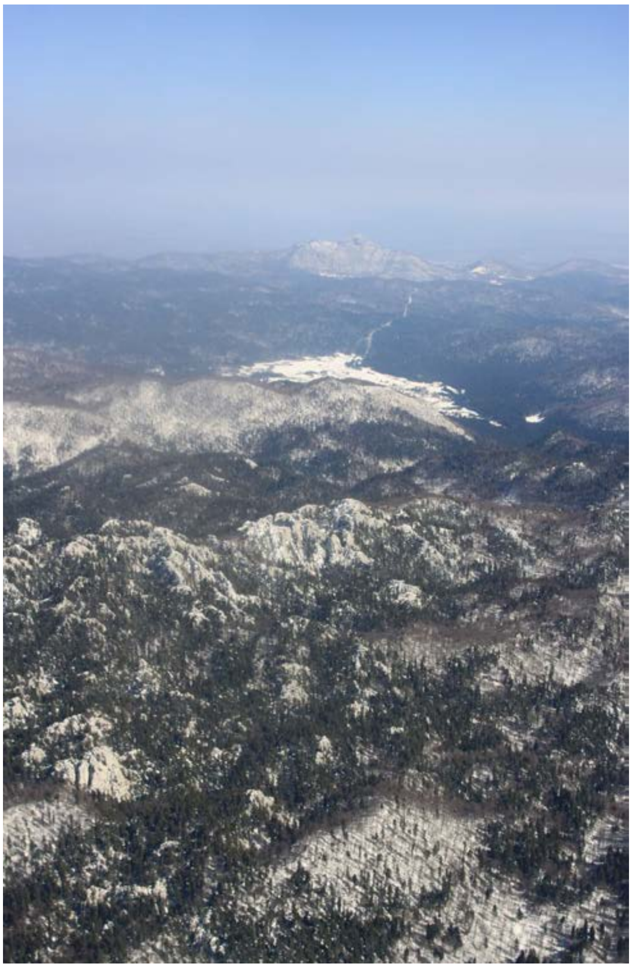
„HUNTing for Sustainability“

A summary of research findings from Croatian/Slovenian brown bear case study



Cultural meanings of hunting in Gorski kotar, Croatia

Vesna Kereži, Alistair Bath, Slaven Reljić, Djuro Huber

Background

Organized hunting has been present in Gorski kotar for over a century, and the region is renowned for its diversity of game species and good quality habitat. Most of the hunting is done within hunting clubs that provide hunting opportunities for both the local and foreign hunters. Although ideas of developing hunting (i.e. commercial hunting) into a more prominent division of the tourism industry have been present for some time they have never been acted upon. In general, local communities gain minimal or no benefits from the abundance of natural resource, including game. At the same time, close proximity of game species, especially those whose numbers are high or increasing (e.g. brown bear) might pose a safety risk for the local communities and cause human-wildlife conflicts in the near future. There is also the lack of an objective, science based depiction of local hunting and hunters. In general, hunters are either heavily criticized by the negative media coverage or praised by the Croatian hunting magazines. The existing studies on hunting are predominantly ecology based and there is a clear lack of studies, which focus exclusively on hunting and hunters in Gorski kotar. The lack of socio-cultural research tailored specifically toward hunting in Gorski kotar makes it difficult to determine the level of support for hunting and what the likely future changes to occur in hunting are. This is important not only when determining the role of hunting in wildlife management but also the role hunting has for the local hunters and the non-hunting part of the local communities.

Research Questions

The purpose of this study is to investigate the cultural and social context of hunting in the area of Gorski kotar by exploring meanings that local people, including those who hunt and those who do not, attribute to hunting. The purpose is not to merely determine the value and role of hunting in ones person's life but to understand what role does hunting have for the local community as a whole. The study also aims to reveal the differences and similarities in attitudes toward hunting among hunters and non-hunters from Gorski kotar by exploring the belief systems and values on which hunters and non-hunters base their attitudes toward hunting, and legitimize hunting.

Method

Qualitative data for this study was gathered through semi-structured in-depth interviews (n=9) and focus group discussions (n=5). Overall, 26 participants took part in the study. Data was analyzed using inductive thematic analysis that enables concise organization and description of dataset, and provides interpretation of different aspects of studied phenomena. Identified patterns i.e. themes were data-driven and directly linked to the transcripts.

Key findings

The three major themes that were identified include *Hunting community*; *Multiple dimensions of hunting;* and *Hunting for wildlife management.*

- The theme *Hunting community* depicts hunting in Gorski kotar as a profoundly social activity, a fact recognized and validated by both hunters and non-hunters. The social feature of hunting is formed and maintained through the hunting community i.e. hunting clubs, and these were found to play an immense role in representations of hunters. Indeed, it is hard if not impossible to discuss the individual identities of hunters in Gorski kotar without discussing what membership in such a community means to them. Hunting clubs are not merely organizations through which hunters are initiated into hunting but social networks through which they become embedded into their local social and natural environment.
- *Multiple dimensions of hunting* is a theme, which depicts the variety and complexity of participants' views on motivations and functions of hunting. In comparison to non-hunters, hunters listed more motivations and believed that a single hunter hunts for a variety of reasons. In general, both hunters and non-hunters saw as less positive those motivations that bring direct material or economic benefits to hunters such as meat or trophies. These concerns had a direct impact on the level of non-hunters' support for hunting. If non-hunters perceived that a hunter hunts only in order to gain trophy or meat, such a hunter would be labeled as an improper hunter. At the same time, much more positive were seen those motivations that bring psychological and/or physical benefits to hunters such as hunting to experience nature, to change the pace and socialize.
- Participants understood hunting as a process that provides various functions to Gorski kotar's social and its natural environment. Through participants' descriptions of personal and communal benefits, as well as the benefits for the game, arose the complex portrayal of hunting as a structure composed of varying socio-cultural, economic, and ecological dimensions. Hunters generally perceived all three dimensions as equally relevant, and non-hunters were best supportive of a type of hunting in which all three dimensions of hunting occur simultaneously, and are directed at both hunting and local community.
- The *Hunting for wildlife management* theme revealed the two main messages. Firstly, when it comes to the human-wildlife relationship, the balance is the most desirable state. Secondly, game management is the best approach to attain and maintain the balance. Consequently, the theme uncovers managing game as one of the strongest arguments behind participants' justification of

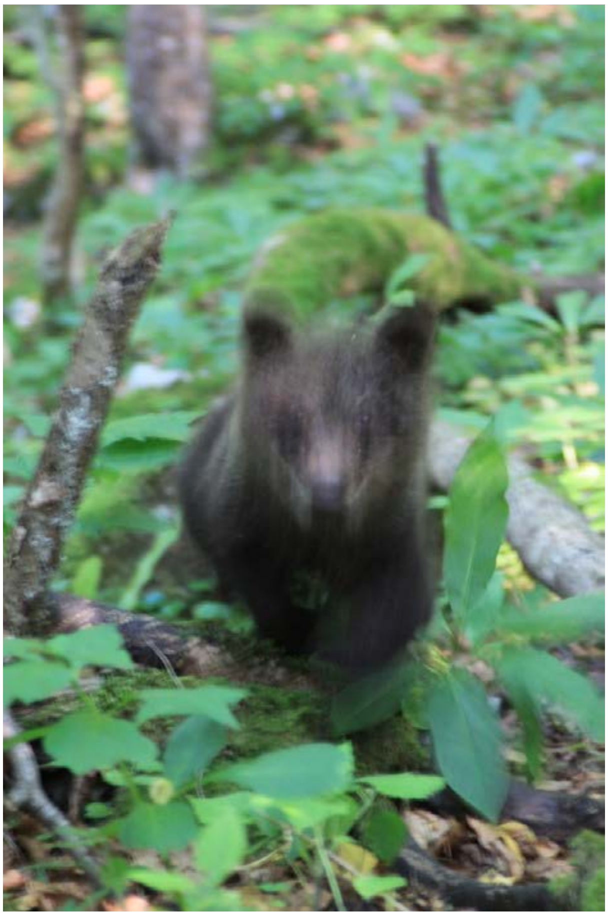
hunting. The unique traits of this argument are that it represents one of the rare occasions where both groups held a unanimous viewpoint, and that the participants rarely questioned the argument or the rationale behind it. Even those non-hunters who were highly critical of some other aspects and dimensions of hunting, supported game management and believed that it truly benefits the natural and social environment

Lessons learnt for best practice

- Although primarily focused on hunting, this study was also beneficial for revealing wider meanings on nature and rurality.
- Despite differences, hunters and non-hunters share many similar views on hunting. In the future, more effort should be put into exploring these similarities.
- There exist a clear support toward hunting among non-hunters, but it is not unconditional. The way in which different motivations and functions of hunting are evaluated has a direct impact on the legitimization of hunting.
- The study showed the importance of environmental and societal context in studies on meanings of hunting and depicted the complexity of processes through which people in Gorski kotar legitimate hunting.

Dynamics of public attitudes toward bears and the role of bear hunting in Croatia

Aleksandra Majić, Agnese Marino Taussig de Bodonia, Djuro Huber, Nils Bunnefeld



Background

The key to successful carnivore conservation in human dominated landscapes lies in stakeholder acceptance. The Croatian context offers a good opportunity to study public attitudes toward carnivores as it has recently experienced changes in brown bear (Ursus arctos) management that are representative of larger scale trends. A more regulated hunting system prompted by European integration and an increase in Croatia's bear population, reflect a general tendency toward more protectionist conservation approaches and expanding carnivore populations in parts of the western world. This study investigates the effects of these changes on public attitudes and acceptance capacity for bears, by surveying Croatian rural inhabitants at two points in time. A better understanding of the changing context of carnivore conservation could facilitate the development of management strategies that are more receptive and adaptive to public opinion.

In Croatia, where the bear is historically a hunted species and where its population has been growing for the past few decades most of the controversy around bear management is focused on determining optimal population levels.

Croatia devised a Bear Management Plan (BMP) in 2005 out of the need to comply with the Bern and CITES conventions, in preparation for European accession in 2013. The plan brought several changes that are likely to have had varying effects on public attitudes. The Bear management regime in place at the time of the first attitude survey in 2002, was run by individual hunting ground units, responsible for setting harvesting quotas for their own grounds. Under the bear management in place at the time of the second attitude survey, in 2008, experts from the scientific community were responsible for setting quotas on a national level, and the hunting season was shortened by 45 days. This more centralized and more regulated form of bear management may have caused the perception in stakeholders that their involvement and agency in bear management diminished. However, other

BMP measures were aimed at increasing public involvement in the drafting and implementation parts of the plan as well as reducing and mitigating human–bear conflicts. Guidelines and recommendati ons for good practice were drafted, a consultation process with various interest groups was initiated and the plan was presented throughout communities of the bear range.

Research Questions

In order to understand the importance of context in the formation of value orientations and acceptance capacity for bears, as well as its relevance with respect to other factors mentioned in the literature, we formulated the following hypotheses:

- Value orientations are affected by: socio-demographic variables (H1); experiences with bears (H2); changes in bear population dynamics and bear management (H3).
- Bear acceptance capacity is affected by: socio-demographic variables (H4); experiences with bears (H5); changes in the bear population dynamics and bear management (H6); and respondent's value orientations (H7).
- The effects of bear population dynamics and bear management will produce attitude changes at the individual level (H8).

Method

This study was carried out in an area of 9600 km2 spreading through the Dinaric Mountains in Croatia, where bears are permanently present and hunted. Low human density (about 25/km2) is present throughout the area and the primary source of income derives from small farms, livestock grazing and forestry activities. We based the questionnaire on Bath and Majic 's (2000) and Kaczensky's (2000) question format. It consisted of 48 multiple choice questions, mostly on a five point Likert scale regarding general attitudes toward bears, knowledge about bears, opinions about bear management, past experience with bears, and socio-demographic details of respondents. In 2002, questionnaires were sent to randomly sampled households from areas throughout the bear range excluding large urban areas, proportionately to the number of inhabitants. In 2008 questionnaires were mailed to the same addresses as in 2002. Each time 700 questionnaires were sent out, followed by a reminder/thank you card. The question ''Have you participated in such a survey in 2002?'' was included in the 2008 questionnaire to identify the respondents that were surveyed both times. Personal information was handled in accordance with the personal information protection legislation. Return rates reached 40.86% in 2002 and 53.14% in 2008, with a total of 658 responses.

We designed three models to test our hypotheses. The response variables used in the models were the scores of the principal components mentioned above, while the explanatory variables used in the models were derived from the questionnaire. The models contained a dummy variable for ''year'' with two levels to represent the year in which the survey was carried out (2002 and 2008). Our data on damages and encounters with bears in the wild does not allow us to measure whether the intensity and frequency of the experience increased for the same respondents between 2002 and 2008. Therefore we included interactions between 'year' and other variables in the models to see whether the experience of damage, seeing a bear in the wild and being a hunter produced a change in attitudes over time. To check for goodness of fit, we inspected the residual plots of the full models and found signs of heteroscedasticity on the first and third model. We performed Box-cox transformation on the variable ‘‘existence, bequest and use values’’ to stabilize its variance, and used regression diagnostics to identify and exclude 17 and 29 influential points from the first and third model, respectively. Since the data in this study is observational (not subject to experimental manipulation) and non orthogonal (variables are autocorrelated), the significance of factors depends on the order in which they are removed from the model. For this reason, multi model inference was carried out with the R package ‘‘MuMIn’’, by running models for all the possible combinations of the variables. We used second order Akaike Information Criterion (AICc) to account for the small sample size and the high number of parameters. We then generated a confidence set of models by using the cut off point of 2 AICc differences. The ‘‘MuMIn’’ package performed model averaging across the confidence set, to produce averaged parameter estimates, standard errors and confidence intervals. Furthermore it calculated the relative importance of each variable. This is measured across the confidence set of models by adding the weights of all the models in which each variable features, thereby ranking variables by importance according to their contribution to the entire set of likely models.

Key findings

Overall, results reflect a general positive attitude toward bears. The majority of questions pertaining to existence and bequest value orientations and perceived damages from bears did not differ significantly between the two surveys. However, the belief that attacks from bears are common was generally limited but more widespread in 2008. Tests run on the management section of the questionnaire show that overall respondents remained positive towards increasing the bear population, but significantly less in 2008. In 2008 significantly less people agreed with further increasing the bear population and less people disagreed with the statement that there are enough bears in Croatia. Answers to questions about compensation issues varied considerably, but on average respondents agreed that the state and hunting grounds should pay for damages caused by bears. Although responses did not change radically between 2002 and 2008, significantly less people in 2008 agreed that compensation should be paid only when appropriate precautions are taken, and significantly less people in 2008 agreed that farmers should buy insurance against damages. Lastly, results show support for a controlled system of bear hunting. Respondents disagreed with killing bears by all means, expressed low support for year round hunting, and in 2008 significantly more people agreed with the statement that bears should be hunted in a specific season. The majority of respondents agreed with the statement that quotas should be decided on a national level but in 2008 significantly more people thought that they should be decided on a county level.

The paired Wilcoxon and chi-square tests performed on the dataset containing only the responses of those that had answered the questionnaire both times support the main findings from the larger dataset. More people in 2008 agreed that there are already enough bears in Croatia (Wilcoxon = 40.00, $p = 0.0045$), more were aware that the bear population is growing (Chi-square = 8.44, df = 3, $p = 0.0377$), and more were in favor of hunting bears in a specific hunting season (Wilcoxon = 47.50, $p = 0.0030$). Furthermore, fewer respondents agreed with deciding on quotas at the national level (Wilcoxon = 279.00, $p = 0.0294$). No other significant changes were detected. Still, these results show that the change in respondent's opinions about bear management was consistent at the individual level and not simply due to different samples.

We ran 3128 models to explain respondents' ''support for limiting bear numbers'' and included thirteen in the confidence set. The best model contained the variables: ''existence, bequest and use values''; ''perceived threat from bears''; year of survey; and whether respondents had seen a bear in the wild. Stronger ''existence bequest and use values'' decreased respondents' ''support for limiting bear numbers'', while stronger ''perceived threat'' increased it. Moreover, respondents in 2008 were slightly more in favor of limiting the bear population than respondents in 2002, and respondents that had seen a bear in the wild were slightly more in favor of limiting bear numbers. The figure representation and the R2 values of the model ($R^2 = 0.47$, adjusted $R^2 = 0.47$) show that its explanatory power is higher than the previous two models. Several other variables included in the averaged model have low relative importance, small effect sizes and large standard errors, these are: experience of damage, age, knowledge, gender, being a hunter and the interactions between year of survey and other variables.

Lessons learnt for best practice

The results of this study show that respondents' existence bequest and use value orientations and their overall level of perceived threat did not change significantly over time, while instead acceptance capacity for bears was reduced. We hypothesize that this reduction might be due to changes in bear population and management. We also discuss the formation of value orientations and the socio-demographic and experience factors that influence them. Our findings offer insights into the general structure of attitudes and the direction of attitude change over time. Overall attitudes toward bear management have remained largely intact and the majority of respondents are still in favor of increasing the bear population.

Despite the changes mentioned above, attitudes towards bears in Croatia were overall positive and the majority of the public is still willing to accept an increase in the bear population. Some literature divides value orientations into ‘‘use’’ and ‘‘non-use’’ values, placing them on opposite sides of the same scale. Findings in this study do not support that division, and show that use values correlate with existence and bequest values in the first principal component. Hunters made up a large part of the sampled population and scored higher on the scale of ‘‘existence, bequest and use values’’ of bears. It is likely that their utilitarian values contributed to strengthen the existence and bequest values of non hunting members in the community. Since bear hunting is a historically established tradition in Croatia, the bear may have come to symbolize an aspect of rural and national cultural heritage. Moreover, because compensation for damage is paid by local hunting grounds, trophy hunting provides the financial means to cover some of the costs of bear conservation as well as profit for the hunting grounds and the local tourism industry. Changes in attitudes and acceptance levels of the bear over the past decade provide insight regarding the role of hunting as a tool to maintain local rights over land use and livelihoods. Results suggest that when faced with a growing bear population and a more centralized bear management some respondents asserted their hunting rights with more intensity. More people in 2008 were in favor of hunting the bear and less wanted it to be protected. Treves (2009) argues that hunting can increase support for conservation by contributing a sense of ownership and control over carnivore populations. Our results support this view, and suggest the need for management strategies that further public participation in bear management and decision making. In Croatia hunting forms an important aspect of public involvement, and given the appropriate institutional and ecological mechanisms to ensure its sustainability it can constitute an effective conservation instrument. The general trend of increasing bear populations in several European countries, and the future extension of the European Union will affect management of bears and other large carnivores in more countries. These changes suggest the need for continued monitoring of wildlife populations and attitudes of stakeholders toward wildlife. They also highlight the importance of context specific management strategies that help build local support for wildlife conservation.

Possible futures of brown bear population management in the Northern Dinarics: A scenario workshop method

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Background

Brown bear population in Slovenia and Croatia presents north-western edge of the continuous Dinaric-Eastern Alps bear population. The countries' main bear population management goal is its long-term conservation in the Dinarics, including habitat and to ensure coexistence of bears and humans. The countries share common views on importance of cross-border coordination, raising public awareness of bear population and involving public in bear population management decision-making. Croatia continues to find economic benefits for local people through bear hunting tourism, in contrast to Slovenia where those options are rarely used nowadays. In Slovenia, since 2004, bears are protected species and management plans allow a limited bear hunt with permission from the government, whereas Croatia has continued trophy hunting as one of the options for bear management where bear is a protected species, but it is also a game species (subject to regulated hunting). Bear management falls under the jurisdictions of different ministries, though in both yearly cull is carried out as a tool for controlling bear population size, as well as to resolve bear – human conflicts (i.e. removal of problem bears). Contrasting legal bear status (game species vs. protected species) presents the key challenge from the legislative point of view which the countries will have to overcome once Croatia joins EU. The differences between Slovenia and Croatia are most likely attributable to the different attitudes of people, the different historical and economic development of the countries and the fact that Slovenia as an EU member has to act within its regulations in contrast to Croatia.

In both countries careful evaluation of actions affecting population size represents the important point in the long-term bear conservation. One of the crucial parts of efficient bear population level management is cooperation between Slovenia and Croatia. Since countries in Europe are small in area, bears may cross several national borders which means that any management activities, interventions or actions have direct impact on the population of the neighbouring countries and vice versa. In our case we noticed the lack of cross-border cooperation on institutional levels of bear management despite the many recent initiatives to start management of large carnivores on population level.

Research Questions

With the use of scenario analysis method we research institutional interplay of bear management in Slovenia and Croatia, therefore identify and argument challenges and solutions to bear conservation in the Northern Dinarics. In addition, we explore how does the scenario analysis method contribute to creation of recommendations for bear management, as well as try to find valuable insights of the use of this method that in contrast to other public involvement method.

Method

Scenario analysis workshop is a novel approach which involves different stakeholders in decision-making process and enforces participant to think about the future by focusing on the key uncertainties facing managers and making strategic decisions (Brummel & MacGillivray 2008). We used the method as a tool to research institutional interplay of brown bear management in Slovenia and Croatia. Stakeholders involved were policy makers and representatives of different interest groups directly involved in brown bear management in Slovenia and Croatia. Out of twenty workshop participants in total, there were 10 from Slovenia and another 10 from Croatia. The goal of the workshop was to identify and argument challenges and solutions to brown bear conservation and to draw out recommendation for bear management in the Northern Dinarics.

Key findings

The workshop sought to establish the challenges facing the organisations participating in brown bear conservation across Slovenia and Croatia as well as solutions to this challanges. Identified challeges were: (1) *Conservation status of the bear population*, (2) *trans-boundary cooperation in bear management,* and (3) *public tolerance of bears* for which workshop participants proposed wide specter of solutions on different areas of bear management. This challages and solutions provided a basis for transboudary cooperation and decision-making scenario axes as well as three full descriptive scenarios: Local interest, Integrated management and Science-based decision-making.

Scenario 1: Local interest

The bear is one of the game species that can be hunted. Bear management is decentralized amongst local people, whose interests play a crucial role in the planning of bear management. The decisions are made by the local bear management boards, which act on the level of regions in Slovenia and counties in Croatia. The key topic discussed in the meetings of the local bear management boards is the culling of bears in order to prevent damages occurring. In these discussions, the loud interest groups usually win. The bear management is widely accepted since it is adapted to local needs. The focus of the management is how to satisfy the local interest. The bear conservation system is unstable because it is managed on a very small

spatial level. There is a lack of cross-border consistency and knowledge exchange regarding important issues (deciding culling quotas, structure of culling, sex and age) of bear management, and bear monitoring is state limited. There are few human-bear conflicts and the social carrying capacity is well known. The bear management strongly relies on socio-economic data and can change overnight as a consequence of a quick shift in public attitudes, which adds to the instability of the conservation system.

Scenario 2: Integrated management

Since the status of bears as a game species was agreed through trans-boundary collaboration, there has been an increase in the traditional use of bears and bear products in both Croatia and Slovenia, in particular a rise in the market for bear meat in the urban areas of Slovenia. Local tourism businesses are making considerable profit by providing services to the foreign guests. The initial income from the trophy hunting has inspired the local businesses to ensure more sustainable use of the bear, so they have started offering "experience bears" tours within their eco-tourism provision. The commercial value of bears has increased, however it is uncertain how this has influenced public tolerance of the increasing bear population as damage compensation payments are no longer provided by the government. The collected money is used for population monitoring and research, as well as to pay for organizing workshops and meetings of the different interest groups to talk about the goals and implementation of the bear management. Cross-border bear management is undertaken by a joint commission that incorporates representatives from the different 'bear' stakeholder groups. Reaching decisions and compromise with a large and varied management structure is difficult, requires a lot of resources, and the commission struggles to finalise the review period.

Scenario 3: Science-based decision-making

The decision-making process is based on scientific knowledge regarding population and monitoring. Therefore, there is a good level of knowledge about bears and bear management, so we have enough data to implement a culling system that will maintain the sex and age structure at the proper level. Monitoring and legal status of the bear is harmonized among the two countries and there is a rich scientific database shared between the countries. There is a formally-organized joint political body between Croatia and Slovenia, and common legislation defining this joint management. Due to a top-down decision making process, the protection under the EU legislative does not take into account the needs of local people. As a result, the decision-making process is simplified as the decision-makers need only to accept the proposals from the scientists. However, due to a lack of social research (human dimensions), the actual opinions and attitudes towards bears are not well understood. Since the bear has the status of a protected species and interest groups are not involved in the decision-making, there is opposition to management from the hunters and farmers. There is a low social carrying capacity and a lot of damage compensation. Some speculate that a lot of poaching is occurring. Due to the nature of bear management governance (cooperation, science led decision-making), it is possible to prevent further defragmentation of habitats.

Participants undertook an analysis of the scenario outlines, identifying and noting the potential advantages and disadvantages to their interests given the characteristics of each of the scenarios.

Lessons learnt for best practice

Results of the scenario workshop method and review of the literature which deals with institutional aspects of bear management in Slovenia and Croatia allowed us to draw recommendations for the long-term conservation of bear population in the Northern Dinarics:

- Good knowledge and understanding of the bear population status on one hand, and social carrying capacity on the other hand, is crucial for efficient bear conservation. The effectiveness of the management measures undertaken should be evaluated in that respect on a regular basis.
- A system of cross-border cooperation should be put in place. Frequent and systematically-organized information exchange should be a starting point. Subsequently more formal cooperation should be initiated, and joint vision and management goals developed. The final aim should be coordinated management at the (meta-)population level.
- Management should try to maximize the benefits for local inhabitants in a way that will not endanger the long-term survival of the bear population. The measures to achieve this should not only be directed to the use of culling: ecotourism opportunities should also be investigated and developed in this respect, as well as the direct involvement of the public in bear management. A platform for a more intensive dialogue among different stakeholders from both countries should be established. Resulting experience exchange and social learning will allow for better solutions in the long run. To avoid only the loudest groups influencing decisions, great care has to be taken that all interests have the opportunity to raise their voices.
- In order to achieve and maintain high social carrying capacity, greater emphasis should be given to the prevention of bear-human conflicts including the damages to agriculture and habituation of bears (a direct threat to people's lives).
- Awareness-raising should be undertaken on the local scale to educate and inform local communities of the need to manage and conserve bears. Scientists should be supported to translate ecological monitoring and social survey findings for a non-expert audience, ideally ensuring mutual support for scientific data collection on bear management from the local community.
- We should seek to change the attention from species-focused conservation to holistic, ecosystem scale monitoring and knowledge exchange regarding the benefits of ecosystem conservation, in order to raise public awareness about the important role of bears in the ecosystem.

In such process of scenario analysis method participants often discover they can make modification in their actions which may be of a little cost to them, but of great value to another player and/or future management.

The Value of Hunting Bears as Trophies. A Revealed Preference Application in Croatia

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Background

Life requirements of brown bear (*Ursus arctos*), like as the most of other large carnivores, often lead to conflicts with local inhabitants. That may lower the acceptance to the level when they are not tolerated anymore. Among various measures to gain the better acceptance the most effective are the ones where locals are involved and see the direct benefit of sharing the living space with bears. Different forms of ecotourism may fulfill this role, but the most direct source of income can be trophy hunting. The prerequisites for that are 1) the big enough and stable bear population, 2) well organized infrastructure, 3) adequate legislation, and 4) market interested in bear trophies.

Brown bears in Croatia are game species. Based on the Brown bear management plan for the Republic of Croatia a yearly quota is decided and distributed each year. Out of estimated 1000 bears in the population about 10% are allocated for trophy hunting each year.Hunting units are free to make arrangement with hunters on size of the bear to be hunted and even on the price paid.

Research Questions

We conducted a survey in Croatia to collect information on the expenditures incurred by bear hunters during the hunting trip and the characteristics of the bear trophies and hunting units. The price paid by hunter and substantial part of hunting income in the bear range in Croatia depends on the trophy value based on CIC points. The objective was to use the obtained data and conclusions in the bear management practice, to provide recommendations for stakeholders, with the goal to help maintaining the positive attitudes and secure the long term future of bear population.

Method

The valuation method used for the empirical estimation was the hedonic pricing. The basic hypothesis of the hedonic pricing approach assumes that a good or service can be viewed as a bundle of characteristics or "attributes" from which implicit values can be derived attending the market prices of different versions of the good or service, varying in levels of specific characteristics.

We define the price $P(X)$ of a bear hunting trip with physical attributes, X, such as the bear age, gender and quality (trophy value), the trip services provided, or the environmental characteristics of the hunting ground. Assuming market equilibrium, the implicit valuation or hedonic price of the i^{th} hunting characteristic can be estimated by regressing the hunter expenditure against the relevant attributes, and differentiating with respect to X_i. The hedonic equation to be estimated can be written as

$$P(\mathrm{X}) = f\,(Xb, Xc)$$

where Xb represents the bear attributes and the rest of the non-market relevant hunting attributes, and Xc the travel expenditure and other market costs associated with the hunting trip.

The econometric estimation of model may run into problems of imperfect observation; some significant variables may be missing. For example, there may be relevant characteristics of the hunting units not included in the regression, which are constant within the unit, but vary between units. Failure to control for this heterogeneity can lead to biased results. Fixed effect models can deal with unobserved factors. The following analysis uses this kind of model.

An empirical issue pertaining to the hedonic price model is the choice of the functional form. An incorrect choice of functional form may result in inconsistent estimates. Linear models are often used in the initial estimations. Past researches have supported the application of a semi-logarithmic functional form to the hedonic price model on the choice of a better "goodness-of-fit" criterion. Court (1941) already found the semi-logarithmic (log-linear) form of the dependent variable to give "higher simple correlations". Both functional forms, linear and semi-logarithmic, are considered here.

Survey

Following the team field survey in mid June 2010 in Gorski kotar area in Croatia, a pilot questionnaire was designed. The aim was to apply a hedonic price valuation exercise. On June 30, 2010 in Crni Lug, Croatia Bear management workshop and National Consultative Group (NCG) meeting (for project "HUNTing for Sustainability") were held. The questionnaire was tested by handing out to participants. The responses helped to fine tune the focus and wording of the questions, and the final questionnaire was prepared.

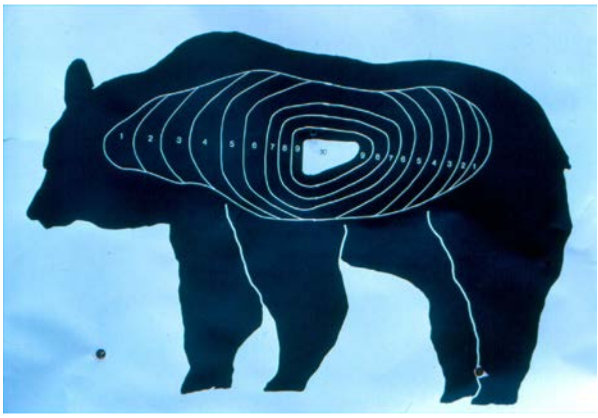
It was sent to all 60 hunting units that manage bears in Croatia in 2011, i.e. that share the national bear hunting quota with at least one bear to be hunted there. The responsible Ministry sent it in February together with the Action Plan for 2011 and official Decision about the allocated quota for each particular hunting unit. At the next Bear management workshop and NCG meeting held on June 15, 2011 the stakeholders were reminded to fill the forms. In total, 35 questionnaires were collected, representing a 58.3% response rate. Most questionnaires provided more than one bear-hunted observation. The number of trophy bears in the sample was 96. However a few of the observations missed some of the information intended to be collected in the survey; this is reflected in the statistical analysis.

Additional information about 96 harvested bears was also collected. Each stakeholder stated up to five characteristic which they highlight in advertising. Characteristic were grouped according to their preference to simplify the built model but still be representative. The statistical analysis was performed with STATA software.

Key findings

Results from the two models do not differ significantly. Taking as a reference the simplest model -the linear one-, the implicit prices for each attribute (variable) is directly the coefficient. Therefore, according to the results most of the expenditures of the bear hunters, apart from the trophy itself, are explained by the precedence of the hunter.

- On average, hunters from outside Croatia spend 135 euro extra per bear hunted than the Croatian nationals.



- Hunters are more likely to spend more money if the hunting unit is strong in legality aspects. The hunting units that stress the compliance with legislation and facilitate the documentation for exporting the trophy tend to increase the willingness to pay of the hunters in some 60 euro on average.

- The economic aspects do also seem to influence hunters' expenditure decisions. In particular, units having a reputation for affordable prices, bargaining possibility and free guidance, tend to attract hunters that, on average, end up spending 30 additional euro in their trip.

- The environmental attributes of the hunting grounds, like the proximity to attractive places like Plitvice Lakes, River Gacka, or Velebit mountain, contribute very little to the willingness to spend extra for the hunting experience. The average value is circa 3 euro, but the variable is not statistically significant.

- The price of bear is not fixed and trophy points (CIC) explain only part of the bear price variation (R-squared= 0,39)

Changes in hunting policy: who bears the cost?

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Background

Many species are coming into conflict with a growing human population. These human-wildlife conflicts can be direct costs to the communities who live with wildlife such as attacks on humans, crop damage and depredation of livestock; or indirect costs, such as financial and time costs in preventative measures. It is the communities surrounding wildlife habitat that must bear the expense of living with conflict, and this disproportionate cost can lead to an incentive to retaliate through killing wildlife or destroying habitat. Reducing this conflict is particularly challenging for predators because they are generally wide-ranging and therefore difficult to adequately conserve solely within protected areas.

Croatia is currently in the advanced stages of the accession process to become a member of the European Union (EU). Under EU legislation the brown bear is a strictly protected species, and trophy hunting or disturbance is prohibited (Counsil Directive 92/43/EEC, 1992). The Counsil Directive, better known as Habitat Directive, however, provides a window for more flexible management through derogations (Art. 16e). The removal of “limited number” of individual animals may be allowed. Slovenia, which joined the EU in 2004, has moved from a trophy hunting management scheme to population management through culling (which is permitted by the same derogations in order to reduce human-wildlife conflict) and government compensation for bear damage, rather than local compensation by the hunting companies.

Research Questions

When Croatia joins the EU, management of the bear population will change. The scenario of full protection is what the EU authorities assume according to the given status of bear in the Habitat Directive. That would mean the complete abandonment of hunting and other related activities and would have associated impacts on the hunting organisations that currently benefit from commercial trophy hunting. It is realistic to expect that Croatia will continue some form of bear hunting using the above described derogations that may lead to a similar management approach to that currently in place in Slovenia. Here we quantify the potential economic impacts of accession if applied as originally meant. Firstly we characterise the current trophy hunting management system in Croatia and quantify the role of the bear in the balance sheets of hunting organisations. Next we model the potential economic effects on the hunting organisations of a change in bear status which precludes trophy hunting, and discuss some of the other possible impacts that this policy change may have at the local level. Finally we use a population model based on data from hunted animals in 2009/10 to assess the effects on population trend of the current bear hunting profile in Croatia, given the estimated population size, in order to clarify the relationship between the current quota and biological sustainability. We conclude by discussing the potential effects of the cessation of trophy hunting on bear population dynamics, hunting organisation economics and conflict with local communities, and reflecting on the wider implications of this case study for conservation of hunted species.

Method

Semi-structured interviews with hunting ground managers were used to gather information about the structure and economics of the current bear management system and the future of bear trophy hunting in Croatia. Hunting-right-owners in Croatia can be split into three different categories: state, private and local hunting clubs. Respondents were selected using opportunistic sampling, ensuring representation from all three hunting organisation categories.

The hunting management was investigated and the economics of hunting were analysed separately within each category of hunting organisation. Following this, a pooled analysis provided an estimate of potential total costs of accession to hunting organisations. All income from and costs of bear management were identified and then split into those that were dependent on the bear trophy hunting quota available to the hunting organisation, and those that were independent of the quota. Each cost was then assessed to determine whether and how it would change if bear hunting was prohibited.

The demographic characteristics of the hunted individuals in 2009 and 2010 were used to determine the age and sex classes targeted for hunting. Details and samples from dead bears (from hunting or other causes) are sent to the Faculty of Veterinary Medicine in Zagreb, including a premolar which is used to determine the age of the bear through cementum aging. In 2009 (n=68) and 2010 (n=75) the majority (49.3%) of the hunted animals were adult male bears four years old or older, 13.3% were older females (4+ years old) and 27.0% were younger males. In 2010 two cubs less than 1 year old were hunted, however as cubs this age are usually accompanied by their mother and it is illegal to hunt them, for the purposes of this study no hunting was permitted in this age class.

Two hunting scenarios were run through the population model, firstly assuming the allocated quota was all hunted (100 bears annually, the annual quota over the past 5 years: 2008-2012), and secondly using the mean realised hunting from 2009 and 2010. In order to explore the effects of the uncertainty of estimates of the brown bear population size on estimated hunting sustainability, a range of initial population sizes from 500 to 2500 individuals was used. The model was run over a 10-year projection with 1000 replicates, and the population trend over this period was reported.

Key findings

Hunting organisations gain income from hunting fees (for trophies), selling the meat from hunted species and, for the local hunting clubs, membership fees. For the purposes of this study, only economic information relating to bear hunting has been included. Expenditure is split into in three categories – the costs that are incurred to maintain the hunting ground regardless of bear hunting in order to continue to hunt other species and are thus on-going (37.8% of costs), those that vary depending on the quota (20.5%), and those that are bear-related but quota-independent, relating to bear damage (41.7%).

Because all three types of hunting organisation sell bear trophy hunting, bear specific costs and income were consistent between types. Post-accession, it is expected that all bear damage to hunting ground property and private property will be compensated for by the state, and therefore these costs would be removed from the hunting grounds.

Administration of bear hunting is a cost which would be removed entirely if bear hunting ceased. However, with all damage compensated by the government rather than locally, additional administration will be required in reporting these incidents when damage is to hunting ground property, for example feeding stations for other species. The size of this additional cost could not be calculated, however it will serve to increase the loss to the hunting organisations.

Information on every dead bear is supplied to the Faculty of Veterinary Medicine in Zagreb, including the CIC value and the mass of meat of trophy hunted bears. The mean trophy size of legally hunted bears in 2010 was 298.10 CIC points (n=68), and the mean mass of meat from the hunted bears in 2010 was 82.75kg (n=40). The approximate income per bear to hunting organisations is 39.615,00 HRK, based on the current state price list for trophy hunted bears (which is used as a guideline by many of the hunting organisations) and the mean value of bear meat per kg (obtained from interviews). Both the income from selling bears meat and from bear trophies will be lost when bear hunting becomes illegal. Local hunting club membership fees were not included in the economic analysis because the bears are not generally hunted by hunting club members; this suggests that the number of hunting club members would not change with a change in the status of the bear. Currently, calculated bear-specific income marginally outweighs bear-specific expenditure.

The current bear population in Croatia is estimated to be about 1000 individuals, and the population is believed to be increasing. The scenario using the actual level of hunted bears from 2009 and 2010 implies that this might be an underestimate, as the population is only stable or increasing if the initial population is at least 1600 individuals. However, if the full quota was realised annually then at an initial population size of 1600 bears, it would be expected that the population would experience a decline of over 40% over 10 years. This model suggests that in order for the full quota (100 bears annually) to be sustainable, Croatia would need to have a population of at least 2300 bears.

Lessons learnt for best practice

The change in policy required by Croatia's entry to the EU may have considerable impacts on hunting organisations, the Croatian government and communities living with bears. It is expected that the Croatian government will pay compensation for bear damage to private property, as is currently the situation for wolves which are no longer legally hunted. Compensation is commonly used in an attempt to mitigate the costs of living with wildlife, which are generally disproportionately borne by farmers and local communities. There is debate concerning the effectiveness of compensation schemes, because stock owners rarely get full compensation, leading to a lack of motivation to carry out appropriate conflict reduction measures and high numbers of false claims, such that these programmes are often extremely costly and rarely provide long term solutions. The current compensation agreement in Croatia between hunting organisations and the local communities is highly successful because there is a consistent source of funds (ultimately from the trophy hunters), and the hunting organisations are generally an important part of the local community (particularly the local hunting clubs) thus ensuring quick, often informal, payments with little incentive to exploit the system. A government compensation scheme on the other hand, will most likely take longer to verify damage and pay legitimate claims, and be more vulnerable to exploitation. Anecdotal evidence from one interview shows that the government compensation scheme for wolf depredation of livestock is already being exploited, with a bear attack on six sheep being reported as a wolf attack in order to get compensation from the government rather than the hunting organisation. Conflict between bears and hunters is likely to increase when the bear becomes a protected species.

We do not intend to imply that trophy hunting is an appropriate management option for all brown bear populations. However, there is strong evidence that this system is more beneficial for the Croatian population and the communities who share its range than a protectionist strategy would be. It is essential to consider both the economic and biological perspective when making management decisions, because a policy in which wildlife pays for itself not only reduces perceived conflict between people and wildlife, but can also result in a long-lasting, effective management scheme. Accurate population estimates are important in order to manage harvested populations sustainably. This research demonstrates the potential for population models to highlight potential monitoring inaccuracies, particularly for cryptic species, therefore indicating where more effective monitoring techniques are required for harvested species.

Demography and mortality patterns of removed brown bears in a heavily exploited population

Miha Krofel, Marko Jonozovič, Klemen Jerina

Background

Hunting can affect demographic parameters, genetic and morphological characteristics, habitat use, social structure, and behavior of individuals in the harvested population. Brown bears (*Ursus arctos*) are a charismatic and highly valued trophy species among hunters. They have low reproductive rates and are sensitive to high harvest rates. Because overharvest is a common concern, analysis and monitoring of bear mortality, especially of bears removed through harvest, is important to ensure population viability.

Most brown bear populations in Europe currently experience low levels of harvest. A notable exception appears to be brown bears in Slovenia, which form the northwestern part of the Dinaric–Pindos population. By the late 19th century, brown bears were nearly extirpated in Slovenia, with only 30–40 bears remaining in 2 forest patches near the Croatian border. Since the 1940s, bear numbers and distribution increased due to conservation measures. An important measure was the establishment of a Core Bear Protective Area of 3,500 km2 within the Dinaric Range in 1966, where bear hunting was strictly regulated. In contrast, bears outside this area (mostly dispersing individuals) experienced higher harvest rates. Thus, the present distribution of brown bears in Slovenia is mainly a function of past management regimes, habitat characteristics, and human infrastructure. In Slovenia, the most important current bear management practices are harvest and supplemental feeding. Legal harvest encompasses: (1) hunting, which is geographically and temporally restricted and has a prescribed structure according to bear weight categories (described below), and (2) management removals of conflict bears, which are prescribed for bears that cause repeated conflicts with people and are not limited by the hunting season or by age or reproductive status. Quota of bears harvested during the hunting season (October 1 through April 30) is prescribed according to the 3 body mass categories: <100 kg (at least 75% of prescribed harvest), 100–150 kg (maximum 15% of harvest), and >150 kg (maximum 10% of harvest). It is illegal to shoot females with offspring; however, it is legal to shoot dependent young.

The high harvest rates of bears in Slovenia have caused concern and have been the subject of criticism; however, the magnitude of this harvest in relation to the population size is unknown. In addition to high harvest quotas, other bear harvest regulations in Slovenia could result in the sex and age structure of harvest bears differing considerably from those of the standing population. This is in contrast to many other bear populations (e.g. Scandinavian), where there is low selectivity among harvested bears. Therefore, there is potential for more pronounced effects of harvest on demographic structure and population dynamics of brown bears in Slovenia.

Research Questions

We analyzed structure and mortality patterns of brown bears removed in Slovenia during 1998–2008. Our objectives were to:

- determine sex and age structure of removed bears and possible temporal changes in this structure

- estimate relative importance of different causes of removal relative to total removal

- explore mortality patterns among sex and age classes

- examine potential differences in demographic structure of removed bears in relation to cause of removal

- estimate proportion of population removed annually by harvest

Method

We used data on all bears removed during 1998–2008, which include sex, estimated age (using cementum annuli), and body measurements along with date, location, and cause of removal. Sex was known for 908 (98%) and age for 918 (99%) individuals. We categorized causes of removal as: hunting, management removals of conflict bears, illegal killings, traffic accidents (animals that died in vehicle collisions on road or railway), found dead (animals that died from natural causes or cases when cause of death could not be determined), removed to sanctuary (orphaned cubs taken to captive facility), and live captures for export (bears captured and translocated to other countries for reintroduction or population augmentation).

We tested variables (annual removal, sex ratio, relative importance of causes of removal) for serial correlation with a 1-year lag and found no indication among years ($r = -0.17$–0.36; $P = 0.30$–0.76, $n = 10$). We tested for temporal trends in the arcsine transformed proportion of females among removed bears using linear regression, controlling for annual removal. The same method was used to analyze temporal trends of relative importance of main causes of mortality (i.e., hunting, management removals, and traffic accidents).

We assessed homogeneity of yearly age structures of removed bears using the exact homogeneity test with 10,000 simulations. Data were combined into 3 periods (1998–2000, 2001–04, 2005–08) and 10 age classes (ages 0, 1, 2, 3, 4, 5, 6, 7, 8–11, and >11 years) to ensure that expected frequencies in each period by age class were >5.

We used generalized linear models (GLM) to test main effects of cause of removal and sex, with annual removal (removed bears/year) and year as covariates and meaningful 2-way interactions on log-transformed age of removed bears. We used logistic regression to explore factors affecting sex of removed bears, including cause of removal, age (ordinal variable: 0, 1–2, 3–7, and >8 years), log-transformed age (covariate), annual removal (covariate), and year (covariate).

For both analyses, we calculated all possible models with algorithm best subsets and selected the models with the lowest Akaike Information Criterion (AICc) value. We explored structure of all candidate models with ΔAICc scores lower than 4, calculated Akaike weights, and used them for model averaging to obtain robust parameter estimates.

Key findings

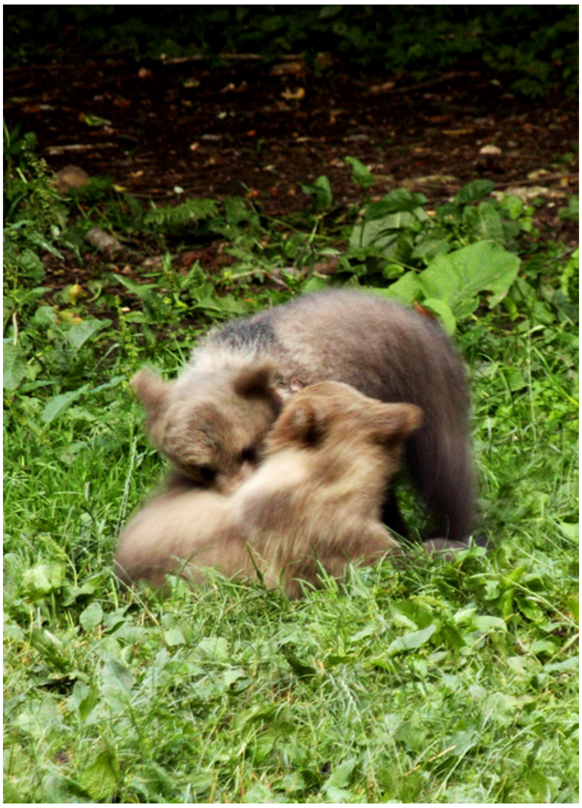
During 1998–2008, 927 bears were recorded as removed in Slovenia. Overall, 97% of recorded removals were human-caused. Most bears (59%) were removed by hunting, the dominant mortality source throughout the study. Legal harvest (i.e., hunting and management removals) accounted for 77% of recorded removals. Vehicle collisions accounted for 16% of removals, with an average of 41% of these on railways, 14% on motorways, and 44% on other roads.

Four models explaining the age of removed bears had ΔAICc score less than 4. Parameter values produced by model averaging showed that age of removed bears was best explained by cause of removal, sex, the cause by sex interaction, and to a lesser degree, by year and by annual removal. The best model explaining the sex of removed bears included variables cause of removal, age, and annual removal.

The percent of females among all removed bears was 41%; the percent was lower in hunting (36%) and higher in traffic accidents (44%) and management removals (52%). The absolute difference overall between males and females removed was 159 animals. Most of this difference was due to hunting (151 more males than females removed), followed by traffic accidents (males – females = 19), illegal killings (males – females = 4), and bears found dead (males – females = 2). Among other causes, females prevailed. Median age was highest for bears removed from hunting (2.8 years), followed by the management removals (1.8 years), and traffic accidents (1.5 years). The GLM model contained a significant interaction of sex by cause of removal, indicating that the group most exposed to the traffic accidents were young males (median age = 1.4 years).

Sex ratios among removed bears differed among age classes. Among removed cubs, the sex ratio was close to unity (males:females = 1:1.02; n = 117). The proportion of females first decreased with age, averaging 37% at years 2–4, but then increased and exceeded the proportion of males at age 8. The oldest removed male was 14 years and the oldest removed female was 21 years. Among all bears removed in Slovenia, 78% were removed before reaching 4 years of age (80% of males and 75% of females). Median age at removal was significantly lower for males (2.3 years) than for females (median = 2.5 years; β males versus females = -0.120; P = 0.001). The sex differential was largest during ages 1–3 years (males removed = 62% [n = 350], females removed = 38% [n = 211]). Mortality within different causes varied with age. For example, hunting was lowest among cubs (18%), increased until age 3 (79%), and gradually declined thereafter.

Annual removal varied from 56 (2001) to 126 (2006) bears. Annual removal increased over the study (β = 5.6; P = 0.01; n = 11). Proportion of females among removed bears varied annually from 34–49% and increased across years (β = 0.0015; P = 0.002; n = 11) and with annual removal (β = 0.012; P = 0.007; n = 11). However, in a linear regression model that controlled for the effect of annual removal, time (year) did not affect the proportion of removed females (partial r = 0.33; P = 0.35; n = 11). Neither proportion of removals being management removals nor proportion of hunting and traffic accidents were associated with total annual removal or year (r = 0.07–0.40; P = 0.22–0.88; n = 11). Age structure of removed bears among periods was similar (χ^2 = 25.05, 18 df; P = 0.12).



Natality calculated according to data from bear monitoring through systematic observations at feeding sites was estimated at 71.5–82.8 bears born/year or 20% (95% CI = 19–22%) of the estimated population.

Lessons learnt for best practice

Most brown bear mortality in Slovenia was human-caused, and harvest rates were considerably higher than harvest mortalities reported in other European countries with legal harvest. Annual mortality due to legal harvest and total human-caused mortality represented 20% and 24% of the December population, respectively. Removal rates varied annually but generally increased in time, together with population growth. High human-caused removal rates in Slovenia suggest potential for more pronounced effects on bear demography and behavior than in other populations. Natural mortality among bears appears low, as was also confirmed with telemetry studies and observations on feeding sites.

In spite of the high rate of human-caused mortality, bear abundance in Slovenia appeared to be increasing, while several other brown bear populations with lower human-caused mortalities were stable or declining. This is partly a result of low natural mortality and high reproduction rate of bears in Slovenia. This may be the result of environmental factors connected to the southern latitude, high proportion of females in the population, intensive supplemental feeding, and decreased age of primiparity. In addition, net influx of bears from Croatia may be an important factor enabling high removal rates, and further studies are needed to evaluate its contribution to the population dynamics.

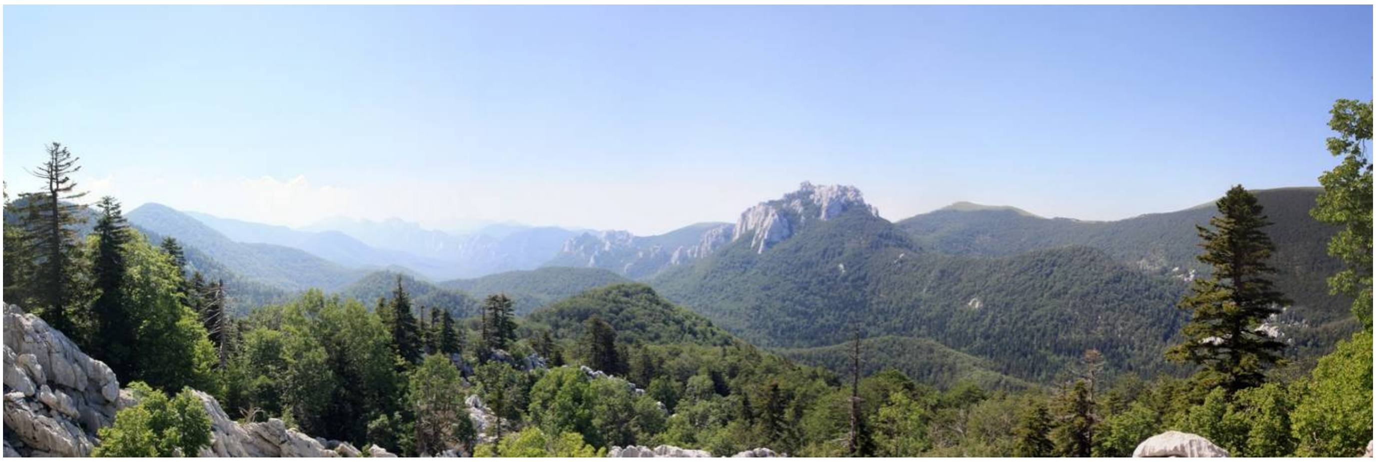
Most bears in Slovenia are removed by hunting, which has prescribed structure that favors removal of smaller and therefore younger animals. Among sexually mature bears, the ban on hunting of females with cubs favors removal of males. It is therefore not unexpected that removal of bears in Slovenia is considerably male-biased. Because of this and because of equal sex ratio among cubs, we would expect a considerable female-biased sex ratio in the living population. However, the genetic survey of bear scats in 2007 showed that the proportion of females in the wild was 55%. Such a sex ratio is less biased than expected according to removal data and may be explained by immigration of dispersing males from Croatia, where legal harvest rates were considerably lower than in Slovenia and have different demographic structure, focused on mature males. This indicates that different harvesting regimes in different parts of the same population may buffer the demographic effects of selective hunting.

The proportion of females among removed bears increased with annual removal. Changes in sex ratio may have important consequences for population dynamics and it was shown that population trends among ursids are most sensitive to female survival rate. However, effects of male-biased removal should also be considered, including increased risk of infanticide, lower female reproduction due to avoidance of food-rich habitats occupied by infanticidal males, and decreased natality rate due to lower age of males caused by harvest.

Conflict bears killed in management removals were younger than bears removed by hunting, even though management removals were not subject to limitations favoring removal of young bears. This indicates that subadult bears came into conflict with humans more frequently than older bears. We attribute the lower age of bears that died in traffic accidents to increased vulnerability due to inexperience. We note, however, that differences in bear ages were relatively small and therefore the explanatory power of our models was low. Nevertheless, the biological importance of these results is still high, because even small changes in demographic structure of removed bears could cause strong effects in population dynamics and sex structure because differences accumulate over time.

About 80% of bears removed in Slovenia were removed when <4 years old. Such removal rate is high compared to other brown bear populations. For females, survival increases considerably after their first litter (typically at 3 or 4 years) and for males when their body mass exceeds 150 kg (on average after 6 years). However, the overall proportion of older bears among removals in Slovenia was small. This is probably a consequence of the high harvest rates of this group in Croatia, where unlike Slovenia, there are no body mass limitations for hunting and sport-trophy hunting (i.e., hunting with more pronounced economic benefits where the main goal is to obtain or sell the trophy) is more prevalent. Adult males in Slovenia have large home ranges and many extend into Croatia (e.g., 9 of 19 males radiocollared in Slovenia had transboundary home ranges), where probably many are removed.

One of the major evolutionary hunting-induced changes, which may be expected in Slovenia, is selection for females with lower age of primiparity. Females that have cubs earlier will on average produce more offspring (and have higher fitness) and should thus be positively selected. Because of high harvest rates among young age classes and complete protection of females from hunting once they have cubs, the impacts of harvest on age of primiparity should be high in Slovenia. This is indicated also by high proportion of females living in Slovenia or originating from this population that have cubs at age 3 or 4 year, whereas in other populations age of primiparity is considerably higher. However, additional research would be needed to rule out other effects (i.e., habitat factors).



Contrasting harvest strategies in a shared population: challenges for transboundary management of the northern Dinaric bear population.

Slaven Reljić, Klemen Jerina, Đuro Huber, John D.C. Linnell, Erlend B. Nilsen, Marko Jonozovič, Josip Kusak

Background

Brown bear habitat in Slovenia and Croatia is within the Alps-Dinara Mountain Range (Figure 1.) which extends southeast across Bosnia and Herzegovina all the way to the Pindos Mountain in Greece. Consequently, Slovenia and Croatia share the same brown bear population, although these countries have two different management regimes. The species is formally strictly protected with harvest regulated through “derogations” from Habitat Directive in Slovenia as a part of European Union (EU) while in Croatia it is still managed as a game species. Currently Croatia closed the negotiations in the accession process to the EU with the projected joining in July 2013 what will change conservation status of brown bear from game to strictly protected species.

Fig. 1. Location of Slovenia and Croatia in Europe and the range of brown bear populations

Research Questions

History of the bear population and development of the management systems in Croatia and Slovenia spread from shared past to divergent present. Based on existing data which is common to both countries the objectives of the study was to:

- describe and quantify the different mangement sytems in two countries sharing a common population,
- to contrast and explore the consequences of these different systems on demographic characteristics, population development and long term sustainability,
- to discuss the challenges of managing shared populations in a transboundary context and to make step forward to population level management.

Methods and Key findings

Bear mortality data (2005-2010; n=614, n=535), census data (2004-2011) and data about planned and realised quota from 1994 till present for Slovenia and Croatia, respectively, have been used.

Numbers of harvested animals from 1994 until present reflect the fact that the population has increased.

The largest proportion in the total reported mortality was legally hunted animals, 68% in Croatia and 64% in Slovenia. Test for equality of proportions indicated the proportion of intervention removals in Slovenia (16,6%) was significantly higher than in Croatia (5,2%; χ-sq.= 35.8, df=1, $p<0.0001$). The proportion of males hunted within the given quota was significantly (χ-sq.= 29.63, df = 1, $p<0.0001$) larger in Croatia

(77%) than in Slovenia (58%). The analysis of deviance for count data indicated the difference between average age of bears killed in quota in Croatia (5.2±0.17 years; 1 s.e., n=364) and Slovenia (3.1±0.14 years; 1 s.e., n=386) was significant. Survival analysis run in "R2.14.0" showed survivorship until the end of the 4th year of life was 0,23 in Slovenia and 0,49 in Croatia. Survival rate for cubs of the year derived from census data was 0,87 in Croatia and 0,88 in Slovenia. These results were obtained with assumption of two closed populations although we are aware bears belong to a single population with a lot of cross border movements. ArcGis spatial analyses showed that 75% and 50% of females and 99% and 55% of males in Slovenia and Croatia, respectively, were killed in a distance of average diameter of home range from the state border (Figure 2.)

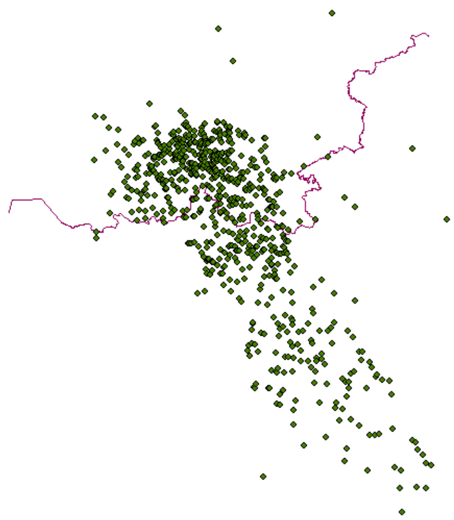


Figure 2. Spatial placement of the locations of brown bear mortality in Croatia and Slovenia from 2005 till 2010 in relation to state border

Lessons learnt for best practice

With respect to population trend study evaluates relative impact of different harvest regimes on population growth rate and on sex composition. Slovenian system has greater impact on lambda while Croatian system has greater impact on sex composition.

ArcGis spatial analyses based on locations of bear mortalities and sizes of home ranges of males and females and regular migration of animals across the border given by telemetry data support theory of one common and close population.

Conclusions reflect need to question existing monitoring systems to detect changes in both number and composition as a foundation to react. We see this approach as a step towards safer decision-making on the bear harvest in Slovenia and Croatia. Transboundary management system in future should be unified or coordinated enough.

Monitoring the effective population size of a brown bear (*Ursus arctos*) population using new single-sample approaches

Tomaž Skrbinšek, Maja Jelenčič, Lisette Waits, Ivan Kos, Klemen Jerina, Peter Trontelj

Background

Effective population size (N_e) is arguably one of the most important parameters both in conservation and evolutionary biology. Not to be mistaken with census population size, the number of individuals in the population, it is defined as the size of an idealized Wright-Fisher population that would lose genetic diversity or become inbred at the same rate as the actual population. It describes the rate of random genetic processes, and can be understood as a direct measure of evolutionary potential and vulnerability of populations to genetic stochasticity. As such it can be used as a basis for a predictive framework for the fate of small populations, and can be used for early detection of both population fragmentation and population decline. Monitoring N_e, if feasible, would provide an excellent tool for monitoring the status of populations of conservation concern.Unfortunately, despite its conceptual simplicity, the effective population size is notoriously difficult to measure in natural populations. While there have been a number of studies dealing with estimations of effective population size of different species, the estimates of changes of N_e through time are rare.

Research Questions

The goal of our study was to trace temporal change in N_e in a monitoring framework for the brown bear (*Ursus arctos*) population in the Northern Dinaric Region of the Western Balkans.

The bears in Northern Dinarides belong to one of the few remaining natural populations in Europe.The entire population spans over 11 countries (including the edge of distribution in Italy and sporadic occurrences in Southern Austria) from the Alps in the north to Rodopi Mountains in the south, and is estimated at 2800 individuals. Although the population is considered stable over most of its range, objective data at the population level is scarce, and not much is known about its long-term viability. In its northern part, a substantial number of bears are harvested yearly, which can affect the population dynamics both directly and through changes in sex and age structure. Coordinated population-level management is critical for long-term survival and coexistence of these bears with humans (Huber et al. 2009; Linnell et al. 2008), but currently the population is spread across many countries with little common vision or cooperation. An important first step towards coordinated, transboundary management would be monitoring of a key population parameter like effective population size.

Methods

We genotyped tissue samples from brown bear mortalities between 2003 and 2008 (n=510) in the northernmost part of the population range, in Slovenia, using 22 microsatellite loci, and determined the age of the animals by tooth cross-section. To trace the temporal change in the effective size of this population, we used the unbiased linkage disequilibrium (LDNe) estimator, as well as three recently developed methods: a method utilizing Approximate Bayesian Computation (ONeSAMP, the Sibship Assignment (SA) method and the Estimator by Parentage Assignments (EPA). While the first three methods measure the effective number of breeders (N_b), the last one measures the effective population size (N_e) directly. It also provides an estimate of the generation time, which we used to extrapolate the N_e from the results provided by the N_b methods.

We applied these methods to this large empirical dataset, obtained plausible estimates of N_e and its change through time, and provided a starting point for genetic monitoring of the bears in Northern Dinarides.

Key findings

All methods used for estimating N_b provided comparable results, although the confidence intervals differed. When we consider the time periods the estimates apply to and that the EPA-estimated N_e should correspond to the harmonic mean of N_e within the generation interval that covers several cohorts, the results obtained by the single cohort methods correspond closely with the EPA estimates (Figure A). The EPA estimates apply to much longer time periods than the estimates obtained by the N_b methods (6.7-8.5 years vs. 3 years), and have consequently a higher degree of smoothing. They show an increasing trend in N_e (Figure A), and are in the beginning lower than the estimates obtained by the N_b methods, but start converging with them from 2004. This indicates a rapid increase in effective population size in 1990s and early 2000s. Overview of the estimates and the time periods they apply to is shown in Figure B.

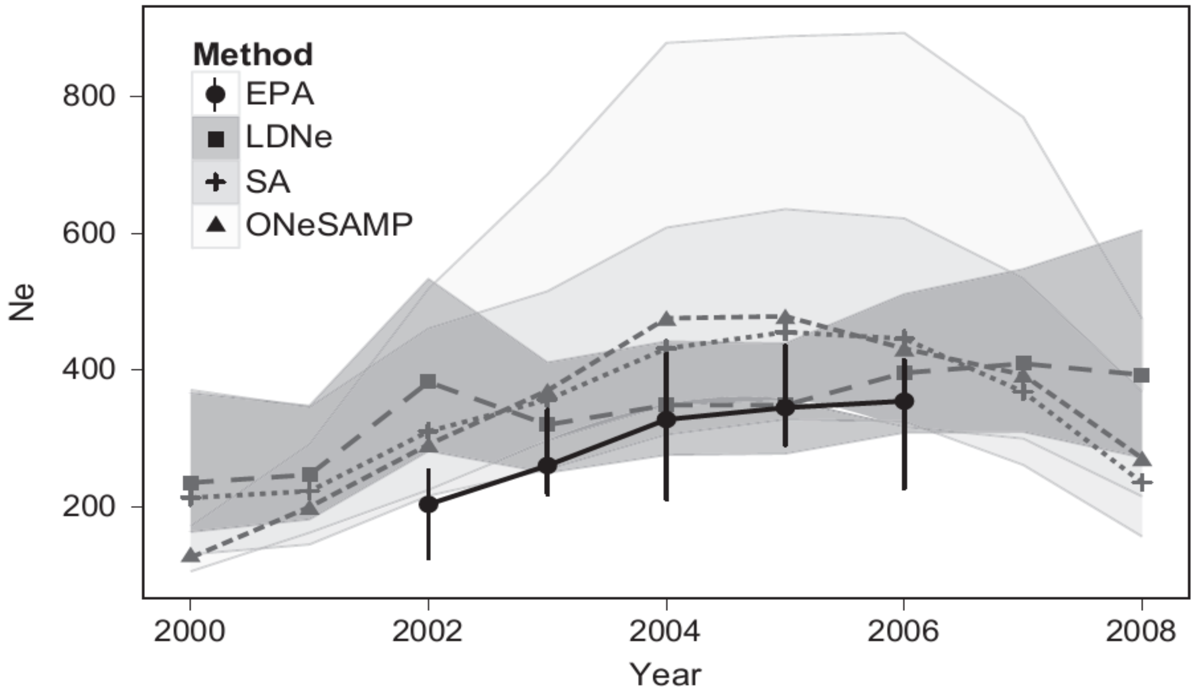


Figure A: Comparison of N_e estimates. The polygons (or handles in case of the EPA) show the confidence intervals. The estimates obtained by the ONeSAMP, LDNe and SA methods were multiplied by the average generation interval obtained by the EPA (7.57 years, 6.68 - 8.51 years averaged 95% CI) divided by the cohort period (3 years). The uncertainty of the generation interval estimate was included in graphing of the confidence interval for these methods. LDNe = Linkage disequilibrium, ONeSAMP = Approximate Bayesian Computation, SA = Sibship Assignments, EPA = Estimate by Parentage Assignments.

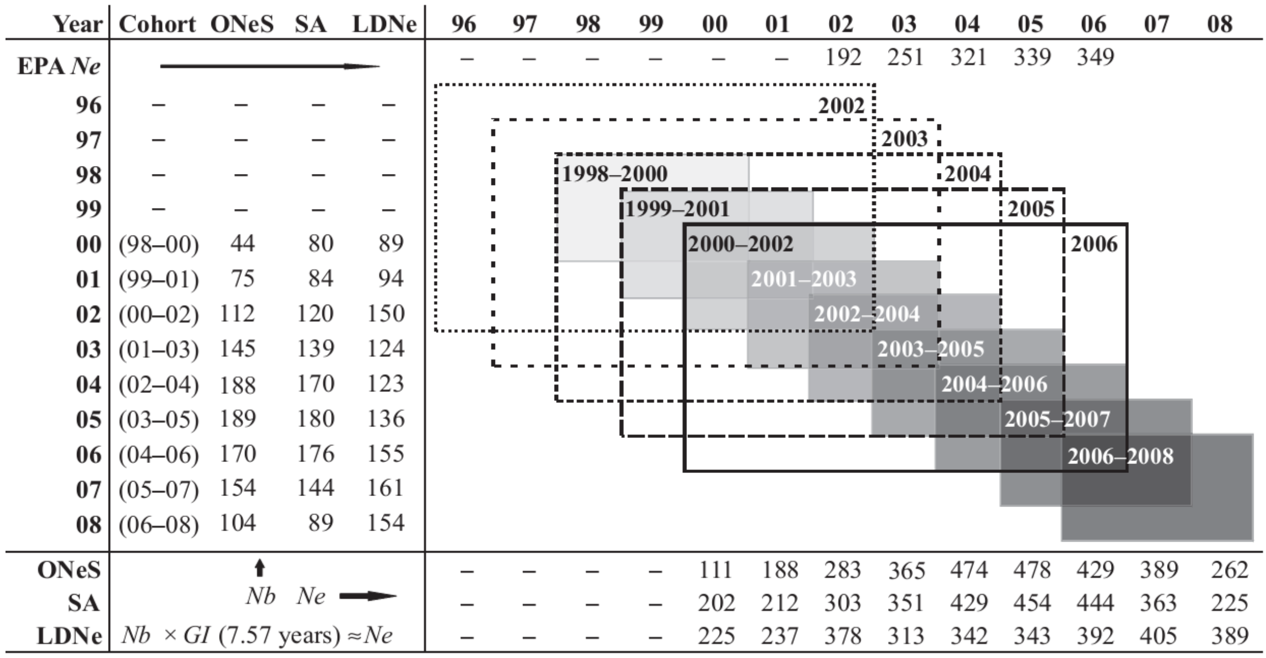


Figure B: N_e and N_b estimates and corresponding time periods. The filled rectangles show the time period for the single-cohort methods (ONeSAMP, SA, LDNe), and the empty rectangles show the time periods covered by the EPA estimates. In the corner of each rectangle is the year of the sample. The estimates of N_b obtained by ONeSAMP, SA and LDNe methods were multiplied by the average generation interval (*GI*) divided by the cohort interval (3 years) to obtain the estimates of N_e comparable with the EPA estimates. However, because of the overlapping generations this N_b -derived estimates should act as an upper limit of N_e, and are thus expected to be higher than the EPA estimates. LDNe = Linkage disequilibrium, ONeS = ONeSAMP, Approximate Bayesian Computation, SA = Sibship Assignments, EPA = Estimate by Parentage Assignments.

Lessons learnt for best practice

Our results show an interesting temporal pattern of a rapid growth of the effective population size. This could be a result of growth of the census size that was probably happening during this period. The results also show that the population of brown bears in Northern Dinarics is relatively large. The harmonic mean EPA-estimated N_e of 276 (183-350 95% CI) does meet the inbreeding-avoidance criterion of $N_e > 50$, but is short of the long-term minimum viable population goal of $N_e > 500$.

Monitoring of change in contemporary effective population size through time is a tempting idea that could, if feasible, provide a very powerful tool for management of populations of conservation concern. Our study shows that it can be done, even with the complications posed by generation overlap, and that it is at least for some species possible to include monitoring of N_e in routine population monitoring with minimal additional resources. While our study focuses on bears, it points out interesting possibilities that the recently developed methods offer for monitoring of N_e in other species that require active conservation effort. These methods also for the first time provide efficient means for including N_e in population monitoring frameworks for species with overlapping generations, and we expect them to be of great importance for management and conservation in the future.

Using a reference population yardstick to calibrate and compare genetic diversity reported in different studies: an example from the brown bear

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Background

Loss of biodiversity is one of the critical challenges faced both by our planet and our species, as many plants and animals have been eradicated from human-dominated landscapes or remain in small populations that face a serious threat of extinction. Conservation of these remaining populations may, in the long run, critically depend on genetic factors. Genetic diversity indicates a population's fitness and evolutionary potential, and consequently its adaptive potential and resilience to environmental change, which makes it a critical issue for conservation. Comparing genetic data between different populations along the range of a species would be useful for understanding and evaluating their genetic health and assessing the risk of inbreeding depression. However, genetic diversity of different populations is often evaluated using different methods and markers, making such comparisons difficult.

Research Questions

We propose a simple approach for calibrating genetic diversity of different populations, reported by different studies, to the same scale relative to a reference population. By using this one well-studied population as a 'yardstick', we can perform large-scale comparisons of genetic diversity across a species range using the existing data. We demonstrate the utility of this concept using the brown bear (*Ursus arctos*), a widely distributed carnivore species that has been extensively studied using genetic methods. In this study, we (1) introduce the reference population approach for calibrating and comparing genetic diversity reported by different studies of different populations, (2) survey the baseline genetic diversity data of the bears in Northern Dinaric Mountains and (3) use the reference population approach with the bears in Northern Dinaric Mountains as a reference population to calibrate and compare genetic diversity reported by different studies of bear populations across the range of the species.

Methods

As a reference population, we genotyped 513 brown bears from Slovenia using 20 polymorphic microsatellite loci. We randomly selected 10% of samples and repeated the genotyping to estimate error rates. We used the methods recommended by Broquet and Petit (2004) to estimate the frequency of allelic dropouts and Q4 false alleles, and program Micro-Checker to check the data for the presence of null alleles, and scoring errors due to stuttering and dropout of large alleles. We used R statistical environment (R Development Core Team, 2011) and 'adegenet' package for data handling and calculation of genetic diversity indices—observed heterozygosity (Ho), expected heterozygosity (He) and allelic diversity (A). Probability of identity (PI) and probability of identity of siblings (PIsib) were calculated. We used the procedure with 1 000 000 steps in Markov chain and 10 000 dememorization steps to detect per-locus significant departures from Hardy–Weinberg equilibrium using the program Arlequin. Holm–Bonferronni multiple test correction with a Ľ0.05 threshold was used to correct for multiple testing.

We used this data set to calibrate and compare heterozygosity and allelic richness for 30 brown bear populations from 10 different studies across the global distribution of the species. The marker set we used for the reference population included the majority or all markers used in any other study, allowing for a large panel of loci for most comparisons. As our data set also included several times the number of samples analyzed in any other study, we always used it as the larger data set for resampling. We made 1000 random subsamples for each comparison. Finally, we calculated the Her and Art indices, and used these to compare genetic diversity of bear populations across the species range. The R code required to run comparisons between populations using the reference population approach (in the form of an R package with user manual and a user-friendly vignette), as well as the genetic data from the Dinaric bear population used for this study, is accessible in the Dryad repository (doi:10.5061/dryad.qt3j5).

Key findings

We compared genetic diversity of a large number of brown bear populations along the global distribution of the species and found considerable differences between populations (see Table). On one extreme, the most diverse is the Carpathian population in Romania, followed by large populations in Canada and Alaska. At the other extreme, the lowest levels of diversity are observed for island populations and very small populations of high conservation concern (Gobi Desert, Cantabrian Mountains—Spain, Kodiak Island—Alaska). This provides us with an understanding where on this gradient lies the genetic diversity of each of the included populations and enables speculations on its conservation status from the genetic perspective.

Table: Comparison genetic diversity between bear populations using bears in NW Dinaric Mountains (Slovenia, population Rodopi-Dinara-Alps NW) as a reference to correct for different panels of loci and sample sizes. N = number of samples, *A* −allelic richness, H_e −expected heterozygosity, *SE = standard error,* H_{er} = heterozygosity ratio and A_{rt} − allelic richness ratio between the compared population / resampling-corrected, marker-set specific values for bears in NW Dinaric Mountains. "Reference pop. (resampled)" column shows the multiple subsampling corrected values from the reference population used for calculating H_{er} and A_{rt} ratios. The studies referenced in the "Study" column are detailed in the Appendix 2 of the published paper.

			Compared population		Reference pop. (resampled)		Ratio	
Population	**N**	**Study**	**A (SE)**	**H_e (SE)**	**A (SE)**	**H_e (SE)**	**A_{rt} (SE)**	**H_{er} (SE)**
Carpathians - Romania (1)	16	5	7.78 (0.81)	0.81 (0.010)	5.15 (0.56)	0.70 (0.030)	1.51(0.23)	1.16(0.05)
Carpathians - Romania (2)	109	10	8.46 (0.57)	0.80 (0.014)	6.33 (0.54)	0.73 (0.023)	1.34(0.15)	1.09(0.04)
Alaska Range, Alaska	28	1	-----	0.78 (------)	5.84 (0.68)	0.72 (0.026)	-----	1.08(-----)
Kluane, Yukon	50	1,2	7.38 (0.56)	0.76 (0.025)	6.12 (0.70)	0.73 (0.026)	1.21(0.17)	1.04(0.05)
Richardson Mountains, NWT	119	2	7.50 (0.63)	0.76 (0.030)	6.48 (0.72)	0.73 (0.025)	1.16(0.16)	1.03(0.05)
Brooks Range, Alaska	148	2	7.63 (0.50)	0.75 (0.019)	6.56 (0.72)	0.74 (0.025)	1.16(0.15)	1.02(0.04)
Croatia (Rodopi-Dinara-Alps NW)	156	9	7.58 (0.54)	0.74 (0.028)	6.48 (0.60)	0.73 (0.025)	1.17(0.14)	1.01(0.05)

Slovenia (Rodopi-Dinara-Alps NW)	513	REF[1]	6.68 (0.41)	0.73 (0.020)	-----	-----	1.00(0.06)	1.00(0.03)
Greece(Rodopi-Dinara-Alps SE)	49	8	6.33 (0.42)	0.76 (0.020)	6.55 (0.52)	0.77 (0.023)	0.97(0.10)	0.99(0.04)
Carphatians - Northern Slovakia	71	10	6.08 (0.29)	0.71 (0.025)	6.20 (0.54)	0.73 (0.023)	0.98(0.10)	0.97(0.05)
Scandinavia - NN	29	3	5.59 (0.40)	0.68 (0.024)	5.59 (0.42)	0.72 (0.020)	1.00(0.10)	0.96(0.04)
Flathead River, BC/MT	40	2	6.50 (0.71)	0.69 (0.027)	6.01 (0.69)	0.73 (0.026)	1.08(0.17)	0.95(0.05)
Carpathians - Central Slovakia	96	10	6.00 (0.25)	0.70 (0.031)	6.30 (0.54)	0.73 (0.023)	0.95(0.09)	0.95(0.05)
Scandinavia - NS	108	3	6.18 (0.35)	0.69 (0.027)	6.10 (0.44)	0.73 (0.019)	1.01(0.09)	0.95(0.04)
West Slope, Alberta	41	2	6.38 (0.56)	0.68 (0.036)	6.03 (0.69)	0.73 (0.026)	1.06(0.15)	0.93(0.06)
Kuskoskwim Range, Alaska	55	1,2	6.13 (0.44)	0.68 (0.026)	6.15 (0.71)	0.73 (0.025)	1.00(0.14)	0.93(0.05)
Scandinavia - M	88	3	5.94 (0.40)	0.68 (0.022)	6.02 (0.44)	0.73 (0.019)	0.99(0.10)	0.93(0.04)
Scandinavia - S	155	3	5.47 (0.33)	0.68 (0.020)	6.20 (0.44)	0.73 (0.019)	0.88(0.08)	0.93(0.04)
East Slope, Alberta	45	2	7.00 (0.82)	0.67 (0.062)	6.07 (0.70)	0.73 (0.026)	1.15(0.19)	0.92(0.09)
Carpathians - Eastern Slovakia	16	10	5.23 (0.22)	0.65 (0.028)	5.47 (0.49)	0.72 (0.025)	0.96(0.09)	0.91(0.05)
Paulatuk Alaska	58	2	5.75 (0.88)	0.65 (0.650)	6.18 (0.71)	0.73 (0.026)	0.93(0.18)	0.89(0.89)
Admiralty Island, Alaska	30	1	------	0.63 (------)	5.88 (0.68)	0.73 (0.026)	-----	0.87(-----)
Coppermine, NWT	36	2	5.75 (1.03)	0.61 (0.073)	5.96 (0.69)	0.73 (0.026)	0.96(0.21)	0.84(0.10)
Pakistan	28	4	3.92 (0.38)	0.58 (0.043)	5.45 (0.53)	0.72 (0.025)	0.72(0.10)	0.81(0.07)
Yellowstone, MT/WY	57	2	4.38 (0.60)	0.55 (0.081)	6.17 (0.7)	0.73 (0.025)	0.71(0.13)	0.75(0.11)
Cantabrian (Spain) - W	39	7	3.44 (0.30)	0.48 (0.050)	5.73 (0.49)	0.71 (0.022)	0.6(0.07)	0.67(0.07)
Baranof and Chicgagof Is, Alaska	35	1	-----	0.49 (------)	5.96 (0.69)	0.73 (0.026)	-----	0.67(-----)
Apennines	17	5	2.44 (0.24)	0.44 (0.069)	5.19 (0.56)	0.70 (0.030)	0.47(0.07)	0.63(0.10)
Gobi (Mongolia)	8	6	2.00 (-----)	0.29 (------)	4.59 (0.62)	0.68 (0.038)	0.44(-----)	0.43(-----)
Cantabrian (Spain) - E	8	7	1.75 (0.17)	0.28 (0.062)	4.56 (0.38)	0.68 (0.026)	0.38(0.05)	0.41(0.09)
Kodiak Island, Alaska	34	1,2	2.13 (0.35)	0.27 (0.098)	5.94 (0.69)	0.73 (0.026)	0.36(0.07)	0.37(0.14)

Lessons learnt for best practice

The reference population approach provides a simple and easy to implement method of comparing genetic diversity between different populations of a species that were analysed in different studies using different loci, while collecting no or only minimal additional data.

Typically, there are two obstacles to comparing genetic diversity reported by different studies of the same species: different panels of genetic markers used and differences in sample sizes. The standard approach to addressing this problem is to shrink the genetic marker set to the largest common denominator of all studies, and use the smallest sample size in any population to correct for unequal sampling. This approach works only if similar sets of markers were used to study all populations or if marker sets are very large, which is often not the case. Also, by using a very small sample size to correct for unequal sampling, the power to detect differences in allelic richness is greatly reduced decreasing the power of all comparisons. The reference population approach overcomes many of these issues with a simple solution of scaling the genetic diversity of each considered population relative to the genetic diversity of a single well-studied population, effectively using this reference population as a calibration 'yardstick'. Its main advantage is the ability to compare studies that would be otherwise impossible to compare—for example, studies that have no common genetic markers—if the markers they used are also used in the study of the reference population. The problem of low power of comparison will still remain when a study with a small sample size is compared, but this would not affect the power of pairwise comparisons of other populations.

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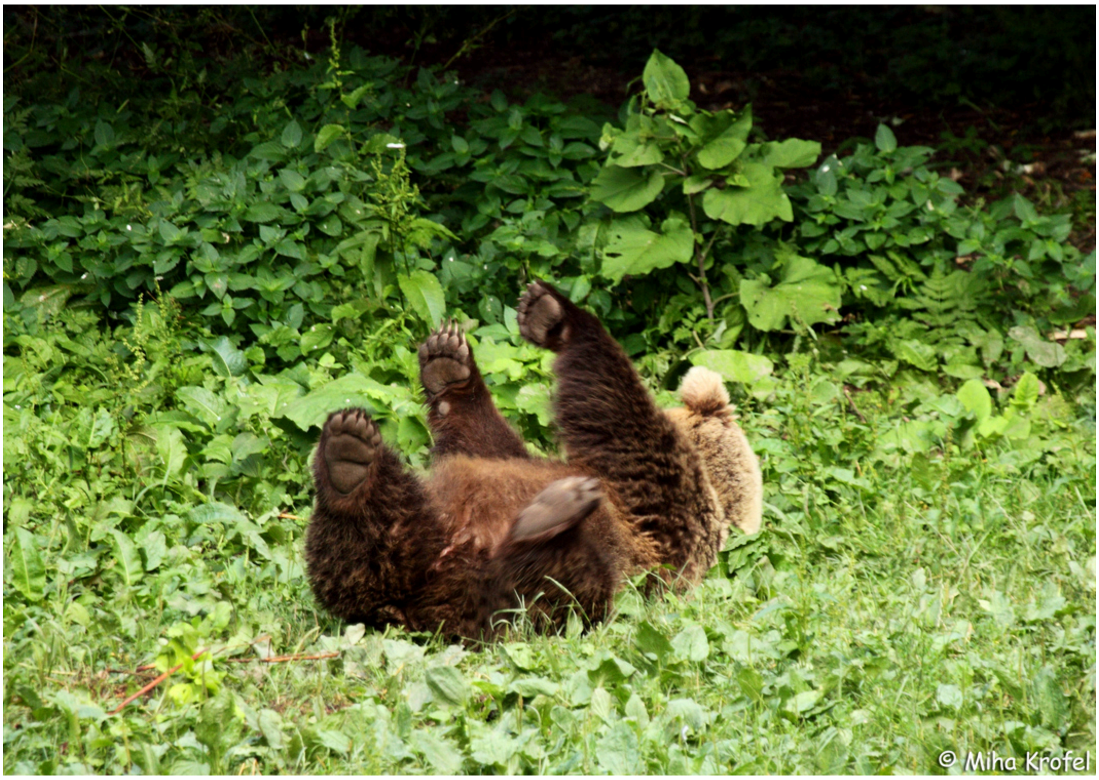
Please note that many of the research findings presented
in this summary are still undergoing analysis,
but will be peer-reviewed through submission
to open-access academic journals.



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