The management of brown bears in Sweden, Norway and Finland

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Abstract: There are about 2,700 bears in the central and northern parts of Sweden, about 150 bears in Norway (most of them along the Swedish, Finnish, and Russian borders), and about 2,400 in Finland, mostly in the eastern parts of the country. The conservation status of the brown bear is considered "Near Threatened" in Sweden and Finland and "Endangered" in Norway. All three countries have well-developed population monitoring programs, but the methods used differ widely. However, because these countries share the same population of bears, cross-border collaboration in research, management, and the sharing of information is well established. All three countries have damage compensation systems in place, however, the type of damages vary; in Sweden and Finland they are mainly due to depredation of semi-domestic reindeer in the northern parts of the countries, while damages in Norway are mainly related to the depredation of free-grazing sheep and they are concentrated in the eastern part of the country, along the border with Sweden. Bears in Sweden and Norway are managed at the regional level, while bears in Finland are managed on the national level. Hunting of bears is allowed in all three countries nowadays.

Introduction

Humans have always been interested in large carnivores, due to the threat they cause to livestock and sometimes to humans as well, but also because their strength, agility and beauty fascinate and inspire the human imagination. Five species of large carnivorous animals exist in the Nordic countries of Sweden, Finland, and Norway, the brown bear (*Ursus arctos*), grey wolf (*Canis lupus*), wolverine (*Gulo gulo*), Eurasian lynx (*Lynx lynx*), and golden eagle (*Aquila chrysaetos*). In this chapter, we focus on the management of brown bears in Sweden, by using Västerbotten County as example, but also provide information on bears and their management in Norway and Finland.

Brown bears were common in northern Europe until the middle of the 1800s, when their populations decreased rapidly due to human persecution. The species was protected in the 1900s, earliest in Sweden and latest in Norway. The populations increased after protection, especially so in Sweden and in Finland, which received immigrants from Russia. The increase in Norway was much less and came later, because the bear had been exterminated as a reproducing species and its return was dependent upon immigration from neighbouring countries (Swenson et al. 1995; see Fig. 1). Today, there are about 2,700 bears in the central and northern parts of Sweden, about 150 bears in Norway (most of them along the Swedish, Finnish, and Russian borders), and about 2,400 in Finland, mostly in the eastern parts of the country (Fig. 2; cf. Bischof et al. 2020). Bear management differs quite a lot among the Fennoscandian countries.

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Historic changes in brown bear populations and distribution in Sweden, Norway, and Finland

Sweden

Swedish public policy regarding the brown bear has changed greatly through the centuries. Early on, the national policy was to exterminate the species, and as early as in the 14th century there were laws in Sweden that required people to take part to meet this goal (Danell/Bergström 2016). Bounties were introduced in 1647 as a measure to help reach the extermination objective. Thousands of bears still existed in Scandinavia in the mid-1800s, with an estimated 3,100 bears in Norway and 1,650 in Sweden. By the end of the 19th century, the numbers of bears were extremely low in both countries. The lowest population level occurred around 1930 and was estimated at 130 bears, all of them living in Sweden (Swenson et al. 1995), although genetic estimates indicate that the numbers were somewhat higher (Xenikoudakis et al. 2015).

However, changing opinions among academics, hunters, and the public resulted in a paradigm shift at the end of the 1800s in Sweden, leading to the removal of bounties in 1893. Several other measures to protect bears, such as restrictions on where they could be killed and making any dead bear the property of the state, additionally contributed to the subsequent population increase (Swenson et al. 2017). The management paradigm in Sweden changed again in 1943, when hunting seasons were introduced. Nevertheless, the bear population continued to increase and reached a size of about 3,300 bears in 2008, some 60 years later (Kindberg et al. 2009). This increase was broken when changed management objectives in the counties with bears caused a decline of the population, which was subsequently estimated to consist of about 2,700 bears in 2018 (Bischof et al. 2020).

Norway

Norway did not change its extinction policy when Sweden did, and bears were virtually eliminated by 1920–1930, even though there were about twice as many bears in Norway as Sweden in the mid-1800s (Swenson et al. 1995). Since 1975, bear observations increased again in Norway, due to immigration from neighbouring countries and coinciding with a pronounced increase in the Swedish bear population; bears reappeared sooner in areas closer to the remnant Swedish populations (Swenson et al. 1995). Large carnivores are managed intensively in Norway, based on small population goals and small management zones where resident brown bears are accepted. In combination with low dispersal abilities of female bears, this reluctant attitude towards bears has prevented the species from re-establishing a large population in the country.

Finland

According to a back-calculation, there had been approximately 1,000 bears in Finland until their decline started around 1875. Thereafter, the population declined by about 210 bears per decade until 1905. The decline continued until 1915, when an estimated population of 129 bears was left in Finland (Mykrä/Pohja-Mykrä 2015). At this time, bears had disappeared from southern, southwestern, and western Finland, with remnants of the population restricted to the northern and eastern parts of the country. By the late 1960s, the number of bears started to increase again, from about 150 bears in 1970 to 450 in 1985. The species also extended its range into the western and southern parts of the country. The first reproducing females were observed in central Finland in the late 1980s, and in the western and southern parts of the country in the early 1990s (Pulliainen 1990; Kojola/Laitala 2000). The bear population in Finland was estimated at 2,300–2,500 individuals in summer 2020 (Heikkinen et al. 2021). Most of the bears in Finland live along the Russian border, and immigration of bears from the Russian part of Karelia explains much of the growth and range expansion of the bear population in Finland, in spite of relatively high harvest rates (Pulliainen 1997; Saarma/Kojola 2007).

The Swedish management system for brown bears is knowledge-based, rather well informed, and is required by law to be adaptive, although that does not always seem to be the case (Swenson et al. 2017). It includes monitoring of the population size and distribution, as well as of human attitudes, in addition to subsidies for measures to prevent depredation on livestock, a system for damage compensation payments, and stakeholder involvement in decision making. The elaborate system for the monitoring and management of large carnivores is in part due to the compensation system for damages to domestic reindeer (*Rangifer tarandus*). Wild reindeer became extinct in Sweden in the 1800s, but today there are about 350,000 domestic reindeer owned by native Sámi people. In accordance with the rules and regulations of the European Union, limited hunting of brown bears is allowed in Sweden as a measure to prevent agricultural damages.

The Swedish Environmental Protection Agency (EPA) is the national authority for nature conservation and environmental issues. The EPA advises the Swedish government on these issues and provides instructions, advice, and information on large carnivores to regional authorities and the public. The EPA puts much effort into the management of large carnivores, including policy tools (legislation), guidelines and strategies, funding (for regional administration, surveillance, research, and information), and issuing hunting permits.

Sweden is subdivided into 21 counties, each with its own administration. The County Administrative Board is a regional authority that is a link between the people and municipalities of the county on the one hand, and the government, Parliament, and national authorities on the other. Environmental issues, such as wildlife management, large carnivore conservation, and reindeer husbandry constitute a major field of work for the county boards. For example, about 20 people are involved in large carnivore management in Västerbotten County, working on topics such as population monitoring, managing hunting, damage compensation, and public information. Regional stakeholder involvement is achieved by so-called Delegations for Game Management at the county boards. They consist of regional politicians and representatives of different interest groups affected by or interested in large carnivores. Delegations for game management give advice to county boards and are charged with making overarching decisions regarding the management of game species in the county (Lundmark/Matti 2015; SFS 2009:1474).

Furthermore, Sweden is subdivided into three areas for the management of large carnivores (Fig. 3). These zones were established to increase and improve the cooperation among the counties and to facilitate cross-boundary management. Within a management area, counties are similar with respect to species composition and population sizes of the carnivore community. They are also comparable regarding human population density and landscape use, as well as types and extent of human-carnivore conflicts. Between management areas, differences in the aforementioned factors are relatively large. The northern management area contains a large population of brown bears and almost the entire reindeer husbandry zone. The central management area contains good numbers of bears, but few reindeer. In the southern area, bears are absent (Schneider 2017).

Monitoring size and trend of bear populations

The population size and trend of brown bears in Sweden are estimated based on a combination of genetic and observational methods. Together, these methods provide a very good overview of the dynamics and spatial distribution of brown bears in Sweden.

DNA-based methods are used to estimate population size (Bellemain et al. 2005; Bischof et al. 2020). Brown bear DNA surveys are usually carried out at five-year intervals in all counties with bears. The management authorities provide sampling kits, and volunteers, commonly hunters, are asked to collect a small sample whenever they find bear feces. These samples are then sent to a desig-

nated laboratory for analysis. The lab results are used to estimate the population size of brown bears at the county, as well as the national, level based on statistical capture-recapture models (Schneider 2006; 2015).

The trend of the brown bear population is monitored annually at the county level using effort-corrected observations of bears by moose (*Alces alces*) hunters (Kindberg et al. 2009). Every autumn, thousands of hunters are in the Swedish forests to participate in moose hunting. Most of the hunters are organised into hunting parties, i.e. groups of people hunting together in an area that they own or lease (Schneider 2017). Hunting parties are required to keep track of bear sightings during moose hunting and to report their results to the Swedish Hunters' Organisation (Kindberg et al. 2009). Based on these data, an annual index of bear sightings per observation effort is published for every county with a bear population. Because the visibility of bears varies among years, due to weather conditions and other factors, and among areas, due to differences in forest density, etc., this index only indicates the trend of the bear population in a given area. Together with results from DNA surveys, trends from observation indices can be used to estimate bear population size in the counties in different years (Kindberg et al. 2011).

Framework for bear management

The brown bear is considered to be "Near Threatened" in the Swedish Red List (Artdatabanken 2020), based on criterion D of the International Union for the Conservation of Nature (fewer than 2,000 reproducing individuals). Article 11 of the European Union Habitats Directive requires member states to monitor the habitats and species listed in the annexes, and Article 17 requires a report to be sent to the European Commission every six years. The core of this Article 17 report is an assessment of the conservation status of the habitats and species targeted by the directive. Conservation status is assessed using a standard methodology as being either "favourable", "unfavourable-inadequate" or "unfavourable-bad", based on four parameters as defined in Article 1 of the Directive. The parameters for species are range, population, habitat of the species, and future prospects (DG Environment 2017). According to the Article 17 reporting by the Swedish EPA in 2019, the reference population size for the brown bear is 1,400 individuals (Naturvårdsverket 2020). That means that at least that many bears must live in Sweden, but the population can be much larger, as long as it does not cause too many problems. Today, the brown bear has favourable conservation status in both biogeographical regions in which it occurs in Sweden (alpine and boreal).

The main goal of the management of large predators in Sweden is stated in Section 1 of the Ordinance on the Management of Bear, Wolf, Wolverine, Lynx and Golden eagle (SFS 2009:1263); these species should occur in such large numbers that they persist in the Swedish fauna in the long term and that they can spread to their natural areas of distribution. This aim is to be achieved at a pace that promotes the coexistence of humans and these species, while preventing and limiting damages and inconveniences. According to the government's proposition "A sustainable predator policy" (Regeringen 2013), the general and long-term objective is that large carnivores in Sweden shall achieve and maintain favourable conservation status in accordance with the European Union's Habitats Directive, at the same time as livestock husbandry is not significantly hindered and socio-economic considerations are taken into account. In 2018, in its "Strategy for Swedish Wildlife Management" (Swedish EPA 2018), the Swedish Environmental Protection Agency has formulated a vision for wildlife management in Sweden. The vision can be viewed as a long-term objective for Swedish wildlife management and draws on the values of wildlife in a broad sense, for nature experiences and tourism, for hunting, for the provision of game meat, and for the conservation of biodiversity. Everyone should have access to these values, regardless of background, gender, disabilities, or other conditions.

National and regional management plans

The national management plan for the brown bear (Naturvårdsverket 2016) translates the general management principles defined by the Parliament and the government into more concrete objectives and measures. According to the Swedish EPA, the following specified goals should be achieved during 2014–2019, the period covered by the plan: 1) Reach and maintain favourable conservations status; 2) Reduced damage; 3) Increase confidence in management; and 4) No illegal hunting of bears. Sweden joined the EU in 1995, which resulted in the protection of the brown bear. However, bears can still be hunted in Sweden, using the derogations (exceptions) allowed in EU's Habitats Directive, which are implemented in national Swedish legislation. The hunting law instituted by Parliament, the hunting ordinance issued by the government, and more detailed regulations from the EPA define bear hunting in Sweden today. Actual decisions on bear hunting are made by county boards at the regional scale, after input from their Delegation for Game Management.

Within the three management zones, county boards cooperate on different aspects of large carnivore management. These include common guidelines and quotas for management removals of problematic animals, justification of and quotas for license hunting, models for administrative routines, collaborative suggestions for county-wise minimum levels, and the production of regional management plans. According to section 7 in the Ordinance for the Management of the Bear, Wolf, Wolverine, Lynx, and Golden eagle (SFS 2009:1263), each county board must establish a regional management plan for large carnivores. Management plans describe the general conditions in the county and assess the basis for large carnivore occurrence. They also describe numbers and distribution of carnivores, the conservation status of the predators, their effects on prey species, the problems they cause, and their socioeconomical consequences for society. Most importantly, regional management plans include concrete objectives for population size and distribution of the species, as well as acceptable levels of problems and inconveniences that carnivores inflict.

Bears in Sweden occur mostly in the six northernmost counties, Norrbotten, Västerbotten, Jämtland, Västernorrland, Gävleborg, and Dalarna. Table 1 summarises minimum levels, management targets, and limits of management intervals for the brown bear in these six counties. Minimum levels sum up to 1,400 bears, which has been defined as the national reference value, i.e. the national minimum level for the population.

Hunting of bears in Sweden

Bears are protected by the EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora), but exceptions can be made, and bears can be killed if the objective of the hunt is to prevent serious damage and there is no satisfactory alternative to solve the problems. In addition, killing bears must not be detrimental to the maintenance of the population at a favourable conservation status in its natural range, at neither the regional nor the national scale.

Two types of bear hunting exist in Sweden, license hunting and protective hunting. License hunting aims at regulating populations by managing the density, size, and growth rate of these populations. It operates at large spatial scales and multi-year time frames, and it is an important and fundamental component in the management of large carnivores in Sweden. Any person who has passed a hunter's exam and purchased a general hunting permit from the EPA can take part in license hunting of bears in areas where he or she has the right to hunt and where the hunting of bears is allowed. There is no governmental fee for killing a bear, but private landowners can sell the possibility to hunt, within the hunting quota that has been set by the county board. Most of the bears are killed by specialised hunters using dogs, many are shot during still hunting (also by people sitting and waiting for moose), some bears are killed by hunters stalking them, and very few by hunters using baits (Bischof et al. 2008; Swenson et al. 2017; Zedrosser et al. 2020). In northern Sweden, license hunting is a well-founded

and planned management effort and an inclusive phenomenon, where reindeer herders and local people can work together for mutual benefit, where bears can be an appreciated resource for hunting instead of being pests, and where the socio-economic and psychosocial impact on reindeer husbandry and other parts of society decreases, at the same time as hunting can generate income for local people. Managers argue that the acceptance for bears as well as large carnivore management increases because of that (see Dressel et al. 2021).

The other type of hunting is termed as protective hunting, i.e. management removals. County boards can grant permits for the lethal removal, i.e. killing of bears, when people who experience problems apply for it. Such applications are relatively rare in central Sweden, but quite common in the northern half of the country, where bears can cause serious damage to young reindeer on calving grounds in spring. A permit to kill a bear, if granted, is usually given to the person applying for it, but if this person does not want to hunt, he or she can ask other hunters to remove the bear. In remote mountain areas, when bears kill reindeer calves in spring, the carnivores often are removed by county board staff using helicopters. Protective hunting of problematic carnivores is an administratively extensive measure, it is usually event-driven (i.e. not planned in advance), it is usually costly, it can be controversial, and it has only a short-term effect within a limited area. In addition, management removals often exclude local hunters, and they reduce opportunities to use the bears as a resource, as the animals that are killed have usually been confiscated by the authorities.

Overall, about 350 bears are shot every year in Sweden. This is far more than were killed in the second half of the 1800s, when the bear nearly was eradicated (cf. Fig. 1). Although authorities welcome the huge interest among hunters, some recent developments in hunting practices are questionable. Hunting quotas are filled increasingly rapidly, which according to Police officials is facilitated by automatic cameras, technical equipment for tracking hunting dogs, motorised vehicles, and illegal bait sites, which some hunters use. Bear hunting has very much become a race between specialised bear hunters with trained hunting dogs, the most successful of which have killed more than 40 bears each. Also, there are indications that the selling of guided hunts is increasing rapidly in Sweden. Baiting for hunting bears was banned in Sweden in 2001 but was allowed again in 2014. Especially in Jämtland County it has become very popular, but only few bears are shot at bait sites (Fig. 4). The character of bear hunting is changing in Sweden, and the manager-caused mortality of bears has increased greatly (Fig. 5). In 2020, unusually many bears were killed on reindeer calving grounds in the spring (see the case study from Västerbotten County, below, for further details).

Bears and people in Sweden

Bear attacks on livestock

Although the bear population is relatively large in Sweden, attacks on livestock (other than reindeer) are comparatively rare, especially when compared to the number of attacks by wolves and lynx (Fig. 6). There are approximately 600,000 sheep, 350,000 dairy cattle, and 1.5 million beef cattle in Sweden. Most depredation cases by bears involve sheep. The number of attacked sheep per bear is much lower in Sweden than Norway, despite the higher numbers of bears (Table 2). There are three main reasons for the low number of bear attacks in Sweden compared to Norway. First, there are relatively fewer farms with sheep in the main area of brown bear distribution in Sweden, although most sheep in Norway also are outside of the bear range. Second, sheep are usually kept within areas protected by electric fences in Sweden. Third, animal welfare legislation in Sweden requires livestock to be visually observed at least once a day. In comparison, Norway has more than two million sheep grazing freely and unsupervised throughout the country. Unattended, free-ranging sheep are an easy prey for any bear in the area. The result is that Norway pays 210 times more in compensation for lost livestock and preventive measures to protect livestock per bear than Sweden, and 138 times more for compensation alone per bear than Sweden. Finland pays ten times more for compensation per bear than Sweden (Bautista et al. 2019).

Over the last 20 years, there has been an increasing trend of bear damages to beehives in Sweden. However, bear attacks on beehives are relatively easy to prevent with electric fencing, and financial assistance is available from county boards for setting up fences to deter bears. If attacks happen anyway, monetary compensation to replace damaged equipment and bees can be paid by county boards.

Bear attacks on people

The Scandinavian brown bear is not particularly dangerous. Very few people actually meet bears in Scandinavia, and the risk of being injured by bears while engaging in outdoor activities is exceedingly low (Støen et al. 2018). Several factors influence the risk of bear attacks on people. These are, in decreasing order of importance: the presence of cubs, proximity to a carcass, proximity to a den, and the presence of a dog (Swenson et al. 1999). Bear physiology at denning, which makes bears more prone to stay than flee, may make encounters with bears riskier in the fall, when they prepare for hibernation. In Scandinavia, although attacks on humans are relatively rare, injuries from bear attacks have increased during the last decades and fatalities have been documented for the first time for more than 100 years. During a period of 40 years (1977–2016), 44 attacks occurred in Sweden and Norway, in which 42 people were injured and two were killed. During the same period, 26 attacks occurred in Finland, in which 25 people were injured and one was killed (I. Kojola, unpublished data). Victims of bear attacks in these three countries are mostly hunters, and the risk of hunters being attacked increases with bear population density in the area. Hunters are more commonly affected by bear attacks compared to other groups of outdoor users or recreationists. A fatal incident in Sweden in 2004 has resulted in information campaigns and annual hunting courses, which focus on bear behaviour and on safety issues during bear encounters (Støen et al. 2018).

People's attitudes towards bears in Sweden

The relationship between people and large carnivores is multi-faceted. Among other things, human attitudes depend on the levels of predator damage to dogs, livestock, reindeer and game animals, on actual or perceived threats to humans, and on levels of local involvement during decision making processes in relation to bears with problematic behaviour. Many people have strong feelings towards large carnivores. Often, it is not the predators that are problematic per se, but the underlying cause is a conflict between a central administrative institution and the countryside community, a conflict that may exist at several scales. People's feelings and attitudes must be taken seriously when managing large carnivores (Schneider 2008).

Thoughts and actions

A multitude of attitude surveys regarding large carnivores have been carried out in Sweden. Since 2004, these surveys have been done at a large scale every five years, encompassing mostly the northern half of Sweden (Ericsson/Sandström 2005). Results from these surveys show that an overwhelming majority of the people is supportive of both large carnivores and their current management, however, many of the people who live closest to the carnivores are negative, and over time, people's support for large carnivores and large carnivore management can fluctuate. This is true especially for wolves and bears (Sandström/Ericsson 2009; Sandström et al. 2014; Dressel et al. 2021). These are important findings for managers, as negative attitudes may result in illegal killings of large carnivores. According to Swenson et al. (2011), illegal killing of bears is low, but more common in the northern part of Sweden; annual rates of illegal mortality among adult females was estimated to be less than 1 % in the south, but 2–3 % in the north. Documented and suspected illegal deaths showed no seasonal trend in the south, but were concentrated to spring and autumn in the north. In the north, illegal mortality has been documented to be especially high in the mountain national parks (Rauset et al. 2016). Generally, illegal killing does not seem to affect population trends among brown

bears in Sweden, but may be important locally. The level of illegal killing appears to be stable and not related to the level of legal hunting. Therefore, mortality caused by illegal killing is probably additive to the mortality caused by legal hunting.

Bears both repel and attract people

Although many people in Sweden seem to be afraid of bears (Dressel et al. 2021), attitude surveys show that most people like the fact that bears occur in the country. After the lynx, the bear is the second most popular species of all large carnivores in Sweden. However, the popularity of the bear decreased between 2004 and 2009, but it increased again between 2014 and 2020. Most people do not like the idea of meeting a bear in the forest (Dressel et al. 2021). However, if bears expose themselves along roads or on fields in the spring, many people will come to watch them. Bears are the object of human curiosity, as long as observing them can be done from a safe distance, and many people can congregate around such bears.

Case study: Bear predation on reindeer calves in Västerbotten – immobile hunters, scarce herders, and climate change increase bear predation on reindeer calves

Västerbotten is the second largest (55,000 km^2) and second-most northerly county in Sweden (Fig. 7). The county stretches from the coast of the Bothnian Bay in the east up to almost 1,800 m above sea level in the mountains along the Norwegian border in the west. The climate varies considerably between different parts of Västerbotten, but generally it is characterised by cold winters with heavy snow. More than 50 % of the county is covered by forest, which is intensively used by large-scale forestry. Most of Västerbotten's about 273,000 inhabitants live along the coast in the east, where the biggest cities are located. Human population density decreases steadily from east to west, with few inhabitants in the forested inland areas and especially so in the mountain range. Most Sámi reindeer herders live in the central and western parts of the county. Today, reindeer herding is not economically rewarding, and in many Sámi families only one person works fulltime with reindeer (Sjölander et al. 2009). As a consequence, there are few people guarding reindeer in the woods and mountains.

The bear population

The number of bears in Västerbotten has been estimated four times, in 2004, 2009, 2014, and 2019. The latest survey revealed a population of about 450 animals in autumn 2019. In recent years, the annual rate of harvest has been about 10 % of the population, but the number of bears has increased, nevertheless. The distribution of bears is uneven, especially so for females, which mostly occur in the southern and northwestern parts of the county. Most males occur in the central parts of Västerbotten, but densities are low in the mountains and in the coastal areas. In 2020, 73 bears are known to have died in the county, and with few exceptions, they were shot during protective or license hunting. During most years since 2005, there has been a special hunting quota for the Västerbotten mountain range, or more precisely the area between the Norwegian border and the *odlingsgränsen*, a border which was legally defined in 1890 as the western (upper) limit of new habitation in order to secure the higher altitudes for Sámi domestic reindeer herding (Lundmark 2006). Most of Västerbotten's calving grounds for reindeer are situated in this area.

Bears kill reindeer

For many years, reindeer herders have identified bears as a big problem on reindeer calving grounds in the spring. During 2010–2012 a study of bear predation on reindeer calves was conducted by the Swedish Wildlife Damage Center and the Scandinavian Brown Bear Research Project in cooperation with two reindeer herding cooperatives in northernmost Sweden (Karlsson et al. 2012). The research showed that the average bear kills and eats eleven reindeer calves during the calving season

in May and June, but that there are big differences among individual bears and between years. The researchers also studied different measures to protect reindeer calves from bears, and they concluded that hunting bears is the most effective measure.

Inspired by traditional Sámi knowledge, the Västerbotten County Administration established three management zones for brown bears in 2005 (Schneider 2006). In Västerbotten, most reindeer calving grounds are situated in the mountains close to the Norwegian border. Therefore, few bears should occur in this region, and the objective was to regulate the population by targeted hunting quotas in the area. Hunting quotas were set, based on the results of bear population size surveys.

Finding bears

Bear surveys to determine population size are organised as citizen science projects by the County Board in cooperation with the regional branch of the Swedish Hunters' Organisation. Sampling equipment for bear scats is distributed to hunters, reindeer herders, hikers, and other people working or relaxing in the outdoors, but the participation is voluntary. The survey period starts on 21 August (the onset of the bear hunting season) and ends on 31 October. Most bear scat samples are collected by hunters while they are hunting moose. Many samples are collected on or close to forest roads, presumably because they are easier to find there and because many hunters and berry pickers do not go very far from roads. In most cases, the calving grounds of reindeer and surrounding lands are rather remote areas that lack a dense network of roads. In consequence, during bear population size surveys, only few scat samples are collected in these areas. Reindeer herders move often off-road, but several of them have declared that they are unwilling to collect bear fecal samples.

An unfavourable spring

When the reindeer herds reached the mountains during their traditional spring migration in 2020, they could not reach their traditional calving grounds at higher altitudes due to large amounts of snow. Instead, they had to stay in the forests of the foothills and wait for the snow higher up to melt. Consequently, the calving season started when the reindeer still were at these lower altitudes, and great numbers of pregnant reindeer and newborn calves were in the area when bears started to emerge from hibernation. Neonatal reindeer and moose calves are preferred food of Scandinavian bears in spring, and the damage inflicted to reindeer herding was massive. In response to the problematic situation, the Västerbotten County Board granted about 50 licenses for protective hunting of bears, and 43 bears were shot.

Outraged hunters

The Swedish Hunters' Organization had a media campaign against the county boards and the bear management in northern Sweden, which according to hunters is a total disaster. They claimed that bears should be shot by hunters during the ordinary hunting season in autumn, as a valuable natural resource for sport and recreation, not as vermin by state officials in spring.

In summary

According to the management plan for the brown bear in Västerbotten, there should be few bears in the mountains, to avoid that bears prey on reindeer calves. Therefore, special hunting quotas were set for this area, based on the results of bear population size surveys, which require that hunters collect samples in the entire county. However, as there are relatively few roads in the mountains, hunters only collected samples in easily accessible parts of the area. Most reindeer herders did not participate in the bear population size monitoring, except in the southern part of the Västerbotten mountains. Therefore, relatively few of the bears in the area were detected during the survey, and hunting quotas were set accordingly too low. In most years, such a situation would not have important consequences,

as reindeer calve at higher altitudes, where there are fewer bears; however, the conditions with an exceptional amount of snow in spring 2020 exacerbated the situation and resulted in high bear depredation. The Västerbotten County Board did its best to help by removing many bears but was accused anyway for being utterly incompetent when it comes to bear management.

Management of brown bears in Norway

Human attitudes and political decisions, rather than natural conditions, determine the numbers and distribution of large carnivores today. This is obvious in Norway, where bear numbers have not increased very much since the reappearance of the species in the country in the 1970s. Norway is not a member of the European Union and therefore not directly affected by the EU Habitats Directive. However, Norway has signed the Bern Convention and therefore is obliged to conserve its large carnivores.

Due to climatic constraints, livestock production, especially sheep production, is important in Norwegian agriculture. Subsidies for livestock production are used to promote the goal of a "living landscape", i.e. economic activity in populated rural areas. More than two million sheep, some hundred thousand cattle and about 160,000 domestic reindeer graze freely throughout Norwegian landscapes. As an example of the conflict between farmers and bears in Norway, we quote Strand et al. (2019): "Bear attacks on grazing sheep has been prevalent in Norway […]. Bears are large, unpredictable, and occasionally violent and therefore represent a threat that the farmers are unable to cope with. Bears can damage carnivore-repellent fences and the damage inflicted on a herd attacked by brown bear is often substantial with many animals killed. The CMZ (carnivore management zone) for brown bear is found in regions where livestock farming is particularly dependent on using outfield resources. Bears are incompatible with free-roaming sheep in the outfields and prevent the farmers from exploiting these resources. Farms in the CMZ for brown bear are small and herds cannot be sustained on their infields alone. The result is that sheep farmers are forced out of business".

Nevertheless, the number of sheep and lambs that farmers received compensation for as killed by bears was only 1,843 in 2019, and 1,054 in 2020 (Miljødirektoratet 2022). The corresponding numbers for domestic reindeer were 347 and 397 in 2018 and 2019, respectively (latest available figures; Miljødirektoratet 2022), although loss of calves is particularly difficult to document. Even if these numbers are not particularly high, the number of bears is low, resulting in Norway (outside of the northernmost province of Finnmark) having the highest number of livestock compensated and greatest compensation cost per bear in Europe, in spite of the second-highest cost of preventive measures per bear (Bautista et al. 2017; 2019). These results highlight the difficulties of trying to conserve bears in an open-range landscape with free-ranging, unguarded sheep.

Management system

Stortinget, the Norwegian parliament, has sought to establish a compromise among stakeholders in the conflict between humans and carnivores. The solution is a political consensus formalised through two parliamentary decisions, the Carnivore Settlements of 2004 and 2011, which seek to reconcile two goals: continued sustainable livestock production in the outfields (open range) and the maintenance of viable carnivore populations. Through the agreements, national objectives have been set that define how large the populations of the predators are allowed to be. These targets for population size and distribution of large carnivores are so low that all of the species are included in the Norwegian Red List; the brown bear is listed as "Endangered" in Norway (www.artsdatabanken.no).

When populations are above or below the targets, it is the task of the environmental administration to find good tools to move and maintain populations close to the targets. The relevant administration

is the Norwegian Environment Agency (Miljødirektoratet), which is responsible for the management of large carnivores on the national level. It has described the Norwegian management system for large carnivores on its website (Miljødirektoratet 2021).

Thus, the objectives are different than in Sweden, where minimum objectives have been set, with no maximum limits on the national level. Large carnivore management is a field where the instructions from Stortinget and the government are particularly detailed, because of the strongly conflicting interests in Norwegian society. Gangaas et al. (2013) found that the conflict associated with large carnivores in Norway is linked to sheep farming and big game hunting and that people living in rural areas with big game hunting and sheep farming are more likely to accept illegal hunting compared to people living in areas with less rural traditions. They also found that Norwegians were four times more inclined to accept poaching than Swedes.

Stortinget decided that carnivores should be managed at a local scale. Therefore, Norway was subdivided into eight management regions for large carnivores (Fig. 8), and a predefined number of each species of predator can occur in each region. These goals are expressed in annual reproductions for each region and can be zero. Within these regions, some areas are defined to prioritise large carnivores; there the threshold for the removal of animals is higher and preventive measures to protect livestock are more relevant. Outside these areas, livestock grazing on open ranges is prioritised and large carnivores are less welcome. The management in each region is governed by a carnivore committee with members consisting of elected politicians appointed by the Ministry of Climate and the Environment and the Sámi Parliament. They are part of the environmental administration and they are subordinate to the Ministry. Within each region, it is the regional carnivore committee that is responsible for ensuring that the populations of large carnivores are maintained at the level set by Stortinget. One of the tasks of the committee is to determine management zones for lynx, wolverine, and bear as part of the regional management plan for large carnivores. However, Stortinget defined the management zone for wolves. The committees also set harvest quotas when the number of reproductions has exceeded the goal. In the regions where the target has not been met, the Norwegian Environmental Agency retains management authority.

Bears in Norway

The Norwegian brown bear population is the western edge of a larger population in Sweden, Finland, and Russia. Stortinget has decided that Norway should have 13 annual reproductions (litters) of bears in the country, and that these should occur in the four regions bordering Sweden, Finland, and Russia (Fig. 8). In the other four regions, the target number of brown bear reproductions is zero. Management zones have been established in those regions, where bear reproduction is a priority. Outside these areas, grazing animals will be given priority and there is a lower threshold for killing bears.

The national population target of 13 litters of bears per year was adopted in the carnivore settlement in Stortinget in 2011, but it has never been reached (Table 3). In 2021, the target had been reached in two regions (Table 3), so the committees in those regions had management authority over bears in their area. The bear population in Norway is increasing slowly, which in part depends on how the bear is managed in Sweden. In recent years, Swedish counties had a goal of reducing the bear population. Due to conflicts with reindeer husbandry, many bears have been killed in border areas with Norway, and many of the killed bears probably had parts of their home ranges on the Norwegian side of the border. In addition, bears can be killed in the fall by hunters who have obtained a license for bears in areas opened for bear hunting, which are primarily areas where the authorities want to reduce the number of bears and their damages outside of the areas prioritised for bears. In 2019, license hunting was allowed for nine bears in two regions and two bears were killed, one of which was a female. Also in 2019, eleven bears were killed as a response to depredation events in areas where

grazing is prioritised, and two others were known to have died (one killed by a train and one died of unknown causes). Thus, 15 bears are known to have died in Norway in 2019 (www.rovbase.no).

In Norway, most brown bears live in the border areas with Sweden, Finland, and Russia. The individuals that have been detected further inland are mainly young males on the move. The female bears in Norway live mostly close to the border; there are relatively few established adult females in the country.

Monitoring

The administration is dependent on accurate data on population size and distribution to follow up the very detailed goals in the large carnivore policy. The institution Rovdata, which is part of the Norwegian Institute for Nature Research (NINA), is responsible for the national monitoring program in Norway, which is part of the joint monitoring of large carnivores in Scandinavia. The Norwegian Nature Inspectorate (Statens naturoppsyn, SNO) is responsible for monitoring in the field and delivers bear excrements and hair collected annually from bears throughout the country to Rovdata. Every year, about 1,500 samples are analysed genetically, which allows the determination of the minimum number of bears in Norway, to follow the same individuals from year to year, and to map spatial use over time, and the distribution of males and females.

Because Stortinget has set a goal of 13 litters to be born in Norway each year, the monitoring scheme is aimed at determining how many reproductions occur annually. However, it is difficult to document females with young of the year for several reasons. When the female leaves the den with her newly born cubs for the first time, the snow, which is crucial for tracking the individuals, is often already gone. It is also hard to distinguish between large young of the year and young from previous years, and many young may not be seen or reported.

Therefore, managers use a model, developed by the Scandinavian Brown Bear Research Project, to calculate the number of reproductions each year (Bischof/Swenson 2012; Table 3). The method is based on several parameters: current results from DNA analyses in Norway, age and sex distribution in the Swedish bear population, time between litters and age at first reproduction, home range sizes, and mortality risk. The parameters are then adjusted in relation to differences between Sweden and Norway, before the probable number of litters in Norway is calculated.

Management in Finland

In contrast to Norway and Sweden, where management of the brown bear population is decentralised, Finland manages the brown bear on the national level. The main goal of the management plan for brown bears in Finland (2007, updated in 2016) is to pursue ecologically, economically, and socially sustainable population management. The brown bear is considered a game species according to the Finnish legislation, and the Ministry of Agriculture and Forestry of Finland (MAFF) is responsible for its management. The population size increased greatly from ~200 bears in the 1970s to ~2,400 in 2020, i.e. by a factor of 12, and it is regulated mostly by recreational hunting. The annual bear population growth rate since the 1970s was substantially higher outside the reindeer husbandry district (0.07) than inside the district (0.02; Kojola et al., unpublished data).

The Finnish Wildlife Agency is responsible for the execution of the management strategy proposed by the MAFF as well as the handling of applications for bear hunting licenses, which are required to hunt bears outside of the reindeer husbandry district. Bear hunting quotas in the reindeer husbandry area are set on a regional level (eastern and western region), and no personal hunting licenses are required.

Finland is divided into four brown bear management zones, i.e. the reindeer husbandry zone in the north, the stable population zone in the east, the bear dispersal zone in central Finland, and the zone for a developing population in western Finland. Bear population densities decrease from the east to the west, and the proportion of females killed during bear hunting is lowest in northern Finland (Kojola et al. 2020). The MAFF sets annual harvest quotas for provinces and management zones, based on population estimates and harvest scenarios provided by the Natural Resources Institute of Finland (LUKE), also considering damages caused by bears. Stakeholder groups are provided the opportunity to comment on a proposal for the size of the annual bear hunting quota prepared by the MAFF.

The Finnish Wildlife Agency may also approve licenses to kill problem bears beyond the quota. The Finnish Police Department has a network of trained hunters that can be used to deter or remove individual problem bears that may pose a risk to human safety in residential areas. The Police may also use hunters to remove bears that have been wounded by hunting or injured in traffic accidents.

The bear harvest scenarios are developed by LUKE, based on a Bayesian model that estimates sustainable harvest rates and the associated uncertainty, based on the annual rates of growth and mortality in the population (Heikkinen et al. 2021). Separate harvest scenarios are produced for the reindeer husbandry district and for the area outside the reindeer husbandry area. The most probable sustainable harvest rate estimates in these population models for recent years have been strikingly high (14–17 % of pre-hunt estimates), which is probably possible due to a high bear immigration rate from neighbouring Russia, where population densities are high and harvest rates comparatively low (I. Kojola/K. Tirronen, unpublished data).

Population monitoring

Every spring, LUKE prepares a bear population size estimate of the pre-hunt season (autumn) of the previous and the ongoing year. Separate population size estimates are produced for 15 provinces and four bear management zones (Heikkinen et al. 2021). The data that are used as basis for these population size estimates are collected by a network of ~2,000 volunteers, most of them hunters. This process can be considered "advanced citizen science", because these volunteers have received training to prepare them for their role as citizen scientists and data collectors. The data on observations of brown bears and other large carnivores collected by these volunteers are uploaded via a link into the online observation data base "Tassu" ("Paw" in English; Kojola et al. 2018). Each observation is attributed with geographic coordinates, date, the type of observation (sighting, track, picture, etc.). More than 10,000 observations are collected annually by this volunteer network. The main focus in the annual population size estimation is on observations of females with cubs of the year (i.e. offspring born in the current year); observations are separated based on the width of footprint of a front paw, and the body size of the dependent offspring is used to differentiate between litters consisting of cubs of the year or yearlings (i.e. offspring born in the previous year). A distance criterion (Ordiz et al. 2006) is used to differentiate between different females with litters of cubs of the year. The population size estimates based on the volunteer network have been shown to correspond well with the ones based on non-invasive genetic sampling, where samples are taken without affecting the bears in any way, e.g. from scats.

Damages and compensation

About 13 % of Finland's bear population live in the area reserved for the management of domestic reindeer (Heikkinen et al. 2021). Most damages by bears are concentrated in this zone, which covers ~36 % of the area of Finland. For example, on average 650 reindeer were reported as killed by bears annually in this area during 2010–2019. Only a small fraction of these kills is actually examined by communal authorities in the field to confirm that the reindeer had been killed by a bear, but most of

these kills are compensated for by the Finnish government. Compensation is only paid for reindeer that are older than one year. Reindeer herding cooperatives (n = 56) are classified into different categories by the number of reported kills by carnivores. The category and herd size determine the sum of money paid for the compensation of calf loss.

South of the reindeer husbandry area, in total bears usually destroy only a few dozen beehives and kill a few dozen of sheep annually. In addition, there are about 100–200 reports every year of bears damaging hay bales or feeding on agricultural crops, especially oats or fruits, such as strawberries. All such types of damages are fully compensated by the Finnish government.

Current cooperative management in Fennoscandia

The management systems in Norway and Finland are rather similar to Sweden, but objectives for carnivore population size and distribution differ widely between countries. However, because these countries share the same population of bears, cross-border collaboration in research, management, and the sharing of information is well established (Table 4).

Where to go from here in Sweden

At least in Sweden, the management system for all large carnivore species is strongly affected by never-ending discussions and controversies about the wolf. During the last 20 years, several changes to the management system were made to accommodate the needs of county boards and different stakeholders in the relatively small counties with wolves in central Sweden. Changes were not always positive for the huge counties in northern Sweden, and it was difficult to have long enough phases of uniform management in between changes, to be able to thoroughly evaluate management actions and different measures that had been applied.

Currently (May 2022), the Swedish government aims at changing the system again, by removing the county-wise minimum levels for population size, at least for the wolf. If this is done, presumably it will become more difficult for county boards to defend large population sizes of carnivores against opposing views in the delegations for game management, where influential stakeholders argue intensively for increased hunting and smaller populations.

Furthermore, the Swedish EPA is currently doing a major revision of the regulations for the hunting of large carnivores. Some of the proposed changes can alter bear hunting tremendously, especially when it comes to the use of baits. Not very much, however, is done against the hurried way in which bear hunting is conducted these days.

In 2021–2022, the Swedish EPA also revises the national action plans for brown bear, wolf, wolverine, and lynx. There are several ideas of submitting assignments to the Scandinavian Brown Bear Research Project and other researchers to compile information on different topics, and of providing funding for the extension of existing studies and for the start-up of new research. The wealth of new knowledge that hopefully will be produced will inform decision making and benefit the future management of the brown bear in Sweden.

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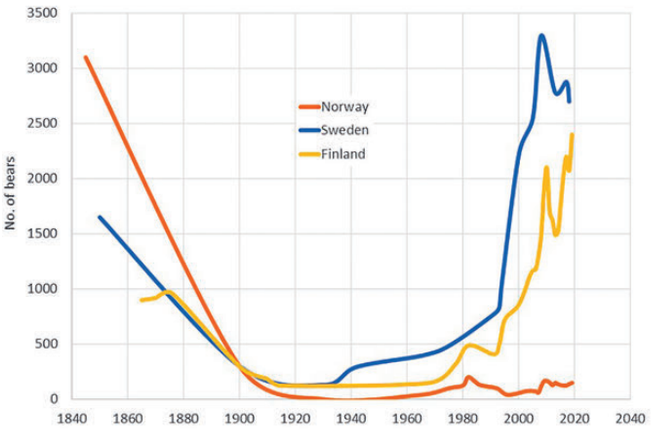

Fig. 1. Population dynamics of brown bears in Norway, Sweden, and Finland between c. *1850 and 2019, compiled from a variety of sources.*

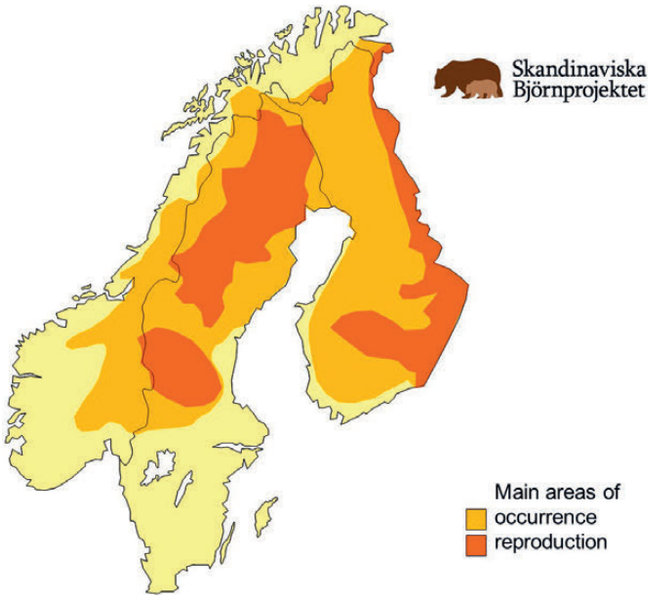

Fig. 2. Current distribution of brown bears in Norway, Sweden, and Finland (map compiled by the Scandinavian Brown Bear Research Project).

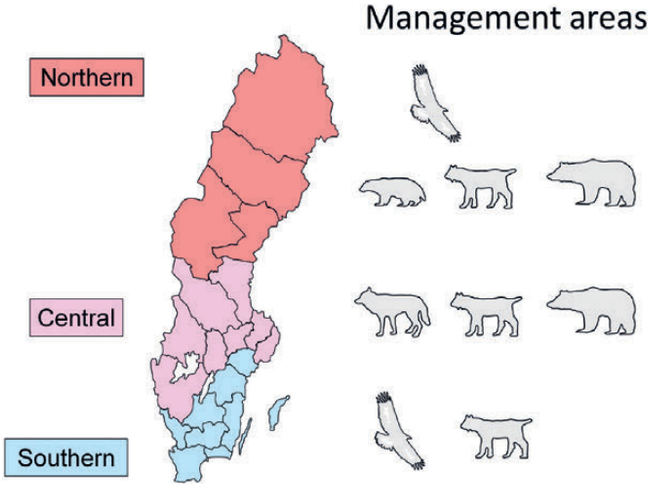

Fig. 3. Occurrence and density of large carnivores (brown bear, wolf, lynx, wolverine, and golden eagle) are different in the three management areas for the species in Sweden. Each area is subdivided into counties, the most important units for carnivore management (after Schneider *2017).*

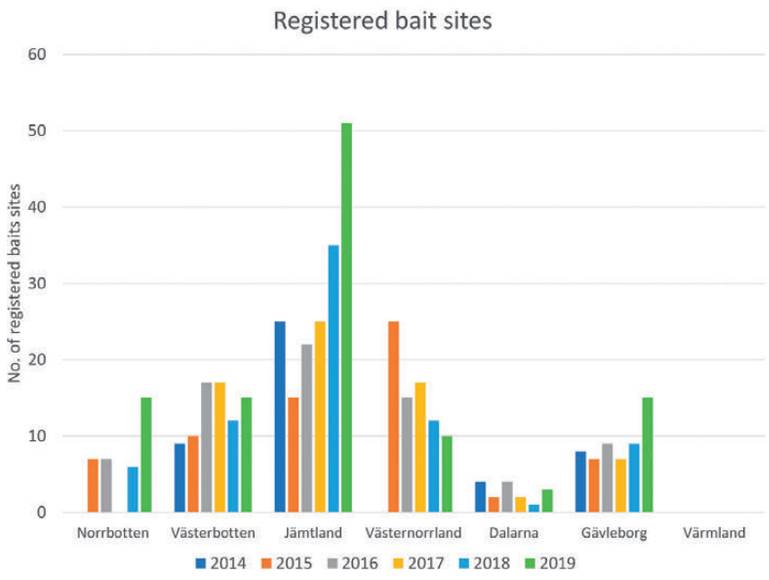

Fig. 4. Baiting for hunting of brown bears had been banned in Sweden in 2001 but was allowed again in 2014. Especially in Jämtland County it has become very popular since 2014 (after Zedrosser *et al. 2020).*

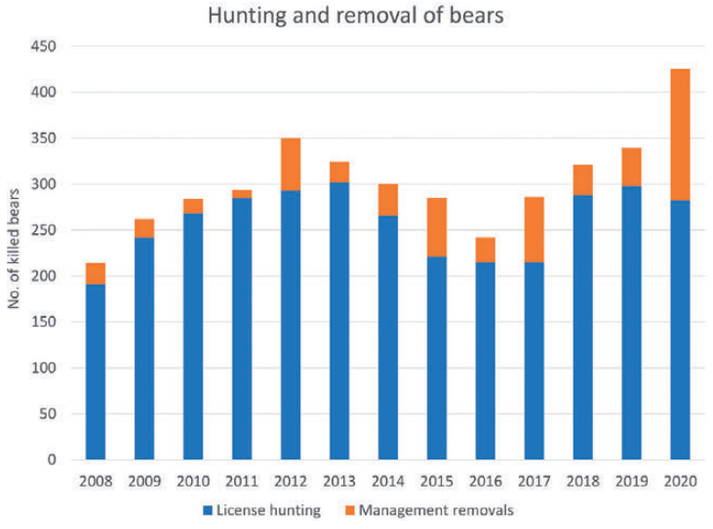

Fig. 5. The number of bears killed in Sweden during license hunting and management removals, respectively (after data from the Scandinavian Large Carnivore Database Rovbase: www.rovbase.se).

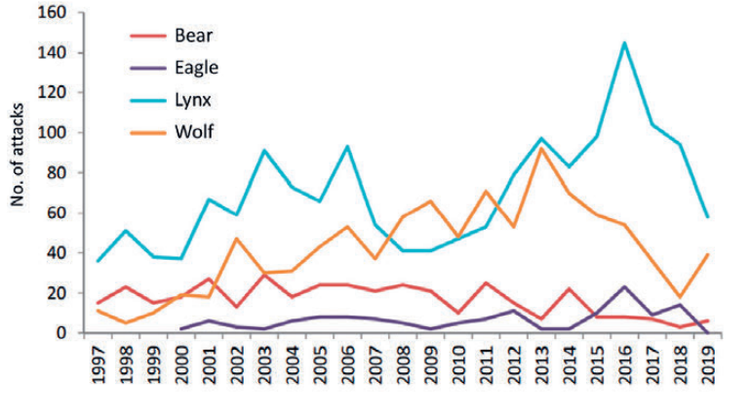

Fig. 6. Attacks by large carnivores on livestock in Sweden during the period 1997–2019. Brown bears cause relatively few problems, and the trend is decreasing (after Frank *et al. 2020, adapted).*

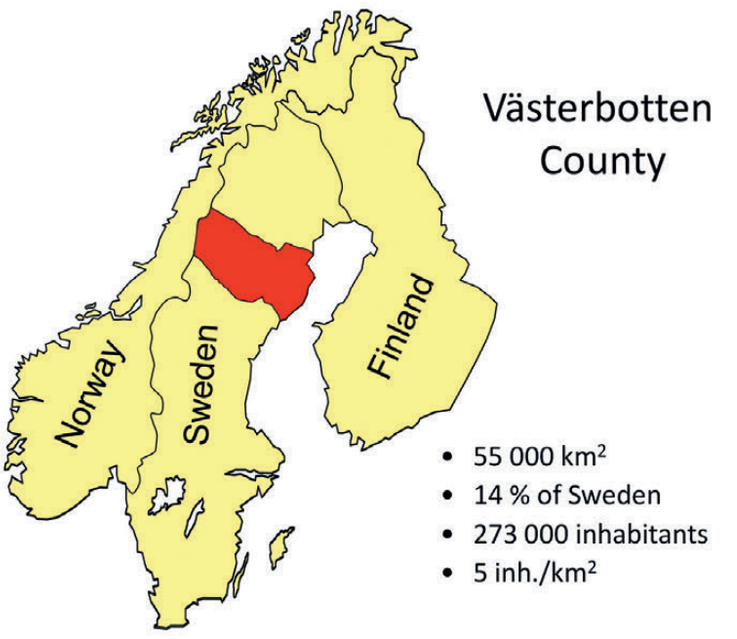

Fig. 7. Västerbotten is the second most northerly and second largest county in Sweden. The human population density is low, and most people live along the coast in the eastern parts of Västerbotten. The entire county is situated within the area of reindeer husbandry in Sweden (map M. Schneider).

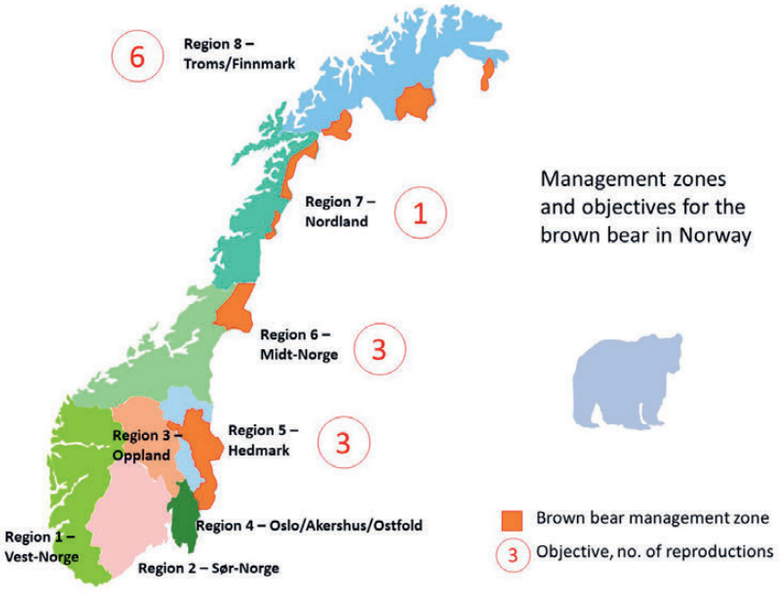

Fig. 8. Norway is subdivided into eight large carnivore management regions. The four northern-most regions have defined management areas for the brown bear and goals for the number of reproductions per year (after a map from Stortingmelding *2016, adapted).*

Table 1. Minimum levels, management targets, and limits of management intervals for the brown bear during the period 2014–2019 in the six northernmost counties in Sweden, where bear populations are rather large. Figures express the number of individuals.

	Norrbotten	Västerbotten	Jämtland	Västernorrland	Gävleborg	Dalarna	Sum
Upper limit	910	432	800	220	460	290	3,112
Target	820	350	650	200	381	270	2,671
Lower limit	730	288	500	180	300	250	2,248
Minimum	330	110	360	100	250	250	1,400

Table 2. Comparison of the number of sheep compensated for as killed by brown bears in Norway, Sweden and Finland in 2020 (after data from the Norwegian Environment Agency [Miljødirektoratet 2022], the Scandinavian Large Carnivore Database [Rovbase 2022], and the Finnish Wildlife Damage Registry [MMM/Riistavahinkorekisteri 2021]).

	No. of sheep compensated	Approximate no. of bears	Compensated sheep per bear
Norway	1,054	150	7.027
Sweden	11	2,700	0.004
Finland	123	2,400	0.051

Table 3. The national objective for the number of litters born in Norway is the sum of the regional objectives in the four northern large carnivore regions. The status in 2020 met the objective in two regions. See text for further explanations (after Fløystad et al. 2021).

Large carnivore region	County	Objective (litters born per year)	Status 2020 (litters born)
Region 5	Hedmark	3	3.1
Region 6	Møre og Romsdal and Trøndelag	3	2.9
Region 7	Nordland	1	0
Region 8	Troms og Finnmark	6	2.5
Norway		13	8.5

Table 4. List of currently active bilateral and trilateral agreements relating to cooperative management of large carnivores in Fennoscandia, i.e. Norway, Sweden, and Finland.

Year	Agreement
2011	Agreement between the Ministry of Environment, Sweden, and the Ministry of Environment, Norway, on management of genetically important wolves in the Scandinavian wolf population. 12 August 2011.
2012	Memorandum of Understanding regarding the establishment and continuance of a public web-based database (Skandobs) for geographic information on large carnivore observations in Norway and Sweden (Norwegian Institute for Nature Research and Swedish Environmental Protection Agency). 25 March 2012.
2012	Memorandum of Understanding regarding management strategies for the Scandinavian wolf population (Norwegian Directorate for Nature Management and Swedish Environmental Protection Agency). 25 April 2012.
2015	Memorandum of Understanding regarding the establishment and continuance of a monitoring system for large carnivores in Sweden and Norway (Norwegian Environment Agency and Swedish Environmental Protection Agency). 25 March 2015.
2020	Tri-lateral framework document for transboundary cooperation on management and conservation of wolves in Fennoscandia (Ministry of Agriculture and Forestry of Finland, Norwegian Environment Agency, Swedish Environmental Protection Agency). September/October 2020.