Final Report:
The Scandinavian Brown Bear Research Project 2012-2014

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from the Scandinavian Brown Bear Research Project
to the Swedish Environmental Protection Agency
and the Norwegian Environment Agency

www.bearproject.info

ABSTRACT

The Scandinavian Brown Bear Research Project (SBP) is a long-term, individual-based project that conducts ecological research, with a focus on research that is relevant for managers. During 2012-2014, the SBP produced 95 publications; 56 international scientific papers, 1 unrefereed scientific paper, 13 student theses (including 3 PhD-level theses), 18 reports to management agencies, and 7 popular articles. Here we provide a summary of our findings and a list of all of the papers, reports, and theses produced during 2012-2014.

We prioritized three areas; 1) bear-caused human injuries, 2) problem bears that approach settlements, and 3) sexually selected infanticide (SSI). 1) The Scandinavian brown bear poses a very low risk to humans, even though incidents do occur. In fact, bears perceive humans as a serious threat, as they respond to meetings with humans or the hunting season by becoming more nocturnal for several days, which could have fitness consequences. Bear-caused injuries have increased with the number of bears shot and the bear population size, but only for armed men. Our results should help to reduce the risk for hunters and other outdoor recreationists of being injured by a bear. 2) Although the generally accepted paradigm is that bears approach human settlements to obtain food, we found that, in Sweden, habituation and food conditioning are proximate responses, as a result of vulnerable bears (subadults and females with young) avoiding dominant males, which is the ultimate mechanism. Bears seeking refuge near settlements should not be viewed as 'unnatural', but rather as an example of an adaptive behavior to avoid dominant conspecifics, which use habitats farther from people, and management should reflect this. 3) Females with cubs select habitats very differently than other bears (especially adult males) during the mating season, most probably in response to the risk of SSI. This has a nutritive cost during the mating season, which probably adds to the females' cost of reproduction. We documented that females come into estrus only 1-2 days after little loss, which is a requirement for SSI. Also hunting has negative indirect effects on the population through an increase in SSI, which explains 13.6% of the variation in population growth.

We found that bears in parts of our southern study area are at a density that affects body growth and condition, but we have not yet documented that density has affected survival, beyond cub survival, or reproductive rates. Individual predation rates on calf moose by bears in Sweden were similar even when moose-bear ratios differed greatly were and similar to those in North America. However, predation on adult moose was higher in Norrbotten than in Dalarna and generally lower than in North America. Because moose concentrate on calves, they have a relatively small effect on moose populations, but managers must change their harvest strategies in areas with both bears and wolves. We have developed a method to estimate the number of annual reproductions in Norway and have estimated the bear population in Sweden in 2013 and Värmland, Dalarna, and Gävleborgs län. We found that sport harvest has an important influence on not only population dynamics, but also the life history of Scandinavian brown bears and that baiting is not an efficient method to hunt bears if the goal is to shoot them at the bait site. Our genetics results documented little east-west gene flow between Russia and Scandinavia and we found no support for mate choice in shaping MHC polymorphism in the brown bear. Our research on the effects of capture on bears has allowed us to continue to improve our methods. Finally, our cooperation with several medical researchers has provided many important results that may be important for answering questions about human diseases in the future.

THE SCANDINAVIAN BROWN BEAR PROJECT
RESEARCH REPORT: 2012-2014

GENERAL PURPOSE AND GOALS

The overall purpose of the Scandinavian Brown Bear Research Project (SBP) is to conduct research that will provide managers in Sweden and Norway with solid scientifically based knowledge to meet the present and future challenges presented by the increasing and expanding population of brown bears; which is both an important hunted species and a source of conflict. To do this, we obtained funding during 2012-2014 to continue gathering and analyzing long-term individually-based data on bears with a goal of following females from birth to death. This method leads to most new insights in ecology, evolutionary biology, management, and conservation (Clutton-Brock & Sheldon 2010, Festa-Bianchet & Appolonio 2003). For clarity, one can view the SBP as working in 4 ways concurrently: 1) research on population dynamics, life-history strategies, and general ecology using the 30-year dataset of individually marked bears (the base project) and additionally, providing infrastructure and marked bears for 2) management-relevant research (e.g. baiting, bears reactions to humans), 3) activities important for management, such as training and testing tracking dogs, and 4) associated research projects, such as human biology. During 2012-2014, we obtained funding to cover infrastructure costs for the base project (wages, field station, capture and following the bears, equipment, travel, data collection and storage, Master students, etc.) and some funding for associated projects. The base project with its personnel has been absolutely essential for the associated research projects and management activities.

Our research during this period focused on the three probably most relevant subjects for bear management in the coming years; 1) consequences of the increasing bear population for both humans and bears, 2) how to harvest the population to reach management goals, and 3) ethical questions regarding research on bears. Many of the associated projects and activities also support management actions. The prioritized subjects fit within the program "Forskning för hållbar förvaltning av vilt", particularly “De stora rovdjuren, bytesdjuren och samhället”, but also included aspects of two other prioritized areas, “Biologiska effekter av jakt och viltförvaltning” and “Landskap i förändring—effekter på och av vilt i ett systemanalystiskt perspektiv”. Our research also included research goals recommended by the Swedish Environmental Protection Agency (SEPA) in their “Åtgärdsprogram för bevarande av björn”. Previous knowledge gained by the SBP has been important for the present policy, monitoring, and management regarding bears in Sweden and Norway. Our research also aimed to meet the need for further long-term research to guide management that has been stressed in recent white papers in both countries.

During 2012-2014, the SBP produced 95 publications; 56 international scientific papers, 1 unrefereed scientific paper, 13 student theses (including 3 PhD-level theses), 18 reports to management agencies, and 7 popular articles. Since 1984, the SBP has produced 509 publications; 180 international scientific papers, 12 books/book chapters, 22 proceedings papers, 98 student theses (including 18 PhD-level theses), 117 reports to management agencies, and 80 popular articles. Thus, it is the world’s most productive carnivore research project, measured in scientific articles or PhD theses. One reason for the high productivity is that the project has systematically collected individually based data for 30 years. This type of

research leads to most new insights in ecology, evolutionary biology, management, and conservation (Clutton-Brock & Sheldon 2010, Festa-Bianchet & Apollonio 2003). This does not explain all of the project's productivity, however, because the SBP has published over 7 times more scientific papers than the average of 51 long-term, individual-based field studies of birds and mammals in the UK that had been active for 30 years (Fig. 1).

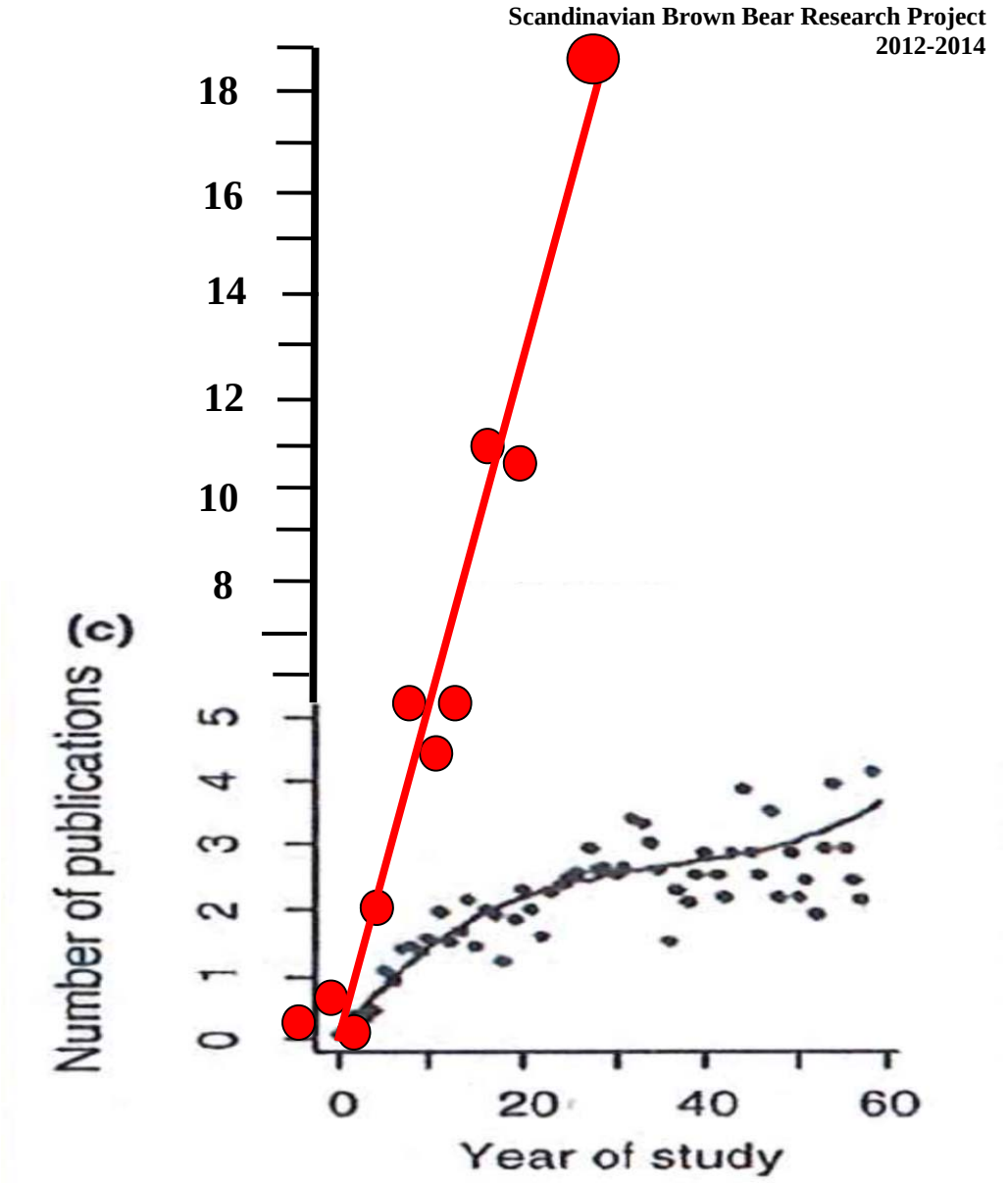

Figure 1. Number of scientific publications per year of study for 51 long-term, individual-based field studies of birds and mammals in the United Kingdom (figure from Clutton-Brock & Sheldon 2010) and those of the Scandinavian Brown Bear Research Project, annual averages for three-year periods (red circles) The large red circle covers the report period (the SBP's years 28-30 of study). The smaller circles show earlier 3-year averages of annual publications.

Below, we provide a short summary of our findings from 2012-2014. The headings are from the proposed areas of research, as described in our application. The resulting publications on the subject from the report period are listed under the appropriate headings below. Please refer to the scientific papers, reports, and theses for a more detailed description of our results and methods. Other citations are given at the end of the report. All publications are available on the SBP's website: www.bearproject.info.

RESULTS, CONCLUSIONS AND RECOMMENDATIONS

Consequences of the increasing bear population for both humans and bears

The effects of human presence on bears:

Aim: determine how bears deal with the presence of people in the landscape. Conflicts between large carnivores and humans can affect attitudes negatively and increase fear among the public. Because encounters between brown bears and humans are becoming more common in Scandinavia, the aim of this subproject was to evaluate bear-human encounters to determine risk factors for humans and how bear-human encounters affect bears. We spent a considerable amount of research effort on this question, including Veronica Sahlén's PhD research and an associated project led by Ole-Gunnar Støen. Six scientific papers were published during the report period, and more are underway.

Our results show that the Scandinavian brown bear poses a very low risk to humans, even though incidents do occur (31 persons injured and 2 killed during 1977-2012; all men). Both single bears and females with cubs respond to approaching humans by leaving and the majority of encounters go unnoticed by humans. However, females with cubs use more open habitats than singles, which may expose them to encounters with recreational forest users. This could explain why presence of cubs is the primary factor involved when unarmed people are injured. The bears' responses to approaching humans indicate that bears perceive humans as a serious threat, as they respond to meetings with humans by becoming more nocturnal for several days, which could have fitness consequences.

Incidents resulting in injuries have increased with the number of bears shot and the bear population size. However, this relationship was only significant for armed men. Most of the injured armed men were hunting when injuries occurred, and the presence of dogs and dens were the most common aggravating factors, often coinciding with the bear den entry period. The risk of injury thus appears to be primarily linked with which type of activity people are engaging in, especially hunting with dogs.

Bears significantly reduced their activity prior to den entry, whether or not they had arrived at their dens, which could affect fight-or-flight responses in encounters with hunters and hunting dogs. We documented high den abandonments during October/November, five times higher than during winter, possibly attributable to hunter activity at this time. The lower abandonment rate during winter is probably due to increased costs of leaving the den, which can be considerable.

We found that brown bears in Scandinavia are exceedingly wary of humans. They use very dense vegetation for daybeds, probably to avoid areas that people usually use for outdoor recreation, at least people who are not hunting. None of the bears we approached in their daybeds showed aggressive behavior. After these approaches, the bears changed their diurnal behavior for about 2 days, becoming more nocturnal. They also became more

nocturnal when the bear hunting season started, except for females with cubs, which probably had to forage during the day, because of high energy requirements. This does not expose them to a higher hunting pressure, because family groups are protect. We also found that bears were more nocturnal in areas with higher road density, which is an index of human environmental encroachment.

We conclude that Scandinavian brown bears avoid confrontations with humans and are generally not aggressive. Our results can be used by managers to help prevent injuries by developing recommendations for recreational users and hunters on how to best avoid risky situations, and evaluate potential impacts of human activity on the bear population. It can also be used in information campaigns to address public fear and lack of acceptance of the brown bear.

Scientific publications

Moen, G. K., O.-G. Støen, V. Sahlén, and J. E. Swenson. 2012. Behaviour of solitary adult Scandinavian brown bears (*Ursus arctos*) when approached by humans on foot. **PLoS ONE** 7(2): e31699.

Ordiz, A., O.-G. Støen, S. Sæbø, J. Kindberg, M. Delibes, and J. E. Swenson. 2012. Do bears know they are being hunted? **Biological Conservation** 152:21–28.

Ordiz, A., O.-G. Støen, S. Sæbø, V. Sahlén, B. E. Pedersen, J. Kindberg, and Jon E. Swenson. 2013. Lasting behavioural responses of brown bears to experimental encounters with human. **Journal of Applied Ecology** 50:306-314.

Ordiz, A., J. Kindberg, S. Sæbø, J. E. Swenson, and O.-G. Støen. 2014. Brown bear circadian behavior reveals human environmental encroachment. **Biological Conservation** 173:1-9.

Sahlén, V., A. Friebe, S. Sæbo, J. E. Swenson, and O.-G. Støen. 2015. Den entry behavior in Scandinavian brown bears *Ursus arctos*; implications for preventing human injuries. **Journal of Wildlife Management**. In press.

Sahlén, V., A. Ordiz, J. E Swenson, and O.-G. Støen. In press. Behavioural differences between single Scandinavian brown bears (*Ursus arctos*) and females with dependent young when experimentally approached by humans. **PLoS ONE**

Popular science

Elfstöm, M. & V. Sahlén. 2014. Björn och människa—inkräktare på varandras områden. **Svensk Jakt** 2014 (8): 56-58

Ordiz, A. 2014. ¿Altera el turismo de naturaleza el comportamiento de los grandes carnívoros? Quercus 341(Julio):14-21.

Student thesis

2013 Veronica Sahlén, Norwegian University of Life Sciences, Ås. **PhD thesis**: Encounters between brown bears and humans in Scandinavia—contributing factors, bear behavior and management perspectives.

Reports

Støen, O.-G. 2012. Årsrapport fra prosjektet: Brown bear behaviour and human perceptions of human-brown bear encounters – implications for management (2009-2012). Kontraktnr: 06040039-3. 2011. Report No. 2012:1 from the **Scandinavian Brown Bear Research Project**.

Støen, O.-G. 2012. Årsrapport fra prosjektet: Brown bear behaviour and human perceptions. Kontraktnr: 12040017 2012. Report No. 2012:5 from the **Scandinavian Brown Bear Research Project**.

Støen, O.-G. 2013. Årsrapport fra prosjektet: Brown bear behaviour and human perceptions. Kontraktnr: 12040017 2013. Report No. 2013:5 from the **Scandinavian Brown Bear Research Project.**

Støen, O.-G & M. Johansson. 2014. Årsrapport fra prosjektet: Brown bear behaviour and human perceptions. Kontraktnr: 12040017 2014. Report No. 2014:4 from the **Scandinavian Brown Bear Research Project**.

The human dimension of bear-human conflicts with an expanding bear population.
Aim: document human attitudes towards bears where they live. Due to less funding than we applied for, we were forced to prioritize our efforts. We chose therefore to not address this question during the research period..

Density-dependent effects on brown bear population ecology and life-history traits.
Aim: document the extent of density-dependent effects in brown bear population dynamics.
When we started this research period, density-dependent reproduction had not been documented for bears, although it had been suggested in one study (Schwartz et al 2006). With our method to estimate the density experienced by each individually marked bear (Zedrosser et al. 2006), we have continued to use our extensive long-term data to study the relationships among life-history traits and trade-offs between them. This is the key to understanding population dynamics and evolution and it is essential for managers to know the pattern of density dependency in reproduction and mortality in bears to build accurate harvest models.

During the report period, we have published results showing that density did not affect litter size nor the survival of female brown bears. We did not find any effect of density on the number of surviving yearlings produced by females, but we did find that density was positively related to the number of litters born. This latter finding seems counterintuitive, but is probably related to sexually selected infanticide, with more infanticide occurring in areas with higher bear density. We also found that density negatively affected the body mass of yearling females and the body condition in all ages and sexes of bears. Thus, we do have indication that bears in parts of our southern study area are at a density that affects body growth and condition, but we have not yet documented that density has affected survival, beyond cub survival, or reproductive rates.

Scientific publications

Elfström, M, A. Zedrosser, K. Jerina, O.-G. Støen, J. Kindberg, L. Budic, M. Jonozovič, and J. E. Swenson. 2014. Does despotic behavior or food search explain the occurrence of problem brown bears in Europe? **Journal of Wildlife Management** 78:881-893.

Gonzalez, O., A. Zedrosser, F. Pelletier, J. E. Swenson, and M. Festa-Bianchet. 2012. Litter reductions reveal a trade-off between offspring size and number in brown bears. **Behavioral Ecology and Sociobiology** 66:1025-1032.

Zedrosser, A., F. Pelletier, R. Bishof, M. Festa-Bianchet, and J. E. Swenson. 2013. Determinants of lifetime reproduction in female brown bears: early body mass, longevity, and hunting regulations. **Ecology** 94:231-240.

Student thesis

2011 Ofelia Gonzalez. The determinants and effects of litter size and cub sex ratio in brown bears. **Master thesis** at the Universitè de Sherbrooke, Sherbrooke, Quebec, Canada.

The problem of nuisance bears—seeking food or avoiding adult bears?

We have known relatively little about the biological mechanisms behind why bears approach humans. Bears near settlements are considered to be a problem, because they may damage property and because people are afraid of them. We have made a major effort during the project period to address this question and it was the subject of Marcus Elfström's PhD project.

The most accepted explanation throughout the world for why some bears occur near settlements is that they associate people with easily accessible foods (i.e. food conditioning). However, we found that the composition and quality of bears' diet in Sweden was similar close to settlements compared to the same bears when in remote areas. Also, there was no correlation between the occurrence of problem bears and food conditions in either southern or northern Europe, and body condition was similar for problem and nonproblem bears. These results give little support to either food search or food shortage as explanations for the occurrence of problem brown bears near settlements in Europe.

We found further that problem bears are younger than nonproblem bears, and that bears are generally younger in areas with higher human density in both southern and northern Europe. Females with young had a diet containing less protein and they showed a lower use of slaughter remains than other brown bear categories in southcentral Sweden, supporting the hypothesis that the distribution of predation-vulnerable bears is affected to some degree by a despotic behavior of dominant bears. However, subadult bears showed no dietary difference from adult males, suggesting no effects from interference competition.

A literature review of brown bears, and American and Asiatic black bears revealed that subadults and females with cubs are overrepresented in areas near settlements in North America, Europe and Japan. This pattern likely occurs because bears are distributed despotically due to interference competition and/or avoidance of aggression or predation, and settlements may function as refuges for predation-vulnerable bears against dominant conspecifics. Thus, we suggested that habituation and food conditioning are proximate responses, as a result of bears' despotic distribution, which is the ultimate mechanism.

The proper management of attractants to bears is important, but failure to consider interactions among bears may lead to only treating the symptoms of habituation or conditioning. Bears seeking refuge near settlements should not be viewed as 'unnatural', but rather as an example of an adaptive behavior to avoid dominant conspecifics, which use habitats farther from people.

Scientific publications

Elfström, M., O.-G. Støen, A. Zedrosser, I. Warrington, and J. E. Swenson. 2013. Gut retention time in captive Scandinavian brown bears *Ursus arctos.* **Wildlife Biology** 19:317-324.

Elfström, M., A. Zedrosser, O.-G. Støen, and J. E. Swenson. 2014. Ultimate and proximate causes behind the occurrence of bears close to settlements and its management consequences: a review. **Mammal Review** 44:5-18.

Elfström, M, A. Zedrosser, K. Jerina, O.-G. Støen, J. Kindberg, L. Budic, M. Jonozovič, and J. E. Swenson. 2014. Does despotic behavior or food search explain the occurrence of problem brown bears in Europe? **Journal of Wildlife Management** 78:881-893.

Elfström, M., M. L. Davey, A. Zedrosser, M. Müller, M. De Barba, O.-G. Støen, C. Miquel, P. Taberlet, K. Hackländer, and J. E. Swenson. 2014. Do Scandinavian brown bears approach settlements to obtain high-quality food? **Biological Conservation 1**78:128–135.

Steyaert S.M.J.G., C. Reusch, S. Brunberg, J. E. Swenson, K. Hackländer, and A. Zedrosser. 2013. Infanticide as a male reproductive strategy has a nutritive risk effect in brown bears. **Biology Letters** 20130624.

Steyaert. M. J. G., F. J. Hütter, M. Elfström, A. Zedrosser, K. Hackländer, M. H. Lê, W. M. Windisch, J. E. Swenson, and T. Isaksson. 2012. Faecal spectroscopy: a practical tool to assess diet quality in an opportunistic omnivore. **Wildlife Biology** 18:431-438.

Steyaert, S.M.J.G., J. Kindberg, J.E. Swenson, and A. Zedrosser. 2013. Male reproductive strategy explains spatiotemporal segregation in brown bears. **Journal of Animal Ecology** 82:836-845.

Popular science

Elfstöm, M. & V. Sahlén. 2014. Björn och människa—inkräktare på varandras områden. **Svensk Jakt** 2014 (8): 56-58

Student theses

2012 Franziska Johanna Hütter. University for Natural Resources and Applied Life Sciences, Austria, **Master thesis**. Fecal analysis suggests that female brown bears with dependent offspring avoid adult males during the mating season to prevent sexually selected infanticide.

2012 Martin Müller. University of Natural Resources and Applied Life Sciences, Vienna. **Master of Science** thesis: Does food matter? Diet quality of Scandinavian brown bears in relation to their sex, age, reproductive status, and distance to settlements.

2013 Christine Reusch. University for Natural Resources and Applied Life Sciences, Austria **Master thesis**: Habitat segregation in brown bears: testing the predation risk hypothesis with nutritional analyses.

2013 Marcus Elfström, Norwegian University of Life Sciences, Ås. **PhD thesis**: Patterns and mechanisms behind the occurrence of bears close to human settlements.

The effects of varying moose density on predation rates by multiple large carnivores

Aim: document the effects of predation on moose. In this subproject, we conducted field work to repeat our study of bear predation on moose calves with two different moose-bear ratios in our southern study area to help managers predict the results of predation with changing bear-moose ratios. We also participated in modeling studies to document the effects of multiple large carnivores on predator-prey dynamics and ungulate management.

In our field work, we developed a model to estimate individual kill rates of moose calves by adult female brown bears, based on spatiotemporal clustering of GPS relocations. We found a mean estimated individual kill rate of 7.6 $\pm$ 0.71 moose calves per calving season, which was comparable to the estimate of 6.8 from an earlier study of radiotracked moose in the same study area (Swenson et al. 2007), even though the moose-bear ratio was twice as high 31 then. This suggests that bears can kill the same number of calves despite large changes in moose density, and therefore have a larger effect on the moose population

when the moose-bear ratio is low. The estimated individual kill rates ranged from 2 to 15 calves per season, indicating a large individual variation in hunting skills and possibly effort.

Bears also killed 0.8% of the radio-collared adult female moose (i.e. ≥ 1 year old) annually, but no adult male moose (≥ 1 year old). Bear predation was the least important mortality factor we documented for adult moose. Based on tracking brown bears on snow during spring, we recorded one successful hunt for every 372 km of tracks and documented attacks only by adult bears and successful attacks only by adult males. We found that yearling moose were more prone to predation by bears than older moose, and that older (i.e. ≥ 2 years) cows were more vulnerable to predation than older bulls. In a limited study in Norrbotten, we found a total average predation rate for 22 bears of 7.3 ±1.1 moose calves and 2.3 ±0.4 adult moose, which is about the same as we found in central Sweden for calves, but more than twice as high for adult moose. Although individual predation rates in Sweden were similar to those in North America for calves, we found a lower tendency for Scandinavian brown bears to prey on moose compared to most North American studies.

The modeling studies confirmed the complex nature of predator–prey interactions in large terrestrial mammals and showed that different carnivores preying on the same prey species can exert a dramatically different demographic impact, even in the same ecological context, as a direct consequence of their predation patterns. The functional relationship of the population growth rates of both roe deer and moose to changes in predation rates from the four predators was remarkably different. Lynx had the strongest impact among the four predators, whereas predation rates by wolves, red foxes, or brown bears generated minor variations in prey population growth. The differences in predation impact were only partially related to differences in kill or predation rates, but were rather a result of different distribution of predation events among prey age classes. Therefore, the age composition of killed individuals emerged as the main underlying factor determining the overall per capita impact of predation. The low effect of bear predation on moose population growth was due to the low predation rate on adult moose.

Our other modeling study examined the effects of combined wolf and brown bear predation on moose and how management could mitigate these effects. This study proposed that one option to balance the predation loss was to accept a more female-biased sex ratio in the winter population. Hence, it may be possible to keep 50% calves in the harvest and still obtain the same total harvest if the proportion of bulls in the harvest is increased to compensate for predation. The increase of large carnivores competing with moose hunting creates conflicts and will inevitably reduce harvest yield unless hunting strategies change. However, increased moose density and redistribution of the harvest towards bulls can mitigate this conflict. We provided a web-based tool, where stakeholders can compare the long-term effects of alternative management decisions and eventually adjust their hunting strategy accordingly.

The project also participated in a study on brown bear predation on domestic reindeer in Norrbotten, which was not funded by the Swedish Environmental Protection Agency or the Norwegian Environment Agency. This study has been successful and the results should be valuable for managers in both countries.

Scientific publications

Dahle, B., K. Wallin, G. Cederlund, I.-L. Persson, L. S. Selvaag, and J. E. Swenson. 2013. Predation on adult moose *Alces alces* by European brown bears *Ursus arctos*. **Wildlife Biology** 19:165-169.

Gervasi, V., E. B. Nilsen, H. Sand, M. Panzacchi, G. R. Rauset, H. C. Pedersen, J. Kindberg, P. Wabakken, B. Zimmermann, J. Odden, O. Liberg, J. E. Swenson, and J. D. C. Linnell. 2012. Predicting the potential demographic impact of predators on their prey: a comparative analysis of two carnivore–ungulate systems in Scandinavia. **Journal of Animal Ecology** 81:443-454.

Jonzén, N., H. Sand, P. Wabakken, J. E. Swenson, J. Kindberg and O. Liberg, and , G. Chapron. 2013. Sharing the bounty—adjusting harvest to predator return in the Scandinavian human-wolf-bear-moose system. **Ecological Modelling** 265:140-148.

Rauset, G. R., J. Kindberg, and J. E. Swenson. 2012. Modeling female brown bear kill rates on moose calves using Global Positioning Satellite data. **Journal of Wildlife Management** 76:1597-1606.

Popular science

Støen, O.-G., P. Segerström, and J. Karlsson. 2012. Bjørnepredasjon på tamrein. **Hjorteviltet** 22:82-83.

Reports

Karlsson, J., O.-G. Støen, P. Segerström, R. Stokke, L.-T. Persson, L.-H. Stokke, S. Persson, N. A. Stokke, A. Persson, E. Segerström, G.-R. Rauset, J. Kindberg, R. Bischof, T. R. Sivertsen, A. Skarin, B. Åhman, I. Ängsteg, & J. Swenson. 2012. Björnpredation på ren och potentiella effekter av tre förebyggande åtgärder. **Rapport från Viltskadecenter** 2012:6.

Kindberg, O.-G. Støen, G. R. Rauset & J. Karlsen. 2012. Brunbjörnars predation på älgkalvar i Norrbottens län—rapport utarbetad på uppdrag av regeringen (L2011/1478). **Rapport, Sveriges lantbruksuniversitet, Institutionen för vilt, fisk och miljö, Umeå.**

Støen, O.-G. 2012. Metodeutvikling for studier av bjørners predasjon på klauvdyr. INA fagrapport 21. **Institutt for naturforvaltning, Universitetet for miljø- og biovitenskap, Ås.**

2) Management dealing with the increasing bear population

Testing methods for population monitoring

Aim: refine the brown bear population monitoring system. The SBP has designed and tested the methods that managers now use to estimate the size and trends of the bear (Bellemain et al. 2005, Solberg et al. 2006, Kindberg et al. 2009, 2012). During the report period, we have developed a method that is now to estimate the number of annual brown bear reproductions in Norway, which is complex because it is a transborder population, but is required by the Norwegian Parliament. In addition, we conducted several population estimates, based on the DNA-based scat survey in Värmland, Dalarna, and Gävleborgs län and a national estimate for 2013. The national estimate was 2782 bears in 2013, which is a 3.2% annual decline since 2008. The decline varied among län, with statistically significant declines in the observation index in Jämtland and Norrbotten and for Sweden as a whole. This decline is certainly due to the recently increased hunting pressure in many län. This work was financed by other sources than the main bear project, but the competence and infrastructure of the SBBRP was important to complete these projects.

Scientific publication

Bischof, R. and Swenson, J. E. 2012. Combining noninvasive genetic sampling and traditional monitoring to aid management of a trans-border carnivore population. **Ecological Applications** 22:361-373.

Reports

Kindberg, J. & J. E. Swenson. 2013. Beräkning av björnstammens storlek i Värmland, Dalarnas och Gävleborgs län. Report No. 2013:4 from the **Scandinavian Brown Bear Research Project**.

Kindberg, J. & J. E. Swenson. 2014. Björnstammens storlek i Sverige 2013 – länsvisa skattningar och trender. Rapport 2014:2 from the **Scandinavian Brown Bear Research Project.**

The demographic and potentially selective effects of hunting on brown bears

Aim: understand the effects of bear harvesting. We have continued to document the demographic effects of various levels of hunting and hunting methods (baits). An ethical question receiving much recent attention is whether harvesting affects life-history evolution (Festa-Bianchet 2003). This theoretically may occur in large mammals due to nonselective hunting (Proaktor et al. 2007, Bischof et al. 2008a) and could occur in bears, as 88% of all mortality of bears >1 year old in Sweden is due to human causes, mostly hunting (Bischof et al. 2008b, 2009).

We found that survival of yearling females to 2 years was not affected by population density or body mass. This was surprising, because body mass has often been positively correlated with survival in studies of large mammals. Yearlings that remained with their mother had higher survival than independent yearlings, partly because regulations prohibit the harvest of bears in family groups. Although mass as a yearling did not affect juvenile survival, it was positively associated with measures of lifetime reproductive success and individual fitness. The majority of adult female brown bear mortality (72%) in our study was due to human causes, mainly hunting, and many females were killed before they reproduced. Therefore, factors allowing females to survive several hunting seasons had a strong positive effect on lifetime reproductive success. Thus, sport harvest seems to be an important influence on not only the population dynamics, but also the life history of Scandinavian brown bears.

We conducted a meta-analysis to evaluate variation in reproductive allocation (mean female body size in relation with mean litter size) among 28 brown bear populations throughout their geographical range. We found that mean litter size was related to mean female body size, but also that persecution history played an important role. In accordance with life-history theory, we found that reproductive allocation was higher in populations with a long (>500 years) and inefficient persecution history than in populations with a short (<150 year) and efficient persecution history. Our results suggest that humans can act as a selective pressure on life-history traits in a large mammals, and probably explain why certain populations of bears (e.g., in Europe) recover rapidly after protective measures, whereas others (e.g. North American) respond slowly.

Our research on the effect of hunting methods was focused on baiting during the report period. We found that bait sites generally attract bears, however to a relatively low extent, primarily due to individual variation in selection for bait sites. Visits to bait sites by

bears varied considerably among individuals and years. Bears visited bait sites mostly during nighttime, except during the mating season (i.e., middle of May–early July), when activity at bait sites was relatively high throughout the day. Few bait site visits were recorded during the legal hunting time (21 August – 15 October, 1 hour after sunrise – 2 hours before sunset), and almost exclusively from subadult bears, which means that baiting is not an effective method to hunt bears, if the purpose is to shoot bears at the bait site. Females with cubs-of-the-year rarely visited bait sites. We found no indications that bears that use bait sites were less shy when approached by humans in comparison to bears that did not use bait sites. Wolverines also used the bait sites.

Scientific publications

Steyaert, S. M. J. G., J. Kindberg, K. Jerina, M. Krofel, M. Stergar, J. E. Swenson, and A. Zedrosser. 2014. Behavioral correlates of supplementary feeding of wildlife: can general conclusions be drawn? **Basic and Applied Ecology** 15:669–676.

Zedrosser, A., Steyaert, S. M.J.G., Swenson, J. E. and Gossow, H. 2011. Brown bear conservation and the ghost of persecution past. **Biological Conservation** 144:2163-2170.

Zedrosser, A., F. Pelletier, R. Bishof, M. Festa-Bianchet, and J. E. Swenson. 2013. Determinants of lifetime reproduction in female brown bears: early body mass, longevity, and hunting regulations. **Ecology** 94:231-240.

Popular science

Kindberg, J., A. Zedrosser, S. Steyaert, J. Swenson, S. Brunberg, and M. Hansson. 2013. När besöker björnen åteln? **Svensk Jakt** 2013: 1114-1115.

Swenson, J. E. 2012. A new management policy for brown bears in Norway. **International Bear News** 21(2):21-22.

Swenson, J., S. Stokke, H. O. Solberg, E. Lurås, R. Lundby, and S. Parmann. 2013. Jakt på bjørn i Norge. **Et informasjonshefte fra Norges Jeger- og Fiskerforund og NIN**A.

Student theses

2012 Eva Filipczyková. Wageningen University, Wageningen, Netherlands, **Master of Science** thesis. To feed or to leave: The effects of bait sites on the behaviour of brown bears towards humans.

2012 Tommy Vestøl. Norwegian University of Life Sciences, Ås. **Master thesis**: Baiting for brown bears (*Ursus arctos*) in Sweden.

Reports

Kindberg, J. & J. E. Swenson. 2013. Jaktens inverkan på björnstammen i Norrbottens län. Report No. 2013:2 from the **Scandinavian Brown Bear Research Project**.

Zedrosser, A. & Kindberg, J. 2012. Åtling. Report No. 2012:2 from the **Scandinavian Brown Bear Research Project**.

Zedrosser, A., R. Bischof & J. E. Swenson. 2012. The influence of the regulation protecting families of brown bears from hunting for the bear population in Sweden. Report No. 2012:3 from the **Scandinavian Brown Bear Research Project**.

Zedrosser, A., J. Kindberg, and J. E. Swenson. 2013. Final report of bait hunting trials in Västerbotten, Norrbotten, and Dalarna counties, Sweden, 2010-2012. Report No. 2013:1 from the **Scandinavian Brown Bear Research Project**.

Zedrosser, A., S. M. J. G. Steyaert, S. Brunberg, J. E. Swenson & J. Kindberg. 2013. The effects of baiting for hunting purposes on brown bears and their behavior. Report No. 2013:3 from the **Scandinavian Brown Bear Research Project**.

Zedrosser, A., M. Lukkari-Arnesen, S. M. J. G. Steyaert, J. Kindberg, J. Persson, M. Aronsson, and J. E. Swenson. 2014. Use of experimental bait sites by wolverines in Dalarna, Gävleborg and Västerbotten counties, 2010-2012, final report. Rapport 2014:3 from the **Scandinavian Brown Bear Research Project** and the Swedish Wolverine Project.

Harvesting a bear population—modeling effects of infanticide (SSI)

Aim: understand the mechanisms behind infanticide. The Scandinavian bear population shows high rates of infanticide that are correlated with harvest rates of adult males (Swenson et al. 1997, 2001, Swenson 2003, Bellemain et al. 2006a). During the report period, we prioritized research to better understand this behavior and its population effects. Sam Steyaert's PhD project focused on this question.

For infanticide to be a male reproductive strategy, i.e. SSI, three requirements need to be fulfilled, i) the killer does not kill his own offspring, ii) the victimized mother enters estrus earlier than if her cubs would have survived, and iii) the killer has a high probability to father the victimized mothers' next offspring. We found evidence for prediction ii, i.e., females rapidly (1-2 days) enter behavioral estrus after litter loss, which is in accordance with preliminary results from an endocrine approach. The vast majority (92%) of females entered estrus after litter loss during the mating season, mated, and gave birth during the next birthing season. Litter loss during the mating season reduced interlitter intervals of females in our study system by at least 50 % and can thus have significant reproductive advantage for males. We also documented infanticide (N = 8), infanticide attempts (N = 3), and litter loss due to unknown reasons (N = 1) between 2009 and 2011, and found that the patterns were in accordance to the SSI hypothesis. All cases occurred during the mating season, and all known perpetrators were adult males. Cub mortality during the mating season averaged 33 % between 2009 and 2011, and 92 % died because of infanticide. Genetic evidence for predictions i and iii has previously been documented in our study population (Bellemain et al. 2006b).

We also investigated how resource selection of various classes of bears was related to each other. We found that females with cubs selected their resources spatially and temporally very differently than conspecifics (especially adult males) during the mating season. For example, females/cubs used areas relatively close to human settlements, far from forest roads, in the least rugged landscapes, and more often in less dense vegetation (e.g., older forest types). Males often used areas close to forest roads, avoided human settlements, used areas in the most rugged landscapes more than expected, and always selected for the most dense habitat types. After the mating season, female/cubs shifted their resource selection towards a similar mode as their conspecifics; i.e. selecting areas far from settlements, in the most rugged terrain, and in denser habitat types. Our results suggest that females/cubs adapt their resource selection in space and time, most probably in response to the risk of SSI. We also show that females/cubs probably pay a nutritive cost during the mating season by selecting their resources in a spatiotemporally different way than conspecifics. This cost probably adds to the females' cost of reproduction.

We found that hunting had negative indirect effects on the population through an increase in SSI, which lowered cub survival and possibly also fecundity rates. Our study suggests that SSI could explain 13.6% of the variation in population growth. Hunting also

affected the relative importance of survival and fecundity of adult females for population growth, with fecundity being more important under low hunting pressure and survival more important under high hunting pressure. Our study sheds light on the importance of direct and indirect effects of hunting on population dynamics, and supports the contention that hunting can have indirect effects on the bear population through SSI. In fact, the annual decline of 2.5% annually in our southern study area during 2006–2011 due to heavy hunting pressure, would have been an annual increase of 5.5% in the absence of SSI.

Scientific publications

Gosselin, J., A. Zedrosser, Jon E. Swenson, and F. Pelletier. 2015. The relative importance of direct and indirect effects of hunting mortality on the population dynamics of brown bears. **Proceedings of the Royal Society of London, B** 282: 20141840.

Steyaert, Sam M.J.G., A. Endrestøl, K. Hackländer, J. E. Swenson, and Andreas Zedrosser. 2012. The mating system of the brown bear *Ursus arctos.* **Mammalian Review** 42:12-34.

Steyaert, S.M.J.G., J. Kindberg, J.E. Swenson, and A. Zedrosser. 2013. Male reproductive strategy explains spatiotemporal segregation in brown bears. **Journal of Animal Ecology** 82:836-845.

Steyaert S.M.J.G., C. Reusch, S. Brunberg, J. E. Swenson, K. Hackländer, and A. Zedrosser. 2013. Infanticide as a male reproductive strategy has a nutritive risk effect in brown bears. **Biology Letters** 20130624.

Steyaert, S.M.J.G., J. Kindberg, J.E. Swenson, and A. Zedrosser. 2014. Litter loss triggers estrus in a nonsocial seasonal breeder. **Ecology and Evolution** ece3.935.

Popular science

Rønning, A. 2014. Bamsefar som er så snill og rar? **Våre Rovdyr** 28(1):22-25.

Student theses

2011 David Haberkorn, Wageningen University, Wageningen, Netherlands, **Master of Science** thesis, Spatio-temporal analysis of brown bear (*Ursus arctos*) interactions in the mating season.

2012 Jürgen Joseph, Humboldt-Universität zur Berlin. **Master of Science** thesis: Zur Physiologie des Infantizides bei einem nicht sozial lebenden Carnivoren, dem Braunbären (*Ursus arctos*) in einer frei lebenden skandinavischen Population

2012 Franziska Johanna Hütter. University for Natural Resources and Applied Life Sciences, Austria, **Master thesis**. Fecal analysis suggests that female brown bears with dependent offspring avoid adult males during the mating season to prevent sexually selected infanticide

2012 Sam Steyaert, Norwegian University of Life Sciences, Ås and University of Natural Resources and Applied Life Sciences, Vienna. **PhD thesis**: The mating system of the brown bear in relation to the sexually selected infanticide theory.

2014 Jacinthe Gosselin. Université de Sherbrooke, Sherbrooke, Québec, Canada. **Grade de maître ès sciences (M.Sc.)**. Influence de la chasse et de l'infanticide sur la dynamique de la population de l'ours brun scandinave (*Ursus arctos*).

Genetics studies to support many subprojects

Aim: use genetics as a method in these projects. Our genetics studies have focused on documenting gene flow among brown bear populations in northern Europe and examining the evolution of Major Histocompatibility Complex (MHC) genes and whether they have an effect on mating success in brown bears.

We examined gene flow between Pasvik (Norway) Karelia (Russia, Finland), Västerbotten (Sweden), and Troms (Norway) and detected four distinct genetic clusters with low migration rates among the regions. More specifically, we found that differentiation was relatively low from the Pasvik Valley towards the south and east, whereas, in contrast, moderately high gene flow values were detected between the east and the west. Our results indicate ongoing limits to gene flow and the existence of barriers to migration between eastern and western brown bear populations in Northern Europe.

Our MHC research showed that historical positive selection has acted on MHC class I, class II DRB and DQB, but not on the DQA locus. The signal of historical positive selection on the DRB locus was particularly strong. The south–north population structure at MHC loci that we found probably reflects origin of the populations from separate glacial refugia. We also investigated the association between male MHC genotype and mating success in the brown bear using the peptide-binding region of the highly polymorphic MHC class I and class II DRB genes, while controlling for genome-wide effects using a panel of 18 microsatellite markers. Male mating success did not depend on the number of alleles shared with the female or amino-acid distance between potential mates at either locus. Furthermore, we found no indication of female mating preferences for MHC similarity being contingent on the number of alleles the females carried. Finally, we found no significant association between the number of MHC alleles a male carried and his mating success. Thus, our results provided no support for the role of mate choice in shaping MHC polymorphism in the brown bear.

Scientific publications

Kuduk, K., W. Babik, K. Bojarska, E. Śliwińska, J. Kindberg, P. Taberlet, J. E. Swenson, and J. Radwan. 2012. Evolution of Major Histocompatibility Complex class I and class II genes in the brown bear. **BMC Evolutionary Biology** 12:197.

Kuduk, K. W. Babik, E. Bellemain, A. Valentini, A. Zedrosser, P. Taberlet, J. Kindberg, Jon E. Swenson, and J. Radwan. 2014. No evidence for the effect of MHC on male mating success in the brown bear. **PLoS ONE** 9(12): e113414.

Schregel, J., A. Kopatz, S. B. Hagen, H. Brøseth, M. E. Smith, S. Wikan, I. Wartiainen, P. E. Aspholm, O. Makarova, N. Polikarpova, M. Schneider, P. M. Knappskog, J. E. Swenson, I. Kojola, M. Ruokonen, J. Aspi, K. F. Tirronen, P. I. Danilov, and H. G. Eiken. 2012. Limited gene flow among brown bear populations in far Northern Europe? Genetic analysis of the east-west border population in the Pasvik Valley. **Molecular Ecology** 21:3474-3488.

Report

Swenson, J. E. 2012. The importance of genetic analyses of hunter-killed brown bears for management and research in Scandinavia. Report No. 2012:4 from the **Scandinavian Brown Bear Research Project**.

3) Ethical questions regarding research on bears

The effects of capture, immobilization, and implanted transmitters on brown bears

Aim: conduct ethical research and understand the effects of our methods on our results. The ethical treatment of wild animals used in scientific research is highly important. We have a responsibility to the bears, the public, and our financing agencies to know how our research affects our study subjects and results. Capturing bears has been reported to cause capture myopathy, affect movements for 1 month, and multiple captures can reduce body condition (Cattet et al. 2008). Although the effects of helicopter capture (our method) were not found to be as serious as those of snaring, these findings show that capture can affect animals and research results. Our commitment to ethical treatment has resulted in a 10-fold reduction in capture mortality during our study (Arnemo et al. 2006), but we still have much to learn about the effects of our methods. Under the leadership of J. Arnemo, we have prioritized work on this theme, which has included the work of postdoctor Åsa Fahlman, PhD students Alina Evans and Núria Fandos Esteruelas.

We documented for the first time that it was feasible and safe to capture hibernating brown bears, although they behaved differently than black bears. We found that it was important that researchers use 25% of the doses of immobilizing drugs used for helicopter darting during the active period and that they should consider increased energetic costs associated with den abandonment, because almost all bears changed dens after capture.

We found that low flow rates of intranasal oxygen improved arterial oxygenation in brown bears anesthetized with MZT. Because hypoxemia quickly recurred when oxygen was discontinued, oxygen, we recommend that supplementation should be provided continuously throughout anesthesia. We tested the EverGoTM Portable Oxygen Concentrator with pulse-dose delivery and found that it was practical to improve arterial oxygenation during anesthesia of brown bears. We investigated the effects of drug dosages for immobilizing yearlings and recommend that, for yearling brown bears captured shortly after den emergence in April and May, total dart doses of 1.0–1.66 mg M/dart, plus 62.5–125 mg TZ/dart, depending on the individual requirements for the length and depth of anesthesia.

We documented biochemical and hematological reference intervals for brown bears and the differences due to host factors of age and gender. These can be useful for evaluation of health status in free-ranging European brown bears. We also investigated the accuracy of various thermometers in providing accurate measurement of core temperatures in anesthetized brown bears. A hand-held digital thermometer did not accurately measure core temperature, but core temperature capsules inserted 15 cm into the rectum did.

Hair cortisol concentration is considered to be a reliable biomarker of long-term stress in mammals. However, we have found that the values change rapidly in response to capture and handling, which may confound interpretations. This must be investigated further before relying on this biomarker for long-term stress. We also cooperated in some comparative studies of steroids.

Scientific publications

Cattet, M., G. Stenhouse, B. Macbeth, D. Janz, A. Zedrosser, J. E. Swenson, and M. Dumond. 2014. Quantifying long-term stress in brown bears with the hair cortisol concentration: a biomarker that may be confounded by rapid changes in response to capture and handling. **Conservation Physiology** 2: doi:10.1093/conphys/cou026.

Evans, A. V. Salén, O.-G. Støen, Å. Fahlman, S. Brunberg, K. Madslien, O. Fröbert, J. E. Swenson, and J. M. Arnemo. 2012. Capture, anesthesia, and disturbance of free-ranging brown bears (*Ursus arctos*) during hibernation. **PLOS ONE** 7(7): e40520.

Fahlman, Å., N. Caulkett, J. M. Arnemo, P. Neuhaus, and K. E. Ruckstuhl. 2012. Efficacy of a portable oxygen concentrator with pulsed delivery for treatment of hypoxemia during anesthesia of wildlife. **Journal of Zoo and Wildlife Medicine** 43:67-76.

Fahlman, Å, J. M. Arnemo, J. Pringle, and G. Nyman. 2014. Oxygen supplementation in anesthetized brown bears (*Ursus arctos*)—how low can you go? **Journal of Wildlife Diseases** 50:574–581.

Græsli, A. R., Å. Fahlman, A. L. Evans, M. F. Bertelsen, J. M. Arnemo, and S. S. Nielsen. 2014. Haematological and biochemical reference intervals for free-ranging brown bears (*Ursus arctos*) in Sweden. **BMC Veterinary Research** 10:183.

Koren, L., D. Whiteside, Å. Fahlman, K. Ruckstuhl, S. Kutz, S. Checkley, M. Dumond, and K. Wynne-Edwards. 2012a. Cortisol and corticosterone independence in cortisol-dominant wildlife. **General and Comparative Endocrinology** 177:113-119.

Koren L, E. S. M. Ng, K. K. Soma, K. E. Wynne-Edwards. 2012b. Sample preparation and liquid chromatography-tandem mass spectrometry for multiple steroids in mammalian and avian circulation. **PLoS ONE** 7(2): e32496.

Ozeki, L. M., Å. Fahlman, G. Stenhouse, J. M. Arnemo, N. Caulkett. 2014. Evaluation of the accuracy of different methods of monitoring body temperature in anesthetized brown bears (*Ursus arctos*). **Journal of Zoo and Wildlife Medicine** 45: 819-824.

Painer, J., A. Zedrosser, J. M. Arnemo, Å. Fahlman, S. Brunberg, P. Segerström, and J. E. Swenson. 2012. Effects of different doses of medetomidine and tiletamine-zolazepam on the duration of induction and immobilization in free-ranging yearling brown bears (U*rsus arctos*). **Canadian Journal of Zoology** 90:753-757.

Book Chapter

Swenson, J. E. In press. A better balance for wildlife: conservation research and animal activism. In L. Kemmerer (ed). Animals and the Environment: Advocacy, Activism, and the Quest for Common Ground, Routledge, Abingdon, United Kingdom. Popular Science

Student theses

2013 Núria Fandos Esteruelas. Universidad de Pablo Olavide, Sevilla. **Master's thesis** in Biodiversity and conservation biology: Leukocyte coping capacity as a tool for assessing capture and handling-induced stress in free-ranging Scandinavian brown bears (*Ursus arctos*).

2013 Anne Randi Græsli. University of Copenhagen. **Master's thesis** in Veterinary Medicine: Haematological and biochemical reference values for medetomidine-tiletamine-zolazepam immobilized free-ranging brown bears (*Ursus arctos*) in Scandinavia and the influence of seasons and host characteristics.

Reports

Arnemo, J. M., A. Evans & Å. Fahlman, (editors), Ahlqvist, P., Andrén, H., Brunberg, S., Liberg, O., Linnell, J. D. C., Odden, J., Persson, J., Sand, H., Segerström, P., Sköld, K., Strømseth, T. H., Støen, O.-G., Swenson, J. E & Wabakken, P. 2012. Biomedical protocols for free-ranging brown bears, wolves, wolverines and lynx. **Report.**

Steyaert, S. 2014. Effects of GPS relocation intervals on behavior metrics in brown bears. Report No. 2014:1 from the **Scandinavian Brown Bear Research Project.**

Externally financed cooperative studies that required the SBP infrastructure

We have begun cooperating with several research teams in human medicine, because the bears' physiological adaptations to hibernation have the potential to help treat several modern human ailments; heart attacks, osteoporosis, kidney failure, muscle loss due to inactivity, obesity, diabetes,etc.

Our results show some amazing adaptations to hibernation in the brown bear. For example, brown bears tolerate elevated cholesterol levels, obesity, physical inactivity, and circulatory slow flow during hibernation without signs of atherosclerosis. During winter hibernation, brown bears also reduce the basal oxygen consumption rate to ~25% of the active state, while decreasing body temperature moderately (to ~30°C). Hemolysates from hibernating bears showed lower cooperativity and higher oxygen affinity than in summer, regardless of temperature. The resulting increase in oxygen affinity and decrease in cooperativity, which was caused by a decrease in the red cell Hb-cofactor 2,3-diphosphoglycerate, may be crucial in maintaining a fairly constant tissue oxygen tension during hibernation. Also, we found that hibernating bears have fewer innate immune cells in circulation, which may represent a suppressed innate immune system. Body temperature appears to be the main driver of immune function regulation during winter dormancy. Bears also exhibit unusual mechanisms to deal with blood urea. Despite prolonged inactivity and reduced renal function, they do not show inflammation and the bears seem to have enhanced antioxidant defense mechanisms during hibernation. A significant decrease in uric acid levels during hibernation, despite reduced renal functions, indicates a reduced nucleic acid catabolism. When active, free-ranging brown bears demonstrate cardiac hemodynamics comparable to humans, however we documented extremely low-flow hemodynamics during hibernation. Understanding these physiological changes in bears may help to gain insight into the mechanisms of cardiogenic shock and heart failure in humans. Finally, we found that remodeling of hydrogen sulfide metabolism and enhanced intracellular glutathione levels in the blood are hallmarks of the aerobic metabolic suppression of hibernating bears.

Scientific publications

Arinell, K., B. Sahdo, A. L. Evans, J. M. Arnemo, U. Baandrup, and O. Fröbert. 2012. Brown bears (*Ursus arctos*) seem resistant to atherosclerosis despite highly elevated plasma lipids during hibernation and active state. **Clinical and Translational Science** 5:269-272.

Jørgensen, P. G., J. Arnemo, J. E. Swenson, J. S. Jensen, S. Galatius, and O. Frøbert. 2014. Low cardiac output as physiological phenomenon in hibernating free-ranging Scandinavian brown bears (*Ursus arctos*) - an observational study. **Cardiovascular Ultrasound** 12:36.

Revsbech, I.G.; H. Malte, O. Frobert, A. Evans, S. Blanc, J. Josefsson, A. Fago. 2013. Decrease in the red cell cofactor 2,3-diphosphoglycerate increases hemoglobin oxygen affinity in the hibernating brown bear *Ursus arctos*. **American Journal of Physiology—Regulatory, Integrative, and Comparative Physiology** 304: R43-R49.

Revsbech, I. G., X. Shen, R. Chakravarti, F. B. Jensen, B. Thiel, A. L. Evans, J. Kindberg, O. Fröbert, D. J. Stuehr, C. G. Kevil, and A. Fago. 2014. Hydrogen sulfide and nitric oxide metabolites in the blood of free-ranging brown bears and their potential roles in hibernation. **Free Radical Biology & Medicine** 73: 49–357.

Sahdo, B., A. L. Evans, J. M. Arnemo, O. Fröbert, E. Särndahl, and S. Blanc. 2013. Body temperature during hibernation is highly correlated with a decrease in circulating innate immune cells in the brown bear (*Ursus arctos*): a common feature among hibernators? **International Journal of Medical Sciences** 10:508-514.

Stenvinkel, P., O. Fröbert, B. Anderstam, F. Palm, M. Ericson, A.-C. Bragfors-Helin, A. R. Qureshi, T. Larsson, L. Bankir, A. Friebe, A. Zedrosser, J. Josefsson, M. Svensson, B. Sahdo, L. Bankir, and R. J. Johnson. 2013. Metabolic changes in summer active and anuric hibernating free-ranging brown bears (*Ursus arctos*) **PLoS One** 8(9): e7234.

Stewart P., L. Campbell, S. Skogtvedt, K. A. Griffin, J. M. Arnemo, M. Tryland, S. Girling, M. W. Miller, M. A. Tranulis, and W. Goldmann. 2012. Genetic predictions of prion disease susceptibility in carnivore species based on variability of the prion gene coding region. **PLoS One** 7(12): e50623.

Additional research results

During the project period, we conducted other research and cooperation that was not specifically planned when we applied for funding. Some of this was publishing the results from previous publication periods. Some of these other publications have come from cooperation with other research groups. We compared our results on social organization of brown bears with that of root voles and provided our data on brown bear numbers and distribution for a description of the large carnivore situation in Europe.

The other papers and theses in this category were descriptions of methods that we developed for our general research project. We tested fecal spectroscopy, which we have used as a tool to assess diet quality and documented gut retention time after bears had eaten different foods. We also described a novel method to detect pregnancy in hibernating brown bears using activity recordings from their GPS collars. This is important to more accurately determine which bears have given birth. By combining this method with body temperature data from implanted sensors, we determined that the mean date of implantation in central Sweden was 1 December, the mean date of parturition was 26 January, and the mean duration of the gestation period was 56 days. Older females started hibernation earlier. The start of hibernation was earlier during years with favorable environmental conditions. Dates of parturition were later during years with good environmental conditions, which was unexpected.

Scientific publications

Chapron, G., P. Kaczensky, J. D. C. Linnell, M. von Arx, D. Huber, H. Andrén, J. V. López-Bao, M. Adamec, F. Álvares, O. Anders, L. Balciauskas, V. Balys, P. Bedo, F. Bego, J. C. Blanco, U. Breitenmoser, H. Brøseth, L. Bufka, R. Bunikyte, P. Ciucci, A. Dutsov, T. Engleder, C. Fuxjäger, C. Groff, M. Heltai, K. Holmala, B. Hoxha, Y. Iliopoulos, O. Ionescu, G. Ivanov, J. Jeremić, K. Jerina, F. Knauer, I. Kojola, I. Kos, M. Krofel, J. Kubala, S. Kunovac, J. Kusak, M. Kutal, P. Mannil, R. Manz, E. Marboutin, F. Marucco, D. Melovski, K. Mersini, Y. Mertzanis, R. W. Mysłajek, S. Nowak, J. Odden, J. Ozolins, G. Palomero, M. Paunovic, J. Persson, H. Potočnik, P.-Y. Quenette, G. Rauer, I. Reinhardt, R. Rigg, A. Ryser, V. Salvatori, T. Skrbinšek, A. Skrbinšek-Majić, A. Stojanov, J. E. Swenson, A. Trajçe, E. Tzingarska-Sedefcheva, M. Váňa, R. Veeroja, M.

Wölfl, S. Wölfl, F. Zimmermann, D. Zlatanova & Luigi Boitani. 2014. Successful recovery of large carnivores in Europe's human-dominated landscapes. **Science** 346:1517-1519.

Elfström, M., O.-G. Støen, A. Zedrosser, I. Warrington, and J. E. Swenson. 2013. Gut retention time in captive Scandinavian brown bears *Ursus arctos.* **Wildlife Biology** 19:317-324.

Friebe, A., A. Zedrosser, and J. E. Swenson. 2013. Detection of pregnancy in a hibernator based on activity data. **European Journal of Wildlife Research** 59:731-741.

Friebe, A., A. L. Evans, J. M. Arnemo, S. Blanc, S. Brunberg, G. Fleissner, J. E. Swenson, and A. Zedrosser. 2014. Factors affecting date of implantation, parturition, and den entry estimated from activity and body temperature in free-ranging brown bears. **PLoS ONE** 9(7): e101410.

Jojola, S. M, F. Rosell, I. Warrington, J. E. Swenson & A. Zedrosser. 2012. Subadult brown bears (*Ursus arctos*) discriminate between unfamiliar adult male and female anal gland secretion. **Mammalian Biology** 77:363-368.

Karamanlidis, A.A., Stojanov, A., de Gabriel Hernando, M., Georgiadis, L., Ivanov, G., Karmbokoukis, L., Melovski, D., and Zedrosser, A. 2014. Distribution and genetic status of brown bears in FYR Macedonia: implications for conservation. **Acta theriologica** 59:119-128.

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Student theses

2012 Erwin Pier. Wageningen University, Wageningen, Netherlands, **Master of Science thesis**. Impact of climate change on bear-movement regarding berry foraging; Feedback on spatio-temporal data analyses.

2013 Anna Maria Petré. Swedish University of Agricultural Sciences, Umeå. **Master thesis** in Biology (30 points): Bears (*Ursus arctos*) use of managed forests in autumn; a comparison between Sweden and Canada.

2014 Lisa A. Klestil. Universität Wien. **Masterarbeit:** Placental scar counts and the assessment of reproductive performance in female brown bears.

Communication efforts

During 2012-2014, the SBP produced 95 publications; 56 international scientific papers, 1 unrefereed scientific paper, 13 student theses (including 3 PhD-level theses), 18 reports to management agencies, and 7 popular articles. We conducted three manager-oriented seminars during the period, two at Grönklitt Bear Park, Orsa and one in Trondheim, Norway. Project personal gave over 100 presentations to managers, politicians, and the public and interviews to the media. We responded to all requests for information from national and regional wildlife managers in Sweden and Norway and participated in determining the Favorable Conservation Status baseline for brown bears in Sweden. We see the project as a natural provider of information to managers outside Scandinavia. During the project period, we have also provided our professional opinions regarding management questions in Belarus, Canada, Croatia, Georgia, Greece, Italy, Poland, Slovenia, Spain, and USA (Yellowstone Ecosystem).

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