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EXPEDITION REPORT

Expedition dates: 28 May – 4 June 2022

Report published: March 2023

Scandinavian brown bears: Winter den sites and feeding ecology of bears in the woodlands of Dalarna county, Sweden

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Authors:
Andrea Friebe
Björn & Vildmark
Scandinavian Brown Bear Research Project

Matthias Hammer (editor)
Biosphere Expeditions

Abstract

This is a report about the second year of collaboration between Biosphere Expeditions and Björn & Vildmark with the overall purpose of researching the behaviour of free ranging brown bears (*Ursus arctos*) in central Sweden for the Scandinavian Brown Bear Research Project (SBBRP). This collaboration investigates, amongst other topics, how climate change as well as human activities affect the brown bear behaviour and population, and provides managers in Sweden with solid, science-based knowledge to manage brown bears.

From 28 May to 4 June 2022, six citizen scientists collected data on bear denning behaviour and feeding ecology by investigating the 2021/2022 hibernation season den sites of GPS-marked brown bears and by collecting fresh scats from day bed sites. All field work was performed in the northern boreal forest zone in Dalarna and Gävleborg counties, south-central Sweden, which is the southern study area of the SBBRP. After two days of field work training, citizen scientists were divided into three to four sub-teams each day. All study positions were provided by the expedition scientist and only data and samples from radio-marked bears with a VHF or GPS transmitter were collected.

Citizen scientists defined den types (anthill den, soil den, rock den, basket den or uprooted tree den), recorded bed material thickness, size and content, as well as all tracks and signs around the den sites to elucidate whether a female had given birth to cubs during hibernation. All first scats after hibernation and hair samples from the bed were collected, and the habitat type around the den and the visibility of the den site were described.

Twenty-six winter positions of 21 different bears were investigated. Two bears shifted their dens at least once during the hibernation season. In total, the expedition found 23 dens; two soil dens, eight anthill dens, one anthill/soil den, one stone/rock den, four dens under uprooted trees and seven basket dens. Unusually, one pregnant female that gave birth to three cubs during winter, and four females that hibernated together with dependent offspring spent the winter in basket dens. Normally basket dens are mainly used by large males.

Excavated bear dens had an average outer length of 2.0 m, an outer width of 2.2 m, and an outer height of 0.8 m. The entrance on average comprised 28% of the open area. The inner length of the den was on average 1.3 m and the inner width was 1.1 m. The inner height of the dens was on average 0.6 m. Bears that hibernated in covered dens used mainly mosses (47%), field layer shrubs (36%) and branches (14%) as nest material, which reflected the composition of the field layer and ground layer that was present at the den site. However, bears that hibernated in open dens such as basket dens, preferred branches (43%) followed by grass (26%); mosses (19%) and field shrubs (12%) as nest material. The expedition found two first post-hibernation bear scats at the den sites.

Ten bears selected their den sites in older forests, and eleven bears in younger forests, only two bears hibernated in very young forest. The habitat around the dens was dominated by spruce (*Picea abies*) 37%, scots pine (*Pinus sylvestris*) 35% and birch (*Betula pendula, Betula pubescens*) 27%.

As part of its intensive data collection activities, the expedition investigated about half of all winter den positions that the SBBRP recorded in 2021/2022 and collected 64 scats at cluster positions, which represents all scat samples that the SBBRP normally collects during a time period of 14 days. A detailed food item analysis will be performed in 2025 and the data will be published.

It appears that climate change is altering bear denning behaviour and may reduce food resources that bears need for fat production. Overharvesting (hunting) of bears and habitat destruction are the major reasons why brown bear populations have declined or have become fragmented in much of their range. In Scandinavia, human activity around den sites has been suggested as the main reason why bears abandon their dens. This can reduce the reproductive success of pregnant female brown bears and increases the chance of human/bear conflict. Understanding denning behaviour is critical for effective bear conservation. Further research is needed to determine whether good denning strategies help bears avoid being disturbed. Additionally, enclosed dens offer protection and insulation from inclement weather. A continued fragmentation of present bear ranges, inhibiting dispersal, together with an increasing bear population, might lead to bears denning closer to human activities than at present, thereby increasing human/bear conflict. The dens that were investigated by the expedition were visible from 22 m on average. Cover opportunities and terrain types not preferred by humans are thereby presumably important for bears that are denning relatively close to human activities, but further research needs to be done to validate this theory.

Through all of the above, the expedition made a very significant contribution to the SBBRP's field work in a showcase of how citizen science can supplement existing research projects run by professional scientists.

Sammandrag

Detta är en rapport om det andra året av samarbete mellan Biosphere Expeditions och Björn & Vildmark med det övergripande syftet att forska om beteendet hos vild levande brunbjörnar (Ursus arctos) i mellansverige för det skandinaviska björnforskningsprojektet (SBBRP). Samarbetet undersöker bland annat hur klimatförändringar och mänsklig aktivitet påverkar brunbjörnens beteende och population, och ger myndigheter i Sverige gedigen, vetenskapligt baserad kunskap för att förvalta brunbjörnstammen.

Från den 28 maj till den 4 juni 2022 samlade sju expeditionsdeltagare in data om björnens idesval och födoval. De undersökte idesplatserna där björnar har legat i vintersömnen under säsongen 2021-2022 och de samlade samla färsk spillning från daglegor från GPS-märkta brunbjörnar.

Allt fältarbete utfördes i norra boreala skogszonen i Dalarna och Gävleborgs län, södra mellersta Sverige, som är SBBRP:s södra studieområde.

Efter två dagars utbildning inom fältarbete delades expeditionsdeltagaren in i tre till fyra grupper. Alla studiepositioner tillhandahölls av expeditionsforskaren och endast data och prover från radiomärkta björnar med en VHF- eller GPS-sändare samlades in.

Expeditionsdeltagaren definierade idestyper (myrstackide, jordiden, steniden, korgiden eller iden under en rotvälta), och undersökte bäddmaterialet i idet, samt alla spår och tecken runt iden för att ta reda på om en hona hade född ungar under vintern. Alla första spillningar samlades in samt och hårprover från bäddmaterialed. Dessutom beskrevs habitatet och hur dold idet var placerad i terrängen.

26 vinterpositioner för 21 olika björnar undersöktes. Två björnar flyttade från sina iden minst en gång under vintersömnen. Totalt hittade expeditionsdeltagaren 23 iden; två jordiden, åtta myrstackiden, ett myrstackide / jordide, ett steniden, fyra iden under en rotvälta och sju korgiden. Ovanligt nog övervintrade en dräktig björnhona ett korgide där hon födde sina ungar under vintern. Dessutom övervintrade fyra honor med ungar i olika korgiden. Vanligtvis är det framförallt hanbjörnar som använder korgiden.

Utgrävda björniden hade en genomsnittlig yttre längd på 2,0 och yttre bredd på 2,2 m och en yttre höjd av 0,8 m. Ingången utgjorde i genomsnitt 28% av det öppna yta. Den inre längden på idet var i genomsnitt 1,3 m och den inre bredden 1,1 m. Den inre höjden på idena var i genomsnitt 0,6 m. Björnar använde främst grenar (43%), gräs (26%) bärris (12%) och mossor (19%) som bäddmaterial, vilket återspeglade sammansättningen av fältskiktet och jordskiktet som fanns vid idesplatsen. Expeditionsdeltagare hittade två första björnspillningar efter vintersömnen.

Tio björnar valde bygga sina iden i äldre skogar, elva i yngre skogar och två björnar övervintrade i väldigt ung skog. Habitatet runt idesplatsen dominerades av tall (Pinus sylvestris) 35%, gran (Picea abies) 37%, och björk (Betula pendula, Betula pubescens) 27%.

Expeditionen undersökte ungefär hälften av alla vinterpositioner som SBBRP registrerade under 2021/2022 och samlade in 63 spillningar på klusterpositioner, vilket motsvarar alla av de spillnings-prover som björnprojektet normalt samlar in under en tidsperiod på 14 dagar. En detaljerad spillnings analys kommer att genomföras under 2025 och uppgifterna kommer att publiceras efteråt.

Genom allt ovanstående gav expeditionen ett mycket viktigt bidrag till SBBRP: s fältarbete som visade hur expeditionsdeltagare kan komplettera befintliga forskningsprojekt som drivs av professionella forskare. Klimatförändringar förändrar björnens beteende och kan minska födotillgången. Intensiv björnjakt och förstörelse av habitat är de främsta orsakerna till att populationer av brunbjörnar har minskat eller blivit fragmenterade i stora delar av världen. I Skandinavien är mänsklig aktivitet kring idesplatser troligtvis det främsta skälet varför björnar byta iden. Detta kan minska reproduktionen bland dräktiga björnhonor och ökar risken för konflikt mellan människor och björnar. Förståelse av vinterbeteende är avgörande för effektiv bevarande av björnen. Ytterligare forskning behövs för att avgöra om goda vinterstrategier hjälper björnar att undvika störningar. Dessutom erbjuder väl isolerade ide skydd från dåligt väder. En fortsatt fragmentering av nuvarande björnstammen, som hämmar spridning, tillsammans med en ökande björnpopulation, kan leda till att björnar kommer närmare mänsklig bebyggelse, vilket ökar konflikterna mellan människa och björnar. De iden som undersöktes av expeditionen var synliga från 22 m i genomsnitt. Täta terrängtyper som inte föredras av människor är därmed förmodligen viktiga för björnar som bygger sina iden relativt nära mänsklig bebyggelse, men ytterligare forskning måste göras för att validera denna teori.

Contents

Abstract	2
Sammandrang	3
Contents	4
1. Expedition review	5
1.1. Background	5
1.2. Dates & team	5
1.3. Partners	5
1.4. Acknowledgements	6
1.5. Further information & enquiries	6
1.6. Expedition budget	7
2. Winter den sites and scat sampling of bears in Sweden	8
2.1. Introduction	8
2.2. Materials & methods	14
2.3. Results	27
2.4. Discussion	30
2.5. Literature cited	30
Appendix I: Den mapping protocol	41
Appendix II: Scat sampling protocol	43

1. Expedition review

M. Hammer (editor)
Biosphere Expeditions

1.1. Background

Background information, location conditions and the research area are as per Friebe & Hammer (2020). The expedition was part of a long-term research project in Dalarna county in Sweden to help study and protect the local brown bear (*Ursus arctos*) population. More about the local brown bear population and the history of the research project that the expedition assisted with is in chapter 2.

1.2. Dates & team

The expedition ran over an 8-day period and comprised a team of national and international citizen scientists, professional scientists and an expedition leader. Group dates were as shown in the team list below. Dates were chosen so that the expedition could visit the bear dens early in the season when tracks and signs were still fresh (bears usually leave their den sites from mid-April until the end of May).

The expedition scientist and co-author of this report was Dr. Andrea Friebe, the expedition leader was Roland Arnison. The expedition team of citizen scientists was recruited by Biosphere Expeditions and consisted of a mixture of ages, nationalities and backgrounds. They were (in alphabetical order and with country of residence):

28 May – 4 June 2022: Christiane Flechtner* (Germany), Evelyn Frey-Royston (Germany), Neil Goodall (UK), Karin Klingner (Germany), Ulrich Klingner (Germany), Patricia Smith (Belgium).

*journalist: See coverage (in German) in Nordis Magazine and Ein Herz für Tiere.

A medical umbrella, safety and evacuation procedures were in place. There were no medical incidences during the expedition.

1.3. Partners

Biosphere Expeditions' main partner on this expedition is Björn & Vildmark (Bears & Wilderness in Swedish), a company responsible for science communication, information and guided tours in the Scandinavian Brown Bear Research Project. Björn & Vildmark was established in 2001 with the purpose of distributing information about bear research and bear behaviour to the local population and managers. Dr. Andrea Friebe of Björn & Vildmark is also a researcher in the Scandinavian Brown Bear Research Project and the expedition followed the project's methodologies and shared its data with it.

1.4. Acknowledgements

This study was conducted by Biosphere Expeditions which runs wildlife conservation expeditions all over the globe. Without our expedition team members (listed above) who provided an expedition contribution and gave up their spare time to work as research assistants, none of this research would have been possible. The support team and staff (also mentioned above) were central to making it all work on the ground. Thank you to all of you and the ones we have not managed to mention by name (you know who you are) for making it all happen. Biosphere Expeditions would also like to thank the Friends of Biosphere Expeditions for their sponsorship and/or in-kind support.

The expedition was embedded within the Scandinavian Brown Bear Research Project and we would like to thank the Norwegian Institute for Nature Research (NINA), the Norwegian Environment Directorate, the Swedish Environmental Protection Agency and the Swedish Association for Hunting and Wildlife Management for funding.

1.5. Further information & enquiries

More background information on Biosphere Expeditions in general and on this expedition in particular including pictures, diary excerpts and a copy of this report can be found on the Biosphere Expeditions website www.biosphere-expeditions.org.

Project updates, reports and publications:
https://www.researchgate.net/project/Sweden-Researching-and-protecting-brown-bears-through-citizen-science

All expedition reports, including this and previous expedition reports:
https://www.researchgate.net/lab/Biosphere-Expeditions-Matthias-Hammer

Expedition diary/blog:
https://blog.biosphere-expeditions.org/category/expedition-blogs/sweden-2022/

Expedition details, background, pictures, videos, etc.
https://www.biosphere-expeditions.org/sweden

1.6. Expedition budget

Each team member paid towards expedition costs a contribution of €2,130 per person per 8-day slot. The contribution covered accommodation and meals, supervision and induction, special non-personal equipment, and all transport from and to the team assembly point. It did not cover excess luggage charges, travel insurance, personal expenses such as telephone bills, souvenirs etc., or visa and other travel expenses to and from the assembly point (e.g. international flights). Details on how this contribution was spent are given below.

Income	**€**
Expedition contributions	18,257
Expenditure	
Base camp and food includes all board & lodging, base camp services	2,989
Vehicles and fuel includes fuel, wear & tear, car hire charges; also includes per km support payment from Scandinavian Brown Bear Research Project	2,069
Equipment and hardware includes research materials & gear, etc.	680
Staff includes local and Biosphere Expeditions staff & expenses	2,963
Administration includes registration fees, sundries, etc.	234
Team recruitment Sweden as estimated % of PR costs for Biosphere Expeditions	3,998
Income – Expenditure	**5,325**
Total percentage spent directly on project	**71%**

Please note: Each expedition report is written as a stand-alone document that can be read without having to refer back to previous reports. As such, much of this section, which remains valid and relevant, is a repetition from previous reports, copied here to provide the reader with an uninterrupted flow of argument and rationale.

2. Winter den sites and scat sampling of Scandinavian brown bears in Sweden

Andrea Friebe
Björn & Vildmark
Scandinavian Brown Bear Research Project

2.1. Introduction

2.1.1. History, distribution and population dynamics of brown bears in Sweden and Norway

The brown bear (*Ursus arctos*) is a large non-social carnivore that is distributed over much of the Northern Hemisphere in Europe, Asia and North America. Bears live in a great variety of habitats, including treeless arctic tundra, grasslands, boreal forest, forested and alpine mountains and deserts. Overharvest (hunting) and habitat destruction are the major reasons why brown bear populations have declined or have become fragmented in much of their range (Tsubota et al. 1987, Servheen 1990, Zedrosser et al. 2001, Dahle 2003).

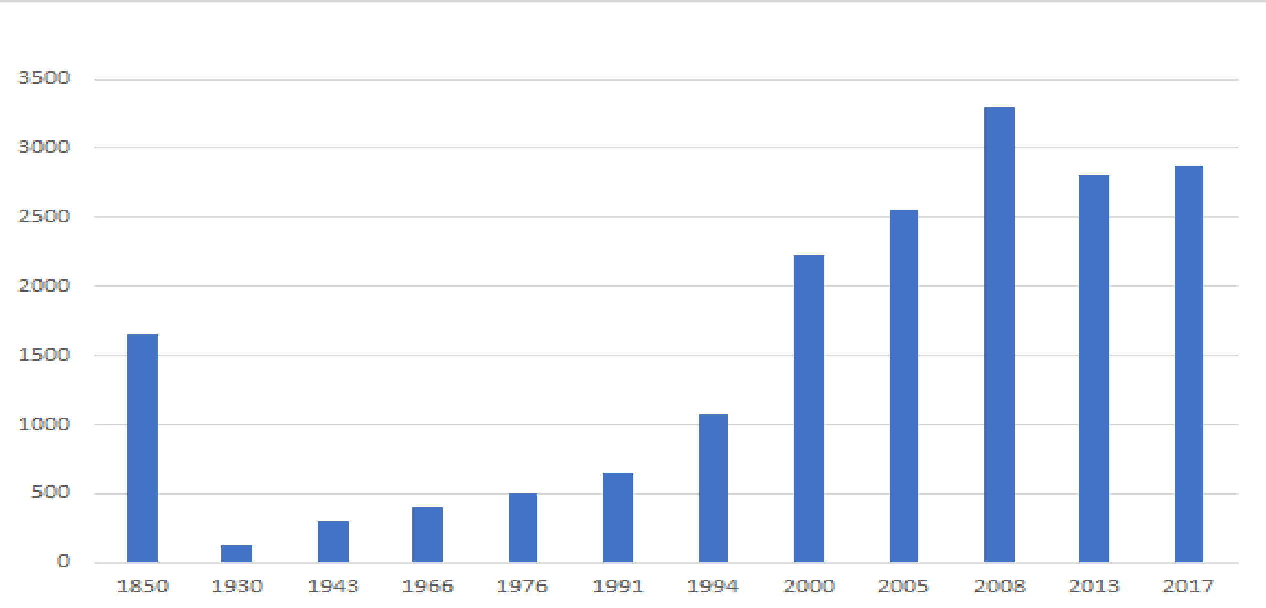

Figure 2.1.1a. Development of the brown bear population in Sweden. Estimated numbers of bears in different years, with 2017 being the last year for which published estimates are available.

Originally, bears were found throughout Scandinavia (Collett 1911-12, Lönnberg 1929). In the early and mid-1800s the brown bear was present throughout the Scandinavian Peninsula at varying densities. The highest density in Sweden was in the central parts of the country, with lower density in the northern parts. In the south, the bear had been largely extinct since the 18th century. Based on records of bear hunters by county, the Scandinavian population was estimated to have consisted of 4,700 to 4,800 individuals around the 1850s with the majority of bears (65%) living in Norway (Swenson et al. 1995).

Between 1856 and 1893, an enormous number of bears were killed: 2,605 in Sweden and 5,164 in Norway, and the population declined quickly, by about 4.8% annually in Sweden and 3.2% in Norway (Swenson et al. 1995). It was government and society policy at the time to exterminate bears and strong financial incentives were provided by government or existed already through the sale of bear skins and meat. As a result, bears gradually disappeared from south to north, and survived only in a few mountainous areas in northern and central Sweden.

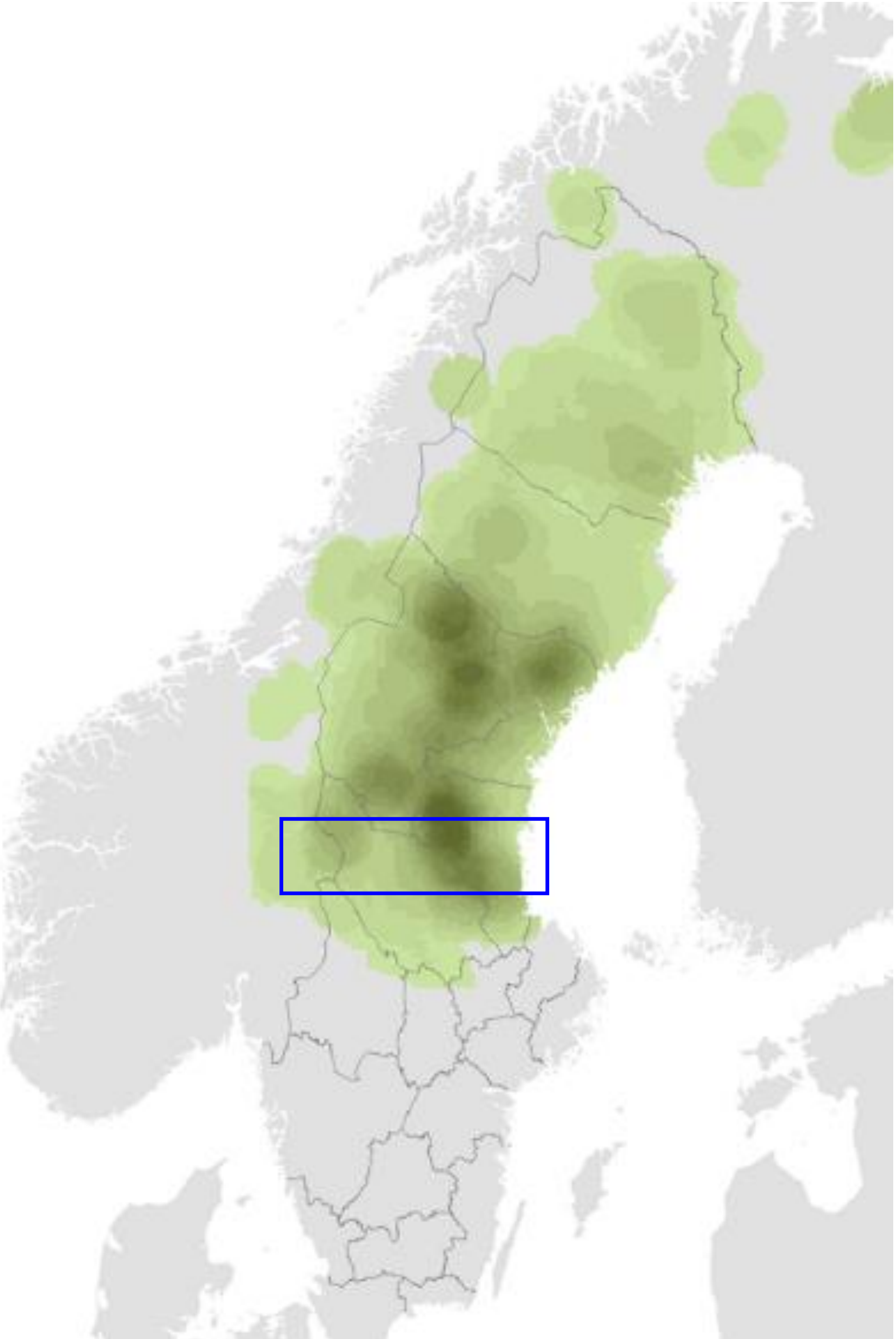

Figure 2.1.1b. Map showing bear population density in 2017 in Sweden and Norway (from Kindberg & Swenson 2018). The darker the colour, the higher the density. Blue rectangle = southern study site of the Scandinavian Brown Bear Research Project = expedition study site.

As the 19th turned into the 20th century, many realised that the situation had become critical for brown bears in Norway and Sweden. As a result, brown bears were protected in national parks in Sweden in 1910, and on Crown land in 1913. In Norway the brown bear only received protection in the whole of Norway in 1973 (Swenson et al. 1995). The low point for the brown bear population in Sweden was around 1930, when about 130 bears were left in four populations. The last population in Norway became functionally extinct in 1931, although brown bears were still observed throughout the 1980s.

In 1942 the Swedish bear population was estimated at 294 and an autumn hunting season for bears was introduced in 1943. The hunting quota was strict and geographically limited during the following years and averaged 5.5% of the calculated population size. Population recovery in Sweden continued at a rate of about 1.5% per year until 1995. In 1993 estimates showed that the Scandinavian population consisted of around 700 individuals.

Calculations previously carried out on marked bears by the Scandinavian Brown Bear Research Project indicated a growth rate in the southern part of the Swedish bear population during the 1990s of about 16%. The total number of individual bears was estimated to be about 3,200 in 2008 (Kindberg and Swenson 2014), with a minimum of 120 individuals in Norway (Wartiainen et al. 2009). A new estimate in 2013 showed a contraction and estimated about 2,800 bears in Sweden (Kindberg and Swenson 2014). The 2017 inventory showed no statistically significant growth compared to 2013 (Kindberg and Swenson 2018).

2.1.2. The Scandinavian Brown Bear Research Project

The Scandinavian Brown Bear Research Project started in 1984 to collect and evaluate facts about the ecology of the brown bear. The project is a co-operation between Sweden and Norway with a number of different goals such as studying the bear's choice of food, weight development, patterns of movement, colonisation of new areas, choice of den, social behaviour, mortality and reproduction. Even interactions with other species, such as moose and domestic livestock have been investigated, as well as the sensitivity of bears to human disturbance and human-bear conflict. Since 1984, the Scandinavian Brown Bear Research Project has published more than 280 scientific articles, reports and popular science publications.

Up to today, more than 900 bears have been captured using a helicopter in spring, shortly after the animals emerge from their dens. Spring provides the best conditions, when remaining snow cover and minimal vegetation make it easier to find bears, open water in the terrain is limited, and ambient temperature is relatively low. Captured bears are fitted with a GPS collar containing integrated activity acceleration sensors, which provide very accurate and frequent information points about the bear's activity and movements, and a VHF implant. GPS location data are then transmitted via the GSM network to a base station from which they can be downloaded remotely. The GPS collars are programmed to collect GPS location fixes at 1-hour intervals during the period of 1 April until 30 November and once per day (at noon) from 1 December until 30 March.

2.1.3. Bear biology

Brown bear weight and body size vary geographically and depend on food availability. North American brown bears, which have access to a high-protein diet, often have a larger body size and the shape of the skull is narrower than in European animals (Hörning 1992).

Brown bears are sexually dimorphic. Males are up to 2.2 times larger than females and the spring body mass of adult individuals averages 115 kg for females and 248 kg for males in central Sweden (Swenson et al. 2007). Annual home ranges in Sweden overlap and male bears typically have larger home ranges (median: 1055 km^2 than females (median: 124-217 km^2, depending on reproductive status) (Dahle and Swenson 2003).

Brown bears are omnivorous and their diet varies among populations and seasons. In Scandinavia, the diet is mainly composed of graminoids, forbs, berries, ants, and ungulates (Dahle et al. 1998, Persson et al. 2001). During spring and early summer, adult brown bears accumulate lean mass reserves (Hilderbrand et al. 1999) from foods rich in protein (Swenson et al. 2007). The period of fat accumulation (hyperphagia) starts in August, when the bears in Sweden consume mainly berries rich in carbohydrates to gain adipose fat tissue before entering the winter den (Dahle et al. 1998).

Bears are the only mammals with delayed implantation, gestation, parturition (birth), and lactation during hibernation. The mating season of brown bears lasts approximately two to two and a half months in Sweden, the main matin season is from mid-May to early July (Dahle 2003, Steyaert 2012). Young bears in Sweden reach sexual maturity at an age of three to five years (Swenson et al. 1995), whereas in North America they are usually older (McLellan 1994, Hilderbrand et al. 1999). Brown bears are promiscuous, both males and females mate with different partners (Bellemain et al. 2006, Spady et al. 2007, Zedrosser et al. 2007, Steyaert et al. 2012). Fertilized eggs undergo diapause at the blastocyst stage for four to five months until delayed implantation occurs in November-December (Wimsatt 1963, Foresman and Daniel 1983. Sato et al. 2000, Iibuchi et al. 2009). A minimum amount of body mass and fat content (about 19% in brown bears) prior to hibernation is necessary for reproduction (Rogers 1976, Beecham 1980, Elowe and Dodge 1989, Atkinson and Ramsay 1995, López-Alfaro et al. 2013). Dates of birth are independent of the dates of oestrus, mating and denning (Dittrich and Kronberger 1963, Sandell 1990, Spady et al. 2007, Friebe et al. 2014). Brown bears commonly give birth to one to three cubs, which are born in the den in January/February (Friebe et al. 2013, Friebe et al. 2014). The neonates, which weigh about 500 g, are naked at birth, and are nursed by their mother with fat- and protein-rich milk in the winter den (Farley and Robbins 1995, López-Alfaro et al. 2013). Gestation in ursids lasts approximately 56-60 days (Tsubota et al. 1987, Quest 2001, Spady et al. 2007, Friebe et al. 2014). Lactation in brown bears lasts about 1.5-2.5 years (Farley and Robbins 1995) and the mean litter interval varies among populations and lasts on average 2.8 years in European brown bears (Nawaz et al. 2008, Zedrosser et al. 2011, Steyaert et al. 2012). Longevity of free-ranging brown bears is 25 to 30 years, and reproductive senescence in females occurs around 27 years (Schwartz et al. 2003).

Hibernation is one of the most efficient energy-saving mechanisms, which is regularly activated early in advance of the beginning of winter (Nelson 1973). In contrast to other hibernating species, the body temperature of bears drops only 2 to 6 °C below the summer core temperature of 37-38 °C, (French 1986, Hissa et al. 1994, Tøien et al. 2011). Heart rate during hibernation can be as low as 8-10 beats per minute (bpm), compared to the heart rate of 30-50 bpm of sleeping bears in summer (Folk et al. 1972, Nelson et al. 1973, Folk et al. 1976, Folk et al. 1980, Nelson et al. 2003, Folk et al. 2008). During hibernation, bears are largely inactive. They do not eat, drink, urinate, or defecate, but subsist on the energy resources they gained during the active season. Their basal metabolic rate decreases by 40%, and their oxygen consumption by about 50% of normal levels (Hellgren 1998). During hibernation, bears lose between 20-45% of their body weight, depending on several factors, e.g., duration of denning, sex, age, and reproductive status (Nelson et al. 1973, Nelson 1973, Kingsley et al. 1983, Swenson et al. 2007, López-Alfaro et al. 2013).

In Sweden all brown bears hibernate and spend five to seven months in their dens, depending on sex, reproductive status, age and latitude (Friebe et al. 2001, Manchi and Swenson 2005). The process when bears enter their dens is called denning. Denning is an essential part of the ecology and reproduction of brown bears, because pregnant females give birth to cubs during winter. The male bears leave their dens at the beginning of April, some males as early as March. Female bears rest until the middle of April. Normally bears leave their den sites directly after the end of the hibernation. However, females that have given birth to cubs during hibernation often stay close to their dens for another two to three weeks, sometimes until the end of May, because dens offer protection against the cold and predators. Bears prefer different types of dens depending on the ground characteristics and the surrounding area, but there are also individual preferences. Bears in Sweden normally do not reuse their dens, but dig a new den every year. Most bears hibernate alone; only females with cubs share their den for one or two winters. Bears have the instinct to dig dens from birth. In Sweden brown bears mainly hibernate in excavated dens such as anthill or soil dens. Brown bears select denning habitats on the landscape scale by avoiding water and intermediate-sized roads and by denning more at lower altitudes (Elfström et al. 2008, Elfström and Swenson 2009).

2.1.4. Background to den site surveys

Bears normally avoid human infrastructure when denning, but due to an expanding bear population some bears den relatively close to humans. Hibernating bears survive on the energy stores they have accumulated during the autumn hyperphagic (fattening) period. Thus, the denning period is a vulnerable time for bears, because they are unable to escape from disturbances without losing valuable amounts of energy (Elowe and Dodge 1989, Welch et al. 1997, Ordiz et al. 2008). Well-nourished females have larger litter sizes and shorter litter intervals (Bunnell and Tait 1981, Rogers 1987, Stringham 1990, Ryan 1997, Welch et al. 1997, McLellan 2011) and disturbances of pregnant female brown bears during the winter can reduce their reproductive success (Swenson et al. 1997b). Especially after females give birth, the cost of den relocation rises dramatically, because young cubs will be exposed to thermal stress. Thus, the choice of a safe place for the den appears to be of vital relevance, particularly for reproducing females.

In Scandinavia, human activity around the den site has been suggested to be the main reason why bears abandon their dens (Swenson et al. 1997b). And indeed, several researchers have suggested that bears select their den sites to reduce such risks of disturbance (Ciarniello et al. 2005, Elfström et al. 2008, Elfström and Swenson 2009, Goldstein et al. 2010). Many wildlife species use cover to avoid human disturbance, presumably because of the reduced detection risk. During the non-denning period, brown bears select resting sites that are more concealed when the risk of human encounters is higher and when resting closer to human settlements (Ordiz et al. 2011).

The moose-hunting season in Sweden starts at the end of September and is most intense during October and beginning of November. Forestry activities also occur year-round. Both activities have great potential for disturbing bears during hibernation, especially moose hunting, which often involves unleashed baying dogs (Sahlén 2013). Although brown bears in Sweden generally are not aggressive, they do sometimes injure humans. The period of highest risk coincides both with brown bear den entry and the moose hunting season, when large numbers of hunters and their hunting dogs are present in the forest (Friebe et al. 2001, Manchi and Swenson 2005, Moen et al. 2012).

In order to understand how to reduce the rate of injury, it is important to learn more about bear choice of denning habitat, but thus far, very little information about brown bear denning behaviour and den site selection is available. Therefore, the results of this study will help managers to improve the safety of both humans and bears, e.g. by developing appropriate hunting restrictions; informing forest managers about brown bears' denning habitat selection in order to preserve areas that brown bears visit during winter; and informing the public on how to minimise disturbances, which can lead to injuries (Sahlén et al. 2011).

Dens built in old anthills appear to be the most common den type in Scandinavia (Swenson et al. 1999, Manchi and Swenson 2005, Nowack 2015), especially among females which are more selective than males in den type selection, considering that they have greater costs related to disturbance during hibernation (Elfström and Swenson 2009). Nowack (2015) found that anthill denning does result in bigger litter size. Therefore, we suggest that pregnant females hibernating in anthill dens can save a significant amount of energy in comparison to hibernating in other den types. Nowak (2015) also reported that clear-cutting forestry may have negative effects on the brown bear reproduction and thus population dynamics. Thus, it is important to gain more detailed knowledge of the den site selection of free-ranging brown bears in Sweden and to evaluate how environmental, behavioural and individual factors, as well as climate change, influence the den site selection.

2.1.5. Background to scat inventory surveys

Understanding a species' feeding ecology is essential for successful management and conservation, because food abundance can influence body mass, survival, reproductive success, movements, and habitat use. One of the "missing links" in the bear project is that we have no good understanding of the foods bears depend upon. We monitor the effects of climate change, but have no data or only very little data about the changes across time and space of essential food resources and how bears use those resources. We also have only a very little understanding around if and how bears switch between major food sources in relation to environmental conditions or anthropogenic changes in the habitat. Most of our knowledge is based on short-term studies carried out in the late 1990s and very early 2000s. Bear densities have likely changed since then, and the bear population is now likely to be at carrying capacity. If we want to understand how climatic and anthropogenic changes in the habitat affect bears, their ecology, fitness and reproductive output, and population development, then we must start monitoring how bears use their food resources over time. The purpose of the scat collection that started in 2015 is to establish and test a long-term routine monitoring programme of bear nutrition/foods based on scats from known individuals.

2.2. Materials and methods

Human disturbance often has a negative effect on bears such as den abandonment, stress, habitat loss, fragmentation of habitat including alterations in food availability and reduced reproductive success. Information about den site selections and the bears' choice of food will be helpful for managers when making decisions for brown bear conservation.

The two main tasks of the expedition were

- to investigate the den sites where radio marked bears of the Scandinavian Brown Bear Research Project have hibernated in order to gain more knowledge about denning behaviour and

- to find and collect scats for future analysis about the bear feeding ecology.

2.2.1. Study area and population

This study was conducted in the northern boreal forest zone in Dalarna and Gävleborg counties, south-central Sweden (~61°N, 15°E), which is the southern study area of the Scandinavian Brown Bear Research Project. The area comprises about 13,000 km^2, is hilly, and is covered with coniferous forests with interspersed lakes and bogs. Altitudes range from 200 m in the southeast to 1,000 m in the west but are mostly (>90 %) below the treeline, which is at about 750 m (Dahle and Swenson 2003). The forest is dominated by Norway spruce (*Picea abies*), Scots pine (*Pinus sylvestris*), and birches (*Betula pendula* and *Betula pubescens*). Ground vegetation includes a variety of species of mosses, lichens, grass, heather and berries. Bilberries (*Vaccinium myrtillus*) and crowberries (*Empetrum nigrum ssp. hermaphroditum*) are the main autumn food resource of brown bears in this area (Opseth 1998).

The landscape is intersected by a dense network of logging tracks (0.7 km/km^2) and a few high-traffic asphalted roads (0.14 km/km^2) (Martin et al. 2010). The human population density is low and only a few small villages exist in the study area (Swenson et al. 1999).

Snow cover lasts from the end of October until late April and mean daily temperatures range from −7 °C in January to 15 °C in July (Swedish Meteorological and Hydrological Institute).

The study area of the Scandinavian Brown Bear Research Project (Fig. 2.1.1b) is part of the southernmost core reproductive area for Scandinavian brown bears, with a population density of about 30 individuals per 1000 km^2 (Bellemain et al. 2005, Solberg et al. 2006, Kindberg et al. 2011). The brown bear is a game species and legal hunting is the single-most important cause of mortality for brown bears in Sweden (Bischof et al. 2009). The annual brown bear hunt runs from 21 August until quotas are reached (45–75 bears are harvested per year in the study area), but stops by no later than 15 October, in order to protect hibernating bears from disturbance.

2.2.2. Training and deployment of citizen scientists

The expedition team comprised six citizen scientists recruited by Biosphere Expeditions, one expedition leader from Biosphere Expeditions and the expedition scientist (and lead author of this report).

During the first two days of the expedition, citizen scientists were introduced to the field work (no prior knowledge was required before arrival). Training was a mixture of presentations (Fig. 2.2.2a), classroom lessons and outdoor practice sessions (Fig. 2.2.2b) to become acquainted with daily routines, safety aspects, field protocols, datasheets, data entry, sample collection and storage, as well as equipment use and handling. The first two den and cluster sites were investigated as one large group under the supervision of the expedition scientist.

Figure 2.2.2a. An indoor presentation as part of the citizen scientists training sessions.

Figure 2.2.2b. An outdoor equipment training session. © Chris Flechtner.

After the training days, citizen scientists were divided into sub-groups of three. Sub-groups differed on purpose in how long and difficult the tasks for the day were so that citizen scientists of varying ability and fitness could decide on which sub-group to join. Each sub-group was briefed at the expedition base on the weather, safety, den positions assigned to it for the day, as well as other tasks and points of note (Fig 2.2.2c).

Figure 2.2.2c. Briefing before going out into the field on research tasks.

The sub-group received a backpack with the equipment required for the den study and for scat sampling including: a road map, a mobile phone with the program tracker, a handheld GPS with a camera and reserve batteries, the field protocols and manuals, pens, a paper map with the daily positions of the dens/scats, a communication radio, plastic bags, hand disinfectant, gloves, sample labels, den measuring tools such as a measuring tape, a torch, a densiometer, a relascope, and a cylinder for the habitat measurements.

Sub-groups then navigated by vehicle to the road points nearest to their assigned study positions and continued on foot to them cross-country and guided by a GPS, performed their research tasks (Fig 2.2.2d), returned to their vehicles and repeated the process for the next position until their work was done or they had run out of time.

Figure 2.2.2d. Data collection and recording.

All study positions were provided by the expedition scientist. Den locations had been identified with telemetry by triangulation from the ground during the winter or by coordinates obtained from GPS-collared bears. Based on the observed movement data, cluster sites corresponding to bed sites of bears were located. A cluster site was defined as a minimum of three consecutive locations within a circle of 30 m radius, i.e. an area where a bear had spent more than two hours, suggesting resting time. Daily research routes for sub-groups were planned each evening for the next day and the positions were inserted into the handheld GPS and then visited in the field. Because bears have large home ranges, it was necessary for the sub-groups to drive on small forest roads to come as close as possible to the study positions. The remaining walking distance from the closest forest road position to the den or cluster position was on average 300 to 1,200 m.

All measurements and observations were noted into the field protocols. The completed protocols received a unique protocol ID to ensure linkage between collected data/samples and a scanned field protocol sheet. The protocol ID contained the name of the study, the year of the data collection, initials of the observer and a running number (e.g. DENS_2022_MaHa_001).

Only data and samples from radio-marked bears with a VHF or GPS transmitter were collected. The bear ID, age, sex and reproductive status were added to the protocol, because denning and foraging strategies often vary among bears in different age, sex, and reproductive classes. The reproductive status contained information if the bear was solitary, accompanied with cubs born in the same year or by older offspring.

2.2.3. Field work

Den sites

When a den was found at or around the study position given (this was not always the case), the actual coordinates of the den position were noted on the protocol, including the time range the bear had been in the den. Some bears shift their dens during winter. If the reason why the bear abandoned the den was known (e.g. forest felling, hunting activities, etc.), the information about the type of disturbance was noted.

Den type

All dens were examined and the den types were defined. In Sweden bears mainly use the following different types of dens:

Anthill den: The most common den type is the anthill den. This den type is significantly more often used by females than by males (Elfström and Swenson 2009). Female preference for specific den types is probably related to the higher degree of insulation and protection from disturbance in anthill dens, especially compared to basket dens, which are almost exclusively used by large adult males (Elfström et al. 2008). The anthill den seems to combine all important attributes to function as optimal shelter. It is composed of thick walls that often are overgrown by bilberries (*Vaccinium myrtillus*), providing good stability in comparison to other den types, which are to varying degrees reliant on a closed snow layer for insulation.

Soil den: Soil dens are often built at or into slopes. It is easier to dig horizontally rather than vertically, and has the advantage of the opening facing to the side. This keeps the warmth inside the den and does not expel the heat upwards. Additionally, the den is better protected from snow and rain if the entrance faces to the side of the den. The difference between the anthill den and the soil den is mainly in the composition of the walls. The walls of an anthill den consist of relatively loose organic material interspersed with roots, creating an additional insulating air layer. Soil dens usually miss this insulating air layer and may also contain more moisture.

Anthill/soil den: This is basically an anthill den that is also dug into the ground soil. For a combination of anthill/soil den the following apply: 1. If the den consists of >80% anthill material = the den is defined as an anthill den; 2. if the den consists of >80% soil material = the den is defined as a soil den; 3. if the den consists of 20-80% anthill with the rest soil material = the den is defined as an anthill/soil den. For dens of this type two digital pictures, one from the front and one from the side are always taken. Some dens collapse during or after hibernation, in which case no measurements were taken.

Stone/rock den: The rock den cannot be adjusted in space and fit, but is the typical bear den that is pictured in many books. The many rocks that remain from the withdrawal of the most recent ice age offer the bear a suitable place to rest during winter. Rock dens only constitute 7% of dens in Sweden (Elfström and Swenson 2009).

Basket den: Only 9% of dens in Sweden are so-called basket dens (Elfström and Swenson 2009). These dens look like giant bird nests made from branches and twigs, without a roof. When it snows, the bear inside the nest is then covered by snow as the only insulating layer. Bears therefore sleep protected as if in an igloo, on top of their beds. Mostly male bears hibernate in this manner, however, it has happened that females give birth to their young in open dens (Elfström and Swenson 2009).

Uprooted tree den: A few bears use uprooted trees as a cover during hibernation. Those dens, just like the basket dens are open and not totally covered during winter if very little snow falls during winter.

Den measurements

The direction of the den entrance was taken with a compass in degrees according on the 360º scale.

Figure 2.2.3a. Investigating and measuring a bear den.

To estimate insulation properties, we estimated the proportion (in %) of the inner surface area of the walls and ceiling that was open. A basket den typically has 100% open area. If a den had several openings, e.g. an entrance that accounted for e.g. 15%, plus a hole that accounted for 5% of the open area, the total proportion was 20%.

Bears usually collect den bed material that mainly contains moss, berry shrubs, heather lichens or grass. The amount of bed material varies among dens. The thickness and the size of the bed, including the material of the bed, were measured and recorded. Some females with new-born cubs (who stay longer at the den site) often remove the bed from the den in order to rest outside of the den. If the bed was removed from the den, we estimated content of the bed material, but did not take bed size measurements.

All other measurements were taken with a measuring tape in accordance with Fig 2.2.3b (see also Fig. 2.2.3a).

DEN MEASUREMENTS

1. OUTER LENGTH..................................CM OBS: CM ! ! !
2. OUTER WIDTH...CM
3. OUTER HEIGHT..CM
4. ENTRANCE HEIGHT*...............................CM
5. ENTRANCE WIDTH*.............................CM
6. ENTRANCE LENGTH**..........................CM
7. INNER ENTRANCE HEIGHT..........................CM
8. INNER ENTRANCE WIDTH**.................CM
9. INNER LENGTH..CM
10. INNER WIDTH...CM
11. INNER HEIGHT...CM
12. BED LENGTH....................................CM
13. BED WIDTH....................................CM
14. BED DEPTH.......................................CM
15. BED THICKNESS...............................CM
16. THICKNESS OF WALLS AND ROOF.........CM..........CM..........CM
    (6 MEASUREMENTS) .........CM..........CM..........CM

*Maximum measurement for the bear, no cracks etc
**when applicable

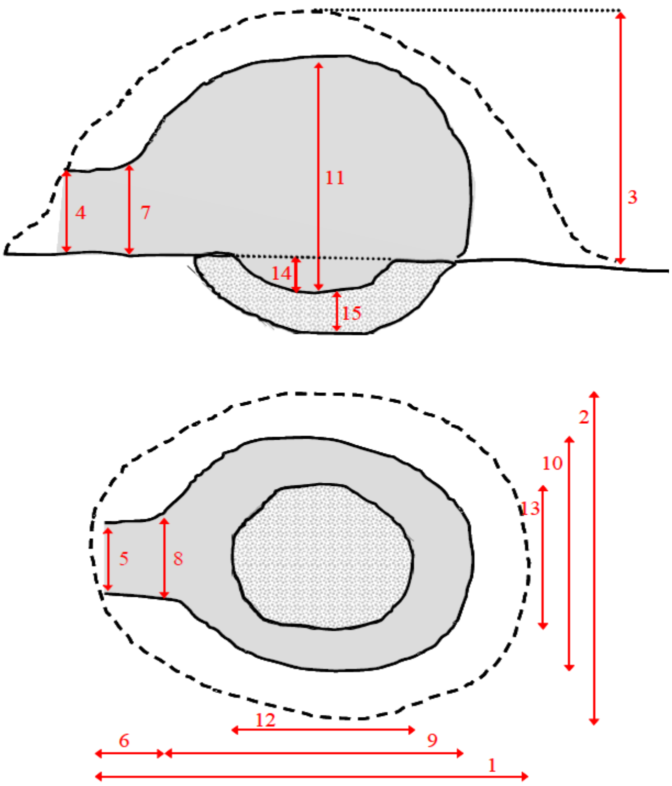

Figure 2.2.3b. Den measurement as per the field protocol.

Tracks and signs at den sites

Tracks and signs around the den sites (Fig. 2.2.3c) can provide important information about winter behaviour, as well as provide hints as to whether a female has given birth to cubs during hibernation. The reproductive success of female bears is often documented by direct observation after a female has left the den with or without offspring. Infanticide is common during the mating season that starts early after the denning season is over. Primiparous female brown bears (bears that give birth to cubs the very first time) lose their cubs often directly after den emergence and as such can be classified into the wrong reproductive class, because no cubs are observed after den emergence. Bear cubs are very curious and active. As such they leave many signs at the den sites, such as scratch marks on trees after climbing. There marks are easily recognized on birch trees, as their bark is very sensitive. Where cub signs were found, they were noted on the protocol.

Figure 2.2.3c. Bear signs: Top left - climbing marks of a bear cub on birch tree, top right - bear cub in tree. Bottom left - climbing marks of adult bear, bottom right - gnaw marks of adult bear.

In addition, all signs of food intake, such as opened tree stumps, where bears had eaten carpenter ants, excavated anthills of *Formica* spp., which is often the first food resource for bears in spring, as well as kill remains from moose and their calves, were recorded.

Samples

The first scat: Bears do not defecate during hibernation and the first scat is most often found around the den. This scat is very large and heavy and easy to distinguish from other scats (Fig. 2.2.3d). It contains concentrated waste products that have accumulated inside the intestines during hibernation. Bear cub claws inside first scats have been reported from North American black bears, which indicates that the mother has eaten its cub during hibernation, probably because the bear cub died (Scanlon et al. 1998). We examined all first scats in the field, and collected them in a plastic bag, to freeze them for future analysis.

Figure 2.2.3d. The first bear scat after hibernation is large, heavy and very dense.

Habitat descriptions

The habitat around the den was described on two different levels: large and small scale.

The large-scale level habitat within a 50 m radius around the den was investigated to obtain more information about the forest category that bears select for denning in general. Sometimes, several habitat types existed within this 50 m radius. In that case only the habitat where the den was situated was described (for detailed information about the habitat and forest categories, see the den protocol in Appendix I). We measured the size of the habitat where the den was located to get an idea about the habitat structure and how limited/extensive the habitat was. In Sweden, intensive forestry is carried out, but sometimes small patches of dense habitat that have been spared from logging remain. A patch size was defined as follows: small <0.1 ha, medium 0.1-1 ha, large >1 ha.

If the den was located in a habitat with elevation, we measured the bearing and the incline of the terrain with the compass, recorded in degrees on the 360º scale. Additionally, we counted the proportion of all tree species that comprised the forest within the defined habitat. Only trees >1 m in height were counted and all recorded tree species (usually only pine, spruce and birch) should add up to 100% in total.

The small-scale level habitat within a 10 m radius around the den site was investigated in order to gain more knowledge about the habitat requirements at the den site. We studied the ground vegetation within the small-scale level habitat. First, we measured the proportion of the area without vegetation (e.g. if the area was covered by rocks or sand where no vegetation was present). Then we divided the ground vegetation into a ground layer (moss and lichens) and a field layer (berry foliage, heather, grass, herbs). The total proportion of ground layer and total proportion of field layer could exceed 100% as different vegetation categories can grow over each other (e.g. berry shrubs often grow in a field layer above a ground layer of mosses or lichens).

Tree density measurements (number and size): We also counted the number of each tree species (>3 m in height) within 10 m from the den entrance. Then we measured the average tree height of all tree species (pine, spruce and birch) present with the habitat with a relascope (Fig. 2.2.3e).

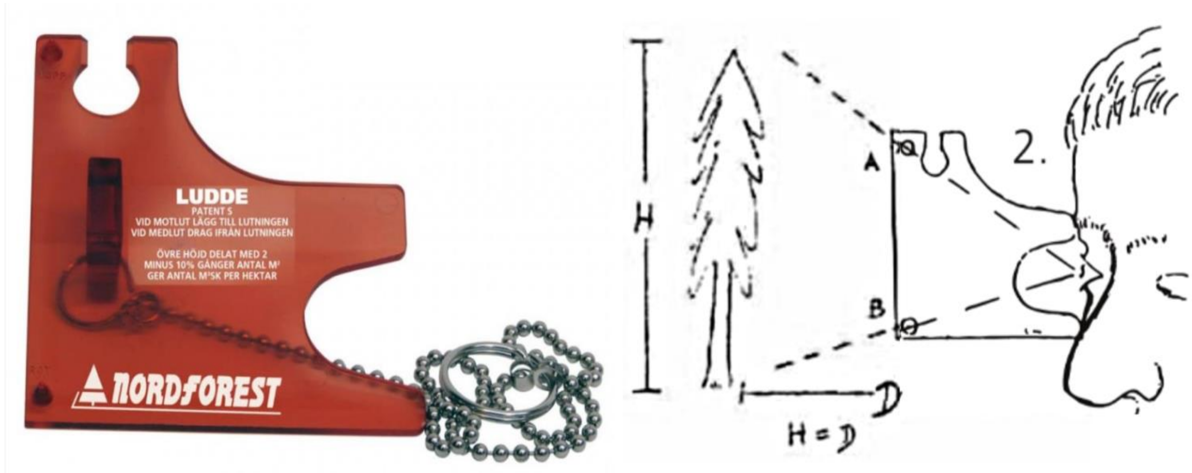

Figure 2.2.3e. Relascope (Ludde) method to measure tree height: When the relascope is placed against one eye as shown and the top and the bottom of the tree are aligned with the measuring pins A and B by walking away from or towards the tree, then the distance D, which can be measured on the ground easily by a measuring tape, equals the height of the tree H.

In order to elucidate forest density, we counted the number of tree stems for each tree species that fell outside the upper relascope gap at breast height level in a circle of 360° around the den entrance. Tree stems that were smaller than the gap were not counted (Fig 2.2.3f).

The horizontal cover represents the visibility of the den from ground level. This was measured by placing a red and white cylinder-shaped device (60 cm high, 30 cm wide, see Fig. 2.2.2g) at the entrances of the dens. We then walked in all four cardinal and one random direction and measured the minimum distance required for the device to be completely hidden from view. Thus, the shorter the sighting distance, the more horizontal cover the den had.

Canopy cover (crown cover) was measured with a spherical convex or concave mirror known as a densiometer (Lemmon 1956). The mirror is divided into 24 fields with each field containing four points (see Fig. 2.2.3h). We performed four measurements (in each cardinal direction) and counted the number of dots that were not covered by vegetation (when the sky reflected in the mirror). The lower the canopy openness, the more canopy cover the den had.

Figure 2.2.3f. Relascope (Ludde) method to score tree stems. Stems that fall inside the relascope gap are not scored (such as the pine tree shown); those that are equal to or larger than the gap are scored.

Figure 2.2.3g. Red and white cylinder-shaped device (60 cm high, 30 cm wide) that was placed at the entrances of the dens.

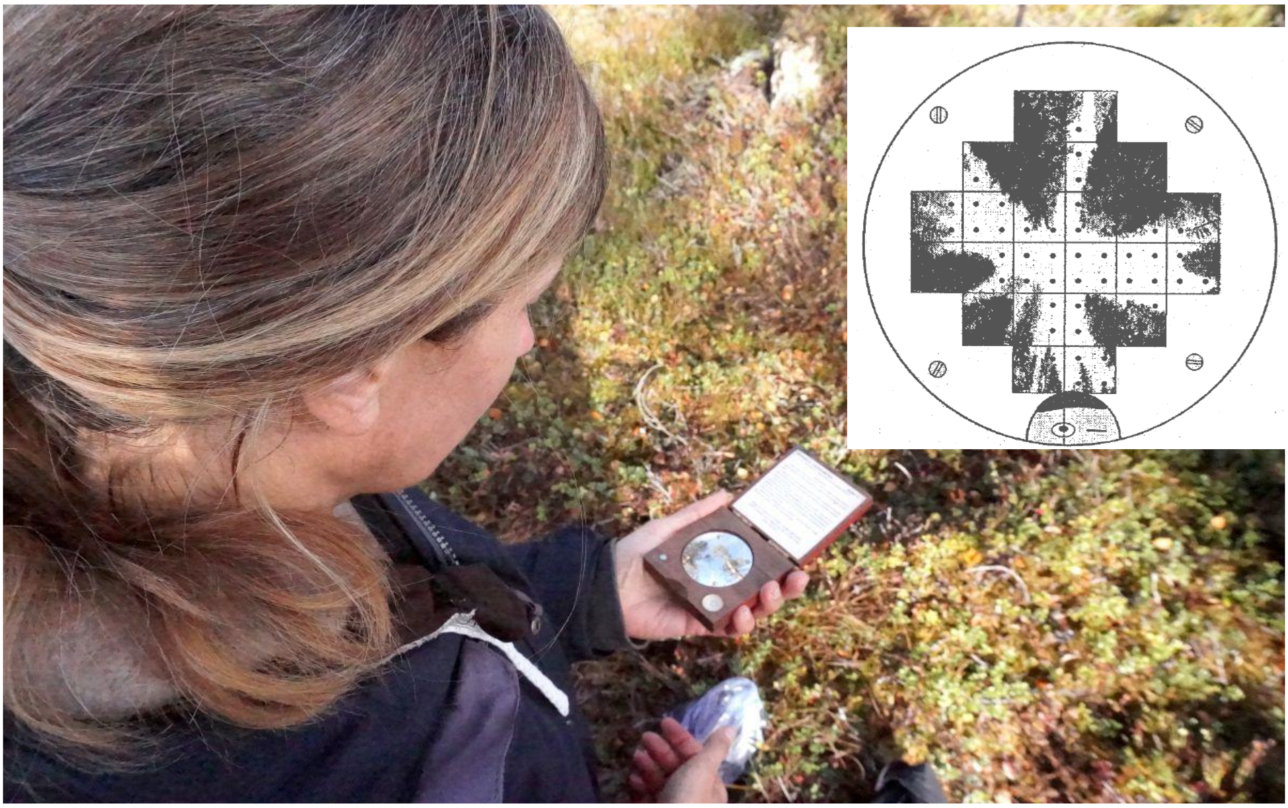

Figure 2.2.3h. Densiometer method to score canopy cover by counting dots not covered by tree canopy. Shown are the densiometer in use and a typical view of the densiometer mirror with trees covering some dots and leaving others clear.

Scat sampling at cluster sites

The Scandinavian Brown Bear Research Project collects scats from GPS-collared bears from late May until late September. One scat of every GPS-collared individual should be collected on a bi-weekly basis. The expedition assisted with this project by collecting scats from bear clusters that had previously been identified between 23 May and 03 June 2022 (see below for cluster identification and location).

Finding scats and day beds

Bear clusters are places where bears remain for longer than two hours, such as day and night beds (resting sites that contain some bear hairs) and as such have a high probability of containing scats. Bear positions were downloaded and visualised every morning on a daily basis. For the bear of interest, all clusters for a given day were filtered out and plotted on a map. Each day a sub-group of citizen scientists started with the cluster that seemed most promising for finding a scat, i.e. the cluster where a bear had remained the longest. In case no samples were found or could be collected at the first site, the next cluster was visited until a scat was found or other tasks were more important. Scats found were documented using the scat collection protocol (see Appendix II).

A bed site is defined as a bear bed only if it contains bear hairs (Ordiz et al. 2011). Some bears collect mosses, shrubs or other material and build a nest that they use as a day bed. However, sometimes bears do not make much effort to build such a resting place; they just lie down and those resting sites are more difficult to detect for a citizen scientist with a relatively untrained eye (Fig. 2.2.3i).

Figure 2.2.3i. Bear day beds. Some bears collect much bed material for building a resting site (left), other bears just lie on the ground. The latter beds are more difficult to detect. On the right picture, a bear has rested for some hours on a stone. No bed material was collected, but signs from the weight of the bear are visible and hair is present.

Bear scat (Fig. 2.2.3j) was only collected if only one bed was present at a site, to avoid collecting samples from unknown individuals accompanying a radio-collared bear during the mating season. Whenever possible, the scat closest to the bed site was collected. Additionally, we noted if a carcass was present at the day bed. Scats were stored individually in plastic bags, marked with a unique identification number and stored in a freezer at -20 °C for later analyses.

Figure 2.2.3j. Bear scats look very different, depending on the bear's diet. Top left: Typical bear scat in spring when bears often forage lingonberries from the last season and plenty of grass and herbs. Top right: Typical bear scat in May/June when bears hunt moose calves; pieces of bones and a lot of hair are visible in the scat. Bottom: Typical bear scat in autumn when bears forage a lot of blue, crown and lingonberries. They eat approximately 30% of their body weight in berries per day. In autumn, often several scats are found around the resting places.

2.3. Results

Den sites

Seven citizen scientists and two staff investigated 26 winter positions of 21 different bears from 28 May to 04 June 2022. All positions investigated were recorded during the winter 2021/2022. Two bears shifted their dens at least once during the hibernation season. At 23 out of the 26 positions the expedition found bear dens. Den positions are shown in Fig. 2.3a.

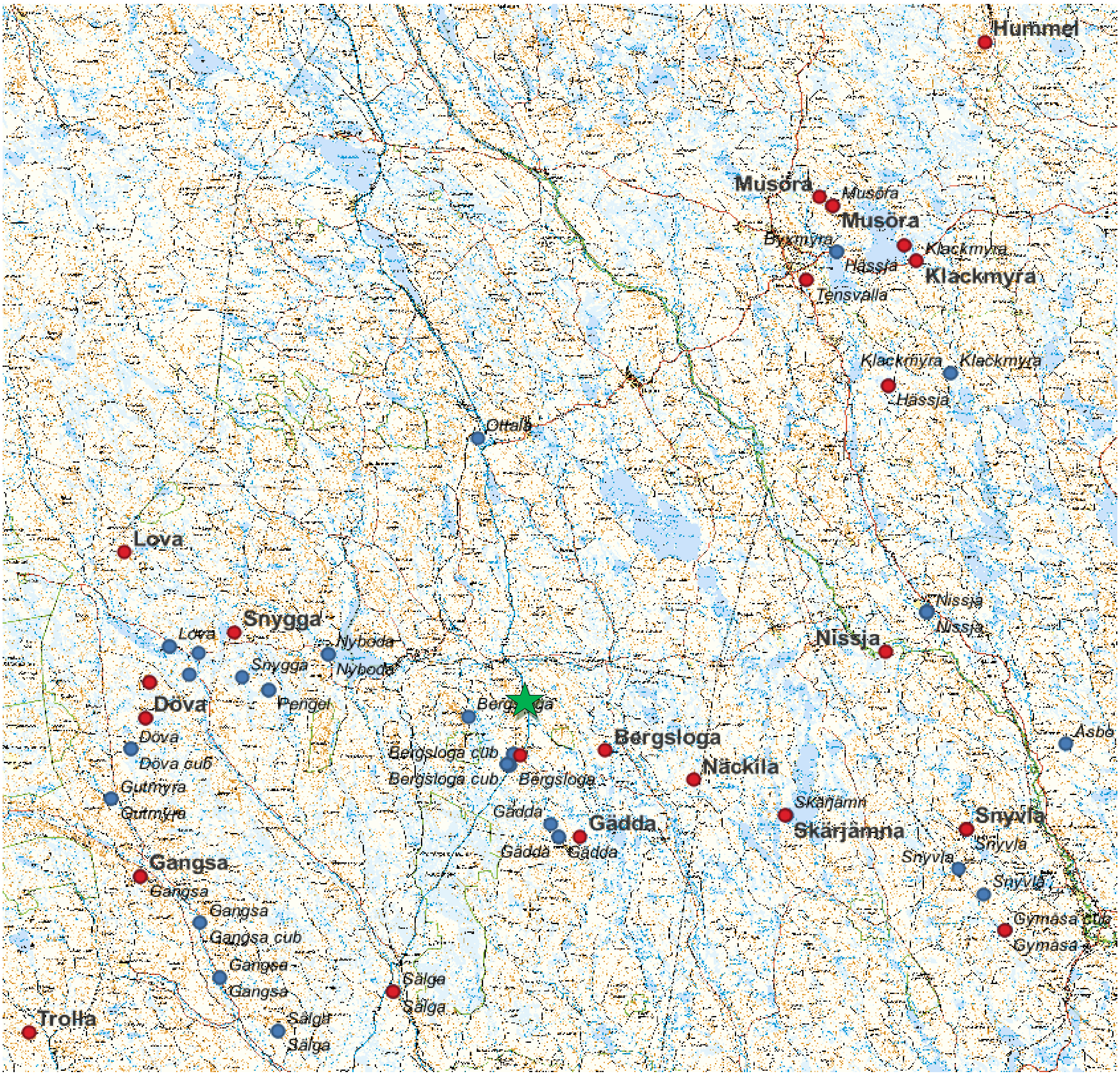

Figure 2.3a. Map of the Orsa Finnmark study site. Red dots = winter den positions with the names of the bears (bold letters), blue dots= cluster positions where scats were found, with the names of the bears (italic letters) green star = expedition base.

Den type

In total, the expedition investigated: two soil dens, eight anthill dens, one anthill/soil den, one stone/rock den, four dens under uprooted trees and seven basket dens (Table 2.3.b). One pregnant female that gave birth to three cubs during winter, and four females that hibernated together with dependent offspring spent the winter in basket dens. Normally basket dens are mainly used by large males. All dens were constructed inside, rather than at the periphery, of the home range.

Den measurements

Excavated bear dens such as anthill and soil dens had an average outer length of 2.0 m (range 1.3 m - 2.9 m), outer width of 2.2 m (range 1.3 m - 2.8 m) and outer height of 0.8 m (range 0.6 m - 1.2 m). Den entrances were on average 0.5 m high (range 0.4 m - 0.8 m) and 0.6 m wide (range 0.4 m - 0.8 m). The entrance represented on average 28% of the open area. The inner length of the den was on average 1.3 m (range 1.1 m - 1.5 m) and the inner width was 1.1 m (range 0.7 m - 1.5 m). The inner height of the dens was on average 0.6 m (range 0.3 m - 0.9 m).

Table 2.3b. Details of bears and bear dens investigated by the expedition. The reproductive status shows if the bear hibernated alone (solitary), gave birth to cubs during hibernation in the den (pregnant), or hibernated together with dependent offspring (with offspring)

Hibernation season	ID number	Bear	Den nr.	Sex	Born	Reproductive status	Den found	Den type
2021_2022	W0605	Sälga	1	F	2005	solitary	yes	anthill
2021_2022	W1203	Pengel	1	F	2008	with offspring	no	unknown
2021_2022	W1304	Bergsloga	1	F	2012	with offspring	yes	basket
2021_2022	W1319	Snygga	1	F	2009	pregnant	yes	anthill
2021_2022	W1418	Hässja	1	F	adult	with offspring	yes	basket
2021_2022	W1505	Gymåsa	1	F	adult	with offspring	yes	basket
2021_2022	W1509	Skärjämna	1	F	2014	pregnant	yes	soil
2021_2022	W1702	Gädda	1	F	2016	pregnant	yes	basket
2021_2022	W1803	Snyvla	1	F	2017	solitary	yes	basket
2021_2022	W1803	Snyvla	2	F	2017	solitary	yes	basket
2021_2022	W1815	Ottala	1	F	2017	solitary	yes	soil
2021_2022	W1909	Döva	1	F	2018	solitary	yes	anthill
2021_2022	W2007	Hummel	1	M	2019	solitary	yes	rock
2021_2022	W2012	Lova	1	F	2019	solitary	yes	anthill
2021_2022	W2014	Nyboda	1	F	2019	solitary	yes	anthill
2021_2022	W2016	Gangsa	1	F	2014	with offspring	yes	anthill
2021_2022	W2019	Nissja	1	F	2016	with offspring	yes	basket
2021_2022	W2025	Trolla	1	f	2019	solitary	yes	anthill
2021_2022	W2103	Klackmyra	1	F	2016	solitary	yes	under tree
2021_2022	W2106	Tensvalla	1	F	2014	pregnant	yes	anthill soil
2021_2022	W2110	Musöra	1	F	2020	solitary	yes	under tree
2021_2022	W2110	Musöra	2	F	2020	solitary	yes	under tree
2021_2022	W2111	Kyrk	1	M	2020	solitary	yes	under tree
2021_2022	W2116	Näckila	1	F	2020	solitary	yes	anthill

Bed material

Bears often use field layer shrubs (from berry bushes or heather) or grass, but also ground layer material like moss and lichens as bed material. Also branches from trees can be collected. The available ground and field layer did not differ significantly among different den types. However, bears that hibernated in covered dens like anthill, soil or rock dens used mainly mosses (47%), field layer shrubs (36%) and branches from trees (14%) as basket material, while bears that hibernated in open basket dens preferred branches (43%) followed by grass (26%); mosses (19%) and field shrubs (12%) as basket material (Fig. 2.3.c).

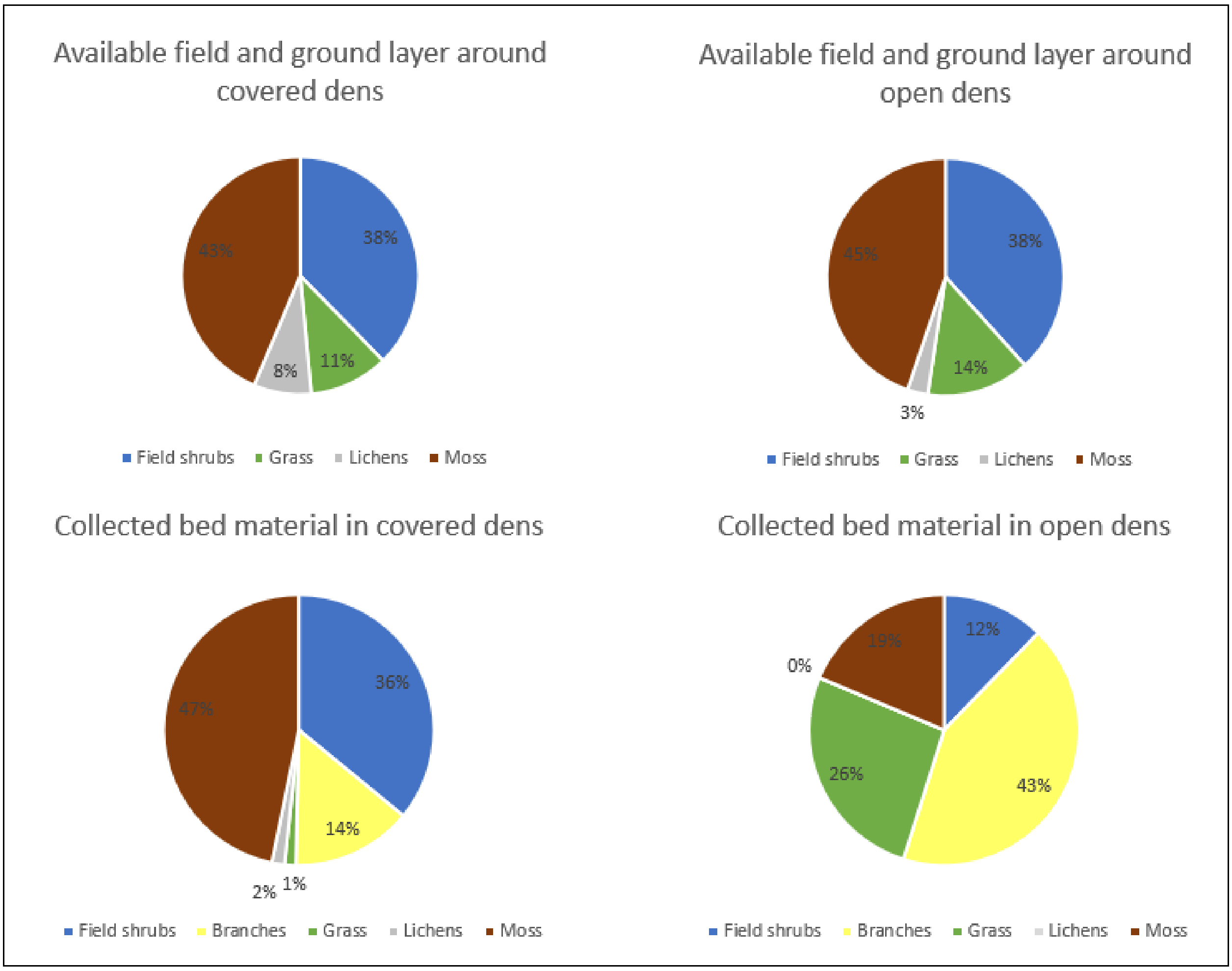

Figure 2.3c. Top: Available field and ground layer, that can be used as bed material in a radius of 10 m around covered and open winter dens from hibernating bears in Sweden. Bottom: Collected bed material that was found in left: covered winter dens (N=15), and right: open winter dens (N=8)

Habitat

None of the dens were located in water-rich areas such as bogs or swamps. Ten bears selected their den sites in older forests (type G1: medium tree > 10 cm diameter at breast height) and eleven bears hibernated in younger forest (type R2: medium tree > 1.3 m but < 10 cm in diameter at breast height (1.3 m)). Only two dens were built in a very young forest with an average tree height smaller than 1.3 m.

The habitat in a radius of 50 m around the den was dominated by spruce (*Picea abies*; 37%), followed by Scots pine (*Pinus sylvestris*; 35%), and birches (*Betula pendula*, *Betula pubescens*; 27%). However, at the den site on a smaller scale (10 m radius around the den) birch trees presented only (16%) of the tree species, spruce and by pine trees were present equally (41%). The sighting distance to the den was on average 23 m. In 87% of cases, it was the vegetation that limited the visibility to the den, in 13% the landscape terrain was the reason.

Samples

The expedition group found two first post-hibernation bear scats at the den sites. We examined the scats, packed and labelled them and stored them in a -20°C freezer for further analysis.

We detected signs of cubs at seven den sites. Climbing marks of cubs and scats from cubs were found, as well as several day beds around the den.

Scat sampling at cluster sites

The expedition group found 63 scats at the visited cluster positions. At 15 (24%) cluster sites the expedition group found remains of kills. All kill remains had been moose calves of very young age, probably only a few weeks old. The remains were often buried in the ground close to the bear's day bed and some bears covered the remains additionally with berry shrubs.

Ten of the 15 kill remains were found at clusters from bears with dependent offspring. All scats were half dry or dry and had a solid formed shape, except one scat that was moist and liquid. Detailed food item analysis of the scats was no task of the expedition but will be done by SBBRP in 2025 and the data will be published after all analyses are done.

2.4. Discussion

The expedition visited 26 winter positions and investigated 23 dens, which represent about half of all winter positions that the Scandinavian Brown Bear Research Project recorded in 2022. Additionally, the expedition collected all the scat samples that the Scandinavian Brown Bear Research Project normally collects during this time period. As such the expedition's citizen scientists made a very significant contribution to the Scandinavian Brown Bear Research Project's field work and we thank all the participants and Biosphere Expeditions for their excellent work.

Den abandonment and disturbance

Understanding denning behaviour is critical for effective bear conservation, for example by minimising human disturbance during the critical hibernation period. During the field season of 2022, the Scandinavian Brown Bear Research Project recorded two cases in which bears shifted dens during hibernation. In one case the bear needed four attempts before successfully locating a place that was used for the rest of the denning period. Only open beds, but no winter dens, were found at new positions after disturbance. This suggests that the quality of hibernation location decreases immensely if a bear gets disturbed during winter and abandons the original den. Brown bears select their den sites shortly before starting to hibernate, typically at least 1–2 km from human activity (Friebe et al. 2001). Sahlén (2013) and Sahlén et al. (2015) documented high den abandonment rates (22%) in our study area. The majority of documented den abandonments appeared to be the result of human disturbance (Swenson et al. 1997b, Linnell et al. 2000). Several studies have shown that bears try to avoid human disturbance during hibernation, e.g. by selecting den sites far from roads or in concealed and rugged terrain (Elfström et al. 2008, Goldstein et al. 2010, Ordiz et al. 2011, Sahlén et al. 2011, Ordiz et al. 2012, Ordiz et al. 2013). Additionally, pregnant females select better concealed den types, such as anthill, soil and rock dens, than male bears (Elfström and Swenson 2009). Bears that hibernate in open "basket dens" are probably more vulnerable to disturbance. However, during this field work season, the citizen scientists found five basket dens that bears built in October. (Two of the seven basket dens were built in the middle of the winter, after the bear had abandoned its original den). All five basket dens were used by females that either gave birth to cubs during hibernation, or hibernated with dependent offspring. It is extremely rare that reproducing bears or family groups hibernate in basket dens. The fact that basket dens had been the main den type of family groups in this season 2021/22 (only one family group hibernated in a covered anthill den) was unexpected. Nevertheless, all basket dens were located deep in the forest, far from snow ploughed roads. Only one subadult and solitary female that hibernated in a basket den was disturbed during winter. She abandoned her first den and built a new basket den circa 2 km from the first den.

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The bears must trade off between the energy costs and benefits to decide on an optimal denning strategy. Studying reproducing females is particularly important, because they play a crucial role in population dynamics (Sæther et al. 1998). Previous studies have shown that disturbance during hyperphagia and hibernation has a negative effect on the bear's fitness and reproductive success (Elowe and Dodge 1989, Swenson et al. 1997b, Welch et al. 1997, Linnell et al. 2000, Ordiz et al. 2008). Free-ranging female brown bears in central Sweden select predetermined places for denning by visiting their den areas on average more than once a month during the season (Friebe et al. 2001). Thus, they choose a known place for the winter den. As such they may be aware of some of the regular disturbances that occur there and are therefore either accustomed to them, or have already selected against such disturbances when choosing their den site (Friebe et al. 2014).

Further research is needed to determine whether good denning strategies help pregnant females avoid disturbance. The Scandinavian Brown Bear Research Project's study of pregnant females showed that 47% of the females started hibernation before 15 October, the last day hunting is permitted if the quota has not been filled. Therefore, an early start of hibernation and the construction of a well-protected den in suitable habitat could also be a strategy to avoid disturbance and loss of energy during the hunting season. Restricted use of their home range, combined with reduced movements, are known strategies of female brown bears with small cubs to avoid male bear encounters during the mating season (Dahle and Swenson 2003, Martin et al. 2013, Steyaert et al. 2013).

More detailed information about den site selection may also improve the safety of humans and bears. Although the Scandinavian brown bear is not an aggressive bear as long as it is not wounded, bears at dens are associated with higher levels of aggression (Swenson et al. 1999, Linnell et al. 2000, Moen et al. 2012). Human encroachment, habitat fragmentation, resource exploitation and hunting can affect the presence (Fahrig 1997), habitat use, behaviour (Swenson et al. 1999) and population dynamics of wildlife (Cartwright et al. 2014). As villages expand and new roads are built in Sweden, human activity relentlessly expands into formerly undisturbed areas, affecting bear behaviour.

A continued fragmentation of present bear ranges inhibiting dispersal, together with an increasing bear population, might lead to bears denning closer to human activities than at present. Cover opportunities and terrain types not preferred by humans are thereby presumably important for bears that are denning relatively close to human activities. This can alter the fine-scale den site selection for these bears, and therefore also their naturally evolved behaviour to endure unfavourable conditions during winter (Mannaart 2016). Therefore, undeveloped forest regions along with corridors for dispersal are probably important to decrease anthropogenic effects on bear denning behaviour. The dens that were investigated in this study were visible from 22 m on average. Therefore, it is possible that bears that are forced to build their dens closer to human activities may need to select for better cover.

Den type

The amount of protection and insulation provided by a den varies depending on the den type. Differences are likely to influence the amount of heat loss and vulnerability to disturbances. Enclosed dens offer protection and insulation from inclement weather. This is especially the case with excavated dens, which can be adjusted by an individual in relation to its body size; radiant heat from the soil and metabolic heat from the bear can be trapped within the den and keep the den temperature higher than the ambient temperature (Shiratsuru et al. 2020). These authors also observed that bears excavate a den cavity in relation to their body size and that older bears tend to excavate better-fitting den cavities compared to young bears. Additionally, bedding materials on the ground enhance insulation, by forming a microclimate between the bear and the soil. All this means that enclosed dens provide bears with a microenvironment where temperatures are relatively warm and stable.

It is more common for adult male bears to select basket dens than sub-adult males or females (Elfström and Swenson 2009). The sex-specific differences in the use of den types may be explained by the generally smaller surface area:volume ratio of male bears that also allows them to hibernate for a shorter time without excessive energy loss. Additionally, male bears can store fat and lose proportionally less weight per day than smaller bears (Manchi and Swenson 2005). The tendency of female bears to prefer anthill or soil dens can be explained by the high energy demand on females for birth and lactation during the denning period. Female bears utilising excavated anthill dens have higher reproductive success compared to those using other den types (Nowack 2015).

Female brown bears depend even more on the occurrence of anthills than males do, by excavating more anthills per km^2 for reasons of nutrition (Elgmork and Unander 1998). There appears to be a decline in the use of anthill dens by brown bears in our study area, which might indicate a decline in the availability of anthills. Our study area is under intensive, highly destructive forestry use with quick plantation and clear-cutting cycles, which may well be a reason for the possible anthill decline. This type of forestry creates monospecific, small and even-aged pine stands with short rotation periods, which have little or nothing in common with natural forests; they are simply pine growth and cutting fields in areas where there was once natural forest. This has had a strong influence on the Swedish flora and fauna, and has caused a decrease of many species that rely on true forest habitats (Berg et al. 1994). Also, mound-living ants (*Formica* spp.), which function as keystone species and are widely spread in the boreal forest, are negatively affected by forestry management in Scandinavia (Gösswald et al. 1965, Kilpeläinen et al. 2008, Nowack 2015).

Their baskets suffer from mechanical damage as well as from changes within the microclimate that occur through removal of aphid-containing trees (Vepsäläinen and Wuorenrinne 1978, Rosengren et al. 1979). Hence, clear-cutting likely increases the abandonment of anthills.

It is thus of immense importance to perform a long-term study of brown bear denning behaviour, in order to elucidate if clear-cutting forestry may have negative effects on brown bear reproduction and thus population dynamics. We suggest that forest management units consider such effects in their management to minimise their impact on wildlife and biodiversity. Future research could be targeted to investigate whether certain den or denning habitat types result in less den abandonment.

However, during the 2019/2020 and 2021/2022 hibernation season, the expedition scientist observed two females that gave birth to cubs in basket dens. This is highly unusual as basket dens are usually only used by large males that are thought to be able to withstand periods of intense cold. It is currently unknown whether climate change is the – or at least part of the – reason why reproducing females are now recorded using open and less insulated dens. To elucidate this further, we will aim to examine whether open denning has an effect on the body condition of the offspring. Bears that hibernated in basket dens used mainly branches as basket material, as well as grass and moss. Branches were used as a ground layer on the bottom of the den, probably so that melting water can drain off better in spring. The top of the bed contained mainly insulating materials such as moss und grass.

Signs and scats

In central Sweden, adult female bears normally either give birth to cubs during hibernation or hibernate together with offspring. In general, we presume that females that have separated from their cubs and mate afterwards during the spring, and hibernate alone in a den, are pregnant. However, in previous studies, the Scandinavian Brown Bear Research Project observed that 60% of the females presumed pregnant emerged from their new dens without cubs (Swenson et al. 1997b). Analysis of activity data during hibernation, however, showed that about 35% of those females in fact had been pregnant, but lost their cubs directly after denning. This shows how tentative conclusions based only on cub observations are. For this reason, we note all signs of cubs at den sites to gain information about reproduction. During the 2022 field season, the Scandinavian Brown Bear Research Project in two instances detected signs of cubs at den sites from females that were not observed with offspring later.

Food availability and climate change

Scandinavia is one of the areas that is likely to be most affected by climate change (Walther et al. 2002, Stenset et al. 2016), which in turn will affect the abundance and variation in food resources for bears (Bojarska and Selva 2012). Unlike other bear populations in Europe or North America that have access to several different food resources in autumn, bears in northern Europe rely almost exclusively on berries during hyperphagia. The bears in this study are able to adapt to annual changes in the availability of berry species by switching between berry species. For example, in years of failure of the bilberry crop, bears rely heavily on lingonberries instead. However, brown bears in Scandinavia depend almost exclusively on berries to gain body mass prior to hibernation and have few other abundant and carbohydrate-rich foods available (Stenset et al. 2016). Food availability has been shown to affect yearling offspring size (Dahle and Swenson 2003) and reproductive success

(Zedrosser et al. 2007). Therefore, changes in climatic conditions that affect the abundance of berry species will be especially problematic for bears in Scandinavia (Stenset et al. 2016). The present study is important for the documentation and understanding of feeding habits of brown bears, to understand the potential responses and adaptations of bears to climatic changes, and ultimately, for the effective management and conservation of the species. The Biosphere Expeditions group helped us to collect 63 scats samples that bears dropped from 28 May- 4 June. At 15 (24%) of the cluster sites we found kill remains of moose calves. In 10 cases, it had been females with dependent offspring that killed the moose calves. Moose calves seem to be an important food resource for lactating females in spring, at a time when only little food is available for bears, compared to autumn during the berry season.

The 2023 expedition should:

- Continue to investigate den sites of brown bears to document effects of climate change and human activity on brown bear den site selection

- Continue to collect bear scat in order to gain more knowledge about the seasonal differences in choice of food

- Start to examine first scats of female brown bears after hibernation in more detail in order to gain more information about the virtually unknown areas of cub loss or foetus abortions during hibernation

- Continue to document signs of cubs at den sites to elucidate brown bear reproduction parameters, such as age of primiparity, cub survival or reproduction rates

- Help the project to search for GPS collars that have fallen off bears in the woods

- Help the project to find remains of dead bears to elucidate reasons of death such as illegal or intraspecific killing

- Increase the expedition slightly in length to 10 days to increase data collection periods.

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Appendix I: Den mapping protocol

Skandinaviska Björnprojektet 2019 **BEAR DEN**	OBSERVER	PROTOCOL ID.:	YEAR (YYYY) MONTH (MM) DAY (DD) ____ - __ - __

RELATED TO	
LOCATION INFO AND YEAR DEN WAS USED	LOCAL NAME · COORDINATES (GPS) (N/E) ________ / ________ · M. S. L. · DEN WAS USED WINTER ________ / ________ ☐ YEAR UNCERTAIN ☐ YEAR EXACT
DEN WAS USED	☐ ALL OF WINTER · ☐ PART OF WINTER FROM TO · ☐ UNKNOWN · ☐ DEN USED IN PREVIOUS YEAR (S) BY BEAR WITH ID-no.: ____________ YEAR(S) _____ / _____
POTENTIAL "DISTURBANCES" DURING USE OF DEN	☐ SKIING ☐ HUNTING ☐ CAPTURE ☐ UNKNOWN ☐ SNOW MOBILE ☐ MILITARY ☐ FOREST FELLING ☐ OTHER (PROVIDE COMMENT) · DISTURBANCE ☐ RECURRING ☐ UNKNOWN ☐ TEMPORARY FROM TO · COMMENT: · BEAR LEFT DEN AFTER DISTURBANCE: ☐ YES ☐ NO ☐ UNKNOWN DATE:
BEAR IDENTITY	DEN WAS USED BY: ☐ UNMARKED BEAR ☐ MARKED BEAR ID-NO.: ____________ · NAME: · SEX:
DEN'S POSITION IN THE TERRAIN WITHIN A 50 M RADIUS AND INCLINE OF TERRAIN	☐ MOUNTAIN (ABOVE TREELINE) ☐ DECIDUOUS FOREST ☐ Evergreen FOREST ☐ YOUNG FOREST (AVERAGE ~3M) ☐ CLEAR-CUT (LOWER THAN 1M) ☐ MOUNTAIN SIDE ☐ RAVINE ☐ CLIFF EDGE ☐ SLOPE ☐ OTHER ____________ ☐ LEVEL GROUND ☐ DEPRESSION ☐ RIDGE ____________ BEARING (360 DEGREES): INCLINE (DEGREES):
VEGETATION WITHIN 50M RADIUS IN PERCENT	TREES TALLER THAN 1M: (SUM OF ALL TREES EQUALS 100%, WRITE A ZERO FOR TREE SPECIES THAT ARE ABSENT) BIRCH: ______% SPRUCE: ______% PINE: ______% OTHER TREE SPP.: ______%, ______%, ______% (PROVIDE SPECIES NAME)
NO. OF TREES TALLER THAN 3M WITHIN 10M RADIUS	(NB: NUMBER! NOT %, WRITE A ZERO FOR SPECIES WHERE NO TREES ARE PRESENT) BIRCH: ______ SPRUCE: ______ PINE: ______ OTHER TREE SPP: ______, ______, ______ (PROVIDE SPECIES NAME)
HABITAT	TYPE: · Patch size: small medium large · TreeHT (m): P: S: D: Densiometer · N · E · S · W · Stems/ha P: S: D: Concealment UR LW · N v t · E v t · S v t · W v t · Relascope P: S: D:
GROUND VEG. & BARE GROUND/ STONE WITHIN 10 M RADIUS, IN PERCENT	UNTOUCHED BARE GROUND AND BARE ROCK ______% · GROUND VEGETATION: ______% · AREA WHERE NOT POSSIBLE TO DETERMINE GROUND VEG COMPOSITION: ______% · ADDS UP TO 100%
GROUND VEGETATION WITHIN 10M RADIUS IN PERCENT (TOTAL GROUND + FIELD LAYER CAN EXCEED 100%	TOTAL GROUND LAYER: % · MOSSES % · LICHENS % · ADDS UP TO 100% TOTAL FIELD LAYER: % · BERRY FOLIAGE % · HEATH. % · GRASSES % · OTHER (SPECIFY) % · OTHER (SPECIFY) % · ADDS UP TO 100% SIGNS: Beds ____ Scats ____ Anthills: ____ Treestumps: ____
ADDITIONAL INFORMATION	☐ YES Picture taken ☐ YES Hair sample from the inside of the den taken

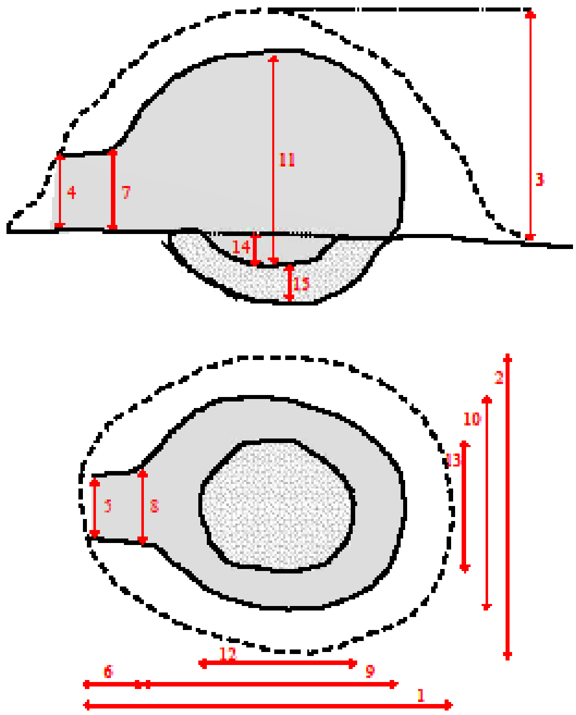
TYPE OF DEN	☐ ANT HILL MIN. 80% ANT-HILL MATERIAL ☐ ROCK DEN ☐ NEST DEN ☐ UPROOTED TREE ☐ SOIL DEN MIN 80% SOIL DEN ☐ ANT HILL/SOIL DEN 20 - 80% ANT-HILL, REST SOIL MATERIALS ☐ OTHER ____________
DEN ENTRANCE & PROPORTION OPEN AREA IN PERCENT	BEARING: DEGREES (360°) ° | NO. OF OPENINGS (>5 CM) PCS | PROP. OPEN AREA INCL. ENTRANCE % | DEN COLLAPSED : ☐ NO ☐ YES ____________ ☐ BEFORE ☐ EFTER ☐ DURING DENNING ☐ UNKNOWN
CEILING & WALL CONSIST OF	☐ SOIL ☐ ROCKS ☐ TREE ROOTS > 5 CM ☐ OTHER ____________

BED CONSISTS OF ADDS UP TO 100%	BERRY FOLIAGE	MOSSES	BRANCHES	HEATHER	LICHENS	GRASSES	OTHER	OTHER	BED REMOVED FROM DEN?
	%	%	%	%	%	%	%	%	☐ YES ☐ NO

DEN MEASUREMENTS

1. OUTER LENGTH.................................CM OBS: CM ! ! !
2. OUTER WIDTH...CM
3. OUTER HEIGHT...CM
4. ENTRANCE HEIGHT*..............................CM
5. ENTRANCE WIDTH*.............................CM
6. ENTRANCE LENGTH**.........................CM
7. INNER ENTRANCE HEIGHT.......................CM
8. INNER ENTRANCE WIDTH**.................CM
9. INNER LENGTH...CM
10. INNER WIDTH...CM
11. INNER HEIGHT...CM
12. BED LENGTH.................................CM
13. BED WIDTH.................................CM
14. BED DEPTH.......................................CM
15. BED THICKNESS.................................CM
16. THICKNESS OF WALLS AND ROOF.........CM.........CM.........CM
(6 MEASUREMENTS) .........CM.........CM.........CM

*Maximum measurement for the bear, no cracks etc
**when applicable



SIGNS OF CUBS ☐ SCAT ☐ SCRATCHES ☐ OTHER ____________

USE DIGITAL CAMERA TO TAKE ONE PHOTO OF FRONT AND SIDE OF DEN, RESPECTIVELY AND ATTACH PRINT TO PROTOCOL. USE THIS SECTION TO DRAW A SCHEMATIC DRAWING OF THE DEN.

Appendix II: Scat sampling protocol

Protocol - sample ID		Date (DDMMYY)	Time
Calendar week	Observer	Study	Bear Status
			Adult male ☐
			Lone female ☐
Bear ID	Name of bear	No. Cluster	Subad male ☐
			Subad female ☐
			Yearling female ☐
			Female/COY ☐
X Coord	Y Coord	No. beds	No. Scats
Bear LMT Start Date*	Bear LMT End Date*	Bear LMT Start time*	Bear LMT End time*
Scat condition	Scat shape**	Percent collected	Carcass***
Moist ☐	Solid ☐		Yes ☐
Half-dry ☐	Liquid ☐		No ☐
Dry ☐			
Comments			

Scats can only be collected if they are within 5m from the bear bed.
If > 1 bed is available or if it unsure if the bear was alone, no scats should be collected.

*Note: these data are from the GIS
** If the shape of the original scat was solid ("sausage") shaped, or liquidish ("puddle")
*** If a carcass was present at the cluster where the scat was collected