Management of Wolf and Lynx Conflicts with Human Interests

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Abstract

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In many areas viable populations of large carnivores are political goals. One of the most important factors in order to achieve viable large carnivore populations is human tolerance for presence of large carnivores. Thus, management of large carnivore populations in multi use landscapes will involve mitigating conflicts with human interests. In order to mitigate conflicts in a effective way, managers need tools for predicting likelihood of large carnivore occurrence, knowledge on which conflicts are considered as most important by humans in different areas, and the most efficient ways of mitigating the experienced problems.
The aim of this thesis is to contribute to some parts of this toolbox for large carnivore managers.

A habitat suitability model, with density of roads and built up areas as the most important variables, classified 79% of Scandinavia outside the reindeer husbandry area as suitable wolf habitat.
Human tolerance towards wolves was lowest inside wolf territories and slowly increased amongst residents living up to 200 km from the nearest wolf territory. Human tolerance towards wolves may however be affected by mitigation measures such as subsidising electric fences in order to reduce the risk of wolf depredation on livestock. Management actions as subsidies for pro active measures or predator control should be targeting specific areas or individuals in order to be effective. It is also important to use the "right" management actions at the right time. Therefore it is, among other things, important to know if a reported bold wolf is acting in a way that most wolves would not, given the same circumstances. Wolves moved away from an approaching human on average at a distance of about 100 m. Wind velocity and wind direction influenced the distance heavily and humans may come as close to wolves as 17 meters before the wolves become aware of the human and react.

Keywords: Large carnivores, wolves, lynx, wildlife management, mitigation, human dimension, habitat suitability, depredation.

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Appendix

Papers I-V

The present thesis is based on the following papers which will be referred to by their Roman numerals:

I. Karlsson, J., Bröseth, H., Sand, H. & Andrén, H. 2007. Predicting occurrence of wolf territories in Scandinavia. Journal of Zoology, *in press.*

II. Karlsson, J. & Sjöström, M. Human attitudes towards wolf conservation, a matter of distance. Biological Conservation, *in press.*

III. Karlsson, J., Jaxgård, P. & Andrén, H. Factors associated with lynx depredation on sheep in Sweden. *Submitted manuscript.*

IV. Karlsson, J. & Sjöström, M. Another brick in the wall? Subsidised fencing of livestock as a means of increasing tolerance for wolves. *Submitted manuscript.*

V. Karlsson, J., Eriksson, M. & Liberg, O. Factors affecting the distance at which wolves move away from an approaching human. *Submitted manuscript.*

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Introduction

The recovery of carnivore populations combined with the expansion and growth of human populations has made conservation of large carnivores in multi-use landscapes necessary (Treves & Karanth, 2003). Human behaviour, either deliberate or in-deliberate, is currently the main factor affecting the distribution and numbers of large carnivores in many parts of the world today (Thiel, 1985; Mech *et al.,* 1988; Mladenoff *et al.,*1995; Mace *et al.,* 1996; Sunde *et al*., 1998; Treves & Karanth, 2003; Andrén *et al*., 2006). Therefore, applied conservation biology is just as much a matter of public relations and politics as it is a matter of biology (Warren *et al.,* 1990; Linnell *et al.,* 2000). Without tolerance from the different human interests involved it will be hard or even impossible to achieve recovery goals of carnivore populations. Decision makers and wildlife managers will in many areas need a toolbox of different mitigation measures to achieve this tolerance. For managers to use public resources in an efficient way, mitigation measures should also be evaluated and tested. This thesis is a small contribution to that work.

Perhaps the first step in most recovery programs of any species is the ability by managers to correctly distinguish between suitable and unsuitable habitats (Shriner *et al*., 2002). Identifying variables that are both readily available over large areas and correlated with species occurrence is essential to effective management (Simberloff, 1988). However, the usefulness of a habitat suitability model increase but the accuracy decreases as the predictions of the model becomes more general and thus applicable across a wide range of ecological contexts (Rodriguez & Andrén, 1999). The disadvantage of reduced accuracy should be weighed against the potential of a model to be generally applied. In a region like Scandinavia, with a small but recovering wolf population, management decisions crucial for wolf conservation are continuously made in the early stages of wolf re-colonisation. Knowledge, models, and predictions from other parts of the world may be used and will thus be more influential in a phase when management decisions have the greatest potential to affect conservation success. Habitat suitability models may indicate if the amount of suitable habitat will limit growth of the population. Habitat suitability models may also aid managers in directing resources for mitigation of conflicts to the areas that are most likely to have the highest density of the carnivore population.

Generally, the management of livestock depredation by carnivores is one of the main problems when devising large carnivore conservation plans (Boitani, 2000; Breitenmoser *et al.,* 2000; Swenson *et al.,* 2000), and it is also a major concern in the Swedish wolf and lynx management (Swedish Environmental Protection Agency, 2000a). On the national scale and outside the reindeer husbandry area, carnivore depredation on livestock occurs on a relatively low level in Sweden. The number of livestock (except semi domesticated reindeer) attacked by large carnivores has ranged between 300 and 600 annually during the last 10 years in Sweden (Swedish Wildlife Damage Centre, 2007). A majority (> 95%) of the attacks involve sheep, in addition, 30-40 dogs and 5-10 calves are attacked each year. Lynx and wolves are the carnivores most often involved in depredation on

livestock and dogs, 50% and 25% respectively, and 40% respectively 50% of the total number of attacks on dogs.

Although sheep losses to lynx were insignificant in terms of the national production of sheep, the issue of sheep depredation by lynx merits attention for several reasons: *i)* over the last five years, hundreds of farms have suffered depredation and the number of farms sustaining depredation annually has increased (Swedish Wildlife Damage Centre 2007); *ii)* lynx and wolf ranges are currently expanding southwards into areas with much higher densities of livestock compared to the present main distribution, potentially leading to an exacerbated conflict with livestock in the future; and *iii)* depredation, even at low levels, may lead to dissatisfaction and frustration and generate massive negative attitudes toward carnivores and carnivore management.

Livestock depredation has been shown to decrease human tolerance for wolves and increase acceptance of lethal control of wolves (Naughton-Treves *et al*., 2003). One way of mitigating conflicts between wolves and livestock owners is through compensation payments for lost animals. The objective of compensation programmes is to increase human tolerance for large carniovores, which may reduce the illegal killing (Van Tassell *et al*., 1999). However, compensation programmes are criticised for being inadequate, complicated and expensive (Saberwal *et al*., 1994; Kaczensky, 1999; Treves *et al*., 2002; Montag, 2003). After a study in Wisconsin, Naughton-Treves *et al*. (2003) concluded that, "compensation payments apparently do not improve individual tolerance toward wolves or people's approval of lethal control". Nyhus *et al*. (2003) suggested that compensation programmes need to be a part of a comprehensive approach that includes options for control of offending animals, proactive mitigation measures and, in some cases, broader financial incentives for changes in land use practices. Substantial amounts of money are spent on compensation and proactive measures each year, also outside the reindeer husbandry area, e.g. Sweden more than EUR 1,000,000, Norway more than EUR 4,000,000. Evaluations of the effectiveness of compensation programmes are extremely few and badly needed (Nyhus *et al*., 2003). Evaluations of government programmes that pay farmers for proactive measures are even fewer but equally necessary.

However, depredation is not the only relevant problem that needs to be addressed by large carnivore managers. For example, studies from many parts of the world show that a relatively large proportion of the humans are afraid of wolves and that wolf presence affects (restricts) the activity of humans. (Kanzaki *et al*., 1996; Bath & Madjic, 2000). Therefore, successful conservation and management of wolves ought to include an effective response to situations where humans express fear because of the behaviour of one or more wolves. Such situations can very coarsely be divided in two types, 1) situations where wolves have acted in a bold manner and 2) situations where human expectations of what is a normal wolf behaviour does not correspond with how wolves normally behave in reality. An effective response from managing authorities would aim at provide information to residents as well as for example aversive conditioning towards wolves in type 1 situations. Habituated wolves are much more likely to show

aggression towards humans than are non habituated wolves (Linnell *et al.,* 2002). It is therefore important for wildlife managers to detect individual wolves that are acting bold in the early stages of habituation. The response in type 2 situations should primarily aim at communicating wolf biology and behaviour and be directed towards the persons filing or supporting the complaint. The wrong, or no response, especially in type 1 situations, can undermine public trust in wolf management and eventually lead to a situation where wolves actually act aggressively towards humans.

Study area

The study presented in papers I and IV was made in south central Scandinavia, mainly in the Swedish counties Värmland, Dalarna, Örebro and corresponding parts of Norwegian counties Östfold and Hedmark. The study in paper II was made on a national sample of Swedish residents, with some oversampling inside the Swedish wolf territories. Paper V was made entirely inside Swedish wolf territories. Paper III was made in the south-central part of Sweden in an area covering one-fifth of Sweden (93,000 km^2), between 59° and 63° N.

Objectives & Methods

Factors affecting occurrence of wolf territories (Paper I)

The objectives of this study were to test the predictive power of a wolf habitat model derived from wolf-habitat relationships in Wisconsin, USA (Mladenoff *et al.,* 1995, 1999) on Scandinavian conditions and to use field data in a GIS to explore which habitat variables are the most important predictors of wolf territory occurrence in Scandinavia. Additionally we were also interested in how the proportion of important habitat variables changed as wolf territory borders changed over time.

We used logistic regression to compare the proportion of open ground, built up areas, the density of three different categories of roads as well as indices of moose (*Alces alces*) and roe deer (*Capreolus capreolus*) densities inside the wolf territories and within randomly distributed polygons of the same shape and size as the wolf territories. This set of variables have been used in other wolf habitat suitability studies (Thiel, 1985; Mech *et al.,* 1988; Thurber *et al.,* 1994; Fritts & Carbyn, 1995; Mladenoff *et al*., 1995, 1999; Harrison & Chapin, 1998).

Effect of location on human attitudes (Paper II)

The objective of this study was to test the hypothesis that location, in this case, distance to regular wolf presence (wolf territory) is an important factor affecting human attitudes towards wolves.

Data on human attitudes was collected using a mail survey to 4 050 Swedes between 18 and 84 years of age. Our sample was stratified in nine strata with respect to the respondents' location in order to avoid the dominance of large cities

and to obtain enough respondents in sparsely populated areas as wolf territories. Three different strata contain the major cities in Sweden - Stockholm, Göteborg and Malmö - which together account for 20% (2 million) of the Swedish population. The rest of Sweden was divided into three areas: wolf territories, the wolf area, and other. In each area there were two strata - one for the people living in urban and built-up areas, i.e. settlements with > 200 inhabitants and houses < 200 metres apart, and one for people living in rural areas. Each respondent was identified by the centre coordinate of the kilometre square he or she lived in.

The respondents were asked: "How important is the existence of wolves in the Swedish landscape to you? Even though you may never see any wolves in Sweden, you perhaps have an opinion?". Possible answers were: very important (3), rather important (2), dose not matter (1), totally unimportant (0) and don't know (not included in the analyses). The dependent variable was an ordered categorical variable, thereby making the ordered probit model suitable for estimation. This kind of model has been used on a wide range of topics, including attitudes. For an extensive introduction to the field of ordered models see Cameron *et al*. (1998).

Depredation on livestock and mitigation efforts (Paper III)

The objective of this study was to assess factors associated with lynx depredation on sheep in Sweden. We predict that lynx depredation should be positively correlated with density of sheep farms, but negatively correlated with the proportion of sheep farms receiving fencing subsidies and the proportion of the lynx population shot by recreational hunters.
For the analyses concerning lynx depredation on sheep, data was available from 46 sub-regions. For the analyses concerning changes in lynx densities, there was sufficient data from 49 sub-regions. Using GIS software (ArcView 3.2a, ESRI, 1999), data on depredation events, number of lynx shot, density of lynx, roe deer index and sheep farm densities was compiled for each sub-region. The division of the study area into sub-regions was based on the distribution of hunting districts (ranging in size between 1 000 and 3 141 km^2) since they are the administrative units for which data on lynx numbers and roe deer hunting bags were available. In addition, data on sheep farm density was available at municipal district level (ranging in size between 1,000 and 3,000 km^2 in the study area), roughly corresponding to hunting districts in most cases. The minimum size of the sub-regions (1,000 km^2) was a compromise between minimising spatial correlation between sub-regions while maintaining regional differences. Sub-regions were larger than the average annual home range for lynx (300 – 600 km^2; Linnell *et al.,* 2001). Data on fence subsidies was obtained from protocols of fence subsidy approvals by county administrative boards. Based on the address of the farm receiving the subsidy, the location of subsidised fences was determined to the level of postcode area.

We used multiple regression models to evaluate the effect of different variables on depredation and changes in lynx densities. Models with ΔAIC_c values < 2 where considered plausible (Burnham & Anderson, 1998). In order to test for

proportionality all variables were log(x+1) transformed. We tested the residuals of the respective models for normality by examining plots as well as using a Shapiro-Wilk test.

Effects of subsidies on human attitudes (Paper IV)

The objective of this study was to assess how subsidies for proactive measures, aiming at reducing livestock losses to wolves, are associated with public tolerance for wolves. In this paper we use two categories of independent variables: 1) socio-economic variables commonly used in studies of human attitudes towards wildlife, such as age, gender, income, education, having a farm or being a hunter (Kellert, 1985; Bath, 1987; Bjerke *et al*., 1998; Williams *et al*., 2002); and 2) wolf territory-specific variables describing the situation within the respective territories. One variable expresses the number of years that the wolf territory has existed, and two variables captured the rate of wolf attacks on sheep and dogs, respectively. To get an estimate of human attitudes the respondents were asked: "What trend would you like to see in wolf numbers in your home area?" Possible answers were: disappear (0), substantial decrease (1), modest decrease (2), no change (3), modest increase (4), substantial increase (5), and don't know (not included in the analyses). The dependent variable was ordered and categorical, we therefore used an ordered probit model. The respondents were also asked about their willingness to financially contribute to a conservation programme for the large carnivores: "Suppose that a government policy for the large carnivores is important for a sustainable survival of the large carnivores in Sweden. Would you consider financially supporting measures to fulfil the governmental policy on carnivore-induced costs?" Possible answers were "yes", "no" and "don´t know". Those responding "yes" were then asked further questions about how much they were willing to pay as an annual tax over five years to support the programme. Data on human attitudes was collected using a mail survey to 4 050 Swedish citizens between 18 and 84 years of age. Each respondent was identified by the centre coordinate of the kilometre square he or she is living in. If the kilometre square was at least partially inside a wolf territory the respondent was considered to be living inside that wolf territory.

What is a bold wolf? (Paper V)

The objectives of this study were to investigate at which distance wolves in a lay choose to move away (Flight Initiation Distance; FID) from an approaching human and to investigate how the Flight Initiation Distance is affected by on site conditions as wind velocity, wind direction and visibility.

Wolves were radio tracked from a distance of one to two kilometres until they stayed at the same place for at least 20 minutes. In cases with more than one radio-collared wolf, positions of all radio-collared wolves within three kilometres were determined before a provocation procedure was started. The wolf/wolves were > 400 metres away when the provocation trial started. The provocateur used a silent receiver (Televilt RX 98) to walk straight towards the wolves at normal hiking pace. A second person, > 400 metres from the wolves used a unidirectional Yagi antenna fixed to a tree-trunk to determine when the wolf/wolves left their lay.

When the provoked wolf/wolves left the lay, the tracker contacted the provocateur who stopped immediately and determined his exact position using a GPS. Flight Initiation Distance (FID) was measured as the distance between the nearest radio-collared wolf and the provocateur when the wolf left its lay. Once the wolf had left the lay, the position of the wolf was determined every second minute. The radio-tracking was stopped after 60 minutes, or if one of the two radio-trackers lost contact with the wolf for more than 15 minutes.

Results & discussion

Factors affecting occurrence of wolf territories

Wolf territories had lower densities of roads, built-up areas and open land than areas outside wolf territories, but there was no significant difference in moose density, i.e. the main prey for wolf. The logistic regression model classified 79% of Scandinavia outside the reindeer husbandry area as suitable wolf habitat, i.e. having a probability of wolf territory occurrence >0.5. The proportion of built up areas within the wolf territories decreased as the "borders" of the wolf territory changed over time. Our model had a reasonably high predictive power, with correct classification for 90 % (18 of 20) of the observed wolf territories within the study area. Polygons, randomly distributed outside the observed wolf territories, were correctly classified as not being occupied by wolves in 85% of the cases (17 of 20). Our results predict a lower likelihood of wolf territory occurrence in areas with a large proportion of open land and built-up areas, as well as relatively high densities of roads. Those variables may serve as indicators of human activity which may affect both habitat preferences by wolves as well as the probability of wolf mortality. Other studies have shown that roads merely seem to serve as indicators of human-related mortality, either through direct mortality from car collisions or through indirect mortality as legal killing of problem individuals, illegal killing (poaching or poisoning) and diseases (Thiel, 1985; Mech *et al.,* 1988; Mladenoff *et al.,* 1995).

The proportion of built-up areas within the wolf territories significantly decreased as the territory-specific boundaries changed over the years. During the same period, the proportion of open land and roads in the territories did not change significantly. A plausible explanation for this is that although built-up areas may fall within the borders of a territory during the first year of territory occupancy, wolves later actively avoid including built-up areas within territories. Areas that wolves prefer to colonise may not necessarily be suitable for colonisation since various mortality factors may be high in these areas (Delibes *et al*., 2001). In our study there was no significant correlation between density of local roads and pack size. Built-up areas, though, showed a tendency to be correlated with pack size in winter. Mortality is probably the most likely explanation why there are fewer individuals in wolf packs living in territories with relatively high proportions of built-up areas compared to wolf packs in the same region of Scandinavia, but with lower proportions of built-up areas.

Direct mortality from car and train collisions was of minor importance, accounting for approximately 6% of the mortality among 32 dead or assumed dead radio-collared Scandinavian wolves between 1998 and 2003 (Linder-Olsen, 2003). Diseases (mainly scabies) and legally killed wolves constituted 19% and 3% respectively of the total mortality in the same study (Linder-Olsen, 2003). Preliminary data from radio-collared wolves confirm that illegal killing is one of the largest sources of mortality among Scandinavian wolves (Liberg, pers. comm.). This has also been shown to be true for wolves and other large carnivores in other countries (Thiel, 1985; Mech *et al.,* 1988; Mladenoff *et al.,* 1995; Mace *et al.,* 1996; Sunde *et al*., 1998, Andrén *et al*. 2006).

The wolf habitat suitability model developed in northern Wisconsin (Mladenoff *et al.,* 1995, 1999) was a good predictor for the presence (100 % correct classification) but not for the absence (5 % correct classification) of wolf territories in Scandinavia. The main reason for this seems to be that the Wisconsin model underestimates the negative effects of roads on wolf occurrence in Scandinavia, since it predicts both observed wolf territories and random polygons without wolves as suitable wolf habitat with a high likelihood of occurrence. This is probably due to road densities in Wisconsin non-pack areas being about three times higher than in Scandinavian non-pack areas, while road densities within wolf territories in Scandinavia and Wisconsin are comparable.

Effect of location on human attitudes

A total of 2,455 respondents answered the questionnaire, giving a response rate of 60.9 percent. In our model, distance to the nearest wolf territory had a significant effect on attitudes. The further from a wolf territory the respondents lived, the more positive they were towards wolf conservation (Table 3). This has also been shown on a more coarse scale in previous studies (Williams *et al*., 2002). The standardized coefficients in our model suggest that distance to the nearest wolf territory may be as closely correlated to attitudes towards wolves as other variables, such as level of education, age, gender, or owning livestock, that are more commonly used in studies of human attitudes toward wolves and other wildlife (Williams *et al*., 2002). Distance to the nearest wolf territory also affected attitudes as much as variables like living on a farm, living in a built-up area, membership of a nature conservation group, being a hunter, having a hunter in the family, or owning a hunting dog. Consequently, surveys of human attitudes towards wolves outside wolf territories will overestimate human support for wolf conservation. This is important knowledge not only for scientists, but also for managers and decision-makers working with wolf conservation.

The positive relationship between distance to the nearest wolf territory and tolerance for wolves can not be explained in terms of direct experience, especially since having seen a wolf was not correlated to attitude scores. Although direct experience of wolf depredation on your own livestock or pets may certainly affect your attitude towards wolves (Boninger *et al*., 1995; Petty *et al*., 1997), the proportion of people having direct experience of wolf encounters or depredation is

simply not large enough to explain why distance to wolf territory seems to be positively associated with attitudes towards wolves. Of the Swedish sheep farms in wolf territories, only 1.3% had at least one wolf depredation event between 1997 and 2004. (J. Karlsson, unpublished data). The proportion of hunters inside wolf territories that have had at least one dog attacked by wolves is far lower than 1 % (J. Karlsson, unpublished data). We suggest that the lower attitude scores inside and close to wolf territories is more commonly a result of indirect experience than direct experience. What friends, peers and enemies think strongly affects a person's attitudes (Boninger *et al.*, 1995; Petty *et al.*, 1997). Indirect experience may be acquired through personal contacts with people or through media. Hook and Robinson (1982) showed that among people with a negative attitude towards wolves, TV and discussions with friends were the most important sources of information about wolves. This may also explain why a wolf territory can affect attitudes of people living up to 200 km outside the wolf territory. The positive relationship between distance to the nearest wolf territory and tolerance for wolves is likely due to people living inside or near wolf territories being more exposed to negative information on wolves, e. g media coverage of depredation on dogs or livestock, than people living far from wolf territories. Bad/negative experiences are usually much more communicated than good/positive ones.

We suggest that people with a positive attitude towards wolves will in general become less positive when wolves form a territory in the vicinity of their homes. As wolves colonise new areas, managers may therefore expect a shift to more negative attitudes in the actual wolf territory and up to a 200 km distance around it.

Our findings are important when interpreting studies of human attitudes towards conservation of controversial species in general and large carnivores in particular, and should be used when designing future surveys of human attitudes towards conservation and management initiatives.

Depredation on livestock and mitigation efforts

The proportional relationship between sheep farm density and the number of depredation events suggests that an individual sheep farm is subject to the same risk of depredation regardless of the density of sheep farms in the area. Thus, money spent on fence subsidies will be just as effective in an agricultural area with high sheep farm densities as it will in areas with low sheep farm densities. Subsidies for installing "predator proof" fences will most likely give a better protection against lynx depredation for the individual farmer, but for a detectable reduction of losses to occur on a regional or national level, the proportion of sheep grazing behind predator-proof fences needs to increase. The main management purpose for subsidising fences is to increase human tolerance for lynx through reducing sheep depredation. However, the relatively low risk of depredation on the individual sheep farm, regardless of fence type used, makes it hard to detect any effect of money spent on fence subsidies. If money are spent on a mitigation technique (i.e. fencing) that, for a long time, can not be demonstrated to have any

effect, then there is a risk of the mitigation technique itself being questioned by farmers, decision makers or the public, although the lack off effect is actually due to the way the mitigation programme is designed. Thus managers should design programmes for mitigation efforts carefully. When working in areas where the risk of depredation is low or resources only allow a certain proportion of livestock operations to benefit from the effort, managers ought to consider giving fence subsidies to a large proportion of livestock owners in smaller regions, one region at a time rather than subsidising a small proportion of farms over a large area. Such a programme would make it possible to demonstrate an effect (or lack of effect) from the effort on a regional scale much faster than if the effort is scattered over a larger area.

Lynx density depends mainly on roe deer densities, but seems to be only marginally affected by lynx hunting at the present level of hunting quotas and the way that lynx are hunted in Sweden (recreational hunting based on county level quotas). If the conflict between lynx and sheep farmers is to be mitigated through recreational hunting of lynx, the regional density of both lynx and roe deer ought to be known in order to issue effective hunting quotas. Accurate monitoring of lynx and roe deer populations is therefore essential. As the number of depredation events seemed to depend on the density of sheep farms, knowledge of the density of sheep farms is also an important tool for managers. When considering selective removal of so called problem individuals that are involved in a large number of depredation events, managers must know the density of sheep farms in the actual area. Otherwise, it will not be possible to distinguish between selective removal of a lynx individual that is more prone to attack livestock than other lynx, and zoning, where an area with high density of sheep farms is more or less permanently kept free of lynx.

Effects of subsidies on human attitudes

Even though the proportion of subsidised sheep farms has not significantly affected the number of depredation events in the wolf territories (J. Karlsson. unpublished data), the fencing subsidies did have an effect on human tolerance.
The proportion of sheep farms that had received fencing subsidies was significantly associated with increased tolerance. Standardized coefficients indicated that this variable was just as strong predictor of human tolerance as, for example, the level of education. One possible mechanism behind this effect may be that the mere existence of a subsidy programme convinces the public that the negative sides of wolf presence are taken seriously by the authorities. It is also possible that the general public, through media, public meetings and discussions, has gained an idea of whether a large or a small proportion of the sheep farms in the area (wolf territory) has received subsidies and new fences. The proportion of sheep farmers that had received fencing subsidies may then have served as an indicator of HOW seriously the authorities regard negative effects on a local scale.

Variables such as age, gender, education, membership of a nature conservation group or being a hunter, which have commonly been associated with attitudes

towards wolves in previous studies (Bath, 1987; Kellert, 1985; Biggs, 1988; Bjerke *et al*., 1998; Williams *et al*., 2002; Ericsson & Heberlein, 2003), were also important in this study. In addition to the proportion of sheep farms that had received government subsidies for proactive measures, we also surveyed other variables more directly related to direct experience of wolves, i.e. if the respondent had seen wolves or not, the proportion of sheep farms per year that had been attacked by wolves, number of dogs that had been attacked by wolves per year in the respective territories, and the number of years that the wolf territory had existed. Neither the proportions of sheep farms that had experienced depredation nor the number of dogs attacked by wolves had any significant effect on tolerance towards wolves expressed by the general public. Approximately 37 % of the respondents within wolf territories had seen a wolf at least once. Respondents that had actually seen a wolf in the wild were more negative towards wolves than those who had not seen one. There have been no reports of wolves behaving aggressively or threatening humans in other ways in the surveyed territories.

Seeing a wolf does not turn a person's positive attitude towards wolves to a negative one, or vice versa, since values are founded very early in life (Bjerke *et al*., 1998; Knight, 2000). However, seeing a wolf may serve as a reminder of personally held values and affect the degree of negative attitudes as well as the will to express them. Among respondents that were more positive towards wolf conservation, i.e. respondents that expressed a willingness to pay for wolf conservation, seeing a wolf in the wild did significantly affect the willingness to pay negatively.

The vast majority of the respondents that are willing to pay for wolf conservation express a positive attitude towards the development of wolf numbers in their own home area. However, the proportion of sheep farms in the respective territories that had experienced wolf depredation tended to be negatively associated with willingness to pay (WTP). This means that, among the respondents having positive attitudes towards wolves, the will to financially contribute to the conservation of wolves was negatively affected by the proportion of depredated sheep farms in the territory where they live. A plausible explanation for this may be that the people that were positive towards wolves lowered their ambitions regarding wolf numbers in their specific area after experiencing the local conflicts following several depredation events. This is not because they had changed their values regarding wolf conservation as such, because values are founded early in life (Petty *et al*., 1997; Bjerke *et al.,* 1998; Knight, 2000), but it is more likely that they realise that the level of conflict with other human interests would be too high. The proportion of farms receiving fencing subsidies significantly affected attitudes towards wolves in the total sample. However, the proportion of subsidized farms was not significantly affecting willingness to pay among those respondents that were willing to pay for wolf conservation (i. e. the most positive respondents). From this we conclude that fencing subsidies do not only affect people that are already having an extremely high tolerance towards wolves.

Socio-economic variables in the studied wolf territories were different compared to the rest of Sweden, as were the attitudes towards wolves. However, we believe that the results from this study will also be relevant if wolves colonise new areas of Sweden. Wolf territories are not randomly dispersed over the landscape. Wolf territories in Scandinavia tend to be in more rural areas containing fewer people, built-up areas and roads than areas outside wolf territories (Paper I, this thesis). Consequently, future wolf territories in Sweden are likely to differ from the rest of Sweden in the same way as the wolf territories studied here.

What is a bold wolf?

In all 34 trials the wolves left their lair after being approached. In no case did we record any sign of aggression or defensive behaviour, not even when the provocateur was within 20 metres of the wolves before being detected. Although we were often not able to record the exact time when wolves detected the provocateur our impression was that they usually left immediately or very soon after becoming aware of the approaching human. Visibility was not significantly correlated with Flight Initiation Distance (FID) in our study, probably because the forest in our study area was so dense (mean visibility 55 metres) that the wolves usually heard or detected scent from the humans before they were able to see them. Hearing seemed to be the most important sense for the wolves in this context since the FID was longer with no wind than with wind towards the wolves. When there is no wind it is hard to detect scent from a distance. Experienced dog trainers claim that dogs can pick up human scent at a distance of up to 80 metres under windless conditions (T. Gustavsson, pers. comm.). If we assume that the ability of wolves to detect scent is not much different from that of trained dogs it seems unlikely that the studied wolves detected the provocateur by scent at a distance of 300 metres under windless conditions. At this distance it is more likely that the approaching human was detected by hearing. Also, the harder the wind was blowing, the shorter FID was recorded. The most likely reason is that the noise of the wind concealed the sounds from the provocateur. Intensive field experiments in two Scandinavian packs indicate that the type of sound has an influence on FID. Surprisingly, the human voice affected the distance at which an approaching human was detected less than noise from the ground (Wam, 2003).

Not only wind velocity but also wind direction was significantly associated with FID. The FID tended to decrease when the wind was blowing from the wolf towards the approaching human. On all three occasions when there was close visual contact with the wolves, the wind was blowing hard and from the wolves. Although wolves may scent humans several hundred metres away under certain weather conditions (Mech, 1970; Chapman, 1977), the human's distance, speed and direction of movement may be difficult to determine by scent alone. For example, Harrington & Asa (2003) reported that wolves must move in a criss-cross fashion in order to follow an airborne scent. This may explain why FID was longer under windy conditions even when the wind was blowing towards the wolf. On three of the 34 occasions we could document by snow tracking that the provoked wolves moved in a semi-circle and intersected the tracks made by the

provocateur 200-300 metres back, possibly trying to catch scent of the intruder before continuing to move away from the provocateur.

Conclusions and implications for management

Location of large carnivores

It is possible to make useful predictions of where wolf territories are more likely to occur (Paper I). However, it seems as the prediction is an indirect model of the risk for wolf mortality. The model in this study had high predictive power, but since it does not take into account the "human dimension", it is an indirect description of a suitable wolf habitat in Scandinavia. If human attitudes towards wolves become more positive variables indicating human activity may not be useful predictors of wolf territory occurrence since degree of human activity will then be weaker correlated with wolf mortality. The same problem will probably affect most habitat suitability models, not only when dealing with large and controversial animals, but certainly also for common species. Incorporation of a human dimension in terms of public attitudes in habitat suitability models may prove to be an important factor in future research concerning habitat preference and suitability. In Scandinavia there are no areas where wolves can not exist *per se* (Paper I).

Management decisions will often have to be made where local habitat suitability models have not been carried out or cannot be carried out because the population is too small. The results in paper I suggests that under such circumstances managers will gain valuable insight by using habitat suitability models developed under similar conditions elsewhere, but on the same species.Hopefully this can encourage others to test habitat models developed in other countries or landscapes. Results from such tests will be invaluable for managers and conservationists all over the world, since they may show to what extent it is possible to use models already developed instead of doing new local models for every population.

Effect of location on human attitudes

The wolf territory may be viewed as a human tolerance sink and the areas far from wolf territories as sources of human tolerance towards wolves. Attitudes towards wolves are more negative, not only inside the actual wolf territories, but also in an area around the territories compared to areas far from wolf territories (Paper II). Direct negative experiences are generally not the main mechanism behind negative attitudes towards wolves. Indirect experiences (experienced by others), may be just as important or even more important in shaping human attitudes towards wolves (Paper IV). When using attitude surveys, for example, to evaluate the effects of management actions, consideration has to be taken to the respondents' location in relation to the nearest wolf territory. Omitting this variable may otherwise distort the results and lead to the wrong conclusions (Paper II).

Within the Swedish wolf territories, attitudes towards wolves were relatively negative despite the fact that direct negative experiences of for example

depredation on livestock and pets are rare (Paper II). Hence, Swedish authorities should at least consider the possibility that past or present management regimes may to a certain extent cause the low tolerance for wolves. Increased knowledge is only partial, and not always positively correlated with positive attitudes towards large carnivores (Hook & Robinson, 1982). Thus, general information about wolf biology is not the most effective management response to negative attitudes towards wolf colonization. On the other hand, only mitigating the negative effects of wolves will probably not be sufficient to increase tolerance for wolves (Paper IV). Managers should also make efforts to communicate "the good examples", for example from successful sheep farmers inside wolf territories.

Active management and targeted mitigation efforts

The number of lynx depredation events in an area with lynx, is among other factors, depending on the density of sheep farms. The more sheep farms, the more depredation events can be expected. The relationship is positive, and just as important, proportional (Paper III). However, the risk for an individual sheep operation suffering from lynx depredation is just as high in an area with many sheep operations as it is in an area with few sheep operations. To reduce the number of lynx depredations on a national or regional level by culling of a limited number of lynx, it would be more effective to remove lynx individuals in agricultural areas with many sheep farms. This would mean that the number of lynx permits issued in areas with fewer sheep farms would have to be very few or none. Since the risk for depredation on the individual farm is the same in areas with few sheep farms, this could affect the tolerance for lynx and lynx management. In paper IV we have shown that the number of wolf depredation events was not affecting human attitudes towards wolves. Thus, if the objective is to reduce the number of depredation events, managers should remove lynx in areas with high densities of sheep farms. If the objective is to increase tolerance for lynx, managers may be better of by removing depredating lynx also in areas with few sheep operations.

Without a well defined goal it is impossible to succeed with any management action. If nothing else, you will never know when the goal is achieved. Efforts to reduce the negative effects on large carnivores should always be preceded by an objective and a clearly stated goal.

Is improved fencing effective ?

There is support for using improved fencing as a proactive measure to reduce the risk of depredation from large carnivores (Nass *et al.,* 1984; Mertens *et al.*, 2002). This far we have not been able to show that subsidised fencing of sheep has reduced the number of lynx depredation events on a national level (Paper III). This is also true for wolf depredation on sheep (J. Karlsson unpublished data). Nevertheless, the subsidies of improved fencing, has affected human tolerance of wolves (Paper IV). On the current level of sheep depredation by wolves in Sweden, the number of depredation events did not affect the attitudes towards wolves among residents in the respective wolf territories (Paper IV). Thus, it may

not be the reduction in depredation risk *per se* that creates the more positive attitudes towards wolves. In paper IV we hypothesize that the proportion of the sheep farmers having received fencing subsidies, is an indicator of how serious the authorities consider their problems. However, conflicts arising from the presence of wolves, does not only concern livestock losses. In addition there is concern for wolf attacks on dogs, fear of wolves attacking humans and competition between wolves and humans for valuable game species such as moose. Proactive measures to reduce livestock losses, as for example fencing subsidies, target one of these problems but it may not be realistic to hope for substantial positive effects on attitudes of the general public.

Management of problem individuals

There are several definitions of a problem individual (Linnell *et al*., 1999). The definition that is best suited for the current Swedish legislation is probably the one that defines a problem individual as a carnivore that attack, for example, livestock more often than most other carnivores of the same species would do in the same area (Paper III). Removing such an individual would, in most cases, mean that the new individual colonising the area after the problem individual has been removed will attack livestock less frequently. In Sweden problem individuals do occur. Both when it comes to depredation on livestock and exhibiting a bold or less shy behaviour towards humans (J. Karlsson unpublished data). Studies from many parts of the world show that fear of wolves is a widespread phenomenon and that it affects the lives of humans in wolf areas (Kanzaki *et al*., 1996; Linnell *et al.,* 2002; Williams *et al*., 2002). Successful conservation and management of wolves should therefore include effective responses to situations where humans express fear due to the behaviour of one or more wolves. Such situations can coarsely be divided into two types, 1) Situations where wolves really have acted in an abnormally bold manner and 2) Situations where human expectations of what is a normal wolf behaviour does not correspond with how wolves normally behave. The correct response from managers on type 1 situations should include actions directed towards the offending wolves, as well as information to residents, about wolf behaviour. The response in the second type of situations should primarily aim at communicating wolf biology and behaviour. The wrong response (or lack of response), especially in the first type of situations, can undermine public confidence in wolf management and eventually lead to a situation where wolves actually act aggressively towards humans. It is therefore important for wolf managers to be able to discern whether a wolf is acting abnormally bold or in a way that could be expected from any wolf in the same situation. To determine whether a wolf has been exerting a bold behaviour or not we found that the distance between the observer and the wolf is necessary but not sufficient information. Knowledge about wind direction and wind speed is also needed. Although the variation is large, most wolves will move away from an approaching human at a distance of approximately 100 m. This baseline information can be used as a reference for managers when assessing public reports on bold wolves. Managers may also "test" the wolves that are suspected to be habituated, by simply approaching the wolf and measure the distance at which the wolf moves

away and compare with the reference distance presented in paper IV. The comparison may then, together with other observations, serve as a coarse but objective indicator of whether the wolf is less shy towards humans than expected or not.

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A note on the human dimension of wildlife research

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Abstract

In this note a simple cowboy wannabe is expressing his sincere but insufficient gratitude towards some of the people who has made his studies possible and fun. However, I have had so much help from so many people it would be impossible to thank them all in this thesis. Thus it is only the top of the ice berg that is properly acknowledged on the following pages. For example many of my friends are not acknowledged although they have been essential for my work. They may work very little or not at all with large carnivores, but it is invaluable to have friends like, for example Anders Palm, Tomer Shalit, Roger Vallin, the Killer Kennholt gang, Andreas Norin, Magnus Sjöström and their families. Without friends like them, who actually does not care if you write a bad paper, say something really stupid on TV or writes a Phd thesis that maybe is not god´s gift to science, everything would be at stake each day. I would not be able to work like that for very long and certainly not long enough to complete this thesis. Without your help I had not finished this thesis, I would not even have started working on it.

Keywords: Thanks, Indispenseble, Viltskadecenter, Grimsö, Love, Support, Joyride.

Grimsö, April 2007

Introduction

Almost ten years ago, in the autumn of 1997, I came to Grimsö to take the course in wildlife biology. One of the first days we had a really enthusiastic, young teacher talking about population modelling. In a break we where standing in the sun outside the lecture room, and I asked him what he was working with in his Phd studies. He answered that he was an associate professor, and head of the research station working with lynx. His name was Henrik Andrén and I was really impressed. A little later during that autumn Henrik and Inga had some practical problems and needed a driver to a meeting in Fredriksberg, Värmland, where radio collaring of wolves was planned for the winter. I was given the opportunity to earn some extra money and drive them there. The meeting was requested by a NGO who strongly objected radio collaring of wolves in the area, since they feared it might increase the risk of poaching, if the wolves, against all odds, should survive immobilisation. Henrik and Inga did a great job persuading them that VHF frequencys, wolves and wolf positions would be treated with caution. However, at the end of the meeting the people from the NGO was not 100% convinced and asked again ´why the lives of the few remaining Scandinavian wolves should be risked in this way´. I was sitting in a corner of the room sipping on a Zingo, when I heared Henrik saying ´…and in addition we need this project to keep a young researcher working at Grimsö, if not we may not be able to make him stay´. That was an unexpected argument, but maybe not the most convincing one given the circumstances. I quickly put the bottle on the table to be able to rush for the car and drive away from an angry mob that might not understand the importance of personal policy over wolf conservation. To my surprise the discussion continued as if nothing had happened. A few minutes later when my eye brows had regained their normal position and Zingo was again pouring down my throat, I had learned two things that are just as true to me know, ten years later. 1. People are generally more interested in what they have to say themselves and less interested in really listening to what their counterpart says. 2. The young researcher that Henrik was concerned about must be really good at what he is doing. His name ? Håkan Sand.

Thanks to colleagues

There has, so far, only been one day when I have not been going to work with a anticipating smile on my face. It was when I learned that the Viltskadecenter car that I had crashed was not insured. I have a feeling that the 25th of may will add a second day with white knuckles on the steering wheel. But what is two days of anxiety compared two ten years of joy? And I owe it to all of you, with whom I have had the pleasure to work.

Thank you……

Henrik and Håkan, my supervisors and Inga, my boss for all help and inspiration. I have been impressed by your skills so many times it is impossible to count them all. A special thanks also to my fellow “viltskadare” Åke, Linn, Mia, Peter, Mikael and Mona.

Everybody on Grimsö for making our place of work fun, creative and relaxed. I can not think of a better place to work, or play floorball for that matter (a special thanks to the floorball players for hitting the ball somewhat more often than hitting various bodyparts). Per A, for providing a lot of wisdom, intellectual gymnastics, common sense and bullshit detection (all badly needed).
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Everybody who works with large carnivores on länsstyrelserna, Naturvårdsverket, Jägareförbundet etc. Maybe I have been harassing Magnus K, Michael S, Gunnar G, Per L, Marcus E and Robban F, more than others. I would of course never admit it, but from you I have gained more insights and experience than I deserve. Magnus S, do you remember when you shook my hand on Greenland and thanked me for taking you there? Now it is my turn to thank you (but without irony), it had been much harder to get to this point without your enthusiasm, knowledge and friendship.

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Many thanks to our wonderful neighbours in Fröddesboda, the Janssons and the Andréns. You make life much easier through helping out with babysitting, hay harvesting, taking care of animals when I am away working and not to be forgotten, having the ability to haul a cold beer out of the pocket when it is needed the most.

Of course moher, father, brother, Stickan and everyone else in our quite big family, which is the anchor to which me and my smaller family in Fröddesboda is firmly attached to the ground. As long as you are there it is no big deal to get yelled at by annoyed people, media or others. Finally I would like to hug the Fantastic four; Karin, Ville, Elias and Cissi for putting up with me for so long.

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