

Brown bear–livestock conflicts in a bear conservation zone in Norway: are cattle a good alternative to sheep?

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Abstract: We evaluated the potential for reducing livestock conflicts within a bear (*Ursus arctos*) conservation zone by replacing sheep with cattle. We interviewed cattle farmers and veterinarians and investigated livestock and depredation statistics from governmental land-use and wildlife management in Hedmark County, south-eastern Norway. This county borders a reproducing brown bear population in Sweden and already contains several resident male brown bears. A brown bear conservation zone, within which bear density is planned to increase, covers 46% of the county's surface. There were about 7 times as many free-ranging sheep (128,600) as cattle (18,200) during summer 1998, with densities lowest inside the bear conservation zone. Estimated free-ranging cattle mortality was about 16 times lower than sheep mortality in summer 1998. During the past 13 years, no cattle were confirmed as killed by brown bears. The perception of the brown bear as a threat to cattle is higher among farmers than among veterinarians or managers. We found little support for the allegation that cattle become more difficult to control in the presence of brown bears. Regarding brown bear predation, we consider cattle a good alternative to sheep in Norway. In southeastern Norway, however, the expected expansion of the brown bear reproduction area and an increasing wolf (*Canis lupus*) population makes this assertion less certain. We stress the need for research on the predatory behavior of large male brown bears and wolves, as well as on measures to protect free-ranging cattle against potential predation.

Key words: brown bear, *Canis lupus*, cattle, domestic sheep, livestock depredation, Norway, *Ursus arctos*, wolf, zoning management

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Livestock production in Norway has a long tradition of using the vast marginal forest and mountain habitat; cultivated land is limited. Current land-use policies still try to use these outlying areas in various sustainable ways (Landbruksdepartementet 1993, Miljøverndepartementet 1997). These policies are intended to help maintain rural settlements and secure the strategic capacity for independent food production. After large carnivores (brown bears, wolves, Eurasian lynx [*Lynx lynx*], and wolverines [*Gulo gulo*]) became reduced or eradicated at the beginning of the twentieth century, sheep could be kept largely untended in the forests and mountain areas during summer grazing (Reinton 1955).

Until 150 years ago, several thousand brown bears inhabited most of the Scandinavian Peninsula (Sweden and Norway; Swenson et al. 1995). However, the number of brown bears decreased to a low of about 120 during the

1920s due to intensive hunting. Gradually improved protection of brown bears in Sweden allowed an increase, resulting in 4 reproduction core areas (Swenson et al. 1995). At present, there are 800–1,300 brown bears in Scandinavia, including 26–55 in Norway (Miljøverndepartementet 1997, Zedrosser et al. 2001). Most bears in Norway are males roaming close to the Swedish border (Swenson et al. 1998b). The Norwegian government has established 5 bear conservation zones along the Swedish border to ensure viable populations (Miljøverndepartementet 1992). This zoning management allows increased control outside the conservation zones. Inside, alternative conflict-reducing measures that still allow some form of land-use are a priority (Miljøverndepartementet 1992, 1997). Sheep losses have increased markedly, and the annual removal of some problem bears has not halted this trend (Wabakken and Maartmann 1994, Sagør et al. 1997). A comparison among European countries revealed Norway had the highest livestock depredation rates by far; at least 25 times as many sheep are annually

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lost to bear predation per brown bear than in other countries (Kaczynsky 1996).

In Norway, large carnivore-livestock conflicts have prompted several studies on the prevention or reduction of sheep depredation, including the economics and social aspects of depredation (Wabakken and Maartmann 1994, Linnell et al. 1996, Mysterud et al. 1996, Flaten and Kleppa 1999, Krogstad et al. 2000, Ringsø et al. 2000). In addition to carnivore management and sheep protection techniques, the government is encouraging farmers, particularly in bear conservation zones, to turn from sheep farming to sources of income less affected by bears (Miljøverndepartementet 1992, 1997). The insufficient cultivated ground makes the use of forest and alpine areas as grazing lands essential to the economy for a majority of these farmers.

Is the replacement of sheep with free-ranging cattle a problem-free solution? Will brown bears and other predators switch to cattle after sheep removal? The governmental Conservation Agency of Hedmark County, southeastern Norway, asked us to answer these questions. They also asked us to investigate a common allegation that cattle become more difficult to handle when exposed to brown bears on summer pasture.

Despite many recent studies on sheep production in Norway, free-ranging cattle farming has rarely been studied. We gathered information from farmers, veterinarians, and governmental agencies on practices and problems with free-ranging cattle in Hedmark County, southeastern Norway. Our objectives were to (1) identify the distribution of free-ranging cattle and sheep ranges in relation to large carnivore distribution, brown bears in particular; (2) quantify qualities of cattle grazing ranges that might expose cattle to increased depredation risk; (3) identify sources of cattle mortality in general and carnivore-related mortality in particular; (4) investigate the allegation that cattle become difficult to manage with brown bear presence.

Study area

The study area (27,388 km²) was situated in south-central Scandinavia and comprises Hedmark County in southeastern Norway (Fig. 1a). Human population is scattered throughout the county and generally has a low density (average 6.8 persons/km²). Lowest densities are in the east and north of the county, commonly with <1 person/km². Boreal coniferous forest dominates the landscape up to 900 m above sea level; alpine vegetation takes over above the treeline. Forestry is the dominant land-use system, but some agriculture occurs in all parts

of the county. Moose (*Alces alces*), roe deer (*Capreolus capreolus*), and red deer (*Cervus elaphus*), as well as wild reindeer (*Rangifer tarandus*) in the mountains are present and subject to intense harvest.

Hedmark County borders one of 4 brown bear reproduction core areas in Sweden. In 1996, an estimated 9–13 males occupied Hedmark County and a few females occasionally crossed the national border (Miljøverndepartementet 1997); bears regularly hibernate on the Norwegian side of the border (Swenson et al. 1996). The Norwegian segment of the population is expected to increase, including more reproducing females in the future.

The Scandinavian wolf population is shared by Hedmark County and neighbouring Norwegian and Swedish counties to the south and east. This population increased from about 10 individuals during the 1980s to 62–78 wolves in 1998 (Wabakken et al. 2001). In winter 1998–99, 2 packs and 2 pairs were located totally or partially inside Hedmark County (Wabakken et al. 1999). Lynx occurred in the forested areas of Hedmark County (Wabakken et al. 1995, Odden et al. 2000), whereas wolverines and golden eagles (*Aquila chrysaetos*) were found in some of the mountain areas and high altitude forests (Wabakken et al. 1995, Landa et al. 1998). In 1998, brown bears accounted for 47%, lynx for 23%, wolves for 14%, wolverines for 10%, and golden eagles for 6% of the livestock losses to predators (E. Maartmann, Hedmark County Conservation Agency, Hamar, Norway, personal communication, 1999).

Methods

We divided Hedmark County into 5 regions defined by the presence of brown bears and wolves (Fig. 1b). The eastern most region (code 3) was the brown bear conservation zone. This zone covered 46% of the county. Breeding female brown bears in the border area, established male brown bears, and some wolves inhabited this zone. Two other regions had occasional occurrence of brown bears and a few locally established wolves (code 2). The remaining 2 regions had rare occurrences of brown bears and lacked established wolves (code 1). The northern-most region is mostly alpine, whereas the southern-most of these 2 regions is dominated by forest.

Data sources

To evaluate the potential of cattle farming as an alternative to sheep production on brown bear occupied

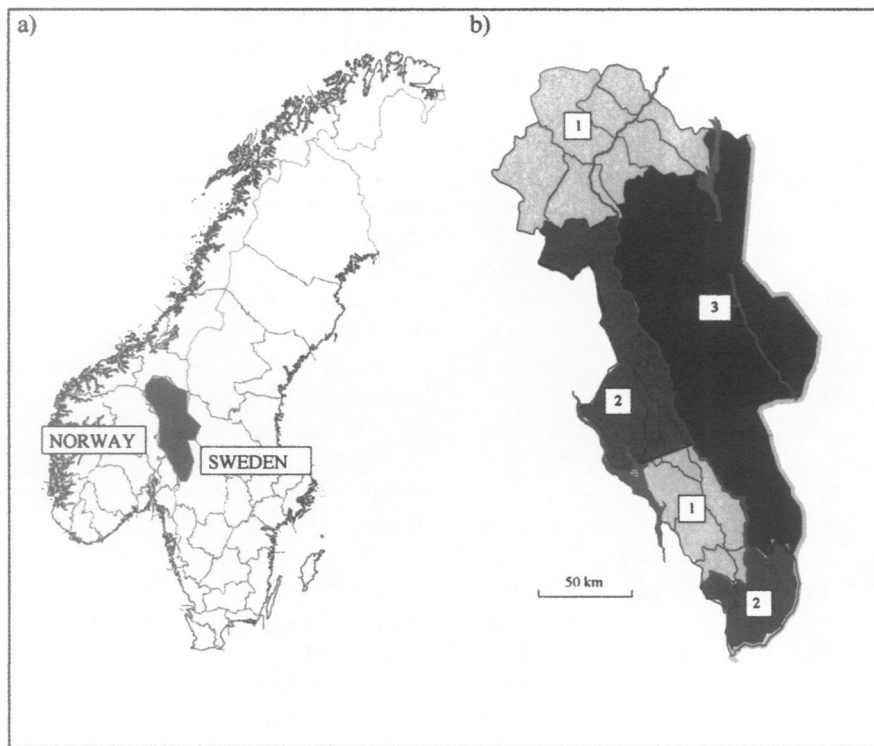


Fig. 1. Study area of (a) Hedmark County in Norway in the Scandinavian Peninsula and wolf and brown bear distribution (b) in Hedmark County: 1 = occasional bear and wolf presence, 2 = occasional bear presence, established wolves in some areas, 3 = bear conservation zone, bears and wolves established in some areas, 1998.

rangelands, we used 3 sources of information: (1) governmental land-use and conservation agencies, (2) farmers who owned free-ranging cattle, and (3) district veterinarians. Sources and sampling methods are detailed below.

Governmental land-use agencies. These provided statistics based on subsidies for all livestock kept free-ranging for at least 8 weeks/year (Statens Kornforretning 1999a; E. Maartmann, personal communication, 1999). Free-ranging is defined here as “kept on non-agriculture areas with <50% cover of grass species suitable for grazing or harvest” (Statens Kornforretning 1999b:9). Governmental conservation agencies provided statistics on livestock losses to large carnivores based on a compensation system. Experienced, trained field personnel annually investigate 10–20% of the farmers’ compensation claims. They conduct necropsies and search for tracks or other species-specific sign of carnivores. If carnivore damage is identified or highly probable, the farmer receives compensation for documented and undocumented losses after subtraction of an estimated non-carnivore mortality rate (E. Maartmann,

personal communication, 2000). On the regional and county level, we considered these numbers reliable.

Cattle farmers. In 1998, 880 farmers in Hedmark County practiced free-ranging cattle farming (Statens Kornforretning 1999b). We sent a questionnaire to 572 of them, followed by 2 reminders. This sample constituted a randomly selected 36% of farmers in the northernmost region and all farmers in the other regions. The reduction in the northernmost region was necessary to balance the number of questionnaires in the different regions and to reduce costs.

District veterinarians. Hedmark County is divided into 14 veterinary districts, 5 of which are within the bear conservation zone (Fig. 1b). The district veterinarians are the chief managing veterinarians for each district. All reports and files are centralized at their offices. However, veterinarians are not responsible for identifying carnivore kills for the compensation system. To increase the sample size and to provide a control group from a practically bear- and wolf-free area, we included the 14 district veterinarians of neighboring

Table 1. Predation risk characteristics of cattle ranges used by cattle that ranged freely for at least 8 weeks in 1998 in Hedmark County, Norway.

Parameters	Code	Description
Carnivore regions	1	Bears and wolves occasionally
	2	Bears occasionally, wolves established in some areas
	3	Bears and wolves established in some areas
Altitude	1	Below tree line
	2	At and above tree line
Cattle range size (km ²)	1-5	<0.05, 0.05-0.49, 0.5-4.9, 5-49, >50
Fence integrity	1	Unfenced
	2	Weak fence (non-electric wire fence)
	3	Strong fence (electric fence or wooden fence)
Calves	0/1	Absent/present
Sheep	0/1	Absent/present
Supervision	1	Daily
	2	Weekly
	3	Monthly
	4	Less
Distance to farm	0	<0.5 km, directly at farm
	1	0.5-5 km
	2	>5 km

Oppland County, west of Hedmark. Veterinarians were interviewed by telephone to ensure a 100% response rate.

Questionnaire surveys

We asked farmers about characteristics of the cattle range used in 1998 (Table 1). We assumed that level of carnivore presence, altitude, range size, fence integrity, distance to farm, and level of supervision could influence predation risk. The presence of sheep could deter the carnivores' interest toward smaller prey; among cattle, calves might be more vulnerable to depredation (Murie 1948).

We asked questions about the number of free-ranging cattle during summer 1998, the number of cattle killed, and the causes of mortality. As a comparison, all 14 veterinarians of Hedmark County were asked how many cattle injuries and losses they assigned to large carnivores during summer 1998. The Governmental Conservation Agency of Hedmark County provided statistics on livestock losses to carnivores during 1986-98. We evaluated data from 1998 and combined data for the entire period.

From a list of potential health problems, farmers were asked to mark problems that had occurred to their free-ranging cattle in the preceding 5 years. The same list

was presented to the veterinarians. They were asked to give a relative frequency of occurrence for each item (never = 0, relatively seldom = 1, relatively common = 2, relatively frequent = 3). Only answers from veterinarians with at least 7 years working experience (mean working experience 16.4 years, SD = 9.4, $n = 23$) were included in the analysis.

The farmers' questionnaire contained 27 statements about free-ranging cattle farming. We asked the farmers how often these statements had applied in the preceding 5 years by using a 4-point scale from "never" to "often". We also asked them if this frequency had increased, decreased, or remained unchanged since they started free-ranging cattle farming. In this paper we focus on statement 7 and statement 13 only: "carnivores frighten the cattle" and "cattle become difficult to control during summer". The allegation that cattle become difficult to control due to large carnivores may gain credibility if frequency and change of occurrence of these statements is similar. Veterinarians also were asked to state if the occurrence of cattle that are difficult to control during summer had increased, decreased, or remained unchanged. Those answering "increased" were asked to give reasons for this increase. As above, we limited analysis to veterinarians with a minimum 7 years of experience ($n = 23$).

We used logistic regression to relate farmers' reported cattle loss to the set of range qualities. Predictor variables were analyzed separately due to a large number of zeroes in the dataset. A χ^2 test of independence was used to compare the frequencies of answers between the statements "carnivores frighten the cattle" and "cattle become difficult to control during summer". Poisson regression was performed in a backward selection procedure when analyzing these variables in relation to range qualities. We compared the answers of the veterinarians of Hedmark County to those of the control group of Oppland County using a Kruskal-Wallis test. All analyses were performed using SAS (version 8.0; Cary, North Carolina, USA).

Results

Free-range farming and range characteristics

During summer 1998, there were 18,255 cattle, 129,032 sheep, 2,016 goats, and 392 horses free-ranging in Hedmark County (Statens Kornforretning 1999a). This constituted 7.6% of the Norwegian stock of free-ranging cattle and 5.1% of sheep. The bear conservation zone and the southernmost region with locally established wolves had the lowest cattle and sheep den-

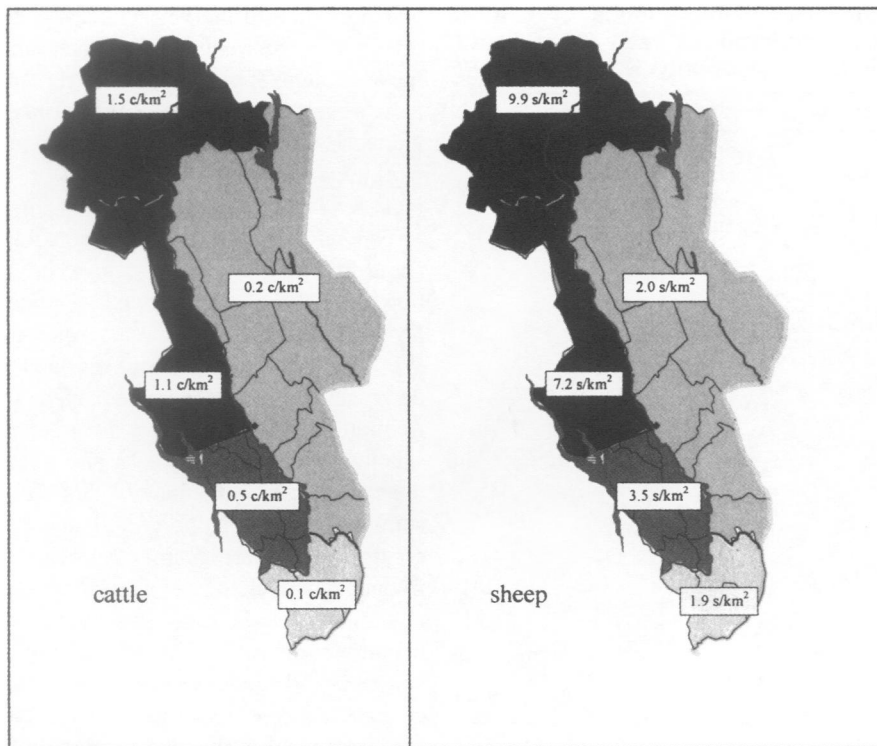


Fig. 2. Densities of free-ranging cattle and sheep during summer 1998 in Hedmark County, Norway. Regions are defined by the distribution of brown bears and wolves (Fig. 1).

sities (Fig. 2a). For both livestock species, the densities in the northern- and the westernmost regions were above the county means of 0.7 cattle and 4.7 sheep/km². These regions had about 6 times as many sheep as free-ranging cattle. The ratio of sheep to cattle was higher in the bear conservation zone (10× as many sheep) and the southern most region (20× as many sheep, Fig. 2).

The response rate from farmers was 65.5% and varied from 62.6%–68.1% among regions. The surveyed farmers represented about 40% of all farmers with free-ranging cattle. Although the response rate was high, we cannot exclude the possibility that those farmers who chose to respond were a biased sample. In the bear conservation zone, 18% of farmers reported that calves were born on the cattle grazing ranges. Five of these 21 ranges were unfenced. In regions with low bear and wolf presence (labeled 1 and 2 on Fig. 1b), 29.4% and 28.1% of the farmers respectively reported calves were born on cattle range. One-quarter of these ranges were unfenced (19 of 76 cases). In total, 7.1% of respondents had calves born on unfenced ranges.

Livestock depredation and cattle mortality

During 1986–98, farmers sought compensation for livestock killed by large carnivores for an annual average of 4,000 sheep, 2 cattle, <1 goat, and no horses (E. Maartmann, personal communication, 1999). The Conservation Agency verified depredation for a total of 8,224 sheep carcasses, all 30 cattle, and 3 goats. Among those, 3,182 sheep, 1 cow, and no goats were listed as confirmed or probably taken by brown bears. During 1994–98, 72.0% of brown bear-killed sheep were located inside the bear conservation zone. This zone comprises 46.0% of the county and is home to about 20% of the county's free-ranging sheep (Fig. 2). The only cattle loss was that of a newborn calf that vanished from an unfenced forest pasture inside the bear conservation zone; nearby bear tracks were found and thus the disappearance was categorized as a 'probable' bear kill (E. Maartmann, personal communication, 1999).

The estimated rate of cattle loss during summer 1998 based on the farmers' survey was 0.5% (27 of 5,505). Loss was not independent of carnivore region ($\chi^2 =$

6.49, 3 df, $P = 0.039$), with highest loss in carnivore region 2. No other variable of grazing range characteristics was significant (all $\chi^2 < 5.39$, $P > 0.068$). The mortality rate of sheep was about 17-times higher than that of cattle, with 8.4% or 10,701 missing sheep in the same period. Carnivores accounted for 64.1% of the sheep mortality or 5.4% of all sheep respectively (E. Maartmann, personal communication, 1999).

In 1998, 2 veterinarians from districts inside the bear conservation zone ascribed the death of a cow and the injuries of a calf to brown bears. Three other veterinarians of Hedmark County doubted, but did not exclude, the possibility of brown bear attacks on cattle in their district in 1998. The other 9 veterinarians did not recognize any cattle depredation problems in their districts. The county management received reports from farmers of 4 cattle claimed killed by brown bears. Two of them were compensated, but none were confirmed as carnivore kills (E. Maartmann, personal communication, 1999). In the farmers' survey, 9 cattle were reported as killed or injured by brown bears in Hedmark County in 1998. Inside the bear conservation zone, farmers referred to 4 of those cases as "their own assumption", and 2 cases as "documented by veterinarians" (probably the same cases as mentioned by the veterinarians). Outside the bear conservation zone, 1 case was an assumption and 2 were called "documented by veterinarians". A complete survey might have revealed additional suspected cattle damage.

According to farmers, brown bear related problems had the second highest frequency on a list of 19 possible problems with free-ranging cattle (Fig. 3a). Eight of 17 farmers who reported brown bear problems grazed cattle inside the brown bear conservation zone (region 3). They comprised 7.7% of all answers from that region. Only 3.7% of respondents from outside the bear conservation zone mentioned bear problems. Twelve of 17 farmers stated bear problems were "their own assumption". Thirteen of those farmers had their cattle range unfenced and none used an electric fence. "Fall injuries", which we defined as cattle injuring themselves by falling while in rough terrain, were reported most often ($n = 24$, or 6.9% of respondents).

In contrast to farmers, veterinarians ranked carnivore-related problems lowest of listed problems with free-ranging cattle (Fig. 3b). Even inside the brown bear conservation zone, brown bears were regarded as a rare threat; 2 veterinarians had never recognized any problems and 2 categorized bear problems as "seldom". However, the brown bear was the only problem factor that differed significantly in relative frequency between

the veterinarians of Hedmark and Oppland county ($P < 0.05$). Veterinarians considered the disease mastitis the most frequent problem and related this to wounds from branches or fences. A comparison of veterinarians' statements with the number of farmers who claimed to have experienced these problems in the preceding 5 years showed discrepancies (Fig. 3a, b).

The allegation that cattle became difficult to control

Nearly half of farmers reported that large carnivores sometimes or often frightened their free-ranging cattle during the last 5 years. Conversely, a majority of farmers had either never (50.6%) or seldom (35.0%) experienced cattle that had become difficult to control during summer (Fig. 4a, b). The frequency distribution of the 2 statements differed significantly ($\chi^2 = 96.7$, 1 df, $P < 0.01$). Carnivore region (Fig. 4a, $\chi^2 = 10.71$, 2 df, $P = 0.005$) and sheep ($\chi^2 = 5.25$, 1 df, $P = 0.022$) affected statement 7: farmers having their cattle in areas with higher carnivore densities and on combined grazing ranges for sheep and cattle were more likely to report that carnivores frightened their cattle relatively often. All other variables were non-significant with $\chi^2 < 1.48$, $P > 0.224$. Supervision had an almost significant effect on statement "cattle become difficult to control during summer" ($\chi^2 = 7.56$, 3 df, $P = 0.056$), the effect increasing with supervision decreasing from daily to weekly to monthly, but with low effect if supervision was said to occur less than monthly. All other range parameters were non-significant regarding this statement ($\chi^2 < 3.42$, $P > 0.181$).

Half of the responding farmers claimed to have experienced increasing problems with carnivores frightening their cattle, whereas the majority did not find a change in the occurrence of difficulty in control (Table 2). Again, the answers of the 2 statements differed significantly ($\chi^2 = 95.8$, 1 df, $P < 0.01$). Eight respondents (5% of the farmers) reported both increased difficulty controlling livestock and increased carnivore problems. No significant effect of any range parameter was found on statement 7 (all $\chi^2 < 1.08$, $P > 0.584$) or statement 13 (all $\chi^2 < 0.20$, $P > 0.903$).

A similar pattern was found in the answers of the veterinarians (Table 2). However, 2 of those 3 veterinarians that regarded difficulty controlling livestock as an increasing problem did not regard carnivores as the main cause, but linked it to a change in the farmers' behavior toward cattle. They claimed that mechanization of livestock production and increased herd size led to

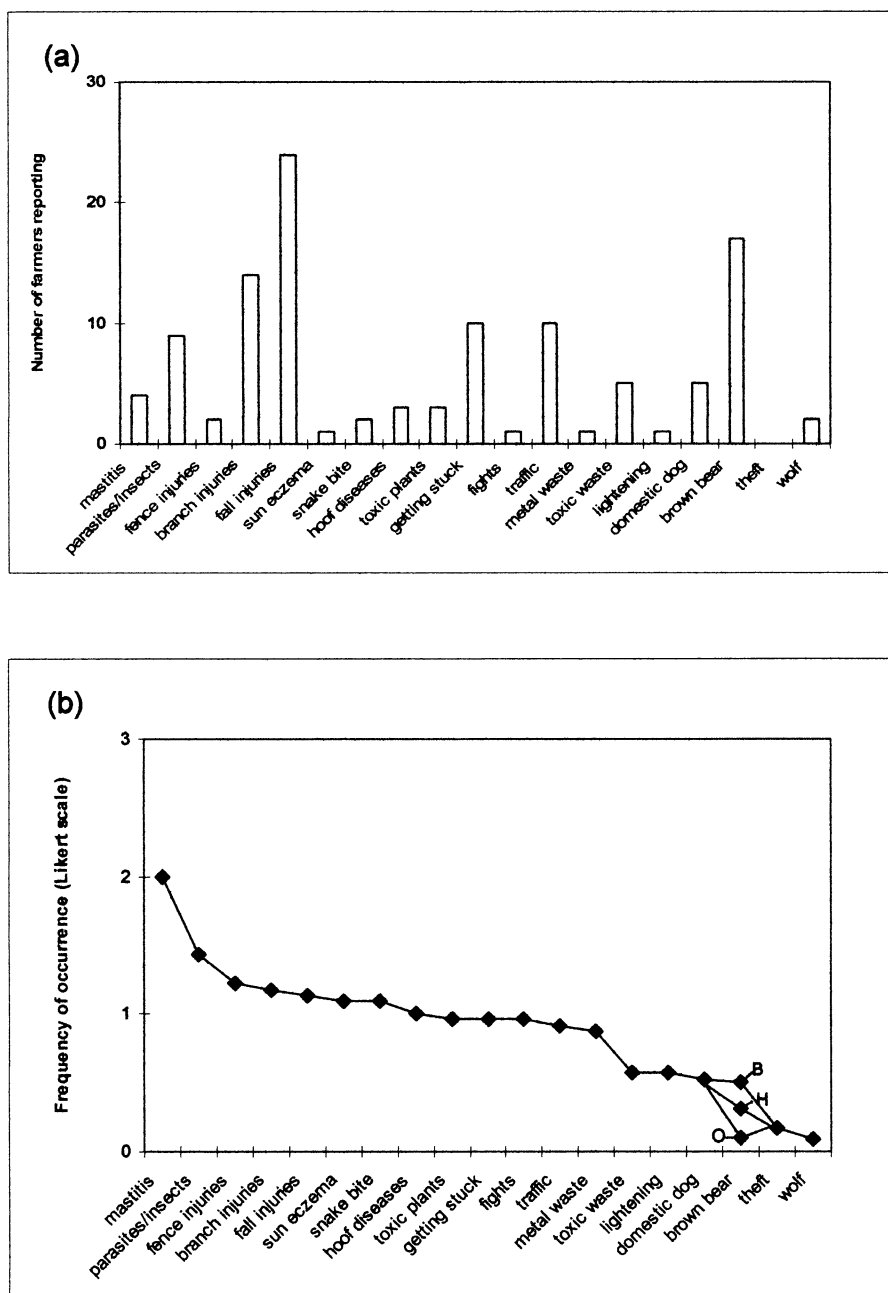


Fig. 3. Problems related to free-ranging cattle as reported by farmers 1994–98 (a), and their relative occurrence, as estimated by 23 veterinarians with at least 7 years of working experience (b). For brown bear damage, the line is split into the group average of the brown bear conservation zone (B, $n = 4$), Hedmark County excluding brown bear conservation zone (H, $n = 6$), and Oppland County (O, $n = 13$).

less human–livestock contacts and less time spent with the animals. The third veterinarian related difficulty controlling livestock mainly to lynx activities in his district.

Discussion

During summer 1998, there were 7 times as many sheep as free-ranging cattle in Hedmark County. Still, free-ranging cattle farming is economically more

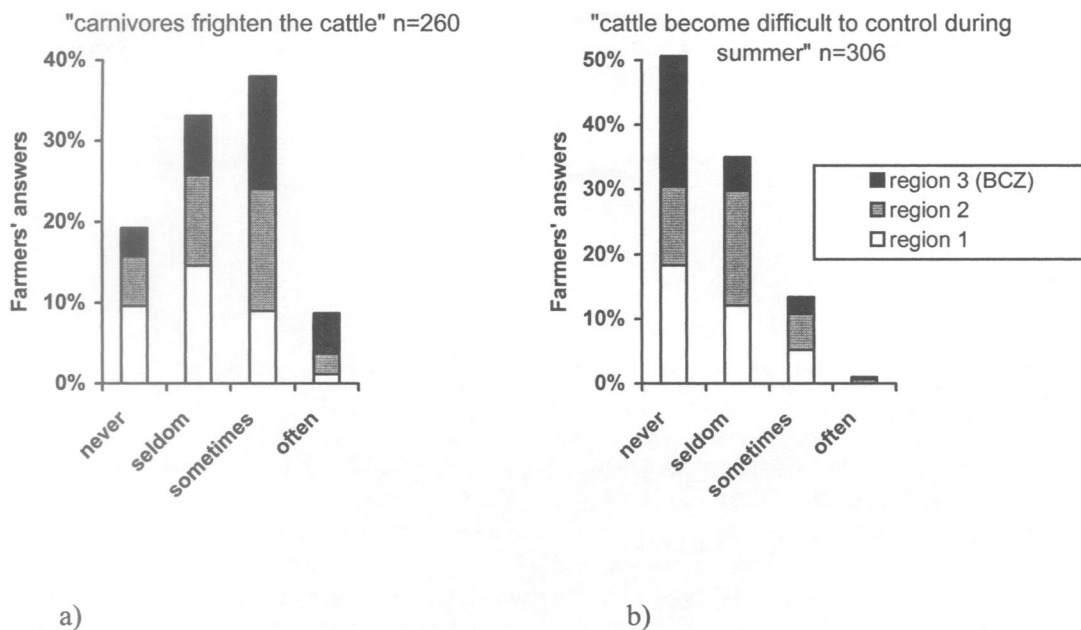


Fig. 4. Farmers' experience of the last 5 years (1994–1998) regarding the frequency of occurrence of (a) "carnivores frighten the cattle" and (b) "cattle become difficult to control during summer", per carnivore region (BCZ = brown bear conservation zone) for Hedmark County, Norway.

important when taking into account higher biomass, higher product prices, lower subsidies (Budsjettnemnda for Jordbruket 1999), and lower loss rate (this study). Additionally, compensation payments for carnivore-killed sheep substantially exceeded those for suspicious but unverified cases of cattle depredation in preceding years (E. Maartmann, personal communication, 1999). The low livestock densities and the higher ratio of sheep to cattle inside the bear conservation zone can be explained by the forestry dominated land-use system of this region. Cattle production for commodities other than milk is relatively new in Hedmark County and has developed more quickly in traditional livestock production regions.

The rate of brown bear predation on cattle was relatively low. However, brown bears have been shown to kill cattle in other countries (Murie 1948, Knight and Judd 1983, Kaczensky 1996, Swenson et al. 1999) and to kill many sheep annually in Norway. What might happen if sheep are removed and replaced by cattle? Which factors could expose those cattle to an increased brown bear predation risk?

Optimal foraging strategy predicts selection for easily accessible prey; prey that are locally abundant, less effective in predator avoidance, or less protected. In many areas with both sheep and cattle, brown bears appear to prefer sheep (Bobek et al. 1995, Garcia-Gaona 1995,

Nedelec et al. 1995, Kaczensky 1996, Swenson et al. 1999). If sheep are removed, cattle may be more exposed. Calves of large prey such as cattle or moose are usually more vulnerable to bear predation than adults (Murie 1948, Swenson et al. 1999).

Body size of the predator may influence prey selection. Consequently, large brown bears may be more likely to kill cattle than smaller bears. Haglund (1968) found that the killing of adult moose was restricted to large male brown bears, and Eide (1965) found the same for cattle on Kodiak Island. In Scandinavia, older, large males are mainly established inside brown bear reproduction areas, whereas a higher proportion of younger males roam the neighboring areas (Swenson et al. 1998a, b). Increased re-establishment of the Scandinavian brown bear population could hypothetically increase the predation risk on cattle.

Forest is the primary habitat of brown bears in south-eastern Norway (Wabakken and Maartmann 1994), and sheep losses are positively correlated with the degree of forest cover and negatively correlated with altitude and degree of alpine areas (Wabakken and Maartmann 1994, Bergø et al. 1998). Cattle ranges in forested areas, the dominant habitat of the brown bear conservation zone in Hedmark County, may therefore be more exposed to predation.

Table 2. Experiences of farmers and veterinarians from inside and outside the Bear Conservation Zone (BCZ) and total county (Hedmark) regarding the occurrence of “carnivores frighten cattle” and “cattle become difficult to control during summer” as reported on a 1998 questionnaire in Norway.

Statement	Respondent	Area	Change (%)			n
			Decreased	Stable	Increased	
“Carnivores frighten the cattle”	farmers	Hedmark	1	48	51	163
		inside BCZ	2	50	48	50
		outside BCZ	0	48	52	113
“Cattle become difficult to control during summer”	farmers	Hedmark	6	89	5	177
		inside BCZ	6	90	4	50
		outside BCZ	6	89	5	122
“Cattle become difficult to control during summer”	veterinarians	Hedmark & Oppland	22	65	13	23

Adult male bears have been shown to be predominantly active during night (Wabakken and Maartmann 1994). Nighttime may be crucial for livestock depredation. Preventative methods to avoid encounters between cattle and brown bears during the night should be considered.

The long term effect of the re-establishment of resident wolves after replacement of sheep with cattle husbandry is more difficult to predict. For the first time in 1999, a domestic calf was confirmed killed by wolves (E. Maartmann, personal communication, 1999). Important factors to deter cattle depredation are livestock protection measures and the presence of natural prey. Meriggi and Lovari (1996) found that local abundance and accessibility of wild and domestic ungulates primarily influenced the selection of livestock or natural prey. In southeastern Norway, however, wolves have access to locally abundant populations of 4 wild cervid species. Until now, wolf–cattle problems in Norway have been absent within most wolf territories.

A higher proportion of farmers inside the brown bear conservation zone compared to those outside claimed to have experienced brown bear attacks on cattle. None of those farmers had their cattle range electrically fenced, and only a few were using a non-electric wire fence. A similar relationship was observed between farmers' perception of how often carnivores frightened cattle and carnivore region and occurrence of sheep, as well as their perception of how often cattle became difficult to control and supervise. Carnivore region, occurrence of sheep, frequency of supervision, and fence integrity seem to play an important role in carnivore–cattle conflicts, either real or perceived. The allegation that cattle became difficult to control due to large carnivore presence was not well supported by the statements of the farmers and veterinarians, independently of carnivore region.

We lack an explanation as to why farmers from areas with medium carnivore presence (region 2) reported

more cattle losses than those from the other regions. Generally, there is a discrepancy between farmers' reported experience of problems with free-ranging cattle and veterinarians' perception of the frequency of occurrence of these problems. This might be partly because fatal cattle accidents often are reported to local butchers without involving veterinarians. Because veterinarians are not responsible for the identification of carnivore-related damage, farmers might contact the county management directly for those cases. In this survey however, farmers reported many more carnivore–cattle problems to us than did the county management. Many of the farmers' reports were based on their “own assumptions”. Management officials seemed to have more critical judgment that was based on necropsies and reliable proof in the field.

Negative attitudes toward carnivores may stimulate the perception of carnivores as a threat and inflate the perceived frequency of carnivore problems. Livestock producers tend to have a more negative attitude toward large carnivores than do wildlife managers (Bjerke *et al.* 1998, Kaltenborn *et al.* 1999). A large majority of sheep farmers distrust the official estimates of brown bear numbers as being too low and as being manipulated by the managers' attitudes (Sagør and Aasetre 1996, Knutsen *et al.* 1998).

Management implications

Regarding depredation of untended livestock by brown bears, we consider free-ranging cattle a good alternative to sheep in the brown bear conservation zones of Norway. To date, brown bears have been a minor threat to cattle inside the bear conservation zone. This could partly be explained by the lower frequency of uncontrolled calving inside the brown bear conservation zone than other regions.

However, cattle depredation risk may increase if sheep, an easier and more accessible prey, are removed. Cattle depredation risk may also increase if the brown bear reproduction area expands, with an attendant increase of older, large males. In bear conservation zones with a re-establishing wolf population, this second carnivore species may add an extra risk factor. The use of additional damage-preventing measures, such as strong electric fences, the use of herders and guard dogs, the gathering of the cattle in a pen during night, and the use of cattle breeds with strong anti-predator behavior, should be evaluated. Studies on the predatory behavior of brown bears and wolves in relation to carnivore population demography and social organization should be given high priority. Increased monitoring of cattle and predation may be necessary to detect the appropriate individual carnivore causing most problems.

Additional major components of future conflict reduction are economic aspects and farmers' attitudes. An economic analysis should compare the profitability of cattle and sheep production in the forest habitat of brown bear conservation zones, and the potential for a future market of 'wilderness beef' should be discussed, especially with the mad-cow and foot-and-mouth scares in Europe. Information and increased communication could smooth the discrepancy between farmers, veterinarians, and wildlife management regarding loss numbers and the perception of large carnivores' impact on cattle.

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