Skandinaviska Björnprojektet

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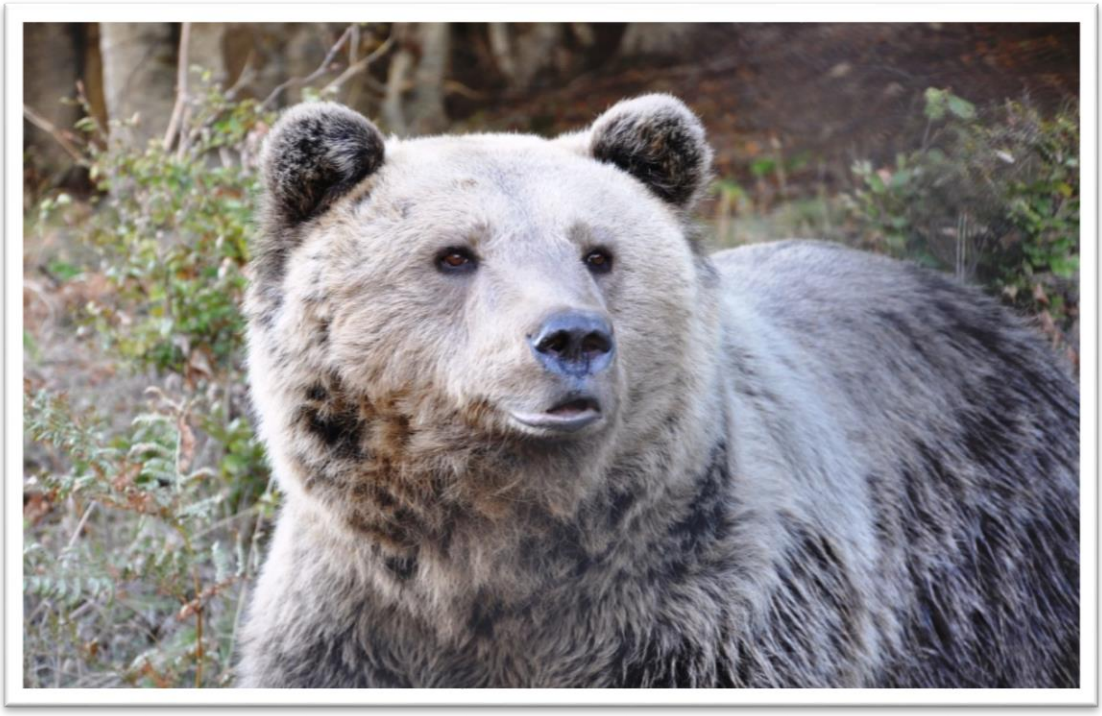
a review of mechanisms and preventive measures



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Det skandinaviske bjørneprosjektet, Rapport 2015 – 4

Occurrence of large carnivores near settlements: a review of mechanisms and preventive measures

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Abstract

We have reviewed the scientific literature regarding mechanisms behind, and preventive measures against, the occurrence of Scandinavian large carnivores (lynx, wolves and brown bears) near human settlements, and evaluated its management implications for Scandinavia. The occurrence of lynx close to settlement depends on the distribution of roe deer, its main wild prey in Scandinavia. Male lynx are generally closer to settlements than females, but during winter all categories may approach settlements to exploit the aggregation of roe deer near agricultural lands. Young wolves exhibiting exploratory movements, especially during dispersal from natal areas, may have an increased potential for occurring near settlements. In brown bears, subadults and females with dependent offspring are more often occurring near settlements than adult males, but not because of searching for food, but because of dispersal and avoidance of dominant conspecifics by predation-vulnerable individuals. In contrast to lynx and wolves, omnivorous bears can readily exploit human derived foods and have thus a potential for becoming food conditioned. We found no study evaluating the effectiveness of preventive measures when dealing with large carnivores near settlements. Several studies deal with livestock depredation and preventing large carnivore access to human derived food sources. Some of these studies might be relevant when preventing large carnivore occurrence near settlements. However, the general pattern among large carnivores to avoid settlements indicates that human habituation and food conditioning are uncommon behaviors in Scandinavia. The occasional occurrence of large carnivores near settlements is in general a consequence of intrinsic processes like dispersal in young animals, seeking prey or shelter from conspecifics, and should not be seen as un-natural behavior.

Sammendrag

Vi har gjennomgått den vitenskapelige litteraturen om mekanismene bak, og forebyggende tiltak mot, forekomsten av store rovdyr (gaupe, ulv og bjørn) nær bosetninger, og betydningen av dette ved forvaltningen av disse artene i Skandinavia. Forekomsten av gaupe nær bosetninger avhenger av fordelingen av rådyr, som er gaupas viktigste ville byttedyr i Skandinavia. Hangauper er generelt nærmere bosetninger enn hunner, men i løpet av vinteren kan alle kategorier nærme seg bosetninger for å utnytte ansamlinger av rådyra nære jordbruksland. Unge ulver som gjør utforskende vandringer, spesielt under spredning fra fødestedet, kan ha økt sjanse for å komme nær bosetninger. Hos brunbjørn, er ungbjørner og binner med unger oftere forekommende i nærheten av bosetninger enn voksne hanner. Dette er ikke fordi de leter etter mat, men på grunn av spredning og fordi predasjon-sårbare individer, slik som binner med unger og unge bjørner, prøver å unngå dominerende artsfrender. Derimot, i motsetning til gaupe og ulv, kan altetende bjørner lettere utnytte menneskeskapte matkilder og potensielt bli vandt til å finne mat nær mennesker, såkalt matbetinget. Vi fant ingen studie som evaluerer effekten av forebyggende tiltak mot forekomst av store rovdyr nær bosettinger. Flere studier omhandler tap av bufe og tiltak for å hindre tilgang på menneskeskapte matkilder. Noen av disse studiene kan være relevante for vurdering av forebyggende tiltak mot forekomst av store rovdyr nær bosetninger. Det generelle mønsteret blant store rovdyr er at de unngå bosettinger og viser at tilvenning til mennesker og menneskeskapte matkilder er uvanlig i Skandinavia. Sporadisk forekomst av store rovdyr nær bosetninger er generelt en konsekvens av indre prosesser hos dyrene, slik som spredning hos unge dyr, søk etter byttedyr eller beskyttelse fra artsfrender, og bør ikke bli sett på som unaturlig atferd.

Introduction

Large carnivores are charismatic and few people have a neutral attitude towards them. People have considered large carnivores a threat to life and property for centuries. In Scandinavia, four mammals are considered as native large carnivores; brown bear (*Ursus arctos*), wolf (*Canis lupus*), lynx (*Lynx lynx*) and wolverine (*Gulo gulo*). They can all cause damage to human property when searching for food, mostly by depredation on domesticated sheep (*Ovis aries domestica*) or semi-domesticated rein deer (*Rangifer tarandus*). Other negative impacts from large carnivore occurrence can result from reduced hunting opportunities for ungulate hunters (Nilsen et al. 2005; White et al. 2012). However, in the last centuries the management of large carnivores has changed from persecution to conservation, because most people appreciate them, and they are now increasing in numbers and in range in Scandinavia. This has led to an increasing concern among outdoor users, such as hikers and forest workers, and the general public, on how the expanding populations, especially of brown bears and wolves, will influence their safety. While the presence of large carnivores is exciting to some people, others see it as a nuisance or source of stress (Manfredo 2008). Especially the occurrence of large carnivores near human settlements may result in public anxiety (Røskaft et al. 2003).

One frequently expressed feeling is fear. People can express fear for all large carnivores, but anxiety or fear is more commonly associated with bears compared to wolves, and people are more seldom afraid of lynx and wolverines (Bjerke et al. 2002; Røskaft et al. 2003; Johansson and Karlsson 2011). There is no documentation of people being killed by lynx or wolverine during the last 250 years in Scandinavia (Røskaft et al. 2003), whereas the last documented human injuries caused by wolves were fatal and occurred in 1800 in Norway and in 1821 in Sweden (Linnell et al. 2002). During the last 30 years, 31 persons have been injured and 2 killed by brown bears in Scandinavia (Sahlén 2013). These bear-human incidents have almost exclusively involved armed hunters in remote terrain and are not related with bear occurrence near settlements (Sahlén 2013).

In this report, based on systematic literature reviews, we have identified and summarized the mechanisms behind the occurrence of large carnivores near human settlements and preventive measures applied to deal with such animals. We also discuss the suitability of these interventions in relation to the management of the Scandinavian large carnivore populations. We have focused on wolves and brown bears because of the expressed fear of these animals, but we

have also included lynx because they sometimes occur near settlements. We have not included wolverines, because their distribution range in Scandinavia is mostly mountainous with sparse human population, and they seldom occur near inhabited areas.

Methods

First we conduced a systematic literature search using the database Web of Science (version 5.14,) (https://apps.webofknowledge.com), with the following search string by topic in August 2014: (settlement* OR house* OR village* OR habitation* OR people) AND (garbage* OR food* OR damage* OR conflict* OR problem* OR occurrence* OR habituation* OR stimul*) AND (attract* OR select* OR avoid* OR deter* OR prevent*) AND (Ursus arctos OR Canis lupus OR Lynx lynx OR wolf OR wolves), and with no constraints on time span. Second, we expanded our literature by going through research cited by these authors, and included also studies on other predator species when evaluating preventive measures against the occurrence of large carnivores near settlements.

Results from the systematic literature search

Our systematic search of scientific literature, based on the specific search string above resulted in a total of 86 studies, of which 41 was identified as relevant (Table 1), based on study organism (i.e. lynx, wolf or brown bear), in relation to human activity (i.e. settlement, house, village, habitation or people), human features or studied mechanisms (e.g. garbage, food, damage, conflict, problem, occurrence, habituation or stimuli) and measures related to carnivore management (e.g. attraction, selection, avoidance, deterrence, or prevention).

Few studies scientifically evaluate the mechanisms behind the occurrence of large carnivores near settlements. Most of the studies dealt with spatiotemporal habitat use in relation to one or several proxy for human activity, e.g. distance to settlements, or carnivore-human interaction in more remote areas. The most striking result was our inability to find any studies scientifically testing or evaluating preventive measures of large carnivore occurrence near or within human settlements. Several studies deal with livestock depredation, human dimensions or were only descriptive (Table 1).

Table 1. Categorization of 41 scientific studies found in a literature search in August 2014 in the database Web of Science, regarding mechanisms for lynx (*Lynx lynx*), wolf (*Canis lupus*) and brown bear (*Ursus arctos*) occurrence near human settlements and their preventive measures. Proportions are in parenthesis (in percent) and each study is indicated with small letters referring to a separate reference list.

Categories	Lynx	Wolf	Brown Bear	Total*
Mechanisms				
Evaluating mechanisms for carnivore occurrence near settlements	2 (25.0) s, lz	1 (4.0) lz	5 (22.7) k, l, q, fz, lz	6 (14.0)
Habitat use in relation to human activity	1 (12.5) d	12 (48.0) a, c, f, r, t, v, x, y, z, dz, kz, oz	5 (22.7) i, m, v, x, gz	16 (37.2)
Preventive measures				
Evaluating preventive measures against carnivores occurrence near settlements	0	0	0	0
Other categories				
Carnivore-human interaction in remote areas	1 (12.5) o	1 (4.0) cz	5 (22.7) h, n, o, ez, hz	6 (14.0)
Livestock depredation	0 (0)	6 (24.0) e, p, t, u, jz, mz	1 (4.5) iz	7 (16.3)
Human dimension	2 (25.0) az, bz	3 (12.0) j, az, jz	3 (13.6) g, j, az	5 (11.6)
Descriptive	2 (25.0) nz, pz	2 (8.0) nz,pz	3 (13.6) b, nz, pz	3 (7.0)
Total**	8 (100)	25 (100)	22 (100)	43 (100)

* Total number of studies per study category.

** Total number of studies per listed carnivore species.

Mechanisms behind the occurrence of large carnivores near settlements

Avoidance of human settlements

Avoidance of human activity is common for all large carnivores (Woodroffe and Ginsberg 1998; Frid and Dill 2002). On national and regional scale, the highest densities of large carnivores in Scandinavia are commonly confined to areas which are sparsely populated by people (Karlsson et al. 2007; Nellemann et al. 2007; Basille et al. 2009). Large carnivores avoid human features such as roads and settlements, and have often increased nocturnal activity peaks in areas with increased human activity (Mech and Boitani 2003; Kaczensky et al. 2006; Moe et al. 2007; Ordiz et al. 2012; Zimmermann et al. 2014). In human-dominated landscapes, large carnivores can adjust their behavior and habitat use in order to avoid human activity and disturbance (Ordiz et al. 2011; Zimmermann et al. 2014). The probability of encounter or even observe large carnivores is small because they use extensive ranges and occur in low densities compared to wild ungulates (Linnell et al. 2000). For example, in order to make one observation of a brown bear requires on average 1 000 observation hours for moose hunters within areas of high population density of brown bears in Sweden (J. Kindberg, unpublished data 2014).

Avoidance of settlements by large carnivores creates refuges for prey species near people, referred to as human shields (Berger 2007; Barber et al. 2009). Moose (Alces alces) and roe deer (Capreolus capreolus) may occur close to settlements in order to avoid predation by bears, wolves and lynx (Berger 2007; Basille et al. 2009; Rogala et al. 2011). This phenomenon of prey species avoiding habitats with increased predation risk by large carnivores is often referred to as "landscape of fear" (Kuijper et al. 2013). Within a species, different requirements, naivety and the social organization can explain why some sex, age or reproductive categories are more often occurring near settlements compared to conspecifics (Mech and Boitani 2003; Elfström et al. 2014a).

Which lynx occur closer to settlements and why?

Scandinavian lynx select areas with intermediate density of roe deer while avoiding areas of highest density of roads and human activity (Basille et al. 2009). Adult females show highest degree of territoriality among lynx, and sharing ranges with conspecifics of the same sex is uncommon (Schmidt et al. 1997). Among Scandinavian lynx, females with newborn kittens are using more remote terrain with lower mortality risk from hunting and predation from adult lynx,

compared to adult males which exploit areas closer to settlements with higher density of roe deer but also increased risk of being killed by hunters (Bunnefeld et al. 2006). Females with kittens can be more day active than non-reproducing females, especially during May-August, due to securing food for the kittens (Schmidt 1999). During this summer period, females with newborn kittens have the smallest home ranges (Schmidt et al. 1997). Later in the season, especially during snowy winter conditions, roe deer concentrate closer to settlements, whereas lynx kittens are less vulnerable to predation in combination with having higher food demands (Bunnefeld et al. 2006). Therefore, independent of reproductive status, lynx may occur closer to settlements during the winter (Bunnefeld et al. 2006).

Which wolves occur closer to settlements and why?

Young dispersing wolves, usually 11-24 months old (Mech and Boitani 2003) tend to disperse in all directions in Scandinavia and may sometimes make long routes towards areas densely populated with people (Wabakken et al. 2001). Minimum range of dispersal distance by Scandinavian wolves during the reestablishment 1983-1998 was 20-250 km, and maximum range of dispersal was 210-430 km (Wabakken et al. 2001). Young dispersing wolves usually seek available areas where wolf density is higher to increase the probability of encountering mates, while avoiding areas occupied by territorial conspecifics (Boyd and Pletscher 1999; Mech and Boitani 2003). Males may disperse farther or at higher rate than females (Wabakken et al. 2001). Dispersal may be triggered by food competition forcing young subordinate individuals to make exploratory movements searching for food elsewhere (Mech and Boitani 2003). Aggression related to breeding is largest during spring which may trigger wolf dispersal due to social competition, whereas increased food requirements due to larger movements and body sizes during fall may trigger dispersal later in the season (Mech and Boitani 2003). Most intraspecific killing, typically committed by neighboring wolves, has been reported to occur along the territorial edges and involves the breeding adults (Mech 1994).

Which brown bears occur closer to settlements and why?

A common pattern among brown bears is that young individuals and females with dependent young occur closer to settlements whereas older conspecifics, especially adult males, are more often found in remote terrain (Elfström et al. 2014a). Dispersal of young from their natal home

ranges may explain why brown bears near settlements are younger compared to conspecifics found in remote terrain, especially in expanding populations (Swenson et al. 1998). Dispersing young animals may lack experience of human disturbance and other human-related costs and, thus, approach settlements due to naivety (Kaczensky et al. 2006; Elfström et al. 2014a).Young bears and females with dependent young are vulnerable for predation and aggression from especially adult males (McLellan 1994; Swenson et al. 1997; Swenson et al. 2001). Thus, settlements may function as human shields for subordinate and predation vulnerable brown bears against dominant conspecifics, which explain why young bears and females with young are more common near settlements (Elfström et al. 2014a; b).

Behavioral responses from occurring near settlements - habituation and food conditioning

When wild animals are observed near settlements they may be viewed as displaying an unwary behavior. This increased tolerance of people of some individuals may be a result of learning not to respond to human activity, i.e. to become human habituated (Immelmann and Beer 1989). Consistency and predictability is probably important for this kind of learning response to occur, and can explain why large carnivores may be more tolerant to people on trails than off-road (Jope 1985; Shivik and Martin 2001). In contrast to being naïve, human habituation is assumed to be more common as a result of an increasing frequency of benign encounters between the animal and people. Similarly, wild animals may learn to associate human activity with easy-accessible and/or high-quality food resources, i.e. to become food conditioned (Bejder et al. 2009). Thus, based on earlier experience, animals can learn to either not respond to human activity or to associate settlements with easy-accessible foods. Predation-vulnerable large carnivores that seek refuge near settlements may gain an increased experience of human activity and, thus, have an increased potential of secondarily becoming human habituated or food conditioned (Elfström et al. 2014a). Offspring can also acquire foraging behavior from their mother, e.g. food conditioning in American black bears (*Ursus americanus*) (Mazur and Seher 2008), however, this does not explain why these mothers occur near settlements more than other conspecifics, e.g. adult males, in the first place (Elfström et al. 2014a).

Preventive measures against the occurrence of large carnivores near settlements

During our literature search we were unable to find any study that had scientifically tested or evaluated preventive measures against the occurrence of large carnivores near settlements. We are aware of only one study that measured the behavioral response in a carnivore after applying a preventive measure, namely in red fox (*Vulpes vulpes*, i.e. a mesopredator) when manipulating food availability within settlements (Bino et al. 2010; see also Johnson et al. 2002). The removal of human-derived foods was proven, within only 6 months, to reduce the occurrence of foxes near settlements (Bino et al. 2010).

Several studies dealt with livestock depredation and preventing large carnivore access to human derived food sources. In this following section we list preventive measures that has been described and that may be relevant in preventing the occurrence of large carnivores near settlements.

A variety of non-lethal measures are today used by the public and by managers for changing short-term and long-term behavioral responses in large carnivores. The occasional exposure of negative stimuli towards individual animals may only result in a short-term response, e.g. an individual leaving an area after have been hazed or chased. However, some of the techniques described may be relevant for large carnivore occurrence near settlements. The most applicable techniques can be sorted under one or several of the following categories:

• Attractant management – removal of attractive foods and other resources
• Aversive conditioning – long-term behavioral response (i.e. learning process) after a systematic application of an aversive agent, e.g. acoustic and/or visual scaring devices, aversive chemical agents, and pain stimuli such as projectiles
• Non-lethal removal – translocation or relocation of problematic wildlife (i.e. releasing captured animals outside or within its expected home range, respectively)
• Supplemental feeding –allocating food resources to divert wildlife movements
• Barriers (e.g. fences, preferably electrified) – fencing livestock and excluding areas for wildlife

The effectiveness of preventive measures is dependent on various factors, e.g. time, location and context (Mason et al. 2001). The application of only one non-lethal technique is often not sufficient, but rather a combination of different non-lethal methods, and preferably involving also lethal methods, in order to increase the preventive effectiveness (Mason et al.

2001). In general, it is not clear whether hunting of large carnivores has any effect in preventing property damages (Treves 2009). In Wisconsin, US, the number of shot black bears during regular hunting showed poor relationship with numbers of property damage or complaints of nuisance black bears (Treves et al. 2010).

Attractant management

A variety of measures can be applied to reduce the potential attractiveness to an area and thereby preventing the occurrence of large carnivores near settlements. Most measures focus on mitigating or removing the accessibility to human-derived food resources. Large carnivores can be deterred from attractant resources by physical barriers, such as electrified fences, and the securement of containers (e.g. designing dumpsters and trash cans resistant to bear intrusions). Exposure and accessibility to attractant resources can be reduced by adjusting when and where human-derived resources and activities take place. Avoidance of hot spots such as forest edges and rugged terrain when choosing areas for cultivation and livestock grazing, in combination with shifting crops and night-time penning of livestock are examples of preventive measures to reduce attractiveness to large carnivores (Breitenmoser et al. 2005). The potential of human disturbance can be increased near settlements by reducing the understory vegetative cover, because large carnivores are reluctant to exploit areas with increased human activity without cover (Basille et al. 2009; Ordiz et al. 2011; Zimmerman et al. 2014).

Aversive conditioning against carnivore occurrence near settlements

Aversive conditioning, i.e. to cause discomfort or other negative experience paired with specific behaviors, are of limited use when aiming at reducing depredation attacks (killing behavior) by predators (Koehler et al. 1990; Bangs and Shivik 2001). Disruptive stimuli, e.g. scaring devices, are less effective in general because of a high probability of habituation to these stimuli to occur (Koehler et al. 1990; Bangs and Shivik 2001; Shivik and Martin 2001; Shivik et al. 2003). Therefore, the outcome from applying aversive conditioning differs among studies, indicating low generality and that the suitable technique may be situation-dependent (Shivik 2006). In order to achieve successful aversive conditioning requires intensive monitoring of the animals.

Aversive conditioning, including chasing and yelling, projectiles and pepper spray, has been reported to be successful in keeping American black bears from becoming food conditioned

inside a national park (Mazur 2010). Movements of wolves have been successfully altered over a one year period when applying scent odors in Idaho, US (Ausband et al. 2013). In contrast, ultrasonic deterrents, a type of aversive conditioning, have been reported not to be effective on dingoes (*Canis lupus dingo*) in captivity (Edgar et al. 2007).

Non-lethal removal

Translocation has been used to remove animals without killing them, but many North American agencies have stopped translocating large carnivores, because it is ineffective and costly. Relocated animals tend to leave the release area and return to their capture area (Linnell et al. 1997). Food availability in combination with homing ability may increase return rates of translocated animals (Singer and Bratton 1980; Clark et al. 2002; Landriault et al. 2009). In addition, translocating animals may destabilize the social structure among resident and dominant conspecifics at release sites, resulting in increased intraspecific aggression (Stokes 1970; Treves and Karanth 2003; Elfström et al. 2014a).

Supplemental feeding

Supplemental feeding has the potential to compensate for general food shortage and, thus, reduce the risk of large carnivore occurrence near settlements in search of food (Robbins et al. 2004; Rogers 2011). However, supplemental feeding is a controversial practice due to concerns that food-supplemented animals may become food conditioned, i.e. to learn to associate food resources with human activity and therefore approach settlements (Huber et al. 2008). Evidence from Scandinavia and central Europe suggests that brown bears may approach settlements or depredate on livestock independently of their exploitation of supplemental feeding sites (Kavčič et al. 2013; Steyaert et al. 2014; Kavčič et al. 2015).

Preventing depredation on livestock

All large carnivores can cause damages to domesticated livestock, especially on free ranging livestock. All types of individuals may depredate on livestock and there is no support indicating that only injured, starved or sick animals would attack livestock (Linnell et al. 1999). In general, adult males tend to more often depredate on livestock compared to females and younger conspecifics, perhaps because males may be more risk-prone (Sukumar 1991) and use larger

ranges increasing their encounter rates with livestock (Linnell et al. 1999). However, the risk is relatively small for depredation attacks to occur on fenced domesticated livestock across the overlapping distribution range with that of large carnivores in Scandinavia. One example is the annual risk of a predation event for sheep farms within the wolf distribution range in south-central Sweden which was as low as 0.003 during 1998-2006 (Karlsson and Johansson 2010). But, once a depredation attack has occurred, the risk of depredation increases on the same farm compared to other unaffected farms (Karlsson and Johansson 2010).

Although we may expect an increased human density and activity near pastures with livestock in contrast to in remote terrain (i.e. areas without livestock husbandry), it is important to distinguish between livestock depredation by carnivores and carnivore occurrence near/inside settlements. Livestock depredation by large carnivores can occur without exposure to human activity. Carnivores will have access to depredate on livestock during nocturnal hours when human activity is much reduced near most rural settlements (Chavez and Giese 2006). During diurnal hours when human activity is increased, carnivores may still have access to depredate on livestock at edges of the settlements, i.e. areas associated with lower human activity. Thus, livestock depredation may occur without exposing the depredator to human disturbance, indicating that the animal not necessarily is either human habituated or food conditioned.

Numerous studies have evaluated preventive measures against livestock depredation. Barriers such as fences can function not only to confine livestock, e.g. inside pastures, but also to exclude large carnivores from certain areas. A variety of different types of fences may be subsidized by the Scandinavian governments in order to prevent livestock depredation and to mitigate conflicts (Karlsson & Sjöström 2001).The use of shock collars on wolves in Wisconsin and Michigan, US, has resulted, in combination with fladry, in an avoidance of certain areas with livestock during a period of at least 3 months (Gehring et al. 2006; Lance et al. 2010). Depredation on sheep by coyotes in Colorado, US, has been successfully reduced when applying sound/light deterrents (Linhart et al. 1984), although individual differences (e.g. boldness) also affect the outcome (Darrow and Shivik 2009). Fox depredation on eggs has been reduced when applying long term (28 days) chemical treatment of the eggs with an aversive agent in Australia (Maguire et al. 2009). Morehouse & Boyce (2011) reported that in an area with intense overlap between wolf territories and livestock grazing in Alberta, Canada, cattle livestock is a common

wolf diet and argued therefore that the removal or reduction of dump sites of livestock carcasses would reduce the risk of wolf occurrence also near settlements.

Management implications for Scandinavia

The common behavior among wolves, lynx, and brown bears is to avoid settlements, i.e. areas with elevated human activity (Karlsson et al. 2007; Moe et al. 2007; Basille et al. 2009; Zimmermann et al. 2014). This indicates that the individual occurrence of lynx, wolves and brown bears inside settlements usually occurs when and/or where human activity is reduced in combination with the presence of vegetation providing cover.

Lynx can exploit areas near human settlements in pursue of prey, especially roe deer which is their main wild prey in Scandinavia (Basille et al. 2009). Both females and male lynx are closer to human settlements during winter due to the aggregation of roe deer on agricultural lands (Bunnefeld et al. 2006). Young dispersing wolves can approach human settlements when seeking available areas and mates (Wabakken et al. 2001). A common pattern among Scandinavian brown bears is that young individuals and females with dependent young occur closer to settlements, whereas older conspecifics, especially adult males, are more often found in remote terrain (Nellemann et al. 2007, Elfström et al. 2014a).

The despotic distribution in bears predicts that the type of brown bear(s) observed near a settlement can serve as an indicator whether that area represents high or low habitat quality for brown bears (considering food resources and disturbance) (Elfström et al. 2014a). Observations of large solitary bears (i.e. adult males or lone adult females), suggest dominant individuals which usually exploit the best habitats in terms of food and low disturbance. Therefore, attractant management focusing on the removal of anthropogenic foods and dense understory vegetation (Ordiz et al. 2011), can be relevant in areas where dominant brown bears occur. On the contrary, if mostly small (young) brown bears and females with young are observed near a settlement, indicates that these bears are using the area in order to avoid dominant conspecifics in remote areas (Elfström et al. 2014a). Attractant management focusing on removing food resources may therefore be less effective in reducing the occurrence of these predation-vulnerable categories of brown bears near people (Elfström et al. 2014a; c). The strategy of reducing cover may be applicable also near settlements where lynx and wolves repeatedly occur, considering their

general avoidance of areas with high human activity and thus need of cover to exploit these areas (Basille et al. 2009; Zimmerman et al. 2014).

Lynx and wolves are carnivores which seldom exploit vegetative foods, in contrast to the omnivorous diet in brown bears (Birkeland & Myrberget 1980; Pedersen et al. 1999; Gade-Jørgensen and Stagegaard 2000; Bojarska and Selva 2012). Bears have thus a higher potential of being attracted to a variety of human-derived foods such as fruits and cereals and disposed food in garbage, compared to lynx and wolves. However, there is no difference in the diet composition or quality among remote bears and bears approaching settlements, and problem bears have no different body condition than other bears, suggesting that food search and remote food shortage are uncommon factors behind the occurrence of brown bears near settlements in Scandinavia (Elfström et al. 2014b; c).

Although wolves and lynx are probably more often attracted to domesticated livestock than other human-derived food resources, their general pattern of avoidance of settlements indicates that human habituation and food conditioning are not common behaviors among Scandinavian large carnivores. Prey density is also of minor importance in comparison with human activity in explaining or predicting the occurrence of wolves and lynx (Karlsson et al. 2007; Basille et al. 2009). This suggests that habitat use by Scandinavian large carnivores is poorly predicted by food shortage and, thus, the implementation of supplemental feeding would have low efficiency in reducing their occurrence in areas near settlements. Translocation of individual large carnivores occurring near settlements has been proven costly and ineffective, and there are few suitable release sites in Scandinavia without generating conflicts (Linnell et al. 1997).

Managers are often forced to make arbitrary assumptions whether individual large carnivores near settlements are naïve/human habituated/food conditioned or not. When dealing with large carnivores near settlements, we believe that managers must not forget the ultimate mechanism behind their occurrence when addressing people's fear. Specifically in brown bears, their despotic distribution suggests that human habituation and food conditioning is no prerequisites to explain bear occurrence near settlements and, thus, these bears may not be viewed as 'unnatural', but rather animals showing an adaptive behavior of avoiding dominant conspecifics.

The common pattern of avoidance of human activity by all large carnivores in Scandinavia indicates that the occasional occurrence of individual lynx, wolf or brown bear near a settlement is generally a result of low human activity in combination with vegetative cover. Studying behavioral responses is complex, but needed in order to evaluate preventive measures against the occurrence of large carnivores near settlements.

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