	fell asleep
VERA	09.05.97	6:30	female	1	28	normal	17,9	----	----	nm	45	145	left immediately
JOZE	18.03.98	4:30	male	1	47	normal	31,9	----	----	nm	240	245	left immediately
NEJC	23.03.98	19:30	male	1	55	normal	9,0	----	----	37,6	80	130	left immediately
POLONA	06.04.98	6:15	female	5	110	normal	9,1	----	----	38,3	125	370	fell asleep
KLEMEN	07.04.98	11:00	male	3	118	> 1 hour trapped	12,7	0,0169 Medetomidin	0,0085 Flumazenil	35,0	70	280	fell asleep
ANCKA98[1]	10.04.98	23:35	female	?	92	normal	8,2	0,0217 Medetomidin	0,163 Antipamezol	38,2	180	510	fell asleep
IVAN	14.04.98	1:15	male	2	140	normal	5,4	0,0214 Medetomidin	0,107 Antipamezol	38,2	88	nm	fell asleep
DINKO	31.08.98	14:45	male	2	73	free range traquilized handicapped by oil canister hit by car before	----	8,6 Ketamin 8,6 Xylazim	----	39,6	120	180	left immediately

[1] due to loss of eartags unclear identity

3.3. Radiomarking

For radiomarking we used 18 times radiocollars, 6 times eartag transmitters, 2 times radiocollars plus eartag transmitters and 1 time a hair mount transmitter (Tab.1). The breakage time of the breakaway devices was very variable. Radiocollars remained on the bear with unnotched cotton spacers from 7 to 26 months (n=5), with notched cotton spacers from 2 weeks to 7 months (n=4), with 0.5mm wire loops for 2 months (n=1) and for 1mm wire loops from 2 to 18 months (n=4) (Tab.1).

No radiocollar failed before the expected lifespan of 24 and 36 months. One bear (*JANKO*) dispersed and could not be tracked after dispersal, while one bear (*JURE*) was presumably poached and one (*IVAN*) managed to slip the collar. In two adult females (*ANCKA98* + *POLONA*) the batteries expired, as expected, before the collar broke off.

On one occasion a collar did not come off as expected and resulted in serious neck injuries. We had accidentally attached the collar to a female yearling (*JANA*) which we had judged to be a two year old female. During the 18 months until her recapture she had tripled her bodyweight from 40 kg to 120 kg. The collar had a 1mm wire loop breakaway but had gotten imbedded in the fat of the fast growing bear. The fat had stopped any further corrosion of the wires. We elected to euthanize the bear because of the possible risk that the injured bear might attack a person. The necropsy conducted by Prof. Dr. Bidovec from the Veterinary faculty at the University of Ljubljana revealed a serious infection of the shoulder that had started from where the wires were imbedded in the neck.

The heavier EL-2(42) eartag transmitters lasted from 2,5 to 7 months. In one case a bear (*VERA*) was recaptured and lost the tag at the capture site. Closer inspection showed a slit in the ear, that was just large enough for the tag to slip through. The weight of the tag most likely caused this slip. During 3 occasions when bears with EL-2(42) transmitters were seen by the field crew, the tagged ear was somewhat hanging down. The two tags that lasted for 7 months were worn by bears over the winter denning period.

One of the lighter EL-2(29) eartags lasted the full battery period of 12 months, while one became unscrewed due to insufficient mounting. The two eartag transmitters that were fixed on radiocollared subadult bears for backup purposes, both broke after a short time. The hair mount was fixed on the yearling (*VERA*) that had lost it's eartag transmitter during recapture, as we did not want to cause any irritation to the other ear. The hair mount was fixed in spring, before most of the winter fur was shed and came off after 6 weeks.

In general the range of the eartag and hair mount transmitters was greatly reduced when compared to the radiocollars. During periods of activity it was a matter of pure luck to find bears. In the rugged terrain of our study area the reception range for the small transmitters was generally greatly reduced as compared to the radiocollars due to RT shielding.

4. Discussion

4.1. Trapping with Aldrich snares in combination with an alarm system

Our experience showed that snaring is a safe, very selective and adequately efficient method to capture bears on forested range. Still, the effort is considerable (Tab.2) and it is not possible to selectively capture certain individuals, or avoid catching others (e.g. the young of a family group). In addition it is very difficult to recapture an individual, as bears learn to avoid or even deactivate traps. A phenomena we also observed with bears in Austria.

The risk that a bear injures itself in the snare can be reduced by careful placement (Jonkel 1993) and by minimizing the time the animal has to spend snared (Woodbury 1996). We strongly advocate an alarm system and a trap site arrangement that minimizes this timeframe to 1 or 2 hours. This makes handling at night necessary and exposes the capture team to a higher capture risk due to reduced visibility. The chance to trap a cub and have a free ranging angry female nearby should never be underestimated. In addition our experience seems to demonstrate that bears behave less shy and/or feel more secure at night. We therefore strongly recommend to only trap in places that allow access by vehicle.

To minimize the time a bear is trapped, also has human safety implications. Most bear areas in Europe are not wilderness areas and the forests are heavily frequented by people. This is often facilitated by a dense net of forest roads. Warning signs may act as attractants or are ignored. The risk that a forest worker or hiker accidentally stumbles on a trap site and gets attacked by a snared bear or a female that protects her snared cub is always given and greatly increases during the daytime hours. We stopped trapping altogether with the beginning of May not so much because bears reduced their visits to the feeding sites, but rather because humans started to use the forest quite intensively. Furthermore visibility at the trapsites was greatly reduced due to the growing vegetation.

4.2. Free range darting, an alternative to snaring?

Free-range darting of bears is often considered an alternative to snaring bears. Our experience was that the efficiency is rather low, the possibilities are very restricted and the risks are considerable. Bears in Slovenia are generally shy and only visit bait sites at night. The use of artificial light is possible with some individuals, but most bears seem very sensitive to this kind of disturbance. All our attempts were restricted to nights with full moon or the early evening with enough rest light. Even at the established bait sites, the distance between a bear and the observer almost always exceeds 50m. At this distance most CO_2 activated tranquilizing guns reach their limit. The use of black powder powered guns allows for a wider range, but the distance has to be estimated precisely (e.g. by laser distance measure) as the risk to injure a bear with a projectile of too high impact in the wrong spot is high.

Poor light conditions make it difficult to estimate the weight of a bear. As Zoletil® has a wide safety margin overdosing is not a serious problem. Still, even when overdosed, bears may run for quite a distance. The yearling female (*VANJA*) we free-range immobilized ran off for more than 500m and only the snow cover made it possible to rapidly find her. Without snow or a trained dog it is rather difficult and dangerous to search in the dark, possibly in dense cover and not knowing if the animal is fully immobilized. To reduce this risk, we had attempted to use transmitter darts. The transmitters have to be extremely light weight in order to be able to reliably shoot on a distances of more than 50m. We tested four darts manufactured by Telinject, Germany and provided by Dr. Chris Walzer from the Salzburg Zoo. Unfortunately all 4 darts broke during the test shooting. Apparently the impact of hitting the target is too high and after several test shots transmitters stopped working. Dart transmitters produced by Pneudart and incorporated within the aluminum dart proved more reliable and were used successfully on one occasion to dart a bear in Austria. Development of superior equipment and additional experience is still needed. Good experience was apparently made with ATS transmitter darts for immobilizing urban white tailed deer (*Odocoilus virginianus*, Kilpatrick and Spohr 1999).

Efficiency of free-range darting from the ground is also rather low when compared to using snares. Snares can be set in several places and nobody has to sit next to them all night and consequently does not have to recover during a large part of the next days working hours. We feel that free-range darting is a good alternative to snaring in special situations, e.g. for handicapped bears (e.g. the bear with the plastic container in Croatia, this study), or problem bears that lost their fear of people (e.g. 1 yearling female in Austria, own experience), or for females next to trapped young (1 bear in Romania, A. Mertens pers. comm.). Free range darting from the helicopter on the other hand is very efficient and highly selective (Swenson et al. 1998), but restricted to largely open areas.

4.3. Immobilization

Like other researchers (Ramsay et al. 1995, Jonkel 1993, Kilpatrick and Spohr 1999), we consider Zoletil 100 a very safe and reliable drug. There were no complications even with greatly overdosed bears and no bear suddenly woke up during handling, which is known with Ketamine/Xylazine (Jonkel 1993) and Ketamine/Medetomidine combinations. In our experience the recommended 5 mg Zoletil 100 / kg body weight was not sufficient in several cases and multiple injections of Zoletil® resulted in a far higher total drug dose. In addition the stress level for the animal and the capture team greatly increased. We therefore aimed to use a dosage of 10mg/ kg body weight and in case of doubt always used the highest weight estimate and rather overdosed bears.

The wake up pattern always followed the same scheme and allowed a reliable judgement of how safe it is to handle the bear. This was especially crucial as local hunters or foresters often wanted to be present in case of a capture event and/or inexperienced students accompanied us. Even though we tried to restrict the number of people it was not always possible. We always felt that it is safer to only allow a restricted number of people to be present, but also acknowledge that being present at a bear capture greatly increases peoples support for the bears and the bear research project.

The only disadvantage of Zoletil 100 is that no complete antidote exists. Flumazenil reverses the effects of Zolazepam, but not of Tiletamine. In the Scandinavia bear project Zoletil 100 is used in combination with Medetomidine. The advantage is that only half the Zoletil 100 dosage is needed and that Medetomidine is fully reversed with Antipamezol (Antisedan). Unfortunately our experience with this combination was restricted to only 4 bears, and all four were dosed too high with Zoletil 100 . Experience gained in captive bears within the past two years shows some promise for the combination Medetomidine-Tiletamine-Zolazepam. In contrast to the dosages used in Scandinavia this combination uses high dosages of the reversible Medetomidine (80ug/Kg) and a very low dosage of Tiletamine/Zolazepam (Walzer 1997)

We waited for all bears to wake up and leave the trap site after handling and consider this an important safety aspect. On the one hand the drugged bear might get attacked by an other bear or wild boar, but even more critical, humans may stumble upon the place with the half-drugged bear. Several of our bears were caught in the early morning, so that the wake up period was during daylight, where chances for human bear encounters greatly increase. Three bears reacted very aggressively shortly after they recovered from the anesthesia. A male coy (*VINKO*) attacked our nearby car because the dogs locked in there had barked. A subadult male (*UROSH*) attacked a battery pack we had forgotten next to him and an adult female (*MAJA*) was highly agitated and circling the trap-site for about half an hour, before leaving for dense cover.

4.4. Radiomarking

Our experiences with break away devices were within the range described by Grashelis et al. (1998). In general the duration proved to be very variable, ranging from a few weeks to more than two years. The possible rapid growth of bears (Tab.2 and appendix Tab.1), especially in food-supplemented populations like Slovenia, can be enormous and we would not recommend to fit a collar around the neck of yearling bears in spring. The 3 fold increase in the weight of a yearling female (*JANA*) within 18 month is probably no exception. An other yearling, a male (*KRABAT*) also caught in spring, but not radiotagged was shot 18 month later and had increased his weight from 42 to 99 kg, a 2.4 increase in the body weight.

The weight increase in subadult male bears can also be very high. A 2 year old male (*UROSH*) weighing around 80 kg at capture was killed in the spring 2 years later weighing more than 200 kg, a 2.5 increase in body weight. We therefore recommend to use rather short living break away devices for subadult males (e.g. notched cotton spacers in our case). The unexpected fast increase in body weight, especially of males made it rather difficult for us to differentiate between subadult and adult males. We had to correct our classification for 3 presumably adult males and 1 presumably 2-year old female, after we got the results from the cementum annuli counts from Matson´s Lab. Females on the other hand seem to reach a constant weight much quicker and on average weigh around 100 kg in spring. The heaviest spring weight of an adult female shot in Slovenia between 1991-1998 was 160 kg, the heaviest adult male was 285 kg (B. Krze pers. comm.).

Eartag transmitters have proven to be a reasonable alternative for fast growing yearlings, but the reception range is rather low and lifespan reduced to a much shorter period (in our case 18 and 12 months respectively). The bigger eartag transmitters designed and tested for black bears (H. Jolicoer per. comm.) did not last the expected 18 months on the bear. The weight seemed too heavy, causing the ear to hang down and therefore enlarging the hole through which the tag is fixed in the ear to a slit, through which the tag eventually slipped. Tags lasted a maximum of 7 months, but only those worn over the winter denning period – possibly the drag on the ear of a recumbent bear is much less. The lighter eartags developed for red deer calves on the other hand seemed to fit well and in one case lasted the complete 12 month period. Other alternatives seem tags produced by ATS that may even last 2 years, due to a programmable microcontroller chip with specific on/off cycle (Gibeau 1997). Ear tag transmitters also seem a good back up in case of radiocollar loss or failure. Hair mount transmitters are shed with the fur and therefore can not be expected to last very long. They only seem to be a good alternative to eartag transmitters or radiocollars, in case of a young bear with injured ears. In Spain 1 hair mount transmitter attached on the bear in November lasted until June the following year- a period of 9 months (Fernandez et al. 1999).

5. Management Implications

In general we advocate caution when bear researchers and managers attempt to trap, anaesthetize and radiotag bears. In all these procedures there are certain risks for the bear, the capture team and people frequenting the trapping area. Especially in small and threatened bear populations the decision to trap and handle bears is definitely a trade off: will the information gained be worth the risk to possibly loose a bear of this population? Not all questions can or have to be answered with telemetry. On the other hand telemetry can be a powerful tool in research and management and risks can be minimized.

There is good equipment and a lot of knowledge and experience available. To compile this data and develop a European handling and safety standard manual is planned and will greatly help to make this information more readily available.

6. Acknowledgement

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7. Reference List

Camarra, J. J., P. Y. Quenette, A. Arquillere, L. Chayron, P. Cluzel, E. Dubarry, D. Dubreuil, and J. Troietto. 1998. Capture et reéquipement radio-telemetrique d`un ours brun. Bulletin mensuel de l'Office National de la Chasse, 234:17-24. (in French)

Clevenger, A. P., F. J. Purroy, and M. R. Pelton. 1990. Movement and activity patterns of a European brown bear in the Cantabrian Mountains, Spain. International Conference on Bear Research and Management, 8:205-211.

Fernandez, A., J. Naves, C. Villalba, and M. Delibes. 1999. Forest fragmentation and brown bear forest selection in Somiedo Natural Park (Asturias, Spain). 12th International Conference of Bear Research and Management in Romania, book of abstracts, p:33.

Garshelis, D. L. and C. R. McLaughlin. 1998. Review and evaluation of breakaway devices for bear radiocollars. Ursus, 10:459-465.

Gentile, L., H. Roth, G. Boscagli, and F. Mari. 1996. Immobilizzazione chimica di orsi bruni (Ursus arctos marsicanus e Ursus arctos) nel Parco Nazionale d´Abruzzo. Suppl. Ric. Biol. Selvaggina XXIV:399-414. (in Italien)

Gibeau, M. L. 1997. Innovations in ear tag transmitters for bears. Forum on Wildlife Telemetry, Wildlife Society Conference in Aspen, Coloradoa, p: 31.

Hellgren, E. C., D. W. Carney, N. P. Garner, and M. R. Vaughan. 1988. Use of breakaway cotton spacers on radio collars. Wildlife Society Bulletin, 16:216-218.

Hinterleitner, R. and F. Völk. 1996. Bär & Recht in Österreich. Report, Arbeitsgemeinschaft Braunbär Life, Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria. (in German)

Huber, D. and H. Roth. 1993. Movements of European brown bears in Croatia. Acta Theriologica, 38(2):151-159.

Jonkel, J. J. 1993. A manual for handling bears for managers and researchers. United state department of the interior, U.S. Fish and Wildlife Service, USA, 175pp.

Kilpatrick, H. J. and S. M. Spohr. 1999. Telazol - xylazine versus ketamin - xylazine: a field evaluation for immobilizing white-tailed deer. Wildlife Society Bulletin, 27(3):566-570.

Mertzanis, Y. 1999. Home ranges and movements of brown bears in the Pindos range, Greece. 12th International Conference of Bear Research and Management in Romania, book of abstracts, p:17.

Naves, J., A. Fernandez, F. Carcia-Marin, and M. Delibes. 1999. Brown bear death related to capture myopathy and clostridium chauveoi toxaemia (Somiedo Natural Park, Spain). 12th International Conference of Bear Research and Management in Romania, book of abstracts, p:36.

Ramsay, E. C., J. M. Sleeman, and V. L. Clyde. 1995. Immobilization of black bears (*Ursus americanus*) with orally administered Carfentanil Citrate. Journal of Wildlife Diseases, 31(3):391-393.

Rauer, G. and E. Kraus. 1993. Forschungsbericht Braunbär 2. WWF Austria, Report, 10:1-44. (in German)

Roth, H. 1983. Home Range and movement patterns of European brown bears as revealed by radiotracking. Acta Zoologica Fennica 174:143-144.

Swenson, J. E., R. Franzen, P. Segerström, and F. Sandegren. 1998. On the age of self-sufficiency in Scandinavian brown bears. Acta Theriologica, 43(2):213-218.

Wabakken, P., A. Bjärvall, and F. Sandegren. 1990. Radio-tracking Scandinavian brown bears: progress report. Trans. 19th. IUGB Congress in Trondheim 1989: 572.

Walzer, C. 1997. Beitrag zur Braunbär – Narkose und Fang im Zoo und in der freien Wildbahn. Tagungsbericht 17. Arbeitstagung der Zootierärzte im deutsch-sprachigen Raum. pp. 29 - 31. (in German)

Woodbury M.R. 1996. A brief review of capture myopathy and reperfusion injury. In: M.R. Woodburry (editor) The chemical immobilization of wildlife - CAZWV course Manual pp. F3 - F13.

Appendix 1: Body measures of bears captured in Slovenia 1992-1998.

date	bear	total	scull	scull width	scull	nec	breast	belly	shoulder	front	hind	front	hind	baculum	testis	nippel	nippel	length	width	distance
		length (cm)		(cm)	circumference (cm)				height (cm)	paw length (cm)		paw width (cm)		length (cm)			condition	of canines (cm)		
26.04.93	*YOGI*	110	28	17	nm	40	64	68	64	10,0	16,5	10,0	9,5	9,5	1,5	----	----	1,1	0,9	5,0
28.04.93	*KRABAT*	116	30	17	nm	41	71	71	72	11,0	18,0	10,5	10,0	9,5	1,5	----	----	1,9	1,1	5,1
04.05.93	*JANA*	113	28	17	nm	41	67	73	73	10,0	17,0	10,0	9,5	----	----	nm	unworn	1,8	0,1	4,7
24.03.94	*METKA*	150	36	23	nm	55	89	94	86	11,0	19,0	11,0	11,0	----	----	1,5	worn	3,0	1,8	6,5
25.03.94	*CLIO*	108	26	20	nm	40	60	64	64	10,0	15,5	9,5	8,5	7,0		----	----	0,6	0,5	5,5
28.03.94	*JANKO*	144	38	25	60	nm	96	111	80	12,0	12,5	13,0	12,5	14,0	3,0	----	----	3,0	1,8	7,0
07.04.94	*MISHKO*	189	39	25	nm	69	116	124	104	13,0	15,0	13,0	15,5	0,0	6,0	----	----	4,0	3,0	6,5
22.04.94	*ANCKA94*	150	35	21	nm	60	97	99	85	11,0	17,5	11,0	11,0	----	----	nm	worn	2,7	1,8	5,5
16.11.94	*JURE*	176	39	29	64	61	111	133	112	13,5	23,0	13,0	13,0	nm	6,0	----	----	3,5	2,0	6,8
05.04.95	*UROSH*	150	37	21	63	nm	102	nm	nm	13,0	21,0	14,0	13,0	15,0	7,5	----	----	3,0	nm	nm
15.04.95	*MILAN*	142	34	19	56	55	93	100	80	13,5	21,0	11,5	13,0	12,0	6,8	----	----	3,3	1,8	6,0
19.04.95	*MISHKO*	172	40	22	65	62	116	110	90	14,0	23,0	14,5	12,7	17,0	8,0	----	----	4,0	2,5	6,9
23.04.95	*MAJA*	145	35	19	56	54	88	87	84	12,5	20,0	11,5	11,0	----	----	nm	milk	2,5	nm	5,8
05.10.96	*VERA*	96	24	nm	41	38	59	65	55	9,0	14,0	8,5	7,0	----	----	nm	unworn	nm	nm	nm
18.10.96	*LUCIA*	140	31	17	53	50	82	99	75	11,0	20,5	11,5	11,5	----	----	nm	unworn	2,5	0,0	4,5
31.10.96	*VINKO*	108	26	13	44	40	68	79	68	9,0	15,0	8,0	8,0	0,0	0,0	----	----	nm	nm	nm
28.03.97	*SRECKO*	150	34	16	61	65	nm	120	92	13,0	16,5	13,0	12,0	nm	7,0	----	----	3,5	1,5	6,5
21.04.97	*VANJA*	118	28	15	43	38	62	70	70	10,5	17,0	9,5	9,0	----	----	nm	unworn	1,5	1,0	4,0
03.05.97	*DUSAN*	108	26	13	49	41	62	57	67	10,0	9,5	9,5	16,0	9,0	4,0	----	----	1,2	0,8	4,8
09.05.97	*VERA*	104	27	14	41	36	59	59	67	9,6	15,5	9,3	8,8	----	----	nm	unworn	1,3	0,8	4,6
18.03.98	*JOZE*	122	28	14	50	44	73	78	56	11,0	18,5	10,0	9,0	7,5	3,0	----	----	1,1	0,8	4,5
23.03.98	*NEJC*	121	30	17	56	47	79	86	70	11,0	18,5	11,0	10,0	9,0	nm	----	----	1,0	0,8	3,5
06.04.98	*POLONA*	168	31	17	59	54	96	111	90	12,0	20,0	11,5	11,0	----	----	1,0	worn	3,2	1,8	6,0
07.04.98	*KLEMEN*	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	13,0	nm	nm	nm	----	----	nm	nm	nm
10.04.98	*ANCKA98*	158	33	18	55	54	91	102	86	11,0	18,5	12,0	11,0	----	----	1,5	worn	2,8	1,8	5,5
14.04.98	*IVAN*	170	37	24	66	63	111	124	99	13,5	22,5	14,5	14,0	20,0	8,0	----	----	3,6	2,0	7,0
31.08.98	*DINKO*	131	29	17	59	66	66	nm	66	15,0	20,0	12,0	12,0	10,0	nm	----	----	2,5	nm	6,0

4.2. Activity pattern of brown bears in Slovenia and Croatia. *Petra Kaczensky, Djuro Huber, Felix Knauer, Hans Roth, Axel Wagner and Josip Kusak (29+2pp)*

Activity patterns of brown bears in Slovenia and Croatia

Activity patterns of brown bears in Slovenia and Croatia

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Abstract

The activity pattern of animals is determined by internal and external factors. Light and temperature act as synchronizers for a certain activity pattern, while the availability of resources, competition, predation or disturbance may alter the genetically fixed and physiologically regulated circadian rhythm. Under natural conditions brown bears (*Ursus arctos*) seem to be predominantly diurnal. However in North America diurnal activity levels vary with the intensity of interference with humans. In areas with low intensity of human utilization, bears are largely diurnal, while in areas with high intensity of human utilization or during periods of frequent human access, bears shift to nocturnal behavior.

In Europe true wilderness areas do not exist and bears generally have to cope with a high intensity of human utilization. The few studies in Europe that investigated bear activity demonstrated a predominantly nocturnal and shy behavior of bears. A shift in the natural activity pattern is often regarded to have negative consequence for the individual and to be a sign of a high stress level. However, high reproductive rates in several European brown bear populations suggest no negative consequences on the population level. Contrary, forcing bears into a nocturnal behavior seems an important prerequisite for a low conflict coexistence of bears and people in the multi-use landscapes of Europe. But how is nocturnal activity maintained in a bear population?

We analyzed 18.948 activity samples (about 4000 hours) of 16 different bears between May and October. Data were collected via time sampling in three different multi-use study areas in Slovenia and Croatia from 1982-1998. First we evaluated the influence of age class (yearling, subadult adult), sex, weather conditions, time of the day and date on activity with logistic regression models. We than compared the activity patterns between individual bears by comparing the diurnal and nocturnal activity levels and checked for an influences of sunset and sunrise on the activity levels. In a final step we compared the diel activity patterns of individual bears using a cluster analysis approach.

Our results showed that age class and time of the day were the most important variables predicting activity or inactivity. In general, yearlings were more active during the day, had a less distinct difference between daytime and nighttime activity levels and had a higher diel activity level than adult bears. The distinction between adults and yearlings was even more pronounced when only considering travelling activity, excluding stationary activity. Yearlings did not show a strong response to sunset or sunrise like most adults. Subadults were somewhat intermediate to adults and yearlings. Cluster analysis revealed a rather clear distinction between most adult bears in one group and all yearlings in another coherent group. We conclude, that nocturnal behavior is not passed on via tradition, but rather seems learnt through own negative experiences with humans, giving space for much individual variation. As a consequence, a certain level of disturbance is probably necessary to conserve this behavioral trait in fully protected bear populations.

Activity patterns of brown bears in Slovenia and Croatia

1. Introduction

The activity pattern of animals is determined by internal and external factors. Most vertebrates are either active during the day (diurnal) or during the night (nocturnal) often with peaks of high activity around dawn and dusk (Ashby 1972, cited in Halle and Stenseth 1994). Light and temperature act as external synchronizer for a certain activity pattern (Nielsen 1983), while the availability of resources, competition, predation (Geffen and MacDonald 1993) or disturbance (Liddle 1997) may alter the genetically fixed and physiologically regulated circadian rhythm.

In many animals nocturnal activity is a consequence of avoiding people, which is often referred to as shyness. Shyness or boldness in animals is believed to have a heritable component. However, the natural environment acts to create and maintain individual differences in phenotypically plastic individuals and populations that live in different environmental conditions can be expected to evolve different norms of reactions (Wilson et al. 1994).

Under natural conditions brown bears (*Ursus arctos*) seem to be predominantly diurnal. However in North America diurnal activity levels vary with the intensity of interference with humans. In areas with low intensity of human utilization, bears are largely diurnal, while in areas with high intensity of human utilization or during periods of frequent human access, bears shift to nocturnal behavior (Gunther 1990, MacHutchon et al. 1998, Olson et al. 1998).

The few studies in Europe that investigated brown bear activity demonstrated a predominantly nocturnal and shy behavior (Roth 1980, Roth and Huber 1986, Clevenger et al. 1990, Wabakken and Maartmann 1994, Rauer and Gutleb 1997). The shift in the natural activity pattern is often regarded to have negative consequences for the individual and to be a sign of a high stress level (Roth 1980). However, high reproductive rates in several European brown bear populations (Saether et al. 1998) suggest no negative consequences on the population level. Contrary, forcing bears into a nocturnal behavior seems an important prerequisite for a low conflict coexistence of bears and people in the multi-use landscapes of Europe. But how is nocturnal activity maintained in a bear population?

Most of the larger bear populations in northern and eastern Europe are hunted, but the small bear populations in southern and central Europe are strictly protected. However, this protection does not prevent bears from being disturbed or even accidentally killed during drive hunts for other wildlife species, especially wild boar (*Sus scrofa*). In many protected areas, hunting is an integral part of the management and even if hunting is banned, the size of most protected areas is too small to effectively protect more than a few individual bears (Linnell et al. 1996). In addition, poaching occurs, both accidentally and on purpose (Palomero et al. 1997), especially in areas where bears damage livestock or human property (e.g. Austria: Zedrosser et al. 1999, Greece: Y. Mertzanis pers. comm., Romania: A. Mertens pers. comm.).

The pressure on bears to behave inconspicuously and to avoid humans is therefore high, even in protected populations. In Europe large wilderness areas do not exist (EUROPARC and IUCN 2000) and human access in many areas is facilitated by a dense network of forest roads. Human activity in forests ranges from hiking, mountain biking, berry and mushroom picking, to forestry and hunting. Most of these activities are confined to daytime hours and for bears one way to avoid encounters with humans is to be nocturnal. Many game animals have adopted a nocturnal behavior due to human persecution (Georgii 1980) and readily switch back to a diurnal activity when protected (e.g. Kitchen et al. 2000).

For a close coexistence of brown bears with humans in Europe it is essential to separate both, either in space or time. As it is almost impossible to restrict human access into bear habitat and because a viable bear population needs a huge area, a separation in time is a good possibility to reduce the probability of encounters between bears and humans. Surprise encounters have resulted in human injury or death (Adamic 1996, Swenson et al. 1996, Swenson et al. 1999) and subsequently in the killing of the involved bears. Public acceptance of brown bears is greatly challenged by such accidents and may hinder or even stop bear conservation efforts (Kaczensky 2000). Therefore, shy and nocturnal behavior in European brown bears is preferable and deserves more intensive studies. Since bears in undisturbed areas are diurnal, nocturnal behavior is most likely not genetically fixed, but rather is learnt.

Bears that are diurnal and do not avoid people are more easy to kill, legally and illegally, a rather strong negative selection pressure. In addition bears may learn through own negative experience, e.g. a bear frequently runs into people during the day and is chased away (Ayres et al. 1986) or even wounded. Both factors together will result in a largely nocturnal bear population. Young bears should be nocturnal if this behavior is passed on from mother to cubs by tradition, alternatively they should be less nocturnal if they have to learn through own negative experience. If tradition is the main factor for nocturnal behavior, it may persist even after hunting and poaching pressure stopped, because generation times are long in bears.

We analyzed bear activity data from three different areas of the continuos bear population in the Dinaric mountain range of Slovenia and Croatia. In all areas bears are exposed to hunting and live close to people. We expected bears to be largely nocturnal, but also wanted to find out, if this behavior is more likely passed on by tradition or is a result of negative experience with humans and/or the removal of diurnal bears due to legal and illegal hunting. Our working hypothesis was that nocturnal behavior is largely a result of own negative experiences and hunting pressure and our expectations were the following:

(1) Adult bears are nocturnal, while yearling bears may be active at any time and subadults are intermediate

(2) Daytime activity of adult bears is restricted to small scale movements in hardly inaccessible areas

2. Study area

All three study areas were located in the Dinaric Mountain range in Slovenia and Croatia (Fig.1). They are within the range of the contiguous Dinara-Pindus bear population stretching from Slovenia in the north into Albania and Greece in the south. The total number is estimated at about 2800 bears, of which 300-500 are believed to live in Slovenia and about 400 in Croatia (Servheen et al. 1998). In both countries bears are hunted between 1 October and 30 April after a quota system.

The relief shows typical karst phenomena, dolines, steep canyons, caves and shallow soils. Surface water is rare as water run off is largely underground. Periodical lakes, poljes and rivers that submerge after short distances are typical landscape features. Elevations range from 300m to 1200m in the Menisija region, from 600m to 1500m in Gorski Kotar and from 500m to 1200m in the Plitvice Lakes area. Bear habitat consists of mixed, uneven aged forest stands. The most common forest type in our study areas (*Abieti-Fagetum dinaricum*) is dominated by beech (*Fagus silvatica*) and fir (*Abies alba*) - intermingled with varying amounts of spruce (*Picea abies*), maple (*Acer pseudoplatanus*) and elm (*Ulmus spec.*). Only selective cutting is allowed, resulting in a dense network of forest roads. Overall forest cover is high and varies between 66% in Gorski Kotar and 74% and 75% in the Menisija and Plitvice Lakes area, respectively.

Human population density is low to moderate for European standards and ranges from 13 inhabitants per km² in the Plitvice Lakes area to 27 and 42 inhabitants per km² in the Gorski Kotar and Menisija area, respectively. Concerning the intensity of human use, the Plitvice Lakes area is famous for Plitvice Lakes National Park which is a major tourist attraction. The Menisija area is located only 30 km from Ljubljana, the capital of Slovenia and is heavily used for recreation. The Gorski Kotar area is known for Risnjak National Park, but receives only few backpackers. Even though there is no bear hunting within Risjnak and Plitvice Lakes National Park, movements of all monitored bears covered ranges larger than the parks (Huber and Roth 1993) and it can be assumed that bears in all three areas are exposed to hunting pressure at least in part of their range.

A more detailed description of the study areas can be found in Huber and Roth (1993), Kaczensky (2000, this thesis chapter 3), Kusak and Huber (1998), Roth and Huber 1986).

Fig.1: Location of the three study areas in Slovenia and Croatia.

3. Methods

3.1. Capture and radiomarking

We captured bears with Aldrich foot snares at bait sites and tranquilized them with either Tiletamin and Zolazepam or a mixture of Ketamin and Xylazine. Trapping, chemical restrain and radiomarking procedures followed methods described by Huber et al. 1996) and Kaczensky et al. (2000, this thesis chapter 4.1.).

Bears were fit with different types of radiocollars (Croatia: Advanced Telemetry Systems (ATS), USA and AVM Instruments Company, USA; Slovenia: MOD-600, MOD-400 Telonics, USA) or eartag transmitters (EL-2(42), Holohil, Canada) and bear activity pattern was monitored via time sampling (Tyler 1979). Only clearly audible signals were used to determine the activity status of monitored bears. We used analogue receivers with a meter for signal strength that can be adjusted to reception strength (Croatia: AVM Instruments Company, USA; Slovenia: YAESU, Wagener, Germany).

3.2. Activity monitoring

In Croatia, bear activity was recorded at sampling intervals of 15 minutes. Observers listened to at least 40 signals and classified the bear as active if the strength in the signal fluctuated clearly in at least 4 beeps and as inactive if there were less than 4 fluctuations (for details refer to: Roth 1980, Roth and Huber 1986). In this way we realized a maximum of 4 activity samples per bear and hour during each monitoring session.

In Slovenia, bear activity was recorded slightly different. Activity was checked at sampling intervals of 10 minutes and observers listened for a one minute sampling period. Like in Croatia, we considered the bear active if the strength in the signal fluctuated clearly in at least 4 beeps and inactive if it fluctuated in less than 4 beeps. This activity criteria was previously determined from Zoo experiment, where we had simultaneously radio-monitored and observed a radio-collared bear (Kaczensky et al. 2000). In Slovenia we realized a maximum of 6 activity samples per bear and hour during each monitoring session.

3.3. Triangulation of monitored bears

In the Slovenian study area, we continuously followed bear movements during 24 hour monitoring sessions by car or on foot. Due to a dense network of forest roads, the distance between observer and bear was generally less than 1000m. After each activity sample we checked whether the bear had changed its position. If so, we determined the new position by triangulation taking successive bearings by a single observer within 5min. The accuracy of the position was subjectively estimated by the observers from the signal strength, the angle between the different bearings and the topography and was classified as:

(1) location error ≤ 50m: bear circled on close range and/or radiosignal close to maximal

(2) location error ≤ 250m: bear only partly circled or circled at a longer distance and/or topography limits the maximum distance between bear and observer

(3) location error ≤ 500m: bear not circled, or circled on long distance (>1 km), and/or azimuth between most distant bearings less than 120° apart

We classified bears as travelling (travelling activity), when the distance between two locations was more than the expected location error, as active on the same area (stationary activity) when no change in the position could be detected or if the change was within the expected location error.

3.4. Data analysis

Activity per sampling interval

Each activity sample resulted in information on the activity status, coded as a dichotomous variable and the time of the day. We used local summer and winter times, but for the analysis we converted all times to middle European standard time (MEZ). To compare different bears and age groups we only used data collected between 1 May and 31 October, the time when all bears were active outside their winter dens and did not make intensive use of food provided by humans at feeding sites. We grouped bears according to three age-classes: yearlings (1 year), subadults (2-3 years) and adults (≥ 4 years). All yearlings monitored had already separated from the mother. All adult females monitored were without offspring.

For analysis we only used bears that were monitored for at least 48 hours evenly distributed over all hours, which means a minimum of 192 activity samples for the Croatian dataset and 288 activity samples for the Slovenian dataset. In the Croatian study areas, several bears were monitored over several years. If the number of activity samples for each year were larger than the minimum sample size required, different years were treated like data sets of different bears (bear-years). If a bear changed the age class, different bear-years were treated as different age classes. If data sets were smaller than the minimum sample size, bear-years of the same bears were pooled if the bear did not change the age class or discarded otherwise (Tab.1). With this approach we also got an idea of the individual variation of the same bears between different years as compared to the variation between different bears.

Tab. 1: Dataset used for individual analysis.

bear	age	sex	activity monitoring start	end	N	data from > 1 season	area[1]
adults:							
GABI	5	female	14.06.86	12.10.86	577	pooled	GK
	6	female	21.05.87	19.09.87	143		
INGA89	5	female	04.05.89	11.09.89	370	not pooled	GK
MAJA	9	female	01.05.97	19.06.97	600	not pooled	MN
ANCKA	8-18[2]	female	14.05.98	09.10.98	1.982	not pooled	MN
POLONA	5	female	15.05.98	24.10.98	2.259	not pooled	MN
FRANJO82	5	male	21.06.82	06.02.82	299	not pooled	PL
FRANJO83	6	male	14.05.83	04.10.83	288	not pooled	PL
FRANJO84	7	male	20.05.84	09.09.84	802	pooled	PL
	8	male	26.05.85	07.09.85	6		
HAL	6	male	16.05.83	19.09.83	281	not pooled	PL
HANS	5	male	18.05.85	28.10.85	451	pooled	PL
	7	male	10.05.87	05.09.87	222		
DADO	4	male	16.05.86	06.10.86	224	not pooled	PL
subadults:							
LILI83	2	female	09.05.83	30.07.83	539	not pooled	PL
INGA87	3	female	27.05.87	10.09.87	233	not pooled	GK
LUCIA	2	female	04.05.97	08.10.97	3.337	not pooled	MN
SRECKO	3	male	04.05.97	09.10.97	2.634	not pooled	MN
yearlings:							
VANJA	1	female	01.05.97	11.08.97	1.615	not pooled	MN
VERA	1	female	07.05.97	28.05.97	590	not pooled	MN
LILI82	1	female	01.05.82	17.10.82	867	not pooled	PL
DUSAN	1	male	10.05.97	09.07.97	718	not pooled	MN
PEPI	1	male	10.07.87	19.09.87	450	not pooled	GK
			total		***18.948***		

[1] MN=Menisija (SLO), GK=Gorski Kotar (HR), PL=Plitvice Lakes (HR)
[2] recapture but unclear identity due to loss of eartags

Average activity per hour

For all bears of Tab.1 the average activity per hour was calculated from all activity samples that fell in the same hour interval (unsmoothed data). For each bear we only used hours with a total of $\geq$ 4 activity samples for the analysis. To account for differences in the sample size between different bears, the average activity per hour was smoothed using a weighted (by sample size) centered running mean of five hours (smoothed data). Thus the value of any hour interval equals the mean of the actual interval and the two intervals before and after.

For the Slovenian dataset the same methods were used to calculate average travelling activity per hour and average stationary activity per hour.

Regression models

Using regression models we checked for the influence of the following factors on bear activity:

(1) age class (yearling, subadult, adult)

(2) sex

During activity monitoring we failed to systematically measure climatic and light conditions. In order to get a rough estimate of the importance of these ambient variables for bear activity we used:

(3) daily sunrise and sunset times for Ljubljana (latitude: 46°07', longitude: 14°64') to distinguish between day- and nighttime activity samples. We defined daytime from sunrise to one minute before sunset and nighttime from sunset to one minute before sunrise.

(4) daily moonrise and moonset times to distinguish between full moon - and no full moon activity samples. We defined activity samples as full moon samples when they were collected between moonrise and moonset. In addition activity samples had to fall into the nighttime during 3 nights prior until 3 nights past the actual date of full moon.

From the meteorological station in Ljubljana we got average daily values for temperature and precipitation. All activity samples of a days session were given the same value.

(5) average daily temperatures

(6) average daily precipitation

To check for the influence of feeding sites on habitat use and activity of bears we had mapped all bear- and wildlife feeding sites within our study area (Kaczensky 2000, this thesis chapter 4.3.). For each activity sample we noted:

(7) whether or not the monitored bear was within 250m of a feeding site

We further wanted to see how much the time of the day and the date played a role for bear activity. Both variables are circular, but are in a linear format. In the regular 24 hour and 12 month format the distance between 0:00 and 23:50 or 1 and 12 seems maximal, but in reality is small (cross over problem). We therefore transformed the date and time into a radiant format and subsequently derived the sine and cosine values of the radiant values (Zar 1999). From a first visual analysis of activity patterns, it seemed that most bears roughly followed a monophasic or 24 hour activity rhythm, which can be approximated by a normal sine curve (2π = 24 hours) or biphasic or 12 hour activity rhythm, which can be approximated by two consecutive sine curves (2π = 12 hours):

(8) sin (radiant time) and cos (radiant time)

(9) sin (2 x radiant time) and cos (2 x radiant time)

Our expectation was that the diel activity pattern rather than the diel activity level differs between age classes and therefore we also included an interactive variable of age and time, both for the 24 hour rhythm and the 12 hour rhythm:

(10) age* sin (radiant time) and age*cos (radiant time)

(11) age*sin (2 x radiant time) and age*cos (2 x radiant time)

As day length over the year follows a rhythmic pattern, we also approximated the influence of the variable date as a sine and cosine curve:

(12) sin (radiant date) and cos (radiant date)

We did not have the same data available for all three study areas, as variables 4-7 were only available for the Slovenian dataset. To determine what factors influence bear activity in all study areas we calculated three different regression models with two different approaches. We used the forced-entry option as both, sine and cosine radiant values had to be entered together for the variables time and date. All variables that were not significant on the $p<0{,}005$ level were manually removed in a stepwise fashion. Corresponding sine and cosine values were removed only, when the F-test failed to be significant at the $p<0{,}05$ level.

In a first approach we used two logistic regression models, in model 1 testing for the influence of the variables 1-12 (Slovenian dataset) and in model 2 for the influence of the variables 1-3 and 8-12 (Slovenian and Croatian datasets) on the ability of the model to predict active or non-active sampling intervals. We used the deviance in the –2*Log Likelihood as a measure for the predictive strength of the variable.

As our analysis of activity patterns were not only based on the sampling intervals, but also on the smoothed average activity per hour, we additionally tested for the influence of the variables 1-3 and 8-12 using a general linear model (GLM) for the Slovenian and Croatian dataset together.

Differences in daytime and nighttime activity levels

We averaged the activity level for all activity samples of the same category (day or night) and compared day- and nighttime activity levels between individual bears.

In order to check for the influence of sunset and sunrise, we determined how many sampling intervals were between each activity sample and sunset and sunrise, respectively. As the time between sunrise and sunset varies from 11-15½ hours between May and October, we only used 32 (Slovenian dataset) and 48 (Croatian dataset) intervals (this equals 8 hours) around sunset and sunrise. In this way we got a clear separation between daytime and nighttime intervals.

To account for differences in the sample size and for better visualization we again smoothed the data using a weighted (by sample size) centered running mean of 5.

Comparing diel activity patterns of individual bears

Additionally to a comparison of daytime and nighttime activity levels, we wanted to describe similarities in the diel activity pattern over 24 hours. Hence we run a cluster analysis using squared Euclidean distances between all bears over each of the 24 hours. Bears were attributed to clusters using the between group linkage. This method uses the average distance between all samples in a cluster to determine the distance to a new cluster, this way considering all samples of a cluster.

Data from bears with less than 200 activity samples

We pooled activity samples of different bears that did not have the minimum number of activity measures required for individual analysis according to age groups (Tab.2) and compared the resulting activity patterns with the results from the individual analysis.

Tab. 2: Dataset of bears with less than 200 activity samples, used for analysis pooled by age class.

			activity monitoring			data	area[1]
bear	**age**	**sex**	**start**	**end**	**N**	**> 1 season**	
adults:					***332***		
VIOLET	10	female	10.07.87	05.09.87	87	no	GK
NIVA	13	female	02.05.90	13.10.90	71	no	GK
BOB	5	male	16.05.86	29.08.86	6	no	PL
VLADO	5	male	16.05.86	17.05.86	5	no	PL
NENO	12	male	30.07.86	19.10.86	140	no	GK
FRKO89	4+5	male	0.5.05.88	12.05.89	20	yes	GK
MATE	4	male	02.05.90	10.06.90	3	no	GK
subadult					***380***		
JURICA	2	female	03.05.85	31.05.85	160	no	PL
JURA	3	male	18.05.83	30.07.83	28	no	PL
GORAN	3	male	06.07.86	17.09.86	49	no	GK
FRKO87	3	male	27.05.87	03.08.87	143	no	GK
yearlings					***414***		
LINDA	1	female	07.07.90	12.12.90	69	no	GK
DARKO	1	male	03.05.85	11.09.85	152	no	PL
MIKI	1	male	11.06.90	12.10.90	52	no	GK
NEJC	1	male	12.06.98	14.07.98	141	no	MN
			total		**1.133**		

[1] MN=Menisija (SLO), GK=Gorski Kotar (HR), PL=Plitvice Lakes (HR)

General statistical procedures used

All statistical analysis were done with SPSS 9.0. For comparing mean values of multiple groups we used the two-tailed parametric analysis of variance (ANOVA) tests. Subsequently we compared groups pair-wise with t-tests. We corrected for the expected total error rate using the Bonferoni method when the Leveen test revealed no significant deviance from equal variance or otherwise with the Tamhane-T2 method for unequal variance.

4. Results

4.1. Data basis

We analyzed a total of 18.948 activity samples from 16 different bears which were monitored during 20 bear-years (comprising 5 yearlings, 3 subadults and 12 adults, Tab.1). An additional 1.133 activity samples of 15 individual with less than 200 activity samples and therefore pooled by age class were available for comparison (Tab.2).

4.2. Main factors influencing activity

The outputs of both logistic regression models, produced very similar results (Tab.3, Tab.4). An underlying 24 hour activity cycle and the 24 hour activity cycle modified by age class were the most important factors predicting activity or non-activity of the sampling intervals. Third and forth most important factors were age and an underlying 12 hour activity cycle, respectively. Rather unimportant, but still significant, were the vicinity to a feeding place, the date, the 12 hour activity cycle modified by age and the sex. Average daily precipitation, average daily temperature, full moon and day/night did not show any significant influence. Both models correctly predicted 67% of all activity samples; 84% of the active intervals and 46% of the inactive intervals.

The results of the GLM produced a slightly different picture (Tab.5). For predicting the smoothed average activity per hour the 12 hour activity cycle and the 24 hour activity cycle were almost equally important, followed by the 24 hour activity cycle modified by age class and age class alone. Sex and date had a significant, but very small influence.

*Tab. 3: Results of the Logistic regression model for variables 1-12, which were only available for 8 bears from the Slovenian study area. Average daily precipitation, average daily temperature, full moon and day/night were removed from the model as they failed to be significant on the 0,05 level. The deviance of the –2*Log Likelihood (last column) is a measure for the relative strength in the predictive value of the variable.*

Model 1[1]	**Beta**	**Exp(B)**	**df**	**Sig.**	**diff. -2*LL**
SIN_24 hour cycle	-0,04	0,96	2	0,00	996
COS_24 hour cycle	1,53	4,60			
age * SIN_24 hour cycle			4	0,00	566
age(1) by SIN_24 hour cycle	-0,25	0,78			
age(2) by SIN_24 hour cycle	-0,24	0,79			
age* COS_24 hour cycle					
age(1) by COS_24 hour cycle	-1,57	0,21			
age(2) by COS_24 hour cycle	-1,22	0,30			
age			2	0,00	325
age(1)	0,73	2,08			
age(2)	0,75	2,12			
SIN_12 hour cycle	-0,48	0,62	2	0,00	263
COS_12 hour cycle	-0,61	0,54			
within 250m of feeding place	0,00	1,00	1	0,00	54
SIN_date	0,15	1,16	2	0,00	46
COS_date	0,45	1,57			
age* SIN_12 hour cycle			4	0,00	43
age(1) by SIN_12 hour cycle	0,26	1,30			
age(2) by SIN_12 hour cycle	0,08	1,08			
age* COS_12 hour cycle					
age(1) by COS_12 hour cycle	0,32	1,38			
age(2) by COS_12 hour cycle	-0,04	0,96			
const.	0,05	1,05	1	0,44	

[1]age(1) = yearling, age(2)=subadult, age(3)=adult
SIN = sine, COS = cosine

*Tab. 4: Results of the Logistic regression model for variables 1-3 and 8-12, which were available for all bears (Slovenian and Croatian study areas). The variable age class by 12 hour cycle was removed from the model as it failed to be significant on the 0,05 level. The deviance of the –2*Log Likelihood (last column) is a measure for the relative strength in the predictive value of the variable.*

Model 2[1]	**Beta**	**Exp(B)**	**df**	**Sig.**	**diff. -2*LL**
SIN_24 hour cycle	0,02	1,02	2	0,00	1342
COS_24 hour cycle	1,27	3,55			
age* SIN_24 hour cycle			4	0,00	521
age(1) by SIN_24 hour cycle	-0,33	0,72			
age(2) by SIN_24 hour cycle	-0,32	0,72			
age* COS_24 hour cycle					
age(1) by COS_24 hour cycle	-1,14	0,32			
age(2) by COS_24 hour cycle	-0,87	0,42			
SIN_12 hour cycle	-0,45	0,64	1	0,00	403
COS_12 hour cycle	-0,53	0,59	1		
age			2	0,00	291
age(1)	0,60	1,83			
age(2)	0,52	1,67			
SIN_DATE	0,10	1,10	2	0,00	29
COS_DATE	0,29	1,33			
sex(females)	-0,15	0,86	1	0,00	18
const.	0,10				

[1]age(1) = yearling, age(2)=subadult, age(3)=adult
SIN = sine, COS = cosine

Tab. 5: Results of the GLM with smoothed average activity per hour as dependent variable. The variable age class by the 12 hour cycle was removed from the model as it failed to be significant on the 0,05 level. The square sumIII is a measure for the influence of the variable.

source	**square sum III**	**df**	**sig.**
SIN_ 12 hour cycle	16,62	2	0,00
COS_12 hour cycle			
SIN_24 hour cycle	15,33	2	0,00
COS_24 hour cycle			
age * SIN_24 hour cycle	5,72	4	0,00
age * COS_24 hour cycle			
age	4,37	2	0,00
sex	0,32	1	0,01
SIN_date	0,14	2	0,07
COS_date			
const.	85,83	1	0,00

R-square = ,456 (adjusted R-square = ,451)

4.3. Daytime and nighttime activity

In a first step we tested for differences in the activity level during daytime and nighttime. For the nighttime activity level we did not find a significant difference between age groups (means: adults: 68%, subadults: 69%, yearlings: 62%; ANOVA, p=0,745). But during daytime, yearlings showed a significantly higher activity level than adults (ANOVA, p=0,025; multiple comparison with t-tests assuming unequal variance and using the Tamhane correction: adult-yearling p=0,002; adult-subadult p=0,300; subadult-yearling p=0,517) (Fig.2). The overall activity level of subadults (mean: 53%) was between the values of adults (mean: 40%) and yearlings (62%).

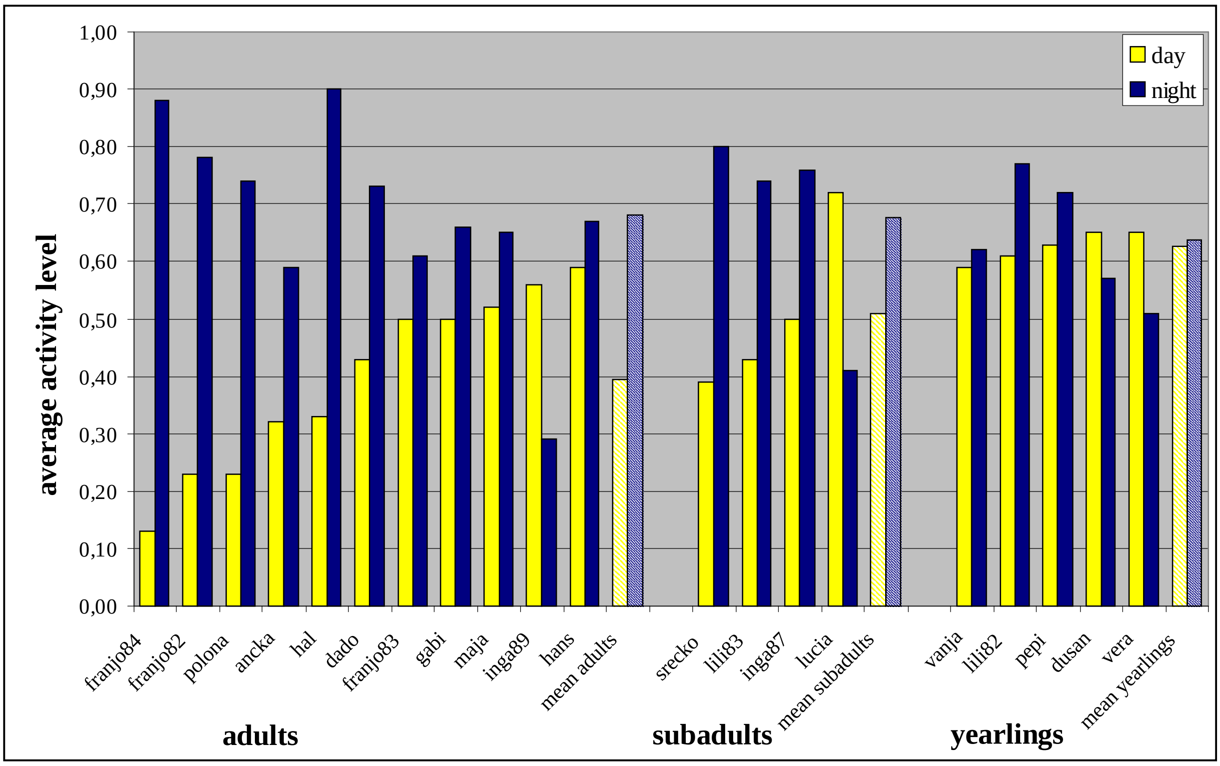

Fig. 2: Activity level during daytime (yellow) and nighttime (blue) hours for adult, subadult and yearling bears. The shaded bars show the mean of each group.

Because the light phase seems to play a rather important role for the activity pattern, we checked if sunset and sunrise caused any distinct change in the activity level (Fig.3). For several bears, especially for adults, there was a peak in activity just around sunset and/or sunrise. Adults seem to respond, but showed great individual variation in the exact time and duration of activity peaks (appendix 1). Most yearlings on the other hand did not seem to react much to sunset and sunrise, as their overall patterns were rather erratic.

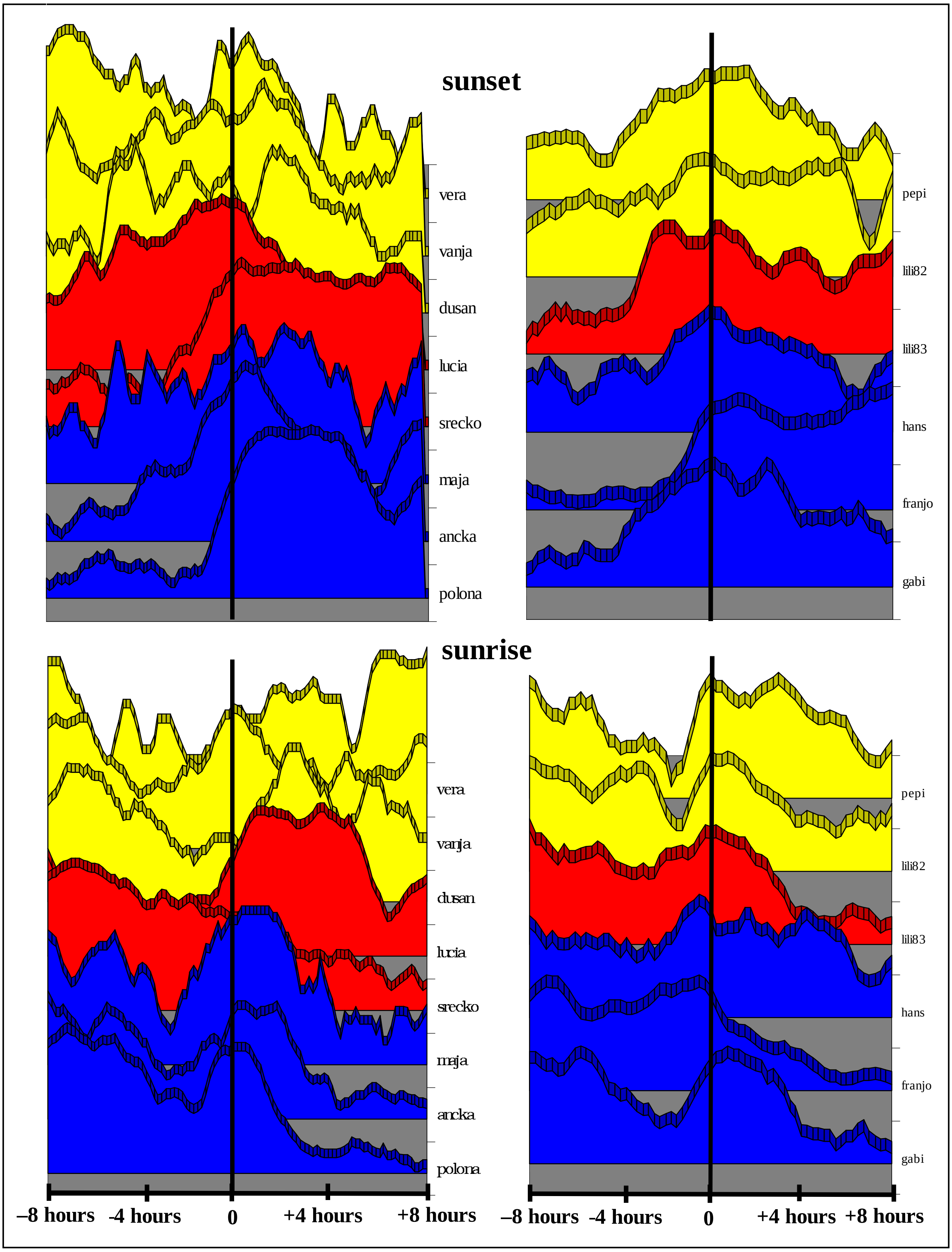

Fig. 3: Average activity at sampling intervals eight hours before and eight hours after sunset (top) and sunrise (bottom). Left side Slovenian dataset with 10 min sampling intervals, right side: Croatian dataset with 15 min intervals. Blue: adults, red: subadults, yellow: yearlings. Only bears with ≥ 4 activity samples per interval were included. Y-axis: average activity level per sampling interval.

4.4. Comparing diel activity patterns of individual bears

Activity pattern is more than just a difference in the day and night time activity level. We therefore compared the diel activity pattern over 24 hours and grouped bears according to similarities. The results of the cluster analysis showed that individual bears can be roughly split in two groups. Age composition of these two groups is rather different, group1 consists of 9 adults and 2 subadults and group2 of 2 adults, 2 subadults and all of the 5 yearlings (Fig.4). One bear (*FRANJO*) did not change the age status, but was monitored over 3 different seasons. Even though all 3 seasons were within group1, the „adult bear group", differences between different years, were larger than differences to some other bears. The bear *LILI* that changed the age status from yearling (*LILI82*) to subadult (*LILI83*) changed from group2, the „young bear group" to group1. The bear *INGA* that changed from subadult (*INGA87*) to adult (*INGA89*) remained still more similar to group1 than to group2, but the difference between the activity pattern in 1987 and 1989 was very large.

There seems to be a trend that adult bears are more similar with other adults, as are yearlings with other yearlings, while subadults are somewhat in between. Even though all yearlings belonged to group2, two adults (*INGA89* and *HANS*) were actually more similar to the „young bear group" than to the „adult bear group".

Main differences between groups were that bears of group2 had a less distinct difference between day and night activity levels and showed a more biphasic activity pattern (12 hour cycle) as compared to the largely monophasic activity pattern (24 hour cycle) of bears in group1 (Fig.5). However, Both groups had peak activities in the early morning at 4:00 and 6:00 respectively, a depression around noon, a second peak in the early evening around 20:00 and an other depression around midnight. For the average of all bears in group1 the depression around midnight was very shallow, but several individuals showed a distinct depression; but always less distinct than the depression around noon (Fig.5).

Two bears from group2 (*LUCIA* and *INGA89*) did not follow the general pattern. Contrary to all other bears, *LUCIA* had a peak at noon, while *INGA89* only showed one peak in the evening (Fig.5).

Diel activity levels within 24 hours were higher for bears in group2 as compared to bears in group1 (group1: 60%, group2: 53%, t-test for unequal variance, p=0,001). For individual bears diel activity levels varied between 43% and 68% and when ranking bears by diel activity levels, only two bear from group1 were among the highest ranking and only one bear from group2 was among the lowest ranking individuals (Fig.6).

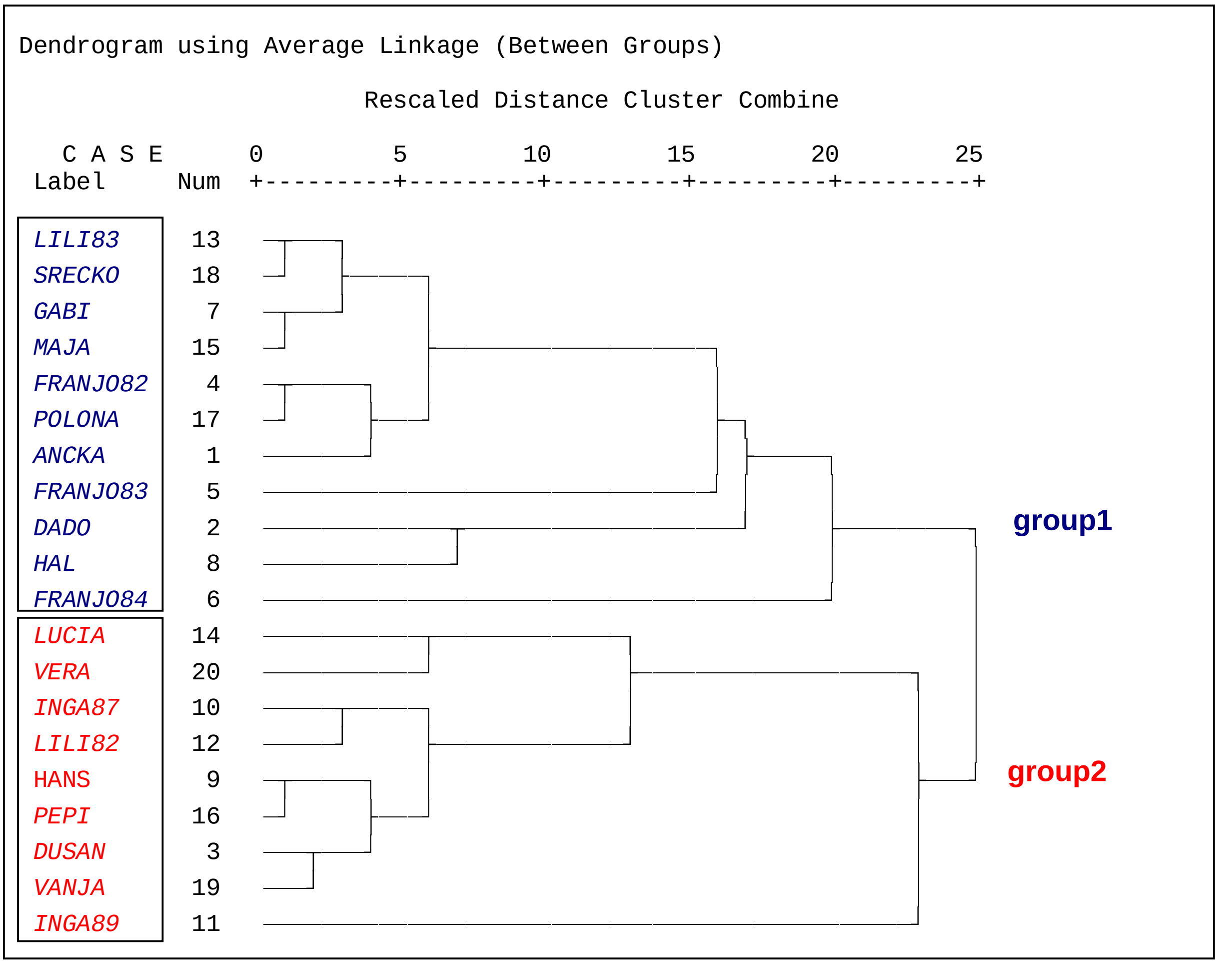

Fig. 4: Results of the cluster analysis for comparing diel activity patterns between individual bears. Bears marked in blue (top) all belong to group1, the age composition is 9 adults and 2 subadults. Bears marked in red (bottom) belong to group2, their age composition is 5 yearlings, 2 subadults and 2 adults (INGA87 and HANS).

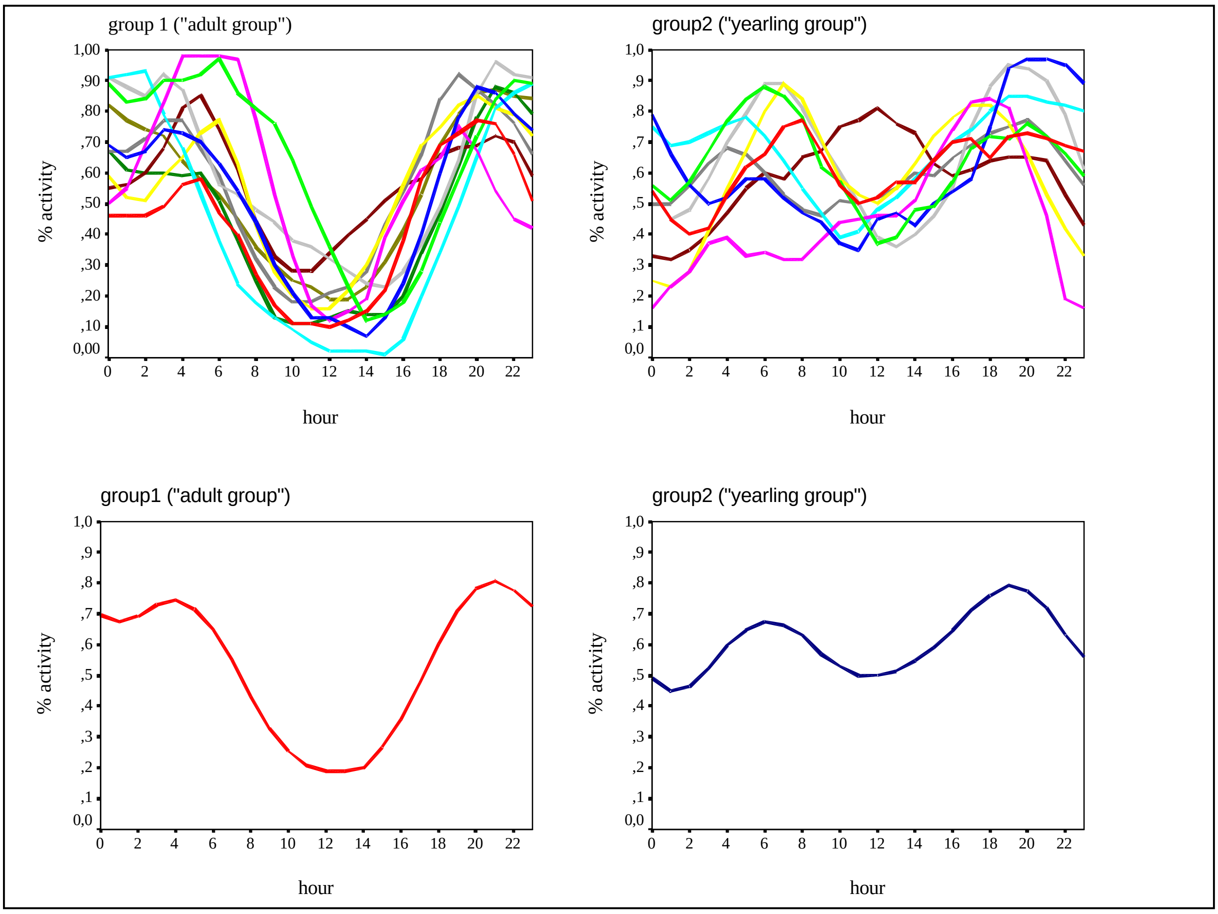

Fig. 5: Upper left and right: average smoothed activity per hour of all bear in the two groups. In group2 VERA (brown) and INGA89 (purple) are somewhat opposite to the general trend. Lower left and right: average smoothed activity per hour, averaged over all bears in group1 (left) and group2 (right).

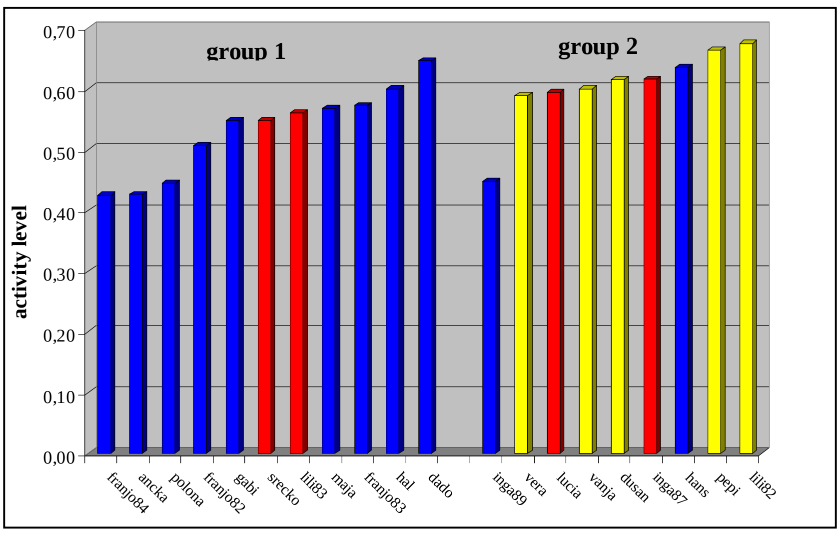

Fig.6: Diel activity levels, averaged over all hours for bears in the two groups distinguished with the cluster analysis. Blue bars: adult bears, red bars: subadult bears and yellow bars: yearlings.

4.5. Stationary versus travelling activity

The difference in the activity patterns between adult bears and younger ones was even more distinct when comparing the 24 hours distribution of travelling activity (Fig.7). While three adult females hardly traveled at all between 8:00 and 16:00, three yearlings frequently traveled during daytime. One of the yearlings (*VERA*) even showed a peak of travelling activity around noon. Of the subadults, one (*SRECKO*) showed a similar pattern than the adult females, while the other (*LUCIA*) almost exclusively traveled during the day, with a small depression around noon. Total travelling activity levels did not differ significantly between adult (17%), subadult (22%) and yearling (21%) bears (ANOVA, p=0,027; multiple comparison with t-tests assuming unequal variance and using the Tamhane correction: adult-yearling p=0,053, adult-subadult p=0,123, yearling-subadult p=0,953).

Stationary activity levels were higher than travelling activity levels and yearlings had the highest overall levels, while adults had the lowest (adults: 24%, subadults: 34%, yearlings: 38%; ANOVA, p=0,000; multiple comparison with t-tests assuming unequal variance and using the Tamhane correction: adult-yearling p=0,000, adult-subadult p=0,000, yearling-subadult p=0,120). For the adults and the subadult bear *SRECKO* differences in the 24 hour activity pattern were less distinct between day and night than for travelling activity (Fig.7). In addition, the adult female *MAJA* showed a higher stationary activity level than the two other adult females and in this respect was more similar to the yearling pattern.

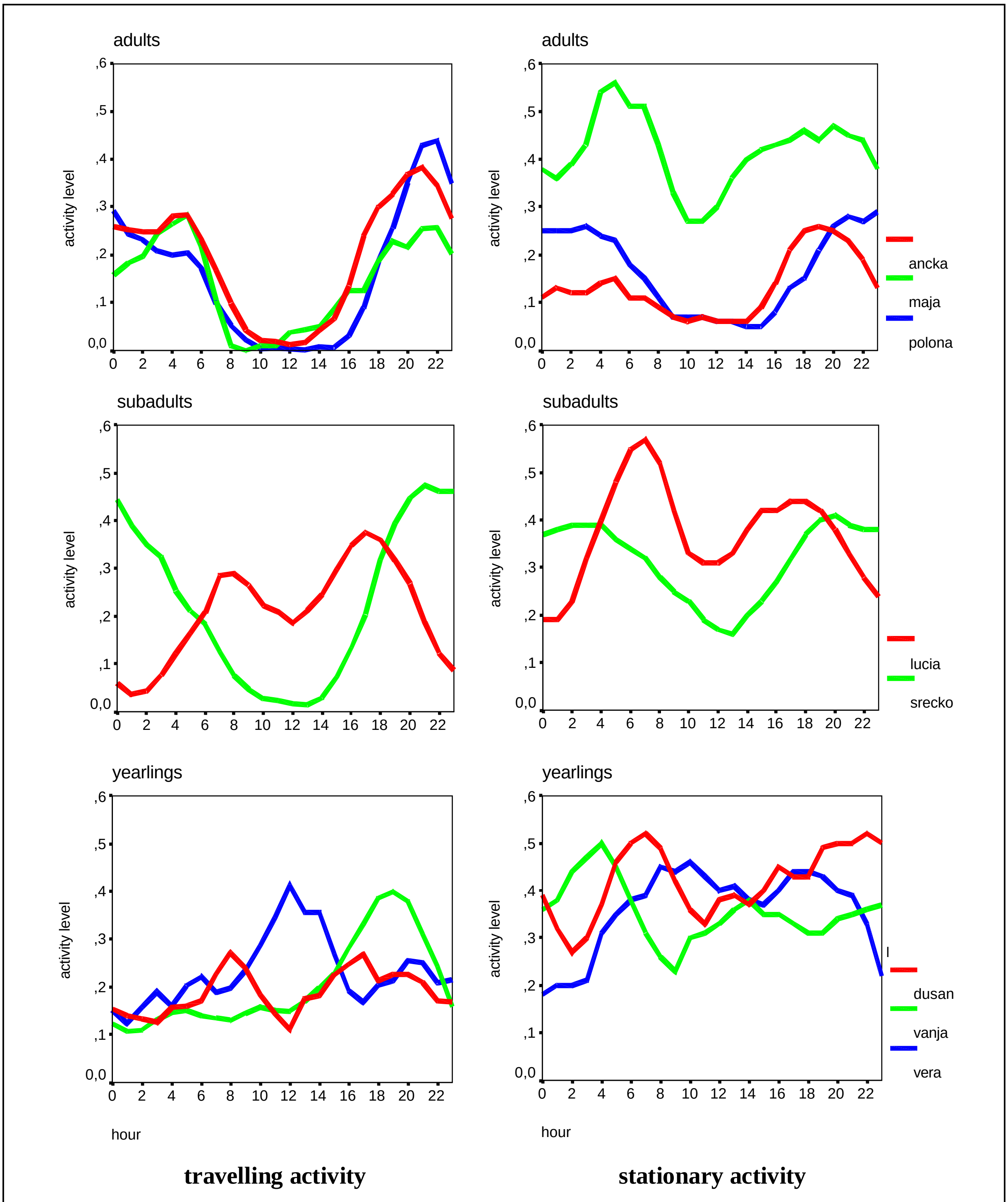

Fig. 7: Average smoothed travelling and stationary activity per hour in the three age groups. This data was only available for the Slovenian study area.

4.6. Data from bears with less than 200 activity samples

24 hour activity patterns of bears with less than 200 activity samples pooled by age classes, also produced the expected difference between the age classes (Fig.10). Adults showed a monophasic or 24 hour activity pattern with a very distinct day / night difference (daytime: 36%, nighttime: 88%). Contrary, subadults and yearlings showed a biphasic or 12 hour activity pattern, were more active during the day (yearlings: 54%, subadults: 50%) and less active during the night (yearlings: 44%, subadults: 40%). The differences between adults and yearlings and between adults and subadults were statistically significant for daytime and nighttime activity levels (ANOVA p=0,000 for daytime and nighttime activity level, multiple comparison with t-tests assuming unequal variance and using the Tamhane correction: *daytime*: adult-yearling p=0,000, adult-subadult p=0,006, yearling-subadult p=0,665; *nighttime*: adult-yearling p=0,000, adult-subadult p=0,000, yearling-subadult p=0,910).

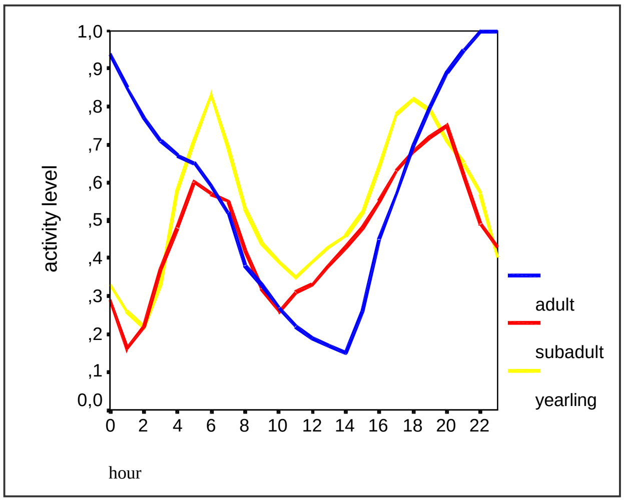

Fig.8: Average smoothed activity per hour for bears with less than 200 activity samples, pooled by age class.

5. Discussion

Methodological considerations

We commonly analyzed bear activity data that were sampled by different observers and with different methods. Reinhardt (1996) compared different time sampling methods with continuos activity monitoring and found only minor difference in the activity levels of hours determined at 10min or 15min sampling intervals, when using a one minute sampling period. The $\geq$ 40 beeps listened to in the Croatian study roughly equaled the one minute sampling period used in the Slovenian study. In addition, in our approach, we did not use distinct hours as sampling unit, but rather averaged all activity measures for one hour. When we reduced the activity samples of a bear (*LUCIA*) measured with 6 samples per hour to 4 samples per hour the outcome did not differ from a 33% random reduction of the overall dataset (P. Kaczensky unpublished data).

A more serious problem was that the data were not evenly sampled over different months nor over the 24 hours period. In addition the data have a circular structure and a distinct pattern, so that most standard statistics were unsuitable for analysis. We therefore used the logistic regression approach and the GLM, assuming a cyclic relationship for time and date. The rather low influence of the variables average daily precipitation, average daily temperature, full moon and date is consistent with the results of a later approach by Bindl et al. (2000). In their analysis they used a semi-parametric general additive model. The variable time was included as an individually fitted cubic B-spline (based on the sampling intervals relative to sunset) for each bear, as compared to our approach using the same underlying sine curve for all bears. But even with their more individually fitted approach, they did not find a consistent trend for the variables temperature, rain and full moon. Only the variable month showed a consistent trend, with slightly reduced activity levels during summer.

Apparently weather conditions and the season are only of minor importance to explain individual bear activity patterns from late spring to fall. On the other hand, we did not continuously measure rain and temperature but rather used average values for 24 hours. It is possible that weather conditions have a certain influence, e.g. that bears are less active during a short and heavy rainfall, but with our data we were unable to detect short term influences. We also did not measure light intensity, nor notify if clouds concealed the full moon. As the number of sampling intervals during full moon nights was rather small (only 7,8% of the total sample), any influence of the full moon might have been concealed because we most likely included activity samples for which the moon was hidden by clouds.

Furthermore it was not possible to measure human activity or the degree of disturbance an individual bear was exposed to. In adults the observed behavior might well be a result of past experiences which would be impossible to assess. Even a bear that lives in a remote area might have dispersed from an area of high human impact, as especially males are known to disperse long distances (Taberlet et al. 1994, Knauer 2000 in prep., Knauer et al. 2000). However, all bears live in landscapes inhabited by people and in all areas hunting occurs, consequently we assume that all bears were exposed to some negative experiences with humans.

Diurnal young bears and nocturnal adult bears

Our results showed a clear difference in the activity patterns of yearlings and adult bears, with subadults being somewhat in between. With two exceptions all adults were mainly active at night, while yearlings could be found active at any time. This difference was even more pronounced when comparing travelling activity only. Adults hardly traveled at all during daytime, while yearlings and some subadults had a much higher travelling activity level during the day. Consequently their chances to encounter people were much higher. In the few cases where we saw bears, it was either a yearling or the subadult female *LUCIA*. Contrary to the yearlings, *LUCIA* did not seem to be afraid of people and often ignored and in a few cases even approached the observers.

For one adult female (*MAJA*) with a relatively high daytime activity level, this activity was largely confined to stationary activity, that is activity in or around the daybed area. As daybeds were mainly located in inaccessible areas (high cover or steep slopes, Kaczensky et al. 2000, this thesis chapter 4.3.) the chances for bear-humans encounters are minimal. For the two adults (*HANS* and *INGA89*) that showed the highest day activity we did not have data to distinguish between stationary and travelling activity.

The fact that subadult bears are more active during the day and expose themselves more frequently to humans than adults is a well known phenomena (Ison et al. 1997). It is often assumed that subadult bears are generally less affected by humans because of greater habituation (MacHutchon et al. 1998). But other authors noted that subadults do not show the same tolerance than habituated adults (Braaten 1988, cited in Olson et al. 1998). The lower wariness is often explained with food competition or the avoidance of aggressive adult bears. In the Slovenia study area we had no indication of intraspecific killing (Swenson et al. 1997) nor of food deficiency. On the contrary, yearlings were rather large during initial capture, weighing up to 55 kg (*NEJC*) in early spring and quickly gained further weight (Kaczensky et al. 2000, this thesis chapter 4.1.).

But even if the avoidance of aggressive adults is the reason for the largely diurnal behavior of yearlings, it does not explain, why a bear would change to nocturnal behavior when adult. Perhaps young bears first consider other bears more dangerous than humans, because they are lacking any negative experience with humans when together with a wary and nocturnal mother. When they separate from the mother they may discover that they can avoid other bears by being active during the day, but will more frequently encounter humans. Negative experiences with humans in combination with the fast gain in body mass (other bears are not a threat any more) might cause bears to change to nocturnal activity at older age.

The first major selection against diurnal behavior will take place during the fall hunting season. By this time most yearlings weigh around 70-100kg and are considered reasonable trophies. There is a quota system, but within a hunting unit there is often several hunters that are interested in shooting a bear. Often different hunters take turns in waiting for a bear at a bait site and normally will size the first opportunity to shoot a bear. The earlier a bear comes to a feeding site, the higher the chances to get shot. The radiocollared bear *LUCIA* was the only bear we had monitored in Slovenia that was active during the day and did not show fear of people. She was frequently seen by hunters at bait sites, but was spared because of her radio collar.

In Slovenia wounding of bears happens, but seems to be a rather minor problem since 1986, when bear hunting was restricted to bait sites (Simonic 1994). Before bears were often harvested during drive hunts, where the chances of wounding a bear were higher. While in the past most harvested bears had old bullet wounds, this is the exception in Slovenia nowadays (A. Simonic pers. comm.). In Croatia wounding also occurs and probably was even more frequent during the time of the Croatian study (1982-1987, see Frikovic et al. 1987) as compared to the Slovenian study (1997-1998). A collared bear shot in Croatia in 1997 had old fractures caused by bullets in the jaw and pelvis, and the skeletons of two other bears had old bullets imbedded in bones (D. Huber unpubl. data). Even though bears are not allowed to be shot any more during drive hunts, they are often chased during these hunts for wild boar. In the Slovenian study area we once documented an adult female (*MAJA*) with her three coys and a subadult female (*LUCIA*) in the same square kilometer with about 60 hunters and their dogs.

In Austria, where bears are strictly protected, several young bears started to be active during the day and did not show much fear of people. They were frequently observed by people with no negative consequences, on the contrary, some might have even been fed by people (Rauer and Gutleb 1997). At least three of these bears were females and two had already raised cubs. Especially when accompanied by cubs these females were often observed on close range (Zedrosser et al. 1999) and cubs might never learn to avoid people predisposing them to come into trouble.

Counteracting this process is a major concern of the Austrian bear conservation program (Zedrosser et al. 1999) and several attempts were made to aversive condition the bears (Gillin et al. 1994). Similar problems arose in Abruzzo National Park, Italy with a female bear, but so far this bear failed to produce cubs (M. Posilico and H. Roth pers. comm.). In small populations adult females are the primary focus of conservation actions as loosing a reproducing female is most critical for the survival of the population. Meagher and Fowler (1989) on the other hand argue that the management efforts to keep problem females in Yellowstone were a failure in the long run. Over time bears again caused problems and non of the females produced offspring that did not cause problems. In any case, it is important to create conditions under which bear-human conflicts can be largely prevented.

We believe that maintaining nocturnal behavior in bears is one important prerequisite, as nocturnal activity allows a temporal segregation of bears and people and is closely linked to shyness in bears. Nocturnal activity allows bears in Europe to live in close proximity with people while avoiding direct confrontations. A very similar situation was observed for the wolf in Italy (Ciucci et al. 1997). As nocturnal activity seems largely a consequence of own negative experiences, a certain level of disturbance is probably necessary to conserve this behavioral trait. In Slovenia and Croatia it seems that bear hunting in combination with other human activities is sufficient to keep bears shy and nocturnal. How much and what negative feedback is necessary to maintain nocturnal behavior is protected population is unknown and should be the focus of further studies.

6. Management implications

Bear conservationists have to be aware that bears when fully protected, might adopt a diurnal activity which most likely will result in more frequent bear-human encounters which eventually might result in the habituation of bears towards people. In small and protected populations, shooting a habituated bear, especially a female, is the very last option and measures should be taken to avoid bears from becoming habituated. Two important prerequisites for these efforts are, (1) a good monitoring program to document bear-people encounters and the circumstances of these encounters and, (2) an experienced field team that is able to deter bears. When a bear is suspected to have lost its fear towards people, aversive conditioning techniques should be used to teach this bear that humans are dangerous and should be avoided in the future.

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8. Reference List

Adamic, M. 1996. Decision making in the conservation management of problem wildlife species in Slovenia, based on the knowledge gained through current research projects. Gozd, 54:297-306. (In Slovenian with English abstract)

Ayres, L. A., L. S. Chow, and D. M. Graber. 1986. Black bear activity patterns and human induced modifications in Sequoia National Park. International Conference on Bear Research and Management, 6:151-154.

Bindl, C., R. Schwarz, and B. Dorsch. 2000. Aktivitätsverhalten von Braunbären. Report at the Statistical Institute of the University in Munich, Germany, 34pp. (in German)

Clevenger, A. P., F. J. Purroy, and M. R. Pelton. 1990. Movement and activity patterns of a European brown bear in the Cantabrian Mountains, Spain. International Conference on Bear Research and Management, 8:205-211.

Ciucci, P., L. Boitani, F. Francisci, and G. Andreoli. 1997. Home range, habitat use, activity and movement patterns were studied in a pack of wolves in a mountainous region of Abruzzo, central Italy from June 1986 to March 1987. Journal of Zoology (London), 243(4):803-819.

EUROPARC and IUCN. 2000. Guidelines for protected area management categories - interpretation and application of the protected area management categories in Europe. EUROPARC and WCPA, Grafenau, Germany.

Frikovic, A., R. L. Ruff, L. Cicnjak, and D. Huber. 1987. Brown bear mortality during 1946-85 in Gorski Kotar, Yugoslavia. International Conference on Bear Research and Management, 7:87-92.

Geffen, E. and D. W. MacDonald. 1993. Activity and movement patterns of Blanford´s foxes. Journal of Mammalogy, 74(2):455-463.

Georgii, B. 1980. Einflüsse menschlicher Stöhrungen auf Standortwahl und Aktivitätsmuster weiblicher Rothirsche (Cervus elaphus L.). Verhandlungen der Gesellschaft für Ökologie, Band VIII, 163-168. (in German with English abstract)

Gillin, C. M., F. M. Hammond, and C. M. Peterson. 1994. Evaluation of an aversive conditioning technique used on female grizzly bears in the Yellowstone ecosystem. International Conference on Bear Research and Management, 9(1)503-512.

Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican valley, Yellowstone National Park. Int. International Conference on Bear Research and Management, 8:73-78.

Halle, S. and N. C. Stenseth. 1994. Mictotine ultradian rhythm of activity: an evaluation of different hypotheses on the triggering mechanism. Mammal Review, 24(1):17-39.

Huber, D. and H. Roth. 1993. Movements of European brown bears in Croatia. Acta Theriologica, 38(2):151-159.

———. J. Kusak, and B. Radisic. 1996. Analysis of efficiency in live-capture of European brown bears. Journal of Wildlife Research, 1(2):162-166.

Ison, T. L., B. K. Gilbert, and R. C. Squibb. 1997. The effects of increasing human activity on brown bear use of an Alaskan River. Biological Conservation, 82(1):95-99.

Kaczensky, P., A. Wagner, and C. Walzer. 2000. Activity monitoring of brown bears - testing field methods in the Zoo. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. 2000. Bear politics in Slovenia. International Bear News, 9(2):9.

Kitchen, A. M., E. M. Gese, and E. R. Schauster. 2000. Changes in coyote activity patterns due to reduced exposure to human persecution. Canadian Journal of Zoology, 8(5):853-857.

Knauer, F. 2000 in prep. Dispersal und Ausbreitung von Braunbären in die Ostalpen. Dissertation an der Forstwissenschaftlichen Fakultät am Fachgebiet für Wildbiologie und Wildtiermanagement an der TU München. (in German)

———. P. Kaczensky, and G Rauer. 2000. A habitat model for bear expansion from Slovenia into the eastern Alps. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kusak, J. and D. Huber. 1998. Brown bear habitat quality in Gorski Kotar, Croatia. Ursus, 10:281-291.

Liddle, M. 1997. A classification of disturbance to animals. In: M. Liddle. Recreation ecology. P: 347-442. Chapman and Hall, University Press, Cambridge, Great Britain.

Linnell, J. D., M. E. Smith, J. Odden, P. Kaczensky, and J. E. Swenson. 1996. Carnivores and sheep farming in Norway. 4. Strategies for the reduction of carnivore - livestock conflicts: a review. NINA Oppdragsmelding 443:1-118.

MacHutchon, A. G., S. Himmer, H. Davis, and M. Gallagher. 1998. Temporal and spatial activity patterns among coastal bear populations. Ursus, 10:539-546.

Meagher, M. and S. Fowler. 1989. The consequences of protecting problem grizzly bears. In: M. Bromley (editor). Bear-people conflicts. Proceedings of a symposium on management strategies. p: 141-144. Northwest Territories Department of Renewable Resources, Canada.

Nielsen, E. T. 1983. Relation of behavioural activity rhythms to the changes of day and night. A revision of views. Behavior, 89:147-173.

Olson, T. L., R. C. Squibb, and B. K. Gilbert. 1998. Brown bear diurnal activity and human use: a comparison of two salmon streams. Ursus, 10:547-555.

Palomero, G., M. Aymerich, A. Callejo, A. Callejo, J. F. Garcia-Gaona, and J. Rasines. 1997. Recovery plan for brown bear conservation in the Cantabrian mountains, Spain. International Conference on Bear Research and Management, 8:205-211.

Rauer, G. and B. Gutleb. 1997. Der Braunbär in Österreich. Umweltbundesamt, Monographie, 88:64pp. (in German)

Reinhardt, I. 1996. Untersuchungen zu Aktivitätsverhalten und Zeitbudget eines Luchsweibchens (*Lynx lynx* L.) in Slowenien in der frühen Phase der Jungenaufzucht und Vergleiche verschiedener time-sampling Methoden hinsichtlich ihrer Übereinstimmung mit einer kontinuierlichen Aktivitätsaufnahme. Diplomarbeit am Lehrstuhl für Ökologie der Biologischen Fakultät, Universität München, 86pp. (in German)

Roth, H. 1980. Diel activity of a remnant population of European brown bears. International Conference on Bear Research and Management, 5:223-229.

———. and D. Huber. 1986. Diel activity of brown bears in Plitvice Lakes National Park, Yugoslavia . International Conference on Bear Research and Management, 6:177-181.

Saether, B. E., S. Engen, J. E. Swenson, O. Bakke, and F. Sandegren. 1998. Assessing the viability of Scandinavian brown bear, Ursus arctos, populations: the effect of uncertain parameter. Oikos, 83:403-406.

Servheen, C., S. Herrero, and B. Peyton. 1998. Conservation action plan for the world bears. IUCN, Gland, Switzerland.

Simonic, A. 1994. The legal protection of the brown bear in Slovene territory-past and present, and some suggestions for the. Braunbär in den Ländern Alpen-Adria, Proceedings, Ljubljana, Slovenia, p:43-75.

Swenson, J. E., F. Sandegren, M. Heim, S. Brunberg, O. J. Sorensen, A. Söderberg, A. Bjärvall, R. Franzen, S. Wikan, P. Wabakken, and K. Overskaug. 1996. Er den skandinaviske bjornen farlig? NINA Oppdragsmelding, 404:1-26.

———. F. Sandegren, A. Söderberg, A. Bjärvall, R. Franzen, and P. Wabakken. 1997. Infanticide caused by hunting of male bears. Nature, 386:450-451.

———. F Sandegren, A. Söderberg, M. Heim, O. J. Sorensen, A. Bjärvall, R. Franzen, S. Wikan, and P. Wabakken. 1999. Interactions between brown bears and humans in Scandinavia. Biosphere Conservation, 2(1):1-9.

Taberlet, P., J. E. Swenson, F. Sandegren, and A. Bjärvall. 1994. Localization of a contact zone between two highly divergent mitochondrial DNA lineages of the brown bear *Ursus arctos* in Scandinavia. Conservation Biology, 9(5):1255-1261.

Tyler, S. 1979. Time-sampling: a matter of convention. Animals Behavior, 27:801-810.

Wabakken, P. and E. Maartmann. 1994. Sluttrapport for bjorn - sauprosjektet i Hedmark 1990-93. NINA forskningsrapport, 58: 41pp. (in Norwegian with English abstract)

Wilson, D. S., A. B. Clark, K. Coleman, and T. Dearstyne. 1994. Shyness and boldness in humans and other animals. TREE, 9:442-446.

Zar, J. H. 1999. Biostatistical analysis. Prentice-Hall Internationa, Inc., Simon & Schuster/A Viacom Company, Upper Saddle River, New Jersey, USA. 663pp.

Zedrosser, A., N. Gerstl, and G. Rauer. 1999. Brown bears in Austria. Federal Environment Agency, Volume M-117, Vienna, Austria, 42pp.

Appendix1: Average squared Euclidean distances between mean hourly activity levels.

bear	ANCKA	DADO	DUSAN	FRANJO82	FRANJO83	FRANJO84	GABI	HAL	HANS	INGA87	INGA89	LILI82	LILI83	1LUCIA	MAJA	PEPI	POLONA	SRECKO	VANJA	VERA
ANCKA		2,905	1,914	,511	1,693	1,495	,457	1,566	1,726	1,213	1,801	1,730	,537	2,723	,800	1,939	,395	,628	1,320	2,879
DADO	2,905		2,264	1,302	1,471	2,484	1,936	,707	1,243	1,934	5,694	1,735	2,109	3,737	1,632	1,598	2,104	1,549	2,246	3,536
DUSAN	1,914	2,264		2,091	1,671	4,372	1,065	2,060	,380	,797	1,566	,614	1,570	,482	,767	,512	2,462	1,679	,311	,496
FRANJO82	,511	1,302	2,091		1,250	,835	,478	,492	1,414	,980	3,412	1,381	,441	3,421	,768	1,610	,244	,233	1,546	3,465
FRANJO83	1,693	1,471	1,671	1,250		3,326	,979	1,803	,632	2,163	3,177	1,435	1,294	1,821	,755	1,094	2,158	1,660	1,479	2,925
FRANJO84	1,495	2,484	4,372	,835	3,326		2,080	1,023	3,703	2,475	5,475	3,216	1,651	6,536	2,303	4,360	,522	,948	3,426	5,834
GABI	,457	1,936	1,065	,478	,979	2,080		1,085	,743	,541	2,188	,629	,230	1,902	,278	,843	,739	,404	,737	2,353
HAL	1,566	,707	2,060	,492	1,803	1,023	1,085		1,418	,908	4,386	1,043	,822	3,890	,972	1,765	,805	,372	1,505	3,323
HANS	1,726	1,243	,380	1,414	,632	3,703	,743	1,418		,977	2,279	,472	1,137	,792	,426	,218	2,120	1,326	,429	1,166
INGA87	1,213	1,934	,797	,980	2,163	2,475	,541	,908	,977		2,535	,384	,600	2,178	,705	,862	1,163	,478	,618	1,814
INGA89	1,801	5,694	1,566	3,412	3,177	5,475	2,188	4,386	2,279	2,535		2,531	2,361	1,215	1,921	2,558	3,338	3,006	1,194	1,243
LILI82	1,730	1,735	,614	1,381	1,435	3,216	,629	1,043	,472	,384	2,531		,636	1,596	,396	,628	1,871	,829	,337	1,590
LILI83	,537	2,109	1,570	,441	1,294	1,651	,230	,822	1,137	,600	2,361	,636		2,618	,402	1,294	,718	,216	,831	2,795
LUCIA	2,723	3,737	,482	3,421	1,821	6,536	1,902	3,890	,792	2,178	1,215	1,596	2,618		1,459	,946	4,016	3,197	,856	,618
MAJA	,800	1,632	,767	,768	,755	2,303	,278	,972	,426	,705	1,921	,396	,402	1,459		,841	1,040	,650	,334	1,603
PEPI	1,939	1,598	,512	1,610	1,094	4,360	,843	1,765	,218	,862	2,558	,628	1,294	,946	,841		2,453	1,511	,691	1,418
POLONA	,395	2,104	2,462	,244	2,158	,522	,739	,805	2,120	1,163	3,338	1,871	,718	4,016	1,040	2,453		,374	1,822	3,655
SRECKO	,628	1,549	1,679	,233	1,660	,948	,404	,372	1,326	,478	3,006	,829	,216	3,197	,650	1,511	,374		1,109	3,001
VANJA	1,320	2,246	,311	1,546	1,479	3,426	,737	1,505	,429	,618	1,194	,337	,831	,856	,334	,691	1,822	1,109		,645
VERA	2,879	3,536	,496	3,465	2,925	5,834	2,353	3,323	1,166	1,814	1,243	1,590	2,795	,618	1,603	1,418	3,655	3,001	,645	

Appendix 2: Description of activity pattern relative to sunset and sunrise.

	activity pattern	**increase in activity before sunset/rise**	**decrease in activity after sunset/rise**
sunset			
adults			
ANCKA	begin/middle of peak	2h 40min	3h 10min
GABI	middle/end of irregular peak	3h 45min	3h 30min
FRANJO	begin of high activity plateau	1h 30min	3h
MAJA	begin of not very distinct high activity plateau	5h 10min	5h 10min
POLONA	in middle of upward slope of high activity plateau	1h	2h 40min
HANS	begin/middle of slowly decreasing activity plateau	2h	5h 30min
subadults			
SRECKO	begin of high activity plateau	2h	> 8h
LILI83	begin/middle of high activity plateau	3h 15min	1h 45min
LUCIA	middle/end of broad peak	7h	3h 50min
yearlings			
VANJA	middle of high activity plateau	4h 20min	3h 30min
DUSAN	middle of fairly high activity plateau	5h 20min	3h 30min
VERA	begin/middle of peak	2h	2h 40min
PEPI	begin/middle of peak	4h	5h 30min
LILI82	begin of not very distinct activity plateau	4h 30min	6h 15min
sunrise			
adults			
ANCKA	begin/middle of peak	1h 40min	2h 50min
GABI	begin/middle of peak	1h	3h 45min
MAJA	begin/middle of peak	2h 30min	2h 30min
POLONA	middle of peak	2h 20min	2h 40min
FRANJO	on begin of downward slope	3h 15min	0min
HANS	begin of higher activity plateau	no	5h 45min
suabdults			
LILI83	end of high activity plateau	2h 15min	3h 15min
SRECKO	on downward slope	no	low after 5h 40min
LUCIA	on increasing slope of high activity plateau	2h 30min	5h 40min
yearlings			
LILI82	begin/middle of peak	1h	3h 15min
VANJA	middle of peak	2h	2h
VERA	begin of higher activity plateau	no	no
PEPI	begin of higher activity plateau	1h	6h 15min
DUSAN	before increase in activity	no	no

4.3. Habitat use of bears in a multi-use landscape in Slovenia.

Petra Kaczensky and Felix Knauer (45+1pp)

Habitat use of bears in a multi-use landscape in Slovenia

Habitat use of bears in a multi-use landscape in Slovenia

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Abstract

Human population growth, the intensification of agriculture and urbanization have greatly altered the natural landscape all over the world. This has resulted in habitat loss or degradation as well as habitat fragmentation for many wildlife species. Information on habitat use are fundamental for wildlife conservation and are the basis to assess human impact on wildlife habitat and subsequently the effect on the population.

In most parts of Europe brown bears (*Ursus arctos*) have to cope with human land use and human infrastructures. Several habitat suitability models tried to incorporate the impact of human population density and/or infrastructure, but empirical field data of brown bear habitat use relative to human infrastructure is more than scarce. In Slovenia a high density brown bear population (about 1 bear per 10km²) lives in a densely settled (about 42 inhabitants per km²) multi use landscape that is typical for present and potential bear areas in Europe.

Using a total of 1.698 day to day locations of 17 different bears monitored between 1993 and 1998, we analyzed habitat use on two different scales and with three different approaches. On the level of third-order habitat selection we: (1) compared distances to selected habitat features between bear locations and random points within the bears home range, (2) compared availability and use of different distance zones from selected habitat features using compositional analysis statistics. On the level of second-order habitat selection we compared the density of habitat features within different sized range estimates.

Our results show that bears movements were limited to forest cover and that it is mainly forest distribution that explains habitat use. Within the forest, security cover and /or inaccessibility of the area were important for the choice of bedding sites. The different approaches revealed a certain avoidance of houses and paved roads during the day, but only to a distance of 100-150m. The vicinity to the highway and railway tracks was not avoided at all. For forest roads the results were somewhat difficult to interpret, but if there was any affect, the impact did not exceed 10-20m. In addition, forest road density was a poor indicator of bear habitat choice as forest road density was high for all range estimates and even increased when moving from large and rather unspecific range estimators to smaller and more utilization dependent estimators.

In our study area potential habitat effectiveness was only slightly affected by human infrastructure during the day while at night potential habitat effectiveness and realized habitat effectiveness seemed almost equal. We believe that the disturbance potential caused by human infrastructures and human population density on bear habitat use is overestimated in most bear habitat models. In a landscape with a high forest cover and low forest fragmentation the disturbance and displacement potential of human infrastructure seems very low.

We recommend to clearly differentiate between the effects of infrastructure on habitat quality and the conflict potential that might arise from these structures. The latter is a result of human attitude, livestock breeding traditions, garbage storage, hunting traditions, poaching pressure, feeding of wildlife and other human influenced factors. These factors might vary widely from region to region and have to be evaluated separately from habitat quality considerations. Even the best habitat will not help much for bear conservation, if the human dimension is not addressed.

1. Introduction

Human population growth, the intensification of agriculture and urbanization have greatly altered the natural landscape all over the world. This has resulted in habitat loss or degradation (Peyton 1994, Liu et al. 1999, Forman 2000) as well as habitat fragmentation (Grau 1998, Meyer et al. 1998, Dobson et al. 1999) for many wildlife species. All three effects have consequences on the population level, reducing overall carrying capacity and influencing the structure and dynamics of animal populations. Formerly contiguous populations may become divided in several subpopulations. Depending on the dispersal ability of the species and the spatial arrangement of the habitat patches these subpopulation may still be connected through dispersal, thus forming a metapopulation (Hanski 1991, Moilanen and Hanski 1998). Beyond a critical level of fragmentation subpopulations become isolated and the probability of population extinction greatly increases (Wilcox and Murphy 1985, With and King 1999). The impact of habitat loss, degradation and fragmentation on wildlife populations is highly scale and species dependent (Keitt et al. 1997, With and King 1999).

Studying habitat use

Information on habitat use are fundamental for wildlife conservation and are the basis to assess human impact on wildlife habitat and subsequently the effect on the population. Without data on habitat use it is impossible to assess the consequences of ongoing or planned changes in human land use practices. Even though the study of wildlife habitat relationship seems a straight forward approach, there are several considerations which need to be taken into account when designing and interpreting wildlife - habitat studies. Habitat use can be studied on four general scales: first-order selection as the distribution range of a species, second-order selection as the home range of individuals of a species, third-order selection as the habitat use within the home range and forth-order selection as the selection of special habitat components within selected subsamples of the home range (Johnson 1980). Depending on the chosen scale, results are relevant on the local, regional or landscape level. Besides the scale effect, studies of habitat have to consider four main methodological problems: (1) inappropriate level of sampling and sample size, (2) non-independence of proportions, (3) differential habitat use by groups of individuals, and (4) arbitrary definition of habitat available (Aebischer et al. 1993).

Large carnivores and human land use

Large carnivores have large home ranges in the magnitude of several 10 to 1000 km² (Amstrup et al. 2000, Breitenmoser et al. 1993, Jackson and Ahlborn 1988) and thus are especially prone to be affected by human land use. Furthermore, in many areas where large carnivores coexist with humans, being carnivors results in: (1) competition for game animals, (2) livestock depredation and (3) human injury or even death (Jackson and Nowell 1996, Linnell et al. 1996). The consequences are often highly negative attitudes, resulting in intensive persecution.

Even when protected, human caused mortality might remain the most important mortality factor, and in such a situation human infrastructures, like roads, which facilitate human access, may greatly increase the mortality risk. This will result in a large deviance between potential habitat effectiveness (relative probability of using landscape features in the absence of human activity) and realized habitat effectiveness (using landscape features in the presence of human activity, Mace et al. 1999). In the US this negative relationship has been shown for gray wolves (*Canis lupus*) in the Great Lakes Region (Mladenoff et al. 1995) as well as for grizzly bears (*Ursus arctos*) in Western Montana (Mace et al. 1999). Furthermore, human infrastructure and human activity can have a high disturbance potential, resulting in frequent flight reactions or overall displacement of a species (e.g. Dyke et al. 1986, McLellan and Shackelton 1989, Liddle 1997, Linnell et al. 2000).

Brown bears in Europe

In Europe, brown bears were extirpated by the end of the last century in most parts of central and southern Europe (Kaczensky 1996, Breitenmoser 1998). Today attitudes towards large carnivores have changed, and considerable efforts are being put into bear recovery projects. For example, intensive management and reintroduction projects are underway in the Italian (Dupre et al. 1999) and Austrian Alps (Rauer and Gutleb 1997) and the French Pyrenees (Quenette 1999). However, bears in these regions have to cope with multiple human land use practices and human infrastructures. The impact of habitat fragmentation, barriers (especially high speed roads) and other human infrastructure are great concerns for bear recovery.

Several models were developed to assess habitat suitability for bears in south and central Europe (Aste 1993, Arbeitsgemeinschaft Braunbär Life 1997, Kusak and Huber 1998, Clevenger et al. 1997, Corsi et al. 1998, Dupre et al. 1999). These models were based on the available knowledge of the target population, on findings from other European and North American populations and on expert expertise. In all of these models a certain influence of human infrastructure is incorporated, especially an avoidance of roads and villages, or a negative influence associated with high densities of human inhabitants. However, empirical field data on brown bear habitat use and the impact of human infrastructure is scarce for Europe.

The few data that exists, suggest a negative impact of villages and roads on bear movements, but findings are based on few individuals and do not allow for a quantitative assessment (Cicnjak 1991, Clevenger et al. 1997, Quenette 1999). To what extent findings from North America are relevant for the European situation, is questionable. Living conditions of brown bears in North America are quite different from those in Europe, as in North America: (1) there is little overlap between occupied brown bear habitat and areas of high human densities (>25/km^2) (Mattson 1989), (2) bears have not undergone centuries of coexistence/persecution by rural man, (3) bears seem to have a lower reproductive potential ($\geq$3 year reproductive interval as compared to a $\geq$2 year reproductive interval in most European populations), making them more sensitive to human caused losses.

In Slovenia a high density brown bear population (about 1 bear per 10km²) lives in a densely settled (about 42 humans per km²) multi-use landscape a situation that is typical for present and potential bear areas in Europe. Using radio telemetry locations we analyzed habitat use of 17 individual bears with three different approaches and on two different scales:

- On the scale of third-order selection we compared: (1) distances of bear locations and random points to selected habitat features and (2) availability and use of different distance zones around selected habitat features
- On the scale of second-order selection we compared the density of selected habitat features between different sized range estimators

Our expectations were:

(1) Bears avoid the vicinity of forest roads, paved roads, highways, railways, houses and villages, but are attracted to anthropomorphic food sources

(2) Bears avoid disturbance from people by selecting for dense cover, high elevation, or steep slopes and by selecting for areas with a low density of forest roads, paved roads, highways, railways, houses and villages

2. Methods

2.1. Bear data

Capture and telemetry

We captured bears with Aldrich foot snares at bait sites and tranquilized them with Zoletil®, a mix of Tiletamin and Zolazepam. We grouped bears according to four age-classes: cubs of the year (COYs), yearlings, subadults (2-3 years) and adults ($\geq$ 4 years). Adult and subadult bears were fit with radiocollars (MOD-600, MOD-400 Telonics, USA) while yearlings and COYs received eartag transmitters (EL-2(42) and EL-2(29); Holohil, Canada). Trapping, chemical restrain and radiomarking procedures followed methods described by Kaczensky et al. (2000, this thesis chapter 4.1.).

We attempted to locate bears on a day to day basis by car or on foot. Due to a dense net of forest roads, the distance between observer and bear was generally less than 1000m. The quality of the position was estimated by the observers from the signal strength, the angles between the different bearings for triangulation and the topography. Locations were classified as:

(1) location error $\leq$ 50m: bear circled on close range and/or radiosignal close to maximal

(3) location error $\leq$ 250m: bear only partly circled or circled at a longer distance and/or topography limits the maximum distance between bear and observer

(3) location error ≤ 500m: bear not circled, or circled on long distance (>1 km), and/or azimuth between most distant successive bearings less than 120° apart

Winter denning locations were excluded from this analysis. To ensure independence of locations we only used the first location per day with the highest location accuracy. 92% of all daily locations were acquired during daylight hours. We restricted our analysis to bears that were located at least 15 times. Locations of COYs were assigned to the adult female and not treated as independent locations. Locations of yearlings were assigned to the adult female before family breakup and as independent locations of the yearling thereafter. Family breakup was determined via radiotelemetry when the female and the cubs were radiomarked and otherwise was determined from tracks. In total, we used 1.698 daily locations from 17 different bears, monitored between 1993 and 1998 (Tab.1).

Activity monitoring

For several bears, activity patterns were monitored during continuous 24-hour monitoring sessions. Bear activity was recorded at 10 minute intervals for a 1 minute sampling period (for details see Kaczensky et al. 2000, this thesis chapter 4.2.). We assigned each activity sample an active status if there were more than 4 changes in the signal strength or an inactive status if there were less than 4 changes. After each activity sample we checked if the bear had changed position and if so, determined the new position of the bear by triangulation. The accuracy of the locations was estimated in the same way as for daily locations, but in addition, locations of bears were classified as:

(1) Daybed: at least 5 consecutive activity samples with inactive status or 3 hours at the same location and more than 50% of the activity samples with inactive status. As bears often stayed for several hours at the same daybed, only one location per daybed was used for analysis.

If bears were active, we distinguished between two types of activity:

(2) Stationary activity: at least 4 activity samples with active status but without a detectable change in position

(3) Travelling activity: less than 4 activity samples on the same location (the distance between two consecutive locations was more than the expected location error)

Tab. 1: Available data for habitat use analysis. MCP=minimum convex polygon, MCP2500=minimum convex polygon buffered with 2500m.

bear	monitoring period	daily locations	home range size (km²) MCP	MCP250	locations during activity monitoring daybed	travelling
adult females						
ANCKA94	23.04.94 - 15.07.95	110	63	163	0	0
ANCKA98[3]	10.04.98 - 29.09.99	173	39	118	53	137
MAJA	23.04.95 - 20.06.97	236	49	135	8	12
METKA	24.03.94 - 26.09.94	67	59	159	0	0
POLONA	06.04.98 - 15.09.99	171	55	143	49	190
subadult / adult males						
MISHKO	07.04.94 - 06.11.95	126	276	453	0	0
yearling / subadult females						
JANA	04.05.93 - 07.11.94	112	287	538	0	0
LUCIA	18.10.96 - 08.10.97	169	41	123	58	109
subadult males						
UROSH	05.04.95 - 31.05.95	18	99	218	0	0
SRECKO	28.03.97 - 01.11.97	140	516	809	41	68
yearling females						
VANJA	21.04.97 - 12.08.97	73	21	88	32	66
VERA	05.10.96 - 12.06.97	90	44	129	0	0
yearling males						
CLIO	26.03.94 - 31.05.94	21	24	98	0	0
DUSAN	04.05.97 - 12.07.97	42	33	111	9	25
JOZE	18.03.98 - 03.05.98	24	34	121	0	0
NEJC	23.03.98 - 06.03.99	94	396	630	0	0
VINKO	31.10.96 - 20.05.97	32	100	222	0	0

[1]denning period excluded
[2]for resident bears with >100 locations the 95% MCP was used, for all others the 100% MCP
[3]recapture but unclear identity

2.2. Habitat data

Digital database

We used the scanned forest layers of topographic maps in the scale 1:25.000 provided by the Geographical Institute of Slovenia (Geodetski Dokumentacijski Center, Slovenije). The original database was in TIFF format, but most of the scans were of insufficient quality. Therefore we corrected and georeferenciated them again with a comprehensive image processing. For all data processing we used PC ARC/INFO 3.5.1 or ArcView 3.1 and the Spatial Analyst 1.1 extension.

Additionally, we deleted non-forest areas created by forest roads. On the original scans, these forest roads were classified as 25m wide, non-forested areas, but in reality they did not exceed 6m. We deleted all narrow linear features of non-forest areas up to 20m in width by buffering the forest layer by 10m to the outside, dissolving buffers and buffering the forest layer back with 10m to the inside. We converted all corrected data into shape files. Because of the poor quality of the original data and the resulting costs for data processing we limited data processing to an area of 2.114 km², covering 98% of our bear locations (Fig.1).

For this area we also bought digital data on roads in 5 different categories (highway, paved road, forest road, and 2 different categories of logging roads) and individual houses in vector format (ARC/INFO) from the Geographical Institute of Slovenia (Geodetski Dokumentacijski Center, Ljubljana, Slovenia, see Fig.1). Of the road layer, we only used the categories highway, paved road, and forest road for analysis. The two additional categories were former skidding trails or very cryptic paths often completely overgrown and rarely used by humans. All forest roads are open to the public and accessible by regular 2x2 vehicles. As railroads were not included in the road layer, we digitized railway tracks from 1:25.000 topographic maps.

To test whether single house or rather settlements influence bear movements, we outlined settlements by buffering individual houses with a 100m radius, dissolving the buffers, and deleting all areas smaller than 1500 m². In this way, we classified multiple houses standing next to each other as villages and discarded separated houses from the village layer. For analysis we use both, the house and the village layer as separate variables. We calculated aspect and slope from a digital elevation model of Slovenia with a grid size of 100m for the whole study area.

For our core study area we digitized all former clearings and/or spruce plantations (referred to as plantations) from forestry maps in the scale 1:5.000 which were provided by the Slovenian State Forest Service (Zavod za Gozdove Slovenija, see Fig.1). Most of these plantations showed high cover values, which we expected to be select for by bears as security cover.

To test for an influence of feeding sites on habitat use we included all corn and meat feeding sites in the digital database. We derived this information by systematically questioning hunters and foresters within our core study area (Fig.1).

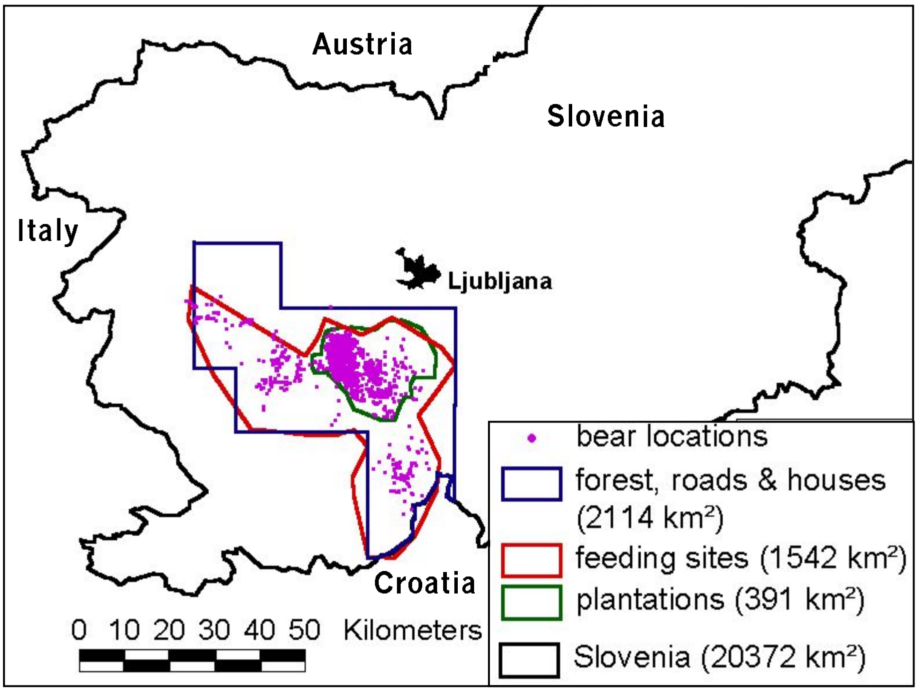


Fig. 1: Bear locations and GIS database.

Day bed investigations

To get information on small-scale habitat features, we investigated 53 day-beds of collared bears within our core study area. On a plot of 20m by 20m around the daybed we measured species composition and age of trees, % cover of the ground (0-20cm), shrub (20-100cm), bush (1-5m), and tree (> 5m) layer, as well as slope and aspect. Overall visibility was estimated by counting paces in the four main compass directions until a colored backpack or Labrador sized dog situated in the center of the daybed was not visible any more. We used the mean number of paces as visibility index. For comparison, 50 random plots were chosen on the map, visited and habitat features measured in the same way than for day bed plots.

Available habitat

As we lacked presence-absence data of bear distribution for Slovenia, we focused most of our analysis on second- and third-order habitat selection, that is habitat selection within the home range and for the home range (Johnson 1980).

We used two different approaches to define habitat availability for third-order analysis: (1) the home range buffered with the average daily distance traveled and (2) the unbuffered home range. The rational behind this two step analysis was that bears might already show a selection by confining their movements to a certain home range. Areas within the range of the average daily distances traveled should be still available, but might not be used because of low suitability.

We used the minimum convex polygon (MCP, White and Garrott 1990) to describe the home range of each bear. For resident bears with ≥100 locations we used the 95%

MCP and for all others the 100% MCP. We considered a bear to be resident, when it showed a high site fidelity during the monitoring period.

For the buffer we used the average straight line distance between locations on two consecutive days, which was about 2500m (Knauer and Kaczensky 2000, Knauer 2000 in prep.). We calculated MCPs and MCPs plus buffer in ArcView, using the Animal Movement 1.1 extension (Hooge and Eichenlaub 1997).

For MCPs and MCPs plus 2500m buffer (MCP2500) we calculated the % forest cover, % plantation cover, % villages and the density of houses, feeding sites, railways, highways, paved roads and forest roads.

Cluster analysis

Because habitat characteristics of MCPs and MCP25000 varied widely for individual bears we tested whether bears form distinct groups. Based on the habitat characteristics of the MCP and the MCP25000 we ran separate hierarchical cluster analyses. We standardized habitat features to a mean of 1, thus maintaining the relative variance. We assigned bears to clusters using the squared Euclidean distances and the between group linkage. This method uses the average distance between all samples in a cluster to determine the distance to a new cluster, this way considering all samples of a cluster.

All statistical analysis were performed with the SPSS 9.0 software. All differences were tested on the p<0,05 significance level.

2.3. Third order habitat selection

Distances to selected habitat features

For comparison with bear locations we generated 200 evenly distributed random points in the MCP and the MCP2500 respectively for each individual bear. Than we calculated the following features for each bear location and each random point:

(1) closest distance to: forest road, paved road, highway, railway, single house, village, feeding site and forest edge

(2) habitat characteristics: forest/non forest, size of forest patch, plantation/non plantation, size of plantation patch, elevation, slope and aspect

For ease of writing we subsequently refer to this dataset as *distance data*. As most distances did not follow a normal distribution we compared random points and bear locations with non-parametric tests, using two-tailed U-tests when comparing two samples and Kruskal Wallis tests for comparison of multiple samples. The significance level was set to p<0,05.

A modeling approach with our telemetric data indicated that the perception range for bears is probably in the magnitude of 500-1000m (Knauer et al. 2000, Knauer 2000 in prep.). This means that habitat features at distances of more than 1000m are probably irrelevant for bears. Hence we ran a second analysis including only distances

≤1000m to the selected habitat features. We subsequently refer to this dataset as the *≤1000m distance data*.

In order to detect possible minimum distances we ran a third analysis for each variable including only the 10% percentiles of the forest random points and the bear locations (derived from each individual bear separately). Due to the small sample sized we did not compare these distances separately but rather compared the pooled bear distances with the pooled random points. We subsequently refer to this dataset as the *10% percentile distance data*.

When comparing the *≤1000m distance data* or the *10% percentile distance data* we used parametric t-tests, as we can assume a normal distribution for the total sample and by definition this dataset does not include outliers any more.

Adult bears and most subadult bears had a largely nocturnal activity pattern (Kaczensky et al. 2000, this thesis chapter 4.2.). As 92% of all daily bear locations were realized during the daytime, we assume that we mostly located inactive bears at their bedding sites. To test for any differences in the habitat use of active and inactive bears we used the locations derived during 24-hour monitoring and compared the distances to the selected habitat features between travelling and bedding bears.

Use of different distance zones from selected habitat features - compositional analysis

When describing habitat use one faces the problem that an animal's proportional use of one habitat type is not independent of all other habitat types because the portions sum up to 1. If an animal prefers any type of habitat, this automatically means that another type is used less, suggesting an avoidance. To correct for this bias we used compositional analysis which allows testing for overall deviance from random use. An other advantage of this method is that it uses the animal as sampling unit and not the radiolocations, hence accounting for individual variation (Aebischer et al. 1993; Aebischer and Robertson 1992). For all features except plantations we applied the non-mapping technique using our random points for availability (Marcum and Loftsgaarden 1980). As bears were never located outside the forest, we based availability only on random points within the forest (*forest random points*).

We classified aspect into 9 categories: flat (maximum slope 5°), N, NE, E, SE, S, SW, W, NW and slope into 4 categories: flat (0-5°), moderate (6-30°) and steep (>30°). We did not used compositional analysis for elevation as the elevation range within several home ranges was very narrow, covering less than 400m.

For human infrastructure we defined 4 distance zones of 0-400m, 401-800m, 801-1200m and >1200m for the relatively rare structures: paved road, houses, villages and feeding sites. Because of the dense net of forest roads it was possible to compare habitat use in 6 distance zones of 0-100m, 101-200m, 201-300m, 301-400m, 401-500m, >500m. Bears that did not have one or more of the 4 or 6 zones available within the MCP were removed from the analysis.

For plantations we did not use distance zones but rather tested, whether plantations were used more intensively than available. Again, only the forested range within the MCP was used for availability.

The highway and railway were excluded from compositional analysis as both structures were only available to a few bears. In addition, both structures were located mainly along the outer edge of the MCP, resulting in very few random points next to the two structures.

2.4. Second-order habitat selection - density of selected habitat features in different range estimators

Each home range estimator has its pros and cons. The MCP is widely used, but depending on the underlying landscape structure (e.g. heterogeneity of habitat, fragmentation and geometric arrangement) and the distribution of the radiolocations it may encompass large areas of unused habitat (White and Garrott 1990). Kernel estimates on the other side, are based on the counts of locations within grid cells, from which isolines of expected utilization distribution are calculated (e.g. 95% probability to be used). By this method, large, unused areas are not included and the resulting range estimate might even be disconnected (White and Garrott 1990, Hooge and Eichenlaub 1997). The advantage is that areas of high use can be easily identified and receive more weight. But both, the MCP and kernel approach, are sensitive to outliers. A more conservative approach is to use a fixed window around the actual locations and use the resulting total area to describe second-order habitat selection (Zimmermann 1998). Depending on the size of the window, the utilized range will only be a fraction of the home range or kernel estimate.

We assumed that habitat choice would be more pronounced when moving from a large range estimate, which is only partly based on actual use (MCP plus buffer) to a smaller and more use-dependent range estimate (fixed window around locations). We compared six different range estimators for their composition in respect to: forest cover (%), plantation cover (%), village cover (%), the density of forest roads (km/km^2), paved roads (km/km^2), houses ($number/km^2$), feeding sites ($number/km^2$) and the total length of highway and railway.

For the range estimators we used the following: MCP2500, MCP, 95% fixed kernel estimate and the area resulting from a point buffer of 1000m (point1000, ~3,14 km^2), 500m (point500, ~0,8 km^2) and 250m (point250, ~0,2 km^2) around each bear location. We calculated the 95% fixed kernel home range utilization distribution using the Animal Movement 1.1 extension (Ad hoc calculation option, Hooge and Eichenlaub 1997). Our expectation was that if bears show second-order habitat selection in respect to our features, the density of human infrastructure would decrease from the largest range estimate to the smallest in the following order: MCP2500 > MCP $\geq$ 95%kernel estimate $\geq$ point1000 > point500 > point250, while forest cover, plantation cover and density of feeding sites would increase in the same order.

3. Results

3.1. Characterization of home ranges

Home range size (MCP)

MCP size was quite variable and depended on sex and residential status. For five adult females MCP size varied between 39 and 63 km² and for one young adult male (*MISHKO*) it was 276 km² (Tab.1). All six bears showed high site fidelity and we considered them to be residents. Five yearling bears, one subadult female (*LUCIA*) and one subadult male (*UROSH*) also showed high site fidelity during the monitoring period. MCP sizes for these seven bears varied between 21-99 km². Even though *UROSH* was only monitored for a short time, he was killed in the same area two years later. One subadult female (*JANA*), one subadult male (*SRECKO*) and two yearling males (*VINKO* and *NEJC*) left the area where they had been captured and had much larger ranges than the other bears of the same age group.

Home range characteristics (MCP and MCP2500)

Habitat features of the MCPs and MCP2500 differed widely for some bears especially in regard to human infrastructure (Fig.2). Cluster analysis identified two coherent groups and one isolated bear (*VINKO*) when comparing bears by their MCP characteristics (Fig.3), but not when comparing bears by their MCP2500 characteristics. Bears in group1 had MCPs <100km² and were living in the area with almost 100% forest cover, without villages, not fragmented by paved roads, but with a high density of forest roads. The highway and railway ran along the edge of this large forest complex. Bears in group2 generally had larger ranges and the MCPs included open areas, settlements and paved roads. While four adult females were found in group1, one adult female (*POLONA*) was also found in group2 (Fig.4) and she successfully raised COYs in 1999. For the isolated bear *VINKO* only few data were available and the habitat characteristics of his MCP were different from those of group1 and group2, especially with respect to the high percentage of village area. When adding a 2500m buffer around the MCP, differences between bears in group1 and group2 were leveled out because for bears of group1 the buffer included areas with a higher density of human infrastructure than found within the MCP (Fig.2).

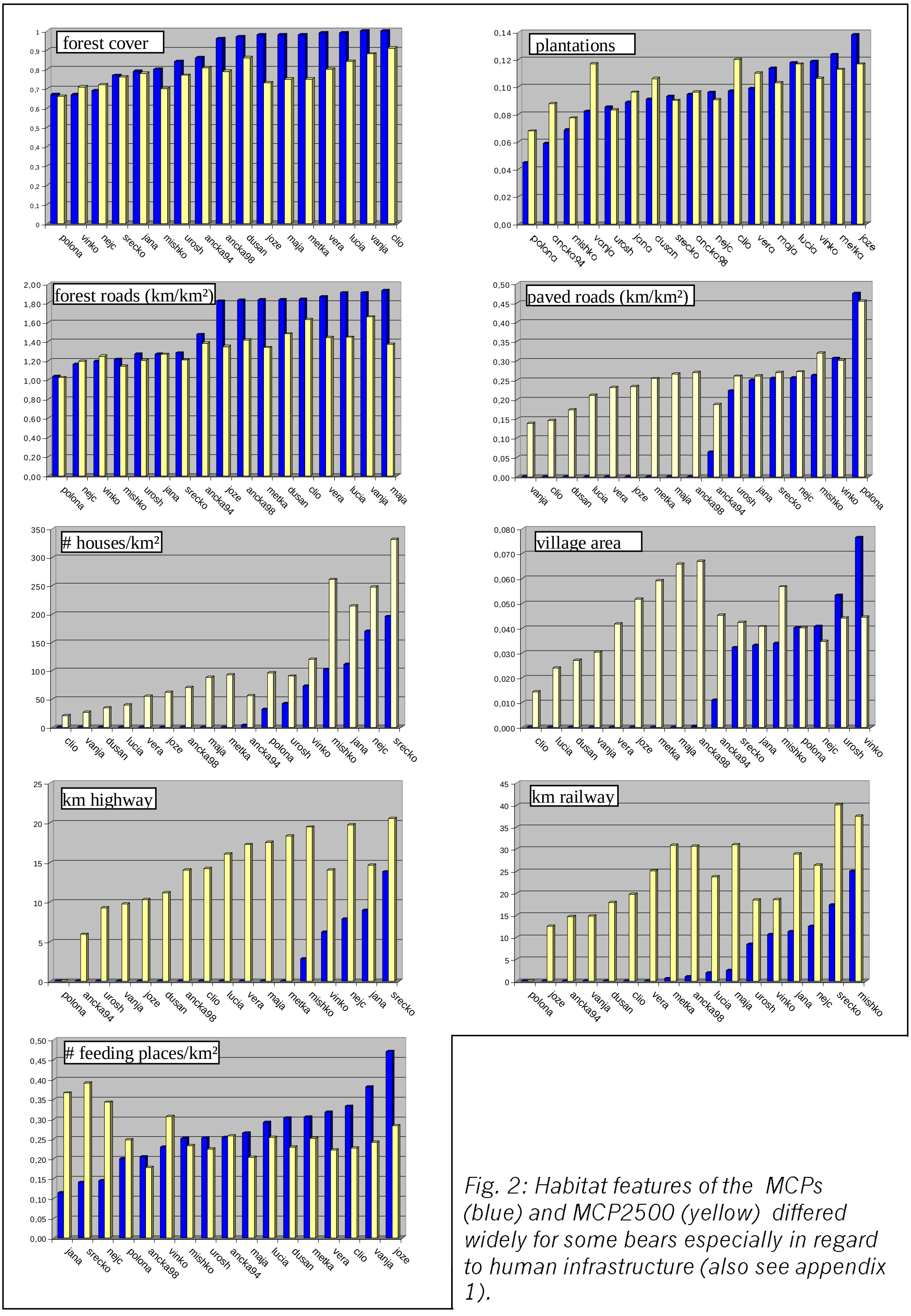


Fig. 2: Habitat features of the MCPs (blue) and MCP2500 (yellow) differed widely for some bears especially in regard to human infrastructure (also see appendix 1).

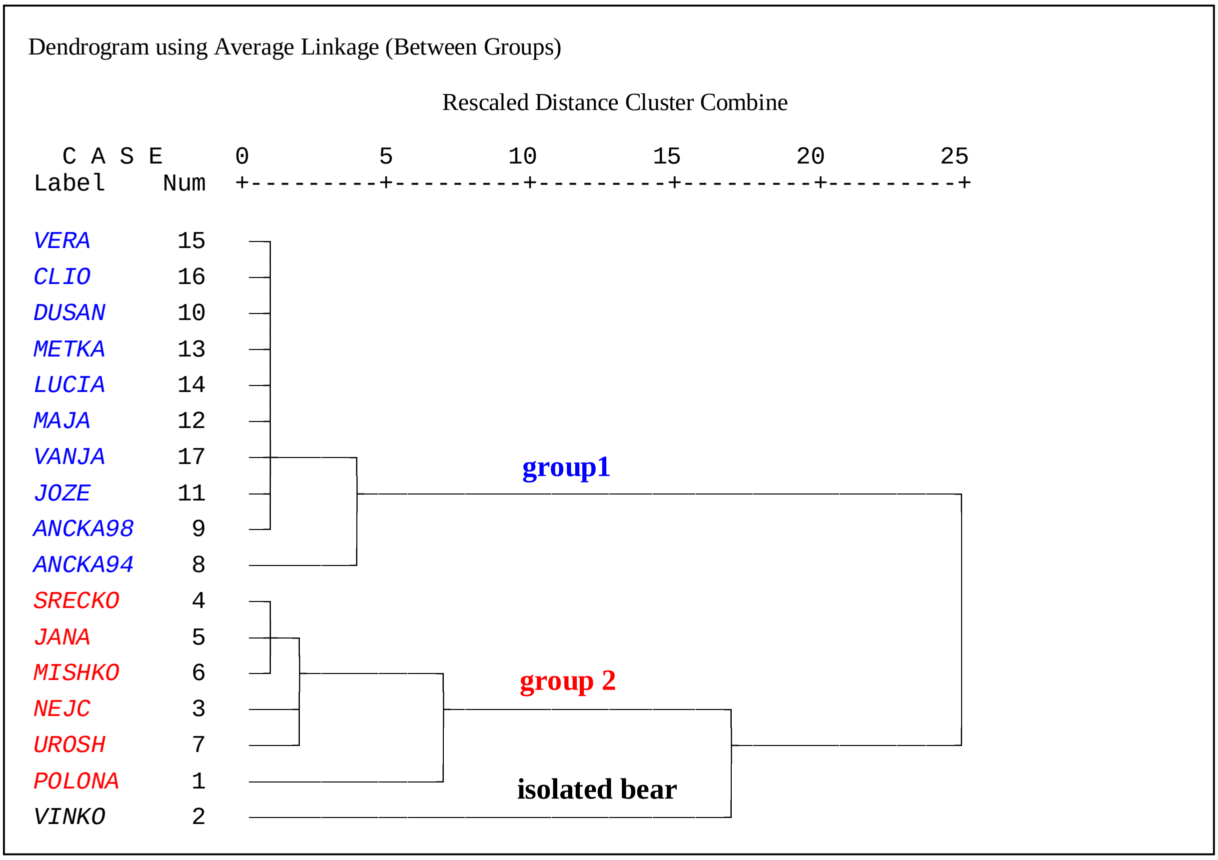


Fig. 3: Cluster analysis with habitat features of the MCPs resulted in two distinct groups and one isolated bear. Group1 (blue) is situated in a large forest patch with almost no human infrastructure, while the MCPs of bears in group2 (red) include villages, paved roads and unforested areas.

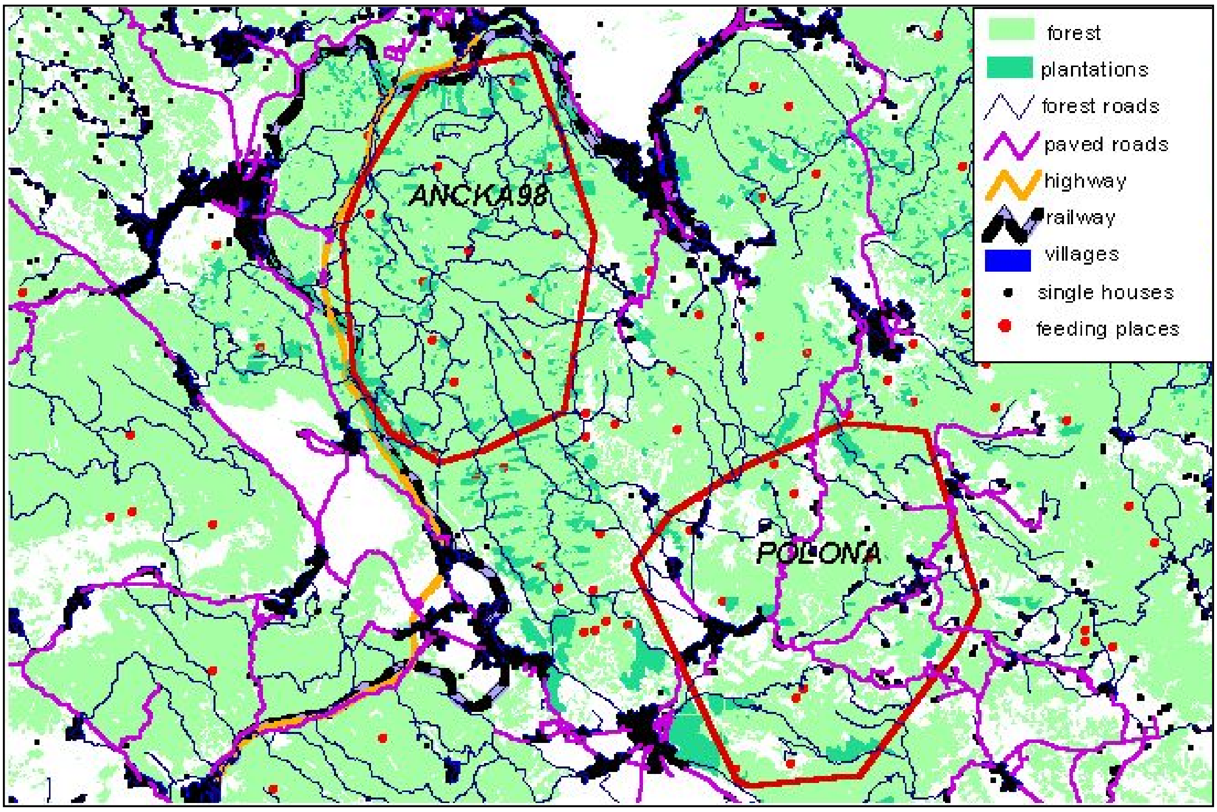


Fig. 4: MCPs of two adult females, the one of ANCKA98 belonging to group1 (low density of human infrastructure) and the one of POLONA belonging to group2 (higher density of human infrastructure).

3.2. Third-order habitat selection – distance data

Comparison of bear locations and random points within the MCP2500

When defining the MCP2500 as available habitat, bear locations were significantly farther away from the forest edge, houses, villages and paved roads and significantly closer to feeding sites than random points for most bears (Tab.2). For the other habitat features no clear trend was obvious, as several bears either did not show a significant difference and/or some bears showed an opposite trend. The observed pattern largely follows our expectations.

*Tab. 21: U-test p value matrix comparing random points within the MCP2500 and bear locations. Only the features forest edge, feeding, house, village and paved roads show a consistent trend for bears in both groups. Features with significant differences are marked * (light gray: trend as expected). The expectation for bear locations were: higher, steeper, closer to plantation and feeding, farther from forest edge, forest road, house, village, paved road, highway and railway.*

group	bear	height	slope	plantation	forest edge[1]	forest road	feeding	house	village	paved road	high-way	rail-way
1	*ANCKA94*	0,29	0,00*	0,02*	0,08	0,01*	0,21	0,00*	0,00*	0,00*	0,00*	0,04*
1	*ANCKA98*	0,00*	0,00*	0,00*	0,01*	0,75	0,01*	0,00*	0,00*	0,00*	0,06	0,03*
1	*CLIO*	0,00*	0,21	0,81	0,25	0,63	0,00*	0,34	0,00*	0,00*	0,02*	0,09
1	*DUSAN*	0,03*	0,28	0,43	0,01*	0,92	0,23	0,00*	0,00*	0,00*	0,35	0,00*
1	*JOZE*	0,69	0,92	0,00*	0,21	0,09	0,03	0,46	0,44	0,05	0,42	0,53
1	*LUCIA*	0,39	0,01*	0,11	0,00*	0,02*	0,00*	0,00*	0,00*	0,00*	0,02	0,26
1	*MAJA*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,12	0,00*
1	*METKA*	0,07	0,23	0,00*	0,00*	0,09	0,00*	0,00*	0,00*	0,00*	0,36	0,01*
1	*VANJA*	0,00*	0,11	0,04*	0,00*	0,13	0,01*	0,00*	0,00*	0,00*	0,01*	0,00*
1	*VERA*	0,00*	0,03*	0,81	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*
2	*JANA*	0,00*	0,51	0,00*	0,99	0,14	0,00*	0,00*	0,00*	0,00*	0,04*	0,04*
2	*MISHKO*	0,00*	0,08	0,04	0,22	0,33	0,00*	0,00*	0,00*	0,00*	0,50	0,79
2	*NEJC*	0,01*	0,00*	0,01*	0,86	0,51	0,62	0,16	0,49	0,00*	0,00*	0,00*
2	*POLONA*	0,08	0,00*	0,75	0,03*	0,00*	0,37	0,98	0,06	0,28	0,01*	0,67
2	*SRECKO*	0,21	0,22	0,00*	0,01*	0,01	0,01*	0,00*	0,00*	0,00*	0,00*	0,12
2	*UROSH*	0,14	0,74	0,09	0,00*	0,28	0,00*	0,00*	0,01*	0,19	0,00*	0,00*
3	*VINKO*	0,98	0,19	0,00*	0,49	0,42	0,00*	0,45	0,75	0,22	0,68	0,25

[1] only locations within the forest were considered

However all bear locations were within the forest and one can assume that the effective bear habitat is restricted to forest range. Therefore it seemed more appropriate to use only random points within the forest (*forest random points*) for comparison. When we compared bear locations with *forest random points*, the picture remained the same for bears of group1, but not for bears in group2 (Tab.3). This result is contrary to our expectation, as it suggests indifferent behavior of bears in the more fragmented habitat towards human infrastructure. It further suggests that for bears of group2, the larger distances of bear locations as compared to all random points can be explained by random points outside the forest. The avoidance of human infrastructure by bears in group1, on the other hand, seemed to be largely attributed to the buffer, which is quite different in composition than the MCP.

Tab. 32: U-test p value matrix comparing forest random points *within the MCP2500 and bear locations. Now only the features forest edge, house, village and paved road show a consistent trend for bears of group1, but not for bears of group2. Features with significant differences are marked * (light gray: trend as expected). The expectation for bear locations was: higher, steeper, closer to plantation and feeding, farther from forest edge, forest road, house, village, paved road, highway and railway.*

group	bear	height	slope	plantation	forest edge	forest road	feeding	house	village	Paved Road	high way	rail way
1	*ANCKA94*	0,12	0,00*	0,00*	0,07	0,00*	0,77	0,01*	0,00*	0,04*	0,00*	0,03*
1	*ANCKA98*	0,04*	0,00*	0,00*	0,01*	0,13	0,65	0,00*	0,00*	0,00*	0,21	0,37
1	*CLIO*	0,00*	0,33	0,46	0,25	0,88	0,00*	0,76	0,00*	0,02*	0,04*	0,18
1	*DUSAN*	0,05	0,14	0,66	0,01*	0,70	0,56	0,00*	0,00*	0,00*	0,03*	0,00*
1	*JOZE*	0,23	0,80	0,01*	0,21	0,30	0,31	0,56	0,41	0,49	0,21	0,22
1	*LUCIA*	0,65	0,00*	0,52	0,00*	0,46	0,02*	0,01*	0,00*	0,00*	0,02*	0,32
1	*MAJA*	0,00*	0,02*	0,00*	0,00*	0,01*	0,03*	0,00*	0,00*	0,00*	0,14	0,00*
1	*METKA*	0,70	0,03*	0,00*	0,00*	0,56	0,05	0,00*	0,00*	0,00*	0,58	0,07
1	*VANJA*	0,00*	0,35	0,00*	0,00*	0,49	0,06	0,00*	0,00*	0,00*	0,00*	0,00*
1	*VERA*	0,00*	0,26	0,37	0,00*	0,03*	0,06	0,00*	0,00*	0,00*	0,00*	0,00*
2	*JANA*	0,00*	0,20	0,00*	0,98	0,20	0,07	0,13	0,05	0,03*	0,04*	0,04*
2	*MISHKO*	0,00*	0,89	0,88	0,22	0,12	0,01*	0,04	0,47	0,13	0,59	0,90
2	*NEJC*	0,24	0,26	0,01*	0,86	0,82	0,41	0,89	0,38	0,28	0,00*	0,00*
2	*POLONA*	0,00*	0,00*	0,36	0,04*	0,00*	0,90	0,00*	0,00*	0,01*	0,01*	0,45
2	*SRECKO*	0,82	0,05	0,04*	0,01*	0,00*	0,05	0,00*	0,00*	0,00*	0,00*	0,08
2	*UROSH*	0,12	0,84	0,19	0,00*	0,40	0,00*	0,00*	0,19	0,55	0,00*	0,00*
3	*VINKO*	0,21	0,02*	0,00*	0,49	0,67	0,00*	0,94	0,09	0,47	0,76	0,21

Comparison of bear locations and forest random points within the MCP

Contrary to our expectations, we also failed to find a consistent trend when comparing *forest random points* within the MCP and bear locations. This was true for bears of both groups and it seemed that within the home range bears are rather indifferent of being close to any of the selected habitat parameters. For several bears from group1 distances to houses, villages and paved roads were actually closer than for random points. The same was true for bears of both groups in respect to the highway and railway. An affinity to plantations and feeding sites was only observed for a few bears, while most bears seemed indifferent.

Tab.4:U-test p value matrix comparing forest random points *within the MCP and bear locations. No features showed a consistent trend any more, neither for bears of group1 nor for bears of group2. Features with significant differences are marked * (light gray: trend as expected). The expectation for bear locations was: higher, steeper, closer to plantation and feeding, farther from forest edge, forest road, house, village, paved road, highway and railway.*

group	Bear	height	slope	plantation	forest edge	forest road	feeding	house	village	paved road	high way	rail way
1	*ANCKA94*	0,01*	0,00*	0,91	0,12	0,00*	0,84	0,91	0,73	0,01*	0,00*	0,33
1	*ANCKA98*	0,00*	0,02*	0,00*	0,00*	0,33	0,76	0,00*	0,12	0,00*	0,00*	0,00*
1	*CLIO*	0,00*	0,16	0,71	0,00*	0,91	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*
1	*DUSAN*	0,71	0,33	0,64	0,92	0,01*	0,18	0,17	0,30	0,87	0,75	0,31
1	*JOZE*	0,77	0,18	0,12	0,11	0,86	0,97	0,02*	0,01*	0,02*	0,39	0,28
1	*LUCIA*	0,07	0,78	0,08	0,02*	0,01*	0,16	0,16	0,23	0,02*	0,00*	0,00*
1	*MAJA*	0,90	0,00*	0,00*	0,32	0,01*	0,25	0,03*	0,38	0,48	0,79	0,82
1	*METKA*	0,02*	0,68	0,00*	0,98	0,28	0,27	0,42	0,08	0,52	0,09	0,41
1	*VANJA*	0,79	0,02*	0,58	0,09	0,42	0,22	0,00*	0,25	0,03*	0,43	0,29
1	*VERA*	0,01*	0,01*	0,13	0,25	0,57	0,69	0,02*	0,47	0,01*	0,00*	0,01*
2	*JANA*	0,00*	0,43	0,01*	0,02*	0,22	0,00*	0,00*	0,07	0,00*	0,02*	0,02*
2	*MISHKO*	0,07	0,87	0,79	0,73	0,45	0,13	0,50	0,48	0,41	0,94	0,58
2	*NEJC*	0,14	0,00*	0,01*	0,20	0,72	0,07	0,62	0,58	0,24	0,00*	0,00*
2	*POLONA*	0,00*	0,01*	0,00*	0,03*	0,00*	0,41	0,50	0,01*	0,25	0,00*	0,05
2	*SRECKO*	0,90	0,13	0,29	0,00*	0,03*	0,01*	0,00*	0,00*	0,00*	0,00*	0,02*
2	*UROSH*	0,47	0,15	0,19	0,08	0,27	0,07	0,18	0,18	0,78	0,20	0,53
3	*VINKO*	0,06	0,44	0,02*	0,21	0,73	0,01*	0,10	0,64	0,42	0,03*	0,40

Even when pooling bear locations by groups, and comparing them with pooled *forest random points* we only found significant and meaningful differences for forest edge, houses, villages and paved roads when comparing bear locations of bears from group1 and *forest random points* within the MCP2500. No meaningful differences were found between bear locations and *forest random points* within the MCP for neither group (Fig.5a+b).

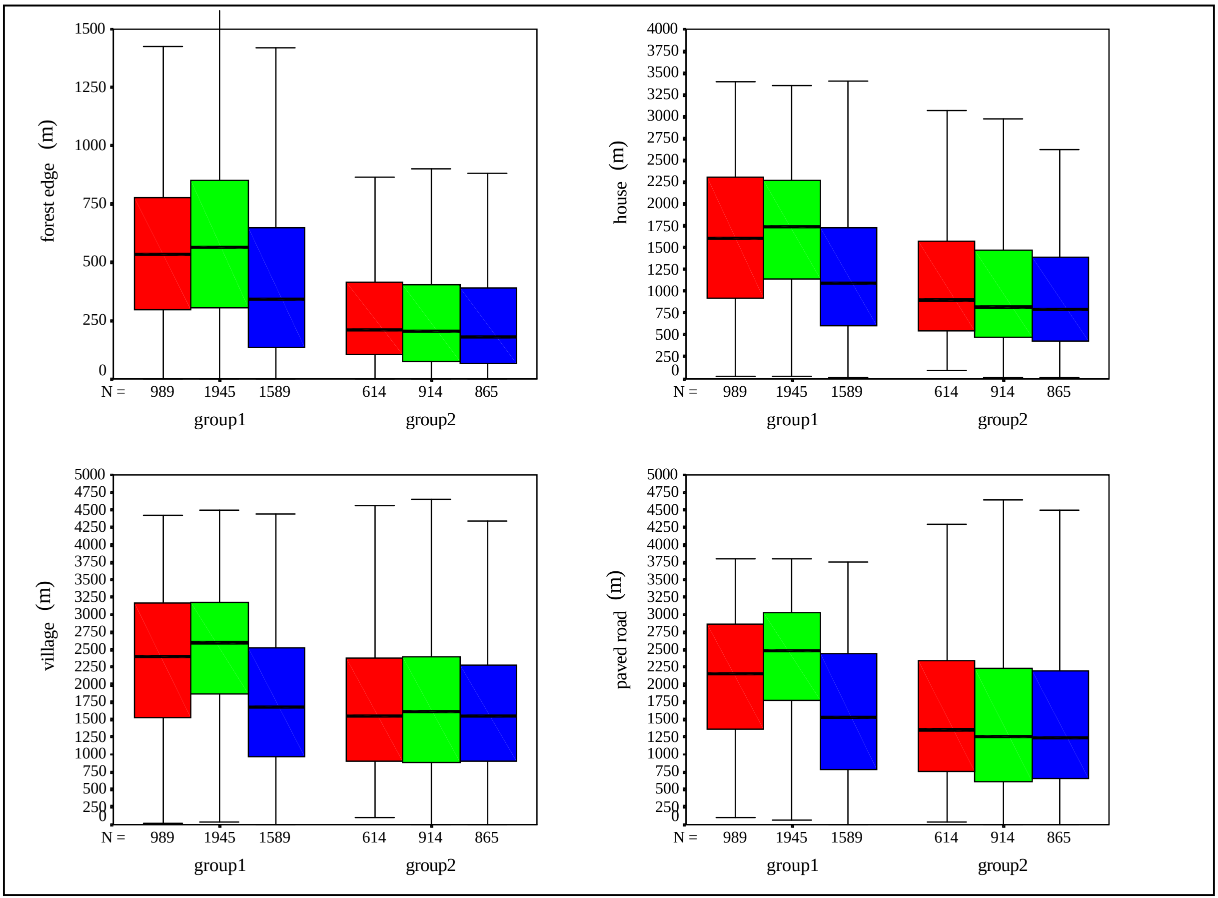
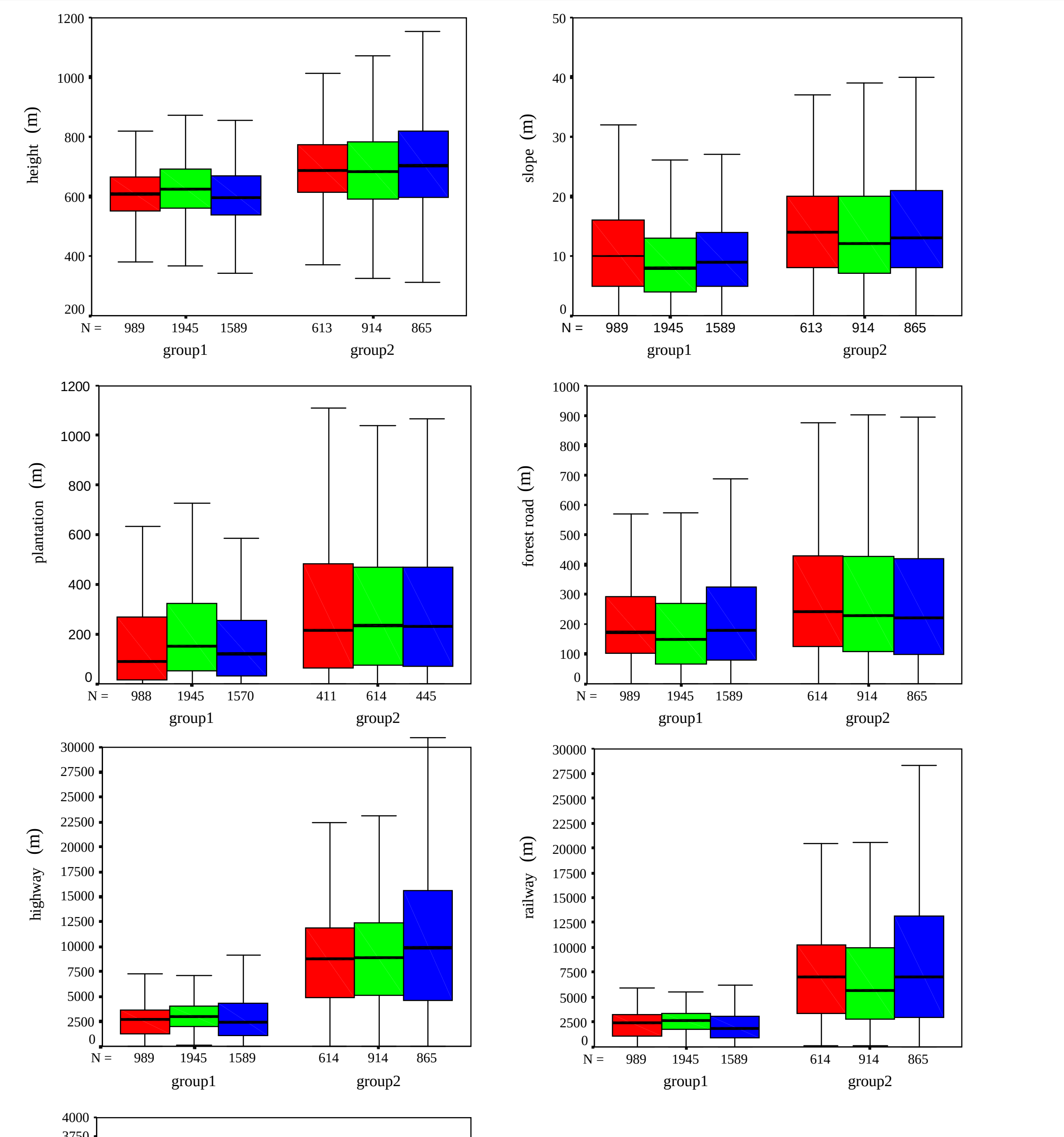


Fig. 5a: Significant and meaningful differences in the distances between forest random points *and bear locations were only found for forest edge, houses, villages and paved roads when comparing* forest random points *within the MCP2500 and bear locations from bears of group1. No differences were found for bears of group2 and for bear locations of both groups and* forest random points *within the MCP. Red boxes: bear locations, green boxes: random points within the MCP, blue boxes: random points within the MCP2500.The box indicates the median, 25% and 75% quartiles and whiskers are the largest values that are not outliers.*



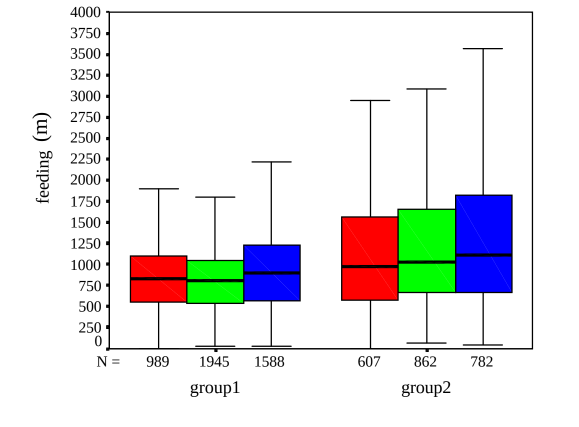


Fig.5b: No significant or meaningful differences in the distances between random points and bear locations were found when comparing forest random points *within the MCP2500 or the MCP for elevation, slope, plantations, forest roads, the highway, the railway and feeding sites. Red boxes: bear locations, green boxes: random points within the MCP, blue boxes: random points within the MCP2500.*

Considering only a subset of all distances – *≤1000m distance data* and *10% percentile distance data*

When comparing the *≤1000m distance data* we again did not find a consistent pattern for all bears (Tab.5). Six out of the 17 bears showed larger distances to forest roads, while one bear was actually closer than the corresponding *forest random points*. Three bears of group2 were significantly farther away from houses, three from the forest edge and all six were significantly or almost significantly farther away from paved roads as compared to the *forest random points*. No bear was farther from the highway or railway and one bear was even closer than the *forest random points*. Only five bears were closer to plantations and three bears were closer to feeding sites than the corresponding *forest random points*.

Our sub-sample did not select against bear locations as there was no difference in the ratio of *forest random points* towards bear locations in the *≤1000m distance data* as compared to the total sample (t-test for one sample, all p>0,05 for goupg1 and group2 and all bears pooled).

Tab. 53: T-test p value matrix for comparison of ≤1000m distance data *of bear locations and* forest random points*. Features with significant differences are marked *. Light gray: trend as expected. The expectation for bear locations was: closer to plantation and feeding, farther from forest edge, forest road, house, village, paved road, highway and railway.*

group	bear	plantation	forest edge	forest road	feeding	house	village	paved road	highway	railway
1	*ANCKA94*	0,69	0,05	0,01*	0,51	0,77	0,99	0,44	---	---
1	*ANCKA98*	0,00*	0,04*	0,78	0,38	0,18	0,43	0,00*	0,37	0,10
1	*CLIO*	0,17	0,00*	0,27	0,00*	0,44	---	---	---	---
1	*DUSAN*	0,76	0,64	0,03*	0,43	0,49	---	---	---	---
1	*JOZE*	0,17	0,36	0,86	0,95	0,27	---	---	---	---
1	*LUCIA*	0,53	0,69	0,04*	0,00*	0,97	0,15	0,27	0,86	0,51
1	*MAJA*	0,00*	0,05	0,02*	0,11	0,52	0,95	0,16	0,29	0,63
1	*METKA*	0,00*	0,81	0,57	0,33	0,15	0,34	0,65	0,00*	0,00*
1	*VANJA*	0,49	0,37	0,66	0,76	---	---	---	---	---
1	*VERA*	0,42	0,51	0,10	0,37	0,40	---	---	---	---
2	*JANA*	0,04*	0,02*	0,04	0,01*	0,00*	0,02*	0,00*	0,28	0,21
2	*MISHKO*	0,76	0,40	0,64	0,32	0,94	0,34	0,04*	---	---
2	*NEJC*	0,05	0,19	0,63	0,78	0,75	0,56	0,06	---	---
2	*POLONA*	0,04*	0,06	0,00*	0,65	0,03*	0,17	0,00*	---	---
2	*SRECKO*	0,07	0,00*	0,01*	0,14	0,01*	0,01*	0,06	---	---
2	*UROSH*	0,89	0,02*	0,25	0,09	---	---	---	---	---
3	*VINKO*	0,57	0,91	0,88	0,57	0,04*	0,05	0,07	0,80	0,99

--- less than 10 distances for bear locations and/or random points

Daybed versus travelling relocations

We did not find the expected pattern that daybeds were located at higher elevation, in steeper terrain, closer to dense cover (plantation) and farther away from human infrastructure. Out of seven bears which we had monitored during continuous 24-hour sessions, only two bears showed significant differences between daybed and travelling locations for at least one habitat variable in the expected direction (*POLONA and VANJA*, see Tab.6). When bedded, *POLONA* was in significantly steeper slopes (but only 15° versus 12°) and significantly farther from the forest edge (mean difference about 30m), from forest roads, houses and villages (mean difference about 100m) than while travelling. *VANJA* was only significantly farther away from the forest edge at daybeds than when travelling (mean difference about 100m).

POLONA was the only adult female and the bear with the smallest MCP of all bears in group2. She had the smallest total amount of forest available of all adult bears (37 km², see appendix 1). In fall she went very close to the villages several times at night, presumably to feed on apples and plums in the orchards, while during the day she was bedded in remote areas. No other bear showed a similar behavior.

Tab.6: U-test p value matrix for comparing differences in the distances of daybed and travelling locations towards selected habitat features. Only the ≤1000m distance data *were used for comparison. Features with significant differences are marked *. Light gray: trend as expected. Our expectation was that daybeds would be at higher elevations, in steeper slopes, closer to plantations and farther away from the forest edge, forest road, highway, railway, house, village and paved road.*

group	bear	height	slope	plantation	forest edge	forest road	highway	railway	house	village	paved road
1	*ANCKA98*	0,15	0,32	0,50	0,67	0,50	0,84	0,49	0,86	0,48	0,43
1	*DUSAN*	0,98	0,78	0,92	0,33	0,46	----	----	----	----	----
1	*LUCIA*	0,15	0,09	0,75	0,47	0,59	0,55	0,19	0,30	0,61	0,98
1	*MAJA*	0,03*	0,45	0,31	0,90	0,93	----	0,97	----	----	----
1	*VANJA*	0,06	0,66	0,58	0,02*	0,97	----	----	----	----	----
2	*POLONA*	0,53	0,03*	0,97	0,02*	0,00*	----	----	0,00*	0,04*	0,47
2	*SRECKO*	0,60	0,52	0,30	0,04*	0,11	----	----	0,09	0,51	0,91

---- less than 10 locations within 1000m either for travelling or daybed locations.

Finally we compared the *10% percentile distance data* of the bear location and forest random point. With this approach, bears of group1 failed to show an avoidance of human infrastructure; for most habitat features the trend was even reversed (Tab.6). Only for forest roads bear distances were slightly larger than random distances, though the difference was only 10m. Bears of group2 were significantly farther away only from paved roads. Here the average distance of bears was about 100m farther than the random point sample. Bear distances were also farther away from houses and villages, but the distance was not significant.

Tab. 74: T-test p value matrix for 10% percentile distance data *for bear locations (group1: n=167, group2: n=280) and forest random points (n=20) within the MCP. Significant differences (t-test, p<0,05) are marked > or <. Light gray: trend as expected. The expectation for bear locations was: closer to plantation and feeding, farther from forest edge, forest road, house, village, paved road, highway and railway.*

	house			**village[1]**			**forest road**			**paved road**			**highway**			**railway**			**forest edge**		
group	**bear**		**rand**	**bear**		**rand**	**bear**		**rand**	**bear**		**rand**	**bear**		**rand**	**bear**		**rand**	**bear**		**rand**
group1	424	<	544	983	<	1123	23	>	13	786	<	1033	584	<	1052	571	<	882	51	<	81
group2	289	-	239	515	-	357	35	-	30	325	>	214	1815	-	2371	1572	-	1676	40	-	24

rand=forest random points

3.3. Third-order habitat selection - compositional analysis

Aspect, slope and forest edge

Compositional analysis of aspect and slope did not show a significant difference from random use, suggesting no general preference or avoidance. Wilks-Lambda significance level for aspect was 0,110 (n=17) and for slope: 0,126 (n=15).

We also did not find a significant difference in habitat use for the 6 distance zones from the forest edge. Wilks-Lambda was 0,834 (n=17), suggesting that bears did not avoid the zones close to the forest edge.

Human infrastructure

Wilks-Lambda for the 4 distance zones for paved roads was 0,679 (n=19), for houses was 0,395 (n=17) and for villages 0,185 (n=10), again suggesting random use of the different distance zones.

For the 6 distance zones for forest roads, Wilks-Lambda was 0,023, suggesting non-random use of the different zones. Ranking of the zones showed a significantly lower use of zone 0-100m as compared to zones 101-200m and 201-300m, but not as compared to the other zones farther away (Tab.8).

Tab. 85: Matrix of the mean log-ratio differences between utilized (bear locations) and available (random points within MCP) distance zone from forest roads for 17 bears. Positive values show preference, negative avoidance. In the lower part of the table preference is ranked by adding up the number of positive signs for each distance zone. Triple signs (--- or +++) show significant differences in observed and expected use (T-test for one sample against 0, all p< 0,05).

	distance zones						
	0-100	**101-200**	**201-300**	**301-400**	**401-500**	**>500**	**rank**
0-100		-0,55	-0,4	0,82	0,55	0,97	
101-200	0,55		0,15	1,37	1,1	1,52	
201-300	0,4	-0,15		1,22	1,01	1,37	
301-400	-0,82	-1,37	-1,22		-0,27	0,15	
401-500	-0,55	-1,1	-1,01	0,27		0,45	
>500	-0,97	-1,52	-1,37	-0,15	-0,45		
0-100		---	---	+	+	+	3
101-200	+++		+	+	+	+	5
201-300	+++	-		+	+	+	4
301-400	-	-	-		-	+	1
401-500	-	-	-	+		+	2
>500	-	-	-	-	-		0

Plantations

Analysis of the differences between random points and bear locations only showed a slight tendency of bear locations being closer to plantations (Tab. 4 and 5). However when comparing the actual use of plantations with their availability, only *VERA* did not select for plantations. When considering all bears we got a highly significant preference for plantations (t-test for one sample against 0, p<0,001; see Tab.9).

Tab. 96: % availability of plantations within the MCP, % of locations within plantations and log-rations for the 2 habitat types plantation and forest for the MCP and for bear locations. A positive differences between the log-ratios of used (locations) minus available (MCP) shows preference, a negative difference avoidance.

	% plantation		ln(plantation/forest)		
bear	**MCP**	**locations**	**MCP**	**locations**	**difference**
ANCKA94	6	9	-2,512	-2,160	0,352
ANCKA98	9	23	-2,159	-0,883	1,277
CLIO	10	14	-2,079	-1,608	0,471
DUSAN	9	14	-2,172	-1,608	0,564
JANA	9	30	-1,914	-0,211	1,703
JOZE	14	33	-1,609	0,283	1,892
LUCIA	12	24	-1,833	-0,762	1,070
MAJA	11	25	-1,933	-0,683	1,250
METKA	12	30	-1,819	-0,218	1,601
MISHKO	7	15	-2,244	-1,501	0,743
NEJC	10	16	-1,589	-1,367	0,222
POLONA	4	6	-2,691	-2,509	0,182
SRECKO	9	13	-1,880	-1,614	0,266
UROSH	9	33	-1,992	0,181	2,173
VANJA	8	8	-2,351	-2,322	0,029
VERA	10	16	-2,067	-2,322	-0,255
VINKO	12	43	-1,276	1,679	2,956
mean	***8,94***	***19,56***	***-2,007***	***-1,037***	***0,970***

Field investigations of 52 daybeds and 50 random plots showed that most day beds were in rather dense cover, often in spruce plantations and had a significantly reduced visibility index (Fig.6). While almost 70% of all daybeds were in vegetation plots with more than 50% bush cover, only 12% of the non-investigated daybeds were classified from the map as being within plantations and an other 47% to be within 100m of plantations. Bears did not show a preference for large plantations over small ones (U-test, all p values between 0,085-1,00 for 7 bears with more than 10 locations and random points in plantations) and a lot of the daybeds might actually be located in small natural thickets or clearings that were either wrongly marked on the forestry maps or not mapped at all. We believe that with our data we underestimate bears' selection for areas of dense cover.

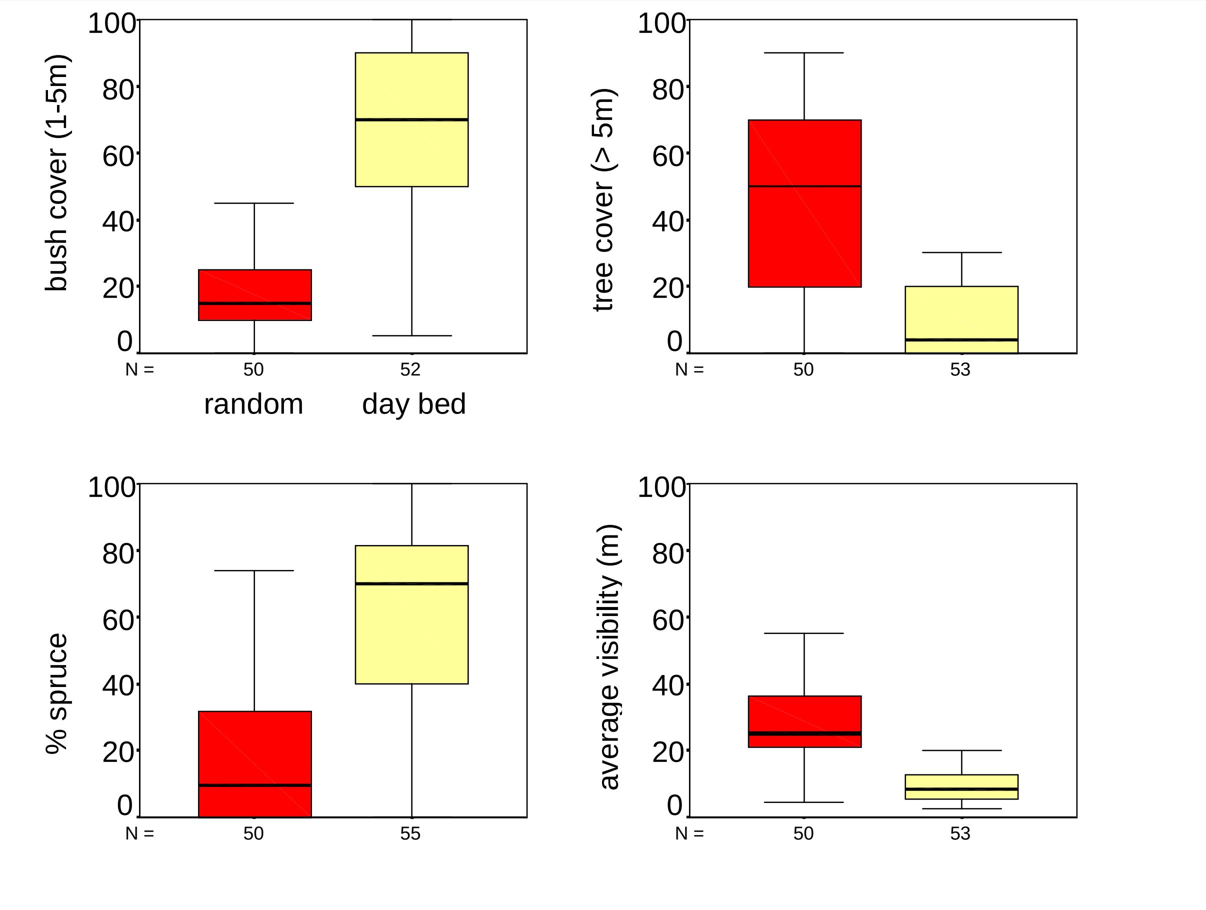


Fig.6: Results of field investigations of day beds (dark gray) as compared to random plots (light gray). Bears selected for areas with low visibility which meant areas with a dense bush layer and consequently a low tree canopy cover. Most beds were located in 10-15 year old spruce plantations. The box indicates the median, 25% and 75% quartiles and whiskers are the largest values that are not outliers.

Feeding sites

Compositional analysis revealed a statistically significant non-random use of the 4 distance zones (Wilks-Lambda: 0,013). Habitat ranking showed a significantly higher use of areas 0-400m from feeding sites. The preference was significant as compared to the use of areas 401-800m and 801-1200m away, the difference to areas >1200m away was not significant (Tab.10). The result is rather difficult to interpret, especially since it was difficult to prove without direct observation whether a bear just passed by, foraged in the vicinity, or actually visited a feeding site.

Tab.10: Matrix of the mean log-ratio differences between utilized (bear locations) and available (random points within MCP) distance zone from feeding sites for 17 bears. Positive values show preference, negative avoidance. In the lower part, preference is ranked by adding up + signs. Triple signs (--- or +++) show significant differences in observed and expected use (T-test for one sample against 0, all p< 0,05).

	distance zones				
	0-400	**401-800**	**801-1200**	**>1200**	**rank**
0-400		0,41	0,64	0,35	
401-800	-0,41		0,23	-0,06	
801-1200	-0,64	-0,23		-0,29	
>1200	-0,35	0,06	0,29		
0-400		+++	+++	+	**3**
401-800	---		+	-	**1**
801-1200	---	-		-	**0**
>1200	-	+	+		**2**

3.4. Second-order habitat selection - different range estimators

Total area of the different range estimates varied considerably and sharply decreased in size from the MCP2500 (range: 88- 809) to the point250 (range: 3 - 22 km²) range estimate (Fig.7). Concerning the density of habitat features there were significant differences for all variables except the density of feeding sites for all bears pooled and for bears of group1 separately. For bears of group2 there were no significant differences for forest roads, the highway and railway (Kruskal Wallis, all p values < 0.05, Tab.11).

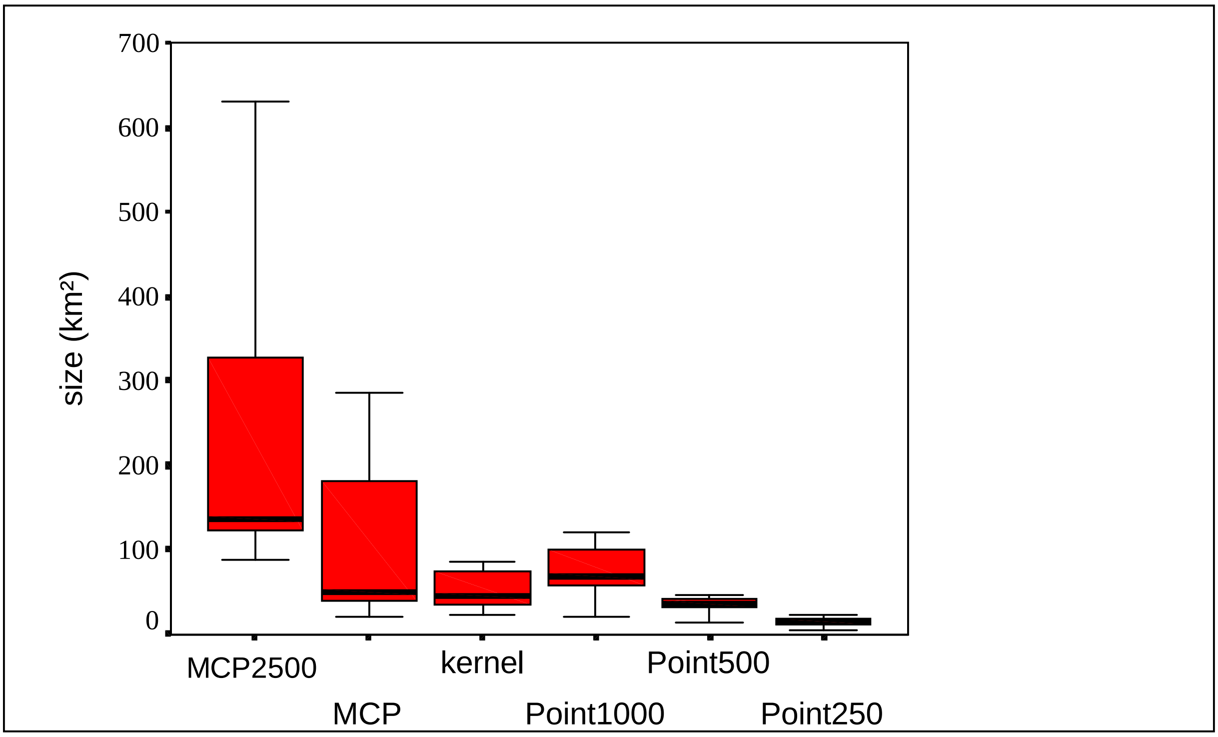


Fig.7: Size distribution of different range estimates. The box indicates the median, 25% and 75% quartiles and whiskers are the largest values that are not outliers.

Tab. 117: Kruskal Wallis p value matrix for differences in the density of habitat features of the range estimates (df=5).

groups		forest cover	forest road	paved road	highway	railway	feeding	house	village	plantation
all bears	sign.	0,00	0,03	0,00	0,00	0,00	0,04	0,00	0,00	0,17
group1	sign.	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,34
group2	sign.	0,00	0,08	0,04	0,18	0,84	0,03	0,00	0,00	0,87

If there is avoidance or preference for the density of certain habitat features this should be more distinct, the smaller the range estimate and/or the more precise it describes the area of bear activity. However, we only found a consistent trend in the density of the habitat features for bears from group2 for the variables: forest cover, paved roads, houses and villages. The trend for forest roads was opposite to our expectation, but forest road density within the range estimate is highly correlated with forest cover. Bears of group1 did not show a consistent trend for any of the variables. They seem to live in a high quality habitat (in respect to the selected features) and the selected habitat features are rather evenly distributed. Any sub-sample of the MCP is almost equal in composition to the MCP (Tab.12).

feature	range estimators	ranks group1 (n=10)	ranks group2 (n=6)
forest cover	MCP2500	7	7 ↓ (green)
	MCP	42	11
	kernel	31 ★	15 ★
	Point1000	27	22
	Point500	34	26
	Point250	42	30
forest roads	MCP2500	10	10 ↓ (red)
	MCP	34	13
	kernel	40 ★	19
	Point1000	27	24
	Point500	40	26
	Point250	33	20
paved roads	MCP2500	55	28 ↑ (green)
	MCP	15	25
	kernel	33 ★	18 ★
	Point1000	37	17
	Point500	25	15
	Point250	18	10
highway	MCP2500	30	15
	MCP	11	11
	kernel	38 ★	21
	Point1000	39	24
	Point500	37	24
	Point250	29	17
railway	MCP2500	48	21
	MCP	14	20
	kernel	32 ★	22
	Point1000	34	17
	Point500	29	15
	Point250	26	16
houses	MCP2500	54	30 ↑ (green)
	MCP	15	27
	kernel	31 ★	24 ★
	Point1000	35	15
	Point500	26	10
	Point250	22	5
villages	MCP2500	54	29 ↑ (green)
	MCP	18	27
	kernel	30 ★	24 ★
	Point1000	37	15
	Point500	24	10
	Point250	20	6
feeding sites	MCP2500	14	25
	MCP	35	12
	kernel	31 ★	11 ★
	Point1000	28	15
	Point500	36	21
	Point250	39	27
plantations	MCP2500	26	16
	MCP	21	16
	kernel	34	16
	Point1000	32	20
	Point500	33	21
	Point250	38	22

[1] *POLONA* excluded, as there is no highways nor railways available in any of the range estimators

Tab.12: Mean ranks of the density of habitat features for different range estimates (Kruskal-Wallis test).

Green arrow: expected trend, red arrow: trend contrary to expectation.

Our expectation was that the density of human infrastructure would decrease from the largest range estimate to the smallest in the following order: MCP2500 > MCP ≥ 95%kernel estimate ≥ point1000 > point500 > point250, while forest cover, plantation cover and density of feeding sites would increase in the same order.

★ : differences significant on the p<0,05 significance level. The red arrow results from a positive correlation of forest road density and forest cover.

Pair wise comparison of the MCP with the other range estimates shows a very similar picture as the *distance data* (Tab.13). For bears of group1 there were significant differences in the expected direction between the MCP and the MCP2500 for all variables, except for forest roads and plantations. For bears of group2 there was no such trend.

The kernel estimate resulted in a higher density of roads, highway and railway as compared to the MCP for bears of group1. For bears of group2 the density of paved roads was lower, but for all other features there were no significant differences.

For bears of group1, the point1000 had a higher density of all human infrastructures, except forest roads, and showed no difference for the other features as compared to the MCP. For bears of group2, forest cover and density of forest roads was higher, and the density of villages and houses was lower than for the MCP.

Habitat composition of point500 and point250 did not differ from the MCP for bears of group1, but had higher forest cover, a higher density of feeding sites and a lower density of paved roads, houses and villages for bears of group2. As with the *distance data*, the presence of the highway and railway does not seem to affect second-order habitat selection. However, this is clearly an artifact of the range estimators, as no resident bear had a range that was dissected by the highway and the parallel railway.

*Tab.13: U-test p value matrix for differences in the density of habitat features. Features with significant differences are marked *. Light gray: trend as expected. Our expectation was that the density of human infrastructure would decrease from the largest range estimate to the smallest in the following order: MCP2500 > MCP ≥ 95%kernel estimate ≥ point1000 > point500 > point250, while forest cover, plantation cover and density of feeding sites would increase in the same order.*

range type & group	forest cover	forest roads	paved roads	highway	railway	houses	village	feeding sites	plantations
MCP - MCP2500									
group1	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,00*	0,26
group2	0,30	0,29	0,13	0,11	0,69	0,34	0,34	0,04	1,00
MCP - kernel									
group1	0,12	0,36	0,01*	0,00*	0,01*	0,02*	0,06	0,45	0,11
group2	0,20	0,05	0,04*	0,19	0,75	0,34	0,29	0,87	1,00
MCP - 1000point									
group1	0,05	0,08	0,00*	0,00*	0,00*	0,01*	0,00*	0,17	0,13
group2	0,02*	0,04*	0,08	0,04	0,63	0,01*	0,02*	0,52	0,52
MCP - 500point									
group1	0,14	0,23	0,04*	0,00*	0,05	0,06	0,16	0,60	0,23
group2	0,02*	0,05	0,20	0,04*	0,42	0,00*	0,02*	0,20	0,52
MCP - 250point									
group1	0,61	0,76	0,36	0,01*	0,11	0,20	0,63	0,36	0,11
group2	0,01*	0,52	0,04*	0,51	0,42	0,00*	0,00*	0,02*	0,33

3.5. Summing up of results

To facilitate overall interpretation of results Tab.16 gives an overview of the results from the different analysis. Our initial expectations were:

(1) Bears avoid the vicinity of forest roads, paved roads, highways, railways, houses and villages, but are attracted to anthropomorphic food sources

(2) Bears avoid disturbance from people by selecting for dense cover, high elevation, or steep slopes and by selecting for areas with a low density of forest roads, paved roads, highways, railways, houses and villages

*Tab.16: Overview of the results of the second- and third-order habitat selection analysis. 0 stands for no consistent trend detected (less than half the bears showed the same trend or some bears showed an opposite trend), ++: preference, -- : avoidance; in brackets: half the bears showed the expected trend, ? interpretation not clear; *: trend as expected from the initial hypothesis; nm=not measured.*

analysis	group[1]	topography			forest characteristics			human infrastructure						
		altitude	**slope**	**aspect**	**forest**	**plantation**	**forest edge**	**forest road**	**paved road**	**house**	**village**	**highway**	**railway**	**feeding**
Third-order habitat selection														
distance data														
MCP2500	1	0	0	nm	++*	0	--*	0	0	--*	--*	0	--*	++*
(all random points)	2	0	0	nm	++*	0	--*	0	0	--*	--*	0	0	++*
MCP2500	1	0	0	nm	nm	0	--*	0	0	--*	--*	0	--*	(+)
(forest random points)	2	0	0	nm	nm	0	(-)	0	0	0	0	0	0	0
MCP	1	0	(+)	nm	nm	0	0	0	0	0	0	0	0	0
(forest random points)	2	0	0	nm	nm	0	(-)	0	0	0	0	0	0	0
MCP	1	nm	nm	nm	nm	0	0	0	0	0	0	0	0	0
≤1000m distance data	2	nm	nm	nm	nm	0	(-)	0	--*	--*	0	0	0	0
compositional analysis														
MCP	1+2	nm	0	0	nm	++*	0	--?	0	0	0	nm	nm	++?
Second-order habitat selection														
different range estimates														
rank	1	nm	nm	nm	0	0	nm	0	0	0	0	0	0	0
of density	2	nm	nm	nm	++*	0	nm	++	--*	--*	--*	0	0	0

[1] as specified by cluster analysis (Fig.3)

4. Discussion

4.1. Methods used

Bear behavior is highly flexible even in relation to human infrastructure and might vary greatly, e.g. depending on previous experiences of the bear, human persecution, habitat availability, or the distribution of food sources. Although we used data from 17 bears, we do not have a representative sample of all age and sex classes. Hence we chose to analyze habitat use on the individual level first and in the next step filter general patterns from the individual variance.

It was very clear from the beginning of the analysis that habitat use, especially in regard to any preference or avoidance of human infrastructure, depended on the habitat available within the MCP. Ten out of 17 bears had overlapping MCPs in an area with almost 100% forest cover that was undivided by paved roads and where there were almost no houses or villages. As these bears were located in an area with low human infrastructure one can hardly expect to see an avoidance of these structures (Aberg et al. 2000). Hence for analysis we split bears in two groups, group1 living in the low impact and group2 in the higher impact area.

Third-order habitat selection

The most critical point was defining habitat availability, even when analyzing third-order habitat selection (Neu et al. 1974, Aebischer et al. 1993). When using the MCP2500 for availability and comparing bear locations with all random points we saw some of the expected patterns with most bears being farther away from the forest edge, paved roads, houses and villages and closer to feeding sites (Tab.2). However, all bear locations lay within forest cover, suggesting that the effective habitat is restricted to forest cover. Hence in a second step we compared only *forest random points* with bear locations, with the result, that an avoidance was only detectable for bears living in the unfragmented landscape, but not for bears living in the fragmented landscape (Tab.3). This rather unexpected outcome seemed largely attributable to the buffer around the MCP. This buffer greatly differed in habitat composition as compared to the MCP for bears of group1, but not for bears of group2.

Therefore in a third step we used the MCP for availability and again compared bear locations with *forest random points*. Now neither the bears of group2 nor those of group1 showed any difference to *forest random points* in respect to any of the selected habitat features, suggesting no third-order habitat selection in respect to the selected habitat features. However, bears have a certain perception range and a grid based habitat use analysis made us believe that it is in the range of 500-1000m (Knauer et al. 2000, Knauer 2000 in prep.). When using the *≤1000m data* for comparing bear locations and forest random points we suddenly saw an avoidance of paved roads and houses for bears in group2. Bears of group1 can hardly show an avoidance of these habitat features, as they are available only at the edge or in a small part of their MCP. On the other hand, both groups showed a largely indifferent reaction to the habitat features that were available to both groups (forest roads, plantations, feeding sites, the highway and railway).

In a second approach to study third-order habitat selection we used compositional analysis. Due to the small sample size of bears we had to conduct compositional analysis for all bears pooled, because six individuals is the minimum number required to show a significant deviance from zero at p < 0,05 by randomization (Aebischer et al. 1993). By pooling both groups, bears of group1 apparently masked the avoidance of paved roads and houses found for bears of group2 with the *distance data* analysis. The results for forest roads and feeding places are rather difficult to interpret. For forest roads it is true that zone 0-100m was used significantly less, but only as compared to the two zones of moderate distance and not as compared to the zones at large distance (Tab.8). The same is true for feeding sites where bears showed a significantly higher use of areas 0-400m from feeding sites as compared to the two zones at moderate distance, but again not to the more distant zone (Tab.11). For plantations on the other hand the difference to the *distance data* is less surprising. Obviously the distance to a plantation does not matter, but bears selected to be in plantations over being in the rest of the forest.

The results of our analysis show how important it is to use different approaches for habitat use analysis. By applying only one method it is very easy to detect trends that might not be there in reality or that do not have any biological meaning. Bears were limited in their movements primarily by forest cover, and it was forest distribution that almost completely explained the habitat use of bears. Of course, bears did not use villages, but these habitat types are mainly outside the forest or surrounded by large open areas (meadows and fields) and therefore this avoidance is already explained by the forest distribution. This finding is supported by a grid based habitat model based on the same bear locations. Forest cover and forest fragmentation were the best predictors of bear use and it did not improve model fit to include human infrastructure (Knauer et al. 2000, Knauer 2000 in prep.). The deviance between potential and realized habitat effectiveness seems rather small in Slovenia.

Second-order habitat selection

Results from the analysis of second-order habitat selection, comparing different sized range estimators, were largely consistent with the second-order analysis and also showed a selection against paved roads and houses for bears in the more fragmented landscape. Additionally, these bears also showed a selection against villages (Tab.14). However, our data do not allow to define any minimum requirements of a bears' range in Slovenia, as apparently bears can live and reproduce in both types of habitat.

As we did not follow bears over long enough time periods we were unable to compare survival rates and reproductive success of bears in the two habitat types and we are unable to assess whether both habitat types are equally suitable. We also do not have any reliable density estimates for the different habitats nor proved bear absence data. The results have to be interpreted with caution and in the following discussion we rather focus on second-order habitat selection.

4.2. Avoidance and preference of single habitat features

Topography

Independent of the applied methods, we found no influence of elevation, aspect or slope. However, the resolution of our elevation model may not be sufficient to demonstrate preferences for inaccessible terrain. In our study area forest distribution is correlated with the relief. Steep and rocky terrain is mostly covered by forest because it is not suitable for any other economic use. Rocky but flat terrain is not detectable by the elevation model with a 100m resolution. Our study area was characterized by a very rugged topography. In such a setting, a flat area scattered with holes and rocks is equally inaccessible than a steep slope. Even within a slope, aspect and steepness can change rather dramatically within a small distance.

Avoidance of human infrastructure

Most of the bears in the more fragmented landscape (group2) showed an avoidance of paved roads and houses. The *10% percentile distance data* suggested that the area of avoidance does not exceed 100-150m (Tab.6). These findings are similar to results from the central Pyrenees in France, where Quenette (1999) found a lower than expected use of the area within 0-403m of heavy traffic roads and within 0-261m of light traffic roads by 3 reintroduced bears. In Spain on the other hand, Clevenger et al. (1997) assume a negative influence on bear habitat for up to 4.5 km from village and for up to 3.9 km from paved roads. However, the later data are based on radiolocations of one male bear and 105 scats and tracks collected over a six year period.

In North America, several studies have shown a seasonal or year-round avoidance of the vicinity of roads by black (*Ursus americanus*) and grizzly bears (McLellan and Shackleton 1988, Mattson 1989, Kasworm and Manley 1990) as well as an avoidance of the vicinity of hiking trails, occupied campgrounds (Gunther 1990) or other human developments (Mattson 1989). This avoidance of roads and human infrastructure may result in a significant loss of habitat. For the Flathead study area in Montana a density of 0,7km/km² of open road is believed to result in a corresponding daytime habitat loss of 8.7% for grizzly bears (McLellan and Shackleton 1988). In Yellowstone National Park, daytime habitat use of grizzly bears was 15.7% less than expected without roads and developments (McLellan 1989). And in the Kimsquit River valley, coastal British Columbia, grizzly bears were displaced within 150m of logging road when hauling was in progress. This made an average 7% of the seasonal home ranges of two adult females unavailable for them during 14 hours a day (Archibald et al. 1987).

Bears in our study area behaved rather indifferent towards forest roads and the density of forest roads seems a rather poor indicator to predict bear habitat use, or evaluate bear habitat quality. In our study area forest road density within a bear's range is positively correlated with forest cover, and if bears select for forest cover they almost automatically end up in areas with a higher density of forest roads. For bears in group1 the average density of forest roads within their MCP was 1,83 km/km² (Tab.14). This density is well above the 0,6 km/km² which is believed to be the upper threshold for functioning large carnivore populations in North America (Mladenoff et al. 1995, Mattson 1989).

Contrary to North America, where a dense net of forest roads often results in a higher hunting and poaching mortality (LeFranc et al. 1987, McLellan 1989), this is not the case in Slovenia. Bears are only allowed to be hunted at bait sites from elevated hides, while shooting from the car or during drive hunts are prohibited. Hunters are strictly organized in hunting clubs. Each hunting club consists of about 40-50 hunters, that are responsible for an average area of 2000-4000ha. As the brown bear is a highly valued game species (Kaczensky et al. 2000, this thesis chapter 4.5.) and the possibility to shoot a bear is a once in a lifetime opportunity, peer pressure and self controlling amongst hunters is high and poaching remains a minor problem.

All forest roads are open for public access and are well maintained. We did not have the capacity to measure traffic volume on these roads and are aware that their use by people differed widely. On the other hand, bears were regularly located close to forest roads that are known to have a high frequency of human use. We located bears in daybeds less than 20m from “busy” forest road several times and these bears did not seem to mind passing people or cars. However, any attempts to close up on bears away from forest roads normally resulted in a disturbance and the flight of the bear. While during bedding, bears had a minimum distance to forest roads, the high frequency of tracks and scats on forest roads showed that bears regularly used them for travelling at night. In Croatia Cicnjak (1991) found that bears avoided to be closer than 50m from roads while bedding and denning, but not while feeding.

The generally low degree of avoidance of villages and paved roads in Slovenia might be explained by the rugged terrain, the high percentage of forest cover and the low degree of forest fragmentation in our study area. Forest cover within the study area was highly connected and only 5,3% of the area consisted of forest patches <10km^2, 3,4% of patches <1 km^2 and 0,3% of patches <1ha. Furthermore, large tracts of successional vegetation and spruce plantations on former clearings provide bears with areas of high cover, often close to forest roads. The results from the compositional analysis and day bed investigations showed that bears selected for these dense cover areas. Other studies in Europe and North America alike have shown the high importance of security cover at bedding sites (Cicnjak 1991, Mysterud 1983, Mollohan 1987).

Our general experiences with bears in Slovenia was that they were rather tolerant to predictable sources of disturbance as long as there was inaccessible habitat close by. This inaccessibility could be due to dense cover, rugged terrain or darkness during nighttime hours. Similar findings also come from some studies in North America. On Kodiak Island, Alaska grizzly bears showed a fairly high tolerance towards hydroelectric development, even during the construction period in areas where adequate protection cover was present (Smith and Daele 1990). In British Columbia, Canada McLellan and Shackleton (1989) found no or little displacement of grizzly bears from active logging, road maintenance, or seismic exploration. And even in the Kimsquit River valley the zone of hauling was only avoided during hauling and bears did not shift their home ranges (Archibald et al. 1987) while in the Flathead study the area near to roads was only avoided during the day, but used at night.

Our findings support the assumption by McLellan (1990), that the reaction of bears to people or vehicles is probably the consequence of several factors including: security cover, habitat quality, predictability of the disturbance, frequency of the disturbance and direct persecution by man.

The highway and railway

For all bears the *distance data* clearly showed no avoidance of the vicinity of the highway and railway, moreover some bears even seemed to be attracted. This is quite contrary to findings from the Bow River Valley, where grizzly bears clearly avoided the vicinity of the Trans Canada Highway (Gibeau 2000). Even though in Slovenia the highway and railway did not seem to reduce the habitat available in the vicinity, the highway clearly acts as a barrier and in combination with the railway is a significant source of mortality (Kaczensky et al. 1996, Kaczensky et al. 2000, this thesis chapter 4.4.). The attraction to the highway and railway in our study area might be explained by large complexes of successional areas and spruce plantations nearby. In addition, cars on the highway and trains do not stop and therefore are a very predictable source of disturbance and people only rarely hike along these structures. The disturbance potential of a highway is probably not much different from that of a large river.

We did not have any indication that bears were feeding on road kills next to the highway, but in at least one case an adult female with COYs (*ANCKA98*) was obviously feeding on deer remains next to the railway tracks (M. Blazic pers. comm.). Huber and Frkovic (1998) also suspected that bear-train accidents in Croatia are caused partly due to an attraction of bears to carcasses or food stuffs (e.g. grain, garbage) spilled along the railway tracks. Along the Canadian Pacific railway line grain spills attract bears and frequently resulted in moralities (Gibeau and Herrero 1998, Van der Grift 1999). Apparently bears also use the railway tracks for easy travelling (Kaczensky et al. 2000, this thesis chapter 4.4.).

Attraction to human infrastructure

In densely populated Europe where bears and people share a multi-use landscape one major concern is how to prevent bear from becoming attracted to human infrastructure and points of human activity. Bears are known to be attracted to agricultural fields (especially corn and oats), beehives, sheep (Kaczensky 1996, Kaczensky 2000 in press), bait and feeding sites, garbage and other food stuff (Rauer and Gutleb 1997). The close coexistence of bears and humans often results in bears becoming food conditioned, that is seeking for food close to human settlements or other sites of human activity (Herrero and Fleck 1989, McCarthy and Seavoy 1994, Rauer and Gutleb 1997). In Austria, single food conditioned bears approached forestry workers in search of chain saw oil, broke into barns and cellars to raid stored food or unplugged fish ponds to feast on trout, just to mention a few of the attractions associated with humans.

Only two of our collared bears in Slovenia showed some attraction towards human infrastructure. During 24-hour activity monitoring we noticed that the adult female *POLONA* went close to villages or single houses at night. This attraction was restricted to the fall and we suspect that she fed on apples and plums in the orchards. She was extremely wary and to our knowledge people did not see her. The subadult female *LUCIA* on the other hand clearly showed signs of habituation and was frequently observed by hunters and field staff. Because she lived in the area of low fragmentation she never came close to villages, but was close to single houses several times and destroyed multiple beehives. In the more fragmented area she would certainly have caused greater troubles. In general there were very few problems with bears visiting human infrastructure in our study area. Furthermore we had no indication that any of our bears visited open garbage pits. Surprisingly, bears also did not make much use of slaughtering remains dumped in the outskirts of villages. A possible explanation for this low attraction might be the overabundance of wildlife feeding sites in the forest.

Although our analysis failed to show a strong influence of feeding sites on bear habitat use, it was obvious that feeding sites were regularly frequented by bears. All bears were initially captured at feeding sites and the high amount of corn and meat in bear scats during all seasons is a good indicator for this (Große 1999, Große et al. 2000). The density of feeding sites within the MCPs of bears was very high and averaged 0,31 and 0,18 feeding sites per km² for bears in group1 and group2, respectively. Minimum number of feeding sites in a bears range was eight, the maximum was 65! Possibly, this high density makes it unnecessary for bears to stay close by feeding sites. Even though we can not show much of an influence of feeding sites on the habitat use, we can only speculate on the situation without feeding.

We estimated bear density in our study area at about 1 bear per 10 km². Despite this high density there is very little problems with food conditioned bears. The rational behind feeding bears in Slovenia is three fold (Simonic 1994): (1) to keep bears in the forest and out of trouble with people, (2) to get population estimates through direct observations, (3) to allow for safe and efficient hunting. In our study area this approach seems to work; bears are shy, stay in the forest and avoid human settlements despite a high bear density and no special policy of garbage storage or removal. However, the low conflict potential is also due to the absence of free ranging sheep. In southern Slovenia, in the area of Kocevje, where there is also intensive feeding of bears the number of sheep has increased in recent years and consequently also the number of bear damages.

In North America feeding of bears is largely considered the first step towards the end of a bear or bear population, as bears become food-conditioned and develop problematic behaviors. On the other hand, baiting of black bears for hunting purpose is also used in several states (Pacas and Paquet 1994, S. Klenzendorf pers. comm.) and does not seem to automatically create problem bears. On the Olympic Peninsula of Washington, USA black bears are intentionally fed to reduce damage to trees (Ziegeltrum and Nolte 1997). If the feeding happens in a way that bears do not become food conditioned or habituated, it remains largely an ethical question whether or not bears should be fed.

5. Management implications

Our data show that in Slovenia the habitat loss bears experience from human infrastructure is of minor importance. Given that legal and illegal persecution of bears is not a problem, bears can cope quite well with human activities. Bears in Europe are generally nocturnal, which greatly reduces the chances of bear human encounters. During the day the potential habitat effectiveness was only slightly affected by roads, houses and villages and at night potential habitat effectiveness and realized habitat effectiveness seemed almost equal. Forest roads were used for easy travelling, paved roads were regularly crossed and bears passed by houses and villages at a very close distance.

We believe that the disturbance potential caused by human infrastructures and human population density on bear habitat use is overestimated in most bear habitat models. In a landscape with a high forest cover and a low degree of forest fragmentation, the disturbance and displacement potential of human infrastructure seems very low. We believe that in such a setting managers should be more concerned about how to prevent bears from becoming attracted to human infrastructure rather than about the displacement and disturbance potential. Even though the habitat quality might not be reduced, the potential for conflicts is likely to increase, especially in times of nutritional deficiency.

We recommend to clearly differentiate between the effects of infrastructure on habitat quality and the conflict potential that might arise from these structures. The latter is a result of human attitude, livestock breeding traditions, garbage storage, hunting traditions, poaching pressure, feeding of wildlife and other human induced factors. These factors might vary widely from region to region and have to be evaluated separately from habitat quality considerations. Even the best habitat will not help much for bear conservation, if the human dimension is not considered.

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7. Reference List

Aberg, J., G. Jansson, J. Swenson, and G. Mikusinski. 2000. Difficulties in detecting habitat selection by animals in generally suitable areas. Wildlife Biology, 6(2):89-99.

Aebischer, N. J. and P. A. Robertson. 1992. Practical aspects of compositional analysis as applied to pheasant habitat utilization. In: Wildlife Telemetry: Remote Monitoring and Tracking of Animals. Ed: I.G. Priede and S.M. Swift. p:285-293. Ellis Horwood Ltd, Chinchester, UK.

———. P. A. Robertson, and R. E. Kenward. 1993. Compositional analysis of habitat use from animal radio-tracking data. Ecology, 74(5):1313-1325.

Amstrup, S. C., G. M. Durner, I. Stirling, N. J. Lunn, and Messier F. 2000. Movements and distribution of polar bears in the Beaufort Sea. Canadian Journal of Zoology, 78(6):948-966.

Arbeitsgemeinschaft Braunbär Life. 1997. Managementplan für Braunbären in Österreich. WWF Austria, Vienna, Austria. (in German)

Archibald, W. R., R. Ellis, and A. N. Hamilton. 1987. Responses of grizzly bears to logging truck traffic in the Kimsquit River Valley, British Columbia. International Conference on Bear Research and Management, 7:251-257.

Aste, C. 1993. Untersuchungen zur Lebensraumqualität für Braunbären in Österreich. Report of the Institute of Wildlife Biology and Game Managemet, Agricultural University of Vienna, Vienna, Austria. 95pp. (in German)

Breitenmoser, U., P. Kaczensky, M. Dötterer, C. Breitenmoser-Würsten, S. Capt, F. Bernhart, and M. Liberek. 1993. Spatial organization and recruitment of lynx (Lynx lynx) in a re-introduced population in the Swiss Jura Mountains. Journal of Zooogy, London, 231:449-464.

———. 1998. Large predators in the Alps: the fall and rise of man's competitors. Biological Conservation, 83:279-289.

Cicnjak, L. 1991. Food habits and habitat use by European brown bears in Croatia, Yugoslavia. Masters thesis at the University of Wilconsin – Madison, USA.

Clevenger, A. P., F. J. Purroy, and M. A. Campos. 1997. Habitat assessment of a relict brown bear Ursus arctos population in Northern Spain. Biological Conservation, 80:17-22.

Corsi, F., I. Sinibaldi, and L. Boitani. 1998. Large carnivores conservation areas in Europe: a summary of the final report. Istituto Ecologia Applicata, Rome, Italy.

Dobson, A., K. Ralls, M. Foster, M. E. Soule, D. Simberloff, D. Doak, J. A. Estes, L. S. Mills, D. Mattson, R. Dirzo, H. Arita, S. Ryan, A. N. Norse, R. F. Noss, and D. Johns. 1999. Corridors: Reconnecting fragmented landscapes. In: M.E. Soulé, and J. Terborgh (editors). Continental Conservation, p:129-170, Island Press, Washington, D.C. and Covelo, California

Dupré, E., L. Pedrotti, and P. Genovesi. 1999. Assessing potential habitat suitability for the brown bear in the Italian central Alps. 12th International Conference of bear research and management, book of abstracts, p:13.

Dyke, F. G., R. H. Brocke, H. G. Shaw, B. B. Ackerman, T. P. Hemker, and F. G. Lindzey. 1986. Reaction of Mountain Lions to Logging and Human Activity. Journal of Wildlife Management, 50(1):95-102.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology, 14(1):31-35.

Gibeau, M. L. and S. Herrero. 1998. Roads, rails and grizzly bears in the Bow River Valley, Alberta. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 104-108. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

———. 2000. A conservation biology approach to management of grizzly bears in Banff National Park, Alberta. Ph.D. dissertation. Resources and the Environment Program, University of Calgary, Alberta, Canada (http://www.canadianrockies.net/Grizzly/pubs_and_papers.htm).

Grau, S. 1998. Überblick über Arbeiten zur Landschaftszerschneidung sowie zu unzerschnittenen Räumen in der Bundes-, Landes- und Regionalplanung Deutschlands. Natur und Landschaft, 73(10):427-434. (in German)

Große, C. 1999. Ants - an important food for brown bears (*Ursus arctos*) in Slovenia? Diplomarbeit an der Zoologischen Fakultät der Philipps-Universität in Marburg, 55pp.

Große, C., P. Kaczensky, and F. Knauer. 2000. Ants - an important food source for brown bears in Slovenia? In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican valley, Yellowstone National Park. International Conference on Bear Research and Management, 8:73-78.

Hanski, I. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnean Society, 42:3-16.

Herrero, S. and S. Fleck. 1989. Injury to people inflicted by black, Grizzly or polar bears: recent trends and new insights. International Conference on Bear Research and Management, 8:25-32.

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to arcview, version 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage, AK, USA.

Huber, D. and A. Frkovic. 1998. Traffic kills of brown bears in Gorski Kotar, Croatia. Ursus, 10:167-171.

Jackson, P. and K. Nowell. 1996. Wild Cats. 382pp. IUCN Gland, Switzerland.

Jackson, R. and G. Ahlborn. 1988. A radio-telemetry study of the snow leopard (*Panthera unica*) in west Nepal. Tigerpaper, 15(2):1-14.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology, 61(1):65-71.

Kaczensky, P. 1996. Large Carnivore - Livestock Conflicts in Central Europe. Report of Munich Wildlife Society. Ettal, Germany. 106pp

———. F. Knauer, T. Huber, M. Jonozovic, and M. Adamic. 1996. The Ljubljana-Postojna highway - a deadly barriere for brown bears in Slovenia? Journal of Wildlife Research, 1(3):263-267.

———. 2000 in press. Large carnivore depredation on livestock in Europe. Ursus, 11:00-00.

Kasworm, W. F. and T. L. Manley. 1990. Road and trail influence on grizzly bears and black bears in northwestern Montana. International Conference on Bear Research and Management, 8:79-84.

Keitt, T., D. L. Urban, and B. T. Milne. 1997. Detecting critical scales in fragmented landscapes. Conservation ecology, 4:1-20.

Knauer, F. and P. Kaczensky. 2000. Spatial movement patterns of dispersing brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. P. Kaczensky, and G Rauer. 2000. A habitat model for bear expansion from Slovenia into the eastern Alps. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. 2000 in prep. Dispersal und Ausbreitung von Braunbären in die Ostalpen. Dissertation an der Forstwissenschaftlichen Fakultät am Fachgebiet für Wildbiologie und Wildtiermanagement an der TU München.

Kusak, J. and D. Huber. 1998. Brown bear habitat quality in Gorski Kotar, Croatia. Ursus, 10:281-291.

LeFranc, M. N. Jr., M. B. Moss, K. A. Patnode, W. C. I. E. Sugg, J. Lee, and M Taylor. 1987. Grizzly bear compendium. Interagency Grizzly Bear Committee, Bozeman, Montana, 540pp

Liddle, M. 1997. A classification of disturbance to animals. In: M. Liddle. Recreation ecology, p: 347-442. Chapman and Hall, University Press, Cambridge, Great Britain.

Linnell, J. D., M. E. Smith, J. Odden, P. Kaczensky, and J. E. Swenson. 1996. Carnivores and sheep farming in Norway. 4. Strategies for the reduction of carnivore - livestock conflicts: a review. NINA Oppdragsmelding 443:1-118.

———. J. E. Swenson, R. Andersen, P. Barbu, and B. Barnes. 2000. How vulnerable are denning bears to disturbance? Wildlife Society Bulletin, 28(2):400-413.

Liu, J., Z. Ouyang, W. W. Taylor, R. Groop, Y. Tan, and H. Zhang. 1999. A framework for evaluating the effects of human factors on wildlife habitat: the case of the giant pandas. Conservation Biology, 13(6):1360-1370.

Mace, R. D., J. S. Waller, T. L. Manley, K. Ake, and W. T. Wittinger. 1999. Landscape evaluation of grizzly bear habitat in western Montana. Conservation Biology, 13(2):367-377.

Marcum, C. L. and D. O. Loftsgaarden. 1980. A nonmapping technique for studying habitat preferences. Journal of Wildlife Management, 44(4):963-968.

Mattson, D. J. 1989. Human impacts on bear habitat use. International Conference on Bear Research and Management, 8:33-56.

McCarthy, T. M. and R. J. Seavoy. 1994. Reducing nonsport losses attributable to food conditioning: human and bear behavior modification in an urban environment. International Conference on Bear Research and Management, 9(1):75-84.

McLellan, B. N. and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: Effects of roads an behavior, habitat use and demography. Journal of Applied Ecology, 25:451-460.

———. and D. M. Shackelton. 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin, 17:269-274.

———. 1990. Relationships between human industrial activity and grizzly bears. International Conference on Bear Research and Management, 8:57-64.

Meyer, J. S., L. L. Irwin, and M. S. Boyce. 1998. Influence of habitat abundance and fragmentation on northern spotted owls in western Oregon. Wildlife Monographs, 139:51pp.

Mladenoff, D. J., T. A. Sickley, R. G. Haight, and A. P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the northern great lakes region. Conservation Biology, 9(2):279-294.

Moilanen, A. and I. Hanski. 1998. Metapopulation dynamics: effects of habitat quality and landscape structure. Ecology, 79(7):2503-2515.

Mollohan, C. M. 1987. Characteristics of adult female black bear daybeds in Northern Arizona. International Conference on Bear Research and Management, 5:208-222.

Mysterud, I. 1983. Characteristics of summer beds of European brown bears in Norway. International Conference on Bear Research and Management, 5:208-222.

Neu, C. W., C. R. Byers, and J. M. Peek. 1974. A technique for analysis of utilization-availability data. Journal of Wildlife Management, 38(3):541-545.

Pacas, C. J. and P. C. Paquet. 1994. Analysis of black bear home range using a geographic information system. 9th Int. International Conference on Bear Research and Management, 9(1):419-425.

Peyton, B. 1994. Conservation in the developing world: ideas on how to proceed. International Conference on Bear Research and Management, 9(1):115-127.

Quenette, P. Y. 1999. Reintroduction of three brown bears in the central Pyrenees: Scientific results. Report of DIREN Midi-Pyrénées, France. 53pp.

Rauer, G. and B. Gutleb. 1997. Der Braunbär in Österreich. Umweltbundesamt, Monographie 88. Federal Environment Agency, Vienna, Austria. 64pp. (in German)

Simonic, A. 1994. The legal protection of the brown bear in Slovene territory-past and present, and some suggestions for the. Braunbär in den Ländern Alpen - Adria, Proceedings, 43-76. Ljubljana, Slovenia.

Smith, R. B. and Van Daele L. J. 1990. Impacts of hydroelectric development on brown bears, Kodiak Island, Alaska. International Conference on Bear Research and Management, 8:93-103.

Van der Grift, E. A. 1999. Mammals and railroads: Impacts and management implications. Lutra, 42(1):77-98.

White, G. C. and R. A. Garrott. 1990. Analysis of Wildlife Radiotracking Data. Academic Press, Inc., Harcourt Brace Jovanovich, Publishers, San Diego, New York, Boston, London, Sydney, Tokyo, Toronto. 383pp

Wilcox, B. C. and D. D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist, 125:879-887.

With, K. A. and A. W. King. 1999. Extinction threshold for species in fractal landscapes. Conservation Biology, 13(2):314-326.

Ziegeltrum, G. J. and D. L. Nolte. 1997. Black bear damage management in Washington state. Proceedings of the Eastern Wildlife Damage and Management Conference 7:104-107.

Zimmermann, F. 1998. Dispersion et survie des lynx (Lynx lynx) subadultes dúne population réintroduite dans la chaine du Jura. KORA Report 4. Bern, Switzerland. 50pp

Appendix 1: MCP characteristics of bears in group1 and group2.

group	bear	HR size (km²)	MCP	forest cover (%)	total forest area (km²)	forest roads (km/km²)	paved roads (km/km²)	highway (km)	railway (km)	houses	houses (# / km²)	villages	village (km² / km²)	# feeding sites	feeding sites (# / km²)	plantations (km² / km²)
1	*ANCKA94*	63	95	0,86	54	1,48	0,06	0,00	0,00	114	1,81	5	0,08	16	0,25	0,06
1	*ANCKA98*	39	95	0,96	37	1,83	0,00	0,00	1,05	9	0,23	1	0,03	8	0,21	0,09
1	*CLIO*	24	100	1,00	24	1,84	0,00	0,00	0,00	1	0,04	0	0,00	8	0,33	0,10
1	*DUSAN*	33	100	0,97	32	1,84	0,00	0,00	0,00	1	0,03	0	0,00	10	0,30	0,09
1	*JOZE*	34	100	0,98	33	1,82	0,00	0,00	0,00	2	0,06	0	0,00	16	0,47	0,14
1	*LUCIA*	41	95	0,99	41	1,91	0,00	0,00	1,95	15	0,37	0	0,00	12	0,29	0,12
1	*MAJA*	49	95	0,98	48	1,93	0,00	0,00	2,48	5	0,10	0	0,00	13	0,27	0,11
1	*METKA*	59	100	0,98	58	1,84	0,00	0,00	0,64	4	0,07	0	0,00	18	0,31	0,12
1	*VANJA*	21	100	1,00	21	1,91	0,00	0,00	0,00	0	0,00	0	0,00	8	0,38	0,08
1	*VERA*	44	100	0,99	44	1,87	0,00	0,00	0,00	2	0,05	0	0,00	14	0,32	0,10
mean group1		***41***	***98***	***0,97***	***39***	***1,83***	***0,01***	***0,00***	***0,61***	***15,30***	***0,28***	***0,60***	***0,01***	***12,30***	***0,31***	***0,10***
2	*JANA*	287	100	0,79	227	1,27	0,25	8,99	11,27	2777	9,71	15	0,05	26	0,11	0,09
2	*MISHKO*	276	95	0,80	221	1,21	0,26	2,86	25,03	2134	7,73	18	0,07	65	0,25	0,07
2	*NEJC*	396	100	0,69	273	1,16	0,26	7,89	12,48	4229	11,13	37	0,10	52	0,15	0,10
2	*POLONA*	55	95	0,67	37	1,04	0,48	0,00	0,00	537	9,76	7	0,13	11	0,20	0,04
2	*SRECKO*	516	100	0,77	397	1,28	0,26	13,84	17,39	4342	8,43	33	0,06	61	0,14	0,09
2	*UROSH*	99	100	0,84	83	1,27	0,22	0,00	8,43	1106	11,17	6	0,06	25	0,25	0,09
mean group2		***272***	***98***	***0,76***	***206***	***1,21***	***0,29***	***5,60***	***12,43***	***2520,83***	***9,66***	***19,33***	***0,08***	***40,00***	***0,18***	***0,08***
3	*VINKO*	100	100	0,67	67	1,19	0,31	6,23	10,67	2095	20,95	16	0,16	23	0,23	0,12

4.4. The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia. *Petra Kaczensky, Felix Knauer, Blaz Krze, Marco Jonozovic, Miha Adamic and Hartmut Gossow (24pp)*

The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia

The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia

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Abstract

The Ljubljana-Razdrto highway cuts through brown bear (*Ursus arctos*) habitat in south-central Slovenia and is located close to the main dispersal corridor for bears from the Dinaric Mountain range into the Alps. A high number of bear-vehicle accidents in 1992 raised great concerns about the barrier effect of this traffic axis. We analyzed radiotracking data of 15 individual bears that lived within 10 km of the highway and analyzed highway mortality data and related it to overall known bear mortality, the characteristics of the highway/railway and the surrounding habitat.

The highway posed a clear home range boundary to resident bears, but was not an absolute barrier, as it was successfully crossed by three marked and several unmarked bears. However, transportation-related mortality was high in the vicinity of the highway and averaged 31% of the total known mortality from 1992-1999. During this period 11 bears were hit on the highway and nine on the parallel railway tracks, while 44 were harvested in the hunting clubs within 10 km of the highway. Transportation-related mortality for all of Slovenia was much lower and averaged 10% of the known mortalities. 53% of all transportation-related mortalities in Slovenia occurred on a 30 km stretch of highway/railway between Vrhnika and Razdrto, where the highway/railway cuts through prime bear habitat.

The impact of the traffic axis between Vrhnika and Razdrto at present is judged not to be an immediate threat to the Slovenian bear population because: (1) so far it is the only highway that cuts through prime bear habitat, (2) bear density is high, (3) several bears successfully cross every year, (3) the sex ration of traffic killed bears is skewed towards young males and can be counterbalanced by a reduced harvest rate. Still, mitigation measures are desirable, also to help other wildlife, but need to take into account not only the highway, but also the parallel railway tracks. The area would be well suited to test the efficiency of different mitigation measures for bears and other wildlife.

The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia

1. Introduction

The negative effects of roads and railroads on the biotic integrity of ecosytems has become a major issue for conservation biology (e.g. Bennett 1991, Bekker 1998, Van der Grift 1999, Trombulak and Frissel 2000). Trombulak and Frissel (2000) categorize the effects of roads into seven categories: (1) increased mortality from road construction, (2) increased mortality from collisions with vehicles, (3) modification of animal behavior, (4) alteration of the physical environment, (5) alteration of the chemical environment, (6) spread of exotic species, and (7) increased alteration and use of habitats by humans. For large carnivores with their huge spatial requirements (Linnell et al. 1996) direct mortality due to carnivore-vehicle collisions (Wooding and Brady 1987, Foster 1992), habitat fragmentation due to the barrier or filter effect of high speed, high volume traffic axis (Servheen et al. 1998, Clevenger and Waltho 2000), habitat loss due to noise and increased human use along roadsides (McLellan and Shackleton 1988, Forman 2000) and subsequent increased mortality due to a higher interactive potential between humans and large carnivores (Gibeau and Herrero 1998, Mladenoff and Sickley 1998, Gibeau 2000) are the major concerns when considering the impact of roads (Ruediger 1998).

The Slovenian brown bear (*Ursus arctos*) population is the only source for a natural re-colonization of the Alps and therefore of great international interest. The Ljubljana-Razdrto highway cuts through prime bear habitat in south-central Slovenia and is located close to the main dispersal corridor for bears from the Dinaric Mountain range into the Alps. In 1992 five bear vehicle collisions raised great concern about the connectivity of the bear population on either sides of the highway and about the mortality of bears and other wildlife due to highways in general (Adamic 1994, Jonozovic 1995, Kaczensky et al. 1996). Even though the highway is fenced, the fence does not pose a serious obstacle for bears and from the opening of the highway in 1972 until fall 1994, nine bears have been hit by cars (Kaczensky et al. 1996).

Bear losses due to traffic have been reported from bear populations in Europe (Italy: Boscagli 1987, Croatia: Frikovic et al. 1987) as well as North America (Wooding and Brady 1987, Gibeau and Herrero 1998). Besides the mortality risk, the loss of habitat and the resulting habitat fragmentation has become a focal topic for wildlife mangers in Europe and North America alike (e.g. Foster 1992, Van der Zee et al. 1992, Ruediger 1998, Hubbard et al. 2000). Fencing in combination with mitigation measures like green bridges (Pfister et al. 1997) or wildlife underpasses (Wooding 1993, Clevenger and Waltho 2000) have proven to be effective under certain circumstances and for certain wildlife species. But constructions are expensive and to be effective have to be designed for the species of concern and need to be located in the optimal position (Servheen et al. 1998).

Along the Ljubljana-Razdrto highway no wildlife crossing structures exist, but the possibility of constructing them is still discussed. In addition, there are several underpasses and bridges for forestry traffic that also are used by wildlife (Bürglin

1995, Adamic et al. 1996). Several highway mitigation measures for wildlife were implemented on the extension of the Ljubljana-Razdrto highway beyond Razdrto. Future mitigation measures are being planned for any new highway construction within the bears' range. In spite of this commitment, little is known about the impact of the highway on bear movements and its source of mortality in a high density bear population. We therefore monitored movements and habitat use of radiocollared bears in south-central Slovenia and documented all bear mortalities along the Ljubljana-Razdrto highway. Our main goals were:

(1) to evaluate whether the Ljubljana-Razdrto highway impedes bear movements, and

(3) to assess the importance of transportation-related mortality compared to other sources of mortality in the bear population

2. The Ljubljana-Razdrto highway

Slovenia looks back on a long history of being an important crossroad between three different ecoregions: the Alps, the Mediterranean sea and the Pannonian basin (Cerne 1992). In the 1840´s the Slovenian territory was reached by the Austrian-Hungarian railroad system and the Vienna-Maribor-Ljubljana-Triest connection was one of the first routes. Road transport In Slovenia increased sharply from the 1970´s to the end of the 1980´s. In 1989, 95% of all passengers traveled by road and only 5% by railroad.

In 1972 the first part of the four lane Ljubljana-Razdrto highway, was opened, a 30 km stretch connecting Vrhnika and Postojna. Today this highway is one of the main traffic axis for tourists that come from or through Austria and Germany and head towards the Adriatic sea. The tourist traffic volume was greatly reduced during the Serbian-Croatian war from 1991-1996, but is probably back to the pre-war volume today. Average yearly traffic volume is estimated at more than 7500 cars per day between Ljubljana and Postojna (Cerne 1992). In addition, there has been a significant increase in the domestic traffic volume, as can be seen by the 8% increase in the number of registered passenger cars from 606.820 in 1992 to 727.554 in 1996 (Republic of Slovenia 1997).

In 1996 there was a total of 310 km of highways and 1201 km of railway tracks in Slovenia (Republic of Slovenia 1997), but further new highway construction and upgrades are planned and are partly under construction already (Fig.1). The Ljubljana-Razdrto highway presently extends about 10 km southwest of Razdrto. On this new section, two viaducts and one underpass were built to account for wildlife crossings. Between Ljubljana and Razdrto there are no wildlife passages, but one large viaduct and numerous small bridges and underpasses are present (Fig.2). All highways are fenced on both sides with 1,60m high wildlife fence, which cannot be crossed by ungulates. At present the Ljubljana-Razdrto highway is the only highway in Slovenia that cuts through the bear core area; on long stretches this highway is flanked by forest (Fig.2).

Between Vrhnika and Postojna the highway is paralleled by the railway that connects Ljubljana with Triest and Rijeka, a busy route with international trains about every 30min. The railway is unfenced, but due to the rugged terrain, there are several places where the railway is carved into the rocks. The railway tracks cross over and under the highway in six places between Vrhnika and Postojna.

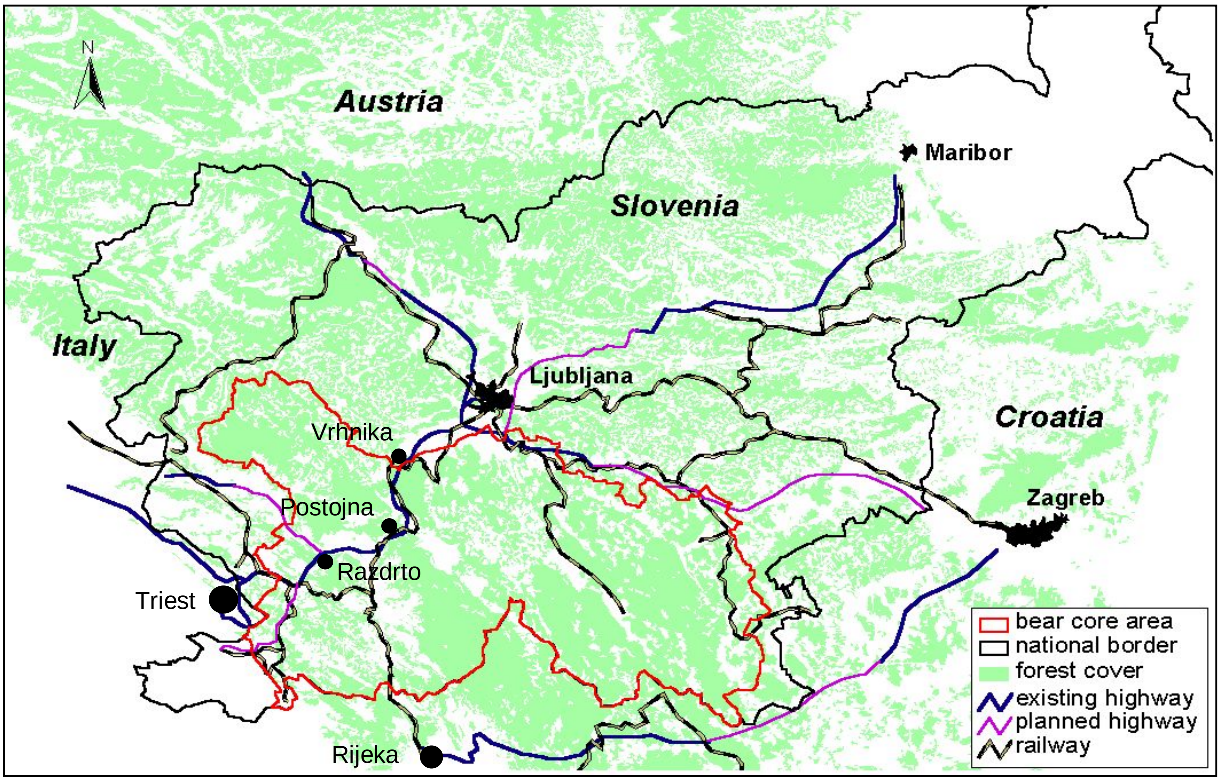

Fig. 1: Highway and railway network of Slovenia in relation to forest cover and the bear core area. The highway Ljubljana-Razdrto is the only highway that cuts through the bear core area.

Fig. 2: The highway Ljubljana-Razdrto.

Upper left: the highway between Postojna and Razdrto, Lower left: the viaduct Ravbarkomanda northeast of Postojna. Upper right: typical highway bridge, designed for forestry traffic. Lower right: typical highway underpass.

3. Methods

3.1. Bear movements

Trapping, handling and radiomarking procedures followed methods described by Kaczensky et al. (2000, this thesis chapter 4.1.). We followed individual bears, when possible on a day to day basis (for details see Kaczensky et al. 2000, this thesis chapter 4.3.). Due to a dense net of forest roads in the whole study area, the distance between observer and bear was generally less than 1000m. The quality of the position was estimated by the observers from the signal strength, the angles between the different bearings for triangulation and the topography. Locations were classified as:

(1) location error ≤ 50m: bear surrounded on close range and/or radiosignal close to maximal

(2) location error ≤ 250m: bear only partly surrounded or surrounded at a longer distance and/or topography limits the maximal distance between bear and observer

(3) location error ≤ 500m: bear not surrounded, or surrounded on long distance (>1 km), and/or azimuth between most distant successive bearings less than 120° apart

For any bear close to the highway we checked whether or not the bear had crossed. To ensure independence of location points we only used the first most precise location per day to calculate home ranges. 92% of all day to day locations were during daylight hours. For the analysis of the impact of the Ljubljana-Razdrto highway we used only bears that did not show long distance dispersal and lived within 10 km of the highway or bears that dispersed and crossed the highway during the monitoring period (Tab.1). We calculated home ranges with ArcView 3.1 using the minimum convex polygon (MCP) option of the extension Animal Movement 2.04 (Hooge and Eichenlaub 1997). For resident bears with ≥ 100 locations we used the 95% MCP and for all others the 100% MCP.

We additionally followed bear movements during more than 2000 hours of continuos activity monitoring (Tab.1, also see: Kaczensky et al. 2000, this thesis chapter 4.2.). Due to a dense network of forest roads, the distance between observer and bear was generally less than 1000m. After each activity sample we checked whether the bear had changed its position. If so, we determined the new position by triangulation taking successive bearings by a single observer within 5min.

Tab. 18 : Bears used for analysis of the impact of the Ljubljana-Razdrto highway.

bear	monitoring period start - end	day to day locations	home range (km²)	activity monitoring (hours)	highway crossings
adult females					
ANCKA94	23.04.94 - 15.07.95	110	63	0	0
ANCKA98[3]	10.04.98 - 29.09.99	173	39	330	0
MAJA	23.04.95 - 20.06.97	236	49	100	0
METKA	24.03.94 - 26.09.94	67	59	0	0
POLONA	06.04.98 - 15.09.99	171	55	377	0
subadult / adult males					
MISHKO	07.04.94 - 06.11.95	126	276	0	2
yearling / subadult females					
JANA	04.05.93 - 07.11.94	112	287	0	3
LUCIA	18.10.96 - 08.10.97	169	41	556	0
subadult males					
UROSH	05.04.95 - 31.05.95	18	99	0	0
SRECKO	28.03.97 - 01.11.97	140	516	439	2
yearling females					
VANJA	21.04.97 - 12.08.97	73	21	269	0
VERA	05.10.96 - 12.06.97	90	44	98	0
yearling males					
CLIO	26.03.94 - 31.05.94	21	24	0	0
DUSAN	04.05.97 - 12.07.97	42	33	120	0
JOZE	18.03.98 - 03.05.98	24	34	3	0

[1]denning period
[2]for resident bears with >100 locations the 95% MCP was used, for all others the 100% MCP
[3]recapture but unclear identity

3.2. Bear mortality

We derived all bear mortality data before 1993 from the highway statistics (Jonozovic 1995), whereas we acquired all mortalities recorded after 1993 directly from the person that discovered the carcass. All bear transportation related mortalities were mapped on the scale 1:25.000. All bear remains had been verified by hunters, highway or railway maintenance personal and after 1993 additionally by Dr. Bidovec of the Veterinary Faculty at the University in Ljubljana, or one of the authors. For most bears the sex and weight was available for analysis.

3.3. Habitat databases

We used the same digital database as described by Kaczensky et al. (2000, this thesis chapter 4.3.). In addition we digitized all bridges, underpasses and viaducts of the Ljubljana-Razdrto highway along the 30 km stretch between Vrhnika and Postojna, where all bear-vehicle collisions occurred.

4. Results

4.1. Home range barrier

None of the adult bears monitored had a home range which included areas frequented on both sides of the highway (Fig.3). None of the five females ever crossed the highway and for three of them (*MAJA, METKA, ANCKA98*) the highway was the western home range boundary. In 1994 the home range of the four year old male *MISHKO* also was restricted to the eastern side of the highway, but he had crossed the highway once as a three year old for an excursion during the mating season in 1994 (see: Kaczensky et al. 1996).

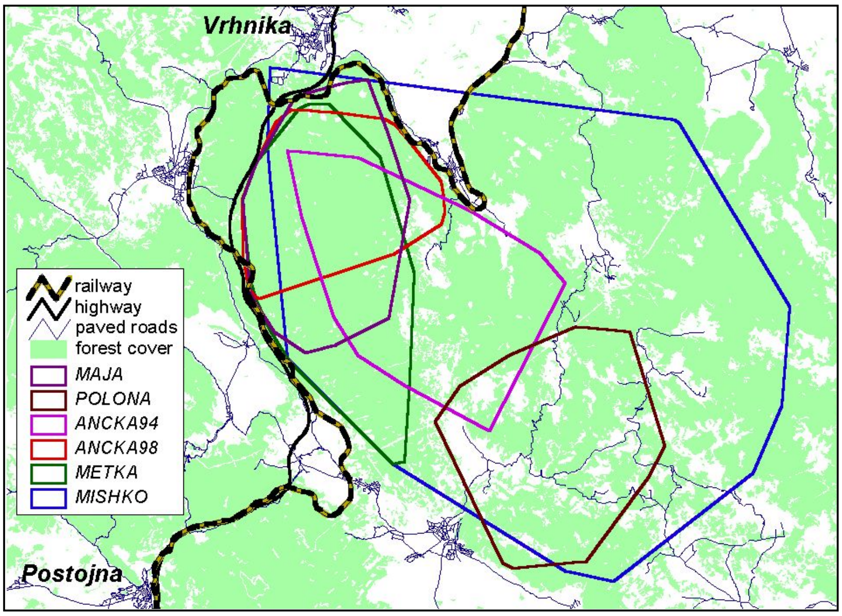

Fig. 3: Home ranges (MCP) of five adult females and one adult male relative to the highway Ljubljana-Razdrto.

None of the two subadults (*UROSH* and *LUCIA*) and five yearlings that showed resident behavior during the monitoring period crossed the highway and for at least five of them the highway was the eastern border of their movements (Fig.4). On the other hand, most of these bears were only monitored for a rather short period (Tab.1). *UROSH* was run over by train 18 month and *VANJA* was shot 12 month after their initial capture, but still on the east side of the highway.

Adult and young bears did not avoid being close to the highway and quite contrary some bears were often located close to it (Kaczensky et al. 2000, this thesis chapter 4.3.). Once a daybed of *JANA* was found only 15 m from the highway fence. We did not register any highway crossings of bears during 24 hour monitoring, but again, bears were often located close to the highway.

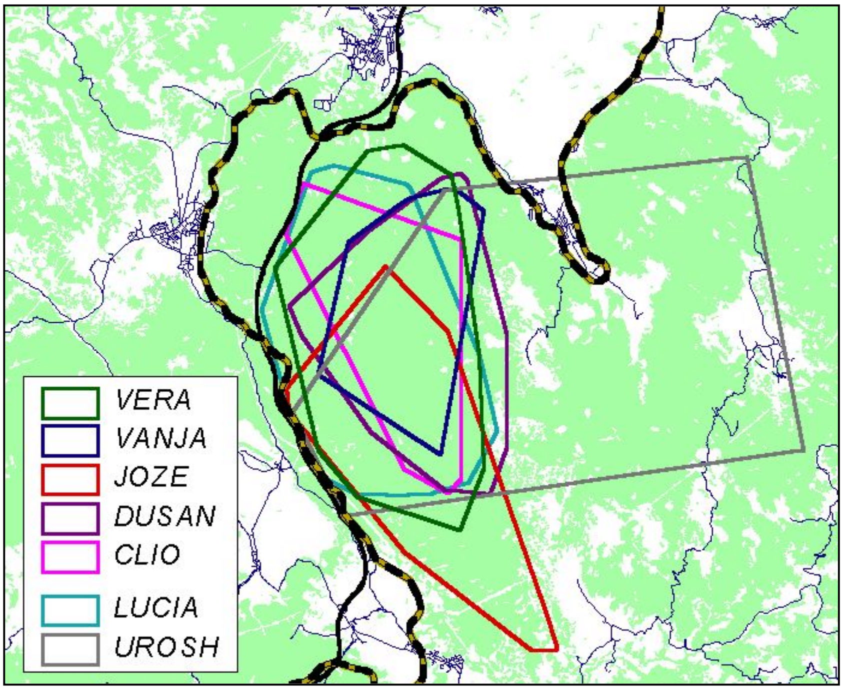

Fig.4: Home ranges of two subadult (LUCIA and UROSH) and five yearling bears relative to the highway Ljubljana-Razdrto.

In the area where the home ranges of the marked bears were located, topography did not pose a natural barrier along the highway and railway tracks (Fig.5, Fig.2). Furthermore, habitat suitability, based on forest cover and forest fragmentation (Knauer 2000 in prep., Knauer et al. 2000) did not differ within two kilometers on both sides of the highway in the northern part, but was less suitable in the southern part (Fig.6).

4.2. Documented crossings of marked bears

We documented a total of seven crossings of the Ljubljana-Razdrto highway by marked bears: (1) the yearling female *JANA* crossed three times during dispersal (Fig.7), (2) the subadult male *MISHKO* crossed for a one week excursion during the breeding season (Fig.8), and (3) the subadult male *SRECKO* crossed two times during dispersal (Fig.9). One yearling male that had just started dispersing lost his eartag transmitter only 300 m from the highway, but we have no information on whether or not he eventually crossed the highway. For none of the bears we know the exact crossing location, nor whether they used a bridge, underpass or climbed over the fence to cross the highway.

We documented one additional highway crossing, but not of the Ljubljana-Razdrto highway, but of the highway Rijeka-Delnice in Croatia. We located the two-year old male on 2 September 1998 near a garbage dump in the morning, but in the afternoon observed him on the other side of the highway, next to the railway tracks. He apparently crossed the highway during the day, possibly using a nearby viaduct.

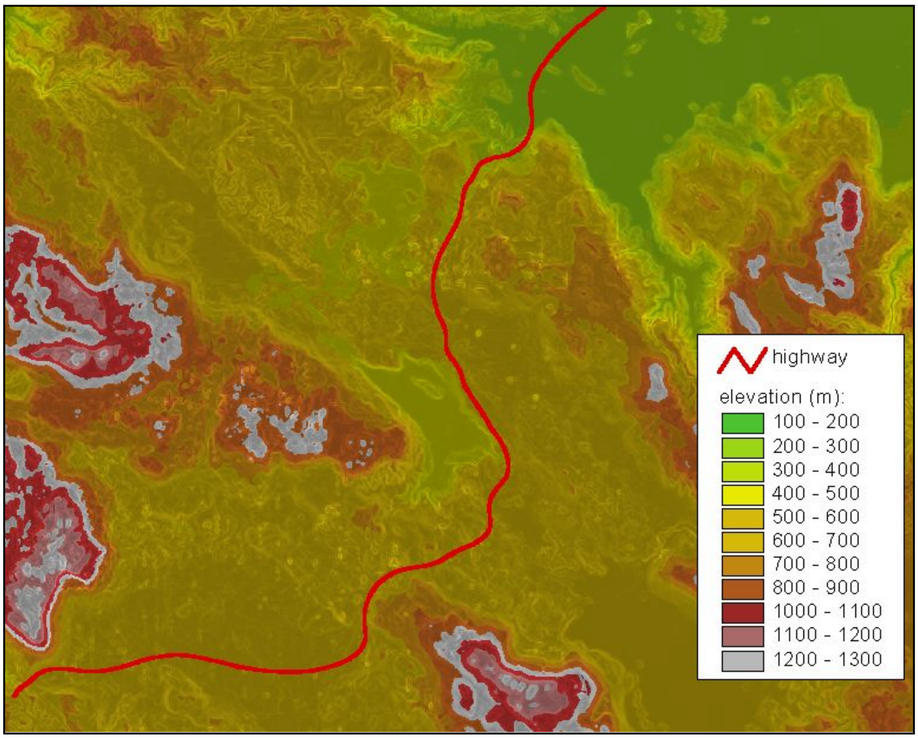

Fig.5: Topography along the highway did not pose a natural barrier to bear movements.

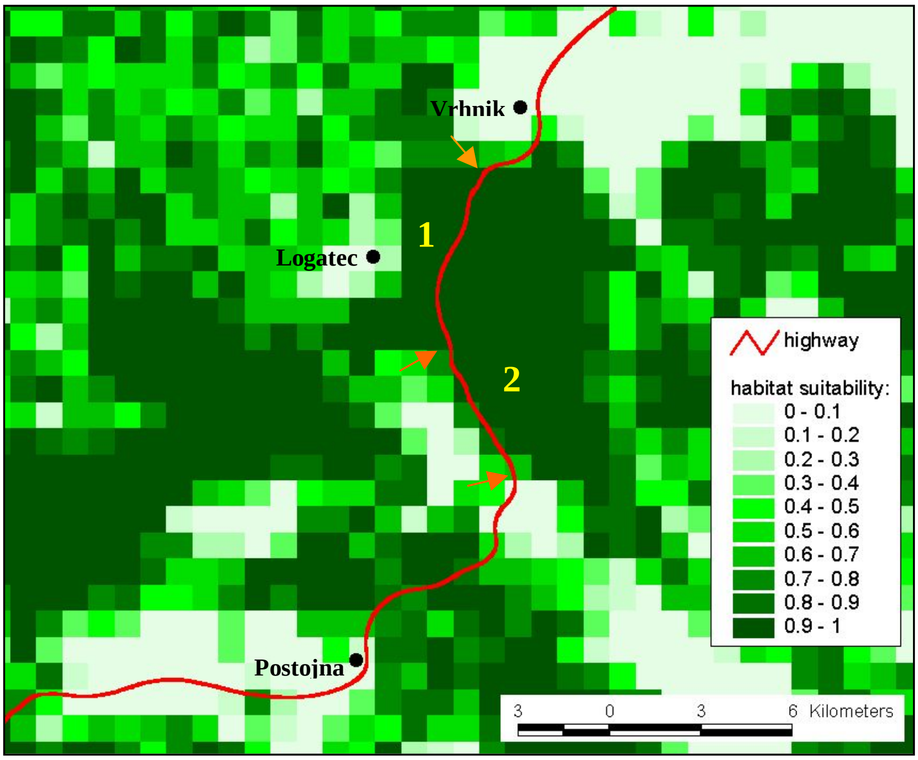

Fig.6: Habitat suitability, based on forest cover and forest fragmentation did not differ within two kilometers on both sides of the highway in the northern part (1), but was less suitable in the southern part (2). Before Postojna habitat suitability was similar, but less suitable than in the northern part. After Postojna habitat suitability was greatly decreased on both sides.

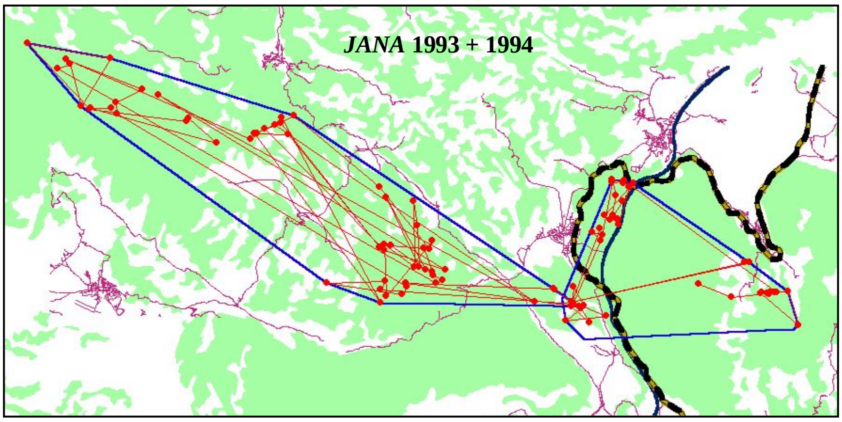

Fig.7: In 1993, as a yearling, JANA crossed the highway in mid May, but stayed close by. In October she crossed the highway back to the east side, but crossed again to den on the west side of the highway. In 1994 she did not cross again and expanded her range quite far to the west.

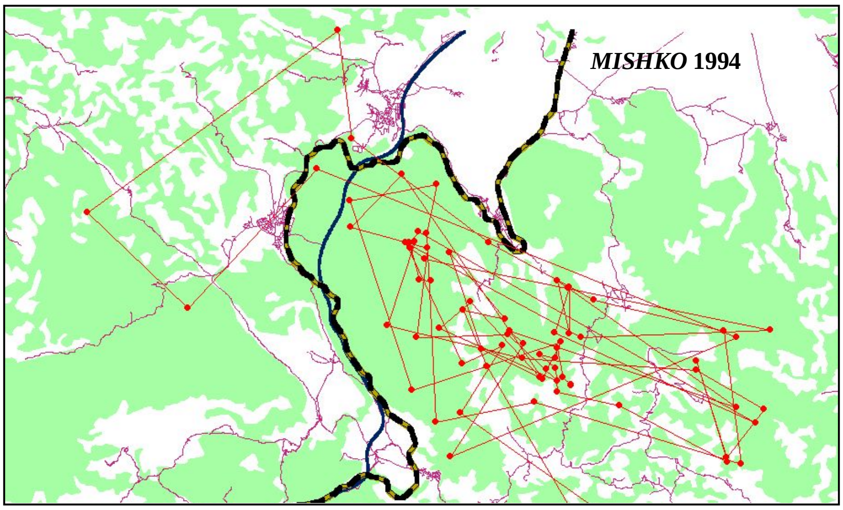

Fig.8: In 1994, as three-year old, the male MISHKO crossed the highway twice for a one week excursion during the mating season in June. In 1995 he did not cross the highway again.

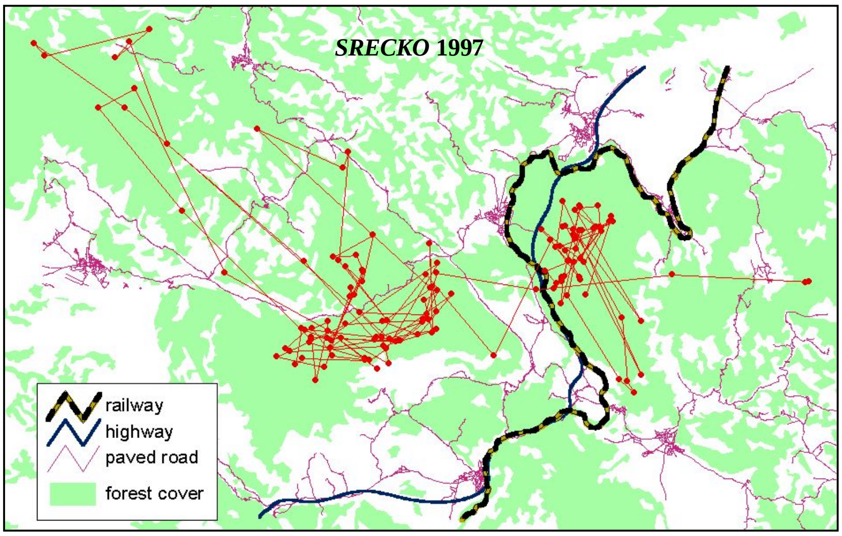

Fig.9: In 1997, as a three-year old, the male SRECKO crossed the highway in June, than stayed on the west side of the highway, where he seemed to settle down. In the end of October he crossed back on the east side of the highway and kept moving east, but lost his collar a week after the crossing.

4.3. Road mortality

Collared bears

We had no mortality of radio-collared bears due to bear-vehicle collisions during our study, but three bears were killed by train on the adjacent railway tracks (Fig.10).

Fig.10: Three collared bears, a yearling male (JOZE) a subadult female (LUCIA) and an adult male (UROSH) were killed by train.

Total bear mortality along the Ljubljana-Razdrto highway

Systematic registering of bear mortality data by the Hunters Association and of transportation related wildlife mortalities by the Slovenian highway authorities did not start before 1992. At least two bears were hit on the highway before 1992 (Tab.2) and it is possible that some additional accidents went undocumented.

Between spring 1992 and fall 1999 a total of 11 bears were hit (10 killed, one hit but not found) on the highway and an other nine bears were hit (eight killed, one hit but recovered) on the railway tracks (Tab.2). One bear hit on the highway in 1993 could not be found after the accident and one yearling bear hit by the train in 1999 was found stunned but alive next to the tracks by locals. The yearling was immobilized by Prof. Dr. Bidovec of the Veterinary Faculty at the University of Ljubljana and brought to the zoo. Radiography revealed no serious injuries and after a few days in the zoo, the bear was released back into the wild.

Age composition of the bears hit was four females, 15 males and one bear of unknown sex. The age of most bears was unknown, but judging from the weights, the majority of bears struck by trains and vehicles were young bears, eight most likely were yearlings (Tab.2). With one exception all bears were hit on a 30 km stretch of the highway between Vrhnika and Postojna or the parallel railway tracks. The yearling that was found next to the railway was the only bear that was hit on the railway where it does not parallel the highway.

Tab. 29 : Bears killed on the Ljubljana-Razdrto highway and the adjacent railway track (nm=not measured/not known).

date	location	hunting unit	weight (kg)	sex	age class[1]	comment	quality of location[2]
05.09.79	highway	Rakek	nm	m	?		1
15.07.87	highway	Javornik	nm	m	?		1
02.05.92	highway	Javornik	nm	m	?		1
16.07.92	highway	Logatec	130	m	?		1
11.08.92	highway	Logatec	nm	m	?		1
24.10.92	highway	Rakek	90-95	m	subadult ?		1
13.12.92	highway	Rakek	nm	m	?		1
1993	highway	?	nm	nm	?	hit but not found	nm
16.06.94	highway	Javornik	130	m	**adult**		2
19.09.94	railway	Rakek	50	f	**yearling**		1
20.10.94	railway	Rakek	150	m	?		2
12.05.97	railway	Rakek	200	m	**adult**	*UROSH*	2
08.10.97	railway	Rakek	110	f	**subadult**	*LUCIA*	2
31.08.98	railway	Rakek	57	m	yearling ?		2
24.09.98	railway	Rakek	60	m	**yearling**	*JOZE*	2
09.10.98	highway	Planina	70	f	yearling ?		2
17.03.99	highway	Rakek	16	m	yearling ?		2
27.03.99	railway	Rakek	91	f	**adult**	lactating female	2
23.04.99	railway	Rakek	75	m	subadult ?		2
10.05.99	highway	Logatec	58	m	yearling ?		2
14.05.99	highway	Planina	54	m	yearling ?		2
04.06.99	railway	Borovnica	34	m	**yearling**	recovered in Zoo	2

[1] bold letters: known age class because of inspection by authors (two yearlings) or from cementum annuli age determination by Matson´s Laboratory, USA.
[2] 1: only approximate location ± 500m, 2: exact location ± 100m

Traffic mortality as compared to overall mortality between Vrhnika and Razdrto

While 20 bears were hit by traffic (train + car) between 1992-1999, 44 bears were legally harvested or found dead during the same period in 18 hunting units that are within 10 km of the highway between Vrhnika and Postojna (Fig.11). In this area transportation-related mortality accounts for 31% of the overall known mortality. Transportation-related mortality was restricted to five hunting units and more than 50% of all accidents happened in a single hunting unit (hunting club Rakek)(Fig.11).

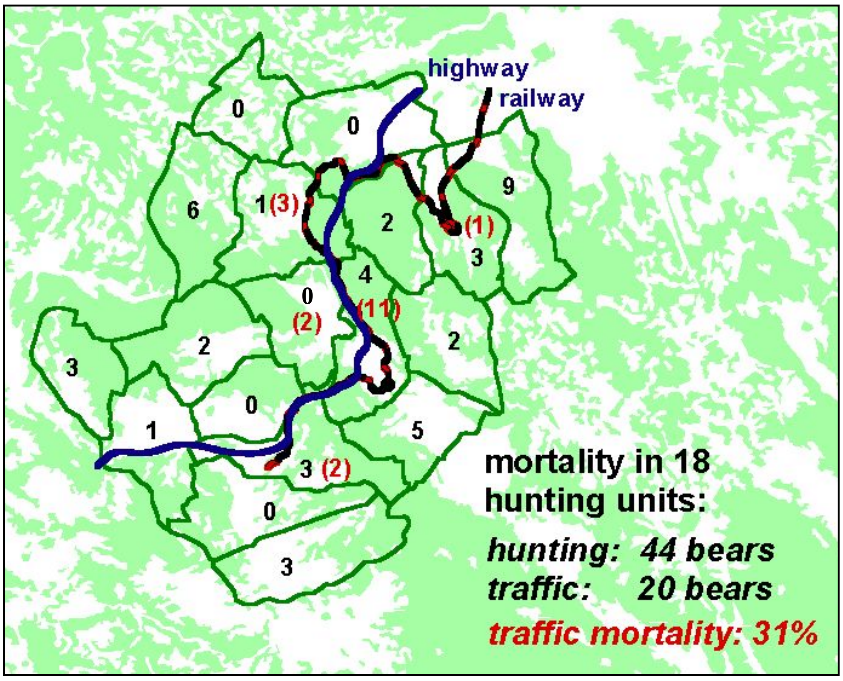

Fig.11: Bear mortalities in 18 hunting units within 10 km of the highway.

Black numbers:

legal harvest

Red numbers in brackets: bears killed/hit by traffic

Total road mortality in Slovenia

Between spring 1992 and fall 1999 a total of 364 known bear mortalities or removals were registered in Slovenia. Hunting accounted for 79% of all known moralities, while transportation-related mortality accounted for 10% of the known mortalities (Fig.12). The remaining 11% (extra removal) were made up by the removal of problem bears, by bears live captured for reintroduction programs, abandoned cubs and bears found dead or dying. Within the nine years no trend is obvious (Kolmogorov-Smirnov test for even distribution of one sample p=0,491), but the number of transportation-related accidents varies from year to year (Fig.12).

While the sex ratio of bears removed by extra removal was about even, transportation-related and hunter-related mortalities were skewed towards male bears (Tab.3). Numbers were too small for meaningful statistical analysis (Kruskal Wallis test, p=0,087, n=12), but the occurrence of transportation-related accidents showed somewhat of a peak in May and June (Fig.13). The peak falls into the mating season and in the time when three of our yearling bears started to disperse. We did not notice an overall increase in the distances between locations of consecutive days in May and June, when pooling over all bears. However the subadult male *SRECKO* showed a tendency to move longer distances in June as compared to the other months (Fig.14). Mortality was lowest from November to April, the period when a large portion of the bear population is denning.

mortality cause	female	male	unknown	ratio female : male
extra	19	20	1	1 : 1
hunting	98	183	5	1 : 2
rail	5	11	0	1 : 2
car	5	15	2	1 : 3
total	**127**	**229**	**8**	**1 : 2**

Tab.3: Sex ratio of bears killed/removed from 1992-1999.

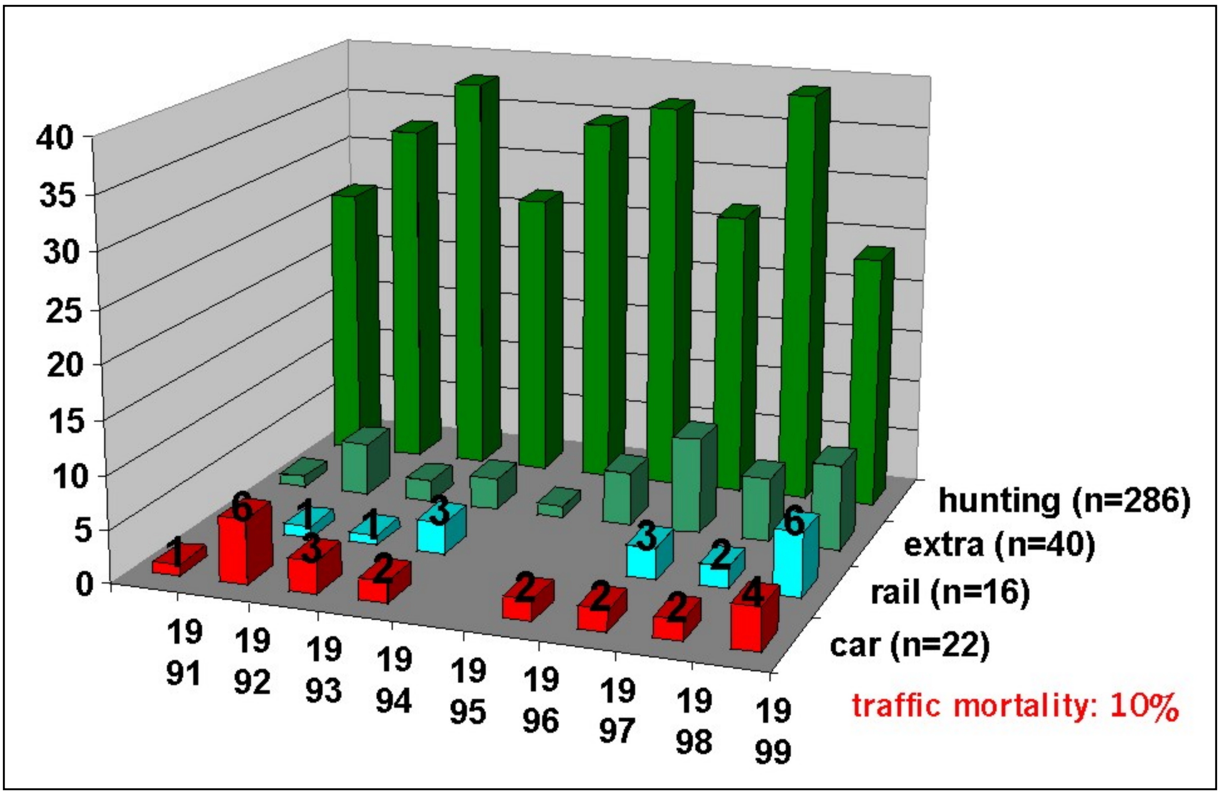

Fig. 12: Known bear mortalities / removals between spring 1992 and fall 1999.

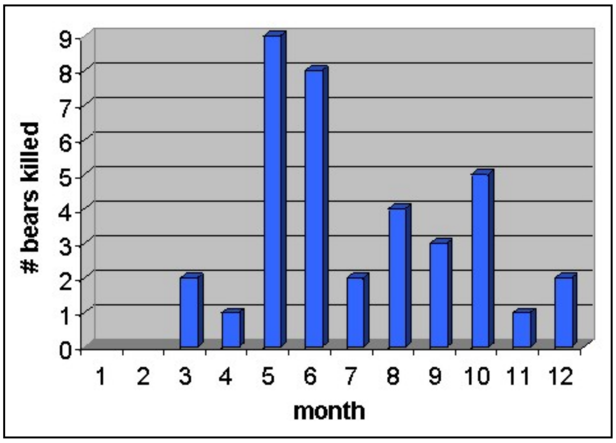

Fig.13: Monthly distribution of bear traffic accidents (p=0,087,Kruskal-Wallis test for one sample and even distribution).

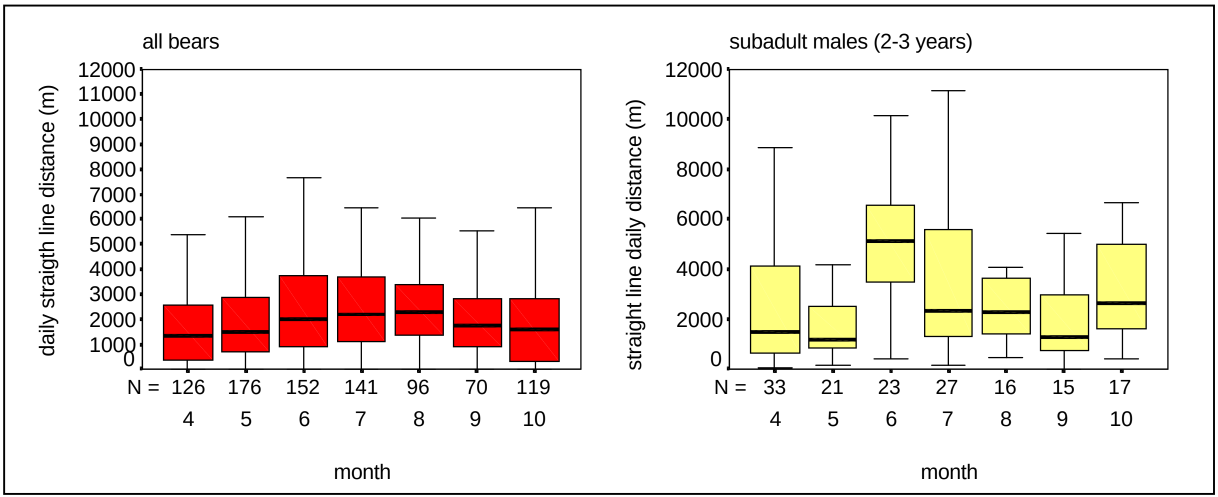

Fig. 14: Straight line distances between locations of consecutive days for all bears pooled and for subadult males only (right). About 90% of the subadult distances are derived from one individual (SRECKO) and therefore can not be considered as representative. For SRECKO there was a tendency to move longer distances in June. The box indicates the median, 25% and 75% quartiles and whiskers are the largest values that are not outliers.

4.4. Location of moralities

18 additional bears were killed by traffic in other places than between Vrhnika and Postojna. That is 53% of all traffic mortality happened along a 30 km stretch of the highway system in combination with the adjacent railway tracks (Fig.15). As we did not do any site investigations for most mortalities, we are not aware of any small scale features which would explain this concentration of accidents. At least two train collisions happened because bears had used the railway for traveling. One bear was killed on a railway bridge above the highway (Fig.10) and an other (*LUCIA*) was killed on a stretch, where the railway is carved into the rocks for several 100 meters. No vegetation is growing on railway bridges, nor along tracks where the railway is carved into the rock and we did not find any food stuff which could have attracted the bears.

Bears occasionally have been observed on bridges and in underpasses. In addition, bear tracks of unmarked bears were found several times on sandbeds in three different underpasses from 1993 to 1998 (Bürglin 1995, Adamic et al. 1996, K. Jerina pers. comm.). Between Vrhnika and Postojna there is one viaduct, 13 underpasses and eight bridges available for safe crossing, or about one crossing structure every 1.4 km (Fig.15). None of the crossing structures were designed for wildlife. Six bridges and eight underpasses just connect forest roads, while two bridges and five underpasses connect paved roads. Parallel to the viaduct is one local road and the railway.

There does not seem to be a close relationship between the presence of bridges and underpasses and the location of accidents as several accidents happened very close to these structures. In addition, three bears were killed within a few hundred meters of the viaduct (Fig.15).

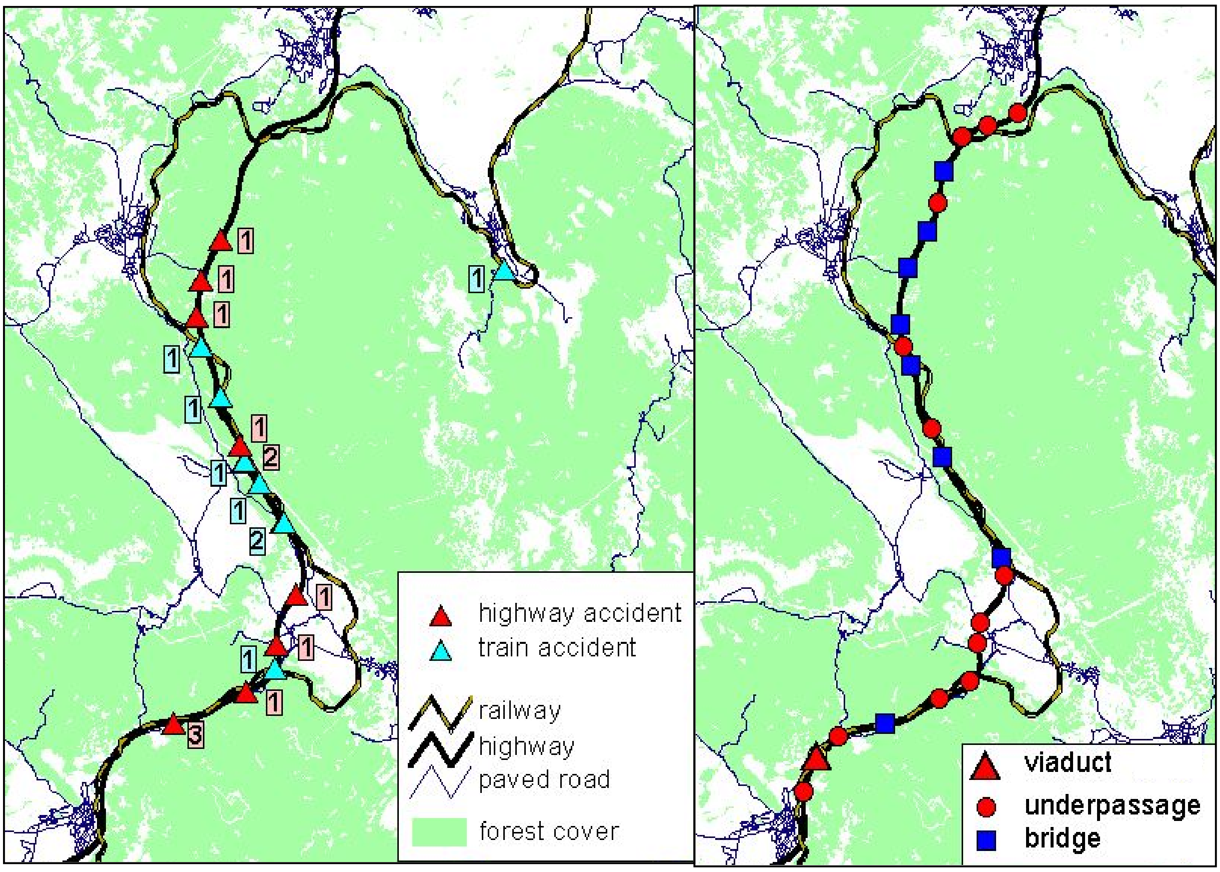

Fig. 15: Location of bear mortalities (left) and crossing structures (left) on the highway and railway between Vrhnika and Postojna.

5. Discussion

The highway as barrier

The Ljubljana-Razdrto highway clearly poses a barrier for bear movements, especially of adult females. On the other hand it is not an absolute barrier and was crossed a total of seven times by radiomarked bears. Additional information from sandbeds on bridges and underpasses (Bürglin 1995, Adamic et al. 1996) and direct observations by locals (Jonozovic 1995) suggest that the highway is successfully crossed by bears several times every year. Concerning the crossings documented with sandbeds, the question remains whether single individuals learnt to cross the highway, or different bears made use of these crossing structures. In Banff National Park, Canada a single adult male was responsible for 22 (67%) out of a total of 33 crossings of the Trans Canada Highway, a high speed, high volume traffic axis in the Bow River Watershed in Alberta (Gibeau 2000).

The marked bears that crossed the highway, were two dispersing individuals (a male and a female) and a three-year old male during the mating season. These findings are similar to the results of a study on bear movements relative to the Trans Canada Highway (TCH). The highway is fenced along a 45 km stretch in Banff National Park and several wildlife crossing structures are available to facilitate wildlife movements across (Clevenger and Waltho 2000). Twelve bears had home ranges bordering the TCH, but only six crossed the highway, three adult males, two subadult males and one subadult female. Like in Slovenia no adult female was observed to cross (Gibeau 2000).

In Slovenia. the highway and the parallel railroad is a significant local mortality factor accounting for 31% of the known bear mortality in the hunting units adjacent to the highway (Fig.11). Even though this number seems rather high, on the population level traffic mortality is not yet a threat to bear conservation in Slovenia. Overall traffic mortality is about 10% of the total known mortality (Fig.12) and is skewed towards males (Tab.3), especially yearlings or subadults (Tab.2). This portion of the population is the least important for population dynamics and can be counterbalanced by a reduction in the hunting quota.

The Slovenian bear population is estimated to number between 300-500 bears, of which 30-50 are legally killed annually (Fig.12). Unregistered natural mortality rates and the amount of illegal killings are unknown, but both seems to be rather low. Dead bears are rarely found and peer pressure and self policing among hunters is high, while other people do not have access to weapons. The impact of road mortality on the bear population is probably rather similar to the harvest rate. The sex ratio of harvested bears is also skewed towards males and the median age of 100 male bears shot and aged (by Matson´s Laboratory, USA) was three-years old (Adamic 1997). On the other hand, there is a great public interest to reduce bear-vehicle collisions. While hunters mainly see the lost trophy, locals pity the bear and are concerned about the risks for the car divers.

Even though bear-traffic collisions are very localized to a 30 km stretch of highway and adjacent railroad, bears are possibly affected in a much larger range. Five radiocollared adult females in Slovenia had home ranges between 39-63 km^2 in size and one adult male 276 km^2 (Tab.1). The diameter of female ranges was in the magnitude of 10 km, that of the male in the magnitude of 20 km. Therefore resident adult females are possibly affected by the highway in a zone of 10 km (total area: 1200 km^2) and adult males in a zone of 20 km (total area: 3000 km^2) on both sides of the highway between Vrhnika and Razdrto. Subadult bears, especially males, are known to disperse long distances (Knauer 2000 in prep., Knauer and Kaczensky 2000, Swenson et al. 1998) and during our study bears dispersed up to 80 km from the place they where initially captured.

We do not know the average dispersal distance, but when assuming an average dispersal distance of 40 km, the possible impact zone of the highway and railway is about 8000 km^2, or almost half the size of Slovenia. As most bears killed on the highway and railway were young males, these animals might have originated from hunting units far away from the highway (Fig.16). This large scale impact clearly shows that bear habitat has to be managed on a landscape level and that international cooperation is much needed. In areas where bears have larger home ranges e.g. Scandinacvia (Dahle et al. 2000), Austria (Rauer and Gutleb 1997) or Banff National Park (Gibeau 2000) the possible area affected by highways can be much larger and a net of high speed traffic axis might result in dividing suitable habitat in areas too small to support female home ranges.

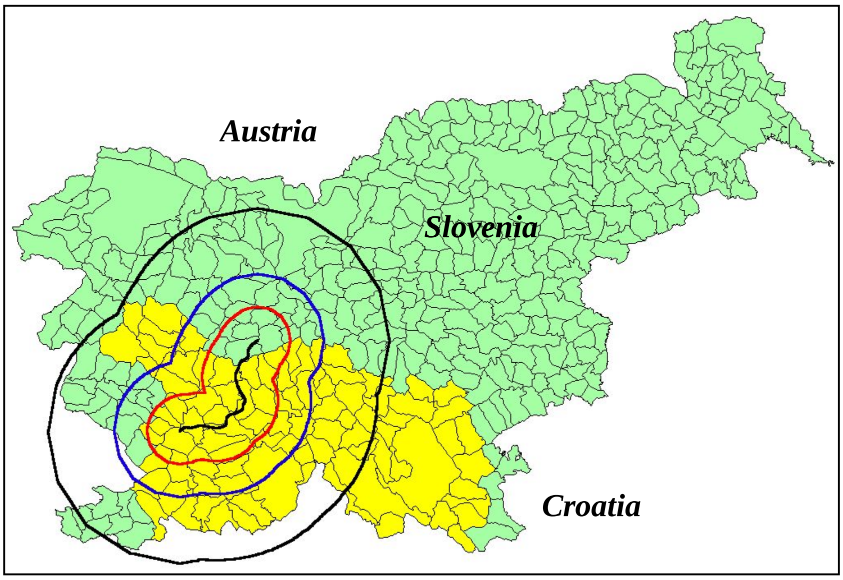

Fig. 16: Possible impact zones of the highway Ljubljana-Razdrto and the adjacent railroad. Due to differences in the home range size, adult females may be affected up to 10 km (red) from these traffic lanes, adult males up to 20 km (blue) and dispersers up to 40 km (black) and more.

Yellow area: the 5200 km² bear core area.

The traffic mortality of the Ljubljana-Razdrto highway and the adjacent railroad clearly demonstrates the detrimental impact busy, high speed traffic axis through prime bear habitat can have. The situation is relaxed only by the fact that bears in Slovenia: (1) have relatively small home ranges (Tab.1), (2) live at a rather high density (about one bear / 10 km²) and (3) that so far the Ljubljana-Razdrto highway and the railway Ljubljana-Triest are the only high speed, high volume traffic axes that cut through the bear core area (Fig.1). In other areas of Slovenia traffic mortality is fairly low.

Contrary, in Gorski Kotar, Croatia overall traffic mortality increased from 11% of the overall known bear mortality for the period 1946-85 to 19% for the period 1986-95 (Huber et al. 1998) and is most likely a result of the increasing traffic and a higher density of roads. Managers should be aware that more high speed traffic axis through prime bear habitat will result in higher losses and greater habitat fragmentation. In the Netherlands an ever increasing net of roads was the most important factor explaining a 30% decline in the overall badger population from 1960 to 1980 (Van der Zee et al. 1992).

Traffic mortality along the highway and adjacent railway was restricted to a 30 km stretch between Vrhnika and Postojna. Knauer et al. (2000 in prep.) developed a grid based habitat suitability model for Slovenia based on radiotelemtry data. With small exceptions, the model categorizes bear habitat on both sides of the highway and railway between Vrhnika and Postojna as prime bear habitat (Fig.13). Furthermore, forest distribution between Vrhnika and Postojna is almost continuous on both sides of the highway (Fig.1). It seems to be these large scale landscape characteristics, rather than small scale habitat factors, that predispose the Ljubljana-Razdrto highway and the parallel railway to cause transportation related bear mortalities. In Gorski Kotar, Croatia Huber et al. (1998) also found that it was not microsite habitat features, but rather large scale landscape characteristics (travel corridors) in combination with food sources related to human activity that were associated with accident sites.

The railway, an underestimated mortality risk

Even though there is great concern about the impact of highways on the bear population in Slovenia, the impact of railways has been largely neglected. Between Vrhnika and Postojna an almost equal number of bears was killed by cars on the highway than by trains on the railway. If mitigation measures are considered the railway also has to be taken into account. Train accidents are also reported from the Abruzzo area (Boscagli 1987) and in Gorski Kotar, Croatia 70% of all traffic killed bears where killed along the Zagreb-Rijeka railroad (Huber et al. 1998). In Canada bears were killed by train, because they were attracted by grain spills along the Canadian Pacific rail line (Gibeau and Herrero 1998).

Unfortunately hardly any experience with mitigation measures concerning railway tracks is available. In Alaska, during winters of deep snow, when animals are attracted to the tracks for ease of travel, a small scooter or track vehicle proceeds the train to scare away wildlife (P. Parquet pers. comm.). Experiences with whistles and noises also have shown some success (P. Wells, Canadian Pacific Railway, pers. comm.). Electric fences are difficult to maintain and animals that manage to slip through the fence are frequently trapped on the inside (T. Clevenger pers. comm.). In addition, by fencing the railway the mortality risk might be reduced, but the railway becomes a serious barrier especially if no passages exist. At least two of the bears killed on the railway used the tracks for travelling and not just crossed the tracks. Anything that would discourage bears from travelling on the tracks, but still allows easy crossing would be desirable. In any case more applied research concerning the mitigation of railway tracks is much needed.

6. Management Implications

Even though the Ljubljana-Razdrto highway and the adjacent railway pose a significant mortality risk for bears, at present these traffic axes are not an immediate threat to bear conservation in Slovenia. On the other hand more than 50% of all transportation-related bear accidents occur on a 30 km stretch, a manageable area for mitigation measures. It also has to be kept in mind that bears are not the only animals affected by the highway. Preliminary data from eartagged wild boars (*Sus scrofa*) suggests that there is no more exchange between the population on the east and west side of the highway (Krze 1994). Species like roe deer (*Capreolus capreolus*) and other medium and small sized mammals suffer a rather high mortality (Jonozovic 1995), while the impact on the population and the barrier effect of the highway remains unknown.

People do not seem to care much about deer or other small creatures, but do not like to see road killed bears. Bears therefore can be used as a flagship species to raise awareness for wildlife-traffic conflicts and the need for mitigation measures. This policy was already successful for the extension of the Ljubljana-Razdrto highway, where two viaducts and a wildlife passage were built. The concentration of bear accidents between Vrhnika and Postojna would allow for testing new methods to reduce bear train collisions, as well as testing measures to make the existing bridges and underpasses more attractive for wildlife, e.g. by providing noise and view screens on the bridges. The construction of new wildlife passages in the form of green bridges would be desirable, but will have to be done in the right location, will cost a lot of money and therefore will need international financing. As experiences with wildlife passages for bears are mainly restricted to North America, such a project could serve as a model of other bear areas in Europe.

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8. Reference List

Adamic, M. 1994. Highways and free-living wild animals - inevitable conflicts and possible alleviation of their effects. Gozd, 52:426-433.

———. K. Jerina, and M. Jonozovic. 1996. The characteristics of the use of underpassages and bridges on the highway section Vrhnika-Razdrto-Cebulovica for. Slovenski Kongres o cestah in prometu, Bled, Slovenia, 351-355.

———. 1997. The analysis of the key sources of mortality of the brown bear (*Ursus arctos* L.) in Slovenia in the last 6 years. Zbornik gozdarstva lesarstva, 53:5-28.

Bekker, H. G. J. 1998. Habitat fragmentation and infrastructure in the Netherlands and Europe. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 151-165. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Bennett, A. F. 1991. Roads, roadsides and wildlife conservation: a review. In: D.A. Saunders and R.J. Hobbs (editors). Nature Conservation 2: The role of corridors. p: 99-117. Surrey Beatty & Sons PTY Limited, Chipping Norton, Australia.

Boscagli, G. 1987. Brown bear mortality in central Italy from 1970 to 1984. International Conference on Bear Research and Management, 7:97-98.

Bürglin, R. 1995. Planung von Grünbrücken an der Autobahn Ljubljana-Razdrto (Slowenien) unter besonderer Berücksichtigung des Braunbären. Diploma thesis at the University of Munich, Germany, 79pp.

Cerne, A. 1992. Geographic openness to transport, and the transit character of Slovenia. In: M. Pak, M. O. Adamic (editors). Slovenia, geographic aspects of a new independent European nation. 27th International Geographical Congress at Washington 1992, p: 77-86. The Association of the Geographical Societies of Slovenia, Ljubljana, Slovenia.

Clevenger, A. P. and N. Waltho. 2000. Factors influencing the effectiveness of wildlife underpasses in Banff National Park, Alberta, Canada. Conservation Biology, 14(1):17-56.

Dahle, B, J. E. Swenson, and F. Sandegren. 2000 in prep. Annual and seasonal home ranges in adult Scandinavian brown bears: effect of density, sex and reproductive status.

Forman, R. T. T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology, 14(1):31-35.

Foster, M. L. 1992. Effects of highways on bobcat survival and movement patterns in SW Florida. Florida Scientist 55:33.

Frikovic, A., R. L. Ruff, L. Cicnjak, and D. Huber. 1987. Brown bear mortality during 1946-85 in Gorski Kotar, Yugoslavia. International Conference on Bear Research and Management, 7:87-92.

Gibeau, M. L. and S. Herrero. 1998. Roads, rails and grizzly bears in the Bow River Valley, Alberta. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 104-108. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

———. 2000. A conservation biology approach to management of grizzly bears in Banff National Park, Alberta. Ph.D. dissertation. Resources and the Environment Program, University of Calgary, Alberta, Canada (http://www.canadianrockies.net/Grizzly/pubs_and_papers.htm).

Hooge, P. N. and B. Eichenlaub. 1997. Animal movement extension to arcview, version 1.1. Alaska Biological Science Center, U.S. Geological Survey, Anchorage, AK, USA.

Hubbard, M. W., B. J. Danielson, and R. A. Schmitz. 2000. Factors influencing the location of deer-vehicle accidents in Iowa. Journal of Wildlife Management, 64(3):707-713.

Huber, D., J. Kusak, and A. Frikovic. 1998. Traffic kills of brown bears in Gorski Kotar, Croatia. Ursus, 10:167-171.

Jonozovic, M. 1995. Impacts of the highway Ljubljana - Razdrto on the wildlife. Graduation thesis at the Biotechnical Faculty of the University of Ljubljana, 83pp. (in Slovenian with English abstract)

Kaczensky, P., F. Knauer, T. Huber, M. Jonozovic, and M. Adamic. 1996. The Ljubljana-Postojna highway - a deadly barrier for brown bears in Slovenia? Journal of Wildlife Research, 1(3):263-267.

Knauer, F. and P. Kaczensky. 2000. Spatial movement patterns of dispersing brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. P. Kaczensky, and G Rauer. 2000. A habitat model for bear expansion from Slovenia into the eastern Alps. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. 2000 in prep. Dispersal und Ausbreitung von Braunbären in die Ostalpen. Dissertation an der Forstwissenschaftlichen Fakultät am Fachgebiet für Wildbiologie und Wildtiermanagement an der TU München.

Krze, B. 1994. Prispevek k poznavanju ekologije populacij divjega prasica v Sloveniji. Lovec, 3:102-105. (in Slovenian)

Linnell, J. D., M. E. Smith, J. Odden, P. Kaczensky, and J. E. Swenson. 1996. Carnivores and sheep farming in Norway. 4. Strategies for the reduction of carnivore - livestock conflicts: a review. NINA Oppdragsmelding 443:1-118.

McLellan, B. N. and D. M. Shackleton. 1988. Grizzly bears and resource-extraction industries: Effects of roads an behavior, habitat use and demography. Journal of Applied Ecology, 25:451-460.

Mladenoff, D. J. and T. A. Sickley. 1998. Assessing potential gray wolf restoration in the northeastern united states: A spatial prediction of favorable habitat and potential population levels. Journal of Wildlife Management, 62(1):1-10.

Pfister, H. P., V. Keller, H. Reck, and B. Georgii. 1997. Bio-ökologische Wirksamkeit von Grünbrücken über Verkehrswege. Final report of the research project 02.143R91L. Vogelwarte Sempach, Sempach, Switzerland.

Rauer, G. and B. Gutleb. 1997. Der Braunbär in Österreich. Federal Agency of Environment, Monographie, 88:64pp. Vienna, Austria.

Republic of Slovenia. 1997. Statistical Yearbook 1997. Statistical Yearbook 1997, Issue 36, Statistical Office of the Republic of Slovenia, Ljubljana, Slovenia, 657pp.

Ruediger, B. 1998. Rare carnivores and highways - moving into the 21st century. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 10-14. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Servheen, C., J. S. Waller, and W. F. Kasworm. 1998. Fragmentation effects of high speed highways on grizzly bear populations shared between the United States and Canada. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 97-103. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

Swenson, J. E., F. Sandegren, and A. Söderberg. 1998. Geographic expansion of an increasing brown bear population: evidence for presaturation dispersal. Journal of Animal Ecology, 67:819-826.

Trombulak, S. C. and C. A. Frissel. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology, 14(1):18-30.

Van der Grift, E. A. 1999. Mammals and railroads: Impacts and management implications. Lutra, 42(1):77-98.

Van der Zee, F. F., C. J. F. Ter Braak, R. C. van Apeldoorn, and J. Vink. 1992. Landscape change as a possible cause of the badger *Meles meles* L. decline in The Netherlands. Biological Conservation, 61:17-22.

Wooding, J. B. and J. R. Brady. 1987. Black bear roadkills in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 41:438-442.

———. 1993. Evaluation of a new wildlife underpass on S.R. 46 in Lake County, Florida. Draft Study Narrative.

4.5. The brown bear – a highly valued, controversial species in Slovenia. *Petra Kaczensky, Mateja Blazic, Alistair Bath, and Veronika Szinovatz (42+15pp)*

The brown bear – a highly valued controversial species in Slovenia

The brown bear – a highly valued, controversial species in Slovenia

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Abstract

In most areas where humans coexist with brown bears (*Ursus arctos*) conflicts exist, e.g. livestock depredation, competition for wild ungulates or in more rare cases attacks on people. Direct persecution in combination with habitat destruction led to the near extinction of brown bears in western, southwestern and central Europe. Today international treaties and national laws demand the recovery of large carnivores in suitable areas. However, in the multi-use landscapes of Europe, the future of large carnivores will foremost depend on the acceptance by the local people and not only on the availability of suitable habitat. Due to international interest in the natural re-colonization of the Alps by brown bears, current policy in Slovenia supports the northward expansion of the country's bear population. This policy is challenged by a sharp increase in sheep depredation and other bear human conflicts.

We examined people's attitudes towards bears and the related management, their knowledge about and their personal experience with the species in two different study areas: in a low conflict, but high bear density area in Notranski (NOT) and in the high conflict, low bear density area in the Alps (ALP). Target population of the inquiry was the local population 16 years and older and two special target groups: hunters and pupils. After quality control a total of 1519 questionnaires were used for analysis. Questions were grouped to calculate four different scores as estimates of: general attitude towards bears (AS), attitude towards the utility of bears (US), attitude towards a further increase in bear numbers (NS) and general knowledge about bears (KS).

Mean scores were more similar between the two study areas than between target groups. AS were very positive in both areas and in all target groups. US was in the neutral range indicating that people regarded the bear neither particularly harmful, nor useful. Differences in KS were highly significant between target groups: hunters knew the most about bears while pupils knew the least. Differences in NS were also highly significant between target groups with hunters scoring lowest, indicating a low support for a further increase in the bear population and pupils scoring highest, indicating a moderate support for a further increase in the bear population.

Stepwise multiple regression showed that socio-demographic factors and place of residence had little predictive value to explain variation in scores. It was the US and the perception of whether or not the bear is dangerous for humans, that were most important predicting AS in all three target groups. Like AS, US was highly dependent on the perception of whether or not the bear is dangerous for humans, and additionally on own negative experiences with bears. NS was mainly influenced by AS, the perception of the bear population trend and the US.

Even though the bear is a highly valued species in Slovenia, if the present bear expansion policy is to be continued, it needs to be accompanied by a well designed public information program, focusing especially on fear-related topics. Clear statements about the management goals, especially the targeted bear population size and the desired future distribution area, as well as a program, on how to deal with bear-human conflicts will be necessary.

1. Introduction

In most areas where humans coexist with brown bears (*Ursus arctos*) conflicts exist, e.g. livestock depredation (Kaczensky 1996, Linnell et al. 1996, Sagor et al. 1997, Kaczensky 2000 in press), competition for wild ungulates (Dahle 1996) or in more rare cases attacks on people (Herrero and Fleck 1989, Swenson et al. 1999). Direct persecution in combination with habitat destruction led to the near extinction of brown bears in western, southwestern and central Europe (Breitenmoser 1998). Today international treaties and national laws demand the recovery of large carnivores in suitable areas. However, in the multi-use landscapes of Europe, the future of large carnivores will foremost depend on the acceptance by the local people and not only on the availability of suitable habitat.

Human dimension in wildlife management

Even though it has been acknowledge for a long time that wildlife management largely means the management of people (Thomas 2000), until recently it had been a discipline mainly based on the biological basis in the decision making process. But with the general public becoming more knowledgeable and engaged in issues on natural resources, it becomes crucial to integrate the human dimension into the decision-making process (Bright and Manfredo 1995). Following a definition by Bath (1996), human dimension research is "the understanding and documenting of public attitudes that can help wildlife managers better market their decisions, minimize public controversy and minimize delay in implementation of management plans, programs and policies". More specifically Bright and Manfredo (1995) see the main advantage of attitudinal information to help managers to: (1) understand the diverse sides of an issue, (2) determine the extend to which the public will accept and support management practices, (3) project future demands, (4) understand new and diverse user groups and (5) use information programs to influence the public.

Sociological background

The conceptual foundation of most human dimension research roots in attitude and value theory, which postulates that human thought is arranged in a hierarchy of cognitions (Decker et al. 1987, Manfredo et al. 1995). Values are the basis and fall into two concepts, assigned and held values. Assigned or external values refer to how worthy or important something is considered to be (e.g. often measured in economic value), while held or internal values refer to basic evaluative beliefs, percepts or ideals. Based on the held values are a restricted number of basic beliefs and based on them are numerous higher-order beliefs, resulting from every day information and experiences. Attitudes are a result of these higher-order beliefs. Even though people can hold very many of these beliefs, only a few – about eight to nine – come to mind spontaneously and it is these salient beliefs that are thought to determine a persons attitude (Ajzen 1993, Manfredo et al. 1999).

Values are very difficult to change as they are generally shaped early in a persons life. Changing people's attitude on the other hand is possible, but still difficult (Manfredo et al. 1995). The rational behind focusing on people's attitude is the assumption that by knowing somebody's attitude it is possible to predict the persons behavior, referred to as the attitude-behavior consistency (Ajzen 1993). Several studies have shown, that the predictive value of the attitude concerning a certain behavior is influenced by several factors, e.g. attitude strength (people that hold a extreme attitude are more predictable), attitude certainty (people that are more sure about their attitude are more predictable) (Bright and Manfredo 1995) and the specificity of the situation (a general attitude might not predict a specific behavior) (Manfredo et al. 1998).

Personal importance of the issue (the more important the better the prediction) and information available (the more information the better the prediction) may act as moderating factors of the attitude-behavior consistency (Bright and Manfredo 1995). Ajzen (1993) on the other hand states that moderating factors are too complex to be of any use, and in his theory of planned behavior, postulates that the attitude-behavior consistency is mainly a result of the attitude towards the behavior, subjective norms (the perceived social pressure to act in a certain way) and the degree of perceived behavioral control (to what extent a person thinks it has the resources and skills available to perform the behavior under consideration).

Socio-demographic characteristics such as age, sex, profession, urban versus rural mode of living, place of residence in relation to large carnivore distribution, as well as the knowledge and fear component were found to be critical factors influencing attitude and acceptance of a controversial wildlife species in previous research (Hook and Robinson 1982, Bath 1991, Kellert 1994). Objective knowledge represents the extent to which individuals believe that certain factually-based statements about bears are true or false. Usually one expects more positive attitudes with increasing knowledge (Bath 1989). But especially in the case of a highly controversial large carnivore species a negative relationship between knowledge level and acceptance may be found (Bath 1994, Bright and Manfredo 1996, Kellert et al. 1996).

In Europe the importance of human dimension research for carnivore conservation was only recently acknowledged, but triggered multiple studies using questionnaire and interview surveys (e.g. Bjerke and Reitan 1994, Cicnjak and Huber 1995, Korenjak 1995, Baumgartner 1998, Hunziker et al. 1998, Kvaalen 1998, Caluori 1999, Ueberschär 2000, Szinovatz and Bath 2000 in press, Szinovatz and Gossow in prep., Zimmermann et al. 2000 in prep.). Most studies were pilot projects and only little peer reviewed literature on this topic is available. Even though great progress has been made to understand the habitat requirements and behavior of large carnivores, the knowledge on how to achieve and maintain long term acceptance of the local population still remains a major challenge for carnivore conservation in Europe.

The Slovenian bear situation

In Slovenia bear management is zoned. In a 5.200 km² core area in southern Slovenia bears have always been present. Today bear density is rather high (about 1 bear/10 km²) and bears are harvested following a quota system during a limited hunting season. In the rest of the Slovenian territory (14.800 km²) bears are fully protected since 1992 (Simonic 1994, Kaczensky 1996). About 80% of all bears live in the core area, where, so far, bear-human conflicts have been low. Outside the core area, bear presence had been suppressed until 1992, when increasing international interest for the natural re-colonization of the Alps led to a change in policy. Whereas bears could be shot at any time in the outer area before, they are now fully protected.

Unfortunately, this change in policy was not accompanied by any specific education program. In addition, there was a sharp increase in sheep depredation problems, especially in the pre-alpine and alpine areas.

In Slovenia we had the chance to collect data in the bear core area, an area with unbroken bear-human coexistence and low conflict level and compare it with an area in the Alps, where bears just recently re-appeared and were the conflict level was rather high. Using a questionnaire we surveyed the attitudes and knowledge level of three target groups: (1) the local population, (2) hunters and (3) pupils within and outside the bear core area.

Our expectations were that:

(1) there is a great difference in the knowledge level and attitudes between people in the core area and people in the alpine area - people in the alpine area know less about bears and have a more negative attitude

(2) there is a great difference between the target groups – hunters have the highest knowledge level and the most positive attitude towards bears and bear management

(3) socio-demographic factors, the knowledge level and own experience with bears are be important predictors for people's attitude towards bears and bear management

2. Method

2.1. Study area

The two study areas were chosen according to their relative location to the bear core area, to the degree of sheep depredation problems (from 1994-1998, Slovenian Ministry of Agriculture, unpubl. data) and to human population size (Statistical Office of Slovenia, unpubl. data) (Fig.1). The alpine study area (ALP) had a total population of 18.410 inhabitants, while the Notranski study area (NOT) had 24.121 inhabitants. In the alpine study area a higher percentage of people lived in rural areas (villages ≤ 700 inhabitants). For the comparison of rural versus urban respondents within the ALP area, we included the town of Radovlica, which is 17 km northeast of the rest of the ALP study area. Even when including Radovlica, 75% of people in the ALP area lived in towns (≥ 700 inhabitants), as compared to 85% in the NOT area. The largest town in the NOT area was Vrhnika with 7.019 inhabitants and in the ALP area Radovljica with 6.117 inhabitants.

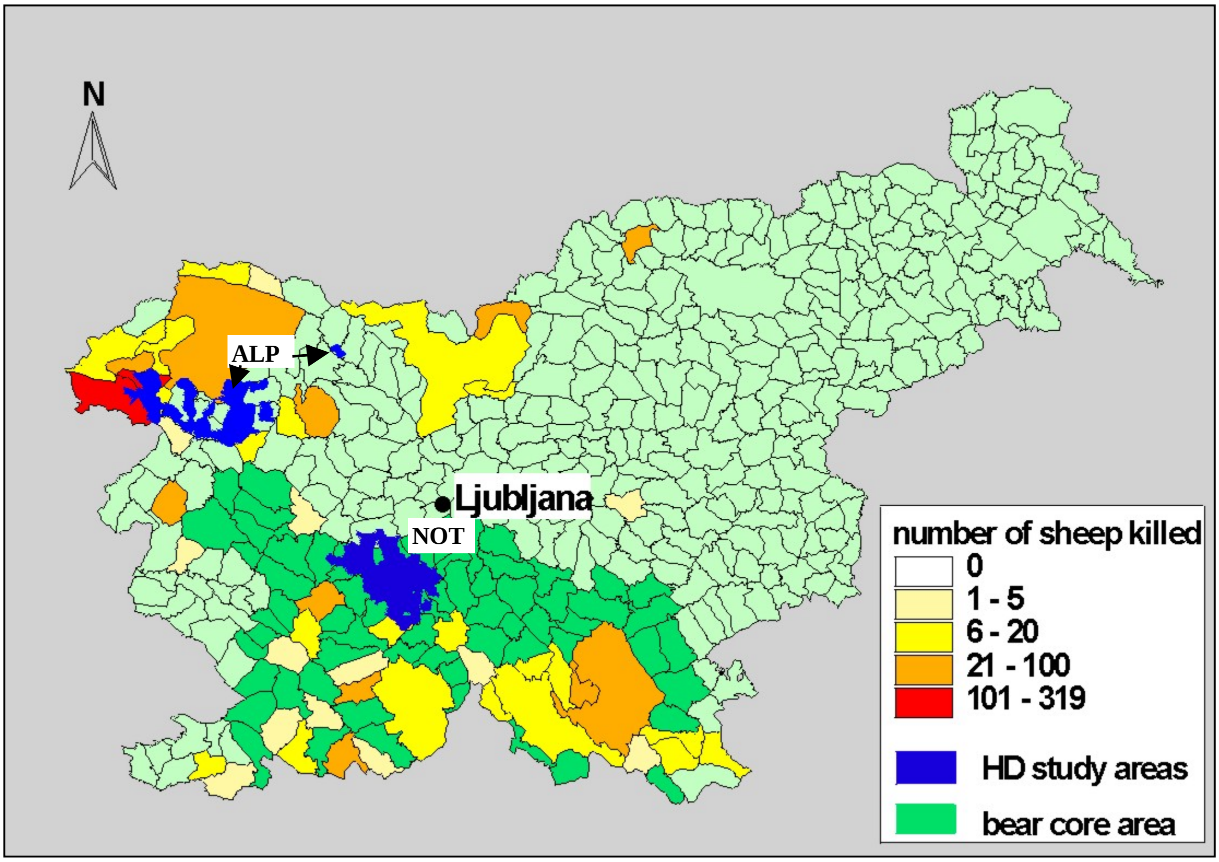


Fig. 1: Location of the study areas (communities) relative to the bear core area and hunting units with sheep depredation problems.

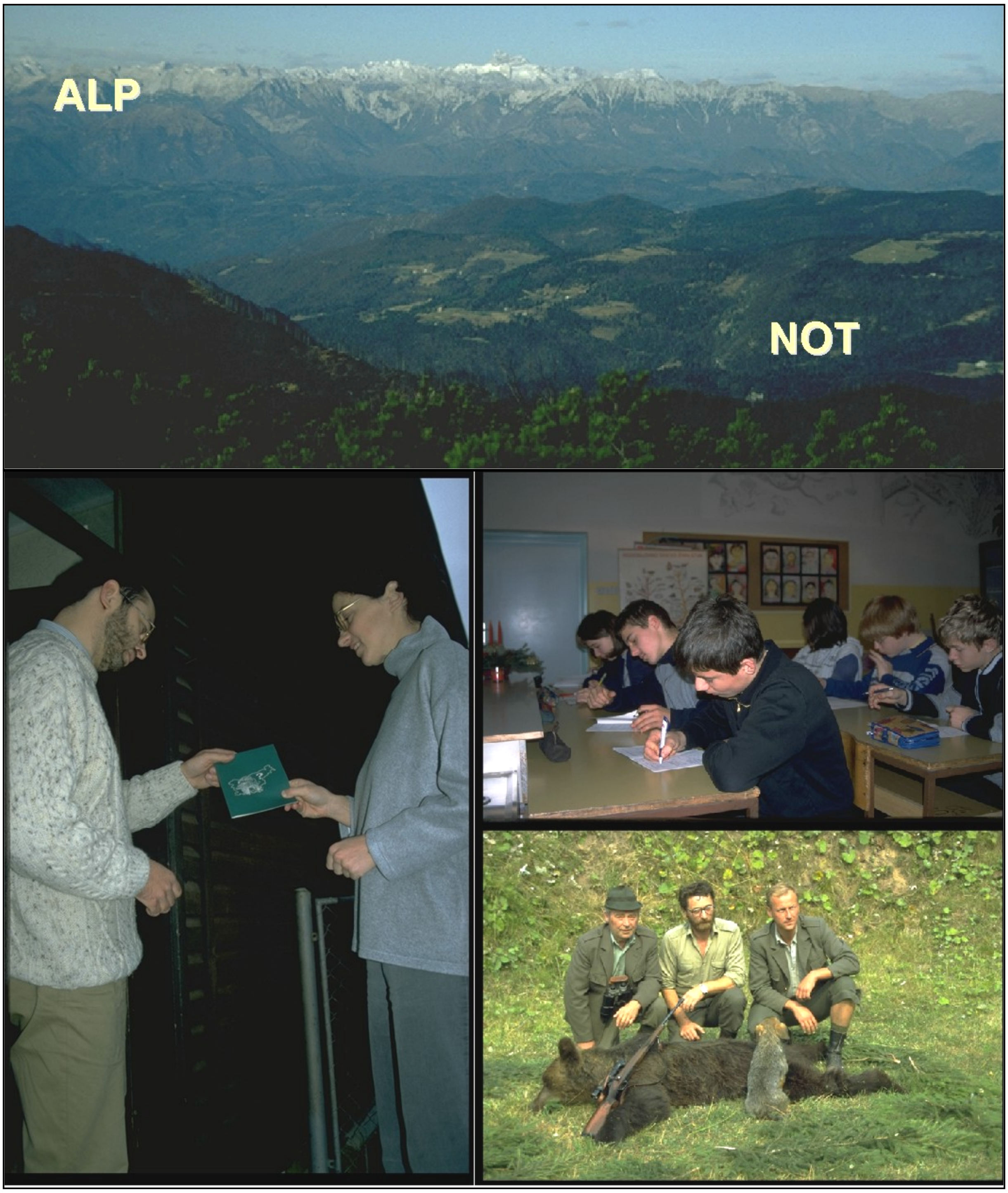


Fig.2: View on part of the NOT and ALP study area. Target groups of the survey: locals, pupils and hunters.

2.2. Target groups

Target of the inquiry was two special target groups: hunters (Tab.1) and pupils 13-15 years old (Tab.2) and the general local public 16 years and older (Tab.3). 100 questionnaires each were distributed to hunters, 200 to pupils and 500 to locals in both, the NOT and the ALP area. For locals 200 (50%) were distributed in villages with up to 700 inhabitants (rural) and the other 50% in towns with more than 700 inhabitants (urban).

Tab. 1: Hunting clubs sampled in the two study areas. All hunters were at least 16 years old.

	hunters in hunting club	**hunters sampled**	***% sampled***
NOT area			
Begunje	62	17	*27*
Borovnica	60	16	*27*
Cerknica	55	15	*27*
Grahovo	48	13	*27*
Rakek	73	20	*27*
Rakitna	69	20	*29*
total	***367***	***101***	***28***
ALP area			
Bohinjska Bistrica	54	16	*30*
Ljubbinj	70	21	*30*
Podbrdo	80	24	*30*
Smast	25	8	*32*
Stara Fuzina	48	15	*31*
Tolmin	52	16	*31*
total	***329***	***100***	***30***

Tab. 210: Primary schools sampled in the two study areas.

	total number of pupils	**pupils sampled**	***% of total sampled***
NOT area			
Borovnica	50	24	*48*
Cerknica	103	46	*45*
Logatec	122	52	*43*
Rakek	32	16	*50*
Vrhnika	164	73	*45*
total	***471***	***211***	***46***
ALP area			
Bohinjska Bistrica	59	38	*64*
Kobarid	47	28	*60*
Podbrdo	27	20	*74*
Radovlijca	112	68	*61*
Tolmin	86	59	*69*
total	***331***	***213***	***66***

Tab. 3: Parameters of the local population living in both study areas (NOT and ALP area) as compared to the local population sampled with questionnaires (NOT and ALP sample).

	NOT area	NOT sample	NOT statistical data	ALP area	ALP sample	ALP statistical data
total population	24121			18410		
total population ≥ 16 years	18301	455	*2.5% sampled*	13435	469	*3.5 % sampled*
urban population (in towns with >700 inhabitants) (in %)	85	50		76	50	
age structure of population > 16 years (in %)			*chi² residues*			*chi² residues*
16-19 years	8	5	*-10,6*	6	5	*-11,1*
20-29 years	21	18	*-11,5*	14	25	*23,9*
30-39 years	22	22	*0,9*	16	19	*-12,6*
40-49 years	16	21	*25,2*	13	20	*17,6*
50-59 years	15	16	*3,9*	12	15	*5,8*
60-69 years	10	11	*5,4*	10	12	*-0,4*
>70 years	8	5	*-13,3*	8	5	*-23,6*
chi² sign.			*0,003*			*0,000*
missing cases		*27*			*14*	
sex ratio (in %)			*chi² residues*			*chi² residues*
females	52	46	*-28,3*	52	45	*-32,7*
males	48	54	*28,3*	48	55	*32,7*
chi² sign.			*0,007*			*0,002*
missing cases		*16*			*4*	
profession (in %)			*chi² residues*			*chi² residues*
farmer + forester	6	7	*5,0*	7	4	*-13,4*
other	94	93	*-5,0*	93	96	*13,4*
chi² sign.			*0,325*			*0,015*
missing cases		*14*			*14*	
working - non working (in %)						
working	-	63		-	65	
student	-	11		-	11	
pupil	-	1		-	1	
housewife	-	5		-	5	
retired	-	20		-	18	
education			*chi² residues*			*chi² residues*
primary school	45	16	*-128,7*	43	16	*-123,7*
secondary school	45	67	*91,9*	44	58	*61,4*
university	4	14	*45,4*	5	21	*73,2*
other	5	3	*-8,6*	6	5	*-11*
chi² sign.			*0,000*			*0,000*
missing cases		*14*			*12*	
% illiterates	0,2	-		0,3	-	

2.3. Questionnaire

The implemented questionnaire was based on a questionnaire from Alistair Bath, Memorial University, Newfoundland, Canada, revised and adapted to the Slovenian situation. The questionnaire was developed in English language and translated into Slovenian language. To identify potential problematic questions or confusion with instructions the questionnaire was first discussed with a group of Slovenian biologists and then qualitatively pre-tested with 10 locals. This procedure resulted in the rewording of several questions and the elimination of 2 questions.

The final questionnaire (appendix 1) was printed as a DINA5 booklet with a colored cover (Fig.3). On the first page was a cover letter briefly introducing the involved organizations, the investigators and the project goals. It also emphasized that respondents will stay anonymous. The cover letter was signed by the three main investigators.

The questionnaire comprised a total of 71 questions organized in 6 sections with a directory at the start of each section that guided through the questions. The last two pages were empty and offered room for additional comments. The sections concentrated on:

1. attitude and believe of people about bears (22 questions)
2. knowledge about bears and bear management (15 questions)
3. attitude towards bear management (13 questions)
4. source of information, certainty and importance of the bear issue (5 questions)
5. own experiences with bears in Slovenia (10 questions)
6. socio-demographic facts (6 questions)

All attitudinal questions were measured on a 5-point Likert scale ranging from "strongly agree" to "strongly disagree". No "do not know" option was included to force people to give a statement. The majority of questions about knowledge was stated as multiple-choice questions, also offering the option "do not know".

Fig.3: The Slovenian bear questionnaire, a DINA5 booklet with 10 pages. The cover page was green and showed a bear within the outline of Slovenia and a big question mark. The inner part was printed on light gray and environmentally friendly paper.

2.4. Distribution of questionnaires

Questionnaires were handed out personally with the help of biology students (Fig.2). The number of questionnaires distributed in each town or village was proportional to the number of inhabitants. We chose people by randomly selecting houses on the map and handling the questionnaire to the person that opened the door or was seen in front of the house. If people were not at home or refused to accept the questionnaire, the next neighboring house was approached in the same way. The questionnaire was left with the people and picked up a few hours later. We offered people a plastic bag and asked them to leave the questionnaire in front of the door in case they had to leave the house.

Hunters were sampled by contacting the presidents of 12 randomly selected hunting clubs in the two study areas. With each president we arranged the mode of distribution which was either done by us during meetings of the hunters or by the president himself. All questionnaires were recollected either at the meeting or from the president.

To survey pupils all 10 primary schools within the two study areas were approached and asked for the permission to distribute the questionnaires during class. Since this resulted in a significant disturbance of the normal schedule, pupils were sampled by class, that means all pupils in a class received a questionnaire which they had to fill in immediately. To avoid any bias, the teacher was previously asked not to give any specific information to the class. But after recollection of the questionnaires or on later occasions we provided short lectures on bears, bear management and bear research in Slovenia.

Due to our distribution mode, return rate was high, averaging 98,5% for locals (Tab.4) and pupils and 88% for hunters in NOT and ALP. Acceptance rate for locals (% that agreed to participate in the survey when first approached) was also high and averaged 75%.

Tab. 411: Sampling success for the local population in both study areas.

questionnaire distribution	NOT	ALP
total number of houses visited	902	866
nobody at home or person too young	196	222
nobody at home (%)	22	26
refusal to accept questionnaire	207	141
acceptance rate (%)	29	22
accepted questionnaires	499	503
recollected questionnaires	491	496
return rate (%)	98	99

To test for a possible non-respondents bias, we noted sex and estimated age of people that refused to participate. We did not notice any strong bias, but a tendency for people between 30-69 to respond less likely (Tab.5).

Tab. 5: Sex and age of non-respondents (%) in the local population.

		age classes								% of total
		16-19	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**≥80**	**refused**
NOT[1]	male	0	7	21	29	21	21	0	0	24
n=63	female	0	4	18	20	8	16	18	14	76
ALP	male	0	3	11	18	24	32	11	3	27
n=141	female	0	3	14	21	17	24	16	4	73

[1]for an additional 144 refusals no data on age and sex was available.

2.5. Data analysis

All data analysis was done with SPSS version 8.0 and 9.0, visualizations in part with EXCEL 97.

Quality control

After data entry, we discarded all questionnaires with nonsense answers, and for the local sample all filled in by children (<16 years) (Tab.6).

Tab. 6: Results of the quality control of the questionnaires.

area	target group	recollected	empty	nonsense / too young	useful for analysis	useful for analysis (%)
NOT	locals	491	12	6	455	93
	hunters	91	2	2	87	96
	school	211	0	2	209	99
ALP	locals	496	15	0	469	95
	hunters	95	0	5	90	95
	school	211	0	4	209	99
	total	***1603***	***29***	***19***	***1519***	***97***

We tested, how representative the basic demographic profile of our sample is for the total population (≥16 years) using chi^2 statistics (Tab. 1). We only found a strong and significant bias in respect to education; people with primary school education were clearly underrepresented in our sample.

Calculation of mean scores

The questions were constructed in a way that enabled grouping of similar questions to calculate mean scores. The rational behind asking similar questions of the same topic is to minimize the effect of questions that were misunderstood, or which were filled in incorrectly, as a single indicator is highly affected by random error (Zeller and Carmines 1980). For questions asking the opposite direction, the coding was reversed, so that for all answers positive feelings were expressed by high values on the Likert scale and negative feelings with low values. For knowledge questions all answers were coded as dichotomous variables, using 1 for correct answer and 0 for uncorrect, don't know and missing answers.

Three questions asking for numbers were filled in only by a very low percentage of the respondents (49% for number of bears present in the two study areas, 36% for annual number of bears shot and 52% for annual number of sheep killed) and hence were not included to calculate the KS.

The following variables were used to calculate the four different scales:

(1) attitude score (AS) :

1. Which answer best describes your feelings towards brown bears?
2. Is having bears in Slovenia (good – bad – neither good nor bad)?
3. It is important to maintain bears in Slovenia so our children can enjoy them.
4. It is important to have "viable" populations of bears in Slovenia.
5. Whether or not I would get to see a bear, it is important for me that they exist in SLO.
6. Bears are a sign of an intact nature.
7. Because many bears live in other parts of Europe, there is no need to have bears in SLO.♦♦♦

(2) utility score (US)

1. Bears have a negative impact on hunting opportunities.♦♦♦
2. Bears greatly reduce deer numbers.♦♦♦
3. Bears increase the value of a hunting area.
4. Bears kill a lot of sheep in Slovenia.♦♦♦
5. In areas where bears live close to sheep, their primary food is sheep.♦♦♦
6. Having bears increases tourism to Slovenia.
7. In areas where bears live close to people, bear attacks on humans are common.♦♦♦
8. I would be afraid to go into the woods if bears are present.♦♦♦

(3) number score (NS) – attitude towards further bear population development

1. Bear numbers in Slovenia should be high enough, so bears can move to Italy and Austria.
2. Bears should not be hunted at all in Slovenia.
3. If bears are hunted, hunting should be restricted to specific areas.
4. Bears should be allowed to be hunted year round in Slovenia.♦♦♦
5. Bear numbers should be increased.
6. There is already enough bears in Slovenia.♦♦♦
7. Bears should only live in restricted parts of Slovenia.♦♦♦
8. Bear should be eliminated in areas with sheep problems.

♦♦♦ coding reversed

(4) knowledge score (KS)

1. How many bears do you think live in Slovenia?
2. Do you believe bear numbers in Slovenia are?
3. Do you believe bears exist in the area between Vrhnika, Krim and Cerknica?
4. Do you believe bears exist in the area between Tolmin, Bohinjsca Bistrica and Kobarid?
5. Do bears get shot in Slovenia?
6. Do bears kill sheep in Slovenia?
7. How much space does one adult brown bear need?
8. Female bears have young every year.
9. Most bears weigh less than 150 kg.
10. Bears mainly feed on meat.
11. Farmers are paid money for sheep killed by bears.
12. Bears can only be hunted in some parts of Slovenia.

Scale reliability, that is how well the single questions fit together to measure a common phenomena (homogeneity of items), was tested with Cronbach's Alpha reliability estimate (Zeller and Carmines 1980).

For comparison between areas and target groups, score distribution was tested for normality with Kolmogorov-Smirnov tests. As all scores differed significantly from a normal distribution we used non-parametric U-tests for pair-wise comparisons and Kruskal-Wallis tests for multiple comparisons. For all statistical test we used $p<0{,}05$ for significance level.

Stepwise multiple regression

Using stepwise multiple regression we evaluated the variables that explain best the variation in the AS, US, NS and KS. As independent variables we used all or parts of the following parameters: (1) socio-demographic variables, (2) KS, (3) AS, (4) NS, (5) interest level and source of information, (6) own experience, (7) Is the bear dangerous for people?, (8) Trend estimate of the bear population (for details see appendix 2).

For each single variable the fit to the regression model as single parameter was evaluated. For the final model only variables that had a significant Pearson correlation factor and explained more that 3% of the overall variance were selected (for details see appendix 3).

We additionally checked which of the single questions of the US were the most relevant to explain the AS and which questions of the single questions of the AS were the most relevant to explain the NS.

Extreme answers and single answer analysis

Since a majority or respondents held rather moderate scores, we compared respondents that held a positive score with those that held a negative score. We defined respondents as positive when they had a score between 4-5 for AS, NS, US and between 9-12 for KS and as negative with a score between 1-2 for AS, NS, US and between 1-3 for KS. We compared the percentage distribution of respondents in respect to their socio-demographic profile, the place of residence and own negative experience with bears.

Key questions and questions that were relevant for the present bear management were tabulated. For ease of interpretation all questions on the 5 point Likert scale were regrouped, by combining the answers *strongly agree* and *agree* into the one category *agree* and *strongly disagree* and *disagree* into the one category *disagree*.

3. Results

3.1. Mean score values

Cronbach`s Alpha was very high for the AS and above the required value of 0,6-0,7 (Litwin 1995, Szinovatz 1997) for US and NS (Tab.7). KS was at the lower limit which is most likely the result of the multidimensional nature of the questions and might also be a result of frequent guessing when filling out the multiple choice questions.

Tab. 7: Mean scores for all three target groups

score	# questions	n	stand. Alpha	correlation min	correlation max	mean	SD	K-S[1] p value for normal distribution
AS	7	1378	0,9018	0,4005	0,7800	4,02	0,90	0,000
US	8	1422	0,7336	0,1170	0,6368	3,24	0,57	0,000
NS	8	1425	0,7522	0,6830	-0,0222	2,88	0,81	0,026
KS	12	1519	0,6491	0,0316	0,2622	6,30	2,50	0,000

[1]Kolmogorov-Smirnov test

We found very high attitude scores for all three target groups, suggesting that bears in Slovenia are a highly valued species. Due to the large sample size, differences between target groups and study areas almost always were significant on the 0,05 level (see: appendix 4), but in most cases these differences were small. Contrary to our expectations we did not find meaningful differences between the study areas, nor between the target groups (Fig.4). The same was true for the US, with the only difference that mean values were much lower. The moderate US suggests, that on average people consider the bear slightly more useful than harmful.

The picture was quite different for the NS and KS. Here we found great differences between the target groups, but again none or minor differences between the study areas. Concerning the NS - contrary to our expectations - it was hunters that had the lowest scores, demonstrating low support of a further increase in the bear population. Locals held a more neutral position while pupils even showed a slight tendency to support a further increase. The KS was almost opposite to the NS, hunters had by far the highest knowledge level, while pupils had the lowest and locals were somewhat in-between (Fig.4). For hunters there was a significant and meaningful difference between the two study areas. Hunters from NOT had a higher knowledge level and were somewhat more positive about a further increase of the bear population, than hunters from ALP.

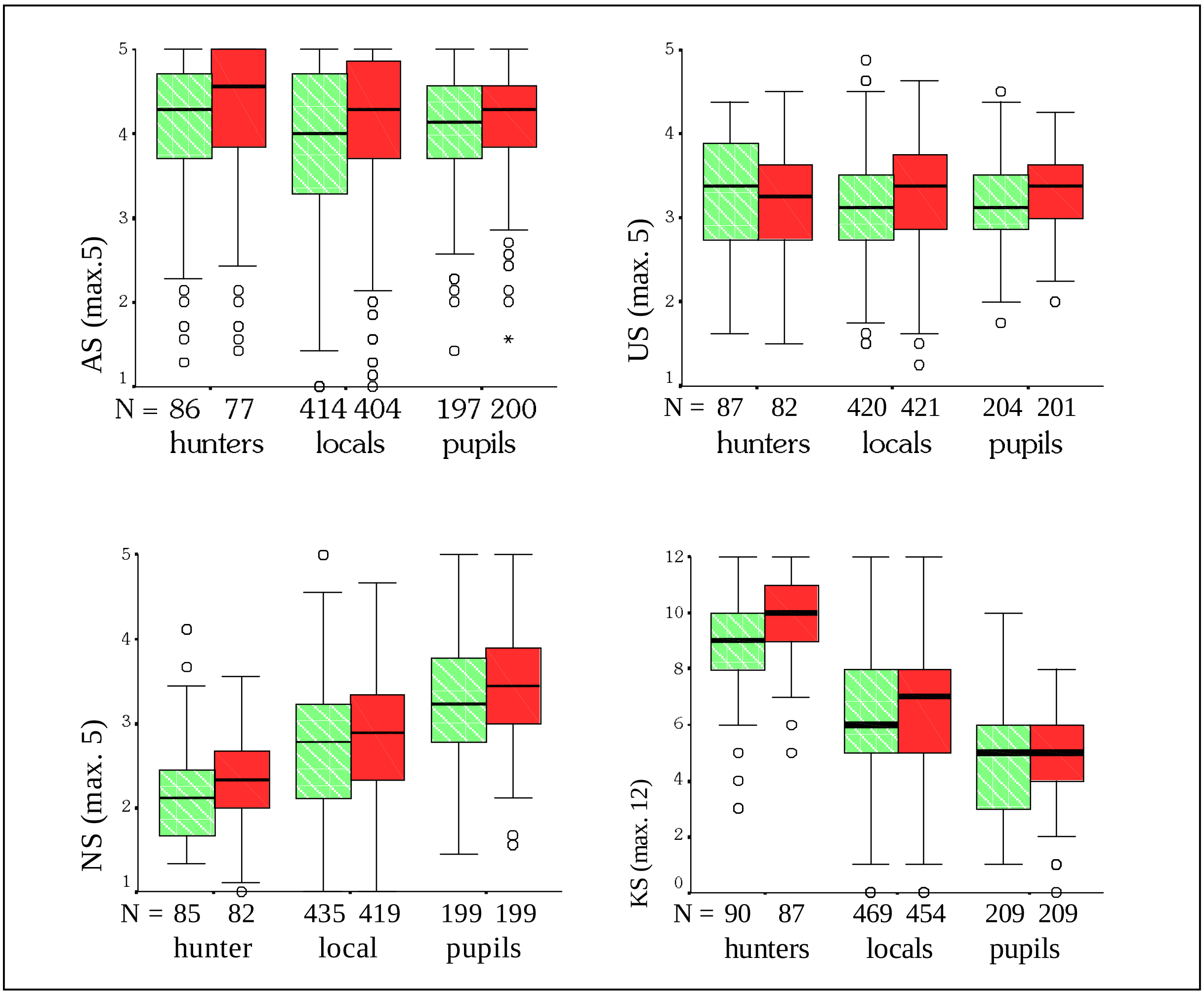


Fig. 4: Mean attitude score (AS), utility score (US), number score (NS) and knowledge score (KS) for the three target groups in the two study areas (green shaded/left box =ALP, red/right box =NOT). The box indicates the median, 25% and 75% quartiles and whiskers are the largest values that are not outliers, while circles mark outliers.

3.2. Stepwise multiple regression model

Overall model fit was moderate to good for AS for all three target groups and moderate to good for US and NS for locals and hunters. Model fit was poor for KS for all target groups and for AS and US for pupils (Tab.8).

Tab.8: Model fit and number of variables that explain variation in the mean scores.

target group	# variables	r^2	df2	sig. F
Attitude				
locals	7	0,462	602	0,030
hunters	2	0,425	124	0,014
schools	4	0,223	373	0,020
Utility score				
locals	6	0,425	721	0,000
hunters	4	0,367	149	0,025
schools	3	0,182	385	0,003
Numbers				
locals	6	0,557	667	0,023
hunters	4	0,375	134	0,031
schools	3	0,423	359	0,002
Knowledge				
locals	4	0,144	882	0,000
hunters	2	0,140	151	0,001
schools	1	0,028	414	0,000

Attitude score

For locals the most important factors predicting the attitude towards bears were the US, own negative experience with bears and whether or not bears were regarded as dangerous for people. These three factors alone explained 43% of the overall variation, with US already explaining 36%:

Attitude score (locals) = 2,209 + 0,351[1] (US) – 0,221 (own negative experience[2]) – 0,178 (Is the bear dangerous for humans?) + 0,124 (How was the character of the bear in bear stories?[3]) – 0,081 (Are bear issues in the media exaggerated?[4]) + 0,073 (KS) + 0,066 (education[5])

[1] the standardized beta coefficient was used in all equations
[2] mean of: “Have you or your family experienced any damage by bears?” and “Did you ever feel threatened by a bear?”
[3] rank variable: 0=negative, 0.5=mixed, 1=positive
[4] rank variable: 1=not at all, 2=somewhat, 3=a great deal
[5] rank variable: 1=primary school, 2=secondary school, 3=university, (4=other excluded)

For hunters the US alone explained 41% of the overall variation in the AS and together with the KS explained 43%:

Attitude score (hunters) = 0,581 + 0,588 (US) + 0,176 (KS)

For pupils overall model fit was rather poor, but variables were the same as for locals and hunters. US, KS, own negative experience and whether or not the bear is perceived dangerous for people together explained 22% of the variance with US alone explaining 17% :

Attitude score (pupils) = 2,326 + 0,334 (US) + 0,193 (KS) – 0,121 (own negative experience) – 0,116 (Is the bear dangerous for humans?)

Since the US played a rather important role we additionally checked which questions of the US were the most important to explain the overall variation in the AS. For hunters "bears increase the value of a hunting area" (r^2=0,370) and "bear attacks on people happen every year" (r^2=0,330) were most important, while "bears increase tourism" (r^2=0,116) and "bears reduce deer numbers" (r^2=0,110) were least important. For locals "bear attacks on people happen every year" ranked highest (r^2=0,257), while the questions concerning tourism, fear and sheep ranked about equally (mean: r"=0,212) and the questions concerning hunting ranked lowest (mean: r"=0,154). For pupils almost the same pattern as for locals was observed, but regression coefficients were much lower (range: 0,012 - 0,137) (appendix 5).

Utility score

For locals the most important parameters were whether or not people regarded the bear as dangerous for humans, own negative experience and sex, with females being more negative than males. KS and education only played a minor role:

Utility score (locals) = 3,438 – 0,431 (Is the bear dangerous for humans?) – 0,208 (own negative experience) - 0,184 (female) –0,132 (Are bear issues in the media exaggerated?) + 0,118 (KS) + 0,114 (education)

For hunters the most important parameters were whether or not hunters regarded the bear as dangerous for humans and the perception of media message reliability. Education and KS were rather unimportant:

Utility score (hunters) = 2,916 – 0,387 (Is the bear dangerous for humans?) – 0,236 (Are bear issues in the media exaggerated?) + 0,156 (education) + 0,155 (KS)

For pupils model fit was again rather poor, but main variables were similar to locals and hunters – again, the fact whether or not the bear was regarded as dangerous for humans was most important:

Utility score (pupils) = 3,447 – 0,317 (Is the bear dangerous for humans?) – 0,202 (female) – 0,144 (own negative experience)

Number score

The most important variable for the NS was the AS for all three target groups and the second most important variable the US and/or the perception of the bear population trend. Respondents were more positive if they believed that the bear population was decreasing or stable rather than increasing:

Number score (locals) = 1,103 + 0,430 (AS) – 0,224 (trend estimate[6]) + 0,194 (US) – 0,098 (Is the bear dangerous for humans?) – 0,089 (age class[7]) – 0,064 (own negative experience)

Number score (hunters) = 1,396 + 0,243 (AS) + 0,243 (US) – 0,208 (Is the bear dangerous for humans?) – 0,154 (trend estimate)

Number score (pupils) = 0,254 + 0,517 (AS) + 0,198 (US) – 0,124 (trend estimate)

Since the AS played such an important role predicting the NS, we checked which of the 7 questions within the AS showed the highest correlation with the NS. For locals almost all questions were of equal importance (r^2 range: 0,497-0,588). For hunters the question "Is having bears in Slovenia good, bad or neither good nor bad?" ranked lowest (r^2=0,296) while "Which answer best describes your feelings towards bears?" ranked highest (R^2=0,465). For pupils the question "It is important to have viable populations of bears in Slovenia" was most important (r^2=0,533) while "Bears are a sign of an intact nature" was least important (r^2=0,245)(for details see: appendix 6).

Knowledge score

Model fit for the KS was poor for all three target groups and no general pattern emerged, only that respondents that were frequently in the forest had a higher KS. Locals and hunters from NOT knew slightly more about bears than those from ALP:

Knowledge score (locals) = 4,710 + 0,183 (How often do you walk in the forest?[8]) - 0,176 (ALP) – 0,162 (females) + 0,146 (bear information from source "other"[9])

Knowledge score (hunters) = 10,283 – 0,312 (How interested are you in learning more about bears?[10]) – 0,250 (ALP)

Knowledge score (pupils) = 3,361 + 0,175 (How often do you walk in the forest?)

[6] rank variable: 0=decreasin, 1=remain the same, 2=increasing
[7] rank variable: 0=13-15, 1=16-19, 2=20-29 .....6=60-69, 7=$\geq$ 70
[8] rank variable: 1=never, 2=few times (1-7 days/year), 3=often (8-30d/y), 4=very often (>30d/y)
[9] dummy variable: 0=no, 1=yes
[10] rank variable: 1= not at all, 2=somewhat, 3=a great deal

3.3. Extreme answers

Stepwise multiple regression did not identify socio-demographic variables, place of residence (NOT-ALP, urban-rural), and KS as important factors predicting AS, NS and US. The same was true for KS in respect to socio-demographic variables, place of residence and interest level. But since a large number of respondents held moderate scores, we checked whether these variables were of any important for respondents that held negative or positive scores. For the two special target groups hunters and pupils, numbers for respondents with positive and/or negative scores were often too small for a meaningful comparison and have to be treated with caution (Tab.9-12).

In the target group locals respondents with positive and negative scores for AS, US, NS and KS differed significantly for 4-6 of the 7 test variables (Tab.9-12). Respondents that held a positive AS were on average: (1) younger, (2) did not work as farmers or foresters, (3) had a higher education, (4) had a slightly higher KS, (5) were to a higher percentage from NOT, and (6) lived to a higher percentage in towns (Tab.9). Respondents that held a positive US showed the same pattern, but were not significantly different in respect to profession (Tab.10).

Respondents that had a positive NS were on average: (1) younger, (2) did not work as farmers or foresters, (3) had a higher education, and (4) lived to a higher percentage in towns (Tab.11). Respondents that had a high KS were on average: (1) older, (2) were to a higher percentage males, (3) had a higher education, (4) had a lower interest level in learning more about bears, (5) lived to a higher percentage in NOT and (6) to a higher percentage in villages (Tab.12). In the few cases of significant differences between respondents with positive and negative scores for the target groups hunters and pupils, they showed the same trend as locals.

*Tab. 9: Socio-demographic variables, KS and place of residence for respondents with positive AS (mean score:4-5) and negative AS (mean score: 1-2). For comparison between negative and positive respondents the U-test was used. * mark significant differences between the two attitude groups, --- is used when the variable was a constant.*

target group	N	age classes mean rank	sex (%) male:female	profession (%) other:farmer[1]	education (%) prim:sec:uni[2]	KS mean	area (%) ALP:NOT	location (%) village: town
hunters								
hunters								
negative	10	65	---	90:10	40:60:00	7,80	50:50	40:60
positive	111	56	---	85:15	21:65:14	9,77	49:51	57:43
p-values		0,424	---	0,680	0,096	0,006*	0,935	0,309
locals								
negative	54	349	57:43	86:14	38:58:04	6,11	67:33	63:37
positive	497	258	59:41	97:03	09:68:23	6,79	47:53	47:53
p-values		0,000*	0,717	0,000*	0,000*	0,043*	0,005*	0,029*
pupils								
negative	4	---	75:25	---	---	4,25	50:50	---
positive	264	---	53:47	---	---	4,90	47:53	---
p-values		---	0,376	---	---	0,685	0,892	---
p-values		---	0,376	---	---	0,685	0,892	---

[1]farmer=farmer & forester, [2]prim.=primary school, sec.=secondary school, uni=university

*Tab. 10: Socio-demographic variables, KS and place of residence for respondents with positive US (mean score:4-5) and negative US (mean score: 1-2). For comparison between negative and positive respondents the U-test was used. * mark significant differences between the two attitude groups, --- is used when the variable was a constant.*

target group	N	age classes mean rank	sex (%) male:female	profession (%) other:farmer[1]	education (%) prim:sec:uni[2]	KS mean	area (%) ALP:NOT	location (%) village: town
hunters								
hunters								
negative	3	23	---	80:20	40:60:00	8,20	60:40	100:00
positive	32	18	---	84:16	06:75:19	10,13	63:38	53:47
p-values		0,303	---	0,880	0,117	0,051	0,949	0,097
locals								
negative	27	81	65:35	92:08	38:58:04	6,33	63:37	67:33
positive	110	61	75:25	95:05	06:67:27	7,49	30:70	44:56
p-values		0,013*	0,350	0,538	0,000*	0,007*	0,001*	0,033*
pupils								
negative	5	---	20:80	---	---	4,80	60:40	---
positive	15	---	87:13	---	---	5,60	40:60	---
p-values		---	0,025*	---	---	0,672	0,553	---

[1]farmer=farmer & forester, [2]prim.=primary school, sec.=secondary school, uni=university

*Tab. 11: Socio-demographic variables, KS and place of residence for respondents with positive NS (mean score:4-5) and negative NS (mean score: 1-2). For comparison between negative and positive respondents the U-test was used. * mark significant differences between the two attitude groups, --- is used when the variable was a constant.*

target group	N	age classes mean rank	sex (%) male:female	profession (%) other:farmer[1]	education (%) prim:sec:uni[2]	KS mean	area (%) ALP:NOT	location (%) village: town
hunters								
hunters								
negative	64	32	---	87:13	23:69:08	9,20	66:34	59:41
positive	2	23	---	100:00	50:50:00	11,50	00:100	50:50
p-values		0,496	---	0,781	0,480	0,015*	0,451	0,839
locals								
negative	160	112	61:39	88:12	27:61:12	6,57	61:39	62:38
positive	53	72	64:36	100:00	04:67:29	6,45	45:55	43:57
p-values		0,000*	0,661	0,010*	0,000*	0,989	0,051	0,019*
pupils								
negative	10	---	60:40	---	---	4,60	70:30	---
positive	81	---	50:50	---	---	5,05	40:60	---
p-values		---	0,554	---	---	0,509	0,068	---

[1]farmer=farmer & forester, [2]prim.=primary school, sec.=secondary school, uni=university

*Tab. 12: Socio-demographic variables, interest level and place of residence for respondents with high KS (mean score: 9-12) and low KS (mean score: 1-3). For comparison between negative and positive respondents the U-test was used. * mark significant differences between the two attitude groups, --- is used when the variable was a constant.*

target group	N	age classes mean rank	sex (%) male:female	profession (%) other:farmer[1]	education (%) prim:sec:uni[2]	interest level mean rank	area (%) ALP:NOT	location (%) village: town
hunters								
hunters								
low	2	126	---	50:50	50:50:00	129	00:100	50:50
high	134	65	---	86:14	19:69:12	67	48:52	60:40
p-value		0,006*	---	0,415	0,408	0,009*	0,244	0,811
locals								
low	95	108	34:66	96:04	26:63:11	141	62:38	42:58
high	163	129	72:28	92:08	12:66:22	111	35:65	55:45
p-value		0,029*	0,000*	0,177	0,002*	0,001*	0,000*	0,043*
pupils								
low	114	---	50:49	---	---	59	60:40	---
high	6	---	67:33	---	---	77	100:00	---
p-value		---	0,453	---	---	0,164	0,048*	---

[1]farmer=farmer & forester, [2]prim.=primary school, sec.=secondary school, uni=university

3.4. Single answers

Interest level and certainty about the bear issue

Interest level in the bear issue was high and 59% of hunters, 50% of locals and 65% of pupils were very interested to learn more about bears. All three target groups strongly agreed that more information and research about bears is necessary in Slovenia. In addition, 12% of hunters, 17% of locals and 8% of pupils used the spare page of the questionnaire for additional comments on bears and bear management. Interest level for respondents with a negative AS was much lower than for respondents with a positive AS. Certainty of the bear issue was rather low and only 33% of hunters, 9% of locals and 10% of pupils felt that they knew a great deal about bears (Tab.13).

Tab. 13: Interest and certainty level about the bear issue.

How interested are you in learning more about bears? *all respondents*			
target group	**not at all**	**some what**	**a great deal**
hunters	11	30	59
locals	19	31	50
pupils	8	27	65
How interested are you in learning more about bears? ***for people with positive and negative AS***			
target group	**not at all** positive : negative	**some what** positive : negative	**a great deal** positive : negative
hunters	04 : 50	23 : 20	73 : 30
locals	07 : 61	26 : 30	66 : 09
pupils	05 : 25	21 : 50	73 : 25
More info for people about bears is necessary.			
target group	**disagree**	**neutral**	**agree**
hunters	5	7	88
locals	4	4	92
pupils	3	4	93
More research about bears is necessary.			
target group	**disagree**	**neutral**	**agree**
hunters	11	19	70
locals	7	16	78
pupils	4	17	79
How knowledgeable do you feel about bears?			
target group	**not at all**	**some what**	**a great deal**
hunters	6	61	33
locals	39	52	9
pupils	29	61	10

Fear and own negative experience

The fear of bears and own negative experience were key factors predicting peoples AS and US. In spite of the high AS, 41% of locals think that the bear is dangerous for people and 45% would be afraid to go into the forest if bears are present (Tab.14). 15% think that in areas where bears live close to people, bear attacks on humans are common and 32% think that bear attacks on people occur every year in Slovenia. A surprisingly high percentage (20%) of locals had already felt threatened by a bear, while 6% had experienced a damage within the family by bears (mainly livestock depredation, destroyed bee hives and fruit trees).

Less hunters regarded the bear dangerous, but 25% also believed that bear attacks on people occur every year in Slovenia. Even though hunters were less afraid of bears, 20% had felt threatened by a bear and 26% had experienced bear damages within the hunting club (mainly livestock depredation, fruit trees). While for locals and pupils the percentage of respondents that were afraid to go into the forest was similar to the percentage that thought the bear is dangerous for humans, in hunters 35% thought the bear was dangerous for people, but only 13% were afraid to go into the forest if bears are present. It seems that the higher knowledge level and rather frequent encounters with bears make hunters feel more self-confident around bears.

Less pupils than locals regarded the bears as dangerous for humans, but 15% thought that in areas close to people bear attacks are common and 36% thought that bear attacks happen in Slovenia every year. 15% already felt threatened by a bear, while 3% experienced a damage within the family (Tab.14).

We were surprised by the high percentage of people that had felt threatened by bears and checked, if all of them had actually seen a bear. We found that 5,2% of hunters, 14,8% of locals and 14,3% of pupils that had felt threatened by a bear, had never actually seen a bear. This discrepancy was higher for hunters in NOT (25%) as compared to hunters in ALP (4%) but similar for locals (NOT: 17%, ALP: 14%) and pupils (NOT: 17%, ALP: 12%) in both study areas.

Stepwise multiple regression showed that the level of fear to go into the forest if bears are present, is best predicted by whether or not respondents thought “the bear is dangerous for people” and whether or not people thought that “in areas close to people bear attacks on people are common”. On the other hand it was not important whether or not people thought that “bear attacks on humans happen ever year in Slovenia” (Tab.15).

Tab. 14: Answers (%) to fear-related questions and own negative experience with bears by the three target groups.

Is the bear dangerous for humans?			
target group	**no**		**yes**
hunters	65		35
locals	59		41
pupils	72		28
I would be afraid to go into the forest if bears are present.			
target group	**disagree**	**neutral**	**agree**
hunters	76	11	13
locals	43	12	45
pupils	60	13	27
In areas close to people, bear attacks on humans are common.			
target group	**disagree**	**neutral**	**agree**
hunters	74	17	9
locals	66	19	15
pupils	67	19	15
Bear attacks on people occur every year in Slovenia.			
target group	**false**	**not sure**	**true**
hunters	36	39	25
locals	30	38	32
pupils	25	40	36
Did you ever feel threatened by a wild bear?			
target group	**no**	**yes**	
hunters	80	20	
locals	80	20	
pupils	85	15	
Have you ever experienced a damage by bears?			
target group	**no**	**yes**	
hunters	74	26	
locals	94	6	
pupils	97	3	
Have you ever seen a bear?			
target group	**no**	**yes**	
hunters	32	67	
locals	69	31	
pupils	79	21	

Tab. 15: Stepwise multiple regression with "I would be afraid to go into the forest if bears are present" (fear) as dependent variable and the independent variables (1) "The bear is dangerous for humans", (2) "In areas close to people, bear attacks on humans are common" and (3) "Bear attacks on people happen every year in Slovenia".

target group	independent variable	r^2 of single variable	sig.
dependent variable: "I would be afraid to go into the forest if bears are present."			
locals	(1) Is the bear is dangerous for humans?	0,265	0,000
	(2) In areas where bears live close to people, bear attacks on humans are common	0,219	0,000
	(3) Bear attacks happen in Slovenia every year.	0,011	0,001
	total model (1) + (2)	0,340	0,000
model equation (standardized beta values) fear = 0,288 (1) + 0,292 (2)			
hunters	(1) In areas where bears live close to people, bear attacks on humans are common	0,310	0,000
	(2) Is the bear is dangerous for humans?	0,192	0,000
	(3) Bear attacks happen in Slovenia every year.	---	0,618
	total model (1) + (2)	0,351	0,000
model equation (standardized beta values) fear = 0,231 (1) + 0,450 (2)			
pupils	(1) In areas where bears live close to people, bear attacks on humans are common	0,164	0,000
	(2) Is the bear is dangerous for humans?	0,107	0,000
	(3) Bear attacks happen in Slovenia every year.	---	0,324
	total model (1) + (2)	0,212	0,000
model equation (standardized beta values) fear = 0,203 (1) + 0,345 (2)			

Bear population numbers and bear damage

Locals and especially hunters in both, ALP and NOT, clearly opposed a further increase in the bear population size (Fig.4). An evaluation of the answers concerning the perception of the bear population size, the hunting quota and the damage level showed that local respondents consistently underestimated the bear population size, the yearly harvest level and the extent of sheep depredation problems in Slovenia, but perceived the bear population trend largely as increasing. A surprisingly high proportion of 38% of locals were not aware of the fact that bears are hunted in Slovenia (Tab.16).

Hunters most often estimated the bear population size correctly, perceived the bear population size as increasing, but underestimated both, the yearly bear harvest and the extent of sheep depredation. Contrary to hunters and locals pupils believed that the bear population is largely decreasing, but like locals and hunters they underestimated the bear population size, the yearly bear harvest and the number of sheep killed by bears. Half of the children did not know that bears are hunted in Slovenia (Tab.16).

Tab. 16: Questions concerning bear numbers and bear depredation.

Perception of bear population size				
target group	**under-estimated (0-299)**	**correct estimate (300-500)**	**over-estimated (>500)**	**missing**
hunters	24	56	4	16
locals	49	13	4	34
pupils	42	15	17	26
Perception of bear population trend				
target group	**decreasing**	**remain the same**	**increasing**	**missing**
hunters	2	10	87	2
locals	17	16	62	5
schools	56	20	23	2
Are bears hunted in Slovenia?				
target group	**yes**	**no**		**missing**
hunters	91	7		2
locals	55	38		7
schools	47	49		4
Perception of yearly bear harvest				
target group	**under-estimated (0-39)**	**correct (40-50)**	**over-estimated (>50)**	**missing**
hunters	40	14	1	45
locals	31	2	1	66
pupils	23	4	6	67
Perception of sheep killed per year				
target group	**under-estimated (0-149)**	**right estimate (150-650)**	**over-estimated (>650)**	**missing**
hunters	39	14	1	46
locals	40	8	1	51
pupils	46	7	5	43

Present bear management

Numbers and distribution

Locals and hunters did not agree with the present management that tolerates a higher number of bears in order to increase bear dispersal into the Austrian and Italian Alps. They also clearly disagreed with a further increase in the bear population and rejected to have bears present in all parts of Slovenia, but rather wanted to restrict the bear population to certain areas. Pupils were indifferent about higher bear numbers for dispersal, but supported an increase in the bear population size. Concerning the bear distribution in Slovenia, pupils were more positive about having bears in all of Slovenia than hunters and locals, but the majority also disagreed on it (Tab.17).

All three target groups agreed that bear management has to be done jointly with the neighboring countries. So far, several international research initiatives exist and there is informal exchange about the bear situation in Slovenia, Croatia, Italy and Austria – but management actions are not coordinated. In all countries bear management and bear conservation is dealt with on a regional or national level.

Tab. 17: Single questions concerning bear numbers and distribution.

Bear numbers in SLO should be high enough, so bears can move to Italy and Austria.				
target group	**disagree**	**neutral**	**agree**	**present management**
hunters	59	18	23	rejected
locals	40	32	28	rejected
pupils	27	40	33	rejected
Bear numbers should be increased.				
target group	**disagree**	**neutral**	**agree**	**present management**
hunters	85	10	5	no clear statement
locals	56	25	19	no clear statement
pupils	22	25	53	no clear statement
Bears should live in all parts of Slovenia.				
target group	**disagree**	**neutral**	**agree**	**present management**
hunters	77	9	14	no clear statement
locals	58	20	22	no clear statement
pupils	43	24	33	no clear statement
Bears should only live in restricted parts of Slovenia.				
target group	**disagree**	**neutral**	**agree**	**present management**
hunters	14	10	75	no clear statement
locals	25	14	60	no clear statement
pupils	35	21	44	no clear statement
Bear management has to be done together with the neighboring countries.				
target group	**disagree**	**neutral**	**agree**	**present management**
hunters	17	11	72	first attempts
locals	7	13	80	first attempts
pupils	8	29	63	first attempts

Bear hunting

Hunters and locals largely agreed with the present bear hunting regulations (Tab.18). They agreed that bears should be hunted, but disagreed with a year-round hunting season. Hunters were ambivalent to a zoned hunting management, while locals supported it. Pupils on the other hand were largely against hunting bears, refused a year-round hunting season and strongly supported a spatial restriction in bear hunting.

Tab. 18: Single questions concerning bear hunting.

Bears should not be hunted at all.				
Target group	**disagree**	**neutral**	**agree**	**present management**
hunters	89	6	5	supported
locals	48	19	33	supported
pupils	19	15	65	rejected
Bears should be hunted year-round in Slovenia.				
Target group	**disagree**	**neutral**	**agree**	**present management**
hunters	69	7	24	supported
locals	58	20	22	supported
pupils	82	12	6	supported
If bears are hunted, hunting should be restricted to specific areas.				
Target group	**disagree**	**neutral**	**agree**	**present management**
hunters	47	6	47	ambivalent
locals	19	17	64	supported
pupils	14	12	74	supported

Sheep depredation

All three target groups agreed that bears should be eliminated in areas with sheep depredation (Tab.19). This is in contrast to the present bear management and would mean the elimination of the bear from large parts of its present range in Slovenia (Fig.1).

All three target groups agreed that farmers should be paid compensation for losses by bears, but only 68% of hunters, 45% of locals and 34% of pupils actually knew about the existence of a compensation program (Tab.19). Even though people support the present management of compensation payment, managers seem to have poorly communicated these actions. While locals and hunters were indifferent about whether or not farmers should receive compensations only if they try to protect their sheep, pupils were in favor of this approach.

Tab. 19: Single questions concerning sheep depredation and compensation.

Bears should be eliminated in areas with sheep problems.				
Target group	**disagree**	**neutral**	**agree**	**present management**
hunters	31	15	54	rejected
locals	26	19	55	rejected
pupils	30	28	42	rejected
Money should be paid to farmers that have sheep killed by bears.				
Target group	**disagree**	**Neutral**	**agree**	**present management**
hunters	5	1	94	supported
locals	6	6	88	supported
pupils	18	17	65	supported
Money should only be paid to farmers that try to protect their sheep.				
Target group	**disagree**	**neutral**	**agree**	**present management**
hunters	50	8	42	no clear statement
locals	40	13	47	no clear statement
pupils	29	23	48	no clear statement
Farmers are paid compensation for sheep killed by bears.				
Target group	**false**	**not sure**	**true**	**present management**
hunters	7	25	68	poor communication
locals	10	45	45	poor communication
pupils	23	43	34	poor communication

Most important bear management issue in Slovenia

A high percentage of respondents wrote comments on the open end questions "What is the most important issue concerning brown bear management in Slovenia?" (Tab.20). The topics listed most often by hunters and locals were comments on the distribution range, with most people favoring a restriction or even more specific a restriction to the Kocevje area (a heavily forested district in southern Slovenia, Fig.5). The second most important topic was the number of bears in Slovenia with most locals favoring a well balanced population size and most hunters favoring a reduction in the population size. Pupils on the other hand were more concerned about better protecting bears, reducing hunting and making sure that bears have enough food. These findings are well in accordance with the trend in the NS.

The third most important issue for locals was bear hunting. Most respondents felt that hunting is necessary but a large number also was in favor of just killing problem bears. The forth most important issue for locals and pupils was more information for people about bears, again stressing the high interest level and the information deficit in the Slovenian public. For hunters the third and forth position of the issues listed most often, were the protection of the bear and the protection of the habitat, which shows a high interest in maintaining bears in Slovenia. Hunting issues were listed not nearly as frequently as these protection issues.

Tab. 20: Comments on the open question "What is the most important issue concerning brown bear management in Slovenia?".

target group	% filled	1. Important	2. Important	3. Important	4. Important
locals	60,9	**distribution range**	**bear numbers**	**hunting/control**	**more information**
		1.restricted	1. balanced	1. hunting necessary	more information
		2. Kocevje	2. reduced	2. only selective killing	
hunters	78,5	**distribution range**	**bear numbers**	**protection**	**habitat protection**
		1.restricted	1. reduced	bears should be protected	better habitat protection
		2. Kocevje	2. balanced		
pupils	67,5	**protection**	**hunting/control**	**feeding/food base**	**more information**
		bear should be protected	1. reduced hunting	1. more feeding sites	more information
			2. no hunting	2. enough food is important	

4. Discussion

Methodical considerations

Return rate and costs

Mail surveys are probably the most common approaches when attempting to get a representative sample of the local population. However, we were told that in Slovenia people are flooded with this kind of questionnaires and therefore were concerned about a low return rate. Even with a careful design and reminder postcards the return rate of mail surveys is expected to be in the magnitude of only 50% (Szinovatz and Bath 2000 in press, Bath 1991). We therefore chose to directly distribute questionnaires which was a very effective and rather inexpensive method (Tab.20). We had a return rate close to 100% (Tab.4) and in addition got information on the age and sex for non-respondents (Tab.5). Because the students that distributed the questionnaires had to briefly explain the purpose of the survey to any chosen household, the survey increased the awareness of people about our research project. In general people reacted very interested, supportive and friendly upon being approached with the questionnaire. Especially in the villages people were often disappointed that they had not been chosen. On the comment section of the questionnaires a lot of people expressed their satisfaction about being ask for their opinion and praised the nice design. Several people added their name and address in case we would have any further questions.

Tab. 21: Collection costs per questionnaire. The costs for design and data processing (data input and data analysis) are not included.

	total number	costs in US$
printing costs	1700	255
working hours	384	1860
kilometer driven	4281	833
useful questionnaires	924	
total costs per questionnaire		***3,19***

exchange rate: 1 US$=2,20DM (September 2000)

How representative is the sample?

When comparing the basic demographic profile of the questionnaire sample of the local population with the total population profile ($\geq$ 16 years), we found that our sample showed only very small deviations in respect to age, sex (Tab.5) and profession (Tab.3). Illiteracy was not a problem, as it is well below 1%. Only in respect to education we found a strong bias - people with a primary school education were strongly underrepresented (Tab.3).

However our regression model did not identify education as an important factor predicting AS, NS and KS. Only for the US education had a certain predictive value (appendix 3). The analysis of the extreme answers indicated that education is a significant factor predicting extreme positions for AS, US, NS and KS (Tab.9-12). Because in our sample people with primary school education were underrepresented, it is possible that overall attitude towards bears and bear management is somewhat lower than expressed by our results. On the other hand the percentages of locals that held negative scores was small, 7% for AS, 3% for US, 19% for NS and 10% for KS. As it is not to be expected that all non-respondents with primary school education hold a negative attitude, we assume that the general picture we got is rather representative for the local population in the two study areas ALP and NOT.

This assumption is further supported by a short version of the questionnaire which we had published in the national daily newspaper DELO. Results from 849 returns showed the same patterns regarding AS and NS score levels for the three target groups and also identified the perception of whether or not the bear is dangerous for humans as the key question predicting AS for locals (Kaczensky 2000b).

For hunters we had less control about non-respondents and the distribution might not have followed a purely random scheme. On the other hand, this target group is rather homogeneous and we do not expect that we missed a large portion of different views due to our sampling scheme. The same is true for pupils as we assume that a class is a random sub-sample of all pupils of the same level.

Key factors influencing peoples attitudes

Attitude towards bears (AS)

Our results are quite encouraging for bear conservation in Slovenia. We did not find the expected polarization of a largely negative attitude in the ALP region and largely positive attitude in the NOT region. Quite contrary, in both areas all target groups had very positive attitudes towards bears (Fig.4). The bear in Slovenia is definitely a highly valued species. This is in accordance with findings from adjacent Italy (Pedrotti et al. 1997) and Austria (Szinovatz and Gossow in prep.), but contrasts sharply with findings from Norway (Szinovatz and Bath 2000 in press).

People showed a high interest level, suggesting that the bear issue is indeed an important issue to them. Extreme attitudes (positive or negative) and personal importance are believed to be important moderators for the attitude-behavior consistency (Bright and Manfredo 1995). Furthermore, people were very interested in learning more about bears, which is an important prerequisite for any PR strategy (Tab.18). It has to be noted though that people that held a strongly negative attitude expressed only a small interest in learning more about bears (Tab.13), which makes it difficult to reach this group with information campaigns.

The key factor in predicting AS was the perception of how useful/harmful the bear is, with a special focus on how dangerous the bear is for humans (appendix 3). Logar and Komac (1999) also found that the fear of bears is an important factor for peoples attitude in the Selska Valley in Slovenia, the same was found by Bath (1991), Hook and Robinson (1982) and Kanzaki et al. (1996) for wolves (*Canis lupus*) in North America and Japan, respectively. In Slovenia all 8 questions of the US were of almost equally high interest for locals, only hunting related questions ranked somewhat lower. For hunters the increased value of hunting, fear-related topics and sheep depredation were most important. For pupils fear-related topics and sheep depredation were most important while hunting-related questions were only of low interest. Future PR activities need to be designed accordingly and focus on the relevant target group.

Socio-demographic variables, place of residence and KS, only played a minor role predicting AS towards bears in Slovenia, which was in contrast to other studies (Kellert 1985, Bath 1991, Bjerke and O. Reitan 1994, Szinovatz 1997, Szinovatz and Bath 2000 in press). From the low importance of the KS one should not conclude that knowledge about bears is unimportant altogether. Knowledge was also found to be a moderating variable in the attitude-behavior consistency and the availability of information increased the ability to predict behavior (Bright and Manfredo 1995). In addition, people that hold a higher knowledge normally feel more certain about an issue which again increases the ability to predict behavior. On the other hand, increased knowledge often is a basis to reinforce and rationalize attitudes rather than cause a change in attitudes (Kellert 1994).

The fact that only a small group (5,6% of hunters and 5,8% of locals) holds negative attitudes towards bears is encouraging. On the other hand this group seems to express their attitude much louder and more frequently than the majority of people that hold a positive attitude. Before our questionnaire the impression of bear managers was that people in the ALP area are very much against bears and are very afraid of bears as compared to people in the NOT area. Because this small group is frequently present in the media it might change attitudes of people that are unsure about bears. Counteracting this process with a pro-active PR strategy would be much desirable. Furthermore, a small group of people holding a negative attitude and having the skill and tools to remove a controversial species, may well be able to stop recovery, as has been the case with wolves in Michigan (Hook and Robinson 1982).

Perception of how useful/harmful the bear is (US)

The key factor predicting US was the perception of how dangerous the bear is for humans, again stressing that this is a key question for people in Slovenia. In general people expressed a moderately to slightly positive attitude in questions related to the utilitarian value of bears. Again we did not find the expected difference between people living in NOT (the low damage area with a long history of coexistence of people with bears) versus people living in ALP (a high damage area where bears just recently showed up). Surprisingly there were only minor differences between hunters from NOT and ALP. The latter is of special interest because hunters in NOT have the chance to hunt bears, while hunters in ALP are not allowed to do so. Apparently the perspective of getting the chance to hunt a bear and receive a trophy is rather unimportant for predicting the US. This is further supported by the fact that there were almost no differences in the US between hunters, locals and pupils (Fig.4). Contrary to findings by Kellert (1994) the utilization of bears does not seem to be an important variable for respondents in Slovenia. The high attitude score that was mainly composed of questions/statements concerning humanistic, existence, naturalistic or ecologistic values already suggests that these believes are more important than utilitarian, recreation and domination values.

The perceived bear-people conflict is important to predict peoples attitude towards bears (Kellert 1994). Therefore it is not surprisingly, that own negative experience was an important predictor of peoples US. A rather high percentage of respondents had already felt threatened by a bear. On the other hand, bear human encounters that resulted in human injury or death were rare in the past (Adamic 1996, Frikovic et al. 1987, Kaczensky 2000a). Chance conversations with recreationists during 5 years of field work often showed that people did not know about the presence of bears and were rather shocked to hear that a radiocollared bear was within several hundred meters of the forest road. A further evaluation why people had felt threatened, especially since a high percentage of those had not even seen the bear, should reveal if the threat was real or just perceived because of a misunderstanding of the situation or bears in general. For example, several people, including hunters, were convinced that a bear that stands up on two legs shows aggressive behavior. In the fall people frequently call the Hunters Association because they had felt threatened by bears, misinterpreting the sounds of rutting red deer (*Cervus elaphus*) to be vocalizations of aggressive bears (B. Krze pers. comm.).

26% of hunters, 6% of locals and 3% of pupils had experienced bear damage themselves or within the family or hunting club. Most of these damages included livestock depredation, destroyed bee hives and damages to orchards or fields. Informing people about defense options and supporting measures to protect flocks, bee hives or orchards should be first priority. In addition the compensation system needs to be better communicated (Tab.17), but should be linked to the use of protection measures when possible – as otherwise a reduction in the damage level will be difficult to achieve (Linnell et al. 1996).

Attitude towards a further increase in the bear population

Even though AS was high, support for a further increase of bear numbers in Slovenia was very low for hunters, low for locals and indifferent to slightly supportive for pupils (Fig.4). This apparent discrepancy might be explained by the fact that the attitude score is composed of questions asking for rather general value-laden believes, while the questions of the US ask for rather specific consequences. The same was observed in a study about acceptable options for cougar (*Felis concolor*) management (Manfredo et al. 1998).

For hunters, locals and pupils AS, US, the danger of the bear and the trend estimate of the bear population were the most important factors predicting NS (appendix 3). While AS and US were rather similar for the three target groups (Fig.4), the perception of bear population size and population trend differed widely between the three target groups. While 56% of hunters correctly estimated the bear population at 300 to 500 bears, only 13% of locals and only 15% of pupils gave the correct estimate. Both groups generally underestimated numbers. The same could be seen for the perceived trend of the bear population. 87% of hunters believed that the bear population is increasing, 62% of locals but only 23% of pupils thought so (Tab.16). The same pattern was observed for the estimated extent of bear depredation problems.

Although the general knowledge about bears was a poor predictor for AS, US and NS, the knowledge about bear population size, bear population trend and the amount of damages by bears seemed to be rather important predicting NS. Hunters who had the most realistic estimate on bear numbers and damages were the least likely to support a further increase in the bear population, while pupils who had the least realistic estimates where the most supportive of a further increase and locals were somewhat in-between the two groups. These findings are in accordance with other studies where conservation status (e.g. red list species, protected species, pest species, rare or common species) was found to be an important predictor of peoples attitude towards a species (Kellert 1994).

While information on the estimated bear population size is readily available from the newspaper, it is difficult to receive information on the distribution and annual amount of bear damages. Most newspaper articles just mention the location and number of sheep killed in a particular event (Kaczensky et al. 2000a). Because people actually underestimate bear numbers and the extent of the depredation problems, one can not expect to change NS into a positive direction through more information. A similar situation seems to exist in Norway, where the knowledge level was actually negatively correlated with the attitude towards bears (Szinovatz 1997, Szinovatz and Bath 2000 in press). A study dealing with attitudes towards polar bears (*Ursus maritimus*) also showed that people with better knowledge, tended to score more negatively than less knowledgeable ones (Bath 1994).

Support for the present bear situation

Respondents of all three target groups did not support the official policy of increasing bear dispersal into the Alps through higher bear numbers in Slovenia. This was in accordance with the fact that hunters and locals alike rejected a further increase in bear numbers (Tab.15). Respondents did not want to have bears in all parts of Slovenia (Tab.14) and wanted bears to be eliminated in areas with sheep depredation problems (Tab.15). We believe that most respondents are not aware that bear depredation problems are not restricted to the pre-alpine and alpine areas outside the bear core area (Fig.1) and therefore do not know that the consequence of their request would be the elimination of the bear on most of its range in Slovenia. At least 20.000 sheep, or 30% of the total sheep flock, are present on bear range in the core area (Fig.5) and 33% of the overall damages between 1995-1998 have occurred there (Fig. 6).

Reasons for the present pattern of damages are complex and are most likely a combination of the following factors: (1) in recent years subsidies for sheep husbandry have been paid and together with attractive possibilities to lease pastures made sheep farming attractive in the bear core area, (2) there was a 1,8-fold increase in sheep numbers from 1995 to 1998 (Statistical Office of Slovenia pers. comm., Fig.5) (3) government compensation payments started in 1994, (4) no protection measures are required for people that start sheep farming and (5) an increase in bear numbers and/or change in the distribution range (B. Krze pers. comm., M. Jonozovic pers. comm.). Our impression was that the public discussion is largely focused on the idea that increasing sheep damages are solely a result of increasing bear numbers.

At present, bear management in Slovenia is zoned and while bears in the core area are hunted following a quota system during a limited time period, bears outside the core area are fully protected. With the exception of pupils that generally opposed hunting and wanted to increase bear numbers, locals and hunters mainly supported the present hunting regulations. While locals clearly supported a zoned management, hunters were ambivalent about this. As we did not ask for the reasons behind the answers nor whether respondents supported the present zoning or just wanted bears to be protected in “suitable” areas and removed in areas with problems deserves further investigations.

The answers on the open question about the most important management issues suggest that people want a separation of bears and people and bears and sheep in order to minimize problems (Tab.20). A large portion of the respondents that favored a range restriction for bears wanted to restrict bears to the Kocevje area (district in southern Slovenia, Fig.5), or to special protected areas, some even wanted the bear area to be fenced. Even though most people support the statement that bear management needs to be done jointly with the neighboring countries (Tab.17), most greatly underestimate the spatial requirements of a viable bear population.

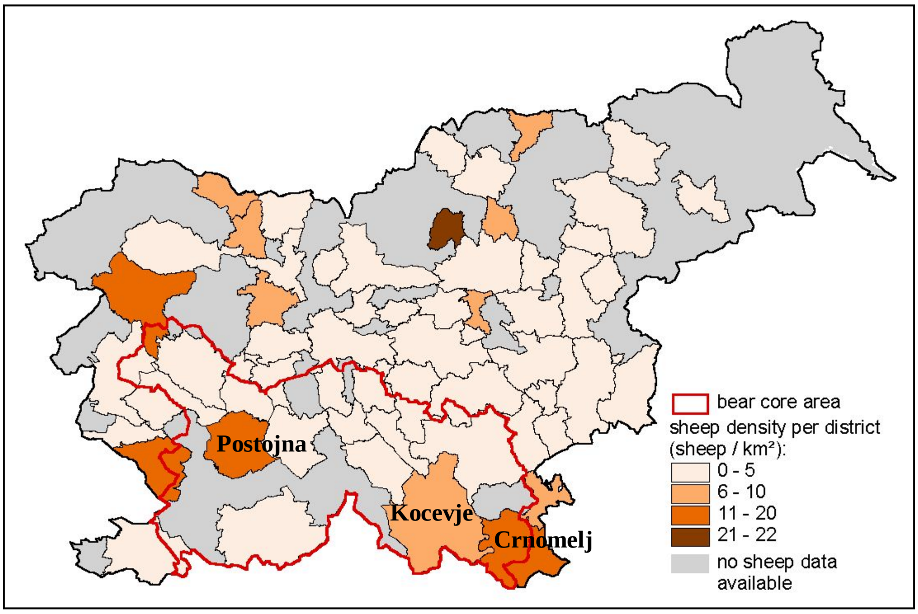


Fig.5: Sheep densities (sheep / km²) per district (pers. comm. from the stock breeders district offices).

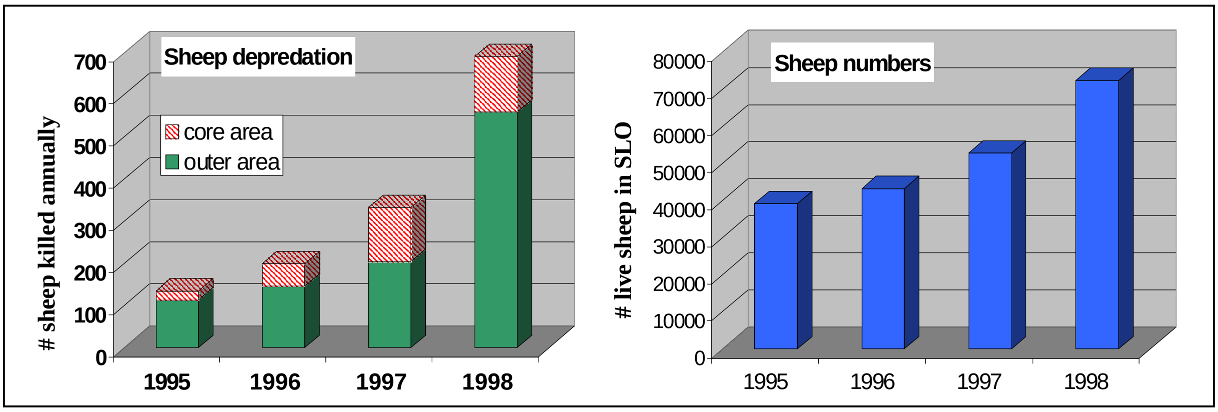


Fig. 6: Sheep depredation (in number of killed sheep) (Ministry of Agriculture and Forestry, unpubl. data) and live sheep (Statistical Office of Slovenia) kept in Slovenia 1995-1998.

5. Management Implications

To counteract the impression that bears are solely a problematic species a pro-active PR program from the side of the bear managers is needed. Education programs should focus on the questions how dangerous the bear is for people and what impact on the local economy bears might have. Information under which circumstances a bear might be dangerous and how to behave in case of a surprise encounter are of higher interest than facts about the biology of bears. Further information should be given on the risks of livestock depredation and on what possibilities there are to reduce the depredation risk and to receive financial support for preventive measures and in case of damages. Another focus should be on the value of the bear and on examples from other bear areas in Europe where the presence of bears is advertised in a positive way.

Clear statements from the bear managers about aims for population size and distribution in Slovenia are needed. For a long term acceptance it would be necessary to develop these aims together with concerned interest groups and stake holders. Hunters and locals made very clear, that they do not support a further increase in the bear population. Human safety, damage reduction and compensation are key issues for the future of the bear in Slovenia, especially outside the bear core area. Since bear dispersal towards the Alps has to happen through high conflict areas in Slovenia, international interest to allow bears to live in these areas is high. But without international support it seems unlikely that Slovenia will continue protecting bears in these regions, especially since public support for such a policy is low.

Despite increasing problems with sheep depredation and a bear attack on an old man in 1996, the bear was still considered a highly valued species in Slovenia in 1998. At this time it did not seem necessary to improve the attitude towards bears but rather make sure that this positive attitude persists. In spring 2000 an other bear attack happened in the course of which a forestry worker was badly wounded. This accident in combination with an early start of sheep depredation problems made bears and bear management in Slovenia become a highly political topic (Kaczensky 2000a). What consequences this had on peoples attitudes and believes is unknown, but would be important to evaluate.

6. Acknowledgements

We would like to thank Hartmut Gossow and Blaz Krze for supervision and support in fund raising. Without the dedicated help of Barbara Arzensek, Vesna Grobelnik, Karel Kolaric, Primoz Leben, Sandra Lesnik, Manca Pavsic and Irena Sereg distribution of the questionnaires and/or data input would not have been possible. Thanks also to Hubert Zeiler for designing the nice bear for the questionnaire cover. A big thank you also to all locals, hunters, pupils and teachers that took their time to fill in the questionnaire. We also would like to thank Thomas Rödl for corrections and comments on earlier drafts of the manuscript.

7. Reference List

Adamic, M. 1996. Decision making in the conservation management of problem wildlife species in Slovenia, based on the knowledge gained through current research projects. Gozd, 54:297-306.

Ajzen, I. 1993. Attitude theory and the attitude-behavior relation. In: D. Krebs and P. Schmidt (editors). New directions in attitude measurement, p:41-57, Walter de Gruyter, Berlin and New York.

Bath, A.J. 1989. The public and wolf reintroduction in Yellowstone National Park. Society and Natural Resources, 2:297-306.

———. 1991. Identification and documentation of public attitudes toward wolf reintroduction in Yellowstone National Park. In: J.D. Varley, and W. Brewster (editors). Wolves for Yellowstone? A report to the United States Congress, Volume III, Research and Analysis. National Park Service, Yellowstone National Park, Wyoming.

———. 1994. Public attitudes toward polar bears: An application of human dimensions in wildlife resource research. Proceedings of the International Union of Game Biologists XXI Congress. Vol.1: 168-174, Halifax, Canada.

———. 1996. Human dimensions in wildlife resource management in Nova Scotia. Report for: Nova Scotia Dept. Natural Resources, Wildlife Division, 82pp.

Baumgartner, H.-J. 1998. Public involvement in the lynx project in the North-Western Swiss Alps. KORA Report, 3:13-14, Bern, Switzerland.

Bjerke, T. and O. Reitan. 1994. Attitudes towards wolves in a rural part of Hedmark, Norway. NINA Oppdragsmelding, 263:1-37.

Breitenmoser, U. 1998. Large predators in the Alps: the fall and rise of man's competitors. Biological Conservation, 83:279-289.

Bright, A. D. and M. J. Manfredo. 1995. The quality of attitudinal information regarding natural resource issues: the role of attitude strength, importance. Society and natural resources, 8:399-414.

———. and M. J. Manfredo. 1996. A conceptual model of attitudes toward natural resource issues: a case study of wolf reintroduction. Human Dimensions of Wildlife, 1(1):1-21.

Caluori, U. 1999. Füchse in der Stadt - missliebige und geliebte Nachbarn. Report of the WSL, Zürich, Switzerland, 57pp. (in German)

Cicnjak, L. and D. Huber. 1995. Public attitudes towards brown bears in Croatia. International Conference on Bear Research and Management in Grenoble, French Ministry of Environment, France. (abstract only)

Dahle, B. 1996. Nutritional ecology of brown bears (*Ursus arctos*) in Scandinavia with special references to moos (*Alces alces*). Diploma thesis at the Norges Teknisk-Naturvitenskapelige Universitet (NTNU), Norway. 33pp.

Decker, D. J., T. L. Brown, B. L. Driver, and P. J. Brown. Theoretical developments in assessing social values of wildlife: toward a comprehensive understanding of wildlife. In: : D.J. Decker and G.R. Goff (editors). Valuing wildlife, economic and social perspectives, p:76-95, Westview Press, Boulder.

Frikovic, A., R. L. Ruff, L. Cicnjak, and D. Huber. 1987. Brown bear mortality during 1946-85 in Gorski Kotar, Yugoslavia. International Conference on Bear Research and Management, 7:87-92.

Herrero, S. and S. Fleck. 1989. Injury to people inflicted by black, Grizzly or polar bears: recent trends and new insights. International Conference on Bear Research and Management, 8:25-32.

Hook, R. A. and W. L. Robinson. 1982. Attitudes of Michigan Citizens toward predators. In: L.N. Carbyn, S.H. Fritt, and D.R. Seip (editors). Ecology and conservation of wolves in a changing world. p:3-12. Canadian Circumpolar Institute, University of Alberta, Edmonton, Alberta, Canada.

Hunziker, M., E. Egli, and A. Wallmer. 1998. Return of predators: Reasons for existence or lack of public acceptance. KORA Report, 3:25-30, Bern, Switzerland.

Kaczensky, P. 1996. Large Carnivore - Livestock Conflicts in Europe. Report of Munich Wildlife Society, Ettal, Germany. 103pp.

———. 2000a. Bear politics in Slovenia. International Bear News, 9(2):9.

———. 2000b. What do DELO readers think about bears? Final report of "Project Medved", Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. 2000 in press. Large carnivore depredation on livestock in Europe. Ursus, 11.

Kanzaki, N., N. Maruyama, and T. Inoue. 1996. Japanese attitudes towards wolves and its recovery. Journal of Wildlife Research, 1(3):268-271.

Kellert, S. R. 1985. Public perception of predators, particularly the wolf and coyote. Biological Conservation, 31:167-189.

———. 1994. Public attitudes toward bears and their conservation. International Conference on Bear Research and Management, 9:43-50.

———. M. Black, C. R. Rush, and A. J. Bath. 1996. Human culture and large carnivore conservation in North America. Conservation Biology, 10:977-990.

Korenjak, A. 1995. Man and large predators in Austria and Slovenia. Graduation thesis at the Biotechnical Faculty of the University of Ljubljana, 71pp. (in Slovenian with English abstract)

Kvaalen, I. 1998. Acceptance of lynx by sheep farmers - a sociological comparison. Council of Europe Publishing, 59-64, Straßbourg Cedex.

Linnell, J. D., M. E. Smith, J. Odden, P. Kaczensky, and J. E. Swenson. 1996. Carnivores and sheep farming in Norway. 4. Strategies for the reduction of carnivore - livestock conflicts: a review. NINA Oppdragsmelding 443:118pp.

Litwin, M. S. 1995. How to measure survey reliability and validity. The Survey Kit 7. Sage publications. 85pp.

Logar, J. and U. Komac. 1999. Public opinion on bear in the upper Selška valley case. Gozdarski vestnik, 381-393. (in Slovenian with English abstract)

Manfredo, M. J., J. J. Vaske, and D. J. Decker. 1995. Human dimensions of wildlife management: basic concepts. In: R.L. Knight and K.J. Gutzwiller (editors). Wildlife and Recreationists. p:17-31. Island Press, Washington, D.C., Covelo, California

———. H. C. Zinn, L. Sikorowski, and J. Jones. 1998. Public acceptance of mountain lion managemenr: a case study of Denver, Colorado, and nearby foothills areas. Wildlife Society Bulletin, 26(4):964-970.

———. C. L. Pierce, D. Fulton, J. Pate, and B. R. Gill. 1999. Public acceptance of wildlife trapping in Colorado. Wildlife Society Bulletin, 27(2):499-508.

Pedrotti, L., E. Dupré, and P. Genovesi. 1997. Attitudes of human population towards the re-introduction of the brown bear in the Italian central Alps: Preliminary results of a survey. 11th International Conference on Bear Management and Research in Graz, Austria, Book of abstracts, p:53.

Sagor, J. T., J. E. Swenson, and E. Roskraft. 1997. Compatibility of brown bear Ursus arctos and free-ranging sheep in Norway. Biological Conservation, 81:91-95.

Simonic, A. 1994. The legal protection of the brown bear in Slovene territory-past and present, and some suggestions for the. Braunbär in den Ländern Alpen-Adria, Proceedings, p:43-75, Ljubljana, Slovenia.

Swenson, J. E., F Sandegren, A. Söderberg, M. Heim, O. J. Sorensen, A. Bjärvall, R. Franzen, S. Wikan, and P. Wabakken. 1999. Interactions between brown bears and humans in Scandinavia. Biosphere Conservation, 2(1):1-9.

Szinovatz, V. 1997. Attitudes of the Norwegian public toward bear and lynx. Diploma thesis at the Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, 125pp.

———. and A. Bath. 2000 in press. Norwegian attitudes toward and knowledge about brown bears and their management. Ursus 11: in press

———. and H. Gossow. in prep. Die Akzeptanz des Braunbären in Österreich - Eine Langzeitstudie. (in German with English abstract)

Thomas, J. W. 2000. From managing a deer herd to moving a mountain - one pilgrim's progress. Journal of Wildlife Management, 64(1):1-10.

Ueberschär, A. 2000. Die umstrittene Rückkehr des Wolfes in die französischen Meeralpen - Möglichkeiten zur Akzeptanzsicherung aus der Sicht der Schäfer im Nationalpark Mercantour. Diplomat thesis at the Technical University of Munich, 60pp. (in German)

Zeller, R. and E. Carmines. 1980. Measurement in social sciences: The link between theory and data. Chelsea, Michigan, Cambridge University Press. 194pp.

Zimmermann, B., P. Wabakken, and M. Dötterer. 2000 in prep. Human-carnivore interactions in Norway: How does the re-appearance of large carnivores affect people's attitude.

Appendix 1: Approximate English translation of the questionnaire used in Slovenia.

Dear resident,

thank you for filling out this questionnaire about your feelings towards bears. It is greatly appreciated. "Project Medved", the University of Ljubljana and the Memorial University of Newfoundland, Canada are trying to learn more about your opinions about bears and their management in Slovenia. Your opinions are important whether positive, neutral or negative towards bears as we are trying to document the range of attitudes. Your individual answers are strictly confidential and we encourage you to voice your opinions.

Please fill out the questionnaire immediately. It will take you no more than 10 minutes. We will come back later this day to pick it up again. If you have to leave the house meanwhile, please place the completed questionnaire in a plastic bag next to your front door. Thank you again.

Sincerely,

Dipl. Biol. Petra Kaczensky
"Project Medved"

Dipl. Biol. Mateja Blazic
University of Ljubljana

Prof. Dr. Alistair Bath
Memorial University of Newfoundland

I. Here we would like to learn, how you feel about bears. - *Please circle the number or mark the answer that best describes your opinion -*

1. Which answer best describes your feelings towards brown bears?

strongly dislike	→		neutral	→		strongly like
1	2	3	4	5	6	7

2. Is having bears in Slovenia?

good   bad   neither good nor bad

	strongly disagree	disagree	neutral	agree	strongly agree
3. It is important to maintain bears in Slovenia so our children can enjoy them.	**1**	**2**	**3**	**4**	**5**
4. It is important to have "viable" populations of bears in Slovenia.	**1**	**2**	**3**	**4**	**5**
5. We should make sure that our children have an abundant bear population.	**1**	**2**	**3**	**4**	**5**
6. Whether or not I would get to see a bear, it is important for me that they exist in Slovenia.	**1**	**2**	**3**	**4**	**5**
7. Bears are a sign of an intact nature.	**1**	**2**	**3**	**4**	**5**
8. Because many bears live in other parts of Europe, there is no need to have bears in Slovenia.	**1**	**2**	**3**	**4**	**5**

	strongly disagree	disagree	neutral	agree	strongly agree
9. Bear numbers in Slovenia should be high enough, so bears can move to Italy and Austria.	**1**	**2**	**3**	**4**	**5**
10. Bears have a negative impact on hunting opportunities.	**1**	**2**	**3**	**4**	**5**
11. Bears greatly reduce deer numbers.	**1**	**2**	**3**	**4**	**5**
12. Bears increase the value of a hunting area.	**1**	**2**	**3**	**4**	**5**
13. Bears should not be hunted at all in Slovenia.	**1**	**2**	**3**	**4**	**5**
14. If bears are hunted, hunting should be restricted to specific areas.	**1**	**2**	**3**	**4**	**5**
15. Bears should be allowed to be hunted year round in Slovenia.	**1**	**2**	**3**	**4**	**5**
16. Bears kill a lot of sheep in Slovenia.	**1**	**2**	**3**	**4**	**5**
17. In areas where bears live close to sheep, their primary food is sheep.	**1**	**2**	**3**	**4**	**5**
19. Having bears increases tourism to Slovenia.	**1**	**2**	**3**	**4**	**5**
20. In areas where bears live close to people, bear attacks on humans are common.	**1**	**2**	**3**	**4**	**5**
21. I would be afraid to go into the woods if bears are present.	**1**	**2**	**3**	**4**	**5**

22. Which of the three predators do you think are dangerous to humans?

lynx bear wolf
equally dangerous none is dangerous

How would you rank these three predators?	strongly dislike	dislike	neutral	like	strongly like
lynx	**1**	**2**	**3**	**4**	**5**
bear	**1**	**2**	**3**	**4**	**5**
wolf	**1**	**2**	**3**	**4**	**5**

II. The next questions ask about your general opinion of the bear? - ***Please fill in blanks or circle the response that best describes your opinion -***

1. How many bears do you think live in Slovenia? ___________

2. Do you believe bear numbers in Slovenia are? in-creasing de-creasing remain the same

3. Do you believe bears exist in the area between Vhrnika, Krim and Cerknica? yes no If yes, how many?_________

4. Do you believe bears exist in the area between Tolmin, Bohinjsca Bistrica and Kobarid? yes no If yes, how many?_________

5. Do bears get shot in Slovenia? yes no If yes, how many?_________

6. Do bears kill sheep in Slovenia? yes no If yes, how many?_________

7. How much space does one adult brown bear need?
- you can give your answer in km² <u>or</u> ha - _______km² _______ha

	Basically true	Basically false	Not sure
8. Female bears have young every year.	**1**	**2**	**3**
9. Most bears weigh less than 150 kg.	**1**	**2**	**3**
10. Bears mainly feed on meat.	**1**	**2**	**3**
11. Bears will kill sheep only if they can not find enough other food.	**1**	**2**	**3**
12. Farmers are paid money for sheep killed by bears.	**1**	**2**	**3**
13. Bears can only be hunted in some parts of Slovenia.	**1**	**2**	**3**
14. Bear attacks on people occur every year in Slovenia.	**1**	**2**	**3**
15. The war in Croatia and Bosnia made bears move to Slovenia.	**1**	**2**	**3**

III. Here we would like to learn, how you feel about bear management in Slovenia. - *Please circle the response that best describes your opinion -*

	strongly disagree	disagree	neutral	agree	strongly agree
1. Bear numbers should be increased.	**1**	**2**	**3**	**4**	**5**
2. There is already enough bears in Slovenia.	**1**	**2**	**3**	**4**	**5**
Bears should live in all parts of Slovenia	**1**	**2**	**3**	**4**	**5**
4. Bears should only live in restricted parts of Slovenia.	**1**	**2**	**3**	**4**	**5**
5. Bears have enough good habitat in Slovenia.	**1**	**2**	**3**	**4**	**5**
Bears should be fed in the forest.	**1**	**2**	**3**	**4**	**5**
7. Bear should be eliminated in areas with sheep problems.	**1**	**2**	**3**	**4**	**5**
8. Money should be paid to farmers that have sheep killed by bears.	**1**	**2**	**3**	**4**	**5**
9. Money should only be paid to farmers who try to protect their sheep.	**1**	**2**	**3**	**4**	**5**
10. More information for people about bears is necessary.	**1**	**2**	**3**	**4**	**5**
11. More research about bears is necessary.	**1**	**2**	**3**	**4**	**5**
12. Bear management has to be done together with the neighboring countries.	**1**	**2**	**3**	**4**	**5**

13. In your opinion, what is the most important issue concerning brown bear management in Slovenia?

____

____

____

IV. Here we would like to know where you have heard about and learned about bears? - Please mark all that apply-

1. Where did you hear about bears?: - *circle all that apply*

radio	brochures	friends/colleges
TV	books	family
newspaper	school	other

	not at all	somewhat	a great deal
2. Are bear issues exaggerated in the media?	**1**	**2**	**3**
3. How knowledgeable do you feel about bears?	**1**	**2**	**3**
4. How interested are you in learning more about bears?	**1**	**2**	**3**
5. Have you heart of an international research project, called "Project Medved"?	**1**	**2**	**3**

V. Here we would like to learn about your own experience with bears in Slovenia. - Please circle the response or set a cross for the answer that best describes your opinion -

1. How often do you walk into the forest during a year?
   Never
   Few times (1-7 days/year)
   Often (8-30 days/year)
   Very often (more than 30 days/year)

	Yes	No
2. Would you like to see a bear in the wild?	**1**	**2**
3. Have you ever seen a wild bear in Slovenia?	**1**	**2**
4. Did you ever feel threatened by a wild bear?	**1**	**2**
5. Have you ever shot a bear in Slovenia?	**1**	**2**
6. Have you or your family ever experienced a damage by bears?	**1**	**2**

7. If you have seen a wild bear in Slovenia, how many times did you see one?
____

8. If you or your family have experienced bear damage, what kind of damage did bears cause?

____

____

9. Did you get told "true" bear stories from Slovenia when you were a kid?
   yes   no   I do not remember

10. If you got told true bear stories, how was the bear described in the story/stories:
   mainly positive   mainly negative   mixed   I do not remember

VI. This final section will help us to learn more about the respondents of this survey. Your answers will be grouped together with those of others and will not be individually identifiable. All information will be kept strictly confidential! - *Please fill in blanks or mark the right answer -*

How old are you?______   2. Are you?   female
   male

Your profession is?   farmer   pupil
   forester   homeworker/housewife
   industry   retired
   student
other__________________

4. What is your educational background?
   primary school   university
   secondary school
other____________

5. Are you a hunter?   yes   no
6. Are you a member of a nature protection group?   yes   no

THANK YOU VERY MUCH FOR YOUR COOPERATION!

Please feel free to write any additional comments on the last page.

Appendix 2a: *Independent variables used for stepwise multiple regression.*

dependent variable: AS

independent variables:

Socio-demographic parameters:
1. age categories
2. sex (dummy variables: female / male)
3. profession (dummy variable: farmers / foresters / others)
4. education (primary school / secondary school / university)

Place of residence:
5. study area (dummy variable: NOT / ALP)
6. location (dummy variable: town / village)

7. Utility score

8. Is the bear dangerous for humans? (yes / no)

9. Knowledge score

Interest level/own experience:
10. How often do you walk in the forest during the year?
11. Did you ever feel threatened by a wild bear, or experienced damage?
12. How was the character of the bear in true bear stories?

dependent variables: US

independent variables:

same as far AS 1-9 plus:

Interest level/own experience:
10. Are bear issues exaggerated the media?
11. How often do you walk in the forest during the year?
12. Did you ever feel threatened by a wild bear or experienced damages?

dependent variables: NS

independent variables:

same as AS 1-9 and US 10-12 plus:

13. Attitude score
14. Perceived trend of the bear population (decreasing / remain the same / increasing)

Appendix 2b: Independent variables used for stepwise multiple regression.

dependent variable: KS

independent variables:

same as AS 1-6 plus:

Interest level/own experience
7. Where did you hear about bears?
8. Are bear issues exaggerated the media?
9. How interested are you in learning more about bears?
10. How often do you walk in the forest during the year?
11. Did you ever feel threatened by a wild bear or experienced damage?

Appendix 3a: Pearson correlation coefficient and significance level of the independent variables selected for stepwise multiple regression of the dependent variables AS, US, NS, and KS.

Significant variables for regression model AS:

target group	independent variables	n	Pearson	Pearson sig.	r^2
hunters	utility score	155	0,659	0,000	0,434
hunters	bear dangerous	155	-0,444	0,000	0,192
hunters	knowledge score	163	0,380	0,000	0,145
hunters	exaggerated	163	-0,292	0,000	0,085
hunters	walk in forest	161	0,242	0,001	0,059
hunters	character of bear	147	0,242	0,002	0,058
hunters	education	159	0,233	0,002	0,054
hunters	negative experience	163	-0,186	0,009	0,035
locals	utility score	782	0,631	0,000	0,399
locals	bear dangerous	755	-0,488	0,000	0,238
locals	negative experience	811	-0,375	0,000	0,141
locals	character of bear	707	0,278	0,000	0,077
locals	exaggerated	794	-0,277	0,000	0,077
locals	education	781	0,271	0,000	0,073
locals	knowledge score	817	0,186	0,000	0,035
locals	age class	790	-0,156	0,000	0,024
locals	profession	799	-0,144	0,000	0,021
locals	area code	818	-0,128	0,000	0,016
locals	location code	818	-0,125	0,000	0,016
locals	walk in forest	808	0,065	0,032	0,004
locals	sex	805	-0,640	0,035	0,004
schools	bear dangerous	384	-0,280	0,000	0,078
schools	negative experience	396	-0,213	0,000	0,045
schools	knowledge score	397	0,176	0,000	0,031
schools	character of bear	323	0,160	0,000	0,026
schools	walk in forest	394	0,149	0,001	0,022
schools	exaggerated	396	0,102	0,021	0,010

Appendix 3b: Pearson correlation coefficient and significance level of the independent variables selected for stepwise multiple regression of the dependent variables AS, US, NS, and KS.

Significant variables for regression model US:

target group	independent variables	n	Pearson	Pearson sig.	r^2
hunters	is the bear dangerous	161	-0,495	0,000	0,245
hunters	exaggerated	169	-0,380	0,000	0,144
hunters	negative experience	169	-0,264	0,000	0,070
hunters	knowledge score	169	0,253	0,000	0,064
hunters	education	164	0,243	0,001	0,059
hunters	how often walk in forest	167	0,200	0,005	0,040
locals	is the bear dangerous	788	-0,537	0,000	0,288
locals	negative experience	831	-0,320	0,000	0,103
locals	exaggerated	814	-0,301	0,000	0,090
locals	sex	826	-0,216	0,000	0,046
locals	education	799	0,206	0,000	0,043
locals	knowledge score	840	0,192	0,000	0,037
locals	area code	841	-0,156	0,000	0,024
locals	how often walk in forest	828	0,140	0,000	0,020
locals	location code	841	-0,098	0,002	0,010
locals	age class	810	-0,062	0,039	0,004
schools	is the bear dangerous	394	-0,357	0,000	0,127
schools	negative experience	404	-0,214	0,000	0,046
schools	sex	401	-0,188	0,000	0,035
schools	how often walk in forest	403	0,159	0,001	0,025
schools	area code	405	-0,128	0,005	0,016

Appendix 3c: Pearson correlation coefficient and significance level of the independent variables selected for stepwise multiple regression of the dependent variables AS, US, NS, and KS.

Significant variables for regression model NS:

target group	independent variables	n	Pearson	Pearson sig.	r^2
hunters	utility score	160	0,529	0,000	0,280
hunters	attitude score	155	0,480	0,000	0,231
hunters	bear dangerous	158	-0,440	0,000	0,193
hunters	bear population trend	165	-0,275	0,000	0,076
hunters	walk in forest	165	0,245	0,001	0,060
hunters	exaggerated	167	-0,220	0,002	0,048
hunters	knowledge score	167	0,214	0,003	0,046
hunters	negative experience	167	-0,206	0,004	0,043
locals	attitude score	792	0,670	0,000	0,449
locals	utility score	816	0,546	0,000	0,299
locals	bear dangerous	788	-0,475	0,000	0,226
locals	bear population trend	823	-0.387	0,000	0,150
locals	negative experience	849	-0,333	0,000	0,111
locals	exaggerated	831	-0,232	0,000	0,054
locals	age class	829	-0,216	0,000	0,046
locals	education	813	0,163	0,000	0,027
locals	profession	838	-0,159	0,000	0,025
locals	location code	854	-0,134	0,000	0,018
locals	area code	854	-0,081	0,009	0,007
locals	knowledge score	853	-0,057	0,049	0,003
schools	attitude score	381	0,619	0,000	0,384
schools	utility score	390	0,436	0,000	0,190
schools	bear dangerous	384	-0,245	0,000	0,060
schools	negative experience	394	-0,186	0,000	0,034
schools	bear population trend	398	-0,089	0,000	0,008
schools	knowledge score	398	0,146	0,002	0,021
schools	area code	398	-0,127	0,006	0,016
schools	walk in forest	396	0,088	0,040	0,008

Appendix 3c: Pearson correlation coefficient and significance level of the independent variables selected for stepwise multiple regression of the dependent variables AS, US, NS, and KS.

Significant variables for regression model KS:

target group	independent variables	n	Pearson	Pearson sig.	r^2
hunters	how interested in more info	176	-0,031	0,000	0,098
hunters	area code	177	-0,231	0,001	0,053
hunters	education	172	0,214	0,002	0,046
hunters	character of bear	160	0,183	0,010	0,033
hunters	age class	168	-0,162	0,018	0,026
hunters	walk in forest	175	0,158	0,019	0,025
hunters	boschures	177	0,136	0,035	0,019
hunters	other	177	0,127	0,046	0,016
locals	walk in forest	902	0,264	0,000	0,070
locals	sex	903	-0,241	0,000	0,057
locals	other	923	0,216	0,000	0,046
locals	area code	923	-0,180	0,000	0,033
locals	exaggerated	882	-0,145	0,000	0,021
locals	education	864	0,137	0,000	0,019
locals	how interested in more info	891	-0,123	0,000	0,015
locals	family	923	0,108	0,001	0,012
locals	friends	923	0,102	0,001	0,010
locals	books	923	0,096	0,002	0,008
locals	character of bear	777	0,087	0,008	0,008
locals	profession	895	0,078	0,010	0,006
locals	negative experience	904	0,076	0,011	0,006
locals	age class	882	0,073	0,015	0,005
schools	walk in forest	415	0,175	0,000	0,031
schools	other	418	0,132	0,004	0,017
schools	family	418	0,109	0,013	0,012
schools	TV	418	-0,099	0,021	0,010
schools	negative experience	417	0,082	0,046	0,007

Appendix 4: Statistical differences for the scores between the study areas and between target groups.

	attitude score	knowledge score	utility score	number score	statistical test
general					
ALPS-NOT	0,000	0,000	0,000	0,002	Man-Whitney Test
locals-hunters-schools	0,014	0,000	0,725	0,000	Kruskal Wallis Test
NOT locals-NOT hunters-NOT schools- ALPS locals-ALPS hunters-ALPS schools	0,000	0,000	0,000	0,000	Kruskal Wallis Test
within target groups between the two study areas					
locals	0,000	0,000	0,000	0,021	Man-Whitney Test
hunters	0,103	0,005	0,319	0,042	Man-Whitney Test
schools	0,150	0,400	0,011	0,012	Man-Whitney Test
between target groups					
ALPS hunters-ALPS locals	0,036	0,000	0,019	0,000	Man-Whitney Test
ALPS hunters-ALPS schools	0,164	0,000	0,093	0,000	Man-Whitney Test
ALPS locals-ALPS schools	0,190	0,000	0,172	0,000	Man-Whitney Test
NOT hunters-NOT locals	0,044	0,000	0,116	0,000	Man-Whitney Test
NOT hunters-NOT schools	0,007	0,000	0,174	0,000	Man-Whitney Test
NOT locals-NOT schools	0,428	0,000	0,516	0,000	Man-Whitney Test

Appendix 5: Correlation of each of the eight single questions of the US with the AS. All correlation were significant on the p>0,05 level.

target group	independent variables	n	Pearson	r^2	df2
hunters	increase value of hunting	162	0,611	0,370	160
hunters	attacks on people every year	161	-0,574	0,330	159
hunters	kill a lot of sheep	162	-0,491	0,241	160
hunters	afraid to go in woods	160	-0,426	0,182	158
hunters	near sheep food is sheep	160	-0,405	0,164	158
hunters	negative impact on hunting	163	-0,403	0,163	161
hunters	increases tourism	162	0,340	0,116	160
hunters	reduce deer	162	-0,332	0,110	160
locals	attacks on people every year	802	-0,507	0,257	800
locals	increases tourism	802	0,462	0,213	800
locals	afraid to go in woods	804	-0,460	0,212	802
locals	near sheep food is sheep	802	-0,459	0,211	800
locals	kill a lot of sheep	815	-0,459	0,210	813
locals	increase value of hunting	811	0,437	0,190	809
locals	reduce deer	811	-0,377	0,142	809
locals	negative impact on hunting	813	-0,361	0,130	811
school	attacks on people every year	394	-0,370	0,137	392
school	near sheep food is sheep	394	-0,345	0,119	392
school	kill a lot of sheep	397	-0,269	0,072	395
school	increases tourism	392	0,263	0,069	390
school	afraid to go in woods	393	-0,224	0,050	391
school	reduce deer	397	-0,185	0,034	395
school	increase value of hunting	397	0,168	0,026	395
school	negative impact on hunting	395	-0,108	0,012	393

Appendix 6: Correlation of each variable of the seven single questions of the AS with NS.

target group	independent variable	n	Pearson	r^2	df2
hunters	Which answer best describes your feelings towards bears?	163	0,465	0,212	161
hunters	It is important to have "viable" populations of bears in SLO.	167	0,424	0,175	165
hunters	Weather or not I get to see a bear, it is important for me they exist in SLO.	166	0,409	0,162	164
hunters	Bears are a sign of nature in balance.	167	0,408	0,162	165
hunters	It is important to maintain bears in SLO for future generations.	167	0,404	0,158	165
hunters	Because many bears live in other parts of Europe, there is no need to have bears in SLO.	167	0,306	0,088	165
hunters	Is having bears in SLO good, bad or neither?	159	0,296	0,082	157
locals	It is important to have "viable" populations of bears in SLO.	853	0,588	0,345	851
locals	It is important to maintain bears in SLO for future generations.	852	0,579	0,334	850
locals	Which answer best describes your feelings towards bears?	834	0,554	0,306	832
locals	Weather or not I get to see a bear, it is important for me they exist in SLO.	831	0,548	0,299	829
locals	Is having bears in SLO good, bad or neither?	835	0,522	0,271	833
locals	Because many bears live in other parts of Europe, there is no need to have bears in SLO.	848	0,497	0,247	846
locals	Bears are a sign of nature in balance.	850	0,459	0,210	848
schools	It is important to have "viable" populations of bears in SLO.	398	0,533	0,282	396
schools	It is important to maintain bears in SLO for future generations.	398	0,520	0,268	396
schools	Is having bears in SLO good, bad or neither?	394	0,502	0,250	392
schools	Weather or not I get to see a bear, it is important for me they exist in SLO.	398	0,429	0,182	396
schools	Because many bears live in other parts of Europe, there is no need to have bears in SLO.	397	0,398	0,156	395
schools	Which answer best describes your feelings towards bears?	387	0,372	0,136	385
schools	Bears are a sign of nature in balance.	394	0,254	0,062	392

5. General Discussion *(5pp)*

General Discussion and Management Implications

Discussion

Bears in Slovenia proved to be shy and strictly forest dwelling. They avoided people mainly through temporal segregation (chapter 4.2.) while the displacement and disturbance potential of human infrastructure was low (chapter 4.3.). This is contrary to most findings from North America (McLellan and Shackleton 1988, Mattson 1989, Gunther 1990, Kasworm and Manley 1990) and does not support the assumptions behind several bear habitat model for Europe which all assume a significant negative impact of human infrastructure or points of human activity on bear habitat use (Aste 1993, Arbeitsgemeinschaft Braunbär Life 1997, Kusak and Huber 1998, Clevenger et al. 1997, Corsi et al. 1998, Dupre et al. 1999). The low displacement potential of human infrastructure in our study area might be explained by the predominantly nocturnal activity pattern, the high percentage of forest cover (70% in our study area), the low degree of forest fragmentation and the insignificance of poaching.

Although bears were not displaced from the vicinity of high speed traffic axis in our study area, these structures did pose a barrier to bear movements and were a significant source of mortality (chapter 4.4.). This is in accordance with other studies from North America (Wooding and Brady 1987, Gibeau and Herrero 1998, Gibeau 2000) and Europe (Boscagli 1987, Frikovic et al. 1987). Contrary to many other bear areas, the impact of the Ljubljana-Razdrto highway and the railway Ljubljana-Triest does not yet pose an immediate threat to bear conservation. This is attributed to the high bear density, the predominance of young males among the traffic victims and the fact that so far the Ljubljana-Razdrto highway and the railway Ljubljana-Triest are the only high speed traffic axes that cut through prime bear habitat (chapter 4.4.). However, the high transportation-related mortality in the vicinity of this highway and railway show the detrimental effects high speed, high volume traffic axes have in prime bear habitat. Our findings are a clear warning for other bear areas in Europe, especially those with small and threatened bear populations.

The low conflict level in our study area was surprising, as the bear density is high and no special precautions are taken not to attract bears to houses or villages. On the contrary, slaughtering remains are often dumped just next to the villages and food stuff and garbage is commonly stored next to the house. On the other hand, small livestock is rather rare and bears have easy access to numerous wildlife feeding sites in the forest (chapter 4.3.). The stable food supply in combination with a certain hunting pressure might explain the rare occurrence of habituated and/or food conditioned bears. In other countries, where bears also live in close co-existence with humans, but were there is no feeding and no hunting (e.g. in Austria or northern Italy) the conflict level might be higher (Rauer and Gutleb 1997).

In the past years the Slovenian bear population has expanded beyond the bear core area and more bears have reached the pre-alpine and alpine areas in Northern Slovenia. In these areas extensive sheep farming is practiced and immigrating bears cause considerable damages (chapter 4.5.). In spite of these problems Slovenians have a very positive attitude towards bears, which is in accordance with findings from

Northern Italy and Austria (Pedrotti et al. 1997, Szinovatz and Gossow in prep.), but contrasts to findings from Norway (Szinovatz and Bath 2000). However, the support for any further increase in the bear population is low due to increasing numbers of bear-human conflicts. In contrast to western Europe, Slovenia has a relatively large and viable bear population. Although the present bear expansion into the pre-alpine and alpine areas is of high international concern, it is of rather low national importance. Pro-active information campaigns from the part of the bear managers, focusing on fear related topics are desirable but might not suffice for a continuation of the present bear expansion policy. Without political and financial support from the countries interested in bear re-colonization, we doubt that bear managers in Slovenia will be able to defy the growing pressure of the various interest groups (Adamic 1996, Kaczensky 2000 in press).

Natural conditions for bears are still very favorable in Slovenia (chapter 4.3., Knauer et al. 2000) and contiguous habitat exists that allows bear movements into and from neighboring countries (Knauer 2000 in prep.). High speed, high volume traffic axis like highways and railways affect movements on a large scale and pose a significant mortality risk (chapter 4.4.). Although at present these linear barriers do not disrupt the population, any new constructions in the present or in potential bear range need to be assessed on the landscape level - requiring international cooperation and coordination. The same is true for the human dimension in bear management. At present the problems with sheep depredation and the resulting conflicts with the various interest groups are largely considered a national problem that needs to be solves on the national level. However, problems are far from being unique (Sagor et al. 1997, Kaczensky 2000 in press) and much could be learnt from other countries (e.g. Arbeitsgemeinschaft Braunbär Life 1997, Servheen et al. 1998, Quenette 1999, Herrero et al. 2000). In this respect more initiatives from the responsible agencies in Slovenia, but also in Austria and in Italy would be necessary. It should always be kept in mind that the development of the bear population in the Alps will largely depend on the bear management policy in Slovenia.

Management Implications

- We recommend to clearly differentiate between the effects of infrastructure on habitat quality and the conflict potential that might arise from these structures. The latter is a result of human attitude, livestock breeding traditions, garbage storage practices, hunting traditions, poaching pressure, feeding of wildlife and other human induced factors. These factors might vary widely from region to region and have to be evaluated independently of habitat quality considerations.

- The concentration of bear accidents between Vrhnika and Postojna predestines the area for the testing of new methods to reduce bear traffic collisions, including measures to increase the attractiveness of the existing bridges and underpasses for wildlife. As experiences with wildlife passages for bears are mainly restricted to North America, such a project could serve as a model for other bear areas in Europe and should receive international funds.

- Given the strong impact of high speed, high volume traffic axes on bear movements and mortality, any further projects should be assessed on the landscape level, making international cooperation and coordination necessary.
- A pro-active information program about bears and bear management in Slovenia from bear managers would be desirable. Such public education programs should focus on the questions on how dangerous the bear is for people and what impact on the local economy bears might have.
- Clear statements from the bear managers about the aims in respect to bear population size and distribution in Slovenia are needed. For a long term acceptance it would be necessary to develop these aims together with concerned interest groups and stake-holders.
- Since bears dispersing towards the Alps have to pass through high conflict areas in Slovenia, international interest to allow bears to live in these areas has to result in clear political statements and sound financial support of bear conservation in Slovenia.

Reference List

Adamic, M. 1996. An expanding brown bear population in Slovenia: current management problems. Journal of Wildlife Research, 1(3):297-300.

Arbeitsgemeinschaft Braunbär Life. 1997. Managementplan für Braunbären in Österreich. WWF Austria, Vienna, Austria. (in German)

Aste, C. 1993. Untersuchungen zur Lebensraumqualität für Braunbären in Österreich. Report of the Institute of Wildlife Biology and Game Managemet, Agricultural University of Vienna, Vienna, Austria. 95pp. (in German)

Boscagli, G. 1987. Brown bear mortality in central Italy from 1970 to 1984. International Conference on Bear Research and Management, 7:97-98.

Clevenger, A. P., F. J. Purroy, and M. A. Campos. 1997. Habitat assessment of a relict brown bear Ursus arctos population in Northern Spain. Biological Conservation, 80:17-22.

Corsi, F., I. Sinibaldi, and L. Boitani. 1998. Large carnivores conservation areas in Europe: a summary of the final report. Istituto Ecologia Applicata, Rome, Italy.

Dupre, E., L. Pedrotti, and P. Genovesi. 1999. Assessing potential habitat suitability for the brown bear in the Italian central Alps. 12th International Conference of bear research and management, book of abstracts, p:13.

Frikovic, A., R. L. Ruff, L. Cicnjak, and D. Huber. 1987. Brown bear mortality during 1946-85 in Gorski Kotar, Yugoslavia. International Conference on Bear Research and Management, 7:87-92.

Gibeau, M. L. and S. Herrero. 1998. Roads, rails and grizzly bears in the Bow River Valley, Alberta. In: G. Evink, D. Ziegler, P. Garrett, and J. Berry (editors). Proceedings of the International Conference on Wildlife Ecology and Transportation. pages: 104-108. Publication FL-ER-69-98. Florida Department of Transportation, Tallahassee, USA.

———. L. 2000. A conservation biology approach to management of grizzly bears in Banff National Park, Alberta. Ph.D. dissertation. Resources and the Environment Program, University of Calgary, Alberta, Canada (http://www.canadianrockies.net/Grizzly/pubs_and_papers.htm).

Gunther, K. A. 1990. Visitor impact on grizzly bear activity in Pelican valley, Yellowstone National Park. International Conference on Bear Research and Management, 8:73-78.

Herrero, S., J. Roulet, and M. Gibeau. 2000. Banff National Park: Science and policy in grizzly bear management. Ursus, 11:00-00.

Kaczensky, P. 2000. Bear politics in Slovenia. International Bear News, 9(2):9.

———. 2000 in press. Large carnivore depredation on livestock in Europe. Ursus, 11:00-00.

Kasworm, W. F. and T. L. Manley. 1990. Road and trail influence on grizzly bears and black bears in northwestern Montana. International Conference on Bear Research and Management, 8:79-84.

Knauer, F., P. Kaczensky, and G Rauer. 2000. A habitat model for bear expansion from Slovenia into the eastern Alps. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

———. 2000 in prep.. Dispersal und Ausbreitung von Braunbären in die Ostalpen. Dissertation an der Forstwissenschaftlichen Fakultät am Fachgebiet für Wildbiologie und Wildtiermanagement an der TU München. (in German)

Kusak, J. and D. Huber. 1998. Brown bear habitat quality in Gorski Kotar, Croatia. Ursus, 10:281-291.

Mattson, D. J. 1989. Human impacts on bear habitat use. International Conference on Bear Research and Management, 8:33-56.

McLellan, B. N. and D. M. Shackelton. 1989. Immediate reactions of grizzly bears to human activities. Wildlife Society Bulletin, 17:269-274.

Pedrotti, L., E. Dupré, and P. Genovesi. 1997. Attitudes of human population towards the re-introduction of the brown bear in the Italian central Alps: Preliminary results of a survey. 11th International Conference on Bear Management and Research in Graz, Austria, Book of abstracts, p:53.

Quenette, P. Y. 1999. Reintroduction of three brown bears in the central Pyrenees: Scientific results. Report of DIREN Midi-Pyrénées, France. 53pp.

Rauer, G. and B. Gutleb. 1997. Der Braunbär in Österreich. Umweltbundesamt, Monographie 88. Federal Environment Agency, Vienna, Austria. 64pp. (in German)

Sagor, J. T., J. E. Swenson, and E. Roskraft. 1997. Compatibility of brown bear Ursus arctos and free-ranging sheep in Norway. Biological Conservation, 81:91-95.

Servheen, C., S. Herrero, and B. Peyton. 1998. Conservation action plan for the world bears. IUCN, Gland, Switzerland.

Szinovatz, V. and A. Bath. 2000 in press. Norwegian attitudes toward and knowledge about brown bears and their management. Ursus, 11:00-00.

———. and H. Gossow. 2000 in prep. Die Akzeptanz des Braunbären in Österreich - Eine Langzeitstudie. (in German)

Wooding, J. B. and J. R. Brady. 1987. Black bear roadkills in Florida. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 41:438-442.

6. Summary *(2pp)*

SUMMARY

Brown bears (*Ursus arctos*) are making a comeback into the Alps and other areas of their former distribution range. Slovenia is located at the transition between the Dinaric Mountain Range in the south and the Alps in the north. Its bear population is of high international interest, because presently it is the only source for a natural re-colonization of the Alps. In addition, life conditions of bears in Slovenia are similar to those in other present and potential bear areas in central and southern Europe. Thus, strategies developed in Slovenia will be highly relevant for bear management elsewhere. So far, few data on activity patterns, movements and habitat use of bears in densely populated multi-use landscapes are available.

Although it has been acknowledged for a long time that wildlife management largely means the management of people, until recently it had been a discipline based mainly on biology. But with the general public becoming more knowledgeable and engaged in issues of natural resources, it becomes crucial to integrate the human dimension into the decision-making process. In Slovenia the present bear management is challenged by an increase in bear-human conflicts. Without information on the attitudes and knowledge of the involved public it will be difficult to find compromises and develop a widely acceptable management strategy, which is a major prerequisite if the present policy of allowing bears to expand northwards is to be continued.

The goal of my thesis was: (1) to assess the influence of human land use on the activity pattern and habitat use of individual bears, (2) to evaluate whether the Ljubljana-Razdrto highway impedes bear movements, and to assess the importance of transportation-related mortality compared to other sources of mortality in the bear population, and (3) to examine people's attitudes towards bears and bear management, their knowledge and personal experiences with the species.

- In chapter 4.1. we describe our experiences with trapping, chemical restraint and radiotagging of 25 different bears during 31 capture events in Slovenia from 1993-1998. A special focus is on safety considerations for trapping, tranquilizing and radiotagging of bears, but also on how to minimize the risk for the capture team and for local people frequenting the trapping area. Given adequate safety considerations, trapping bears at bait sites with Aldrich snares is a safe, highly selective and sufficiently effective method to capture brown bears on forested range.

- In chapter 4.2. we present data on the activity patterns of 16 different bears monitored in Slovenia and Croatia from 1982-1998. Logistic regression analysis, bivariate comparison of diurnal and nocturnal activity levels and cluster analysis showed that age class and time of the day were the most important variables predicting activity or inactivity. From our findings we conclude that nocturnal behavior is learnt through own negative experiences with humans, giving space for much individual variation. As a consequence, a certain level of disturbance is probably necessary to conserve this behavioral trait in fully protected bear populations.

- In chapter 4.3. we describe habitat use of 17 different bears monitored from 1993-1998. By merging 1.698 daily locations with habitat data in a Geographic Information System (GIS) we investigated bear-habitat relationships on two different scales and with three different approaches: (1) a comparison of bear locations and random points (2) compositional analysis and (3) the composition of different size range estimators. Bears were limited in their movements to forest cover, but showed only a weak avoidance of human infrastructure. In a landscape with a high forest cover, a low degree of forest fragmentation and where illegal killing is a minor problem, the disturbance and displacement potential of roads and villages seems low. In our opinion there should be more concern about the risk of bears becoming habituated or food conditioned.

- In chapter 4.4. we assessed the impact of the Ljubljana-Razdrto highway by analyzing movement patterns and home ranges of 15 individual bears that lived in the vicinity of the highway and by analyzing transportation related mortality statistics. The Ljubljana-Razdrto highway and the parallel railway were not avoided by bears but the highway acts as a filter for bear movements and both traffic axes pose a significant mortality risk. Although at present these traffic axes constitute no immediate threat to the bear population, mitigation measures would be desirable and also help other wildlife. We suggest to test the efficiency of different measures for bears and other wildlife species along this 30km stretch of highway, as empirical data are much needed.

- In chapter 4.5. we addressed the human dimension of bear-man co-existence in Slovenia. The multivariate analysis of 1519 questionnaires from two different study areas (a high bear density, low conflict area and a low bear density, high conflict area) revealed that the three target groups, locals, hunters, and pupils hold very positive attitudes towards bears, regardless of the different conflict level. However, respondents indicated a low support for a further increase in bear numbers. Fear and damage related topics were the most important factors predicting attitude, while knowledge level, place of residence and socio-demographic factors only played a minor role. Respondents had a high interest in the bear issue and were mostly concerned about population numbers and the distribution range of bears. Bear managers should develop a pro-active PR strategy focusing on these topics.

The natural conditions for bears are still very favorable in Slovenia and contiguous habitat exists that allows bear movements into and from neighboring countries. Although, at present high speed, high volume traffic axes do not disrupt the bear population, any new constructions in the current or potential bear range need to be assessed on the landscape level - requiring international cooperation and coordination. The same is true for the human dimension in bear management. So far, sheep depredation and the resulting conflicts with the various interest groups are largely considered a national problem that needs to be solved on the national level. However, problems are far from being unique and much could be learnt from other countries. In this respect, more initiatives from the responsible agencies in Slovenia, but also in Austria and Italy would be necessary, including financial support. It should always be kept in mind that the development of the bear population in the Alps will largely depend on the bear management policy in Slovenia.

7. General Appendix *(10pp)*

Appendix 1: List of Diploma and Ph.D. thesis within the frame of "Project Medved":

Bürglin, R. 1995. Planung von Grünbrücken an der Autobahn Ljubljana-Razdrto (Slowenien) unter besonderer Berücksichtigung des Braunbären. Diplomarbeit an der LMU München, 79pp.

Große, C. 1999. Ants - an important food for brown bears (*Ursus arctos*) in Slovenia? Diplomarbeit an der Zoologischen Fakultät der Philipps-Universität in Marburg, 55pp.

Jonozovic, M. 1995. Impacts of the highway Ljubljana - Razdrto on the wildlife. Graduation thesis at the Biotechnical Faculty of the University of Ljubljana, 83pp.

Knauer, F. 2000 in prep.. Dispersal und Ausbreitung von Braunbären in die Ostalpen. Dissertation an der Forstwissenschaftlichen Fakultät am Fachgebiet für Wildbiologie und Wildtiermanagement an der TU München.

Petram, W. 1999. Der menschliche Einfluß auf die Wahl der Winterlager des Braunbären (*Ursus arctos*) in Slowenien. Diplomarbeit am Lehrstuhl für Tieräkologie der Julius-Maximilian-Universität Würzburg, 67pp.

Wagner, A. 1998. Aktivitätsmuster des Europäischen Braunbären (*Ursus arctos arctos* L. 1758) in Zentral-Slowenien. Diplomarbeit an der Mathematisch-Naturwissenschaftlichen Fakultät der Rheinischen Friedrich-Wilhelms-Universität.

Appendix 2: Curriculum vitae

Petra Kaczensky

Born	11.11.65 in Munich, Germany
Nationality	German
Marital status	unmarried, no children
Languages	German, English, basic skills in French
Present address	Obere Dorfstr. 7 82488 Ettal Tel./Fax: (++49) 8822-945643 e-mail: PKaczensky@t-online.de

EDUCATION

2000	Dissertation *Co-existence of brown bears and men in Slovenia* at the Fachgebiet für Wildbiologie und Wildtiermanagement, Department für Ökosystem- und Landschaftsmanagement der Technischen Universität München
1991	Diploma thesis *Spatial organization of female lynx (*Lynx lynx*) and dispersal and mortality of their young in the Swiss Jura Mountains* at the biology Department of the Ludwig-Maximilian-University of Munich.
1988-1991	Graduate studies in biology at the Ludwig-Maximilian-University of Munich, Germany.
1987 - 1988	Two semesters graduate school in biology at the University of Colorado at Boulder, USA.
1985 - 1987	Undergraduate school in biology at the University of Regensburg, Germany.
1976 - 1985	Gymnasium Neubiberg, Germany.

WORKING EXPERIENCE

March 1993 - October 2000

Project leader *Coexistence of brown bear and man in a multi-use landscape in Slovenia*

- Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria
- Fachgebiet für Wildbiologie und Wildtiermanagement, Technischen Universität München, Germany
- Munich Wildlife Society, Linderhof, Germany

since January 1996

Trainer and member of the *Austrian bear emergency group*, an interagency group experienced in capturing, deterring and monitoring bears in case of conflicts.

- Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria

August 1994 - May 1998	Co-operation in a project to *develop and start implementing a management plan for brown bears in Austria,* supported by the European Union ("Braunbär Life" Austria). • Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria • Munich Wildlife Society, Linderhof, Germany
January 1996 - June 1996	Co-operation in a study on *Carnivores and sheep farming in Norway* • Norsk Institutt for Naturforsknig (NINA) in Trondheim, Norway • Munich Wildlife Society, Linderhof, Germany
November 1993 - November 1995	Co-operation in a project on *Spatial organization and feeding ecology of reintroduced lynx in Slovenia*. • Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria
December 1992 - April 1993	Co-operation in a project on *Status and monitoring of the Austrian lynx population in Carinthia*. • Institute of Wildlife Biology and Game Management, University of Agricultural Sciences in Vienna, Austria
May 1992 - October 1992	Co-operation in a project on *The impact of large scale clear-cutting on black bear population dynamics, spatial organization and ecology on Vancouver Island, Canada*. • British Columbia Ministry of Environment, Lands and Parks (Wildlife Branch), Canada
September 1992	Co-operation in a project an *Bear-human interaction and spatial organization of grizzly bears in Tweedsmuir Provincial Park, British Columbia*. • British Columbia Ministry of Environment, Lands and Parks (Wildlife Branch), Canada
January 1992 - March 1992	Co-operation in a project on *Predator prey relationship between wolves, moose and caribou during wolf control and subsequent wolf recovery in the Yukon, Canada*. • Yukon Renewable Resources (Fish and Wildlife Branch), Canada
August 1989 - February 1991	Field work for diploma thesis on *Spatial organization of female lynx (*Lynx lynx*) and dispersal and mortality of their young in the Swiss Jura Mountains*. • Swiss lynx project, Switzerland • Ludwig-Maximilian-University of Munich (Biology department), Germany
June 1988 - August 1988	Raising and/or caring of arctic foxes, lynx, wolves, martens and raccoons for the Zoologist and film producer Dr. Eric Zimen. • Bavaria Film, Germany

GRANTS

March 1997 - October 2000	Research Grant of the Austrian Science Foundation (FWF project: P 11529-BIO) for a research project on *Coexistence of brown bear and man in a multi-use landscape in Slovenia*.
August 1994 - July 1996	Graduate Grant of the Ludwig-Maximilian-University of Munich, Germany

DIPLOMA STUDENTS (TOPIC AND SUPERVISION)[1]

1999 *Ants - an important food for brown bears (*Ursus arctos*) in Slovenia?* Christine Große, Diplomarbeit an der Zoologischen Fakultät der Philipps Universität in Marburg.

[1]*Der menschliche Einfluß auf die Wahl der Winterlager des Braunbären (*Ursus arctos*) in Slowenien.* Welf Petram, Diplomarbeit am Lehrstuhl für Tierökologie der Julius-Maximilian-Universität Würzburg.

1998 [1]*Ein Habitat- und Ausbreitungsmodell für den Luchs.* Stephanie Schadt, Diplomarbeit am Lehrstuhl für Landschaftsäkologie der Technischen Universität München.

*Aktivitätsmuster des Europäischen Braunbären (*Ursus arctos arctos *L. 1758) in Zentral-Slowenien.* Axel Wagner, Diplomarbeit an der Mathematisch-Naturwissenschaftlichen Fakultät der Friedrich-Wilhelms-Universität in Bonn.

1996 *Untersuchungen zu Aktivitätsverhalten und Zeitbudget eines Luchsweibchens (*Lynx lynx *L.) in Slowenien in der frühenPhase der Jungenaufzucht und Vergleiche verschiedener time-sampling Methoden hinsichtlich ihrer Übereinstimmung mit einer kontinuierlichen Aktivitätsaufnahme.* Ilka Reinhardt, Diplomarbeit am Lehrstuhl für Ökologie der Biologischen Fakultät der Universität München.

INTERNATIONAL CONFERENCES:

2001 13th International Conference on Bear Research and Management, Jackson Hole, Wyoming, USA (posters announced):

- *Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia* (P. Kaczensky, F. Kauer, M. Jonozovic, C. Walzer and T. Huber)
- *Activity patterns of brown bears in Slovenia and Croatia* (P. Kaczensky, D. Huber, F. Knauer, H. Roth, A. Wagner and J. Kusak)
- *Experiences with Problem bear management in Austria and other European countries* (G. Rauer, P. Kaczensky and F. Knauer)

1999 2nd TWS International Wildlife Management Congress, Gödöllö, Hungary:

- Poster: *The importance of ants as food for brown bears in Slovenia* (C. Grosse and P. Kaczensky).
- Poster: *Availability and use of caves as winter dens relative to human presence by brown bears in Slovenia* (W. Petram, F. Knauer and P. Kaczensky)

12th International Conference on Bear Research and Management, Brashov, Romania:

- Talk: *The brown bear, a highly valued controversial species in Slovenia.*
- Chair of the workshop: *The impact of political changes to the bear management in Eastern Europe*

1998 Carnivore conservation, Zoological Society of London, London, Great Britain

1997 11th International Conference on Bear Research and Management, Graz, Austria (*member of the scientific committee*):

- Talk: *Problem bear management in Austria, a new approach in European bear management?*
- Talk: *Large carnivore – livestock conflicts in Europe.*

[1]together with Felix Knauer, Munich Wildlife Society

- Poster: *Activity monitoring of brown bears - testing field methods in the Zoo* (P. Kaczensky, A. Wagner and C. Walzer)
- Poster: *Project Medved - Studying the coexistence of brown bears and men in Slovenia* (P. Kaczensky, F. Knauer, M. Prosen, M. Jonozovic, T. Huber, A. Wagner, M. Adamic, B. Krze, W. Schröder and H. Gossow).

The Wildlife Society 4th Annual Conference, Snowmass, Colorado, USA:

- Talk: *Setting up "bear advocates" and a bear emergency team in Austria, a new approach in European wildlife management.*

1995 10th International Conference on Bear Research and Management, Mora, Sweden

1994 1st International symposium on the Coexistence of Large Predators and Man in Bieszczady, Poland

- Poster: *Highways in Slovenia – deadly barries for brown bears?* (P. Kaczensky, F. Knauer, T. Huber, M. Jonosovic and M. Adamic)
- Poster: *Project Lynx Kocevska – Slovenia* (T. Huber, P. Kaczensky, C. Stanisa and J. Cop)

1991 10th Congress of the International Union of Game Biologists (IUGB), Gödöllö, Hungary:

- Poster: *Tracking female lynx and their young in the Swiss Jura mountains* (P. Kaczensky, U. Breitenmoser, and S. Capt).

INTERNATIONAL SEMINARS AND WORKSHOPS:

2000 Wildlife monitoring – recent developments in techniques and applications, Workshop at the Swiss Federal Institute for Forest, Snow and Landscape Research, Birmensdorf, Switzerland

Symposium: Hat der Braunbär im Alpenraum noch eine Chance?, Nationalpark Kalkalpen, Austria (*main organizer*):

- Talk: *Zusammenleben von Mensch und Braunbär in der Kulturlandschaft Sloweniens*
- Talk: *Wie steht die Bevölkerung zum Bären in Slowenien?*

Symposium on the Future of the brown bear in Slovenia, Kocevje, Slovenia (*invited talk*):

- Talk: *Lessons learnt from brown bear research in Slovenia*

1999 2nd technical commission to Evaluate the brown bear project using radio telemetry in Asturias, Spain, Gijon, Spain (*expertise*).

Traffic and its effect on wild animal populations, International workshop at the Environmental Research Center (UFZ) in Leibzig, Germany (*invited talk*):

- Talk: *The impact of highways and railways on a bear population in Slovenia*

1998 5th Brown Bear "Life" meeting of organizations receiving money from the European Union "Life" Program for bear conservation in Europe, Toulouse, France (*invited talk*)

- Talk: *Large carnivore livestock conflicts in Europe*.

Seminar on the Action Plans for Large Carnivores of Europe, Council of Europe and Large Carnivore Initiative for Europe, Tale, Slovakia

1997 Der Luchs in Mitteleuropa, Symposium of the Landesjadgverband Bayern, Bund Naturschutz and Landesbund für Vogelschutz, Deggendorf, Germany (*invited talk*)

- Talk: *Schadensaufkommen und Kompensationssysteme für Luchschäden in Europa*

1995 1st Conference on the Status and Conservation of the Alpine Lynx Population, Engelberg, Switzerland (*invited talk*)

- Talk: *Status and distribution of the lynx in the German Alps*

1992 International Workshop on the Status and future of the brown bear in the Alps, Linderhof, Germany

1991 The return of the cervine-wolf, International Seminar on the possibility of reintroducing lynx in Abruzzo National Park, Pescasseroli, Italy:

- Talk: *Mortality of young lynx in Switzerland.*

1990 Seminar on The situation, conservation needs and reintroduction of lynx in Europe, Council of Europe, Neuchatel, Switzerland

PUBLICATIONS:

in peer reviewed journals:

Breitenmoser, U., P. Kaczensky, M. Dötterer, C. Breitenmoser-Würsten, S. Capt, F. Bernhart and M. Liberek. 1993. Spatial organization and recruitment of lynx (*Lynx lynx*) in a re-introduced population in the Swiss Jura Mountains. Journal of the Zoological Society of London, 231:449-464.

Huber, T. and P. Kaczensky. 1998. The situation of the lynx *(Lynx lynx*) in Austria. Hysterix, 10(1):43-54

Kaczensky, P., F. Knauer, M. Jonozovic, C. Walzer, and T. Huber. 2001 submitted to Ursus. Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia.

Stephanie Schadt S., F. Knauer, P. Kaczensky, E. Revilla, T. Wiegand, and L. Trepl. 2000 submitted to Ecological Aplications. Dealing with limited resources in conservation planning: rule-based assessment of suitable habitat and patch connectivity for the Eurasian lynx.

Kaczensky, P. 2000 in press. Large carnivore depredation on livestock in Europe. Ursus, 11:00-00

Kaczensky, P. 1998. Status and distribution of the lynx in the German Alps. Hysterix 10(1):39-42

Kaczensky, P., F. Knauer, M. Jonozovic, T. Huber and M. Adamic. 1996. The Ljubljana-Postojna highway - a deadly barrier for brown bears in Slovenia? Journal of Wildlife Research, 1(3):263-267.

proceedings:

Kaczensky, P., F. Knauer, B. Krze and M. Blazic. 2000. Kaj smo se naucili o rjavem medvedu v Sloveniji? (*Lessons learnt from brown bear research in Slovenia). Pages:75-86 In*: B. Flajsman, J. Cernac, B. Krystufek and C. Strumbelj (editors). Clovek in velike zveri, Ekoloski forum LDS, Ljubljana, Slovenia.

Kaczensky, P. 1998. Schadensaufkommen und Kompensationssysteme für Luchsschäden in Europa. Schriftreihe des Landesverbands Bayern e.V., 5:41-46

Schadt, S., F. Knauer, and P. Kaczensky. 2000 in press. Ein Habitat- und Ausbreitungsmodell für den Luchs. ANL Tagungsbericht.

Walzer, C, L. Slotta-Bachmayr, G. Rauer, and P. Kaczensky. Submitted 2001 for proceedings. Support for in-situ projects – examples of a zoo's potential role. Proceedings of the

workshop on the Evaluation of bear rehabilitation projects from a conservationist's point of view in Rhenen, The Netherlands.

final reports:

Arbeitsgemeinschaft Braunbär Life (ABL). 1997. Managementplan für Braunbären in Österreich. WWF Austria, Vienna, Austria, 157pp.

Große, C., P. Kaczensky, and F. Knauer. 2000. Ants - an important food source for brown bears in Slovenia? In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Huber, T., P. Kaczensky, C. Stanisa, J. Cop, and H. Gossow. 1995. Luchs-Telemetrieprojekt Kocevska, Slowenien. Final report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria, 24pp.

Kaczensky, P, F. Knauer, M. Jonozovic, C. Walzer, and T. Huber. 2000. Experiences with trapping, immobilization and radiotagging of brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P., A. Wagner, and C. Walzer. 2000. Activity monitoring of brown bears - testing field methods in the Zoo. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P., D. Huber, F. Knauer, H. Roth, A. Wagner, and J. Kusak. 2000. Activity monitoring of brown bears in Slovenia and Croatia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P. and F. Knauer. 2000. Habitat use of bears in a multi-use landscape. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P., F. Knauer, B. Krze, M. Jonozovic, M. Adamic, and H. Gossow. 2000. The impact of the Ljubljana-Razdrto highway on brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P., M. Blazic, A. Bath, and V. Szinovatz. 2000. The brown bear - a highly valued, controversial species in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P. 2000. How do DELO readers think about bears in Slovenia? In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P., M. Blazic, A. Bath, and H. Gossow. 2000. The brown bear in the Slovenian press 1991-1998. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Kaczensky, P. 1996. Large Carnivore - Livestock Conflicts in Europe. Report. Munich Wildlife Society, Ettal, Germany , 106pp.

Knauer, F. and P. Kaczensky. 2000. Spatial movement patterns of dispersing brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Knauer, F., P. Kaczensky, and G Rauer. 2000. A habitat model for bear expansion from Slovenia into the eastern Alps. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

Linnell, J.D.C., M.E. Smith, J. Odden, P. Kaczensky and J.E. Swenson. 1996. Strategies for the reduction of carnivore - livestock conflicts: a review. NINA Oppdragsmelding, 443:1-118.

Mysterud, I., J.E. Swenson, J.D.C. Linnell, A.O. Gautestad, I. Myterud, J. Odden, M.E. Smith, R. Aanes and P. Kaczensky. 1996. Carnivores and sheep farming in Norway: a survey of the information and evaluation of mitigation measures. Final report, 18pp. NINA Trondheim, Norway.

Petram, W., F. Knauer, and P. Kaczensky. 2000. Availability and use of caves as winter dens relative to human presence by brown bears in Slovenia. In: P. Kaczensky (editor). Co-existence of brown bears and men in the cultural landscape of Slovenia. Report of the Institute of Wildlife Biology and Game Management at the Agricultural University of Vienna, Austria.

other:

Kaczensky, P. 2000. Co-existance of brown bears and men in Slovenia. Dissertation am Fachgebiet für Wildbiologie und Wildtiermanagement, Department für Ökosystem- und Landschaftsmanagement der Technischen Universität München, 216pp.

Kaczensky, P. 2000. Der Braunbär. Wildbiologie in der Schweiz, 1/40a

Kaczensky, P. F. Knauer, G. Rauer and C. Walzer. 1997. Handbuch für die Eingreiftruppe - Vergrämen, Fangen, Narkotisieren und Überwachen von Bären. Manual. Arbeitsgemeinschaft Braunbär Life, Munich Wildlife Society, Ettal, Germany.

Kaczensky, P., T. Huber, D. Huber, A. Frkovic, and R. Fico. 1997. Wer War Es? – Expanded 2. Edition. Brochure, 56pp. Munich Wildlife Society, Ettal, Germany.

Kaczensky, P. and T. Huber. 1996. Scheinluchs - *lynx phantoma*. Carinthia, Säugetiere Teil II, p: 72-74.

Kaczensky, P. and T. Huber. 1994. Wer War Es? - Identifikation und Dokumentation von Raubtierrissen. Brochüre: 39pp. Zentralstelle der Österreichischer Landesjagdverbände, Vienna, Austria.

Kaczensky, P. 1993. Zur Mortalität von Jungluchsen. Mitteilungen aus der Wildforschung, 125:4pp.

Kaczensky, P. 1990. Viele Luchse sterben früh. Wildtiere 3:13-15.

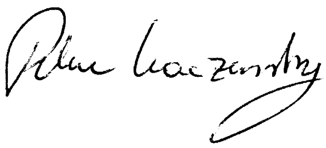
Kaczensky, P. 1991. Untersuchungen zur Raumnutzung Weiblicher Luchse (*Lynx lynx*), sowie zur Abwanderung und Mortalität ihrer Jungen im Schweizer Jura. Diplomarbeit am Lehrstuhl für Wildbiologie und Jagdkunde der Ludwig Maximilians Universität München. 80pp

Wiegand, T., F. Knauer, P. Kaczensky, and J. Naves. 1998. Facing a world of sparse and messy data: Lessons from a spatially explicit population model simulating the invasion of brown bears (*Ursus arctos*) into the Eastern Alps. Habilitationsschrift an der Forstwissenschaftlichen Fakultät der Ludwig-Maximilians-Universität München, 87-138.

Appendix 3: Bestätigung.

Bestätigung

Hiermit bestätige ich die vorliegende Arbeit selbständig und nur mit den von mir angegebenen Hilfsmitteln angefertigt zu haben.



Petra Kaczensky, Ettal den 25.10.00