THE SCANDINAVIAN BROWN BEAR PROJECT

Avtalenummer 15010645 (Miljødirektoratet)
Report for 2015

Jon E. Swenson and Jonas Kindberg

(Photograph by Jon Swenson)

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The Scandinavian Brown Bear Research Project
(www.bearproject.info)

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The project was carried out according to the plan in the application. Here, we summarize the purpose and goals of the project and the results of our fieldwork and research during 2015. The publications referred to below can be downloaded from the Scandinavian Brown Bear Research Project (SBP) website www.bearproject.info.

PURPOSE AND GOALS

The overall purpose of the SBP is to conduct research that will provide managers in Norway and Sweden with solid, scientifically based knowledge to meet present and future challenges presented by managing the population of brown bears; which is both an important hunted species and a source of conflict, and whose management has been changing rapidly in recent years. We gather and analyze long-term individually-based data on bears with a main goal of following females from birth to death. This method leads to most new insights in ecology, evolutionary biology, management, and conservation. The SBP works in 4 ways concurrently: 1) research on population dynamics, life-history strategies, and general ecology using the 32-year dataset of individually marked bears (the base project), 2) management-relevant research, in addition, we provide the infrastructure and marked bears for 3) activities important for management, such as training and testing tracking dogs, and 4) associated research projects, such as veterinary and human physiology. Knowledge gained by the SBP has been important for the present policy, monitoring, and management regarding bears in Norway and Sweden. The need for further long-term research to guide management has been stressed in recent white papers in both countries and is evident from the recent changes in management policy and harvest levels and methods.

Below, we summarize the SBP's activities and publications during 2015. When reading this report, please be aware that the application was based on a 3-year period, we did not obtain the funding level we applied for, and we are reporting the first year of what hopefully will be a 3-year project period. Our report is based on the structure of our application, so that it will be easier to track our production in relation to our proposal. The original language from the application is summarized in italics and the report for 2015 is given in normal font. Following each section, we provide the citation of papers or reports that have been produced.

FIELDWORK

During the 2015 field season, we captured and radio-marked 10 new females (8 yearlings with marked mothers and two adults) and we followed a maximum of 54 females during the season. Nine of these died during the year and we lost contact with one, leaving 44 females at the end of the season. We also captured and radio-marked 4 new males; one adult, 2 yearlings with their mothers, and 1 cub-of-the-year, whose mother had been killed by a hunter. We followed a maximum of 13 males, but 3 were shot and 1 lost its collar, leaving 9 at the end of the year. In summary, we followed a maximum of 67 radio-marked bears during 2015 and ended the year with 53.

The capture period for our main project was divided into two periods, 13-27 April and 12-17 May. However, we also had a winter hibernation capture period during 24-28 February. The bears caught during this period were recaptured during 5-7 July. The same samples were taken from these bears in both periods to compare their physiology during hibernation and when they are active.

Our student field period began on 25 May and lasted until 12 September. They conducted fieldwork in 8 different studies; approach study, dog study, GPS collar study, berry study, scat study, den survey, accelerometer test, and anthill study.

The field station and 6 study bears were used for training in bear tracking by personnel from SNO and Länsstyrelsen during 2 June to 25 July. The Skandulv Wolf Project also used the field station during wolf capture in the winter and fieldwork during the spring and summer. We also hosted personnel from the Norwegian Ministry of Climate and Environment and the Nowegian Center for Advanced Studies. In total, the field station had 1209 overnight stays.

RESEARCH

Because of the value of long-term, individually based projects to answer basic ecological questions (Clutton-Brock & Sheldon 2010) and because the base project is essential for all associated projects, we have maintained our major goals and methods throughout the 32 years the project has been active. Our study has resulted in a unique data set that we use to answer basic questions about population dynamics, life history traits, and basic ecology of a long-lived carnivore. Our results are also important for managers and researchers internationally. Our genetics samples from a large proportion of the population over its entire range is also unique, and allows studies of genetic structure, "landscape genetics", paternity studies, heritability of traits and the effects, inbreeding, and outbreeding on life-history traits. Our mortality and survival data allow analyses of population dynamics, the effects of hunting, and possible human-induced selection caused by hunting. We have developed an individually based density index, which allows us to examine density dependence on important life history characteristics, which has rarely been done before in large carnivores (McLellan 1994).

1.2 Tools for wildlife management; methods for wildlife monitoring

The "observed bear" monitoring method. *Aim: improve the accuracy of the bear population monitoring system. The SBP has designed and tested the method used to estimate the size and trends of the bear population. Although this trend method works well, its predictive ability could be improved by correcting for sources of annual variation, such as variation in environmental conditions, bears killed before the moose hunt, and proportion of females with young. We also propose to examine trend estimates separately in the bear population's core and peripheral areas and determine if that affects the county-wide estimates.*

We have obtained data on berry occurrence during the period we will analyze. We have dedicated two month's salary for PhD student Anne Hertel to conduct this analysis, which she will do before the three-year project ends.

Bischof, R., H. Brøseth, and O. Gimenez. In press. Large carnivores in a world divided by political borders: focus on jursidiction leads to inflated abundance estimates. **Conservation Letters**.

1.2 Tools for wildlife management; measures to regulate populations and prevent damage

Human injuries. *Aim: document factors associated with bear-caused human injuries and evaluate the effectiveness of the hunter-education program. We have interviewed all people injured by bears in Scandinavia since 1977 and will continue to do so. We will provide information to managers and the public about factors associated with risk of injury by bears and will evaluate whether the bear hunter education program has influenced rates of human injury.*

We have provided our data for a global study of this problem (see below) and we have produced a manuscript that will soon be submitted to a scientific journal. In addition, we have published three other papers and one Master's thesis on bear behavior in relation to potential human injuries and fear of bears in Scandinavia. We also published two popular articles in Norwegian on the topic.

Sahlén, V., A. Friebe, S. Sæbo, J. E. Swenson, and O.-G. Støen. 2015. Den entry behavior in Scandinavian brown bears: implications for preventing human injuries. **Journal of Wildlife Management**. 79:274–287.

Sahlén, V., A. Ordiz, J. E Swenson, and O.-G. Støen. 2015. Behavioural differences between single Scandinavian brown bears (*Ursus arctos*) and females with dependent young when experimentally approached by humans. **PLoS ONE** 10(4): e0121576.

Penteriani, V., M. del Mar Delgado, F. Pinchera, J. Naves, A. Fernández-Gil, I. Kojola, S. Härkönen, H. Norberg, J. Frank, J. M. Fedriani, V. Sahlén, O.-G. Støen, J. E. Swenson, P. Wabakken, M. Pellegrini, S. Herrero, and J. V. López-Bao. 2016. Human behaviour may trigger large carnivore attacks in developed countries. **Scientific Reports** 6:20552.

Johansson, M., O.-G. Støen, and A. Flykt. In press. Exposure as an intervention to address human fear of bears. **Human Dimensions of Wildlife**

Stenset, N. E. 2015. Behaviour of brown bears (Ursus arctos) when repeatedly approached by humans on foot. **Master thesis**, Norwegian University of Life Sciences.

Johansson, M., A. Flykt, J. Frank & Ole-Gunnar Støen. 2015. Redsel for bjørn og ulv blant mennesker som bor i rovdyrområder. **Rovdyrviten** 3:12-13.

Sahlén, V. 2015. Når bjørn og menneske møtes. **Rovdyrviten** 3:14-15.

Summer farms. *Aim: determine if the presence of bears reduces cows' milk production, as farmers fear. We will test experimentally if experiencing bear feces affects milk production.*

We have conducted this experiment at NMBU's dairy farm. A Master's student collected the data and is analyzing it at this time, but we do not yet have any results to report.

Hunting mortalities on the landscape. *Aim: document landscape features associated with hunter mortalities. Brown bear mortality is often associated with identifiable factors in the landscape, such as roads (Nielsen et al. 2004) and "attractive sinks" might account for a high proportion of bear mortalities (Naves et al. 2003). Managers should know these landscape factors to evaluate the effect of hunting on the population.*

We are working with this question from several perspectives and in several manuscripts. One of these manuscripts is currently in press. Another, related paper on the negative effect of national parks on illegal killing of large carnivores is also in press. We will continue to work on this topic.

Rauset, G. R., H. Andrén, J. E. Swenson, G. Samelius, P. Segerström, A. Zedrosser, and J. Persson. In press. National parks as refuges for illegal killing of large carnivores. **Conservation Letters**

Steyaert, S. M. J. G., A. Zedrosser, M. Elfström, A. Ordiz, M. Leclerc, S. C. Frank, J. Kindberg, O.-G. Støen, S. Brunberg; and J. E. Swenson. In press. Ecological implications from spatial patterns in human-caused brown bear mortality. **Wildlife Biology**

Hunting methods. *Aim: document the effect of new or popular hunting methods, especially the use of dogs and bait. A study of the effect of baiting was funded by SEPA and an ongoing study of the effect of hunting with does was funded by the Norwegian Environment Agency (NEA), both using the SBP's infrastructure. Both methods are increasingly used by bear hunters. We will analyze the data and publish the results in scientific journals and hunter magazines.*

We are in process of analyzing the results of the studies. One Master's thesis has been produced from the data from the bait study in 2015.

Arnesen, M. L. 2015. Use of experimental bait sites by wolverines. **Master thesis**, Telemark University College, Bø.

Rapid changes in bear harvest. *Aim: analyze the effects of today's level of harvest rates, harvest methods, and management kills. We have analyzed the use of hunting methods during 1981-2004 and effects of hunting on the bear population during 1984-2006. Both have changed dramatically recently, with potentially great effects on the bears. We aim to repeat these analyzes.*

We are conducting an analysis of the effects of hunter harvest using Integrated Population Models, led by Richard Bischof and Christophe Bonenfant. This should give us the desired insight into the effects of today's high rate of bear harvest in Sweden.

1.3 Tools for wildlife management; harvest models

Sexually selected infanticide (SSI). *Aim: document whether hunting-induced SSI affects population growth. The Scandinavian bear population shows high rates of infanticide that are correlated with harvest rates of adult males. We will model if SSI influences population growth.*

During this period, we have published a paper showing that hunter harvest of adult males does affect the growth rate of the brown bear population through the indirect effects of SSI. In fact, it accounted for about 14% of the variation in the population growth rate (λ). We have submitted two manuscripts that have examined the spatial aspects of SSI.

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.

Density and social organization. *Aim: document whether the presently high level of harvest influences bear social organization. Hunting can indirectly affect social organization (Treves 2009). Female bears form matrilinear assemblages, with home-range overlap correlated with relatedness, allowing for higher densities of bears. We will determine whether hunter-caused mortality is higher in high-density areas, whether today's hunting rate has changed the pattern of matrilineal social organization, and how that affects the bear population.*

This is Shane Frank's PhD project. He is analyzing data for at least on manuscript on this topic.

Density dependence. *Aim: document the extent of density-dependent effects in brown bear population dynamics. Density-dependent reproduction has not been documented for bears, although it has been suggested in one study (Schwartz et al 2006). We can estimate the density around each marked bear and will use our long-term data on body size, age of reproduction, long-term reproductive success, survival, home-range size, mortality, individual density, etc. to continue to study the relationships among life-history traits and trade-offs between them. This is the key to understanding population dynamics and evolution (Stearns, 1992, Clutton-Brock & Sheldon 2010) and it is essential for managers to understand density dependency in bears to build accurate harvest models.*

Density dependence will be a part of several of the analyses that are presently ongoing and has been included in some submitted manuscripts. Basically, we are documenting several effects of density on life-history parameters, particularly juvenile survival and growth. We are conducting a literature review with the Greater Yellowstone Grizzly Bear Project on density dependence in bears, which we hope to publish.

Selective effects. *Aim: understand the possible evolutionary effects of bear harvesting. A question receiving much recent attention is whether harvesting affects life-history evolution (Festa-Bianchet & Apollonio 2003). This theoretically may occur in large mammals due to nonselective hunting (Proaktor et al. 2007) and could occur in bears, as almost all mortality of bears >1 year old in Sweden is due to human causes, mostly hunting. We will evaluate whether management regimes might act as a selective agent in brown bears, using our long-term dataset data on life-history parameters and estimates of the individuals' contribution to population growth (Coulson et al. 2006) and include comparative datasets from Alberta and Alaska. The question of the long-term effects of hunting is certainly one that managers will have to face in the near future (Festa-Bianchet & Apollonio 2003).*

This topic is part of the PhD projects being conducted by Martin Leclerc and Joanie van der Walle. They are working on several manuscripts and one has been accepted for publication.

Leclerc, M., E. Vander Wal, A. Zedrosser, J. E. Swenson, J. Kindberg, and F. Pelletier. In press. Quantifying consistent individual differences in habitat selection. **Oecologia.**

2 From one- to several-species management

Bear and wolf predation on moose. *Aim: determine the synergetic effects of bear and wolf predation on a moose population. The new Swedish moose management system requires information about predation, both from wolves and bears, but also their combined effect. We now have a situation with varying moose, bear and wolf densities, both at spatial and temporal scales. We propose to repeat our studies on individual kill rates for both bears and wolves in cooperation with the Wolf Project. Here, we apply for funding for fieldwork to study 1) kill rates of calves and adult moose by following different categories of GPS-marked bears and wolves using clusters of positions and 2) the effect of predation on moose population size by combining censuses of moose (pellet counts in co-operation with Svenska Jägareförbundet (SJ)) with the recent estimate of the bear population in Dalarna and Gävleborg.*

Bear—wolf interactions. *Aim: determine if bear-wolf interactions influence predation rates. We will visit sites where wolves or bears have killed moose (from GPS clusters) and use cameras to determine if the other species utilizes the kill, forcing one species to make more kills, as has been shown for wolverines that utilize kills made by lynx. It is important to understand predator-prey dynamics and moose management in a two-predator system, especially with the adaptive ecosystem management for moose in Sweden*

We have conducted almost all of the field work described above and are almost done with a manuscript showing that the presence of brown bears does not shorten the wolves' interkill interval, which is normally assumed. In fact, the interkill interval increases when bears are present and steal part of the wolves' prey. However, we have also found that the presence of bears had a negative effect on the expansion of wolves in Scandinavia. This result has been published. We also produced one Master's thesis and wrote a popular-science article in Norwegian on brown bears' predation on semidomestic reindeer.

Ordiz, A., C. Milleret, J. Kindberg, J. Månsson, P. Wabakken, J. E. Swenson, and H. Sand. 2015. Wolves, people, and brown bears influence the expansion of the recolonizing wolf population in Scandinavia. **Ecosphere** 6(12): article 284.

Romairone. J. 2015. Habitat characteristics between different clusters of wolf (*Canis lupus*) activity before and after brown bear (*Ursus arctos*) emergence in Central Sweden. **Master of Science thesis**, Pablo Olavide University, Seville, Spain.

Støen, O.-G., P. Segerström, B. Åhman, L. T. Persson, & J. Frank. 2015. Bjørnens predasjon på tamrein—og forebyggende tiltak. **Rovdyrviten** 3:40-41.

Regional variation in bear density and moose recruitment. *Aim: document whether moose calf recruitment is correlated with bear density. Using calves per female in the "observed-moose" data (Älgobs), harvest data, and estimates of relative bear density (LCOI), we will determine whether calf recruitment is correlated with bear density in order to better apply the results of local predation studies to a larger landscape scale, which will be useful for managers dealing with both species.*

We have not worked on this during 2015.

3 Future wildlife management--RS

History. *Document the history of bear management in Sweden. It is often helpful for present management to evaluate the history of management. We will analyze management goals, practices, and resulting bear population change during 1943-2014 to determine the effectiveness of past management and make recommendations for future management.*

Adaptive management (AM). *Document whether AM is working today. The regional Swedish wildlife management authorities have been mandated to use AM. We will evaluate repeated bear censuses and population trends in relation to published goals from an AM perspective.*

We have almost completed a manuscript on these topics. It shows that Swedish wildlife management has been very unsuccessful in meeting stated trend and population estimates for the brown bear population during the past 70 years. The present period, with country-based Wildlife Management Delegations, is no exception. Some major changes must be made to the present system if adaptive management, required by Parliament, is to work.

We have published one paper and one popular-science article in Norwegian on topics that are related to this category.

Gilroy, J. J., A. Ordiz, and R. Bischof. 2015. Carnivore coexistence: value the wilderness. **Science** 347:382.

Swenson, J. E. & J. D. C. Linnell. 2015. Bestandene av store rovdyr er økende i Europa. **Rovdyrviten** 3:42-43.

Attitudes towards bears in relation to local conditions. *Aim: document attitudes towards bears where humans live. Managers must deal with human attitudes and the increasing fear of have conducted an attitude survey during 2004, 2009, and 2014. We will analyze these attitudes at the local scale in relation to relative bear density, the expansion of bears into more populated areas, bear harvest level, and occurrence of injuries. This will help managers understand which attitudes towards bears are transient and which are more permanent.*

We have not worked on this topic during 2015.

4. Other upcoming important topics

Ethics of research methods. *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. Our commitment to ethical treatment has resulted in a 10-fold reduction in capture mortality, but we are continuing our efforts to improve. We will determine the short- and long-term effects of capture on stress, physiology, and reproduction and survival, including the effects of implanted transmitters.*

We are continuing with this research, which is the subject of PhD students Núria Esteruelas and Alina Evans. Several manuscripts are underway and three papers were published in 2015 and early 2016.

Græsli, A. R., A. L. Evans, Å. Fahlman, M. F. Bertelsen, S. Blanc, and J. M. Arnemo. 2015. Seasonal variation in haematological and biochemical variables in free-ranging subadult brown bears (*Ursus arctos*) in Sweden. **BMC Veterinary Research** 11:301.

Ozeki, L. M., N. Caulkett, G. Stenhouse, J. M. Arnemo, Å. Fahlman. 2015. Effect of active cooling and α_2-adrenoceptor antagonism on core temperature in anesthetized brown bears (*Ursus arctos*). **Journal of Zoo and Wildlife Medicine** 46:279-285.

Esteruelas, N. F., N. Huber, A. L. Evans, A. Zedrosser, M. Cattet, F. Palomares, M. Angel, J. E. Swenson, J. M. Arnemo. 2016. Leukocyte coping capacity as a tool to assess capture and handling-induced stress in Scandinavian brown bears (*Ursus arctos*). **Journal of Wildlife Diseases** 52:S40-S53.

Landscape of fear. *Aim: determine how bears deal with human activity and if it has fitness effects. Scandinavian bears generally avoid humans and their infrastructure. We will document whether changing to nocturnal foraging due to human disturbance reduces food intake, whether humans or their activities cause measureable stress to the bears, and whether long-term stress might have consequences for reproduction, growth, or survival. We will use implanted temperature and heart-rate loggers and stress hormones in hair and feces that we collect for this purpose. To generalize our results, we will compare stress hormones in bear hair in relation to humans and their activities in Sweden and Canada.*

This subproject is underway and most of the stress hormone samples have been analyzed in the laboratory. We will begin to work with these results in 2016. We also have several manuscripts underway on various aspects of this topic. One paper using physiology sensors has been published and 2 Master's theses have been produced. All of the results to date have shown that human disturbance is an important factor affecting the behavior, habitat use, and foraging ecology of brown bears.

Støen, O.-G., A. Ordiz, A. L. Evans, T. Laske, J. Kindberg, O. Fröbert, J. E. Swenson, and J. M. Arnemo. 2015. Physiological evidence for a human-induced landscape of fear in brown bears (*Ursus arctos*). **Physiology and Behavior** 152A:244-248.

Gelink, H. W. 2015. Risky berry business? Brown bear (*Ursus arctos*) foraging behaviour in a landscape of fear. **Master thesis**, Norwegian University of Life Sciences,

Lodberg-Holm, H. K. 2015. When the hunter becomes the hunted: Impacts of hunting on the foraging behavior of the brown bear (*Ursus arctos*) in Sweden. **Master thesis**, Norwegian University of Life Sciences.

Cascading effects. *Aim: To combine the "landscape of fear" and "predation on moose" studies to investigate how bears and moose use the landscape in response to human activity and infrastructure. We will compare habitat use by bears and moose to investigate if human activity and infrastructure influence the natural distribution and relationship between these two species and how human activities mediate possible trophic cascades in biodiversity caused by human-induced differential distribution and habitat use by bears and moose in the landscape. All data needed on bears and moose in this project have previously been or are continuously being collected, but more data on other aspects of the study must be collected.*

The first year of fieldwork on this topic was collected in 2015. This is Gro K. Moen's PhD project.

Effects of climate change on bear populations. *Aim: Determine how projected global change may affect the bear population, the rate of human injuries, and harvest of bears. The projected global climate change in Scandinavia could affect bears in several important ways; 1) reduced berry production, and therefore reduced food needed for fat production, due to late-winter freezing episodes, 2) changes in den entry timing and behavior due to changes in food availability and climate, which may affect rates of bear-caused human injury, which are most common at this time, and 3) changes in harvest rates and population modeling accuracy due to weather-related behavior of bears and/or bear hunters.*

Richard Bischof has constructed a climate model that will allow us to determine the temperature and snow depth at any site on any day during our entire study period on our southern study area. This will be very useful in our ongoing studies of this topic. We conducted fieldwork on this topic in 2015 and several manuscripts are underway. In addition, we have a paper in press showing that den entry is climatically determined in brown bears (snowfall and a temperature of 0° C). We have also published data on the diet

of bears on our southern study area 15-20 years ago, which can be used to compare with the present situation. Andrea Friebe's PhD thesis, which was defended in 2015, also is about this topic.

Evans, A. L., N. J. Singh, A. Friebe, J. M. Arnemo, T. G. Laske, O. Fröbert, J. E. Swenson, and S. Blanc. 2016. Ecophysiological drivers of den entry and den exit in the brown bear. **Frontiers in Zoology** 13:7.

Stenset, N. E., P. N. Lutnæs, V. Bjarnadóttir, B. Dahle, K. H. Fossum, P. Jigsved, T. Johansen, W. Neumann, O. Opseth, O. Rønning, S. M. J. G. Steyaert, A. Zedrosser, S. Brunberg, and J. E. Swenson. In press. Seasonal and annual variation in the diet of brown bears (*Ursus arctos*) in the boreal forest of southcentral Sweden. **Wildlife Biology**

Friebe, A. 2015. Winter ecology of free-ranging brown bears (*Ursus arctos*) in central Sweden. **PhD thesis**, Goethe-Universität in Frankfurt am Main.

Habitat use/effects of forestry. *Aim: Document how modern forestry impacts brown bear habitat quality. Modern forestry has a large impact on the forest landscape, affecting two of the most important food items for bears, berries and ants. We will study bear's seasonal habitat use in managed forests in relation to silvicultural methods, clearcut size and age, and food availability. We will use GPS-collared bears and remote sensing and forestry data in combination with field visits. We will also cooperate with the Canadian Foothills Grizzly Bear Research Project on this topic, to determine the generality of our results for boreal bear habitats.*

We are working on a number of manuscripts on this theme. Two papers have been published (one in press), a Master's thesis has been produced, and we published a popular-science article in English.

Frank, S., S. M. J. G. Steyaert, J. E. Swenson, I. Storch, J. Kindberg, H. Barck, A. Zedrosser. 2015. A clear-cut case? Brown bear foraging for carpenter ants on clear-cuts across spatial scales in central Sweden. **Forest Ecology and Management** 348:164–173.

Leclerc, M., E. Vander Wal, A. Zedrosser, J. E. Swenson, J. Kindberg, and F. Pelletier. In press. Quantifying consistent individual differences in habitat selection. **Oecologia**.

Nowak, L. 2015. Reproductive performance of Scandinavian female brown bears (*Ursus arctos*) in relation to the use of den-type. **Master thesis**, University for Natural Resources and Applied Life Sciences, Vienna, Austria

Leclerc, M. 2015. Brown bear habitat selection personality. **Atlas of Science** http://atlasofscience.org/brown-bear-habitat/

Genetics. *Aim: to study mate selection, heritability of traits, and landscape genetics. We will continue to determine the paternity of our bears to document correlates with lifetime reproductive success in males. We will also analyze microsatellites and Major Histocompatibility Complex (MHC) genes and use our data on body size, growth, age of reproduction, long-term reproductive success, survival of offspring, home-range size, social*

organization, mortality, etc. to determine whether life-history traits are correlated with MHC compatibility, genetic heterozygosity, inbreeding and/or outbreeding, and whether MHC compatibility is a factor in mate choice and kin recognition. If we find correlates with reproductive success, we will use this in our study of harvest-induced selection. We will analyze the contribution of individual bears to population growth and the genetic population structure of bears throughout Northern Europe to document gene flow. These subjects are important to understand potential effects of hunting on selection and genetic structure.

Our work with genetics is ongoing and will lead to several more papers, now that the genetics database was updated in 2015. We are almost done with an updated pedigree going back 31 years, based on the genetics database. One PhD thesis on genetics was produced and two papers were published during 2015. The publications have documented that there was a loss of genetic diversity due to the population bottleneck in Sweden, especially in the southern subpopulation (Dalarna, Härjedalen, Gävleborg, Hedmark), but that the current genetic structure predated the bottleneck, and was therefore caused by historical ecological processes, rather than recent persecution. We also found that male gene flow was not the main force of population recovery in Scandinavia.

Schregel, J., H. G. Eiken, F. A. Grøndahl, F. Hailer, J. Aspi, I. Kojola, K. Tirronen, P. Danilov, A. Rykov, E. Poroshin, A. Janke, J. E. Swenson, and S. B. Hagen. 2015. Y chromosome haplotype distribution of brown bears (*Ursus arctos*) in Northern Europe provides insight into population history and recovery. **Molecular Ecology** 24: 6041–6060.

Xenikoudakis, G., E. Ersmark, J.-L. Tison, L. Waits, J. Kindberg, J. E. Swenson, and L. Dalén. 2015. Consequences of a demographic bottleneck on genetic structure and variation in the Scandinavian brown bear. **Molecular Biology** 24:3441-3454.

Schregel, J. 2015. Genetic structure and gene flow in a continuously distributed large terrestrial carnivore – the brown bear (Ursus arctos) in Northern Europe. **PhD thesis**, Norwegian University of Life Sciences, Ås.

5. Associated research topics that are dependent upon the base project

We have begun cooperating with several research teams in human physiology, 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. NAE is funding a project "Biologging techniques in wildlife research" using bears as a model species, which will contribute to several studies of bear-human interactions, effects of hunting, tracking dogs, etc. The base project's marked bears and personnel are essential for these cooperative studies.

Our cooperation with the human physiology researchers continued in 2015 and we published two review papers highlighting the importance of this work. A third published paper used germ-free mice to document the importance of bear gut microbiota in regulating fat deposition, but without the resistance to insulin commonly found in obese humans. The physiologists are working on several manuscripts.

We also found that bears had high levels of antibodies against *Borrelia burgdorferi*, the causative agent of Lyme borreliosis in the south, but lower levels in the north. The antibody levels have been increasing in the south, consistent with the view that ticks and tick-borne pathogens are expanding their abundance and prevalence in Scandinavia. We also documented some bears with pathological effects of high numbers of chewing lice. We have published two papers on these subjects.

Berg von Linde, M., L. Arevström, and O. Fröbert. 2015. Insights from the den: how hibernating bears may help us understand and treat human disease. **Clinical and Translational Science** 8:601-605.

Paillard, L, K Jones, A. Evans, J. Berret, M. Jacquet, R. Lienhard, M. Bouzelboudjen, J. M. Arnemo, J. E. Swenson, and Maarten J. Voordouw. 2015. Serological signature of tick-borne pathogens in Scandinavian brown bears over two decades. **Parasites & Vectors** 8:398.

Stenvinkel, P. J. Kindberg, & O. Fröbert. 2015. Biomimetik – att efterlikna naturen för att förebygga sjukdom. **Läkartidningen** 112:586-590.

Sommer, F., M. Ståhlman, O. Ilkayeva, J. M. Arnemo, J. Kindberg, J. Josefsson, C. Newgard, O. Fröbert, and F. Bäckhed. 2016. The gut microbiota modulates energy metabolism in the hibernating brown bear (*Ursus arctos*). **Cell Reports** 14:1-7.

Esteruelas, N. F., J. Malmsten, C. Bröjer, G. Grandi, A. Linström, P. Brown, J. E. Swenson, A. L. Evans, J. M. Arnemo. In press. Chewing lice *Trichodectes pinguis pinguis* in Scandinavian brown bears (*Ursus arctos*). **Journal of Parasitology: Parasites and Wildlife**

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To date, the SBP has produced 571 publications; 206 international scientific papers, 12 books/book chapters, 22 proceedings papers,109 student theses (including 21 PhD-level theses), 136 reports to management agencies, and 86 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 31 years. This type of research leads to most new insights in ecology, evolutionary biology, management, and conservation (Clutton-Brock & Sheldon, Trends in Ecol & Evol. 25:562-573, 2010, Festa-Bianchet & Apollonio, Animal behavior and wildlife conservation, Island Press, 2003). This does not explain all of the project's productivity, however, because the SBP has published almost 7 times more scientific papers than the average of 51 long-term, individual-based field studies of birds and mammals in the UK (Fig. 1).

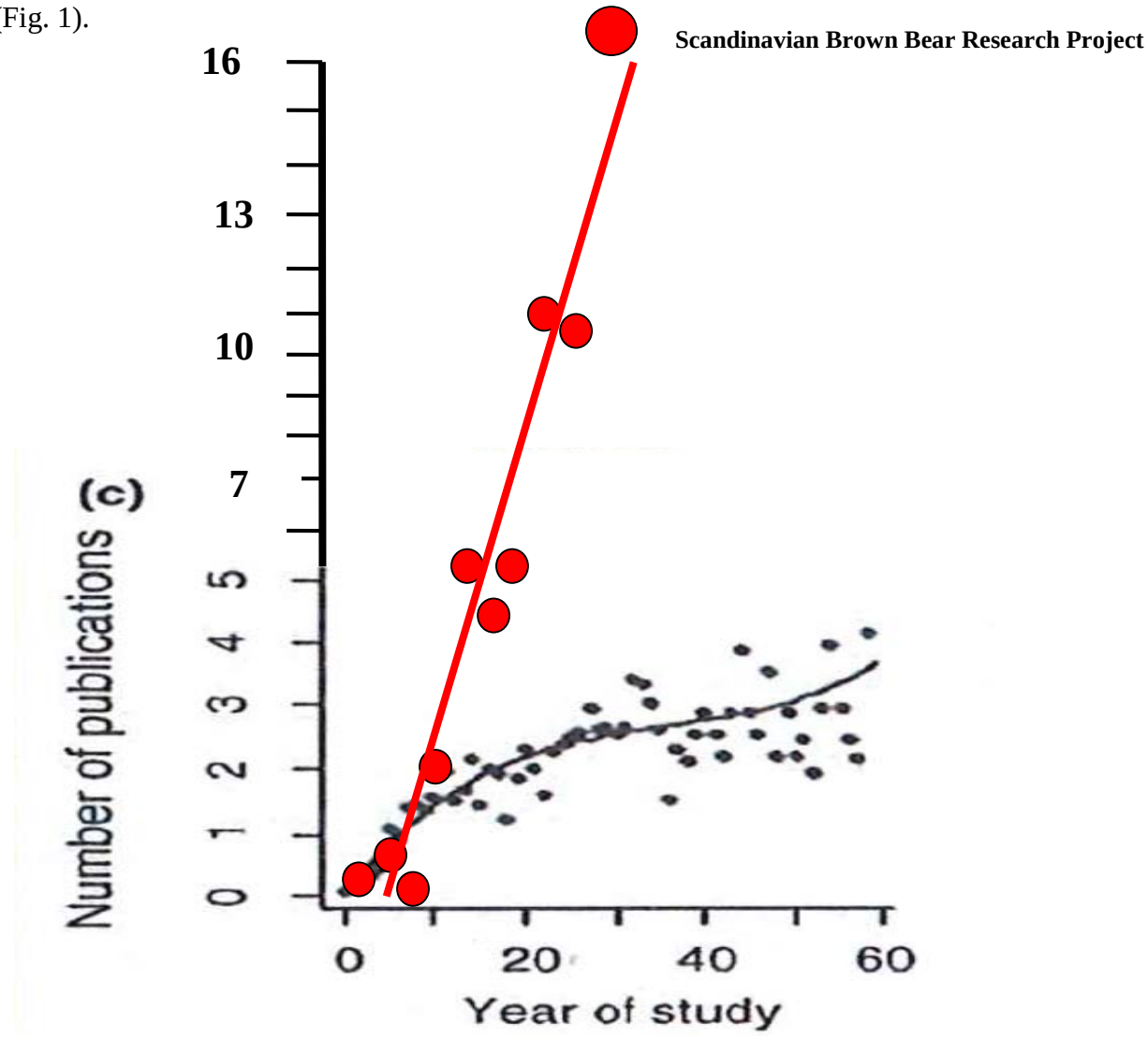

Figure 1. Number of scientific publications per year of study for 51 long-term, individual-based field studies of birds and mammals in the United Kingdom (figure from Clutton-Brock & Sheldon 2010) and those of the Scandinavian Brown Bear Research Project, annual averages for three-year periods (red circles)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