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EXTERNAL EFFECTS OF MITIGATING MEASURES TO REDUCE LARGE CARNIVORE PREDATION ON SHEEP

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Abstract
Outfield range pastures with widely dispersed sheep are quite common in Norway, with a summer population of approximately 2.4 million animals. In many areas losses to predators are considerable and identifying efficient mitigating measures against predation is a prime target in nature management.

In order to assess economic efficiency, any actual effect of the measure on predation and loss regime must be addressed. One problem with some research is the "*scale problem*". While sheep outfield home range areas have been measured from 2.2 - 33.8 km^2, large carnivores on their ranges might use from several hundred up to even thousands of square kilometres. For lynx (*Lynx lynx*) the home range varies between 158 and 433 km^2, wolverine (*Gulo gulo*) between 61 and 970 km^2 and for the brown bear *(Ursus arctos)* from 171 to 33,041 km^2. Thus there emerges a form of statistical dependence, since the exposure of the carnivores to actions and measures in a sheep home range or sample area might influence how the same carnivores behave outside the area. The *external effects* on society, the environment or other farmers may therefore outweigh advantages to farmers introducing the measure, and scale evaluation might be of crucial importance in designing field research projects exploring such measures.

Key words: carnivores, external effects, home range areas, livestock guard dogs, predation, preventive methods, sheep losses.

Introduction
In many areas losses of sheep to predators are considerable in Norway. During the 1990s, losses have increased together with increased numbers of protected predators, although the investments in mitigating measures have been raised. In this period The Norwegian Parliament has discussed and passed two white papers regarding large predator policy, (Ministry of the Environment, 1991-92; 1996-97), and a third one is to be released during 2003. While the report is being completed several preparatory papers and reports signal the direction of the new predator policy, which aims to become geographically differentiated (Linnell *et al*. 2003), as well as more adapted to the different predators. If this proposal is passed the whole country will likely become an active predator management area, however the measures to protect the carnivores will depend on the area, the pattern of conflict and the predators present. Whereas the conflict with grazing sheep is in focus in this paper, other areas of conflicting interests such as the local social acceptability of the predators, game interest (hunting) or conflicts with outdoor recreational life or Sami Reindeer herding interests may be even more controversial. In the end the social sustainability of predators, i.e. how many predators there is an economical possibility or willingness by the population to bear, might determine the number of large carnivores in the country (i.e. "social carrying capacity").

Introduction of efficient mitigating measures against predation on grazing animals is a prime target in Norwegian nature management. During the preparation of the two passed white papers a whole suite of mitigating measures was explored and several projects initiated to test their validity (Linnell *et a*l. 1996, Mysterud & Gautestad 1996, Mysterud *et al*. 1996). Recently high cost projects have been undertaken to test several measures and to estimate the cost of implementing them. The political core target is to achieve a mixture of grazing animals, reindeer herding, predators as well as opportunities for outdoor life, berry gathering and hunting in large areas, trying to satisfy different groups of interest. This creates extreme pressure on the activity to implement efficient and cost-effective mitigating measures for the sheep farmers.

Another co-operative investigation between the industry and the government has been trying to identify the options for mitigating measures. So far the loss reducing effect of the different measures seems limited due to the fact that they do not work as expected, are too expensive or have other disadvantages (Dahle *et al*. 2002). Among the most promising measures, for instance outfield patrolling with dogs as exemplified in this paper, may also incur severe and unexamined external effects, although their testing on local levels may yield interesting and "promising" results. Due to unmeasured effects there may be serious flaws when the results are transferred to the national level. Before commenting on design in mitigating measure

research, we would like to utter a few words about the sheep system to create understanding of the prime uncertainty underlying important parts of the management due to the fact that sheep and predators operate on different scales.

Range land use by sheep and predators

A combination of farmland with outfield range pasture is the most common way of organising Norwegian sheep farming with a summer population of approx. 2.1 million animals. In addition there are about 0.3 million sheep on farmland the whole summer, partly because of predators. On some islands with little snow and no predators some sheep also graze outfield, unattended the whole year. The lambing takes place in April or May and as the pastures become green, spring grazing starts on farmland. The normal spring grazing on farmland lasts about 30 days. In mountainous areas or the Northern parts of the country the sheep may be fed indoors for up to a further three weeks, or are sometimes released directly on the open range pasture.

The summer grazing on outfield pastures and open ranges in forested or alpine areas lasts for around 100 days from the beginning or middle of June (Asheim 1986). Whereas free ranging sheep may have large areas available, studies of sheep home range area, using radio transmitters, reveal that they do not move over very long distances. The sheep home range areas for different breeds have been measured from 2.2 to 33.8 km^2 (Gautestad *et al.* 1996). In spite of the limited grazing period, sheep from a certain farm tend to return to the same area year after year. Another pattern is the widespread utilisation of the pasture, the formation of small flocks or just family groups with few sheep spread out on few square kilometres. When the sheep are collected during the latter part of September it is for about 80 percent of the sheep, done on a community basis (grazing groups) where farmers walk over the whole range collecting all the small flocks to a common facility where they are gathered and sorted.

Four large carnivores, lynx (*Lynx lynx*), wolverine (*Gulo gulo*), brown bear *(Ursus arctos)* and wolf (*Canis lupus*) form the main problem for the sheep industry in Norway together with the protected golden eagle (*Aquila chrysaëtos)*. For lynx the home range varies between 158 and 433 km^2, wolverine between 61 and 970 km^2 and for the brown bear from 171 to 33,041 km^2 (Gautestad *et al.* 1996). For the golden eagle habitat size has not been measured, but it will definitively exceed that of sheep. More recent studies (Linnell *et al*. 2001) show considerably larger home ranges for lynx under Scandinavian conditions.

There may be sporadic predator attacks on the sheep while grazing on fenced farmland, but most of such losses occur while the sheep graze on the outfields. At the open range the sheep are normally unattended, but under different degrees of inspection, and a certain number will die due to diseases or accidents, varying locally due to rough terrain with cliffs, waterholes in bogs etc. According to the central organisation of the grazing groups (Øvervatn *et al*. 2001), the losses have averaged 5.5-6.0 percent since the mid 1990s, compared to less than 4 percent in the 1970s and the 1980s. If grazing is disturbed or the lambs have lost their mother, the weight and meat quality of surviving animals are affected. Whereas bears seem to prefer ewes, the other species predominantly kill lambs. Assessment of the impact of the losses on the farm economy will have to take into consideration that more labour has to be devoted to searching for lost animals and for proving the cause of the loss.

The Norwegian system for compensation payments for predation caused losses places the responsibility for proving the cause on the farmers. This can indeed be very difficult and labour-intensive as often no remains of the sheep are found. When carcass remains are discovered, it can also be difficult to prove whether a predator is the cause or which predator in force, unless the remains are in good condition. Currently the majority of the lost animals are not compensated. In some incidents where the actual predator cannot be identified, compensation may be paid out if it is assumed to be a protected species involved.

When the predator is identified it is most common a lynx or a wolverine while losses to brown bears or wolves are smaller. The official number of predators was assessed to be 5-10 wolves, 700-1,000 pairs of golden eagles, 20-25 brown bears, 200 wolverines and 300-400 lynxes in the early 1990s (Mysterud & Mysterud 1995). In the late 1990s or early 2000s the numbers had increased to a minimum of 28 wolves, 773-1,072 golden eagles, 26-55 brown bears, 271 wolverines and 400-500 lynxes (Andersen *et al*. 2003). Due to the significant increase in losses and compensation payments, increasingly focus has been on identifying and implementing mitigating measures. Any measure to ease the predator-sheep associated conflict dealing with the losses is of prime interest to the nature management authorities. Among the mitigating measures tested have been fencing off parts of the range pasture, moving the sheep to another pasture (if that can be found), early gathering or later release of sheep, night pens and herd inspectors with or without guarding dogs of different kinds, either guarding the sheep or patrolling during the night etc. Simultaneously with projects and field testing Flaten & Kleppa (1999) examined the costs associated with such measures. A core problem is that a calculation of external effects cannot be done due to lack of data from local projects.

Research design implications

In evaluating measures to prevent predation on sheep grazing outfield range pastures, any actual effect of the measure on predation and loss regime must be addressed. Economic losses either borne by farmers or by society should therefore be carefully considered. Realised losses with and without the measure or before and after introducing it must be addressed when deciding upon its effects. In addition the *external effects* on society, the environment or other farmers must be discussed and dealt with. Obviously all these requirements result in a general difficulty in conducting such studies, which require careful planning, the use of adequate control areas or control periods in case of comparing the losses with and without the measure. Obviously the design of all research projects does not meet these requirements.

Some important ongoing field research on mitigating measures suffers from what we will refer to as the "*scale problem*". Sample- and control-areas might be large enough for events within one of the areas to be statistically independent. Events may also be independent between areas as far as the *sheep* are concerned, while this may *not be* the case for the *carnivores* (Gautestad *et al.* 1996). Research areas might well be several times larger than the home range area used by a family group of sheep during the grazing season (which ensures independent events), but this is not the case concerning the large carnivores. Since the home range areas of sheep and predators do not overlap there emerges a form of statistical dependence in such materials. The exposure of the carnivores for actions and measures in one sheep home range area might influence how the same carnivores behave if and when they are inside a "neighbouring area". Scale evaluation might therefore be of crucial importance in designing field research projects, as we will exemplify with outfield patrolling with guard dogs.

Outfield patrolling with livestock guard dogs has been of focal interest in Norway as some recent research (Hansen *et al.* 2002), indicating it may be working locally on pastures with widely dispersed sheep. This measure is different from standard use of guard dogs (see Green & Woodruff 1991) and was performed as the dogs followed a range inspector patrolling the range in 5 hr bouts during three nights per week. The measure was tested during three summer seasons in a total of eight sheep flocks involving three inspectors and four dogs. The study was conducted in three research areas; Amirfjell (in 1996 and 1997), Krokafjell (in 1997) and Vadfjell (in 1999) all located in Hattfjelldal, a municipality in Northern Norway with a total area of 2,682 km_. Lynx, wolverine and the golden eagle were the main predators present in the area.

The authors compare the loss situation in the respective areas before, during and after the measure was introduced. Significant reductions (χ^2, $P<0.001$) in the number of sheep lost were achieved in one of the study areas (Amirfjell) both in 1996 and 1997. In 1998 and 1999, when no dogs were present, the sheep losses increased again (χ^2, $P<0.001$). The results were also "promising" in Krokafjell (χ^2, $P<0.1$). The authors claim, however, that *lack of significance* in the other areas was mainly due to the *size* of the area and the *quality* of the dogs. The range patrolled by one man/dog unit should not exceed 10-12 km^2 and the dogs should be experienced guard dogs properly socialized for the method. The size of Amirfjell is about 12 km^2 whereas Krokafjell and Vadfjell are 30 and 40 km^2, respectively.

Since the method works by range inspections where the dog *chases* potential predators out of the pasture before returning to the inspector, much concern should indeed be paid to examining external effects which the authors do not deal with. The distance (overhead line) between Amirfjell and Krokafjell is only about 10 km whereas Vadfjell is about 30 km from these areas. The predators might thus move from one research area to another and still be within their home range area, i.e. within the area where they would normally operate. The authors fail to examine or pay attention to any direct extra losses caused on sheep in adjacent pastures. It seems, however, highly unlikely that any predator will stop its sheep killing activity because of the dogs.

A closer scrutinization of the data provided by the authors even indicates that some effects might be found in the summer ranges where the method is *not* employed. In particular a strong *increase* in losses in Vadfjell in 1997 must be noted, where losses increased to 14.8 % from an average of 7.8 for the three years 1993-95. In 1997 the method was employed in both Amirfjell and Krokafjell, causing a significant reduction in Amirfjell, whereas it was only partly successful in Krokafjell. The results for 1998 also indicate that some predators stayed in Vadfjell the following year, corresponding well to the finding that the losses were the lowest ever recorded in Krokafjell. Thus when a predator is not allowed to attack in a particular area, it may just switch location and proceed with killing in another area. Designing a study in which the predator is *not* allowed to attack sheep in any area within its home range is doing research on a much larger scale, which would require a completely different project design. In such a situation the predators might as well be chased back requiring more dogs and inspectors per unit area so that only smaller areas can be efficiently guarded with the same input. We actually do not know the consequences and events and how these mitigating measures would work on an extended scale.

In their study of economic analysis of mitigating measures against loss of predation Flaten & Kleppa (1999) claimed that several of the measures examined might incur *damage displacement effects*. Such effects were defined as "damage transferred onto other sheep farmers (within or outside the original area) that do not introduce the measure" (cf. "displaced losses"). Damage displacement effects may be transferred onto other domesticated animals or even game animals. Possible damage displacement effects will yield costs *exceeding* the costs for those implementing the measure.

Conclusion

Failure to take into account external effects on all farmers in the carnivore habitat may lead to wrong conclusions regarding social economy, especially if the major cost of preventive methods against predation of livestock in Norway is to be supported by public funds. As more money is channelled into local mitigating measures, the transfer of costs and losses may lead to more conflicts instead of less if neighbouring farmers sense that the measure just would chase more predators into their pastures. In the local community there may even arise conflicts between those who introduce mitigating measures and those who experience the external effects.

In general it can be maintained that the mitigating measures introduced so far do not work except locally in specific areas under considerable costs. Problems arise regionally because such solutions cannot be employed on all farms and damage displacement
costs are unknown. This may become a national management problem. However, research efforts to improve the infrastructure of the industry by developing a (satellite based) service with a mortality transmitter on each sheep to quickly inform the farmer are in progress. The initiative may represent a long run solution regarding finding the cause of some disputed losses.

On the political front the Norwegian predator situation as mentioned has necessitated the discussion and passing of two parliamentary white papers during the 1990s. As yet another predator policy parliamentary report will be released we anticipate that due to the scale problem important baseline documents might not be reliable. In social economic analysis it will become imperative in management during the present political situation, to carefully correct for external effects when evaluating mitigating measures. Since no impact analysis of increasing carnivore populations has been conducted the basis for decisions are weak due to this insecurity. We conclude that carefully planned research particularly dealing with research project design focused on the unexamined external effects are still not available in Norwegian nature management. Instead of easing the political climate in carnivore management, we anticipate that the lack of scale appropriate research might increase the conflict level further.

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