

On the other side of the fence

Multidisciplinary perspectives on intervention use to
prevent large carnivore attacks on domestic animals in
Sweden

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Abstract

Large carnivore conservation in Sweden relies on land sharing in multi-use landscapes as carnivore populations mainly occur outside protected areas. Prevention of carnivore attacks on domestic animals is prioritised to mitigate potential carnivore *impacts*, and to mitigate *conflicts* between stakeholders over carnivore conservation. Interventions intended to prevent carnivore attacks on domestic animals can only be effective if implemented, and mitigation of social conflicts depends on stakeholders support. The aim of this thesis is to contribute to an increased understanding of the effects that the provision, promotion, and implementation of interventions intended to prevent attacks of large carnivores on domestic animals may have on impact and conflict mitigation across stakeholder groups. A review of scientific literature reveals limited scientific evidence of intervention effectiveness to reduce the risk of large carnivore attacks on livestock. Keeping livestock in enclosures, using livestock guarding dogs or deterrents, or removing carnivores, can reduce the risk and severity of carnivore attacks, but the scientific evidence does not allow generalised assumptions about their effectiveness. Focus group interviews with owners of hunting dogs, pet dogs, sheep, reindeer, and transhumance livestock, combined with a web-based survey to the owner groups and the public, provides understanding of the end-user perspective. For animal owners, the intention to use interventions is influenced by the perceived subjective norms and by experienced worry for carnivore attacks. Beliefs about intervention effectiveness can be important for acceptance of specific interventions but should be considered a prerequisite rather than a guarantee for animal owners' acceptance. These beliefs are weighed against the implications that interventions imply, such as time consumption, money, or compromised animal welfare. Suitable interventions can aid animal owners' coping and reduce worry, but more controversial interventions may stir social conflicts. Provision and promotion of interventions can generate frustration if animal owners are unable to cope with intervention implications, or are presented with interventions appraised as irrelevant or norm incongruent. From a carnivore conservation and management perspective, humility as well as an ability to understand and acknowledge the experiences, concerns, and emotions of individuals is of vital importance to facilitate development of social trust and empathetic dialogue in the future.

Keywords: Large Carnivore, Conservation, Wildlife Conflict, Human Dimensions

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Sammanfattning

Stora rovdjur i Sverige återfinns i huvudsak utanför skyddade områden. Att förebygga rovdjursangrepp på tamdjur är prioriterat eftersom det kan minska negativ påverkan från rovdjuren och därmed minska sociala konflikter mellan olika intressegrupper. Åtgärder avsedda att förebygga rovdjursangrepp är bara effektiva om de används, och för att minska konflikter måste de först accepteras av de djurägare som ska använda dem. Avhandlingens syfte är att bidra till förståelsen för effekter av tillhandahållandet, marknadsförandet, och genomförandet av åtgärder bland de som berörs av åtgärderna. En vetenskaplig litteraturgenomgång visar att det i stor utsträckning saknas evidens gällande åtgärdernas effekt att minska risken för rovdjursangrepp på tamdjur. Att hålla betande djur i hägn, använda boskapsvaktande hundar, skrämvel, eller att avlägsna rovdjur är åtgärder som i studier visat sig kunna minska risken eller omfattningen av rovdjursangrepp. Nuvarande vetenskapliga evidens är dock inte tillräckligt omfattande för att dra generella slutsatser kring effektens omfattning. Fokusgruppintervjuer med ägare till jakthundar, sällskapshundar, får, renar, och fåboddjur i kombination med en webbaserad enkät till samma djurägargrupper och allmänheten ger en förståelse för användarperspektivet. Djurägarnas intention att använda åtgärder påverkas allra mest av närståendes uppfattningar och den oro för rovdjursangrepp man upplever. En tro på åtgärdernas effekt kan vara viktig för acceptans av specifika åtgärder men bör ses som en förutsättning snarare än en garanti för djurägarnas acceptans. Tro på den specifika åtgärdens effekt vägs mot de konsekvenser som åtgärden innebär, som ekonomiska kostnader och tidsåtgång, eller risker för tamdjurens välbefinnande. Lämpliga åtgärder kan hjälpa djurägare att hantera rovdjursituationen och minska oron, men kontroversiella åtgärder kan generera sociala konflikter. Tillhandahållandet och marknadsförandet av åtgärder kan också skapa frustration om djurägarna inte kan hantera åtgärdernas konsekvenser, eller tillhandahålls åtgärder som de bedömer som irrelevanta eller oförenliga med sina egna eller sociala normer. Från ett naturvårdsperspektiv är ödmjukhet och en förmåga att förstå och erkänna individuella djurägares erfarenheter, funderingar, och emotioner helt avgörande för att skapa förtroende och empatisk dialog.

Nyckelord: Stora rovdjur, naturvård, viltkonflikt, människor och vilt

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Dedication

For Moa, whose intelligence and love for people, animals, and the natural environment will always inspire me.

Each one of us matters, has a role to play, and makes a difference. Each one of us must take responsibility for our own lives, and above all, show respect for living things around us, especially each other.

J. Goodall, Reason for Hope: A Spiritual Journey (1999)

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List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

- I Eklund, A.*, López-Bao, J.V., Tourani, M., Chapron, G., & Frank, J. (2017). Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. *Scientific Reports*, 7, 2097.
- II Eklund, A.*, Johansson, M., Flykt, A., Andrén, H., & Frank, J. (2019). Believed effect – a prerequisite but not a guarantee for acceptance of carnivore management interventions. *Biological Conservation*, (in press)
- III Eklund, A.*, Johansson, M., Frank, J., & Flykt, A. Animal owners' appraisal of large carnivore presence and use of interventions to prevent carnivore attacks on domestic animals in Sweden (submitted)
- IV Eklund, A.*, Johansson, M., Flykt, A., Andrén, H., & Frank, J. Drivers of intervention use to protect domestic animals from large carnivore attacks (submitted)

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The contribution of Ann Eklund to the papers included in this thesis was as follows:

- I Main author. Designed the study with co-authors. Analysed literature with MT, with support from JVLB and JF. Wrote the manuscript with contributions from co-authors.
- II Main author. Designed the study and survey with MJ, AF, and JF. Collected all data. Analysed data with support from JF and HA. Wrote the manuscript with contributions from co-authors.
- III Main author. Designed the study with co-authors. Collected data with support and contributions from MJ. Transcribed all data. Analysed data with support from MJ. Wrote manuscript with contributions from co-authors.
- IV Main author. Designed the study and survey with MJ, AF, and JF. Collected all data. Analysed data with support from MJ, AF, and HA. Wrote the manuscript with contributions from co-authors.

1 Introduction

Human domination of the planet has increasingly influenced the ecosystems and species on Earth since the last glaciation (Bar-On, Philips & Milo 2018; Braje & Erlandson 2013), leading to the current biodiversity crisis with species extinction rates above what would be expected in undisturbed systems (Barnosky et al. 2011). Biodiversity is considered a crucial component for ecosystem functioning and a thriving global society (e.g. Dirzo et al. 2014; Griggs et al. 2013; Rands et al. 2010) and its conservation has thus become a priority regulated by international agreements and conventions (Glowka et al. 1994; United Nations Environment Programme 2019). Conservation biology as a discipline arose in response to this crisis to bring forward principles and tools for the preservation of biodiversity (Soulé 1985), but the discipline is not primarily concerned with biological challenges. Instead, its main focus is on the interactions between biodiversity and human society (e.g. Bawa 2006; Thirgood & Redpath 2008; Treves et al. 2006). With current human population growth, a combination of land sparing and land sharing may be argued as the most appropriate approach for many species (Fischer et al. 2008). This is for instance the case for species that occupy vast geographical ranges and require larger areas than may be set off for protection (Linnell, Swenson & Andersen 2000). Long-term conservation of such species will therefore inevitably rely on land sharing with humans in multi-use landscapes (e.g. Chapron et al. 2014; Johansson et al. 2016; Ripple et al. 2014; Treves et al. 2006).

Major conservation challenges in systems where humans and wildlife co-occur are to mitigate potential *impacts* of wildlife on human practices and livelihoods, and to mitigate *conflicts* between stakeholders over wildlife and its management (Decker & Chase 1997; Redpath et al. 2013; Redpath, Bhatia & Young 2015; Thirgood & Redpath 2008; Woodroffe, Thirgood & Rabinowitz 2005). The conflicts primarily occur between people who hold wildlife conservation objectives and those with lifestyles and objectives that are negatively impacted by the wildlife (Redpath, Bhatia & Young 2015;

Sjölander-Lindqvist 2008, 2009). Globally, conflicts and impacts involve a large variety of wildlife species ranging from large grazing animals such as elephants (e.g. Tchamba 1996; Williams, Johnsingh & Krausman 2001), to migratory birds (e.g. Eythórsson, Tombre & Madsen 2017; Fox & Madsen 2017; MacMillan, Hanley & Daw 2004), and marine animals (e.g. Westerberg et al. 2006; Wickens et al. 1992). A wildlife guild of high conservation concern which is often surrounded by conflict is the guild of terrestrial large carnivores (Thirgood, Woodroffe & Rabinowitz 2005). Large carnivores can impact humans and their livelihoods through predation (Bostedt & Grahn 2008), which has historically played a central role in their reduction and extirpation around the world, including Europe and North America (Reynolds & Tapper 1996). They are now recognised as a high conservation priority due to their importance for ecosystem functioning (Lute et al. 2018; Ripple et al. 2014), and based on perceptions of societal responsibility towards the natural environment (Linnell, Swenson & Andersen 2000). Therefore, most large carnivore populations currently benefit from some levels of legal protection, such as the European Habitats Directive 92/43/EEC. Since its implementation, legal protection has played an important role for the carnivores' return in Europe (Chapron et al. 2014; Redpath et al. 2017), and also likely reflects a shift in public attitudes towards these species in the decades prior to protection (Williams, Ericsson & Heberlein 2002).

Like in many other geographical regions, the populations of large terrestrial mammalian carnivores (hereafter “carnivores”) in Sweden were bounty hunted until the early and mid-20th century (Bostedt & Grahn 2008). At that point the populations were either extinct or close to extinction, and the species went from hunted to protected almost overnight (Swedish Environmental Protection Agency 2018a, 2018b, 2019). The main increase in carnivore numbers have occurred since the 1980s and currently the populations comprise approximately 2900 brown bears (*Ursus arctos*), 1200 Eurasian lynx (*Lynx lynx*), 600 wolverines (*Gulo gulo*), and 300 wolves (*Canis lupus*) (Frank & Tovmo 2019; Kindberg & Swenson 2018; Svensson et al. 2019; Tovmo, Höglund & Mattisson 2018). Only a small fraction of these carnivore populations is currently found within protected areas, whilst the main population recovery has occurred alongside the human population in multi-use landscapes. Such a development would likely not have been possible without generally neutral or favourable attitudes towards large carnivores, both in areas with carnivore occurrence and in areas without (Eriksson, Sandström & Ericsson 2015; Krange et al. 2017; Sandström et al. 2014). However, the return of carnivores can create cultural divides between urban society and the rural communities (Eriksson 2016; Sjölander-Lindqvist & Cinque 2014; Skogen, Mauz & Krange

2008) and on a micro-level less positive attitudes are expressed by people who live in close vicinity of carnivore territories (Karlsson & Sjöström 2011), and in areas with long time co-occurrence (Dressel, Sandström & Ericsson 2015; Sandström et al. 2014).

Less positive attitudes are thus thought to be linked to experiences of direct or indirect consequences of carnivore presence, such as predation on domestic animals (Karlsson & Sjöström 2011; Williams, Ericsson & Heberlein 2002). Carnivores kill a total of approximately 50 dogs, 500 sheep, and up to 50 000 reindeer, annually in Sweden (Frank, Månsson & Höglund 2019). The owners of carnivore killed domestic animals receive economical compensation for their losses (Frank, Månsson & Höglund 2019; Zabel & Holm-Müller 2008). However, previous research has established that financial compensation does not necessarily reduce conflict around carnivores (Naughton-Treves, Grossberg & Treves 2003), suggesting that the lost animals do not simply represent a monetary or instrumental value to their owners. Therefore, prevention of attacks has become prioritised to facilitate coexistence between carnivore conservation and practices including domestic animals (Frank, Månsson & Höglund 2019). For this purpose, a large number of interventions intended to prevent carnivore attacks on domestic animals (hereafter “interventions”) are available to carnivore managers and animal owners. It can be challenging to appreciate the full abundance and select the correct intervention to implement in each unique case. The decision could nevertheless make the difference between life and death to domestic animals as well as carnivores (Baker et al. 2008; Reynolds & Tapper 1996). Implemented interventions range from lethal (e.g. culling) to non-lethal methods (e.g. fences, guarding animals, or deterrents). These interventions are either supported and funded by authorities or initiated and undertaken by the affected people themselves.

Interventions could be considered technical solutions intended to reduce impacts of carnivores on human livelihoods, but they can only ever be effective if they are actually implemented and used. Since conflict over carnivores is fundamentally identified as a conflict between people with conservation interests and those who suffer the consequences of conservation, in this case owners of domestic animals, conflict will likely not be mitigated by interventions unless both parties support intervention use (Redpath, Bhatia & Young 2015). Furthermore, as carnivores to some extent attract the attention and support of the public, some interventions (such as removal of carnivores) may be less acceptable to certain groups in society (Bruskotter, Schmidt & Teel 2007; Krange et al. 2017). It is a presumption of intervention use that their implementation should reduce impact as well as conflict and thereby increase the social legitimacy of conservation (Kaplan-Hallam & Bennett 2018). But, if

interventions are implemented without the support of the end-users, other stakeholders, or the public, the process could in the worst case increase segregation and conflict levels between stakeholder groups, and in turn challenge human-carnivore coexistence (Højberg, Nielsen & Jacobsen 2017; Riley et al. 2002). Consequently, in addition to finding interventions which are effectively reducing carnivore impact, there is a need to understand the end-user perspective of interventions to ensure interventions can actually be implemented and do not generate further conflict (Bennett et al. 2017a; Clayton, Litchfield & Geller, 2013; Clayton et al. 2016; Enck & Decker 1997; Gigliotti, Decker & Carpenter 2000; Miller & McGee 2001; Redpath et al. 2013; Redpath, Bhatia & Young 2015).

2 Aims & Objectives

The overall aim of this thesis is to contribute to an increased understanding of the effects that the provision, promotion, and implementation of interventions intended to prevent attacks of large carnivores on domestic animals may have on impact and conflict mitigation across stakeholder groups.

Specifically, the objectives of this thesis are:

- I To review the scientific knowledge of intervention effectiveness in reducing the impact of large carnivore attacks on domestic animals, and to identify potential knowledge gaps (Paper I).
- II To investigate the relationship between believed effectiveness and acceptance levels of available interventions among animal owners in Sweden (Paper II).
- III To assess potential for conflict over intervention use between animal owners and members of the public in Sweden (Paper II).
- IV To explore the psychological antecedents, and gain a nuanced understanding of appraisals, of intervention use among animal owners in Sweden (Paper III, Paper IV).

2.1 Outline of empirical work

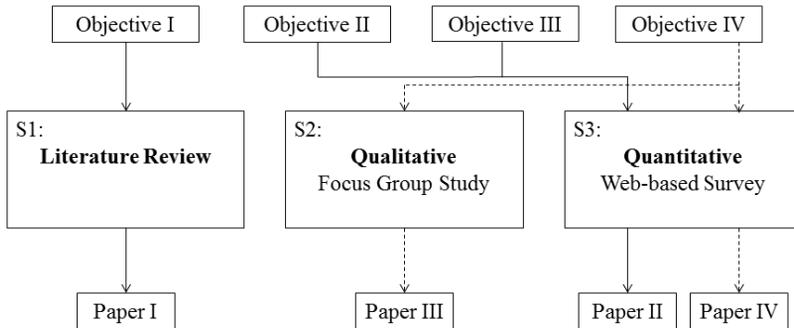


Figure 1. The four objectives were addressed through three studies, here presented from left to right in chronological order (S1-S3). Each study serves to inform the subsequent study (see Methodological considerations). S1 reviews the current knowledge base of interventions and provides a foundation for discussions with animal owners in S2. In turn, S2 provides nuanced understanding of animal owners' perspectives on intervention use which can inform the creation of quantitative survey in S3. To clarify the structure, a dashed line is used where paths overlap.

3 Research context

3.1 Human dimensions of wildlife conservation and management

Wildlife conservation and management is traditionally based in the biological sciences focusing on the species' ecology and behaviour. This perspective largely prevails (Bruskotter & Shelby 2010; Decker & Chase 1997; Treves et al. 2006) although the importance of incorporating social scientific knowledge into the field is increasingly recognised by wildlife managers (Decker & Chase 1997; Manfredo 1989) and in the scientific literature (e.g. Bennett et al. 2017a; Blanchard 2000; Clayton, Litchfield & Geller 2013; Clayton et al. 2016; Enck & Decker 1997; Enck et al. 2006). This need follows the recovery of wildlife populations, which are not limited in growth only by a biological carrying capacity but also by what level is acceptable to the human society (Carpenter, Decker & Lipscomb 2000). Essentially, wildlife practitioners need to understand the impact of conservation and management actions on people in order to mitigate potential consequences (Clayton, Litchfield & Geller, 2013; Kaplan-Hallam & Bennett 2018) and reduce the risk of conflicts over wildlife conservation and management (Redpath et al. 2017). The interdisciplinary research field Human Dimensions of Wildlife (HDW) evolved during the latter half of the 20th century. The field addresses the need for reliable scientific knowledge on human relations to wildlife as well as wildlife conservation and management. Research outcomes can aid practitioners to make informed decisions and avoid mistaken assumptions about local or public opinion based on communication by vocal critics or supporters (Blanchard 2000; Bruskotter, Schmidt & Teel 2007).

Initial HDW work put focus on consumptive and non-consumptive use of wildlife, economic importance of wildlife, and not least on the study of attitudes and values relating to wildlife and reintroductions of controversial

species (Bath 1995; Manfredo 1989; Manfredo, Vaske & Decker 1995; Williams, Ericsson & Heberlein 2002; Dressel, Sandström & Ericsson 2015). Understanding attitudes towards wildlife species is useful for informed management decisions. However, the knowledge is insufficient to predict human behaviour relating to intervention implementation as management actions constitute other attitudinal objects than the species *per se* (Manfredo, Vaske & Decker 1995; Whittaker, Vaske & Manfredo 2006). Finding interventions which are acceptable to stakeholders is challenging, potentially emotion laden, yet essential for sustainable wildlife management (Gigliotti, Decker & Carpenter 2000). As such, HDW research must also expand to human dimensions of intervention provision, promotion, and implementation (Baruch-Mordo et al. 2009; Gore et al. 2008; Triezenberg, Riley & Gore 2016).

Importantly, the interdisciplinary HDW field should make use of rigorous methods within the established bodies of social scientific theory (Bennett et al. 2017a; Bennett et al. 2017b; Dressel, Sandström & Ericsson 2015; Manfredo 1989; Vaske, Shelby & Manfredo 2006). The social sciences cover a broad range of scientific sub-disciplines (Bennett et al. 2017b), which in the context of HDW includes contributions from not least political sciences, social anthropology, economics, and environmental psychology (Sjölander-Lindqvist, Johansson & Sandström 2015). The different theoretical perspectives and sub-disciplines place focus from global to individual scales (Bennet et al. 2017b) and are complementary in their understanding of the interactions between human society and wildlife management as an interplay between the collective and individual level (Sjölander-Lindqvist, Johansson & Sandström 2015).

3.2 Environmental psychology

The empirical work in this thesis takes the perspective of environmental psychology to study the interrelationship between individuals and their environment (Bell et al. 2001; Gifford 2013). Following the scientific tradition of environmental psychology, the work is problem oriented, broadly addressing issues of sustainability in biological conservation, while specifically dealing with the real-life problems of animal owners within the Swedish carnivore ranges (Steg, van den Berg & de Groot 2013). The diversity of methods that the discipline of environmental psychology applies, allows investigation of broad patterns as well as in-depth understanding for the drivers of human thoughts and behaviours (Bennett et al. 2017b; Gifford 2016). The focus in environmental psychology lays mainly on the human reactions and behaviours in relation to the environment, and less on the environmental impact of the behaviours (Gatersleben 2013). Consequently, the discipline appeals to

interdisciplinary collaboration for complementary understanding of the human-environment interrelationship (Bell et al. 2001; Clayton et al. 2016) and provides a suitable approach to respond to my research objectives.

The empirical scientific work in this thesis builds upon previous contributions from environmental psychology into HDW, and adds to the development to incorporate emotion theory in the understanding of human relationships to wildlife management (Jacobs, Vaske & Roemer 2012). Because animals are triggers of strong emotional experiences, which in turn can impact cognitive processes (Dolan 2002), calls have explicitly been made to expand the inclusion of emotion in HDW research (Jacobs, Vaske & Roemer 2012). Until now, contributions incorporating emotion has included work which address drivers of human fear of large carnivores (Johansson et al. 2012), acceptance of management interventions to reduce fear of carnivores (Frank, Johansson & Flykt 2015; Johansson & Frank 2016), and human perceptions and evaluation of the effect of interventions intended to reduce fear of carnivores (Johansson & Frank 2016; Johansson et al. 2017; Johansson et al. 2019).

3.3 Ethical considerations

Research involving humans implies responsibility for the society and the study participants, integrity, justice, and respect for the rights of individuals (American Psychological Association 2017). Prior to the studies in this thesis, the content was scrutinised and research procedures were planned in relation to the code of conduct for good research practice described by the Swedish Research Council (SRC 2017) and the Ethical Principles of Psychologists and Code of Conduct (APA 2017). The research was deemed compliant with the code for research involving humans. None of the methodological approaches imply physical encroachment on the research subjects, affect research subjects physically or psychologically, or carry any obvious risk of physical or psychological harm to the research subjects (SRC 2017). A potential discrepancy was identified for handling sensitive personal data of reindeer herders. Reindeer herding represents a work practice but it is closely tied to cultural heritage and rights of the indigenous Sami people in northern Scandinavia (Jernsletten & Klovov 2002). The inclusion of reindeer herders was considered necessary due to the assumed relevance of the research topic in this stakeholder group. Approval of the project was given by the ethical board in Uppsala, Sweden (Regionala Etikprövningsnämnden Uppsala, Dnr 2017/259), before contact was initiated with the reindeer herding community.

All participants were informed of the project aims, and provided with contact details to the research team for questions, prior to data collection. Information was also provided to participants about the voluntary basis for participation and the possibility for participants to withdraw from the project at any point in time, without a need to provide any explanation to the research team. Informed consent was obtained from all participants before recording focus group interviews. In accordance with the information provided to the participants prior to data collection, data was handled with confidentiality and no information that could be traced to individual participants was shared outside the research group.

4 Theoretical framework

4.1 Intervention effectiveness

In wildlife conservation and management various individuals are involved in decision making and planning for suitable actions to reach intended outcomes. Consequently, many different individual practitioners must deal with wildlife situations that can require rapid responses. Management practices should ideally be based on scientific evidence to reduce the uncertainty of intervention outcomes. However, in reality, management decisions are often based on personal experiences, common sense, and anecdote (Pullin et al. 2004; Sutherland et al. 2004). These are not necessarily bad features but imply that management can become person dependent. When it comes to coexistence of large carnivores and humans, it is conditional upon effective mitigation of the impact that these species may cause through predation on domestic animals. Yet, scientific evaluations of interventions are surprisingly scarce (Miller et al. 2016; Treves, Krofel & McManus 2016) and in general, our understanding of their effect is based on narrative review (Roberts, Steward & Pullin 2006; Shivik 2006). As in the field of medicine, carnivore conservation is expected to benefit from the inclusion of scientific evidence of intervention effectiveness (Sackett 1997; Sutherland et al. 2004; Treves, Krofel & McManus 2016). An evidence-based use of interventions could be cost effective, and increase chances of impact- and conflict mitigation and coexistence, provided that it also incorporates the study of human dimensions and does not disregard social mechanisms of intervention use (Mathevet & Mauchamp 2005).

4.2 Acceptance and conflict

Interventions will be unable to produce a desired outcome unless they are accepted and implemented by the intended end-users. Potential conflict over intervention use may occur between people who do not share similar views on which interventions are acceptable and which are not (Vaske et al. 2010). Acceptance of interventions can be measured as a behaviour or behavioural intention to use interventions (Venkatesh 1999). However, acceptance may be passive and does not require active use of the intervention (Bruskotter & Fulton 2012). Thus, acceptance may also be considered as an attitude, relating to beliefs about positive or negative outcomes of intervention use (vanEeden et al. 2019; Frank, Johansson & Flykt 2015; Heneghan & Morse 2019; Vaske et al. 2006). People may respond to the use of interventions along a scale ranging from acceptance to opposition (Waldo et al. 2013). The acceptance level of interventions in wildlife management can relate to for instance social identity, concerns for wildlife impact on human health and livelihoods, emotional predispositions, or gender (Agee & Miller 2009; vanEeden et al. 2019; Frank, Johansson & Flykt 2015; Loker, Decker & Schwager 1999; Needham, Vaske & Manfredo 2010). Investigations of the antecedents of acceptance using rigorous theoretical models have nevertheless been articulated as an area in need of more research (Gigliotti, Decker & Carpenter 2000).

In relation to wildlife, acceptance has been described as a compromise between *tolerance of problems* and *desired benefits* from the wild animals (Carpenter, Decker & Lipscomb 2000), and the concept has been tied to models including perceptions of risks and benefits, salient value similarity, and social trust (Zajac et al. 2012). However, intervention acceptability represents acceptance of impact mitigation techniques rather than acceptance of wild animals *per se* (Gigliotti, Decker & Carpenter 2000). Looking to other disciplines, acceptance of technological solutions has been described using the Technology Acceptance Model (TAM) which evolved from the Theory of Reasoned Action (TRA) and hypothesises that user acceptance is determined by the *perceived usefulness* and the *perceived ease of use* of the technology (Davis 1989). *Perceived usefulness* is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis 1989) based on the definition of useful as “effective; helping you achieve something” (Cambridge Dictionary online, <https://dictionary.cambridge.org/>). This definition links perceived usefulness to beliefs of effectiveness which is investigated in this thesis in relation to acceptance. The *perceived ease of use* (Davis 1989) is defined as “the degree to which a person believes that using a particular system would be free of effort”

based on the definition of ease as “freedom from difficulty, effort, or pain” (Cambridge Dictionary online).

4.3 Behavioural intention

Understanding behaviours and the underlying drivers of behaviours in relation to wildlife has been a major focus of HDW research (Vaske et al. 2006). One main theoretical framework aiming to describe behavioral intentions and underlying drivers is the Theory of Planned Behavior (TPB, Ajzen 1991; Miller 2017). This theoretical model and its predecessor the Theory of Reasoned Action (TRA) derive from social psychology and have been applied to investigate a broad range of HDW topics such as attitudes towards wildlife introductions (Pate et al. 1996), hunting intentions (Hrubec, Ajzen & Daigle 2010; Rossi & Armstrong 1999; Shrestha et al. 2012), support for hunting management (Campbell & MacKay 2003; Triezenberg, Riley & Gore 2016), human behavior in protected areas (Martin & McCurdy 2009; Miller et al. 2019) and intention to participate in conservation programs (Sorice & Conner 2010; Wilcox, Giuliano & Monroe 2012).

In its original form TPB describes a person’s behavioural intention as the outcome of the person’s attitude, subjective norms, and perceived control of performing the behaviour. In the context of this thesis, the owner’s valuation beliefs about possible positive or negative outcomes of intervention use will determine their attitude towards the behaviour; their subjective norms represent the social pressure or expectations perceived as held by their significant others towards the use of interventions (Ajzen 2006); and finally, the perceived control relates to the own beliefs held about their ability, the ease or difficulty, to use interventions (Ajzen 1991). One main criticism of the TPB is that it leaves a substantial amount of variance unexplained (Miller 2017), and some criticism has also suggested that it does not take sufficient account of human emotion (Ajzen 2011). However, due to the flexible framework of the theory this provides an opportunity for theoretical development and exploration of additional predictor constructs (Manfredo, Vaske & Decker 1995; Miller 2017).

4.4 Appraisals of emotion

Assuming that human decisions and relationships to wildlife and wildlife conservation and management is based entirely on reasoning and deliberation of facts, assumes that people are able to “turn off their emotions” (Slagle, Bruskotter & Wilson 2012) that have developed to aid human decision making

throughout the evolutionary history (Tooby & Cosmides 1990). In reality, emotion induces behaviour, and human responses and actions in relation to wildlife and management decisions are likely guided by emotion (Scherer 2005; Sjölander-Lindqvist 2015). Emotional components may even be necessary for making rational decisions, why an understanding of emotional aspects is essential for informed wildlife conservation and management (Jacobs, Vaske & Roemer 2012; Slagle, Bruskotter & Wilson 2012). Nevertheless, emotions have not yet received substantial focus in relation to wildlife conservation and management (Jacobs 2012). There are various theoretical approaches to the study of emotion (Strongman 2003), where the Appraisal Theory of Emotion provides a parsimonious and theory driven approach (Scherer 2005) that can increase the understanding of human behaviours in the environmental field and can complement theories such as TPB (Brosch, Patel & Sander 2014). In this thesis, the Appraisal Theory of Emotion (Scherer 2009) is incorporated to provide a relevant structure for understanding the emotions and reactions of animal owners in response to carnivore presence and intervention use on two different levels of appraisal; the first relating to carnivore presence and the second relating to the use of interventions as a potential for coping with carnivore presence.

According to the Appraisal Component Process Theory (Leventhal & Scherer 1987; Scherer 2009; Scherer, Schorr & Johnstone 2001), the animal owners would appraise the relevance (e.g. a threat), implications (potential consequences), their own coping potential (ability to handle the consequences), and norms congruence (personal and social) of carnivore presence in relation to the owners' goals, including keeping healthy animals (Larrère & Larrère 2000). Depending on the individual animal owner's emotion traits, the situation, and previous experiences, each of these stimulus evaluation checks would add to an emotional outcome in response to carnivore presence (Moors et al. 2013). The appraisal process involves cognitive functions on various levels of processing but occurs rapidly and usually does not require complex cognitive thought (Scherer 2009). In the context of animal owners' appraisal of carnivore presence, interventions could provide an opportunity to increase the owners' potential to cope with implications of carnivore presence, if their emotional response to carnivore presence so requires. The use of interventions can in turn ignite new appraisal processes as the owners appraise the relevance of intervention use, implications of using the intervention, their potential to cope with these implications, and whether the use of the intervention is compatible with the owners' norms.

5 Materials & Methods

5.1 Methodological considerations

To gain understanding of intervention effects to reduce the impact of carnivores on domestic animals as well as to facilitate conflict mitigation between stakeholders, the work in this multidisciplinary thesis combines knowledge and methodology from the natural and social sciences. The methods are anchored in well-established research practice and chosen to provide complementary approaches for a holistic understanding of the system. The first study comprises a literature review of natural scientific research on intervention effectiveness, which provides a fundamental understanding for which interventions can be proposed to animal owners. The subsequent qualitative social scientific study provides an understanding of the animal owners' perspectives on the use of interventions, essential for the creation of a quantitative survey and data collection (Figure 1).

In reviewing available evidence, the methodology was structured with clear inclusion criteria, and all methodological steps were recorded to enhance the possibility to replicate the work (Collaboration for Environmental Evidence 2013). The empirical studies are based on a mixed methods approach (Robson 2011). Mixed methods research implies collecting, analysing, and interpreting both quantitative and qualitative data complementary in order to investigate a phenomenon (Leech & Onwuegbuzie 2009). The approach was considered suitable for the thesis as the priority of a mixed method design is to provide the best answers for the research objectives by drawing from the strengths and minimising the weaknesses of each method. Whereas either method would fail to simultaneously provide depth as well as breadth if used in isolation, in combination the methodological strengths are complementary. The resulting product is therefore considered superior to what could have been achieved

using either of the two methods separately (Austin et al. 2010; Johnson & Onwuegbuzie 2004). In the first empirical study, focus group interviews are employed to bring depth, rich detail, context, and understanding of the participants' personal experiences with carnivore presence and intervention use (Paper III). In the second study (Paper II, Paper IV) quantitative methodology through a questionnaire survey is employed to allow validation of existing theories, identification of broader patterns, and predictions with regards to intervention acceptance and implementation (Johnson & Onwuegbuzie 2004).

5.2 Participants

The empirical studies included in this thesis involve five primary stakeholder groups that were identified based on statistics of carnivore attacks on domestic animals and national compensation schemes in Sweden (Frank, Månsson & Höglund 2019). These five groups were owners of hunting dogs, pet dogs, sheep, transhumance livestock, and reindeer. These groups represent all stakeholders that are likely to be at risk of suffering attacks from large carnivores on their animals in Sweden. Participants were recruited from the geographical regions where interactions between carnivores and domestic animals were most likely, based on the known distribution and presence of carnivore populations (Eklund et al. 2017b; Kindberg & Swenson 2018; Tovmo et al. 2016; Wabakken et al. 2016). A geographical limitation was set for dog owners and sheep owners to include only participants in regions with established lynx and wolf populations. The main reason for this limitation is that lynx and wolves cause the majority of large carnivore attacks on dogs and sheep. Intervention use was therefore considered relevant mainly to owners of animals that may interact with these carnivore species. For more detail on participant groups, see Paper II-IV.

The characteristics of the animal husbandry practices in Sweden are shaped by traditional knowledge and views as well as legislation. According to Swedish legislation, all dogs must be restrained from running loose on grounds where wildlife occur during spring and summer, and dogs should also be prevented from stalking wildlife during other times of the year except during hunting (SFS 2007:1150). Traditionally, hunting with dogs in Sweden involves one or two free roaming dogs that locate and either push or reveal the location of the hunted wildlife to the hunter. When they are not hunting, hunting dogs are commonly kept as family dogs (Swedish Kennel Club 2019). Sheep owners in Sweden range from hobby holders to professional breeders with larger herds, and sheep are generally kept in predefined grazing grounds restricted by built fences or natural formations and water bodies. Transhumance farmers

represent a decreasingly common traditional smallholder practice in north-central Sweden, employing free roaming summertime forest grazing and often keep traditional breeds of cattle, goats, and sheep (Eriksson 2011). Herding of semi-domestic reindeer in Sweden is a right of the indigenous Sami people and is undertaken in 51 reindeer herding districts restricted to the northern counties (Sami Parliament website: www.sametinget.se) in an area that comprise at least 34 % of the country, or approximately 160 000 square kilometres (Jernsletten & Klovov 2002). Traditionally, the semi-domestic reindeer roam freely except during gatherings and migration which is undertaken either by foot or assisted transportation by the herders (Rivrud et al. 2018).

5.3 Literature review

5.3.1 Inclusion criteria

The inclusion criteria used in the literature review limited the scope to evidence that i) included an empirical study of wild (i.e., not captive) carnivores; ii) included a quantitative evaluation of interventions to prevent/reduce depredation of livestock (excluding apiaries); iii) included a description of the methods used to implement the intervention (treatment) and of a study design sufficient for replication; iv) included a matched control to which the treatment was compared, and v) was written in English and published in a peer-reviewed scientific journal between 1 January, 1990 and 16 June, 2016.

5.3.2 Literature search and screening

Publications were retrieved through the Zoological Record ® through a search of subject descriptors “Carnivora OR Canidae OR Felidae OR Hyaenidae OR Mustelidae OR Procyonidae OR Ursidae OR Viverridae OR Viverridae”, which in total generated 48 894 titles. Titles and abstracts were then screened by the search string: “depredation OR stock OR poultry OR damage OR mitigation OR conflict OR control OR cull OR cow OR bull OR calf OR calves OR chicken OR hen OR ewe OR lamb OR pet OR cat OR hound OR pony OR ponies OR mule OR reindeer OR llama OR yak OR buffalo OR livestock OR cattle OR sheep OR goat OR horse OR pig OR dog OR attack OR camel OR donkey”. The remaining 27 781 titles and abstracts were manually screened to ensure publications were written in English and dealing with predation of domestic animals by large carnivores (body mass of >15 kg),

as listed by Ripple et al. (2014) or coyotes (*Canis latrans*) and wolverines. In the subsequent full text screening of the 562 remaining publications, only publications that included a quantitative measure of the effectiveness of an intervention and had an experimental or quasi-experimental study design, were accepted (all correlational studies were excluded). The analysis in Paper I comprised 21 scientific papers, describing 34 evaluations of intervention effectiveness.

5.3.3 Analysis of effectiveness as relative risk

The relative risk was calculated for each intervention evaluation to allow comparison of effectiveness between interventions. The relative risk is defined as the ratio between the probability of predation by large carnivores in the treatment group and the probability of livestock predation by large carnivores in the control group:

$$\text{Relative Risk (RR)} = \left(\frac{a}{a + b}\right) / \left(\frac{c}{c + d}\right)$$

where a is the number of predated animals/units in the treatment group, b is the number of unharmed animals/units in the treatment group, c is the number of predated animals/units in the control group, and d is the number of unharmed animals/units in the control group. In cases where there is no difference in the risk of predation between the treatment and the control group, the relative risk is 1. When $RR > 1$, the risk of predation is more likely to occur in the treatment group (with larger values of RR indicating a counter-productive intervention), and for $RR < 1$ predation risk is higher in the control group (with values of RR indicating a greater intervention effectiveness as they get close to 0).

5.4 Qualitative study

5.4.1 Participants

In total, 65 animal owners were gathered in focus group interviews comprising three groups of sheep owners, one group of transhumance livestock farmers, three groups of hunters with dogs, one group of pet dog owners, and three groups of reindeer herders. Subgroups were created among sheep owners based on herd sizes. Hunter subgroups were based on the use of different types of dogs, game, and hunting techniques, and reindeer herder subgroups were based on type of reindeer herding practice (Table 1).

Table 1. *Focus group participants.*

Stakeholder group	Sub-group	Characteristics	Gender	Mean age (range)
Sheep owners	Small herd	Participants own on average 50 ewes (range 10-120).	4 (80 %) female 1 (20 %) male	49 years (32 - 61)
	Medium herd	Participants own on average 136 ewes (range 60-300).	2 (50 %) female 2 (50 %) male	
	Large herd	Participants own on average 345 ewes (range 130-500).	4 (100 %) female	
Transhumance farmers	n/a	Keep various cattle breeds, sheep, goats, or horses. Graze animals freely in the forest.	4 (57 %) female 3 (43 %) male	54 years (37 - 70)
Hunters with dogs	Small game hunters	Recreationally hunt small game (forest grouse, hares, roe deer) with hounds and small spitz breeds.	6 (100 %) male	50.5 years (21 - 79)
	Ungulate hunters	Recreationally hunt moose with large spitz breeds.	1 (17 %) female 5 (83 %) male	
	Carnivore hunters	Recreationally hunt carnivores (badgers, fox, lynx, brown bears, wolves) with hounds, spitz breeds, or terriers.	7 (100 %) male	
Pet dog owners	n/a	Own pet dogs of various breeds.	4 (67 %) female 2 (33 %) male	62.5 years (36 - 75)
Reindeer herders	Mountain	Work with reindeer herding in the mountains.	4 (100%) male	44.8 years (23 - 64)
	Concession	Work with reindeer herding in the concession area.	7 (100%) male	
	Forest	Work with reindeer herding mainly in the forest.	6 (100%) male	

5.4.2 Procedures

Information was collected in eleven 2-3-hour focus group interviews during spring and autumn of 2016 and in spring 2018 (for details on participants see Table 1). Focus group methodology allows exploration of the research context to ensure the inclusion of relevant topics in the subsequent quantitative study, which would otherwise have been at risk of exclusion due to researcher confirmation bias (Clark et al. 1994; Johnson & Onwuegbuzie 2004). The methodology was considered suitable as the topic is not considered personally sensitive and participant discussions around the focal topic can be vivid and informative while reducing researcher confirmation bias, as the researcher takes a more peripheral role (Clark et al. 1994; Parker & Tritter 2006; Robson 2011).

Participants in focus groups were recruited via the largest national member organizations among sheep owners (Swedish Sheep Breeders Association), transhumance farmers (Association of Swedish Transhumance), and hunters (Swedish Hunters Association and the Hunters' National Association). Reindeer owners, who were also active herders, were recruited via the Swedish Sami National Association, the Concession Sami Villages Economic Association, and directly via the Sami villages' representatives. Pet dog owners were recruited through personal contacts. All participants were informed of their voluntary participation and that they were free to withdraw at any time without consequences. Consent was given from all participants, and everyone agreed to the digital recording.

Interviews followed a semi-structured interview guide. Key questions focused on the participants' use of interventions: what interventions they had heard of or used, and where they receive information and funding for intervention use. Visual material was used to facilitate discussions (Harper 2002) regarding the participants' experience and perspectives on approximately 20 specific interventions (Table 2). Each intervention was presented on a card with a picture and a description of the intended function (example in Figure 2). Proposed interventions were the same within, but varied slightly between, owner groups. Participants were asked if they would consider using the interventions or not and give reasons for their decision.

Table 2. *The interventions presented to each owner group during focus group interviews.*

Owner group	Interventions presented
Hunting dog owners	Ban bait site, castrating the dog, change dog breed (large size), change dog breed (short roaming), release several dogs, feeding site for carnivores, GPS-collared carnivores, human scent on dog, increase dog training (follow hunted game), information about attacks (from authorities), more people around, proportional removal of carnivores, report chain of carnivore observation, select hunting ground, select location to release dog, selective removal of carnivores, track and search, vest (electric), vest (chemicals), vest (spikes), wolf bell, zoning of carnivores
Pet dog owners	Anti-hunt training, ban bait site, castrating the dog, change dog breed (large size), contact and recall dog, dog on leash, exercise several dogs, feeding site for carnivores, GPS-collared carnivores, human scent on dog, information about attacks (from authorities), more people around, proportional removal of carnivores, report chain of carnivore observation, select location to release dog, selective removal of carnivores, sound deterrents, track and search, wolf bell, zoning of carnivores
Reindeer herders	Actively herding, biofence, calving in enclosure, feeding site for carnivores, lighting fires, GPS-collared carnivores, hazing with snowmobiles, herd moved, human scent on reindeer, increase alternative prey populations, increased supervision, painted eyespots on hind quarters, proportional removal of carnivores, protective collars, report chain of carnivore observations, selective removal of carnivores, sound deterrents, track and search, translocation of carnivores, wildlife cameras for monitoring, zoning of carnivores
Sheep owners	Actively herding, biofence, carnivore deterring fence (5 live wires), carnivore deterring fence (net + live wire), feeding site for carnivores, fladry, fladry on water, GPS-collared carnivores, increased supervision, information about attacks (from authorities), light deterrents, livestock guarding dog, livestock guarding llama, mixed herds (with more aggressive), night time confinement, proportional removal of carnivores, protective collars, report chain of carnivore observation, selective removal of carnivores, sound deterrents, waste disposal, zoning of carnivores
Transhumance farmers	Accelerometer on animals, actively herding, ban bait site, biofence, feeding site for carnivores, GPS-collared carnivores, human scent on animals, increased supervision, information about attacks (from authorities), livestock guarding dog, livestock guarding llama, mixed herds (with more aggressive), night time confinement, proportional removal of carnivores, protective collars, report chain of carnivore observation, selective removal of carnivores, wildlife cameras for monitoring, zoning of carnivores



Figure 2. Example of a card presented to focus group participants. A picture representing the intervention was printed on the front of the card and a written description of its use and intended functionality appeared on the back of the card. The picture on the card comes from the Wildlife Damage Centre.

5.4.3 Coding and analysis

The recorded interviews were transcribed in full and coded using Atlas TI 7.0 (2002-2019). An inductive approach was taken during the initial analysis of the data, when themes that emerged in the data guided the creation of the initial codes. To assess inter-coder agreement, two co-authors coded selected parts of the interview transcripts in parallel to allow a comparison. The initial parallel coding generated a 67 % inter-coder agreement. After discussions, a second parallel coding resulted in an 87 % inter-coder agreement. The remaining disagreements were discussed in the research group until all codes were agreed upon. The initial thematic coding revealed two levels of appraisal made by the participants during their discussions: one relating to the owners' appraisal of carnivore presence and management, and the other relating to the owners' appraisal of intervention use. With this initial understanding of the data, a deductive approach was taken during the continuing analysis of the data. This second thematic coding was based on appraisal theory (Scherer, Schorr & Johnstone 2001) and the deductive analysis guided the themes for appraisal at the two identified levels.

5.5 Quantitative study

5.5.1 Participants

The quantitative survey was distributed to animal owners (n= 4 016, excluding reindeer herders where the number of distributed surveys is unknown) and members of the public. Respondents in all groups were at least 18 years of age. In relation to the total number of web-surveys distributed to animal owners (excluding reindeer herders) the rate of returned surveys where animal owners had at least answered the first question that they owned domestic animals was 43 % (n = 1 713). The number of returned surveys from reindeer herders was 49, and from members of the public 1 115 (Table 3).

Table 3. *Response rates to Qualtrics (Qualtrics, Provo, UT) web-survey.*

Group	n	Response rate [*]	Gender ^{***}	Mean age (years) ^{***}	Age range (years)
Hunters with dogs	1 030	78 %	16 % female	45	18-84
Members of public	1 115	NA ^{**}	53 % female	48	18-87
Pet dog owners	181	20 %	67 % female	48	20-74
Reindeer herders	49	NA ^{**}	26 % female	41	22-65
Sheep owners	430	27 %	50 % female	53	22-85
Transhumance farmers	72	33 %	41 % female	53	25-76

* response rate of returned web-based surveys with positive responses to the first question regarding animal ownership, in relation to the total number of distributed links.

**The total number of distributed surveys is unknown for reindeer herders due to the intermediate step in link distribution. For the Norstat sample, links are distributed to a large number of panel members, but the survey is closed once the requested number of responses is reached and therefore the response rate is not relevant for this sample.

*** Percentage among those reporting gender and mean age among those reporting age.

5.5.2 Materials

The quantitative data was collected in a web based survey developed in Qualtrics (Qualtrics, Provo, UT). The survey included a total of 90 - 100 items to animal owners and 67 items to members of the public. Items related to animal husbandry, specific interventions, experience of carnivores and carnivore management in Sweden, the relationship to managing authorities and the work to prevent attacks on domestic animals, as well as demographic items.

Table 4. *Specific interventions included in the surveys for which respondents estimated their oppose-accept intention and the believed effect of interventions.*

Group	Intervention presented
Hunting dog owners	Change dog breed, increase dog training (follow hunted game), more people around, proportional removal of carnivores, selective removal of carnivores, track and search, vest (electric), vest (spikes), wolf bell, zoning of carnivores
Members of the public	Carnivore deterring fence, fladry, hazing with snowmobiles, light & sound deterrents, livestock guarding dog, proportional removal of carnivores, selective removal of carnivores, zoning of carnivores
Pet dog owners	Anti-hunt training, change dog breed, dog on leash, make noise, more people around, proportional removal of carnivores, recall training, selective removal of carnivores, several dogs exercised together, track and search, wolf bell, zoning of carnivores
Reindeer herders	Calving in enclosures, fires, hazing with snowmobiles, herd moved, increased surveillance, painted eyespots on hind quarters, proportional removal of carnivores, protective collars, selective removal of carnivores, zoning of carnivores
Sheep owners	Carnivore deterring fence, fladry, increased surveillance, light & sound deterrents, livestock guarding dog, livestock guarding llama, night time confinement, proportional removal of carnivores, selective removal of carnivores, zoning of carnivores
Transhumance farmers	Bait site ban, increased surveillance, livestock guarding dog, livestock guarding llama, night time confinement, proportional removal of carnivores, protective collars, selective removal of carnivores, zoning of carnivores

Oppose-accept intention and believed effect items

Items were developed to collect data on oppose-accept intention (OA) and believed effect (BE) for approximately 10 specific interventions in each owner group (Table 4). The BE items followed either of two formats: A) “How well do you believe that *intervention* work to protect *domestic animal* from large carnivore attacks?”, or B) “How well do you believe that *intervention* work to protect *domestic animal* from being killed/injured at the event of a large carnivore attack?”. OA items followed either of two formats: A) “Which is your stand on using *intervention* with the purpose to protect your *animal* from being attacked by large carnivores?”, or B) “Which is your stand on using *intervention* with the purpose to protect your *animal* from being killed/injured at the event of a large carnivore attack?”. Different formulation for the specific interventions is based on variation in the intended functionality of the interventions. When members of the public where inquired about their OA intention, the item was modified using a third formulation as the respondents

were not expected to be animal owners: C) “Which is your stand on *intervention* being used in Sweden, with the purpose to protect *animal* from being attacked by large carnivores?”. The proposed interventions varied between owner groups, as indicated in Table 4. For descriptions of each intervention see Paper II. Responses were given on a 5-point Likert scale, with a neutral central value. For BE items responses ranged from “*Can substantially increase the risk of (or that animals are killed/injured during) an attack*” to “*Can substantially reduce the risk of (or that animals are killed/injured during) an attack*”. Responses to OA items ranged from “*I definitely oppose*” to “*I definitely accept*”.

Theory of Planned Behaviour and emotion items

A general behavioral intention to use interventions was measured with the item “*What is your stand on using some intervention to prevent carnivore attacks within the coming 3 years?*” with responses given on a five point Likert scale ranging from “*Will definitely not use any intervention*” to “*Will absolutely use some intervention*”. Response scales had a neutral central value and were coded 0-4. The TPB latent constructs of attitude, subjective norm, and perceived control were measured by four and three items for indexing (Ajzen 2019). Responses to the predictor variables were also given on a five point Likert scale, coded from 0-4 with reverse coding for negative statements (see Paper IV for more detail). Worry was measured with the item “*Do you feel worry/fear that some large carnivore (bear, wolverine, lynx, wolf) will attack your animals?*” with responses on an eleven point Likert scale between two extremes at “None at all” and “Very strongly”, coded 0-10. This item had previously been used by Johansson et al. (2012) and Frank et al. (2015).

5.5.3 Procedures

Links to the web-based survey were distributed from October 2017 to October 2018. Quantitative survey methodology facilitates collection of precise quantitative data relatively independent of the researchers, and facilitates inclusion of larger participation numbers than do qualitative data collection (Johnson & Onwuegbuzie 2004). A web-based survey was considered suitable to reach our respondents as internet use in Sweden is high. About 93 % of the population (62 % of 75-85 year age group) has internet access at home, and about 80 % report internet use on a daily basis (Statistics Sweden 2016).

Pet/hunting dog owners received the survey link via email addresses obtained from the Swedish Kennel Club. Sheep owners received the link via email from the Swedish Sheep Breeders Association or through email

addresses obtained from the Swedish Board of Agriculture. Transhumance farmers received log in details to the survey on the Swedish Wildlife Damage Centre website, via mail to addresses obtained from the Swedish Board of Agriculture. The survey link was distributed via email to the 48 reindeer herding districts that had email addresses listed on the Sami Parliament website (www.sametinget.se) and forwarded to active herders. Due to this intermediary step in distribution, it was not possible to record how many links to reindeer herders were distributed in total. Members of the public were recruited as a national panel sample from the Norstat sampling firm (www.norstat.se). A minimum of 1000 responses was requested for a representative sample of members of the public at least 18 years of age. The Swedish Society for Nature Conservation (SSNC) and the Swedish Carnivore Association (SCA) were invited to participate in the study, but both organisations were unable to aid the distribution of the survey. For more detail on the quantitative methods see Paper II and Paper IV.

5.5.4 Analyses

Potential for conflict (Paper II)

Only surveys with complete responses for all oppose-accept and believed effect items were included in the analysis. The number of returned and completed surveys was 715 (response rate = 54 %) from hunters with dogs, 117 (13 %) from pet dog owners, 38 from reindeer herders (NA %), 354 (22 %) from sheep owners, and 62 (28 %) from transhumance farmers. Complete responses were given by 947 members of the public (Paper II). The second generation Potential for Conflict Index (PCI_2) was calculated for each intervention in each owner group using the software available from <https://sites.warnercnr.colostate.edu/jerryv/potential-conflict-index/>. PCI_2 and its predecessor have been applied to various topics, including previous investigations of acceptability of management actions (vanEeden et al. 2019; Frank, Johansson & Flykt 2015; Heneghan & Morse 2019; Liordos et al. 2017; Lute et al. 2018). The index is used to illustrate divergence in responses (Manfredo, Vaske & Teel 2003) and takes into account that levels of conflict between people in the sample may differ depending on their relative rating of acceptability, as a function of the distance between responses (Vaske et al. 2010). The least potential for conflict, $PCI = 0$, occurs when all responses in a sample are at equal level of acceptance. The greatest potential for conflict, $PCI = 1$, occurs when polarisation is maximised with responses distributed equally (50 % and 50 %) at extreme points (Manfredo, Vaske & Teel 2003).

Factor analysis (Paper IV)

As the Theory of Planned Behaviour is well established in previous empirical work, a confirmatory factor analysis (CFA) in IBM SPSS Amos 25 Graphics was employed to evaluate model fit and select observed variables for each latent TPB factor prior to regression modelling. In the CFA analysis only surveys with complete responses from animal owners to TPB items were included. All responses with missing TPB values were excluded, generating a total number of 1 252 responses in the CFA analysis. Of these, 677 respondents were hunters with dogs, 127 were pet dog owners, 348 were sheep owners, 64 were transhumance farmers, and 36 were reindeer herders. Based on the CFA results, and supported by calculation of Cronbach's Alpha with recommended cut-off values, observed variables were stepwise removed to improve model fit of the factors. Means indices were created with three observed variables to represent each latent TPB construct; Attitude ($\alpha = .84$), Subjective Norm ($\alpha = .92$), and Perceived Control ($\alpha = .85$). For more detail see Paper IV.

Multiple regression modelling (Paper IV)

Prior to multiple regression modelling all responses with missing values for TPB, appraisals of emotion, and demographic items in our survey were excluded ($n = 550$). Exclusion of missing values avoids reducing variance in the dataset through mean imputation, and allows interpretation of relative weights of model variables. In total, 1 163 participants (362 female and 801 male respondents, ages 18-85 years, $m = 48$ years) provided complete responses. In relation to the total number of survey links distributed to animal owners ($n = 4016$) the response rate in the regression analysis was thus 28 %. The number of returned surveys with complete responses was 633 (48 %) from hunters with dogs, 118 (13 %) from pet dog owners, 33 from reindeer herders (NA %), 323 (20 %) from sheep owners, and 56 (25 %) from transhumance farmers. For more detail on each subsample see Paper IV.

Multiple regression analysis was performed using R Studio 3.5.1 (R Core Team, 2018). The regression model evaluates the owners' behavioural intention to use interventions described by TPB constructs extended with the Worry construct, and the factor "owner group". Due to the large sample size, the single-item dependent variables was approaching a normal distribution despite lacking a true continuous scale and the assumption of a continuous scale was therefore violated (Paper IV).

6 Results & Discussion

6.1 Intervention effectiveness

The review of scientific evidence of intervention effectiveness to mitigate impact of carnivores on domestic animals reveals a currently small evidence base from which inference of intervention effectiveness can be made (Paper I). The lack of treatment-control studies suggests a need for future collaboration between practitioners and researchers in planning and implementing the use of interventions in ways that allow evaluation of effectiveness. Primarily, the lack of standardised measures of effectiveness and limited effect sizes prevent meaningful meta-analysis of evidence, as well as generalised conclusions and quantification of effectiveness for interventions in specific environmental settings and conditions. These findings were supported by three other independent literature reviews with different search criteria, links, and searched databases (van Eeden et al. 2017; Miller et al. 2016; Treves, Krofel & McManus 2016). In an internationally collaborative effort led by the main authors of all four review teams (van Eeden et al. 2017; Eklund et al. 2017; Miller et al. 2016; Treves, Krofel & McManus 2016) the collective conclusions were published in 2018 (van Eeden et al. 2018). These collective results further support the conclusion made in Paper I that there is currently a limited number of scientific evaluations of intervention effectiveness and a broad current knowledge gap.

However, from the available studies that fulfil the inclusion criteria, it is possible to identify 8 groups of interventions that can be effective to reduce the number of domestic animals killed or injured by carnivores, under the appropriate conditions and targeting the appropriate carnivore species (Paper I, Figure 3). These groups of interventions (Figure 3) include a change of livestock type to one less likely to be predated, keeping livestock in enclosures or confinement at night when carnivores are most active, human supervision of

livestock or use of livestock guarding dogs to deter carnivores, removing predators primarily by killing the carnivore or through translocation, using shock collars on the carnivores to condition them to avoid livestock predation, sterilising carnivores to reduce their energetic expenses and need for predation, and the use of visual and auditory deterrents such as fladry (cloth flags tied on a string or rope). These interventions all show some potential to reduce the impact of carnivores on livestock losses, as indicated by the green bars in Figure 3.

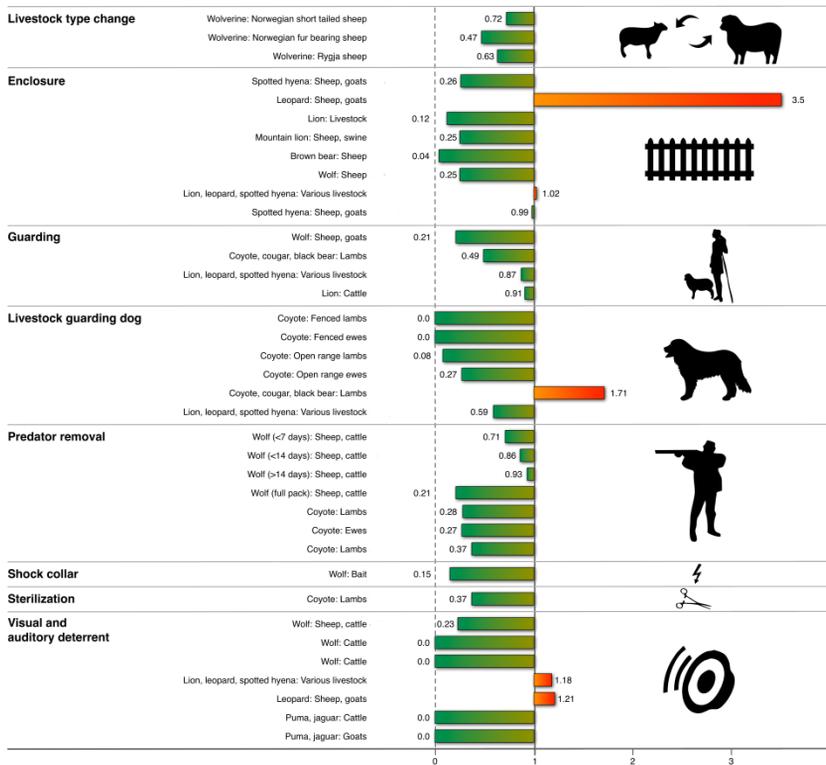


Figure 3. The intervention effectiveness described as relative risk (RR) for each study. RR = 1 suggests no difference in the risk of carnivore attack between treatment and control groups. RR > 1 suggests there is a higher risk of carnivore attack in the treatment group, and the value can be infinitely large. RR < 1 suggests that there is a lower risk of carnivore attack in the treatment group, and the minimum possible value is 0 (no attack in the treatment group). Each row in the figure represents a study or sub-study of an intervention in a certain setting, with the carnivore species and type of livestock described in the figure. For more information of each study and additional information for particular studies in this figure, see Paper I.

To some unknown degree, the low number of contra-productive findings may reflect a publication bias as positive results may be more appealing for publication. However, the review also included examples of studies where livestock losses were greater in the treatment than in the control setting. In one instance a contra productive effect ensued enclosure fortification, in another the use of livestock guardian dogs, and finally with the use of a visual deterrent in the shape of a scarecrow (Figure 3). Similar interventions appeared to be functional in other settings or with other carnivore species. Results with failing effectiveness may thus indicate a mismatch between treatment and control settings if interventions were implemented in an area where carnivore attacks were more common or severe than in the control setting. Results could also relate to a mismatch of intervention design to a specific species, as the intervention could reduce the risk of attacks from one carnivore species but facilitate or fail to reduce the impact by another. Finally, these results may reflect flaws in the range of measurement (e.g. regional livestock unit) in contrast to the range of the intervention effect (e.g. herd unit). Well matched treatments and controls will be important in future studies in order to estimate and compare the effect of various interventions. Estimation of the range and time longevity of intervention effectiveness is also essential.

6.2 End-user acceptance the potential for conflict

To have any practical effect in reducing carnivore impact on domestic animals, interventions must be accepted and implemented by animal owners. Using the TAM (Davis 1989) model as a framework for reasoning, acceptance of an intervention is expected to be predicted by the believed effect (perceived usefulness) and its perceived ease of use. As shown in Figure 4, accepted interventions are all believed effective to reduce the impact of carnivore attacks. Interventions that were believed ineffective or contra-productive were opposed by animal owners. However, several interventions were believed effective but were nevertheless opposed by animal owners. Thus, no 1:1 relationship could be observed between believed effectiveness and acceptance of the proposed interventions. It appears that believed effect is a prerequisite, but not a guarantee for end-user acceptance (Figure 4), corresponding to the assumptions of TAM (Davis 1989).

Interventions for which scientific evaluations indicate an effect in reducing the impact of carnivore attacks such as enclosures/night shelters, increased supervision (guarding), livestock guarding dogs, and removal (Figure 3) were all examples of interventions believed by animal owners to be somewhat

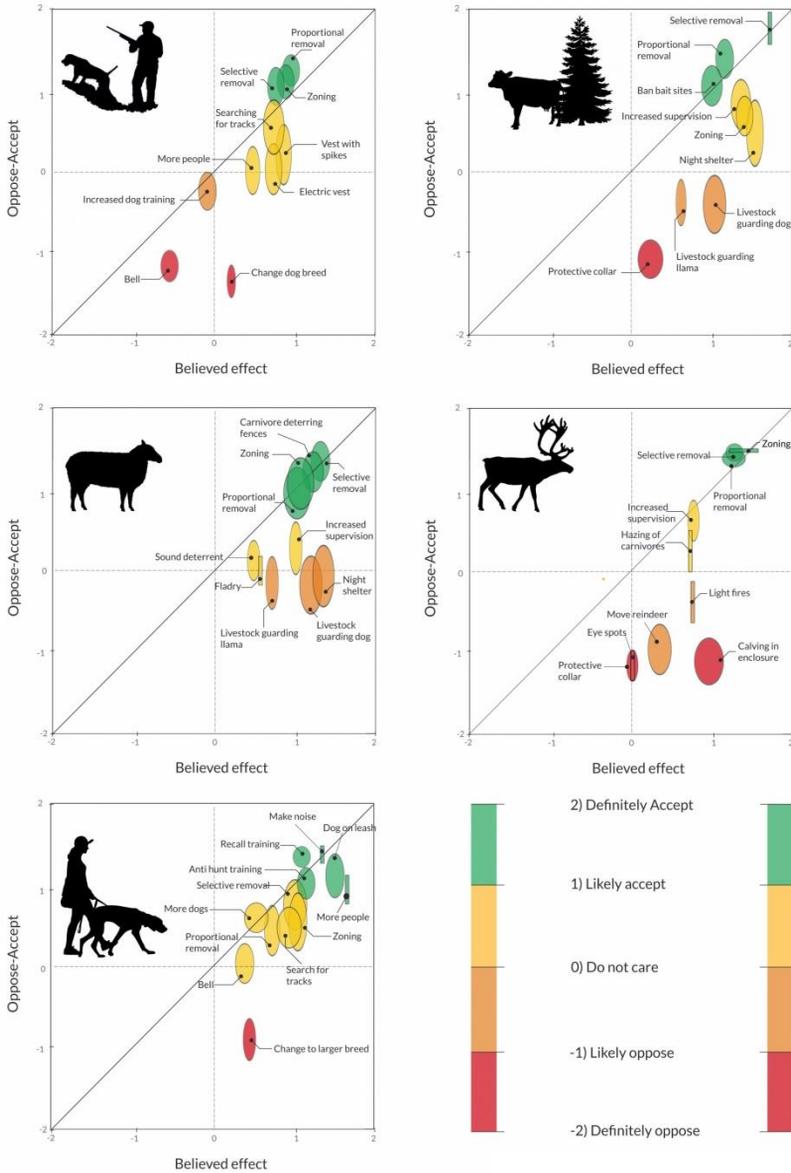


Figure 4. The graphs illustrate the general tendencies and potential for conflict among animal owners with regards to their opposition or acceptance and the believed effect of interventions intended to protect their animals from carnivore attacks. The owner groups are hunters with dogs, transhumance farmers, sheep owners, reindeer herders, and pet dog owners. Each bubble represents a specific intervention, the bubble diameter on the Y-axis the PCI for opposition-acceptance of that particular intervention within the stakeholder group. The bubble diameter on the X-axis shows the PCI for the believed effect of that particular intervention within the stakeholder group.

effective (Figure 4). Yet, several of these evaluated interventions were opposed by the end-users, as illustrated by reindeer calving in enclosures, night shelters and guarding dogs for sheep, and guarding dogs for transhumance livestock (Figure 4). This opposition likely relates to other aspects of intervention use in husbandry specific contexts, such as an expected lack of *ease of use* associated with intervention use (Davis 1989).

Over all, a larger consensus was observed among animal owners with regards to the believed effect of interventions, in contrast to a lower consensus observed for acceptance of intervention implementation (Figure 4). It thus seems that animal owners have a similar view on how effective an intervention would be to reduce impact from carnivores, but that the implementation of interventions may be easier for some animal owners than for others. Implementation of interventions may also be more or less controversial to other people in society who take interest in carnivore conservation and management, or for whom the interventions could cause implications. Overall, responses from members of the public ranged from neutral to acceptance (central tendency = 0 - 2) for all interventions. However, there was a larger potential for conflict over carnivore removal in this sample than among animal owner groups (Paper II, supplementary table A4), with the exception of pet dog owners who also placed removal in the acceptance range 0 - 1 (Figure 5). This suggests that there is weaker consensus about the use of removal among members of the public and pet dog owners than among other groups of animal owners. Considering the diversity of interests among members of the public this lack of consensus is not surprising. The use of removal interventions is known to be controversial (Treves 2009), with previous research indicating a potential for conflict over the use of carnivore removal even among wildlife professionals (Lute et al. 2018).

For all interventions that did not involve removal of carnivores, the central acceptance tendency was higher and the potential for conflict was lesser among members of the public than among groups of animal owners. It thus seems that interventions that are undertaken as part of domestic animal husbandry are not controversial to members of the public, even in cases where interventions may infringe on the possibility of free movement. From a management perspective it is interesting to note that the most acceptable interventions to members of the public are generally the least acceptable to the animal owners (Figure 5); including livestock guarding dogs, fladry, sound deterrents, and carnivore deterring fences for reindeer.

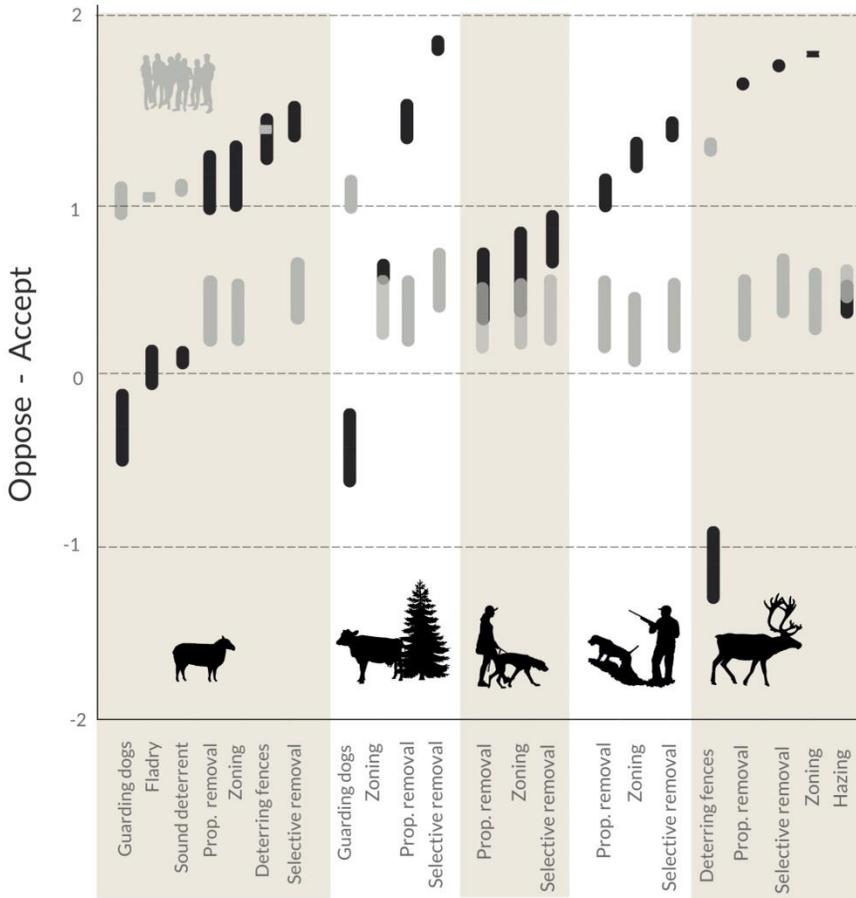


Figure 5. Grey bars illustrate the Potential for Conflict Index for members of the public over the use of various interventions intended to prevent carnivore attacks on specified domestic animals. The black bars illustrate animal owner responses to the corresponding interventions. The bars' vertical centre point indicates the general tendency for acceptance of the intervention within each sample, the PCI value is indicated by the height of the bar.

As discussed previously, low acceptance may relate to difficulties in the implementation of interventions, which would affect animal owners more than others in society. Considering the opposing trends in acceptance of interventions by animal owners and members of the public, the implementation of interventions may have the potential to generate conflict. One exception to this pattern is carnivore deterring fences to prevent carnivore attacks on sheep, which are highly accepted by sheep owners and members of the public alike. A second exception is hazing of carnivores from reindeer herds using snow mobiles where acceptance levels are similar between reindeer herders and members of the public. In this case the general acceptance tendency is similarly

low for both groups. This could reflect perceptions of similar limitations, but may also reflect different limitations. The intervention would likely imply work effort for reindeer herders but not for members of the public. However, members of the public show similar acceptance levels to hazing as to removal interventions and it is possible that ethical concerns limit acceptance of this intervention among members of the public. The results can provide a general picture of oppose-accept intention, but acceptance among individual animal owners may vary and practitioners and providers of interventions must therefore be willing to listen to individual concerns with regards to intervention use.

6.3 Animal owners' appraisal of intervention use

Animal owner appraisals in relation to intervention use were identified as two appraisal processes on different levels, the first level relating to appraisals of carnivore presence as a threat to domestic animals, and the second level relating to appraisals of intervention implementation (Figure 6).

There are several reasons why people keep domestic animals, and ownership implies responsibility for animal well-being and prosperity. Animal owners appraise the situation of recovered carnivore populations as a relevant threat to keeping healthy domestic animals. A potential carnivore attack can have large implications if animals are traumatised, injured, or killed. Unless the animal owners are able to cope with the implications, carnivore presence may generate exacerbated levels of worry similar to what has been identified in previous research (Sjölander-Lindqvist 2015). Pet dog owners were better able to cope with the threat and thus expressed less worry than other groups (Paper III). This finding also corresponds well to the high acceptance of recall training, keeping dogs on leashes, and anti-hunt training of dogs in this owner category (Figure 4). More advanced interventions thus became irrelevant to this group, whereas various interventions were relevant to worried animal owners in the other owner groups. For these groups the interventions can facilitate coping, but intervention implementation starts a new appraisal process (Moors et al. 2013; Scherer 2009) among animal owners (Figure 6).

Hunters with dogs, reindeer herders, sheep owners, and transhumance farmers perceive the carnivores as a threat to their animals' well-being. Interventions therefore become relevant to facilitate coping with this threat, but only when the interventions are appraised as functional and feasible to implement. Functionality of interventions is estimated by animal owners based on available scientific evaluations or from logical reasoning. Animal owners find the available evidence base insufficient to always support their judgment,

in line with the findings of the literature review of scientific evidence (Paper I). Regardless of evaluations or beliefs of intervention effect, interventions must also be feasible for animal owners to implement in order to provide a means of coping. The feasibility of interventions depends on the husbandry system that the animal owner has chosen, which in turn reflects adaptations to the landscape, topography, and climate in which they operate (Paper III).

Intervention use may also cause implications for animal owners. Implications considered by all animal owner groups include economical costs of implementation, establishment, and maintenance of interventions. The use of interventions can also be time consuming and thereby impact the time prioritisation of work hours, leisure time, and recreation time. Furthermore, implications of intervention use relate to expected consequences for others through disturbance and aesthetics. Not least are animal owners concerned with the consequences that interventions may have on the welfare of their animals (Paper III). Welfare may for instance be compromised if grazing animals are restrained in smaller areas which yield a higher parasite pressure and disease transmission, or if animals wear protective vests and collars that can reduce their mobility, bruise them, or cause them to overheat.

Animal owners may be able to cope with the implications, either by reallocating resources such as time and money to intervention use, or refrain from using the intervention. Coping with implications can also be assisted by others, such as peers and carnivore managers. The authorities thus have an opportunity to support the use of interventions, particularly when the main implications relate to economic costs or time consumption. Additionally, the authorities can sometimes aid coping by being responsive to requests from animal owners, for instance regarding access to knowledge about carnivore presence or by providing fast management decisions.

Finally, animal owners will not be able to use interventions which they perceive as norm incongruent by violating the law, which they believe are unethical, perceive as unjust, or regard as a threat towards their cultural heritage. Asking animal owners to use interventions that are irrelevant to them, interventions that cause implications with which they are unable to cope, or interventions that are perceived as norm-incongruent, may undermine relations and spur conflict over carnivore management. Such proposals may be seen as nonchalant and ridiculous, may fail to reduce worry for carnivore attacks and instead risks generating frustration among animal owners (Figure 6). If this happens, then interventions will not increase levels of trust (Johansson & Frank 2016) and are unlikely to benefit neither domestic animal husbandry practices nor carnivore conservation in the long-term.

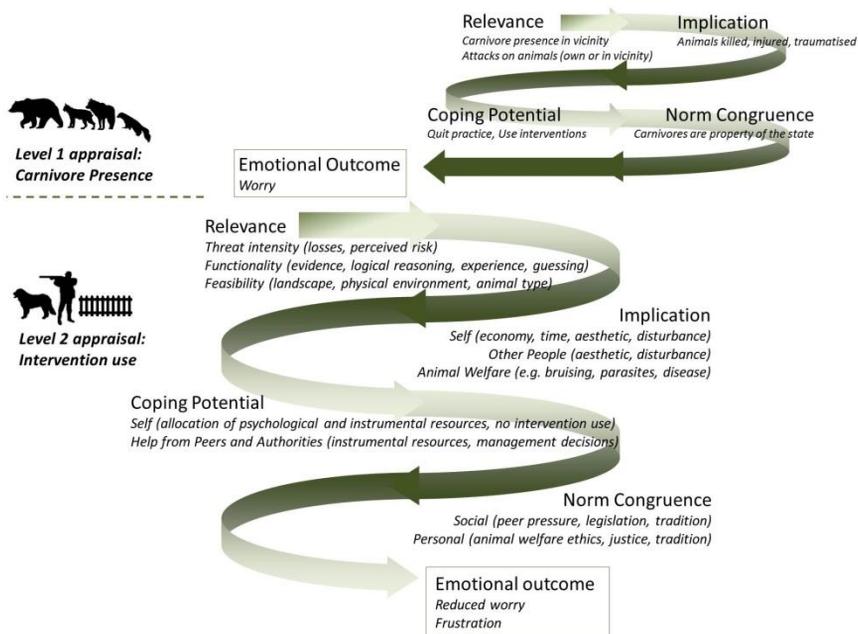


Figure 6. The appraisal process occurred at two levels, the first relating to carnivore presence, and the second to intervention use as a means to cope with carnivore presence and reduce worry. The arrows represent the process as each evaluation check occurs in subsequent order.

6.4 Drivers of intention to use interventions

The animal owners' intention to use interventions on a more general scale may be based on reasoning and deliberation of costs and benefits of intervention use (Ajzen 1991). Indeed, the original constructs of TPB explained 22 % of the variance in owners' general intention to use interventions. However, the findings of Paper III suggest that worry of carnivore presence is an important link to the use of interventions as a means of coping with the perceived carnivore threat (Figure 6). Inclusion of worry and owner group affiliation in the model of general intention to use interventions increased the explained variance to 28 % (Paper IV).

Worry itself explains part of a general intention to use interventions among animal owners (partial $R^2 = .054$, $p < .001$), which supports the findings in Paper III (Figure 6). However, the largest proportion of variation in the intention to use interventions was explained by Subjective Norm (partial $R^2 = .148$, $p < .001$). The Subjective Norm construct reflects the owners' perception of what "significant others" think they should do, and it appears such perceptions are important for the intention to use interventions on a more

general scale. The impact of normative beliefs might be influenced by the importance of peers in recruitment to animal ownership. Influences of family and role models as well as community networks and organizations have been highlighted as important for recruitment to at least the hunter community (Larson et al. 2014). Owner group affiliation also explained part of the intention to use interventions (partial $R^2 = .053$, $p < .001$), which may relate to intergroup differences in the perceived threat and the relevance of intervention use (Paper III). Some variance in the intention to use interventions was also explained by a perceived control over intervention use (partial $R^2 = .021$, $p < .001$) whereas attitudes toward intervention use did not have a statistically significant effect on behavioral intention to use interventions (Paper IV).

Taking into account emotion through worry, an increased variance in the model could be explained in comparison to using the original constructs of TPB. Research on human behaviour and behavioural intentions in the HDW field has largely overseen emotion in the past, but these results support the notion that emotion can play an important role to human behaviour in wildlife management (Jacobs et al. 2013). Exclusion of emotional constructs could lead to omitted variable bias and imply a risk of underestimating predicted behavioural intentions in wildlife management, and also underestimate the importance of addressing emotion in practical conservation and management work.

6.5 Limitations

The scientific work presented in this thesis applies a complementary multidisciplinary approach and mixed methods to reduce the weaknesses of quantitative or qualitative methodology in isolation.

In reviewing the available evidence of intervention effectiveness to reduce impact from carnivores on domestic animals, a full systematic review (SR) that provides a review “gold standard” (Collaboration for Environmental Evidence 2013) was beyond the scope of this thesis. However, the SR steps to publish review protocols, establish an advisory group, and search alternative sources of evidence and grey literature, were not considered necessary to satisfactorily answer the objective of the thesis. To increase the possibility of replication all methodological steps were recorded. The subsequent collaborative effort which included analysis of three other independent reviews complemented the search of only one database, and provided rigour to the review results in this thesis (van Eeden et al. 2018).

Recruitment of focus group participants was initially made through the official organisations for each owner group. For pet dog owners, recruitment

through the kennel club and two dog training centres failed, and participants were recruited as a convenience sample. The difficulty in recruitment may reflect a low relevance of the topic in this group more broadly.

All quantitative data relies on self-report, and may thus be subject to response bias. Responses may be exaggerated or skewed towards perceived social desirability in the respondent group, when respondents respond in a way that make them look as good as possible (Donaldson & Grant-Vallone 2002). The sample may also be biased towards respondents with more extreme views than the average population. To reduce the risk of biases in TPB constructs, items were constructed to indirectly measure the latent variables. For acceptance and believed effect, direct measures were used. It is possible that respondents would have exaggerated their acceptance-opposition or their believed effect of interventions. However, the bias would likely be similar for all interventions, and differing patterns were observed. The risk of misinterpreting the results is also reduced by the mixed methods, where focus group interviews generated an increased understanding of the reasoning behind acceptance-opposition and believed effect in a face-to-face situation.

The use of a web-based survey to collect quantitative data in study 3 (Paper II and Paper IV) may have excluded respondents in social groups with lower internet use such as higher age classes (Statistics Sweden 2016). Web-based surveys are also expected to produce lower response rates than mail surveys (Fan & Yan 2010; Shih & Fan 2008). However, the survey technique is cost and time efficient, and therefore provided a suitable option within the frames of this project. The lack of direct email addresses to reindeer herders limited the number of responses, and the possibilities to draw generalised conclusions about intervention acceptance, in this group.

The potential for conflict over intervention use may be underestimated, particularly for controversial interventions and carnivore removal, as stakeholders with specific conservation interest were not included. The Swedish Carnivore Association and the Swedish Society for Nature Conservation were approached for distribution of the survey to their members, but both non-governmental organisations turned down the request.

7 Conclusions

7.1 Conclusions and management implications

The scientific contribution of this thesis is an increased understanding of the intended and unintended effects that the provision, promotion, and implementation of interventions may have on the impact of carnivores on domestic animals and on conflict mitigation across stakeholder groups. In this thesis a multidisciplinary approach and a mixed methods methodology give insights to both the biological and human dimensions of interventions intended to mitigate impact of large carnivores. These perspectives are equally essential for informed conservation and management of carnivores to minimise the risk for conflict between stakeholders and increase the potential for coexistence between conservation and animal husbandry practices (Treves et al. 2006; White & Ward 2010). Combining quantitative and qualitative approaches allows insight to broader patterns of acceptance, potential for conflict, and drivers for intervention use, while also providing a nuanced understanding for the reasoning behind the observed patterns.

Despite arguments and a need for evidence based intervention use to reduce uncertainty of outcomes, there is currently a lack of scientific evidence to support a well-informed implementation of interventions (van Eeden et al. 2018; Eklund et al. 2017; Treves, Krofel & McManus 2016). Managers, conservationists, and owners of domestic animals will therefore find it difficult to base their choice of interventions on scientific evidence of intervention effectiveness. Available published studies of intervention effectiveness suggest that there are a number of intervention types with a potential to reduce the risk and severity of carnivore attacks. It is questionable if this scientific evidence is solid enough to allow generalised assumptions about the effectiveness of the presented interventions. Not least as the few studies which have attempted to

evaluate intervention effectiveness deal with different systems and carnivore species. The effect will likely vary with how well the intervention targets the “problem” at hand, and an intervention which is effective in one system may be ineffective in another. Such case can be illustrated by deterrents, suggested by scientific evidence to be effective in some livestock husbandry systems impacted by wolves, pumas, and jaguars (Paper I), but which the work in this thesis indicates are believed by reindeer herders to have a relatively low effect in their husbandry system (Paper II). In interviews this was motivated by the reliance of carnivores on free roaming reindeer as the main prey (Mattisson et al. 2011; Mattisson et al. 2016; Pedersen et al. 1999), why effective deterrence of carnivores from one reindeer herd was expected to simply move the “problem” to another herd (Paper III).

Animal owners, as the end users of interventions, request scientific evaluations of intervention effectiveness to make informed choices of interventions (Paper III). An initial intention to use interventions will mainly be influenced by the perceived views of significant others and by the degree to which an animal owner experiences worry for carnivore attacks (Paper IV). However, when it comes to actually accepting and implementing specific interventions, evaluations and beliefs about effectiveness can be important. Functionality adds weight to benefits of an intervention against the implications that intervention use is expected to imply to the animal owner, such as economic costs or time consumption (Paper III). Nevertheless, intervention acceptance is not guaranteed even with the best scientific evaluations of intervention effectiveness. Beliefs about intervention effectiveness should be considered a prerequisite rather than a guarantee for animal owners’ acceptance of interventions (Paper II, Paper III). Additionally, deliberation of intervention implementation includes appraisals of intervention relevance through feasibility of intervention implementation. Appraisals also relate to implications that the interventions have for the owner as well as for other humans and animals, and the owner’s potential to cope with these implications either alone or with the help of others. Finally, animal owners appraise intervention congruence with personal and social norms relating to for instance legislation, ethics, and cultural heritage (Paper III).

Interventions can provide important tools for coexistence between domestic animal husbandry practices and carnivore conservation, as suitable interventions have the possibility to facilitate animal owners’ coping with a perceived carnivore threat, and thereby reduce their experienced worry (Paper III). However, the use of more controversial interventions may stir a potential conflict with members of the public (Paper II). The provision and promotion of interventions can also induce frustration in animal owners who are unable to

cope with the implications of specific interventions, or are presented with interventions that they appraise as irrelevant or norm incongruent (Paper III). Active promotion of interventions that are not acceptable to animal owners, could thus increase segregation between animal owners and those promoting the intervention use, for instance carnivore managers, conservationists, or advocate researchers (Redpath, Bhatia & Young 2015). Thereby, interventions could have a potential to generate conflicts over carnivore management rather than to mitigate it (Redpath, Bhatia & Young 2015; Vaske et al. 2010). From a carnivore conservation and management perspective, humility, an ability to understand concerns and emotions of the individual, and acknowledgement of animal owners' experiences, are thus of vital importance to facilitate development of social trust and empathetic dialogue in the future.

7.2 Future perspectives

Conservation of large carnivores relies on coexistence with animal husbandry practices within multi-use landscapes (Chapron et al. 2014; Treves et al. 2006). Interventions to mitigate impact of carnivores on domestic animals will thus be important tools for conservation in the long term (Shivik 2006; White & Ward 2010). Interventions should be implemented in ways that allow scientific evaluation and inference of their effectiveness (van Eeden et al. 2018). Such evaluations are important to support end-user acceptance (Paper II, Paper III) and should aim for well-designed treatment-control comparisons to allow estimation of the interventions' quantified effect in reducing the impact of carnivore attacks on domestic animals (Paper I). Future research should also provide more detail of the context in which interventions are effective or ineffective by considering the characteristics of animal husbandry systems and the target carnivore species, as well as provide estimates of the longevity and geographical range of intervention effectiveness. This knowledge is currently scarce (Paper I), but would likely improve the rigour of carnivore management and conservation (van Eeden et al. 2018).

Ecological research alone cannot inform and ensure long-term success of carnivore population recovery (Thirgood & Redpath 2008; Treves et al. 2006; White & Ward 2010). Further investigation and understanding of relationships between stakeholders over wildlife conservation and management are needed to mitigate conflicts. HDW research will be essential to conservation and management practices, and represents a research field that evolves with contemporary challenges (Vaske, Shelby & Manfredo 2006). Interdisciplinary HDW contributions can aid the work of practitioners on a day to day basis, when faced with the challenges of human carnivore co-occurrence and

conflicts (Bennett et al. 2017b; Clayton et al. 2016; White & Ward 2010). Vice versa, practitioners can aid researchers within the HDW field identify contemporary needs and research objectives, and should not be forgotten as an important stakeholder group in these systems (Redpath, Bhatia & Young 2015). Necessarily, for interventions to work in a conservation context, intervention impact on carnivore populations as well as end-user perspectives of intervention use must also be continuously monitored and evaluated (Clayton et al. 2016; White & Ward 2010). Studies that combine quantitative and qualitative data collection in a mixed methods approach should be prioritised for more in-depth understanding of underlying factors in wildlife related conflicts (Austin et al. 2010).

Evaluations and future research thus need to be a collaborative effort between researchers, conservationists, managers, and end-users of interventions (Thirgood & Redpath 2008). Animal owners, as intended end-users, should be involved at an early stage of planning and evaluation to ensure that the evaluated interventions are relevant and feasible to implement, but also to avoid hindsight investigations of their perceptions (Redpath et al. 2017). The individual perspective taken with a psychological approach to HDW research can be further expanded through the incorporation of emotion theory (Jacobs 2012; Miller 2017). Human behaviour and decision making has been guided by emotions throughout evolutionary history (Dolan 2002; Tooby & Cosmides 1990), and is unlikely to be switched off in future wildlife conservation and management (Slagle, Bruskotter & Wilson 2012). Calls have been made to expand our understanding of emotion in wildlife related behaviours (Jacobs 2012), which is supported by the findings in this thesis (Paper III, Paper IV). As indicated by the work in this thesis, negative emotions such as frustration may ensue where communication or empathic understanding fails (Paper III). The Appraisal Theory of Emotion provides a structured and parsimonious way of investigating the role of emotion further, but instruments for this purpose still need development for quantitative investigations (Brosch, Patel & Sander 2014). In HDW research more broadly, continuous investigations are needed throughout the scale from individual to global level (Bennett et al. 2017b; Sjölander-Lindqvist, Johansson & Sandström 2015).

The work in this thesis adds to the knowledge base for informed conservation and management of carnivores in Sweden, and similar research approaches can be taken in other systems. In the future we need to consider how the knowledge can be used and implemented in practice to maintain or increase trust and facilitate empathetic dialogue around interventions. From the research and management perspective it might be useful for practitioners to gain experience from animal husbandry as well as being informed of

intervention effectiveness. Training in communication or including periods of work practice with stakeholders may prove useful, and evaluation of such approaches would likely benefit conservation work in the future. The future of global biodiversity relies on the coexistence between wildlife and humans on an individual and on a collective level (Redpath et al. 2017). Large carnivores represent a small part of the global biodiversity (Bar-On, Philips & Milo 2018) but have an important role in their ecosystems (Ripple et al. 2014), and are valuable to human society (Linnell, Swenson & Andersen 2000). They are therefore prioritised in conservation. To achieve carnivore conservation goals, and goals of biodiversity conservation at large, it is essential for future work to actively seek ways to minimise conservation impact and conflicts.

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Popular science summary

Various interventions intended to reduce the risk of carnivore attacks on domestic animals are used in Sweden. Social conflicts around carnivores may also be reduced if the interventions are effective and are supported by the end-users. This thesis investigates how effective interventions are to reduce the risk of carnivore attacks as well as how they are perceived by the intended end-users.

Large carnivores such as bears, lynx, wolverines, and wolves have regained their place in the Swedish fauna after years of absence or near extinction. Carnivores evoke human emotions – both of a positive and negative kind. Differing views of what is acceptable or not in carnivore conservation and management can lead to social conflict. Not least do such conflicts relate to the negative impact that carnivores can have on domestic animals. Up to about 50 dogs, 500 sheep, and 50 000 reindeer will be killed by bears, lynx, wolverines, or wolves annually in Sweden. Various interventions are available to reduce the risk of attacks. These interventions include livestock guarding dogs, carnivore deterring fences, deterrents, removal of carnivores, and protective vests. The hope is that the interventions can reduce the problems carnivores cause to people and their animals. If the interventions can reduce the problems and increase the acceptance of carnivores, then conflicts too could be mitigated.

So how well do the interventions work? Currently there are few scientific evaluations available and it is difficult to say how well the interventions protect animals from carnivore attacks. This does not necessarily mean that the available interventions are useless, but it means that we cannot be sure how large their effect is. For animal owners and carnivore managers to know what effect to expect from an intervention in a given situation, researchers must collaborate with animal owners and carnivore management. Then interventions can be implemented in ways that allow evaluation of their effect. A few interventions have been evaluated and can be effective. These include night

enclosures to keep livestock confined when carnivores are most active, livestock guarding dogs, deterrents, and to some extent removal of carnivores. How large the effect is and for how long it lasts in different situations, for instance with different carnivore species, remains to be investigated.

One thing is certain. The interventions will not have any effect if no one is using them. In a web-based survey to 1 286 hunters with dogs, pet dog owners, reindeer herders, sheep owners, and transhumance farmers, it was apparent that a belief in the intervention effect is a prerequisite to acceptance of the interventions. The need for interventions to be effective in order to be relevant is also highlighted during 11 group interviews with animal owners. Just like the researchers, animal owners conclude that the knowledge of intervention effectiveness is currently limited. Some groups also perceived that interventions may have a low effect in Sweden because of the way that animal husbandry works. For instance, if a carnivore is deterred from a reindeer herd it must find another herd where it can feed, since carnivores rely on reindeer meat in northern Sweden.

Even if animal owners believe in the effect of an intervention, it is not a guarantee that he/she will accept it. Some interventions are not accepted although the respondents believe them effective. The intervention can be difficult to implement in their everyday life, be expensive, or be time consuming. In such cases, the authorities may be able to facilitate intervention use by providing economic support or fund labour. But sometimes the implications are more difficult to handle. Animal owners may be concerned that the intervention will be a nuisance to other people. Sound deterrents may cause disturbance to neighbours, and carnivore deterring fences and aggressive guard animals may limit the free movement. Not least are animal owners concerned for their own animals' wellbeing. Keeping sheep confined or reindeer in enclosures can lead to higher risks of parasites and disease. Hunting dogs that wear protective vests may bruise, get caught in the terrain, or overheat.

An intervention must also be considered ethical, just, and compliant with legislation to be accepted. Transhumance farmers that keep their animals free ranging in the forest may risk violating the legislation of dog supervision if they use livestock guarding dogs. Sheep owners who regard dogs as family members may find it unethical to leave the livestock guarding dog in the field with the sheep herd. Similarly, a reindeer herder may find it unethical to chase a carnivore from the herd and see it struggle in the deep snow without a clear plan for where it should go. In such instances it does not really matter how effective the animal owner believes that the intervention is. It will still not be acceptable for the person to use it.

Aside the animal owners there may also be other groups in society whose interests are in some way affected by the interventions and thereby are more or less inclined to accept the use of interventions. Acceptance for interventions among members of the public looks different than acceptance among animal owners. Members of the public largely accept interventions that are implemented by the animal owners, and the animal owners accept the removal of carnivores to a greater extent than the public. Carnivore deterring fences to prevent attacks on sheep appear to be the intervention where animal owners and the public are in agreement of its acceptance.

However, specific interventions may be more or less acceptable to individual animal owners. Representatives of the authorities that support animal owners with interventions therefore have an important role. They must be willing to listen to the individual animal owner and try to empathise with the owner's situation. If animal owners' perceptions are ignored, then there is a high risk that the authorities suggest interventions which are perceived as irrelevant, ignorant, or impossible to implement. Then frustration will increase in the animal owner. This could fuel social conflicts that surround carnivore management. On the other hand, if interventions are implemented with consideration to the animal owner's situation then there is a possibility to facilitate coping with experienced worry for carnivore attacks. The interventions may then support a future for large carnivores and animal husbandry in coexistence.

Populärvetenskaplig sammanfattning

I Sverige används flera åtgärder som ska minska risken för angrepp av rovdjur på tamdjur. Även de sociala konflikter som finns kring rovdjuren skulle kunna minska om åtgärderna är effektiva och har stöd av de människor som ska använda dem. I den här avhandlingen undersöks både hur effektiva åtgärderna är för att minska rovdjursangrepp och hur de tänkta användarna ser på dem.

Stora rovdjur som björn, järv, lodjur, och varg har åter blivit en del av den svenska faunan efter att ha varit helt eller nästan försvunna under lång tid. Rovdjur väcker känslor hos människor – både positiva och negativa. Olika syn på vad som anses acceptabelt i rovdjursförvaltningen kan leda till sociala konflikter. Inte minst handlar konflikterna om rovdjurens negativa påverkan på tamdjurshållning. Varje år dödas upp emot 50 hundar, 500 får och 50 000 renar av björn, järv, lodjur och varg i Sverige. För att minska risken för rovdjursangrepp på tamdjur finns olika förebyggande åtgärder att ta till. Det handlar till exempel om boskapsvaktande hundar, rovdjursavvisande stängsel, skrämnel, skydds jakt och skyddsvästar. Förhoppningen är att åtgärderna ska minska problemen för människor och deras tamdjur. Om åtgärderna kan minska problemen och därmed öka acceptansen för rovdjuren så skulle också sociala konflikter kring rovdjuren minska.

Men hur effektiva är åtgärderna? Eftersom det i dagsläget finns få vetenskapliga utvärderingar så är det svårt att säga hur väl de skyddar mot rovdjursangrepp. Det betyder inte nödvändigtvis att åtgärder som används idag är dåliga, bara att vi inte vet säkert hur effektiva de är. För att tamdjursägare och rovdjursförvaltare i framtiden ska kunna veta hur stor effekt de kan förvänta sig av åtgärderna i olika situationer behöver forskare, myndigheter och djurhållare samarbeta. Då kan åtgärderna tillämpas på ett sätt som gör att effekten går att utvärdera. Några åtgärder har utvärderats i viss utsträckning och verkar kunna fungera. Det gäller hägn där man håller tamdjuren under natten när rovdjuren är mest aktiva, boskapsvaktande hundar, skrämnel och i viss mån jakt på rovdjur. Hur stor effekten är och hur länge den varar i olika

situationer, till exempel med olika rovdjursarter, behöver man fortfarande utreda.

Helt säkert är i alla fall att förebyggande åtgärder inte har någon som helst effekt om ingen använder dem. I en enkätundersökning som besvarades av totalt 1 286 fårägare, fäbodbrukare, jägare med hund, renskötare och sällskapshundsägare blev det tydligt att tilltron till att en åtgärd fungerar är helt central. Även under 11 intervjuer med grupper av tamdjursägare framkommer det att åtgärderna måste kunna minska risken för rovdjursangrepp för att vara relevanta. Tamdjursägarna drar samma slutsats som forskarna att kunskapen om åtgärdernas funktion idag är för begränsad. Några av de intervjuade grupperna tänkte också att utvärderade åtgärder kan ha låg effekt i Sverige på grund av att djurhållningen inte ser likadan ut över hela världen. Ett exempel är skrämning av rovdjur i renskötselområdet. Även om åtgärden kan vara effektiv och skrämja bort rovdjuret från en renjord, så tvingas rovdjuret att söka sig till nästa jord för att hitta föda eftersom de är beroende av renkött för att överleva i norra Sverige.

Att tamdjursägare tror att åtgärden är effektiv är dock ingen garanti för att den accepteras att använda den. För flera åtgärder är acceptansen låg trots att de tillfrågade bedömer att den fungerar bra. Det kan bland annat bero på att åtgärden är svår att genomföra i vardagen, att den är dyr eller tar mycket tid. Där kan myndigheterna underlätta med ekonomisk hjälp eller genom att finansiera arbetskraft. Ibland är dock konsekvenserna svårare att hantera. Det kan finnas oro för att åtgärderna ska störa andra människor. Till exempel kan ljud från skrämningar höras av grannar, medan stängsel och användning av aggressiva vaktdjur kan begränsa allemansrätten. Tamdjursägarna är förstås också måna om att deras djur ska må bra. Att hålla får i små fållor eller renar i hägn kan öka risken för smittspridning och parasiter. Jakthundar som bär skyddsvästar riskerar att få skavsår, fastna i ris och buskar eller överhettas.

För att en åtgärd ska accepteras av tamdjursägarna måste den också anses vara etisk, rättvis, och följa lagstiftningen. För fäbodbrukare som har sina djur på fritt bete i skogen så riskerar boskapsvaktande hundar att bryta mot lagstiftningen om tillsyn av hundar. För fårägare som ser hundar som familjemedlemmar kan det upplevas som oetiskt att lämna en boskapsvaktande hund ute i en hage med fårfloken. På samma sätt kan en renskötare anse det oetiskt att skrämja ett rovdjur från renjorderna och se rovdjuret kämpa sig fram i djup snö och skare utan att det finns någon plan för var det ska ta vägen. I sådana fall spelar det inte så stor roll hur effektiv djurägaren tror att åtgärden är, det är ändå inte acceptabelt för personen att genomföra den.

Förutom tamdjursägare så kan även andra grupper i samhället, vars intressen påverkas av åtgärderna på ett eller annat sätt, vara mer eller mindre

benägna att acceptera åtgärdernas användning. Allmänhetens acceptans för olika åtgärder skiljer sig från tamdjursägarnas för de flesta åtgärder. Generellt accepterar allmänheten i störst utsträckning de åtgärder som ska genomföras av tamdjursägarna, och tamdjursägarna accepterar i större utsträckning än allmänheten jakt på rovdjur. Rovdjursavvisande stängsel för att skydda får verkar vara den åtgärd där störst enighet råder mellan djurägare och allmänhet.

Men alla åtgärder kan vara mer eller mindre acceptabla för enskilda tamdjursägare. Därför har representanter för myndigheterna som ska stödja tamdjursägarna med åtgärder en viktig uppgift. De måste vara lyhörda och försöka sätta sig in i den enskilda tamdjursägarens situation. Om tamdjursägarnas synvinklar inte uppmärksammas riskerar myndigheterna att föreslå åtgärder som upplevs som irrelevanta, nonchalanta eller omöjliga att genomföra. Det kan öka frustrationen hos tamdjursägaren. Då finns en risk att man underblåser de sociala konflikter som omgärdar rovdjursförvaltningen. Om man å andra sidan lyckas tillämpa åtgärder utifrån hänsyn till tamdjursägarens situation så kan man göra det lättare för tamdjursägare att hantera oron för sina djur. Åtgärderna kan då bidra till en framtid för både stora rovdjur och tamdjurshållning.

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