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**Obsessive about shades of grey:
Attitudes towards wolves and trust
in large carnivore science**

PhD Applied Ecology and Biotechnology
2022



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Sammendrag

Utbredelsen av rovdyr er ulikt fordelt i landskapet, noe som gir opphav til ulike nivåer av erfaring med disse artene. Tilbakekomsten av store rovdyr, kombinert med rask vekst i den menneskelige befolkningen, resulterer i økt overlapp mellom mennesker og rovdyr. I områder hvor de vender tilbake etter å ha vært lokalt utryddet, kan store rovdyrarter være lokalt uvelkomne, selv om økningen i populasjonene er en ønsket utvikling styrt gjennom nasjonale og internasjonale bestemmelser. For å hjelpe beslutningstakerne, i tillegg til å bygge legitimitet i beslutningene, er forskningsbasert kunnskap inkludert når forvaltningstiltak skal fattes. Hvordan denne kunnskapen oppfattes kan imidlertid variere avhengig av hvordan en person er påvirket av tilstedeværelsen av store rovdyr. Vi ønsket å vurdere tilliten folk hadde til store rovdyrforskning og forskernes utsagn. For å få innblikk i lokale variasjoner, gjennomførte vi en undersøkelse med et geografisk stratifisert utvalg som samlet inn fem respondenter fra alle Norges 422 kommuner. Resultatene våre indikerer at eldre menn, personer med lavere utdanning, de som har opplevd tap av husdyr til rovdyr, har lavere tillit til rovdyrforskning. Lavere tillit til rovdyrforskning ble også funnet blant storviltjegere og folk som frykter store rovdyr. Tillit til rovdyrforskning var lavere enn tillit til klimaforskning og medisinsk forskning. Videre fant vi at 25 % oppfattet utsagn som manipulasjon, noe som indikerer at ikke alle nødvendigvis oppfatter forvaltning basert på forskningsbasert kunnskap som legitim. Alder, miljøverdier og negative opplevelser av rovdyr økte sannsynligheten for å oppfatte forskningsuttalelser som manipulerende eller som politiske argumenter. I en systematisk oversikt over publiserte forskningsartikler fra hele verden som har studert holdninger til ulv, fant vi at mennesker som bodde i områder hvor ulv hadde vært tilstede kontinuerlig, generelt hadde mer negative holdninger enn mennesker som bodde i områder der ulv hadde kommet tilbake. Jegere og bønder hadde en tendens til å ha de mest negative holdningene til ulv, og nesten alle utfall ble funnet for en rekke variabler testet for påvirkning på folks holdninger.

Nøkkelord: Rovdyr, ulv, tillit, holdninger, menneske-vilt interaksjoner

Abstract

Large carnivores are unequally distributed in space, giving rise to differing levels of experience with these species depending on where a person live. Recovery of large carnivore species combined with rapid growth in the human population results in increased co-occurrence of humans and large carnivores. In areas where they are returning, large carnivore species may be locally unwelcome, yet governmental or international policies are facilitating their return. To aid the management decisions, as well as building legitimacy in those decisions, scientific knowledge is included in management policies. However, how this knowledge is being perceived may differ depending on how a person is influenced by the presence of large carnivores. I assessed the trust people have in large carnivore science and scientists' research claims. To allow for local patterns to emerge, I carried out a survey using a geographically stratified sample collecting five respondents from all of Norway's 422 municipalities. My results showed that elderly men, people with lower education, those who had experienced loss of livestock to large carnivores were associated with lower trust in large carnivore science. Lower trust was also found among big game hunters and people who fear large carnivores. Trust in large carnivore science was lower than trust in climate science and medical science. Further, we found that 25 % of the respondents perceived statements as manipulation, which indicate that not all perceive policies guided by large carnivore science to be legitimate. Age, environmental values and negative experiences of large carnivores increased the probability of perceiving research statements as manipulative or political. In a systematic review assessing attitudes towards wolves globally, I found that people living in areas where wolves had been continuously present generally held more negative attitudes than people living in areas where wolves had returned. Hunters and farmers tended to hold the most negative attitudes towards wolves, and almost all outcomes were found for a variety of variables tested for the influence on attitudes.

Keywords: Large carnivores, wolf, trust, attitudes, human-wildlife interaction

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List of papers

This thesis is based on the following publications and manuscripts.

Paper I

Barmoen, Magnus, Kim Magnus Bærum, Maria Johansson, and Kristin E. Mathiesen. 2021. Trust in large carnivore science in Norway (2021). *European Journal of Wildlife Research* 67, 98. <https://doi.org/10.1007/s10344-021-01538-7>

Paper II

Mathiesen, Kristin E., **Magnus Barmoen**, Kim Magnus Bærum, and Maria Johansson. 2021. Trust in researchers and researchers' statements in large carnivore conservation. *People and Nature* 00: 1– 14. <https://doi.org/10.1002/pan3.10282>

Paper III

Barmoen, Magnus, Kim Magnus Bærum, and Kristin E. Mathiesen. 2021. Attitudes towards gray wolves – systematic review 1980-2020. *Manuscript*

1 Introduction

1.1 Conservation conflicts

Human impacts on life on earth are increasing, and biodiversity is under heavy pressure (Diaz et al. 2019). Efforts to conserve biodiversity are often at odds with other human interests (Woodroffe et al. 2005), such as urban development (Moilanen et al. 2011) and food production (Shackelford et al. 2015), leading to conservation conflicts. Redpath et al. (2013) have defined conservation conflicts as situations that occur when two or more parties disagree over conservation objectives and the interest of one party is perceived to assert its interests at the expense of another. Such conflicts are one of the most significant challenges to biodiversity conservation worldwide (Woodroffe et al. 2005, Dickman 2010, Redpath et al. 2015). Superficially, these conflicts often appear to concern the impacts of species on human interests, such as the perceived impact of carnivores on livestock or game species or the degradation of improved land by wildlife species (Thirgood and Redpath 2008, Mason et al. 2018). However, the origins often go beyond material differences between stakeholders, arising from underlying social factors such as clashing values or attitudes (Dickman 2010, Redpath et al. 2013, Madden and McQuinn 2014). Knowledge about the motivation that drives peoples' attitude in conflicts is essential when trying to mitigate conservation conflicts (Kansky and Knight 2014, Kansky et al. 2016, Hill 2017).

1.2 Human-carnivore interactions

Large carnivores have proven to be especially controversial and challenging to conserve, and give rise to strong public engagement (Fritts et al. 2003, Macdonald et al. 2016). They require extensive areas of suitable habitat (Gittleman et al. 2001, Ripple et al. 2014), which often puts them in conflict with humans and livestock, and has resulted in local extinctions and severe declines in abundance worldwide (Woodroffe 2000, Berger et al. 2001, Cardillo et al. 2004, Ripple et al. 2014). However, since the 1970s, several large carnivore species have increased in abundance in Europe due to protective legislation and supportive public opinion (Chapron et al. 2014). At the same time, rapid growth in the human population has caused reductions in natural habitats leading to growing competition for areas between humans and wildlife (Diaz et al. 2019). This creates shortages of space, meaning that conservation of large carnivore species requires not only protected areas but also land sharing between carnivores and humans outside protected areas as well (Treves and Karanth 2003, Linnell 2015, Di Minin et al. 2016). Potential win-win solutions are difficult to realize in these conflicts, with outcomes being trade-offs

between ecological, social, and economic interests (McShane et al. 2011, Pooley et al. 2017). Balancing such trade-offs is a challenging task, as these conflicts are loaded with clashing knowledge claims, values, attitudes and norms, as well as issues of social and political trust (Sjölander-Lindqvist 2009, Dickman et al. 2013). Most countries are therefore striving to develop carnivore management policies that are acceptable to all (Chapron et al. 2003). As a contribution to this, human dimensions research aims at gathering knowledge about how the public thinks and acts towards large carnivores, to support the development of stronger policies and management (Vaske and Needham 2007, Vaske and Manfredi 2012).

1.3 Human-carnivore interactions in Norway

Large carnivores are unequally distributed in space, giving rise to differing levels of experience with these species. In areas where they are returning, large carnivore species may be locally unwelcome, even though governmental or international policies are facilitating their return to their former ranges. Norway provides a good example. Decentralized management has been introduced as a measure to reduce conflict levels (Norwegian Carnivore Regulation 2005). Still, different perceptions on whether these species still belong in the wild, or at least where they should be allowed to establish, fuel conflicts between different stakeholder groups, including farmers, hunters, conservationists and those implementing policy (Skogen et al. 2008, Tangeland et al. 2010, Figari and Skogen 2011). The negative material consequences, such as livestock predation and competition for big game, often get significant attention. However, large carnivores may also be seen as symbolic species, and for example the wolf (*Canis lupus*), has become a symbol of urban power over rural decisions (Enck and Brown 2002, Skogen and Krangle 2003, Sjölander-Lindqvist 2009). While national surveys repeatedly report a preponderance of positive attitudes, local resistance and negative attitudes towards management actions is common as well (Skogen et al. 2017, Krangle and Skogen 2018, Skogen et al. 2018).

People holding more negative attitudes towards large carnivores often claim that local knowledge is ignored by those in power, e.g., politicians, managers, biologists, and conservationists (Skogen and Krangle 2003). Norwegian studies report that large carnivore science is regularly being challenged (Skogen et al. 2018) and stakeholders cherry-pick certain results to benefit their own interests (Skogen and Thrane 2007). People tend to trust others whom they perceive to hold the same values as themselves (Stern and Coleman 2015, Johansson et al. 2017). Considering the difference in attitudes towards large carnivores between people living in more urban compared with rural areas, I looked at whether trust in science and scientists also could be an important part of the conflict frame. I expected that trust in science

would vary depending on how people experience the influence of scientific recommendations for carnivore management on their everyday life. Farmers and hunters in large carnivore areas are more likely to experience negative consequences of large carnivore presence, and thus may be more likely to express lower trust in science due to their direct negative impact (Bright and Manfredo 1996, Ericsson and Heberlein 2003, Kleiven et al. 2004).

2 Aims and Concepts

2.1 Aims

This PhD project aimed to examine trust in large carnivore science in general (Paper I) and trust in large carnivore scientists' statements (Paper II). Research on trust in science has identified a variety of motivational reasons why people might question science in different research fields (Kahan 2012, Campbell and Kay 2014, Hornsey and Fielding 2017). Within the field of human-wildlife research, attitude surveys have discovered a range of variables that influence attitudes towards large carnivores and the management of these species (Paper III), many of which we would expect to vary across the landscape. Norway hosts four large carnivore species: brown bear (*Ursus arctos*), wolf (*Canis lupus*), Eurasian lynx (*Lynx lynx*), and wolverine (*Gulo gulo*). By surveying respondents throughout the whole of Norway, in which the presence of large carnivores varies from none to all four species, I specifically wanted to assess whether trust in large carnivore science was associated with the geographical variance of carnivore abundance and the negative consequences this may entail for the inhabitants. In that way, I wanted to provide a better understanding of the characteristics that describe people with low trust in large carnivore science, thus potentially helping communicators to identify needs leading to more efficient science communication.

Paper I investigated trust in large carnivore science through a national sample and tested for the association between trust and variables known to influence attitudes towards large carnivores. This included carnivore presence and experience with these species, but also rural context variables and sociodemographic variables. We examined whether the level of trust in large carnivore science could simply be described by sociodemographic patterns and the local presence of carnivores, or whether it followed a more complex pattern based on multiple factors. By using a geographically stratified sample, the survey included a larger proportion of those living in large carnivore areas who might be adversely affected (Ericsson et al. 2006), to test whether they were more inclined to have low trust in large carnivore science.

Paper II investigated trust in scientists and how their research statements were interpreted by the public. If stakeholders' trust towards scientists is lacking, as some studies suggest (e.g., Skogen et al. 2006), then it would be interesting to know if this is derived from an inherent mistrust in science communicators. Evidence-based management is considered key to achieving successful management. Science is thought to serve as an objective information source that helps society to reach the best solutions. However, large carnivore science is not

universally trusted (Krange and Skogen 2018) and some people may not consider statements communicated by large carnivore scientists as being science. Previous research in Norway has shown that statements from the government and scientists may be perceived as political manipulation (Skogen et al. 2018). Using data from the same survey as Paper I, we assessed the respondents' trust in statements coming from large carnivore scientists and tested the probability that respondents would change their perception depending on information about the source of the statements.

In Paper III, we synthesized attitudes towards wolves reported in peer-reviewed articles.

Social trust has been studied in relation to cognitions known to influence behavior and behavioral support for management actions (Sponarski et al. 2014, Harper et al. 2015). Our findings in Paper I and Paper II showed that several of the variables often found to influence attitudes towards large carnivores were associated with trust in large carnivore science and scientists. Further, presence of wolves and fear of wolves seemed to be more associated with a lack of trust than same comparable variables including other large carnivore species. Due to the development of protection and implementation of effective policy over recent decades, large carnivores are recovering in both Europe (Linnell et al. 2001, Trouwborst 2010, Kaczensky et al. 2013, Chapron et al. 2014) and North America (Harding et al. 2016, Jimenez et al. 2017, Mech 2017). However, human-dominated landscapes are increasing, leaving less space available for large carnivores (Ripple et al. 2014, Diaz et al. 2019). As knowledge about the public's attitudes towards large carnivore species such as wolves can help to predict the social foundation for future conservation (Bruskotter et al. 2009, Vaske and Manfredo 2012), attitude surveys on wolves have become relatively abundant in the literature. I wanted to take advantage of this to investigate how attitudes were associated with wolf presence. Our main objectives were to test whether attitudes towards wolves were influenced by the local presence of wolves and the type of respondent group included in the surveys. We set up a test to assess whether people were more negative towards wolves in areas in which wolves had been continuously present than where they had returned to after being locally extinct.

2.2 The concepts of values, beliefs, attitude and trust

By building on relevant theory, human dimensions of wildlife research have contributed a cognitive approach that includes concepts from social psychology such as values, attitudes and norms, that may influence how people behave (Vaske and Manfredo 2012). These cognitions can be arranged in a hierarchy from general to specific concepts (Homer and Kahle 1988), see Figure 1.

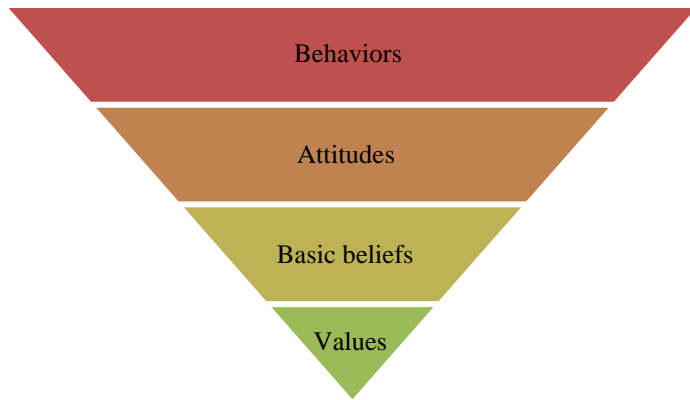


Figure 1: Cognitive hierarchy model of human behavior (Fulton et al. 2008).

Located at the bottom of the hierarchy, we find a few general stable abstract values, defined as desirable individual states or qualities that we hold dear (Rokeach 1973). Values are formed early in life and reflect our most basic desires and goals and are therefore very resistant to change. As values tend to be shared by many members of the same cultural group, they are unlikely to account for much variability in behavior. The concept of Wildlife Value Orientations (WVO), however, has been developed to describe peoples' basic values regarding wildlife on a scale with direction and intensity and is therefore more suitable to use as a predictor of behavior (Fulton et al. 1996). Manfredro et al. (2009) proposed that values relative to wildlife could be oriented in terms of one of two cultural ideologies: domination or egalitarianism (mutualism). Based on this framework, a categorization of people into domination (a view of wildlife that prioritizes human wellbeing over wildlife) and mutualism (a view in which wildlife is perceived as companions with humans) has been developed to categorize stakeholder groups in social conflicts over wildlife issues (Teel and Manfredro 2010). Researchers have found WVO to influence attitudes towards large carnivores and large carnivore management (Pate et al. 1996, Ericsson and Heberlein 2003, Sponarski et al. 2016, Landon et al. 2019).

At higher levels of the hierarchy, we find cognitions that evaluate objects or situations in daily life, such as attitudes and norms (Eagly and Chaiken 1993). Attitudes can be defined as “a disposition or tendency to respond with some degree of favor, or not, to a psychological object” (Fishbein and Ajzen 2010). Attitude towards an object determines a person’s willingness to behave in a certain manner (Manfredro 2008, Vaske and Manfredro 2012), and is one of the most studied concepts in the social sciences (Manfredro et al. 2004). Knowledge about public attitudes towards large carnivore species such as wolves can help to predict the social foundation of future conservation (Bruskotter et al. 2009, Vaske and Manfredro 2012), as these views will determine whether an interaction with the species is expressed as a conflict or coexistence. The

more specific the cognitions are, the better predictors of behavior they are thought to be (Whittaker et al. 2006). Attitudes have both cognitive and evaluative components (Vaske and Manfredo 2012). The evaluative component refers to whether a person views the object as positive or negative. Emotional responses to large carnivores range from admiration to hate, causing diverging perceptions of management goals and actions (Wilson 1997, Sjölander-Lindqvist et al. 2015).

Trust is not part of the cognitive hierarchy model described above. However, it plays a key role in how people behave in response to the conservation and management of conflict species (Young et al. 2010, Stern and Coleman 2015, Young et al. 2016). A willingness to rely on those responsible for developing policies, called social trust (Cvetkovich and Winter 2003), is essential for establishing cooperation between an agency and the public (Beierle and Konisky 2000, Cvetkovich and Winter 2004). Lack of trust in management agencies can result in opposition or disapproval of management options (Cvetkovich and Winter 2004, Borrie and Liljebblad 2006, Nyaupane et al. 2009). Consequently, trust in the management agency influences the attitude towards management actions (e.g., Vaske et al. 2007). As with attitudes, social trust also seems to be influenced by a person's values, with several studies investigating the relationship between values and trust in nature management (e.g., Vaske et al. 2007, Ford et al. 2014, Harper et al. 2015, Gigliotti et al. 2020). As a consequence, people may not support resource management strategies because they lack trust in the management agency (Cvetkovich and Winter 2003, Nyaupane et al. 2009) or perceive that they hold different values from those with the responsibility to set policies (Needham and Vaske 2008). Regarding human-carnivore interactions, trust has been proposed to affect acceptance of wildlife (Zajac et al. 2012) and support for management of wildlife (Sponarski et al. 2014). In summary, studies suggest that social trust is associated with attitudes towards the object of interest, and subsequently the level of support for management actions towards that object. The conceptual model including trust in large carnivore science describes our perspective on how trust in large carnivore science may be related to other described concepts, without discussing direct and indirect effects or directions of influence (Figure 2).

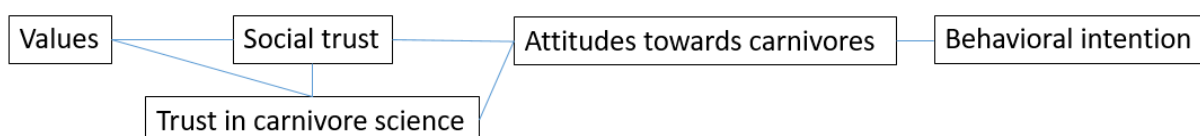


Figure 2: Conceptual model placing the trust in large carnivore science in relation to other concepts important for human behavior in relation to large carnivores.

While trust in management authorities has been widely discussed in the literature (e.g., Lute and Gore 2014a, Sjolander-Lindqvist et al. 2015, Hare et al. 2017), trust related to wildlife research has received less attention. As an essential knowledge provider in tackling challenges in conservation conflicts, science has been argued to play an important role (Pullin et al. 2004, Sutherland et al. 2004). The inclusion of evidence-based information can improve the probability of management decisions being successful, by building trust in the decision makers and ultimately support for their management policies (Pullin et al. 2004, Bennett 2016, van Eeden et al. 2018). Bridging the divide between scientists and management agencies is seen as crucial to improve conservation success (Cook et al. 2013, Durant et al. 2019). Considering the important role science has, or should have, in decision making, it is important to investigate trust in it.

3 Materials and Methods

3.1 Study area

Norway is approximately 385 000 km², with 37 % of the land covered by forest (www.forest.eea.europa.eu) and ca 3 % being cultivated (www.nibio.no/en). There are nearly 5.4 million inhabitants in total in Norway today (2021), with the population density per municipality varying from 0.32 in Kautokeino municipality to 1971 in Stavanger municipality. Rural areas struggle with urbanization as younger people and people with higher education move into more urban areas. In 2021, approximately 17 % of the population lived in rural areas compared to ca. 30 % in 1990 and 50 % in 1960 (www.ssb.no). In the same period, large carnivore populations have increased since they were protected by law in the beginning of the 1970s.

Today's carnivore population sizes have been estimated to be 395 lynx (estimated based on family groups), 109-114 wolves (57-58 only in Norway), 378 wolverines (estimated from DNA), and 150 brown bears (minimum number based on DNA) (www.rovdata.no). Norwegian large carnivore populations are dependent on immigration from the larger population of large carnivores in Sweden (Krange et al. 2016). The wolf population has grown from only one family group in 1984 (Trouwborst et al. 2017), to 57 or 58 individuals in Norway, a further 58 individuals using both Norway and Sweden, and a total of approximately 400 individuals in Norway and Sweden together (www.rovdata.no; Figure 3).

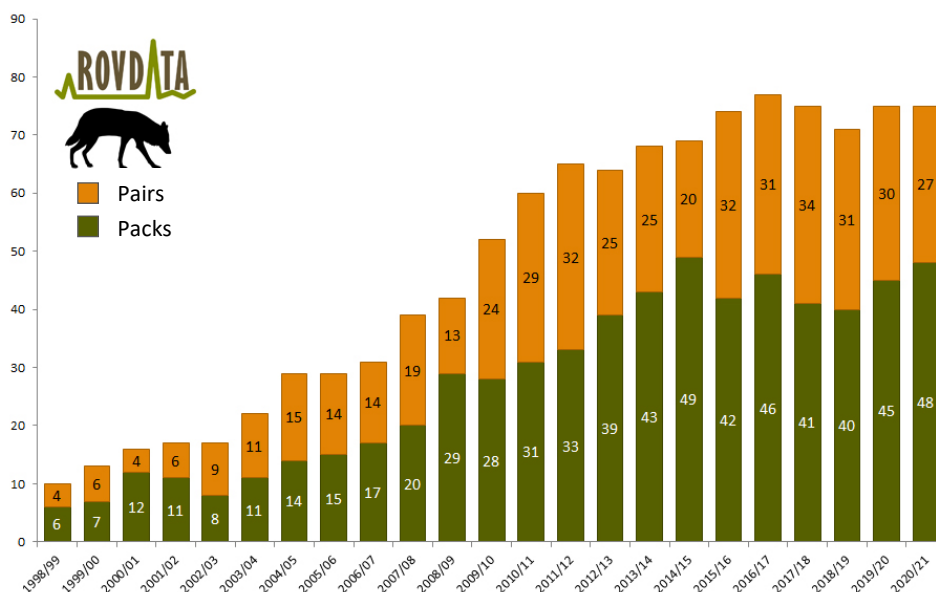


Figure 3: The Scandinavian wolf population growth since 1998, where yellow gives the number of pairs of wolves, and green gives the number of family groups with three or more individuals (www.rovdata.no).

To meet the two-folded objective of large carnivore management in Norway, ensuring both viable populations of large carnivores and securing a sustainable grazing industry, the Norwegian parliament have established a zonal management system (Ministry of Environment 2003, Hansen et al. 2019). Approximately 55 % of Norway is covered by carnivore zones prioritizing at least one large carnivore species, while the remaining area is prioritized for livestock (Strand 2016, Strand et al. 2019). Consequently, large carnivore presence varies geographically in Norway, with some regions having all four large carnivore species (brown bear, wolf, Eurasian lynx, and wolverine), some having 1-3 species and others having none (Figure 4). The local presence of large carnivores also varies both within zones and outside, as some individuals or groups do occur outside designated carnivore zones. Thus, the costs of living with these animals are also unevenly distributed (Andersen et al. 2003, Asheim and Mysterud 2004, Strand et al. 2019).

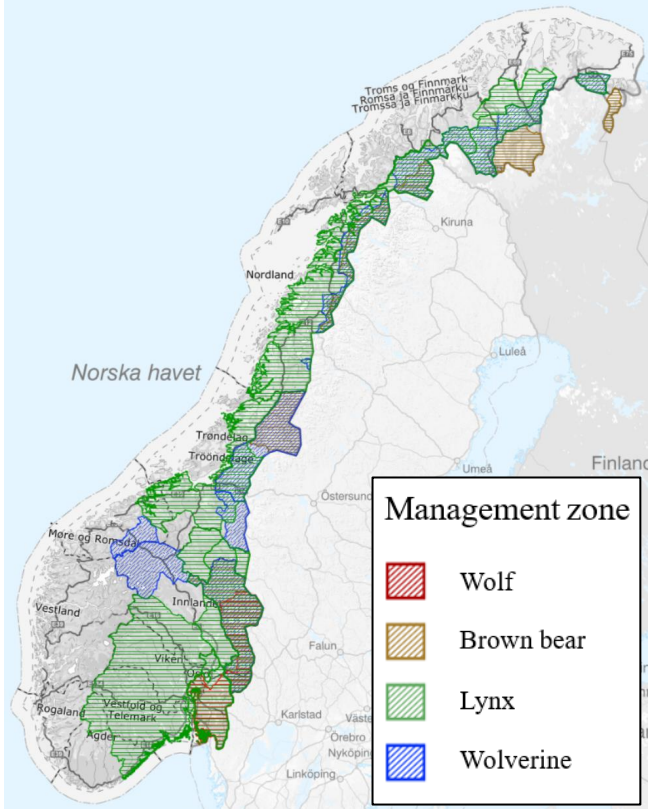


Figure 4: Large carnivore species management zones in Norway (miljoatlas.miljodirektoratet.no).

3.2 Survey

We carried out a telephone survey to assess the trust in large carnivore science and research statements. Considering the important influence of large carnivore presence, and any associated negative experiences, on people’s attitudes towards these species, we wanted to assess whether the spatial variation in carnivore distribution also influenced trust in large carnivore science.

To capture trust measurements at local scales, non-proportional sampling methods are useful to capture voices from low density rural areas that would be lost in proportional surveys (Ericsson and Heberlein 2003, Ericsson et al. 2006). Therefore, we sampled five respondents from each of Norway's 422 municipalities (as was the number in 2019), giving a total of 2110 respondents. Due to the geographically stratified sample, the results do not reflect mean attitudes of Norwegians in general, as urban areas are under-represented despite being the most populous areas. The survey consisted of a set of variables known to be associated with attitudes towards large carnivores, as previous literature within wildlife research suggests a relationship between trust and attitude (e.g., Vaske et al. 2007, Sponarski et al. 2014, Gigliotti et al. 2020). We reviewed data on large carnivore presence from Rovdata (rovdata.no) and defined a carnivore species to be present in the municipality if the species, or its tracks or signs, had been observed there within the last five years. We also created a variable based on the number of large carnivore species prioritized within any management zones in each municipality, to see whether management policies were more important to people than actual large carnivore presence (miljostatus.miljodirektoratet.no). We further included a separate binary variable on whether the respondent lived within or outside the national wolf zone, as attitudes towards wolves have been observed to be more negative than attitudes towards other species (Røskaft et al. 2007, Tangeland et al. 2010). In addition, respondents were asked whether they thought each of the four large carnivore species were present in their municipality or not. This was included because we wanted to assess whether the respondents' awareness of large carnivore presence explained more variation in trust than actual carnivore presence. In addition, we asked the respondents whether they had experienced loss of livestock to large carnivores. This would likely only be relevant to a very few participants in a proportional survey, but the stratified sample gave a higher chance of sampling respondents who had experienced losses to predation.

We included several variables to describe big game hunting: being a hunter, perceiving strong big game hunting traditions in the local municipality, and the hunter ratio (proportion of inhabitants being big game hunters in the local municipality). The last item was retrieved from Statistics Norway (www.ssb.no). In Norway, hunting traditions are deeply established in the country's history and culture, with big game hunting including the hunting of moose (*Alces alces*), roe deer (*Capreolus capreolus*), wild reindeer (*Rangifer tarandus*), and red deer (*Cervus elaphus*). Generally, local hunters have good access to hunting through informal

connections with landowners or through organized hunting teams. Hunters are often found to have negative attitudes towards large carnivores, particularly wolves, and represent a strong voice in social debates about wildlife management (Naughton-Treves et al. 2003, Karlsson and Sjoström 2007, Agarwala et al. 2010, Torres et al. 2020).

Previous studies have shown that people living in rural areas with large carnivores traditionally express more negative attitudes towards large carnivores and their values tend to be more anthropocentric than those of people in urban areas with no or very few carnivores (Skogen and Kränge 2003, Sponarski et al. 2013). To assess whether value orientation could influence trust in large carnivore science, we included items developed by Dunlap et al. (2000) to measure pro-environmental orientation. The New Environmental Paradigm (NEP) scale (Dunlap and Van Liere 1978) has frequently been used to measure values within human dimensions of wildlife conservation (Dunlap et al. 2000, Klain et al. 2017, Xiao et al. 2019). We used a seven-question version of NEP (Bjerke and Kaltenborn 1999, Dunlap 2008, Kaltenborn et al. 2008), translated into Norwegian (see Kaltenborn et al. 2012, Gangaas et al. 2015). The NEP is rooted in individual basic values, having both emotional and cognitive (knowledge) components (Dunlap 2008). We have therefore chosen to use it to explore how people's environmental value orientation may relate to their trust in researchers and research statements. High NEP-scores correlate with pro-environmental values, also called ecocentrism, where nature is seen to have an intrinsic value regardless of human utilitarian needs (Dunlap et al. 2000, Kortenkamp and Moore 2001). Low NEP-scores correlate with anthropocentrism, where humans value nature that is beneficial to humans and believe that nature is to be utilized (Rauwald and Moore 2002, Kaltenborn et al. 2008).

3.3 Analysis procedures

Trust in science (Paper I)

To measure trust in large carnivore science, we used the respondents' rating of the statement "I trust large carnivore science produced in Norway". In addition, respondents were asked to rate statements about their trust of science in general, of climate science, and of medical science in the same format. The statements were rated on a five-point Likert scale from 1 = "strongly disagree" to 5 = "strongly agree" with 3 = "neutral". In total, ten science-related items were included in the survey, but for Paper I, only the item concerning trust of large carnivore science was included in the analysis. We analyzed how trust in large carnivore science varied in response to different combinations of variables using multiple regression models. To assess which types of variables best explained the variation in trust, we tested the following groups of

variables: Sociodemographic (e.g., age, gender), carnivore presence, rural context (e.g., being a hunter, sheep density), and fear.

Research claims (Paper II)

To explore variations in how the statements were perceived and how this perception changed when told that the statements were made by a large carnivore researcher, we set up two multinomial logit models. The first model explored how the statements were initially perceived (i.e. the probability a respondent would categorize each statement into each of the following five categories: *research*, *political*, *conjecture*, *a manipulative statement* or *do not know*) in an unspecified setting. The second model focused on responses in a setting where participants were told the same statements were made by a large carnivore scientist. We explored how the perception of these statements depended on their source and how this related to environmental values, rural context and local carnivore presence. As wolf study in Scandinavia has been going on for a long time (www.scandulv.no), and represents almost every perspective of the ongoing debate about trust in large carnivore research (Wilson 1997, Skogen and Kränge 2003, Linnell et al. 2017), we only used factual research statements from Scandinavian wolf research.

Systematic review of attitudes (Paper III)

Our review of attitudes towards wolves focused specifically on quantitative studies to allow us to compare reported attitude scores. Only English-language peer-reviewed articles were included to ensure we located all papers of interest within the search frame and to make the study replicable, as well as avoiding the challenges related to translation. From our initial search, 1980s seemed to be a natural starting point as very few available peer-reviewed studies were conducted before then. We searched for articles using two electronic databases: Web of Knowledge and Scopus, and followed the guidelines for systematic reviews provided by Pullin and Stewart (2006). We chose to only include wolves as this species is by far the most studied, in terms of human attitudes, of the large carnivore species found in Norway. Furthermore, the findings in Paper I suggested that wolves were the most important species in influencing trust in large carnivore science. A total of 137 surveys, from across the global wolf range, met our inclusion criteria. We made a descriptive summary of the reported trends in variables tested for their influence on attitudes, based on reported p-values and AIC values. We also summarized sociodemographic variables and information about samples. We then constructed models using the *glmmTMB*-library (Brooks et al. 2017) in the statistical environment R (R Core Team 2020) to assess the influence of carnivore presence and respondent groups surveyed on measurements of attitudes.

4 Results and Discussion

4.1 How trust varies geographically (Paper I and Paper II)

In Paper I, lower trust in large carnivore science was associated with the presence of wolves locally, being a big game hunter, having experienced loss of livestock to carnivores, older age, a lower level of education, being male, and self-reporting a higher level of fear of wolves. Essentially, the results showed that there was no single variable that alone predicted a lower trust in large carnivore science, but rather there was a combination of variables, many of which were related to large carnivores (e.g., wolf presence, experience of loss of livestock, fear of wolves). As the presence of large carnivores varies greatly between different parts of Norway, so did the potential negative consequences of living with these animals. We observed that respondents who lived in municipalities with large carnivores generally had a lower trust in large carnivore science than respondents living elsewhere, and the effect was strongest for the presence of wolves. Attitudes seem to be more negative towards wolves than towards the other three large carnivore species in Norway (Røskaft et al. 2007, Tangeland et al. 2010). The wolf is a flagship species, i.e. a charismatic species that serves as a symbol to stimulate conservation action and awareness (Heywood and Watson 1995, Douglas and Veríssimo 2013). The symbolic role of the wolf stems from a construction of mastery and control over the hunt, and a fear of the “wild”, the “irrational”, or the “different” (Emel 1995, Fritts et al. 2003). This symbolism contributes to why wolves are the focus of conflicts associated with large carnivores, even in cases where other large carnivore species do more damage to livestock (Andersen et al. 2003, Figari and Skogen 2011, Zahl-Thanem et al. 2020), although incidents where wolves cause large amounts of damage to herds (e.g., Ertesvåg 2017), also fuel negative attitudes.

The “not in my back yard” (NIMBY) effect has been discussed in relation to peoples’ perception of large carnivores in Scandinavia relative to where they live (Ericsson et al. 2008, Gangaas et al. 2013, von Essen and Allen 2020). According to this concept, people express a general acceptance of the idea that wolves should be allowed to establish in the country, yet are not prepared for them to do so close to where they themselves live. A similar effect could be reflected in trust even though we have not used the NIMBY-concept in this study. People who live close to where wolves are established may express lower trust precisely because they are the ones who experience the costs of having wolves nearby, while at the same time research claims state that wolves are not dangerous. However, whether the observed Norwegians’

perception of wolves actually qualifies as a proper NIMBY-effect has been questioned (Krange and Skogen 2018).

Reported observations of large carnivores (or their signs or tracks) were the variable in the carnivore presence variable-group that explained the most variation in trust in large carnivores, as we observed in Paper I. Further, personal negative experiences, measured by self-reported loss of livestock, was associated with low trust in large carnivore science and has previously been shown to be associated with negative attitudes towards large carnivores (Kleiven et al. 2004, Røskaft et al. 2007). Social scientists have argued that personal importance of an issue is a key feature in studies of attitude-behavior relationships (Bright and Manfredi 1996, Ajzen and Fishbein 2005). Farmers owning free ranging sheep and big game hunters wanting to maximize the abundance of big game will have an interest in reducing the population sizes of large carnivores. Previous research has suggested that vested interests in a topic may motivate people to reject science communicated to them that is not compatible with their interests (Kunda 1987, Hornsey and Fielding 2017). Stakeholders that perceive large carnivore science as being unbeneficial may thus be more likely to repudiate information communicated to them. Also new relevant information that contradicts currently held experiences and views may result in cognitive dissonance, making people reject it (Festinger 1957).

Perceptions of not being heard, or one's competence or role being dismissed by the central management, can lead to political alienation (Eriksson 2017, Zahl-Thanem et al. 2020). Political alienation, or general distrust of the actors and institutions of the political system, has been shown to be a mediator between place of residence and attitude towards wolf policy (Eriksson 2017). This may reduce trust in the government but considering the role of large carnivore science in management policies, an interesting question is whether it may also reduce trust in large carnivore scientists. Local knowledge is represented through regional large carnivore committees in Norway. These may be overruled by national government through their work of revising carnivore management plans (Krange et al. 2016, Sjölander-Lindqvist et al. 2020). Sjölander-Lindqvist et al. (2020) observed that local actors struggle to get acknowledgement of their views and knowledge when interacting with upper governance level agencies. Local actors report that they meet an established knowledge hierarchy, where scientific knowledge consistently trumps solutions based on personal experience in the local context (Sjölander-Lindqvist et al. 2020). This reduces trust and the legitimacy of decisions for those who perceive other types of knowledge to be more reliable, and may ultimately lead to skepticism in science as a knowledge provider (Skogen et al. 2017). Another negative consequence of science being

positioned at the top of a knowledge hierarchy is that it may intimidate some stakeholders or lead them to adopt ecological language in their arguments. Von Essen and Allen (2020) argue that ecological knowledge may have gained a hegemonic status over other arguments, resulting in a simplification and polarization of views on wolves down to being either self-interested NIMBY-ism or objective ecological assessments. This has caused Swedish hunters to use wolves' *right to exist* in their arguments, but in an ambivalent way, arguing that wolves have the right to exist, but not where the hunters live themselves (von Essen and Allen 2020). Sticking to ecological knowledge as an objective truth emphasizing the need for wolf conservation will not open for more collaborative environment in such situations.

4.2 Confusion of trust in science management (Paper I and Paper II)

While large carnivore scientists are not directly responsible for management decisions, people may still have the expectation that scientific knowledge is implemented in the management principles. Distinguishing how the various roles and responsibilities are distributed between decision makers, managers and scientists in relation to highly complex large carnivore issues may be difficult for people in general. If people fail to recognize the contributions of large carnivore scientists, they might lose trust in their role as knowledge providers.

Whether people distinguish between scientists and managers is not clear and should be an issue for further research. Rejecting large carnivore scientists as knowledge providers is most likely to happen in the context of a person perceiving other types of knowledge as more important. As found in previous research in Norway, finding traditional knowledge to be the most trustworthy source was associated with more negative attitudes towards management (Skogen et al. 2018). Thus, if people do not distinguish between the roles of managers and scientists, negative attitudes towards management actions and policies might lead to reduced trust in large carnivore scientists. This could perhaps also apply to dissatisfaction in governance systems, such as shortcomings in the zoning strategy or decentralized carnivore governance (Risvoll et al. 2016, Risvoll and Kaarhus 2020, Sjölander-Lindqvist et al. 2020). The way that science is communicated is important but might be closely interlinked with management in the case of large carnivore conservation. If science is being perceived as supporting, redirecting or motivating management decisions to be taken in a certain direction, then trust in scientists can decrease. Ideally, scientists should be perceived as objective and be trusted by stakeholders from all sides.

We found in Paper II that regarding perception of research statements about wolves from scientists, respondents perceived 60 % of the statements to be genuine when given no information of who had made them. Although this increased to 75 % when informed that the statements were made by a large carnivore researcher, there was still a 25 % probability that the statement was perceived as manipulative or political, which indicates that not all perceive policies guided by large carnivore science to be legitimate. Discomfort about the notion of the potential influence of scientists' policy preferences has been discussed in previous research (Lackey 2007), and it is likely that local people in large carnivore areas consider large carnivore scientists to hold values that differ from their own and therefore have different objectives. Previous research has shown that farmers hold different environmental values than research biologists and wildlife managers (Kaltenborn et al. 1999). Furthermore, research from Norway on attitudes towards large carnivores has found that trust in the institutions responsible for large carnivore management may be the variable explaining the most variation in attitudes to large carnivore management (Skogen and Thrane 2008, Krangle and Skogen 2018). This is very likely to be linked to ones own perception of their position in relation to those holding power in society (Skogen et al. 2017).

4.3 How trust is associated with attitudes and other cognitions (Paper I and Paper II and Paper III)

Based on our findings in Paper I and Paper II, it seems likely to believe that trust and attitudes do associate in one way or another. However, there is a need to remember that while the definition of attitudes deals with the *evaluation of an object* (Fishbein and Ajzen 2010), trust is about the *willingness to rely on* (those responsible for developing policies, management, reserachers or others; Cvetkovich and Winter 2003). In other words, I think that the concept of trust impacts on how a person might evaluate an object if they trust the information they get about the object (e.g. scientific knowledge). If, however, the person does not trust this external information, or has contrary experience himself or herself that deems the information unreliable, attitudes towards the object will remain unchanged (Figure 5).

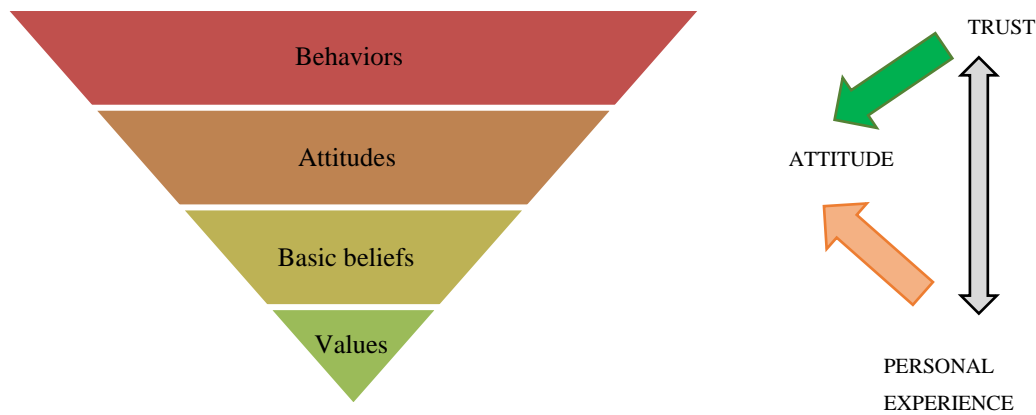


Figure 5: Both trust and personal experience may impact on peoples attitudes, but trust and personal experience will also have mutual influence.

In Paper II, we found that environmental values associated with the probability of perceiving a research statement as a political claim or manipulative statement. This is in accordance with Manfredi et al. (2017) and Schroeder et al. (2021) who found a negative correlation between domination values and trust in the state wildlife agency. Further, an important feature of the development of social trust is the emphasis on shared values and knowledge base between people (Balliet and Van Lange 2013, Stern and Coleman 2015, Johansson et al. 2017). If people perceive managers and scientists to hold different values from themselves, trust in these sources will likely be low. Shifts in values from domination to mutualism may increase societal tolerance of large carnivores (Bruskotter et al. 2017, Manfredi et al. 2017, Manfredi et al. 2020). However, this may not reduce the conflict level if those having low tolerance do not shift their values. A cohort effect is possible, as previously discussed (Williams et al. 2002, Ericsson and Heberlein 2003), with attitudes towards large carnivores being developed to a great extent during adolescence and thereafter remaining relatively stable (Blekesaune and Rønningen 2010). In this case, future generations are likely to hold more mutualistic values, and be more positive towards large carnivores (Williams et al. 2002, Heberlein 2012).

The perception of sharing similar values with the managers responsible for decision making, has been observed to influence peoples' attitudes, as well as social trust (Vaske et al. 2007, Sponarski et al. 2014, Gigliotti et al. 2020). However, in Paper II we used a more general value measurement, the NEP-scale, which measures environmental value orientation rather than wildlife value orientation, yet still has been found to be associated with attitudes towards large carnivores in Norway (Gangaas et al. 2015). We observed that respondents that leaned towards anthropocentric values were more likely to interpret a research statement as manipulative or political when they were informed that it was made by a large carnivore scientist. This shows

that environmental values are related to how people perceive research statements from large carnivores. Yet we did not test specifically for whether this response was a result of the respondents perceiving that scientists held different values from their own.

Without making a directional assumption of the association between values, trust and attitudes, based on our findings we could speculate that motivational reasoning in large carnivore science seems to share similarities with what is found in other science disciplines. As psychologists have found in their attempts to understand the controversy over climate change, inferences drawn from the same evidence differ between people with different values (Kahan et al. 2011). A close relationship between attitude and trust has been observed in other scientific disciplines as well (Pechar et al. 2018), and the underlying motivations to reject scientific evidence within these is receiving increased attention (e.g., Fielding and Hornsey 2016). Many of the “attitude roots” identified in other areas of scientific dissent such as climate change and the anti-vaccination movement (Campbell and Kay 2014, Hornsey et al. 2018b, Hornsey et al. 2018a) are likely to apply to human-wildlife interactions as well. Vested interests, social identity, personal identity, fear and worldview are all concepts found to be included in attitude surveys towards large carnivores. Those negatively affected by large carnivore presence, with a social identity corresponding to negative attitudes, or viewing carnivore management to be a top-down decision regime imposed on them, may be more negative towards large carnivores. Perceptions of wolves are often polarized and the “we vs them” mentality is common in many stakeholder groups (Lute et al. 2014a, Lute and Gore 2014b). The social group one belongs to will very likely shape attitudes and trust. Whether a person who communicates knowledge is perceived to be an expert or not depends on whether the view of the scientist (or any other communicator) matches the dominant view of the evaluator’s cultural group (Kahan et al. 2011). In Paper III, we found that farmers and hunters held more negative attitudes towards wolves, followed by the public in wolf areas, than other respondent groups. This is in line with what Dressel et al. (2015) found in their systematic review. Social identity can influence attitudes towards large carnivores even more strongly than personal experience and regional differences (Kellert et al. 1996, Naughton-Treves et al. 2003, Chavez et al. 2005, Lute et al. 2014b). In addition, a recent study showed that social identity and values influenced trust in a large carnivore management agency (Schroeder et al. 2021).

4.4 Motivations to not trust large carnivore science (Paper I and Paper III)

In paper I, both climate change science and large carnivore science showed much lower trust among the public than trust in medical science. The observed lower trust in large carnivore

science and climate change may be partly explained by the different nature of the scientific disciplines included in the survey. Previous studies have suggested a trend towards lower levels of trust in what may be called “impact science”, e.g. science that identifies environmental and public health impacts on economic production, than in “production science”, e.g. science that provides new inventions for economic production (McCright et al. 2013). Denying evidence that does not conform to one’s worldview, values or ideology, is not uncommon, exemplified by the denial of climate change by many political conservatives in the United States (McCright and Dunlap 2011, Dunlap and McCright 2015).

Trust in science and scientists is a prerequisite for science to be included in decision-making processes and to ensure that people behave in accordance with science-based information and guidance. In our modern society, science is more available than ever. Yet, worrying minorities of the general public reject conclusions widely accepted by scientists (Fischhoff and Scheufele 2014). Despite great effort from science communicators conveying findings to the public, many people are skeptical of scientifically acknowledged theories, such as anthropogenic climate change (Hmielowski et al. 2014), vaccination (Browne et al. 2015) and evolution (Williams 2009), and as in this study, large carnivore science. One explanation for why people do not believe in evidence-based information is called the deficit model which suggests either a lack of access to accurate information or insufficient scientific literacy to understand it leads to rejection of science (Sturgis and Allum 2004). However, theorists increasingly believe that this model has limits (Sturgis and Allum 2004, Kahan et al. 2012, Scheufele 2013, Hornsey et al. 2016). Simply repeating the message does not convince those that rejected the message in the first place (Lombrozo et al. 2006, Shtulman 2006). An alternative explanation is motivational reasoning (Kunda 1990). People rarely evaluate proposed facts and draw conclusion based on the most probable arguments. They rather tend to choose the arguments that fit best with their already established perspectives and are therefore likely to arrive at the conclusions they want to arrive at (Weinstein et al. 2005, Browne et al. 2015).

Attempts to quantify conservation conflicts, including those associated with large carnivores, have often focused on the importance of ecological, economic or societal costs that different stakeholders have experienced due to conservation actions (Young et al. 2010, Redpath et al. 2013). However, perhaps too much focus has been given to negative impacts through oversimplification of the level of conflict relative to the level of damage (Pooley et al. 2017). The economic cost is not always the most important, and economic compensation is often insufficient as additional psychological costs to local farmers occur, associated with the anxiety

and emotional strain of losing domestic animals, depression and insecurity about the future (Kansky and Knight 2014, Strand et al. 2019). Addressing the real sources of conflict will be essential for establishing trust and dialog between people with different goals towards large carnivore management.

We observed that carnivore presence is not the only important variable explaining levels of trust, which may be partly because the level of direct experience and perceived risk varies among those living in areas where large carnivores are present. Thus, people within areas where large carnivores exist can also hold positive views (Kränge et al. 2017, Kränge and Skogen 2018). In Paper III, we saw that attitudes did not differ between surveys of people living in areas where wolves had returned and areas where they were not present. This could indicate that low wolf population sizes, combined with a short time period between recolonization and time of survey, may contribute to a low frequency of personal negative encounters (Anthony and Tarr 2019). This results in a minor influence of the returned wolves on public attitudes towards the species as they largely go unnoticed. Alternatively, it could indicate that people show tolerance for wolves up to a certain threshold, beyond which the perceived costs are too high and negative attitudes are a consequence.

To build trust, realistic expectations and outcomes need to be better communicated to those living in large carnivore areas. As opposing stakeholders hold different priorities, no win-win solution is achievable, in common with conservation conflicts in general. However, the dual objectives of large carnivore management in Norway create an expectation that this is achievable. Studies suggest that the population goals for large carnivores are not large enough to sustain viable populations, while simultaneously expectations of grazing areas being totally free for carnivores are not possible to achieve (Kränge et al. 2016). The zoning system does not suit both farming and carnivore interests inside the zone, and for those living in these areas, management decisions may seem unfair and come with perceived negative consequences (e.g., Strand 2020). Furthermore, a significant proportion of documented livestock damage occurs outside prioritized carnivore management zones, in areas prioritized for livestock (Strand 2016, Zahl-Thanem et al. 2020). This could potentially undermine the legitimacy of management policies (Risvoll et al. 2016), and with that, the knowledge providers, if the roles are not clearly stated. Perceived risks, such as competition for big game and of livestock losses, are frequently included in the attitude measures reported in the surveys included in Paper III (e.g., Schroeder et al. 2018, Anthony and Tarr 2019, Grima et al. 2020). Motivation is a strong predictor of cooperation intention and behavior within natural resource management (Hamm 2017). People

may be skeptical of information that can come with costs and research suggests that risk and fear may reduce acceptance for management actions (Johansson et al. 2012, Slagle et al. 2012, Lute and Carter 2020), and be a driver of reduced human acceptance towards wolves, and wildlife in general (Dickman 2010, Bhatia et al. 2020).

5 Conclusions and management implications

We observed in Paper I that wolf presence and fear of wolves were associated with a lower trust in large carnivore science. Experiencing losses of livestock to predation and being a hunter were also negatively associated with trust, indicating that perceived risk and losses are important factors influencing the trust people have in large carnivore science. As we saw in Paper II, research statements were more likely to be viewed as manipulative claims or political arguments by people with anthropocentric values, indicating that they did not trust large carnivore scientists, or they did not consider science to be an independent knowledge base. Our findings in Paper I and Paper II indicated that trust in large carnivore science and research statements most likely relate to attitudes towards large carnivores, without testing for the relationship between the concepts. This is in accordance with previous Norwegian studies that found trust in environmental institutions and support of management policies were associated with attitudes towards large carnivores (Skogen et al. 2018). In Paper III, we found that attitudes towards wolves globally tend to be more negative among hunters and farmers, compared to the general public. Further, surveys of people that lived in areas where wolves had been present continuously reported more negative attitudes than surveys of people living in areas where wolves had recolonized after being locally extinct for a while and areas where wolves were absent.

To achieve human-carnivore coexistence, society needs to adjust to and accept some level of cost associated with large carnivores (Carter and Linnell 2016, Carter et al. 2019). However, support for this will be limited in those who are likely to experience those costs personally. If ecological science is used to justify the management leading to such a state, a lack of trust in science and negative attitudes should be expected. In that scenario, science may become a threat to local peoples' interests, and associated with the unfair policies resulting in an uneven distribution of costs between urban and rural people (Ericsson et al. 2008). Even though scientists may perceive themselves as neutral, contributing objective scientific knowledge to facilitate better management decisions, they will not be perceived in that light by all. Further, ecological science is only relevant to the ecological side of the socio-ecological system and should avoid being mixed in with other arguments over values and beliefs. Related to this, closer cooperation between scientists and managers has been suggested as a way of improving management success (e.g., Cook et al. 2013, Swenson et al. 2017, Durant et al. 2019). However, this may make it more challenging for the public to distinguish between the two and may make

people doubt scientists' motivation in management recommendations further. If this is true, building trust in large carnivore science will rely on simultaneously building trust in carnivore management agencies. Science communicators should be aware of their role and consider appointing specific local carnivore experts to engage with the media and verify information.

The public does not necessarily have direct contact with scientists, at least not on a regular basis. Instead, they largely derive their knowledge from the media, such as newspapers, magazines, TV, radio and social media. Arbieu et al. (2019) found that people receiving their information about wolves from scientist through the Wolf Centre, perceived themselves as better informed and had on average more positive attitudes towards wolves compared to those getting their information from news and social networks. As the source of information varies with attitudes, possible future research regarding trust in large carnivore science should look at where people with the least trust in science get their information from. Given the rural vs urban perspective, with Paper I and Paper II indicating that lower trust is associated with variables common for rural areas, it would be interesting to know how the information sources differ. Analysis of media news coverage has found that local news tends to be framed more negatively (Chandelier et al. 2018) with a focus on the conflict, while national outlets report more on topics relating to wolf policy and biological status (Killion et al. 2019). As local media tends to mention wolves in cases where losses or damage have occurred locally, it could change weak and neutral attitudes into negative attitudes, as has been speculated to happen in local areas in Norway (Krange et al. 2017). Information in social media can be biased towards a graphic/sensationalist depiction of carnivores, which can spread unjustified fear towards these species (Nanni et al. 2020). In Norway, the grazing industry, especially sheep farmers, have a strong voice (Sandström et al. 2018), and consequently policies seem to focus less on other stakeholders (Skogen et al. 2017). We urge that attention is also given to people that does not feel strongly about large carnivores, as these are the ones that are most likely to change their attitude as a result of information interventions (Heberlein 2012). It is important to target communication and education at these groups as well, as they are more likely to be swayed by messages about wolf management issues.

Among groups with low levels of trust in carnivore science, such as hunters, citizen science could help make results more likely to be accepted as unbiased and reliable as a basis for management decisions (Ostermann-Miyashita et al. 2021). Increased efforts to include these groups in research projects, or involve them in discussions, may help to bridge perceived gaps between scientists and hunters, as well as other stakeholder groups. It might further help

stakeholders to get a better understanding of the roles of managers and scientists. Acknowledgment of different types of knowledge and knowledge sources, including local knowledge, such as personal experiences, traditions and culture, in addition to science, can help to improve legitimacy in management decisions (Sandström et al. 2015). Co-creation of knowledge including both scientists and stakeholders may improve the perceived legitimacy of the knowledge used to inform management decisions and consequently increase support for large carnivore management policies.

Future research

In Paper III, we assessed peer-reviewed studies and discovered that the frequency of assessing attitudes towards wolves is increasing and is spreading to cover the global distribution of the species. The ultimate goal of measuring attitudes is to use the results to predict how people will behave towards future management policies. As seen in Paper III, attitudes ranged from negative to positive, but to achieve the study's objective, simplifications were needed, reducing the levels into negative, neutral, and positive. In doing so, we lost information regarding how strongly held the attitudes were, and therefore could not assess the probability of attitudes being changed. As we live in a world where the human impact on wildlife is increasing and large carnivore species are recovering in many areas, human-wildlife interactions will continue to be dynamic, knowing more about how likely these attitudes are to change will be important.

A question we have not been able to investigate is whether disagreements in scientific results are also associated with mistrust in science in general. Another issue for further investigation is the relationship between trust in large carnivore science and trust in management agencies, as well as political trust. Kahan (2017) refers to the problem of communicating science, arguing that a central point of solving disputes is to understand how the people have come to know what they know about science. This is a task for future research on trust in large carnivore science. A better understanding and further monitoring of social trust and trust in large carnivore science, and the linkages to attitudes and, ultimately, behavioral intention to support management, will help to tailor trust-building outreach. Large carnivores are on the increase due to favorable policy changes and a greater focus on conservation (Trouwborst 2010, Kaczensky et al. 2013, Chapron et al. 2014). As people may change their attitude with more experience of the animals, scientist need to monitor changes in both trust and attitudes. I recommend that future attitude surveys should incorporate a standardized system for reporting attitudes towards wildlife species to facilitate spatio-temporal analysis of perceptions of wildlife species. Secondly, social science competence is required to achieve more comparable

measurements, ideally including both cognitions and emotions, to improve predictions of people's responses to wolf management actions (Jacobs and Vaske 2019, Straka et al. 2020, Dheer et al. 2021).

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Trust in large carnivore science in Norway

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Abstract

Large carnivores are controversial species, and associated conflicts between stakeholders with opposing views on large carnivores are observed across the globe. Social trust, the public's willingness to rely on those responsible for developing policies, has gained much attention regarding the acceptance of large carnivores and large carnivore management. However, trust in large carnivore science has not received as much consideration. In Norway, administrative management authorities are responsible to execute the political framework decided by the Norwegian Parliament while basing their decisions on recommendations from large carnivore science. As large carnivore science is the main knowledge provider for monitoring and measures implemented in management decisions to achieve viable carnivore populations, trust in science is crucial. Yet, scientific information is often challenged. As attitude studies show a tendency for the wider general public to be more positive towards large carnivores than people most adversely affected, we wanted to examine whether the trust in large carnivore science follows the same pattern. We used a geographically stratified sample of 2110 respondents, five respondents from each municipality in Norway, to model how trust varies across the sample. Our results indicate that elderly men, people with lower education, those who have experienced loss of livestock to carnivores associate with lower trust in large carnivore science. Lower trust was also found among big game hunters and people who fear large carnivores. This knowledge could help to guide targeted science communication and contribute to a more comprehensive understanding of cognitions important for management of conflicts involving large carnivores.

Keywords Large carnivores conflict · Wildlife management · Human dimensions · Trust in science · Science communication

Introduction

Large carnivores are controversial species (Dickman 2008; Lewis et al. 2017), and associated conflicts between stakeholders with opposing views on large carnivores are observed across the globe (Chapron et al. 2014; Lozano et al. 2019; Treves and Karanth 2003). Emotional responses to large carnivores range from admiration to hate (Johansson et al. 2012; Sjölander-Lindqvist et al. 2015). As general attitudes towards

an object are a relevant predictor of broad behavioral patterns (Fishbein and Ajzen 1977; Fiske and Taylor 1991), knowledge about the public's attitudes towards large carnivore has been used to predict the social foundation for future conservation (Vaske and Manfredi 2012). Negative attitudes at an individual level can, for instance, lead to poaching, a frequently observed problem for the conservation of several threatened carnivore species (Gangaas et al. 2013; Liberg et al. 2012; Woodroffe and Ginsberg 1998). At a societal level, negative attitudes can induce public resistance to conservation plans and policies (Bruskotter and Fulton 2012; Sandström et al. 2015). Social-psychological theories have contributed to an understanding of behavior based partly on concepts involving general cognitions, such as attitudes, beliefs, norms, and trust (Schwartz 1992; Siegrist et al. 2000; Stern et al. 1999). Such theories are used extensively to guide research in human dimensions of wildlife, and the importance of attitudes has, for example, been highlighted as the basis for people's assessment of environmental management (Bright and Manfredi

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1996; Teel and Manfredo 2010; Vaske and Manfredo 2012). The cognitive hierarchy theory (Fulton et al. 1996; Homer and Kahle 1988; Vaske and Donnelly 1999) states that behavior can be predicted, to some extent, by lower levels of cognition, but more specific levels of cognition such as attitudes and norms have proved to be better predictors (Ajzen and Fishbein 2005; Whittaker et al. 2006). Attitudes are considered rather stable positive or negative evaluations of an object, and the more specific they are in terms of the object in question, the better the attitude becomes as a predictor (Heberlein 2012). Moreover, it has been suggested that people's attitudes towards objects such as policies are influenced by the trust they have in the management agency (Vaske et al. 2007).

Trust has been claimed to have a fundamental role in conservation conflicts (Stern and Coleman 2015; Young et al. 2010, 2016). It has been suggested that a willingness to rely on those responsible for developing policies, called *social trust* (Cvetkovich and Winter 2003), is essential for establishing cooperation between an agency and the public (Beierle and Konisky 2000; Cvetkovich and Winter 2004). Ultimately, the public may not support management options because they lack trust in the management agencies (Borrie and Liljeblad 2006; Cvetkovich and Winter 2004; Nyaupane et al. 2009). It has been proposed that social trust mediates the relationship between shared values and attitudes towards environmental management such as wildland fire management strategies (Vaske et al. 2007), sharpshooting programs to reduce the spread of chronic wasting disease (CWD) (Harper et al. 2015), and large carnivore management (Sponarski et al. 2014).

In addition to management agencies, scientists have been argued to play an important role in conservation conflict management (Pullin et al. 2004; Sutherland et al. 2004), for example, by providing a better understanding of the root causes of conflicts, helping to discover and test mitigation techniques, and exploring trade-offs (Bennett et al. 2017a, b; Redpath et al. 2013). Yet, scientific inquiry is constantly at risk of being politicized in environmental controversies (Sarewitz 2004), challenging the trust people hold in scientific knowledge. Scientists can be perceived as biased if they advocate positions fitting with only some of the stakeholders (Sutherland et al. 2004) or frame questions and interpret results supporting one side rather than the other (Treves et al. 2006). Furthermore, stakeholders may focus solely on findings that support their own position, contributing to an impression of science being politicalized (Thirgood and Redpath 2005). The Norwegian large carnivore management is based on a national policy defined by the Norwegian Parliament, where the government prepares specific management goals for the large carnivore species. The administrative management authorities are responsible for ensuring that the political framework is followed at both local (Municipality) and regional (County) levels. This makes the

large carnivore management a mixture of centralized and decentralized processes (de Boon et al. 2020). The county governor is responsible for implementing state directives together with local carnivore committees (rovviltnefder), and local politicians will work for local democratic influence that is not necessarily in line with national administrative goals. In the midst of this complexity between local and national governance and influence, large carnivore science works as a knowledge provider giving professional recommendations.

Norwegian studies report that large carnivore science is regularly being challenged (Skogen et al. 2018) and cherry-picked by stakeholders to benefit their own interests (Skogen and Thrane 2007). This may cause people to lose trust in carnivore science. We believe it is important to include trust in carnivore science when trying to understand the cognitions important for management of conflicts involving large carnivores. People holding more negative attitudes towards large carnivores often claim that local knowledge is ignored by those in power, e.g., politicians, managers, biologists, and conservationists (Skogen and Krangle 2003). Judgments on trust relies on heuristics (Cvetkovich and Winter 2007), including similarity between oneself and the person or organization to be trusted (Balliet and Van Lange 2013), and positive affect towards that person/organization (Schoorman et al. 2007). People tend to trust those they perceive to hold the same values as themselves (Johansson et al. 2017; Stern and Coleman 2015). We consider it urgent to better understand which variables underlie the lower trust of some people in both carnivore scientists and the management agency. This would strengthening trust.

Direct experience with wolves (*Canis lupus*) have been observed to associate with negative attitudes towards the species (Eriksson et al. 2015; Williams et al. 2002). People living in large carnivore areas are potentially negatively affected by large carnivores (Krangle et al. 2017b), for example, by experiencing losses of domestic animals (Røskaft et al. 2007), being a hunter and thus experiencing competition for big game species (Naughton-Treves et al. 2003; Treves and Martin 2011), and/or fear of meeting these animals in the wild (Krangle et al. 2017a). In addition, as the influence from what friends, peers, and enemies think can strongly affect a person's attitude (Boninger et al. 1995; Petty et al. 1997), indirect experiences (e.g., relying on other people's experiences rather than personally being exposed to carnivores or seeing tracks or signs; Eriksson et al. 2015) can be important influencing attitudes (Karlsson and Sjöström 2007). People living in areas with big game hunting traditions and high sheep densities have earlier reported more negative attitudes towards large carnivores (Gangaas et al. 2013). Further, sociodemographic variables have also been included in attitude surveys. While the association between gender and attitudes toward large carnivores

have been observed to vary, with both males and females being most negative (Kleiven et al. 2004; Røskaft et al. 2007; Williams et al. 2002), higher age (Bjerke et al. 2002; Dressel et al. 2015; Røskaft et al. 2007) and lower education (Dressel et al. 2015; Williams et al. 2002) have been associated with more negative attitudes towards large carnivores.

Large carnivore presence varies geographically in Norway, with some regions having all four large carnivore species, brown bear (*Ursus arctos*), wolf, Eurasian lynx (*Lynx lynx*), and wolverine (*Gulo gulo*) present, while others have none. To meet the two-folded objective of large carnivore management in Norway, both ensuring viable populations of large carnivores and securing a sustainable grazing industry, the Norwegian parliament have established a zonal management system (Hansen et al. 2019; Strand et al. 2019). Carnivore management zones prioritized for large carnivore species are thus separated from areas prioritized for grazing livestock. The uneven distribution of large carnivores and consequently the variation in experiencing negative consequences associated with living close to these species are therefore expected to vary geographically. To capture skepticism and negative perceptions at smaller spatial scales, without losing those voices in proportional surveys, non-proportional sampling methods are useful (Ericsson et al. 2006). Considering the important influence of geographical variation in carnivore presence and any associated negative experiences, on people's attitudes towards these animals, we wonder whether this spatial variation also influences trust in large carnivore science.

Here we wanted to examine whether variables known to influence peoples' attitudes towards large carnivores associate with trust in large carnivore science, as this could contribute to improve future science communication. In order to build trust among the public, a better understanding of the characteristics that describe people with low trust in carnivore science is important, potentially helping communicators to identify needs leading to more efficient science communication. This study aims to contribute to that understanding by exploring the association between trust in large carnivore science and variables related to carnivore presence and consequently how people perceive them. We examine whether the level of trust in carnivore science can simply be described by sociodemographic patterns and local presence of carnivores, or whether it follows a more complex pattern based on multiple factors. Therefore, we hypothesize that respondents living in areas with large carnivores show lower trust in large carnivore science, as they are more directly affected compared to respondents living far away from large carnivore species. We hypothesize that variables within the variable-group of rural context associate with lower trust in large carnivore science. Last, we hypothesize that trust in carnivore

science will differ with age, gender, and education level among our respondents, and that respondents with higher levels of self-reported fear will have lower trust in large carnivore science. Ultimately, we hope that by improving the knowledge of trust in carnivore science, we can facilitate a better understanding of the cognitions important for management of conflicts involving large carnivores.

Method

Respondents and data collection

The study included 2110 respondents (43% female, 57% male), aged between 15 and 92 years (mean age = 45.63, SD = 17.72 years), representing five respondents from each of Norway's 422 municipalities. The sampling was done by a data collection agency (www.norstat.no), and the data frame was based on existing registers that are publicly available, and respondents were sampled randomly within a municipality until five persons from that municipality had completed the survey. This geographically stratified sampling procedure allowed for the inclusion of people from all over the country, and with a mixture of different backgrounds, carnivore presence and experiences with large carnivores. The data collection agency is not required to seek permission for this kind of data collection from the Norwegian Social Science Data Service (NSD; www.nsd.no). NSD is the institution reviewing research proposals for data collection, but an ethics review and a permit are only required in cases where the researchers and/or the data collection agency retain a register of respondents for purposes such as reminders or follow up surveys. This was not the case for our study, and we have no register or any other kind of information that can be used for linking individuals to the data set.

Survey

The questionnaire used for the survey included items on trust, rural context, and sociodemographic variables. Trust in large carnivore science was measured based on how the respondent rated the statement "I trust large carnivore science produced in Norway," and this was used as the response variable in the statistical analysis. Respondents were also asked to rate statements about their trust in science in general, in climate science, and in medical science in the same format. Respondents were asked to respond to these statements using a five-point Likert scale from 1 = "strongly disagree" to 5 = "strongly agree" with 3 = "neutral".

Predictor variables

The predictor variables were collected both through the survey and from official available databases, and were divided into four groups with different themes before the analysis (Table 1). The first group included sociodemographic variables such as age, gender, and education. Age was included as a continuous variable to explore if there is a general trend of changes in trust with increasing age. The second included variables for whether carnivores in general or wolves in particular were present or not in the respondents' residential municipality. Data on large carnivore presence were obtained from Rovdata (<https://rovdata.no/>), while hunter ration and sheep density were obtained from Statistics Norway (<https://www.ssb.no/en>). Given that people may be more aware of carnivore management zones than carnivore distribution, a variable about whether the municipality of the respondent was covered by a management zone of at least one of the four carnivore species was included. In addition, a variable on whether the municipality is within the national wolf zone was also included. Lastly, this group included a question in which respondents were asked which of the four large carnivores they thought were present within their municipality, to examine whether their awareness of carnivore presence was more important than data on carnivore presence regarding their reported trust in carnivore science. The third group was named rural context and focused on respondent's experience of losses of livestock, density of free ranging sheep in the municipality, and big game hunting traditions, which according to previous research are important characteristics defining this context (Gangaas et al. 2013). In addition, we asked whether respondents were big game hunters themselves. In Norway, hunting traditions are deeply established in the country's history and culture, with big game hunting including the hunting of moose (*Alces alces*), roe deer (*Capreolus capreolus*), wild reindeer (*Rangifer tarandus*), and red deer (*Cervus elaphus*). Generally, local hunters have good access to hunting through informal connections with landowners or through organized hunting teams. The final group of factors consisted of a self-reported level of fear towards each of the four large carnivore species present in Norway (see full variable description in Table 1).

Statistical analyses

Trust in carnivore science was a 5-level categorical response variable. We analyzed how it varied in response to different combinations of the explanatory variables (Table 1) using multiple ordinal linear regression models. We also wanted to understand which of the variables in the different group best described the variation in the level of trust in large carnivore science. For example, within the group "carnivore presence, was it the presence of

carnivores in general, the presence of wolves in particular or whether, or not a respondent lived within a defined carnivore zone that best described the variation in trust? The candidate models constructed and the model selection procedure reflect these considerations. Although it might be expected that some of the variables would interact, we only considered additive effects and no interaction effects due to data restrictions. The models were constructed using the MASS-library (Venables and Ripley 2013) in the statistical environment (R Core Team 2019), and we used an information theoretic approach based on AIC-values (Burnham and Anderson 2002) to objectively select the most supported model for variation in trust.

Results

Trust in science in general and specific scientific disciplines

We found lower levels of trust in large carnivore science and climate science compared to medical science (Table 2). While approximately four out of five either agreed or highly disagreed with the statements on having trust in medical science, only 58% did so for carnivore science. Almost one out of five respondents disagreed or highly disagreed in having trust in large carnivore science.

Models of trust in carnivore science

The most supported model describing the variation in trust in large carnivore science included variables from all groups and were gender, age, education, wolf presence, big game hunter, experienced loss, and fear of wolves (Table 3). The specific effects within each variable group are described in more detail below.

Sociodemographic variables

The probability of agreeing with the statement concerning trust in large carnivore science decreased as a function of age (Fig. 1a). Gender differences were less obvious, but females showed a slightly higher probability of highly agreeing to trust in carnivore science compared to males (Fig. 1b). People who completed high school as their highest education level agreed less with the statement concerning trust in large carnivore science compared to other types of education levels. Besides that, the probability of highly agreeing with the statement concerning trust in carnivore science generally increased with education level (Fig. 1c).

Table 1 Predictor variables included in the model selection. The column named source state whether information about the variable were collected from the survey or are official statistics, named official data, achieved from open data sources

Variable	Description	Numerical summary (total=2110)	Source
(i) Sociodemographic			
Age	Continuous variable representing the individual specific age of the respondents	Mean (yr) = 45.63 (SD = 17.72), range (yr) = 15–92	Survey
Gender	Categorized into “male” or “female”	Female = 906, Male = 1204	Survey
Education	Highest level of education for the respondent. Categorized as primary education, high school, lower degree university (bachelor), or higher degree (master or PhD)	Elementary = 191 High school = 907 Bachelor = 651 Master or higher = 361	Survey
(ii) Carnivore presence			
Presence of carnivores	Officially registered observations or signs (tracks, fur), within the last 5 years of either lynx, bear, wolf or wolverine in the municipality, categorized as “present” or “not present”	Present = 1545 Not present = 565	Official data
Presence of wolves	Officially registered observations or signs (tracks, fur), within the last five years of wolves, categorized as “present” or “not present”	Present = 775 Not present = 1335	Official data
Carnivore zone	Presence of a management zone of at least one of the species wolverine, brown bear, and lynx within the municipality of the respondent. Categorized as “within” or “outside” management zone	Within zone = 1250 Outside zone = 860	Official data
Wolf zone	Municipality being within the national wolf zone. Norway has one established wolf zone, consisting of land in the East bordering Sweden, in which wolves are to be prioritized over other human interests, e.g. livestock farming. Categorized as “within” or “outside” management zone for wolves	Within zone = 265 Outside zone = 1845	Official
Perception of carnivore presence	The respondent’s statement about which of the four large carnivores they think are present in their municipality, categorized as “present” or “not present”	Present = 1480 Not present = 630	Survey
(iii) Rural context			
Big game hunter	Whether the respondent hunts big games (moose, roe deer, wild reindeer, and red deer)	Yes = 410 No = 1700	Survey
Big game traditions in area	To what degree do respondents agree with the statement: “There are strong traditions for big game hunting in your municipality”	Highly agree = 310 Agree = 179 Neutral = 229 Disagree = 432 Highly disagree = 959 No answer = 1	Survey
Hunter ratio	The number of registered big game hunters divided on the total number of inhabitants in municipality of the respondent	Mean = 0.15 (SD = 0.08), range = 0.03–0.43	Official data
Sheep density	The density of free ranging sheep in the municipality	Mean = 178.27 (SD = 222.50)/km ² , range = 0.00–2206.70 / km ²	Official data
Experienced loss	Experience of personal loss of pets or livestock to large carnivores, categorized as “no” or “yes”	Yes = 194 No = 1916	Survey
(iv) Fear			
Fear	Self-perceived fear of each large carnivore species, categorized into “not scared,” “little scared,” “pretty scared,” and “very scared” given for bears/wolves/lynx/wolverine	Not scared = 302/416/507/429 Little scared = 812/648/877/947 Pretty scared = 438/781/339/292 Very scared = 558/265/387/442	Survey

Table 2 The number of respondents reporting different levels of agreement with statements about different science disciplines with the percentages (%) shown in brackets. Total number respondents for each science discipline $n=2210$

Type of science	Level of trust				
	Highly disagree	Disagree	Neither	Agree	Highly agree
Science in general	72 (3.41)	112 (5.31)	349 (16.54)	662 (31.37)	915 (43.36)
Medical science	54 (2.56)	69 (3.27)	241 (11.42)	740 (35.07)	1006 (47.68)
Climate science	170 (8.06)	197 (9.34)	424 (20.09)	591 (28.01)	728 (34.50)
Large carnivore science	186 (8.82)	193 (9.15)	508 (24.08)	669 (31.71)	554 (26.26)

Carnivore presence

All variables included in the section of carnivore presence improved the model compared to a model setup containing only sociodemographic variables (Table 3). However, the most supported model included wolf presence, where respondents living in municipalities with wolves showed lower agreement with the statement concerning trust in large carnivore science, on average (Fig. 2).

Rural context

Including some of the variables describing a rural context improved the model fit (Table 3). Respondents that reported to be a big game hunter themselves were more likely to report lower levels of agreement in the statement concerning trust in carnivore science (Fig. 3a). The likelihood of responding agree or highly agree were higher for non-hunters than for hunters. Relatively few had experienced loss ($n=194$), but they agreed less with the statement concerning

Table 3 The candidate models used in the model selection, with $\Delta AICc$ and degrees of freedom. The candidate model in bold was the most supported model as judged from AICc values

Candidate models	$\Delta AICc$	Degrees of freedom
<u>(i) Sociodemographics</u>		
Gender	205.9	5
Age	203.5	5
Education	163.4	7
Age + education	152.7	8
Gender + age + education	150.5	9
<u>(ii) Sociodemographics + carnivore presence</u>		
Gender + age + education + wolf zone	149.8	10
Gender + age + education + Carnivore presence	141.1	10
Gender + age + education + carnivore zone	139.1	10
Gender + age + education + perception carnivore presence	137.6	10
Gender + age + education + wolf presence	131.2	10
<u>(iii) Sociodemographics + carnivore presence + rural context</u>		
Gender + Age + education + wolf presence + hunter ratio	115.4	11
Gender + age + education + wolf presence + sheep density	132.4	11
Gender + age + education + wolf presence + big game hunting traditions	115.1	11
Gender + age + education + wolf presence + big game hunter + Sheep density	76.6	12
Gender + age + education + wolf presence + big game hunter	75.7	11
Gender + age + education + wolf presence + experienced loss	75.3	11
Gender + age + education + wolf presence + big game hunter + Experienced loss	33.6	12
<u>(iv) Sociodemographics + carnivore presence + rural context + fear</u>		
Gender + age + education + wolf presence + big game hunter + experienced loss + fear of bears	34.7	15
Gender + age + education + wolf presence + big game hunter + experienced loss + fear of lynx	25.1	15
Gender + age + education + wolf presence + big game hunter + experienced loss + fear of wolverines	22.3	15
Gender + age + education + wolf presence + big game hunter + experienced loss + fear of wolves	0.0	15

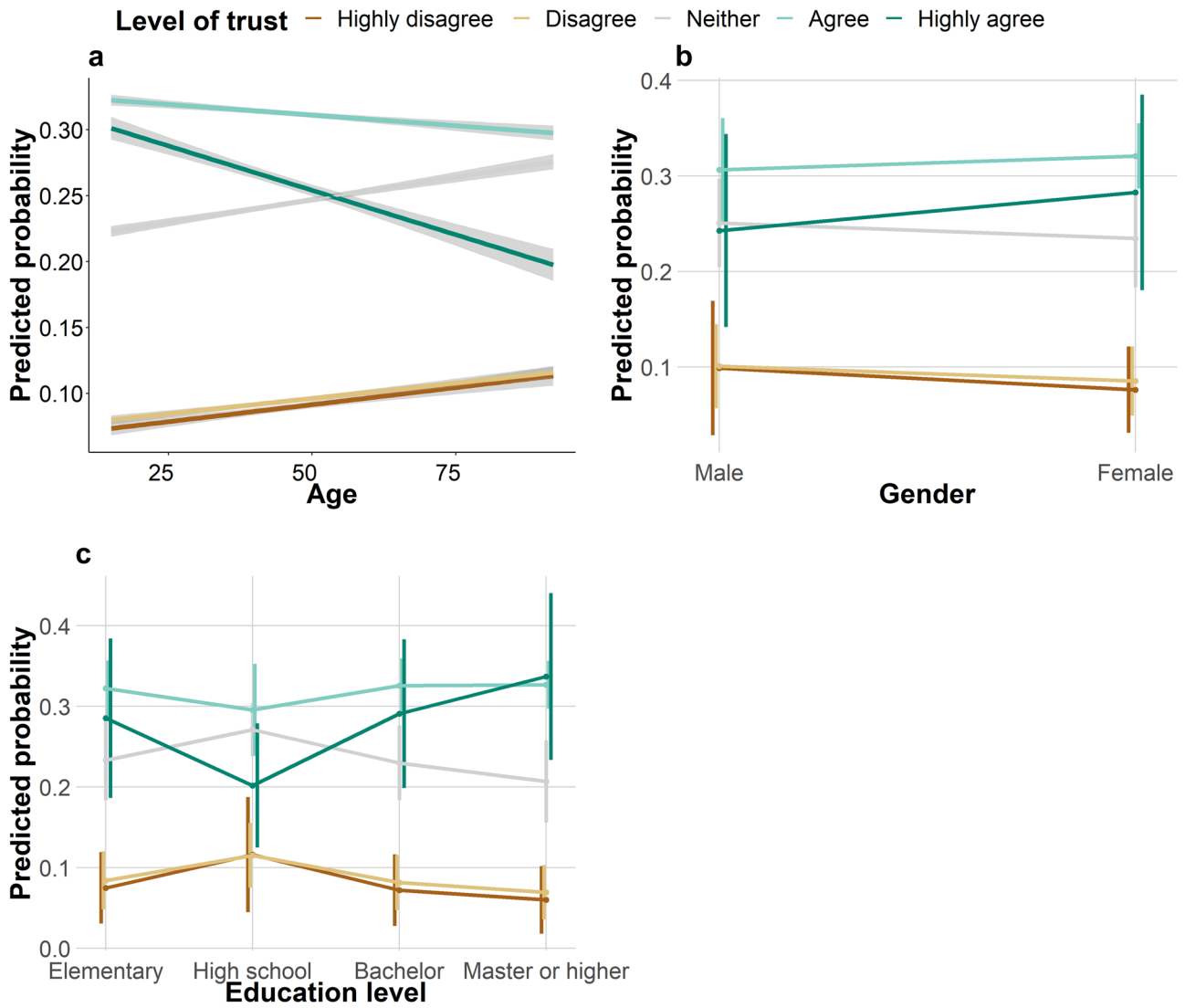
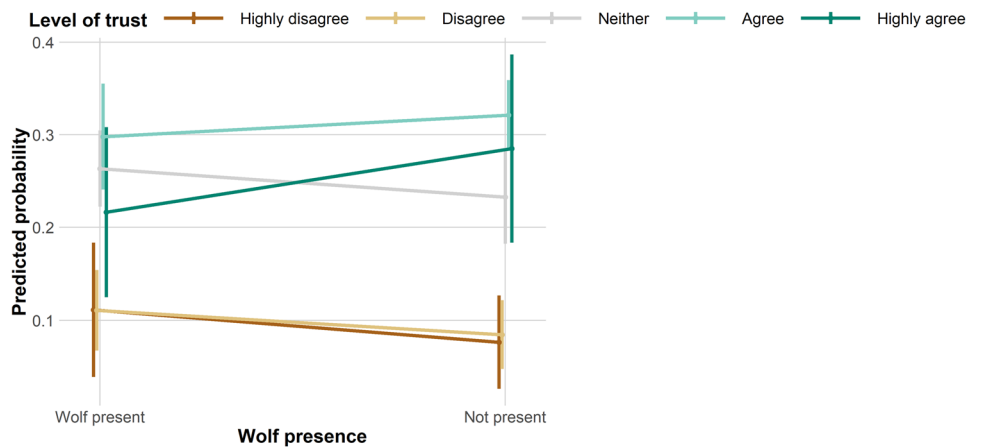


Fig. 1 The predicted probability of each of the five levels of agreement to the statement of trust in large carnivore science as a function of age (a), gender (b), and education level (c). The vertical lines depict the SD for each category

Fig. 2 The predicted probability of each of the five levels of agreement to the statement concerning trust in large carnivore science as a function of whether the respondent lives in a municipality where wolves were present. The vertical lines depict the SD for each category



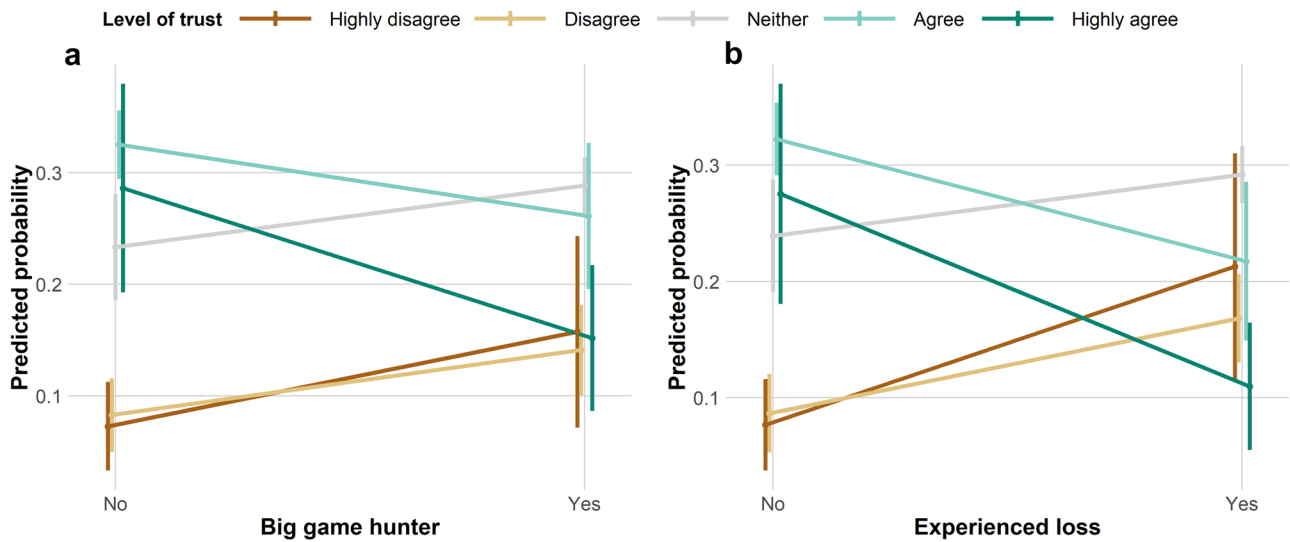
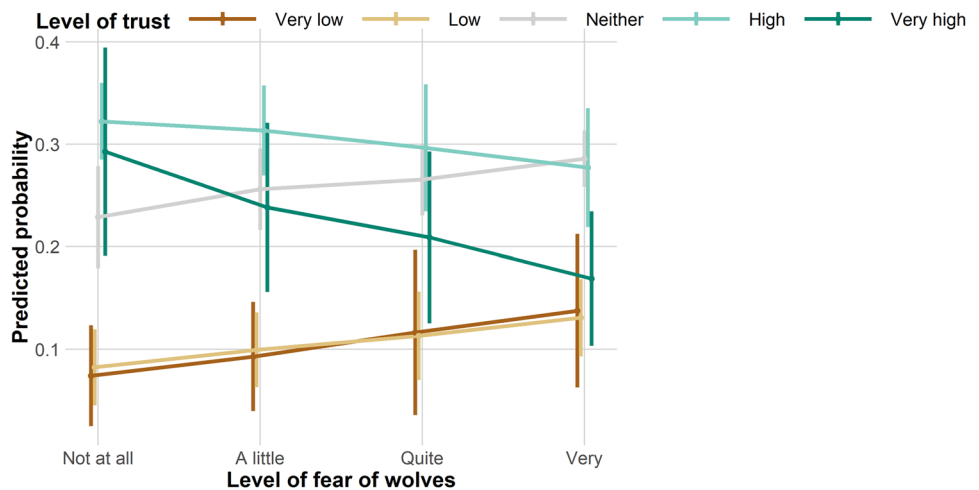


Fig. 3 The predicted probability of each of the five levels of agreement to the statement concerning trust in large carnivore science as a function of being a big game hunter or not (a) and having experienced loss to large carnivores or not (b). The vertical lines depict the SD for each category

Fig. 4 The predicted probability of each of the five levels of agreement with the statement concerning trust in large carnivore science as a function of respondents' self-reported level of fear of wolves. The vertical lines depict the SD for each fear level



trust in large carnivore science than people who had not experienced any loss (Fig. 3b).

Fear

The results suggest that trust in large carnivore science is negatively associated with a fear of wolves, with the probability of responding agree or highly agree to the statement concerning trust in large carnivore science declining with every increase in level of fear, from not scared, little scared, pretty scared, and very scared of wolves (Fig. 4). The probability of responding disagree and highly disagree increased the most with increased fear of wolves. Fear towards the

other species (e.g., wolverine, lynx, and brown bear) were also associated with mistrust in carnivore science, but to a lesser extent.

Discussion

Lower trust in large carnivore science associated with the variables wolf presence, being a big game hunter, having experienced loss of livestock to carnivores, older age, less education, being a male, and self-reported higher levels of fear of wolves. Essentially, the results show that there is no single variable alone that predicts a lower trust in carnivore

science, but rather a combination of variables, many of which vary spatially. Compared to the other categories of science, carnivore science and climate science experience lower levels of trust than medical science. The observed lower trust in climate science, and perhaps carnivore science, may be partly explained by the different nature of the science categories included in the survey. Previous studies have suggested a trend towards lower levels of trust in what may be called impact science, e.g., science that identifies environmental and public health impacts of economic production, than in production science, e.g., science that provides new inventions for economic production (McCright et al. 2013). Denying evidence that does not conform to one's ideological worldview, values or ideology, is not uncommon, exemplified by the denial of climate change by many political conservatives in the USA (Dunlap and McCright 2015; McCright and Dunlap 2011). The presence of carnivores varies greatly between different parts of Norway, and consequently so do the potential negative consequences of living with these animals. We observed that respondents who lived in municipalities with large carnivores generally had a lower trust in carnivore science than respondents living elsewhere, with the strongest effect being found for the presence of wolves. This result is consistent with previous studies showing that people who reported personal experience of signs of wolves in the area where they lived had relatively lower social trust in the managing authorities (Johansson et al., 2012).

Wolf presence has been associated with negative attitudes towards carnivores in several previous studies (Karlsson and Sjöström 2007; Krange et al. 2017a; Skogen and Krange 2003). Direct experience with wolves has been observed to correlate with negative attitudes towards both the animals and wolf policy goals (Ericsson et al. 2006; Eriksson et al. 2015). As zoning has become an important management strategy in Norway, uneven costs of coexistence will continue to be the reality. Based on our results, this will exacerbate regional variation in levels of trust. A person's experience of large carnivores may be perceived differently depending on their attitudes towards the animal. For example, some people living in carnivore areas report their experience of wolves as being unwanted, agonizing, assertive, or unnatural (Skogen et al. 2018). If scientific knowledge presented by large carnivore scientists is not in line with people's personal experience, for example communicating that wolves tend to be shy, people may lose trust in large carnivore scientists.

Both wolf presence and fear of wolves are included in the top model, indicating the importance of wolves in influencing people's level of trust in large carnivore science. Wolves are perceived as a flagship species, and may thus be more frequently associated with social conflicts than other large carnivore species (Douglas and Verissimo 2013).

Researchers have sought to explain the underlying socio-cultural causes of the observed controversies accompanying wolf presence (Kaltenborn and Bjerke 2002; Skogen and Thrane 2007). Among other observations, wolves can symbolize urban dominance over rural areas, contributing to a divide between urban and rural inhabitants (Enck and Brown 2002; Skogen and Krange 2003). Attitudes towards wolves seem in general to be more negative than those towards other large carnivores species in Norway (Dressel et al. 2015; Krange et al. 2017b), and seem to have a special position in people's awareness (Figari 2008; Figari and Skogen 2011). Krange and Skogen (2018) observed an association between lower trust in environmental institutions and negative attitudes towards wolves in Norway. Consequently, it may not be surprising that we observed wolf presence and fear of wolves to be included in the top model rather than variables relating to other species.

Negative experience, such as loss of livestock, was associated with a mistrust of carnivore science and has previously been shown to associate with negative attitudes towards carnivores (Kleiven et al. 2004; Røskaft et al. 2007). Social scientists have argued that personal importance of an issue is a key feature in studies of attitude-behavior relationships (Ajzen and Fishbein 2005; Bright and Manfredi 1996). Farmers owning free ranging sheep and big game hunters wanting to maximize big game abundance will have an interest in reducing the population sizes of large carnivores. Previous research has suggested that vested interests in a topic may motivate people to reject science communicated to them that is not compatible with their interests (Hornsey and Fielding 2017; Kunda 1987). Stakeholders that perceive carnivore science as being unbeneficial may thus be more likely to repudiate information communicated to them. Also, new relevant information that stand against currently held experiences and views may result in cognitive dissonance, making people rejecting it (Festinger 1957). Further, discomfort about the notion of the potential influence of policy preferences of scientists has been discussed in previous research (Lackey 2007). It should be noted that people tend to trust agencies that they perceive to hold similar values as themselves (Siegrist et al. 2000). On the other hand, distrust happens if the management agency is thought to have other values, or if it operates in a perceived inconsistent way with shared values for non-legitimate reasons (Cvetkovich and Winter 2003). Lack of power, e.g., if the management agency is not being perceived to control the situation, can lead to lower trust, as observed in management of threatened and endangered species (Cvetkovich and Winter 2003). While carnivore scientists are not directly responsible for management decisions, people may still have expectations to scientific knowledge being implemented into the management principles. Distinguishing between the distribution

of roles and responsibilities between decision makers, managers, and scientists in relation to the complexity of the large carnivore issues may be difficult for people in general. If people fail to recognize the contributions of large carnivore scientists, they might lose trust in them and their role as knowledge providers.

Social trust plays an important part in achieving efficient nature management (Cvetkovich and Lofstedt 2013; Sponarski et al. 2014). The existence of trust allows agencies to work without the need to continuously ensure that stakeholders will act acceptably. Zajac et al. (2012) argues that raising an individual's social trust in the management agency can indirectly lead to increased stakeholders' acceptance of large carnivores. Trusted organizations do not need to continuously argue for their decisions and defend their policies and actions. We found that trust in large carnivore science is associated with very much the same variables as attitudes to large carnivores. Consequently, provision of science-based information to the public, while simultaneously building trust in information, is an approach that may reduce extreme attitudes and increase acceptance of large carnivores (Arbieu et al. 2019). This may further influence support in management decisions (Heberlein 2012; Sponarski et al. 2014).

Altogether, our results show that distrust in large carnivore science is associated with a distinct suite of characteristics. The variables describing these are available to and could be used by managers and science communicators. Our approach, while not being proportionally representative of the population, show patterns that will be useful for detecting distrust. This can in turn help guide science communication and the use of resources spent on interventions aimed at providing prerequisites for local people to lower their level of fear or increasing their trust in large carnivore science. Large carnivore scientists need to better understand how different factors, processes, and dynamics play in building mistrust in general, and we also think that both large carnivore scientists and management authorities need to clarify roles they fulfill. Closer cooperation between scientists and managers has been suggested to improve management success, but this may make it more challenging for the public to distinguish between them, and may make people doubt scientists' motivation in management recommendations. If this is true, building trust in carnivore science will rely on simultaneously building trust in carnivore management agencies. Wildlife professionals could help in reducing controversy around large carnivores by clearly delineating policy decisions from the scientific contributions used to reach to those decisions (Bruskotter 2013). Science communicators should be aware of their role, and specific local experts could be appointed to engage with media and verify information accuracy of large carnivore science. Further, ensuring the communication of science-based information on both costs and benefits of large carnivores is crucial to gain trust in large carnivore science over time.

To reduce the risk of local communities feeling neglected, citizen science, e.g., involving citizens in data collection such as monitoring, and encourage participation in management strategy development, may help to develop a trustful relationship with science (Anhalt-Depies et al. 2019; Ostermann-Miyashita et al. 2021). In groups with low levels of trust in carnivore science, e.g., hunters, citizen science could aid to make results more likely accepted as unbiased and reliable as basis for management decisions. Increased effort in including these groups in the research projects, or being invited in different discussions, may help bridging the perceived gap between scientists and hunters, as well as other stakeholder groups. Acknowledgment of different types of knowledge and knowledge sources, including local knowledge, such as personal experiences, tradition, and cultural, in addition to science, can help to improve legitimacy in management decisions (Sandström et al. 2015). Co-creation of knowledge including both scientists and stakeholders may improve perceived legitimacy of the knowledge used to inform management decisions and consequently increase support for large carnivore management policies.

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Availability of data and material We will make all data available upon request. The data set will be archived for at least 10 years.

Code availability Open access.

Declarations

Ethics approval and consent to participate The survey was conducted by a data collection agency (NORSTAT; www.norstat.no) between April and June 2019. The interviews follow a strict protocol as dictated by standard research ethics. Neither the research agency nor the data collection agency are required to seek permission for this kind of data collection from the Norwegian Social Science Data Service (Ross et al. 2016). NSD is the institution reviewing research proposals for data collection, but an ethics review and a permit are only required in cases where the researchers and/or the data collection agency retain a register of respondents for purposes such as reminders or follow up surveys. This was not the case for our study, and we have no register or any other kind of information that can be used for linking individuals to the data set.

Consent for publication All authors have been contributing to this work, and all authors agree to the publication of this research.

Conflict of interest The authors declare no competing interests.

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2

Trust in researchers and researchers' statements in large carnivore conservation

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Abstract

1. Human–wildlife interactions occur when humans and wildlife overlap in the same landscapes. Due to the growing human population, the number of interactions will continue to increase, and in some cases, develop further into social conflicts. Conflicts may occur between people disagreeing about wildlife conservation or arguing over which wildlife management measures should be taken. Social conflicts between humans are based on different attitudes, values and land-use aspirations. The success of solving these social conflicts strongly depends on building trust between the public, stakeholders, authorities and researchers, as trust is fundamental to all communication and dialogue.
2. Here we have examined how trust in large carnivore research differs within a geographically stratified sample of the Norwegian population. The comprehensive survey, including 2,110 respondents, allows us to explore how people perceive factual statements about large carnivores depending on the source of these statements. Specifically, the respondents were given multiple statements and asked to judge them in terms of meaning and authenticity depending on whether the statements were made by a politician, the Norwegian farmers' association, the Norwegian Fish and Game association or a large carnivore researcher. Based on the variations in perceptions, we inferred that trust in large carnivore researchers and their research results varied with people's attitudes, values and direct experience of large carnivores.
3. In general, respondents perceived 60% of the statements to be genuine when given no information of who had made them. Although this increased to 75% when informed that the statements were made by a large carnivore researcher, there was still a 25% probability that the statement was perceived as manipulative or political. Age, environmental values and negative experiences of carnivores increased the probability of perceiving research statements as manipulative or political. People living in areas with high proportions of hunters showed particularly polarized views, either more strongly perceiving the statements as political, or in contrast as research.

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4. This study provides a novel perspective in understanding the role trust plays in social conflicts related to human–wildlife interactions.

KEYWORDS

geographically stratified survey, human dimensions, human–wildlife interactions, large carnivores, new environmental paradigm, trust in research

1 | INTRODUCTION

Wild species and their natural habitats are under pressure from multiple anthropogenic stressors (Wittemyer et al., 2008) and climate change (Dawson et al., 2011; Tilman et al., 2017; Vitousek, 1994), resulting in the most dramatic threat to biodiversity ever (Barnes et al., 2014; Ceballos et al., 2017; Diaz et al., 2019; Hampicke, 1994). A key challenge is the loss and degradation of wild habitats, driven by the need for land for food production, human infrastructure and economic development (Barraquand & Martinet, 2011; Gordon et al., 2018; Haines-Young, 2009).

Species such as large carnivores, which require large areas, are particularly vulnerable to land use pressure and interactions with humans, as conservation of large tracts of land is difficult and affects many different land use interests, owners and stakeholders (Gangaas et al., 2015; Pedersen et al., 2020). Human–carnivore interactions create social conflicts between people with differing attitudes, values and tolerances of sharing landscapes with these species. Different kinds of effort have been made to try to understand and mitigate these social conflicts, but it has not been an easy task (Gangaas et al., 2013; Persson et al., 2015; Treves, 2009). Trust is key to enabling sincere and constructive dialogue between different interest groups, in order to achieve understanding and agreement in how such conflicts develop or get resolved (Hendriks et al., 2020; Young et al., 2016). While trust in management authorities has been widely discussed in the literature (Hare et al., 2017; Lute & Gore, 2014; Sjolander-Lindqvist et al., 2015), trust related to wildlife research, has received limited attention. However, there is a growing interest in the role of the public's trust in science and the role played by science in society (Durant et al., 2019; Miller, 2001; Myers et al., 2017). In this study, we have investigated trust in large carnivore research in Norway, and how it may impact on the social conflict related to large carnivores (wolves *Canis lupus*, bears *Ursus arctos*, lynx *Lynx lynx* and wolverine *Gulo gulo*). Our main aim has been to see how people's trust in researchers and their research results may vary depending on people's attitudes, values or personal experiences of living in areas with large carnivores and further, to see whether people change their perception of the research results (presented as statements) depending on who makes claims about research results.

Nature conservation in Norway, including large carnivore management, is steered by an overall political framework set by central government, with the national nature management authorities (e.g. Norwegian Environment Agency; www.environmentagency.no)

ensuring the implementation of this policy. While state governance and national management authorities get professional advice and recommendations from researchers and research institutions, national political parties are heavily influenced by local democratic processes and local politicians (Falleth & Hovik, 2009). Local government and local democracy have strong traditions in Norway, where controversy and conflicts within nature conservation contribute to the tension between local and national governance (Falleth & Hovik, 2009). Large carnivore management has been delegated to local county boards, with the goal of enabling a balance to be made between local interests and use of natural areas, and national commitments to biodiversity conservation (Hovik & Hongslo, 2017). Their decisions are still expected to be based on professional recommendations from research and central management authorities (Eklund et al., 2020a). Yet, local politicians and stakeholders often question these professional recommendations and express distrust in the research recommendations as they also disagree with national commitments and political decisions (Falleth & Hovik, 2009; Lute & Gore, 2014). Hence, social conflicts related to large carnivores are as much about the symbolic value of central authorities that override local democracy as they are about the actual abundance of the animals (Ericsson et al., 2008; Eriksson, 2017; Linnell et al., 2017; Wilson, 1997). This is particularly the case for wolves in Norway, but is also found in several other countries (Skogen & Krange, 2003; Wilson, 1997).

People living in areas with large carnivores may find themselves negatively affected by having large carnivores in their area, for example, by being financially and emotionally affected by experiencing livestock predation, feeling anxiety when carnivores approach close to where they live, or being dissatisfied by reductions in hunting quotas of game species (Stormer et al., 2019; Weladji et al., 2003). This may lead to feelings that large carnivore policy is unfair (Eklund et al., 2020; Konig et al., 2020). A lack of trust in researchers and research statements may also arise due to a disagreement in the preferred knowledge base, in particular if the knowledge that is disseminated from science and from local experience diverges (Durant et al., 2019; Lute & Gore, 2014; Mallory et al., 2006). While researchers advocate science as their knowledge base (Lute & Gore, 2014; Peuhkuri, 2002), local people and stakeholders may oppose this and instead express greater trust in local knowledge (Lute & Gore, 2014; Mallory et al., 2006; Peuhkuri, 2002). In democratic processes, people trusting local knowledge may impact on political decisions in a direction that tends to deviate from professional research-based

recommendations. Such mistrust and social conflict are not specific to Norwegian nature conservation, but have been debated in relation to the wolf's reestablishment in human-dominated landscapes worldwide (Linnell et al., 2017; Skogen & Krange, 2003).

Trust facilitates communication and dialogue between people both at individual and collective levels, that is, between individuals, stakeholders, interest groups and institutions (Kelman, 2005; Sjolander-Lindqvist et al., 2015). However, trust strongly depends both on how people accept or relate to the issue (e.g. acceptance of carnivores in Norway), and how they trust the communicator of the message (here, the carnivore researchers communicating research results; Corner et al., 2015; De Cruz, 2020; Myers et al., 2017). In studies related to nature management, social trust, defined as *the willingness to rely on those who have the formal responsibility to develop policies and take actions* (Cvetkovich & Winter, 2003), has often been used. Social trust also emphasizes the importance of trusting the operation of government and other organizations in democratic societies (Cvetkovich & Winter, 2003). An important feature of the development of social trust is the emphasis of shared values and knowledge base between people (Balliet & Van Lange, 2013; Johansson et al., 2017; Stern & Coleman, 2015).

To better understand people's values and attitudes relating to wildlife (Manfredo et al., 2016; McCleery et al., 2006; Vaske & Donnelly, 1999), the new environmental paradigm (NEP) has been widely used (Klain et al., 2017). The NEP can be considered an environmental value orientation that gives a relatively stable expression of how one evaluates the environment (Fransson & Garling, 1999; Milfont & Duckitt, 2010; Schultz & Zelezny, 1999). The original NEP scale was developed by Dunlap and Van Liere in 1978 (Dunlap & Van Liere, 1978), and revised in 2000 (Dunlap et al., 2000). It includes 12–15 standardized questions that align in an ecocentric to anthropocentric frame. Previous studies have shown that people living in rural areas with large carnivores traditionally express more negative attitudes towards large carnivores and values tend to be more anthropocentric compared to those of people in urban areas with no or very low carnivore abundance (Eklund et al., 2020b; Skogen & Krange, 2003; Sponarski et al., 2013). The NEP is rooted in individual basic values, having both emotional and cognitive (knowledge) components (Dunlap, 2008). We have therefore chosen to use it to explore how people's environmental value orientation may relate to their trust in researchers and research statements. High NEP-scores correlate with pro-environmental values, also called ecocentrism, where nature is seen to have an intrinsic value regardless of human utilitarian needs (Dunlap et al., 2000; Kortenkamp & Moore, 2001). Low NEP-scores correlate with anthropocentrism, where humans value nature that is beneficial to humans and believe that nature is to be utilized (Kaltenborn et al., 2008; Rauwald & Moore, 2002). We expect that low NEP-scores will associate with lower trust in large carnivore researchers, while high NEP-scores are expected to positively associate with high trust in researchers (Ardahan, 2012; Dunlap, 2008; Weladji et al., 2003).

Hunters and hunting traditions have also come to the fore regarding conservation of large carnivores (Ericsson & Heberlein, 2003;

Treves, 2009). Hunters often report negative attitudes towards carnivores, and in particular towards wolf establishment, in addition to representing a strong voice in social debates about wildlife management (Agarwala et al., 2010; Karlsson & Sjoström, 2007; Naughton-Treves et al., 2003; Torres et al., 2020). Researchers, on the other hand, often pinpoint how the politically set management goals for wolves are too low to achieve an ecologically sustainable population, that hunting of wolves should be restricted and these low population sizes will lead to negative factors like inbreeding depression (Akesson et al., 2016; Nilsson, 2004). In Norway, hunting is traditionally a strong part of people's identity in many rural societies, and the option to participate in big game hunting teams is inherited between generations (Herman, 2014; von Essen et al., 2019). We expect that areas associated with strong hunting traditions or with high numbers of hunters, would also express lower trust in research compared to areas with lesser hunting traditions, as carnivores, and wolves in particular, compete with hunters for game or prey species and, in addition, wolves may kill hunting dogs.

A sustainable long-term conservation strategy requires a multidisciplinary understanding of spatial, ecological and social sciences (Andreassen et al., 2018; Johansson et al., 2016; Trouwborst et al., 2017). This study contributes to a better understanding of the social conflict related to the role of trust in research, and how researchers are perceived by the public as providers of knowledge. As people's acceptance of new knowledge usually decreases with age and increases with higher education (Williams et al., 2002), we would expect that trust in large carnivore researchers follows the same pattern. We also expect that people living in rural areas with strong traditional values and experience of losing free-ranging sheep to large carnivores would express a lower trust in large carnivore researchers compared to people living in areas where these values and direct experiences are not so prominent.

2 | MATERIALS AND METHODS

The study is based on a survey conducted over the telephone by a data collection agency (NORSTAT; www.norstat.no) between April and June 2019 and contained approximately 40 questions (see Appendix 1). NORSTAT collects data by interviews with a sample of people, based on existing, publicly available registers. The respondents had given a written agreement to the survey company NORSTAT to participate voluntarily in such surveys, and all participated voluntarily. Our study is based on a sample size of 2,110 respondents.

To obtain responses distributed evenly throughout Norway and independent of population density, we used geographically stratified sampling by surveying 5 people (aged 15–99 years old) in each of the 422 municipalities throughout the country. As the sample represents a very small proportion of people living in high-density areas such as cities and towns, it does not measure the general opinion of people living in a specific region (i.e. county or country).

We used data from the Norwegian large carnivore data base (www.rovdata.no) for the number of carnivores registered in each county, and from Statistics Norway (www.ssb.no) for information such as numbers of hunters (hunter ratio) and free-ranging sheep per municipality (sheep density). In line with earlier studies, we defined rural areas as areas characterized by free-ranging sheep, loss of sheep to large carnivores and strong traditions of big game hunting (Gangaas et al., 2013).

2.1 | Questionnaire

The questionnaire was in Norwegian and included demographic variables like age, gender, home municipality, and final level of education. We assessed respondents' general trust in large carnivore research by asking the extent of their agreement with the statement 'I have confidence in large carnivore research in Norway', 'I think large carnivore researchers hold a high level of expertise', and 'I think large carnivore researchers seem to have high credibility'. The respondents were also given questions about their attitudes towards large carnivores, and whether they found current carnivore numbers to be 'too many', 'appropriate' or 'too few' in relation to each carnivore species. We also asked questions related to whether or not respondents had experienced predation of sheep or other domestic animals by large carnivores, and whether or not they presently lived in an area they perceived to hold strong traditions of big game hunting. We used a seven-question version of NEP (Table 1; Bjerke & Kaltenborn, 1999; Dunlap, 2008; Kaltenborn et al., 2008), translated into Norwegian (see Gangaas et al., 2015; Kaltenborn et al., 2012) to measure different aspects of the respondents' environmental values (Table 1). The NEP-score for each respondent was estimated as the mean of the seven answers where highly disagree was given the value 1 (highly anthropocentric), and highly agree given the value 5 (highly ecocentric). Question 3, 5 and 7 were reversed when estimating the mean value.

TABLE 1 The seven questions used to estimate the new environmental paradigm answered in a five interval Likert-type scale

New environmental paradigm
(1) The balance in nature is delicate and easily upset
(2) Humans are severely abusing the environment
(3) The so-called 'ecological crisis' facing humankind has been greatly exaggerated
(4) Plants and animals have the same rights to life on earth as humans
(5) The balance of nature is sufficiently stable to withstand the impacts from a modern industrial society
(6) If things continue on their present course we will soon experience a major ecological catastrophe
(7) Human ingenuity will ensure future life and living conditions on Earth

2.2 | Piloting the survey

The questions in the whole survey were piloted and tested on a small sample of researchers and colleagues, and their feedback was taken into account before finalizing the questionnaire.

2.3 | Trust in researchers and their statements

Trust in research statements was measured by respondents' perception of five different statements that were all genuine research results from the Scandinavian wolf research project Skandulv (Table 2). First, all five statements were presented without any information about their origin, and respondents were asked if they perceived the statement to be *a research result*, *a political claim*, *conjecture*, *a manipulative statement* or *do not know*. In the second step, respondents were presented with exactly the same genuine research statements as before, but now were given information that the statements were presented by each of four different communicators (a large carnivore researcher, the Norwegian Fish and Game associations, the farmers associations and by a politician). The respondent was then asked to again evaluate how their perception of each statement might vary with the specific communicator: that is do you perceive the same statements as *a research result*, *a political claim*, *conjecture*, *a manipulative statement* or *do not know*.

The respondents got one statement and communicator combination presented at a time and had to finish considering this before they were presented with a new combination. The order of the communicators was presented randomly. In total, each respondent had then been given 25 different combinations of statement and communicator (the same five genuine statements in combination with all four specified communicators in addition to the same five statements with unspecified communicators to start with). However, to keep the current focus and interpretations as simple as possible we only analysed differences in perception between an unspecified communicator and a large carnivore researcher communicator. When respondents changed their perception of the statements from being a *research statement* to instead be a *political claim*, *conjecture* or a *manipulative statement* when informed that the statement was

TABLE 2 The five different statements presented to our respondents who interpreted the statements as a *research result*, *political claim*, *conjecture*, *a manipulative statement* or *do not know*

Statements
(1) The wolf in Scandinavia is most likely of Finnish–Russian origin
(2) The wolf in Scandinavia has the capacity to migrate from Finland/Russia down to southern parts of Scandinavia
(3) Up to 95% of the Scandinavian wolf diet consist of moose
(4) A total of 5 Swedish migratory wolves have been identified in and outside the wolf zone this year (2018)
(5) The large carnivores tend to have home ranges of hundreds or thousands of square kilometres

claimed by a researcher, we interpreted this as a mistrust in the large carnivore researchers.

2.4 | Response variables

In this paper, we have focused on: (a) the public trust in large carnivore researchers and (b) how trust in research results may change depending on who makes these statements. As wolf research in Scandinavia has been going on for a long time, and represents almost every perspective of the ongoing debate about trust in large carnivore research (Linnell et al., 2017; Skogen & Krange, 2003; Wilson, 1997), we have chosen to use research statements from Scandinavian wolf research in this study.

2.5 | Predictor variables

The main predictor variables in our study are: the respondent's attitudes towards having large carnivores in Norway, their environmental value orientation measured by NEP, the presence of carnivores in their municipality (found in the Norwegian register; www.rovdata.no), their personal experience with large carnivores represented by loss of sheep, and rural traditions in their area represented by big game hunting traditions (defined in Table 3).

2.6 | Statistical analyses

To explore variations in how the statements were perceived among the respondents and how this perception changed when the respondents were told that the statements came from a large carnivore researcher, we set up two multinomial logit models. The first model explored how the statements were perceived (i.e. the probability of falling into each of the five categories across all five statements: *research*, *political*, *conjecture*, *a manipulative statement* or *do not know*) for the unspecified setting while the second model focused on the large carnivore researcher communicator setting. In both models, perception was analysed as a function of the different variables describing the individual respondent. We used an information theoretic approach (Burnham & Anderson, 2002) to objectively decide which variables were meaningful to include in the final models. Based on prior knowledge, age, education and NEP-score were always included in the candidate models (Gangaas et al., 2015; see Table 3). We did, however, explore whether sheep density, loss of sheep to carnivores, big game hunting traditions, trust in large carnivore research and local presence of large carnivores in general, or wolves in particular, were meaningful predictor variables to include in the model (see Table 3). The latter variables were thus either included or excluded as additive effects in different candidate models. We also included a candidate model with only age as a predictor variable, in total testing 10 models against each other in the model selection procedure. As each respondent

TABLE 3 Variables included in model selection. Hunter ratio and sheep density are data from Statistics Norway (www.ssb.no), and carnivore presence are data from Rovdata (www.rovdata.no). Variables in the grey section were always included in the model selection, while variables in the white section were considered in the model selection procedure

Variable	Description
Background	
Age	Continuous, individual specific age of respondent
Education	Highest level of education for the respondent. Categorized into; primary education, high school, vocational school, lower degree university (~bachelor) or higher degree (~master or PhD)
NEP-score	The NEP score for each respondent was estimated as the mean of the seven answers (see Table 1)
Specifics	
Trust in carnivore research	Categorical, 'Agree', 'Do not know' or 'Disagree'
Loss to carnivores	Categorical, 'yes', 'no'
Carnivore presence	Continuous, presence of established groups/individuals of either lynx, bear, wolf or wolverine in the municipality
Sheep density	Continuous, The density of free ranging sheep in the municipality
Hunter ratio	Continuous, the ratio between number of registered big game hunters and number of inhabitants within the municipality
Big game traditions	Categorical, 'yes', 'no'

considered multiple statements, this produced repeated choices made by the same individuals. We therefore implemented mixed-effect multinomial models, treating respondent ID as a random effect (random intercepts only) for all candidate models. The models were constructed using the mlogit-library (Croissant, 2020) in the statistical environment R (R Core Team, 2021). The predictor variables included in the most supported models were the same for the two multinomial logit models.

The most supported models were used to predict the individual respondent's probability of having a specific perception of all the genuine research statements, varying only the communicator setting (unspecified or large carnivore researcher). To better visualize and compare how the mean predicted perception probability varied between the two models/communicator settings, we produced figures showing the difference between the predicted probabilities for large carnivore researcher and unspecified communicator. Thus, by comparing the difference in the mean individual perception probability between the two models, we were able to deduce the level of trust in carnivore researchers and how this trust potentially varied as a function of the variables in focus.

2.7 | Ethics statement

The interviews followed a strict protocol as dictated by standard research ethics of the Norwegian Social Science Data Service (Ross et al., 2016). Neither the Inland Norway University of Applied Sciences (INN) nor the data collection agency are required to seek permission for this kind of data collection from the Norwegian Social Science Data Service (NSD; Ross et al., 2016). NSD is the institution reviewing research proposals for data collection, but an ethics review and permit are only required in cases where the researchers and/or the data collection agency retain a register of respondents for purposes such as reminders or follow up surveys. This was not the case for our study, and we have no register or any other kind of information that can be used for linking individuals to the data set.

3 | RESULTS

Altogether, 2,110 respondents completed the study, corresponding to a response rate of 11%. A response rate of between 10% and 20% has been shown to be typical of these kinds of surveys in Norway (NORSTAT 2020). Out of these 2,110 respondents, 1,204 (57%) were men and 906 (43%) women, and the mean age was 45.6 years old (age range 15–92). The distribution of education level among our respondents was 47.9% with a completed university degree (30.8% bachelor's and 17.1% master's), and 52.1% with high school or junior high as their highest completed educational level (43.0% and 9.1% respectively).

The most supported models from the model selection (second most supported model had $\Delta AIC = 12.2$ compared to the most supported) included all considered predictor variables, except for sheep density (Table 3). In addition, the model included a variable for carnivore presence in general, rather than wolf in particular, suggesting that the probability of changing the perception of the statements was not species specific in regard to the local presence/absence of carnivores.

3.1 | Attitudes towards large carnivores

When asked the question 'how do you find the large carnivore situation in Norway', more than 50% of the respondents felt that there were too few or an appropriate number of carnivores (Table 4;

wolves; 50.4%, bears; 65.2%, lynx; 65.6%, wolverine; 52.8%), though the wolf situation stood out by showing that more respondents (781; 37.0%) felt there were too many wolves than any other species (Table 4).

3.2 | Trust in large carnivore researchers and wolf research statements

When the respondents were presented with the statement 'I think large carnivore researchers seem to have high credibility', 18% of the respondents highly disagreed or disagreed, while 58% answered that they highly agreed or agreed (24% did not know). On the similar statement 'I think large carnivore researchers hold a high level of expertise', 55% reported that they highly agreed or agreed, while 15% highly disagreed or disagreed (29% did not know).

For the unspecified communicator setting, our model predicted a nearly 60% probability that a respondent would perceive the statements as *research results*. Furthermore, we found an almost 20% probability that the statements were perceived as *conjecture*, and less than a 10% probability of their being perceived as *political claims* or a *manipulative statement* (Figure 1).

Thus, the pattern showed that the respondents in general perceived the statements as *research results*, regardless of the context in which the statements were presented. The probability of statements being perceived as *research results* increased to almost 75% when it was claimed that the statements were communicated by researchers, while the chance of the statement being perceived as *conjecture* declined to <10% (Figure 1). The probability of the statements being perceived as a *manipulative* or *political claim* was relatively unchanged.

3.3 | Perception of statements related to environmental value orientation (NEP-scores)

The probability of a respondent reconsidering the statements as *research results* when being informed that they were made by a researcher, increased markedly with increasing ecocentric values (high NEP-scores). Correspondingly, the probability of reconsidering the statements as *conjecture*, a *manipulative statement* or *political* decreased with increasing ecocentric values (Figure 2). By contrast, respondents that leaned towards anthropocentric values (low NEP-scores), showed a higher probability of interpreting the statements

Large carnivore situation in Norway	Numbers of respondents (%)			
	Wolf	Bear	Lynx	Wolverine
Too few	416 (19.7)	429 (20.3)	507 (24.0)	302 (14.3)
Appropriate	648 (30.7)	947 (44.9)	877 (41.6)	812 (38.5)
Too many	781 (37.0)	292 (13.8)	339 (16.1)	438 (20.8)
Don't know	265 (12.6)	442 (20.9)	387 (18.3)	558 (26.4)

TABLE 4 Distribution of attitudes towards large carnivores in Norway when respondents were asked if they found the carnivore situation to be too many, appropriate or too few related to each carnivore species (percentages presented in brackets)

as *manipulative* or *political*, and a lower probability of perceiving them as *research results*, when they were informed that the statement was made by a large carnivore researcher (Figure 2).

3.4 | Hunter ratio

The probability of perceiving the statements as *research results* when stated by a researcher showed a general increase with hunter ratio (number of registered hunters per inhabitant in the municipality). Furthermore, the probability of changing the perception of the statements as *political* were also significantly higher when they were informed that the statements were claimed by a researcher (Figure 2), and the probability of perceiving the statements as *conjecture* decreased.

3.5 | Age and education

Older people were more prone to change their perception of the statements to being *manipulative* or *political* when the statement was made by a researcher, no matter what they had answered in the unspecified setting. The probability of perceiving the statements as *research results*, were higher in younger age classes when informed that the statements were made by a researcher (Figure 2). We did not find any obvious effect on the probability of changed perception among our respondents in relation to education level.

3.6 | Trust in large carnivore research in general

Respondents who expressed trust in large carnivore research in general increased their perception of the statements being research results when informed they were made by a researcher, while respondents who did not trust carnivore research in general did not change their perception very much, and still perceived the statements as political or manipulative (Figure 3).

3.7 | Direct experience with large carnivores

Among respondents who had experienced loss of, for example, livestock to large carnivores, we found a slightly higher probability of perceiving the statements as *manipulative* when informed that the statement was claimed by a large carnivore researcher (Figure 3). People living in areas inhabited by large carnivores did not show any obvious change in how they perceived the statements depending on who the communicator was, and neither did respondents who lived in areas they themselves described as areas with strong big game hunting traditions (Figure 3).

4 | DISCUSSION

In general, our findings show that among the respondents, large carnivore researchers were well trusted as there was a 75% probability

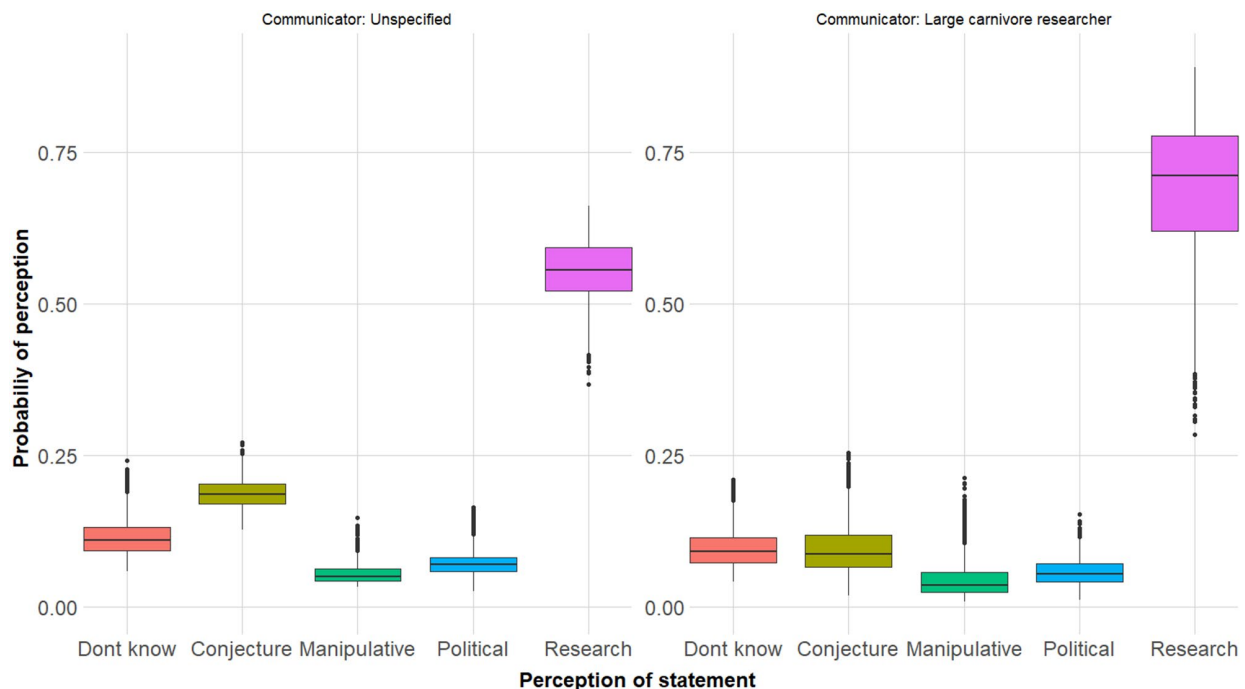


FIGURE 1 Boxplot of the fitted probabilities for the respondents of having a specific perception of wolf research across all five statements, as obtained from the multinomial models exploring variations in the probability of perception given an unspecified communicator setting (left panel) and given a setting where the statements were made by a large carnivore researcher (right panel)

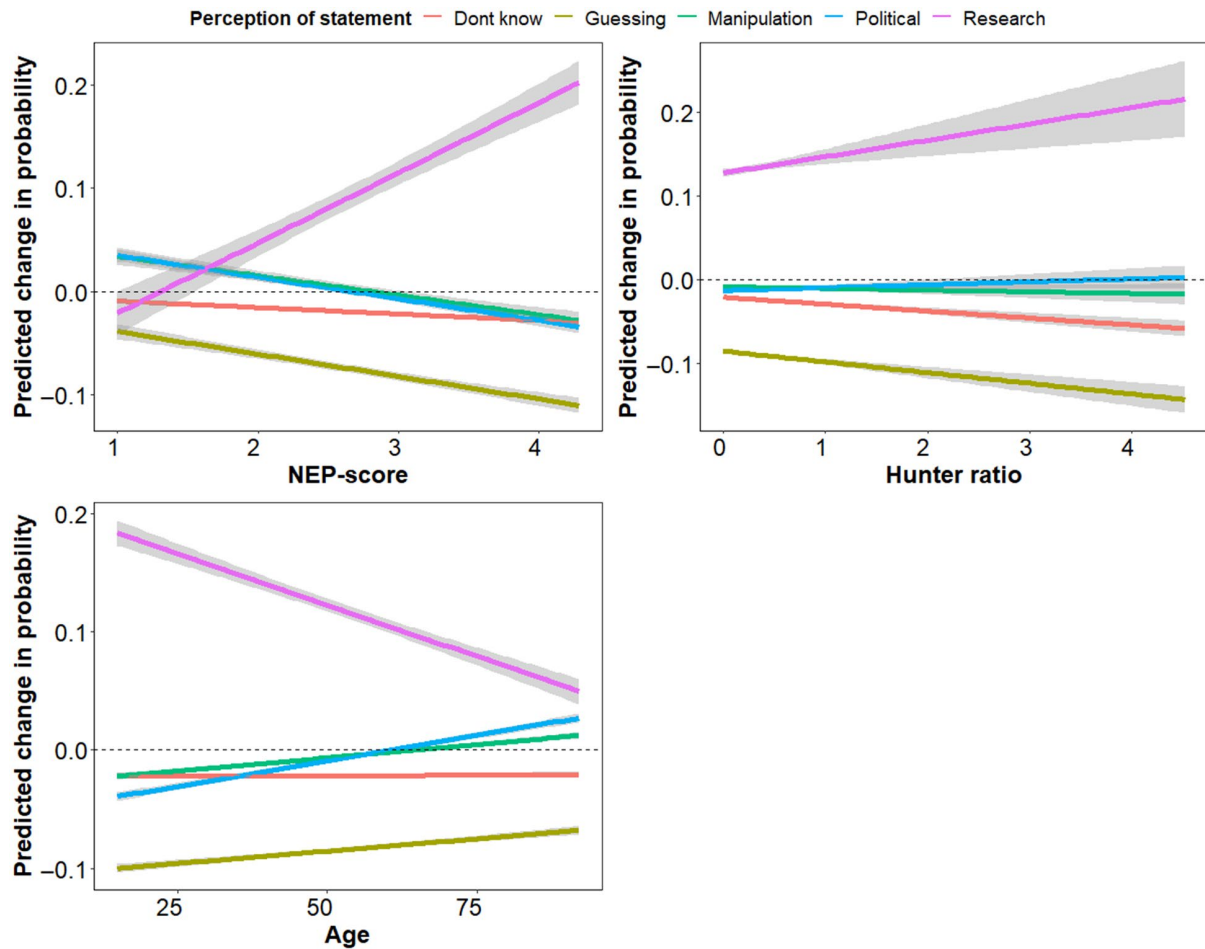


FIGURE 2 Predicted change in the probability (y-axis) of a specific perception of the statement as functions of NEP-score (top left), hunter ratio (top right) and age (bottom left) of the respondents. The change is the difference between a respondent's perception when switching from a setting with an unspecified communicator to a setting with a large carnivore researcher communicator. Positive values on the y axis (i.e. when the trend lines are above the dashed line at zero) indicates that there is an increase in the probability for the respective perception, while negative values (below the dashed line) indicates that there is a reduction in probability of the respective perception. The different lines represent the linear smoothed means of the predicted change as functions of the different variables, and the grey shading indicates 95% confidence interval around the smoothed mean

of the statements attributed to researchers being perceived as *research results*. Furthermore, our results point to how expressing a positive environmental value orientation, and trust in large carnivore research in general, associate with positive perceptions of large carnivore research statements.

Interestingly, trust in researchers' statements increased among respondents living in areas with a high hunter ratio, though we also revealed that respondents living in these high hunter ratio areas also expressed a slightly higher probability of perceiving the statements as *political* when claimed by a researcher. This implies that there might be a wider diversity of views among people in areas with high hunter ratios.

The probability of expressing lower trust in researchers increased with the respondents' age, loss of sheep and with increasing anthropocentric value orientation (low NEP-scores). People with anthropocentric values are generally skeptical of wildlife conservation, deny that climate change is caused by anthropogenic activities, and deny that there is an ecological crisis going on. Older people perceived

research results as *manipulative* or *political* when being informed that the statements were expressed by a researcher. This is consistent with studies of attitudes towards large carnivores, as older people usually show less acceptance of having large carnivores than young people (Bostedt et al., 2008; Roskaft et al., 2007).

Overall, loss of sheep, hunter ratio, and anthropocentric values are all highly associated with rural area characteristics (Andreassen et al., 2018; Kaltenborn & Bjerke, 2002), while the presence of carnivores is no longer specific to rural areas in Norway (e.g. both wolves and lynx have established in areas with high human population density; Kränge et al., 2017). The lower trust among respondents associated with these rural area characteristics may also be an expression of either having more trust in local knowledge, or less trust in the authorities, here represented by researchers as their professional recommendations impact on the livelihoods of local people. This is because it is not the presence of carnivores per se that is important so much as their impact on people's livelihood by, for example, killing sheep. For urban people,

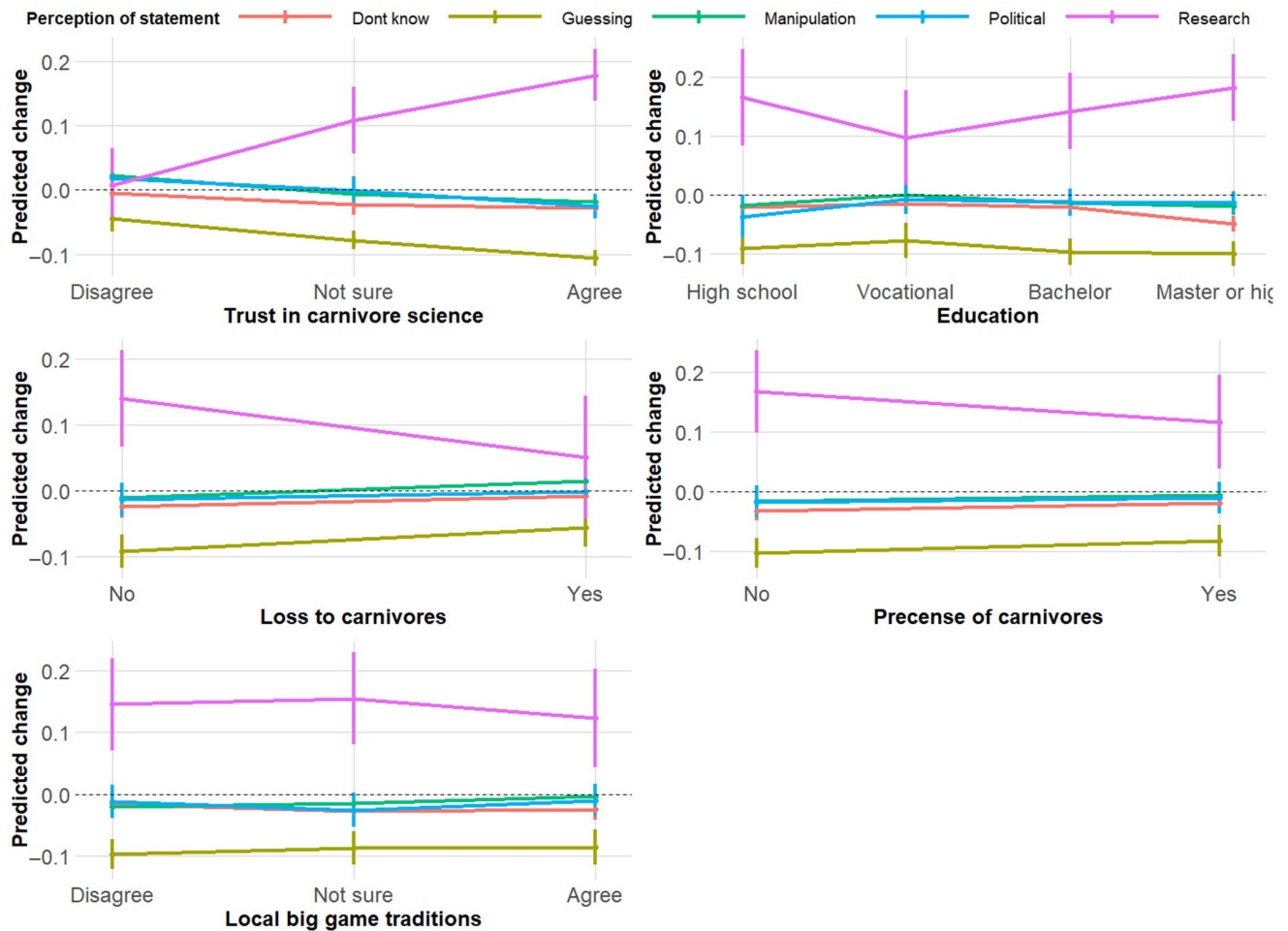


FIGURE 3 Predicted change in the mean probability (y-axis) for respondents having a specific perception of all the statements as functions of trust in carnivore research (top left), education level (top right), experience of loss to carnivores (mid left), presence of carnivores locally (mid right) and perceived traditions for big game hunting in the local area (bottom left). The change is the difference between a respondent's perception when switching from setting with an unspecified context to a setting where the statements were provided by a carnivore researcher. Positive values on the y axis (i.e. when estimated means are above the dashed line at zero) indicate that there was an increase in the probability of the respective perception, while negative values (below the dashed line) indicate that there was a reduction in probability of the respective perception. The fitted lines connect the perception-specific mean estimates for the different levels of the variables, while the vertical lines indicate the standard deviation around the respective mean estimates

living in the presence of carnivores may not be a problem as their livelihoods tend not to be impacted. Lower trust in researchers may also be associated with a respondent's belief or experience of how researchers' recommendations can impact on management decision that directly affect their livelihood. This has been shown in earlier studies, where attitudes towards wildlife species become increasingly negative when people are directly affected (Ericsson & Heberlein, 2003; Eriksson et al., 2015). This strengthens our impression that trust in large carnivore researchers fits well with the definition of social trust (Cvetkovich & Winter, 2003). The views of respondents who expressed lower trust in researchers by perceiving their statements as *manipulative* or *political*, may well impact on societal development. In democracies, trust between the public and the authorities facilitates and improves the performance of important decision-making, for example implementation of critical management measures regarding conservation of wildlife.

The hunter ratio we used was derived from a national database of hunters registered in an area (www.ssb.no) and did not relate to whether a respondent was a hunter or not. In Norway there is a strong tradition of hunting, with approximately 10% of the Norwegian population being registered as hunters. The areas with the highest density of registered hunters have up to 14% of inhabitants who hunt, and these are typically rural districts where there are strong big game hunting traditions. So, even within an area with a high hunter ratio, the majority of inhabitants are still non-hunters. Hunters and hunting associations are particularly important with respect to wildlife conservation as they are one of the most pronounced interest groups to have strong political power both at local and national levels (Cervený et al., 2019; Luchtrath & Schraml, 2015; Pohja-Mykra & Kurki, 2014; Treves, 2009). Hunters are known to express negative attitudes towards having large carnivores, but they also have the most accurate knowledge of carnivores

(Ericsson & Heberlein, 2003; Treves, 2009). However, our findings may reflect the fact that rural areas, including areas with high hunter ratios, in general have become more heterogeneous with people representing a variety of values, livelihoods and attitudes, as in more urban areas (Konig et al., 2020; Sponarski et al., 2013). If these results are represented by hunters versus non-hunters, the reasons behind these differences warrant attention in further studies.

Our study cannot pin-point the reasons why certain people mistrust researchers and their research statements, but it could be that they fear the research results will have a negative impact on their everyday life and livelihood. It could also arise from a generally low trust in researchers, representing a social elite that seems alienating and untrustworthy. The battle over power between central authorities and local society is well known both in Norway and in other countries (Linnell et al., 2017; Lute & Gore, 2014). Traditional top-down wildlife management may be associated with managers in central positions who focus on restrictive conservation and associate with researchers who are their knowledge providers. Local governance, on the other hand, is strongly influenced by local politicians, who focus on local communities and how the residents should benefit from nature (Hovik & Hongslo, 2017). There are important issues to discuss around the role that researchers, as knowledge providers, are expected to play in political decisions or policymaking. Kotcher et al. (2017) looked at how climate scientists could engage in advocating certain statements about climate change and still maintain their credibility and integrity as scientists (Kotcher et al., 2017). However, Beall et al. (2017) argue that this depends on whether or not the public interpret the researchers' information as being motivated to serve or to persuade the public (Beall et al., 2017). In Norway, there is a common expectation that researchers are non-political (Ministry of Education & Research, 2005), particularly in controversial topics like conflicts related to large carnivores. We believe that it is important that researchers manage to build confidence and trust among the public. Earlier studies have emphasized the importance of bridging the gap between conservation managers and ecological scientists (Bertuol-Garcia et al., 2018; Durant et al., 2019). We think that it is also important to understand how to bridge the gap between researchers and local people in rural districts as this may contribute to lessening conflict over social power. Trust in knowledge providers, here represented by large carnivore researchers, is important in order to gain local people's support of management decisions in nature conservation (Liu et al., 2018; Taye et al., 2018). Our results challenge researchers and research institutions to improve relationships and build trust in scientific knowledge. Researchers' role as trusted knowledge providers has the potential to strongly influence conservation management and the political decisions taken.

5 | CONCLUSION

This study shows that in general, most people express trust in large carnivore researchers and their research results. However, there are still some people who express low trust in large carnivore

researchers, and this low trust is primarily associated with inhabitants living in areas with negative experiences of large carnivores, including predation of livestock. Over the last decade, there has been a general decline in trust in research worldwide and the public is increasingly questioning their trust in researchers (Iyengar & Massey, 2019; Johansson et al., 2017). These changes are likely to have a significant impact on both local and national politics, and political decisions may be left to feelings, traditions, or political ideology rather than professional recommendations. This may not benefit forward-looking conservation of nature or resolving difficult issues such as large carnivore conflicts or halting climate change. A general lack of trust in research, together with the growing societal trends of creating 'alternative realities' or 'fake news' are highly problematic and contribute to an increased political polarization, further preventing crucial nature conservation measures, fueling conflicts and disagreements instead (Brandtzaeg et al., 2018; Iyengar & Massey, 2019). We recommend increasing efforts to investigate the reasons and causes of the lack of trust in researchers and scientific knowledge, in order to contribute to a better understanding of what is driving the lower trust. We also recommend implementing trust building measures that benefit research as the knowledge provider of future nature and biodiversity conservation.

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CONFLICT OF INTEREST

All authors have been great contributors, and there are no conflict of interests in this work.

AUTHORS' CONTRIBUTIONS

K.E.M. and M.B. contributed to study concept and design; K.M.B. and K.E.M. contributed to analysis and perception of data; K.E.M., K.M.B., M.B. and M.J. contributed to drafting of the manuscript; M.J. contributed to contribution of psychological theories and concepts; K.M.B. contributed to statistical analysis.

DATA AVAILABILITY STATEMENT

Our data are archived and made available at Dryad Digital Repository at <https://doi.org/10.5061/dryad.6hdr7sr21> (Mathiesen et al., 2021).

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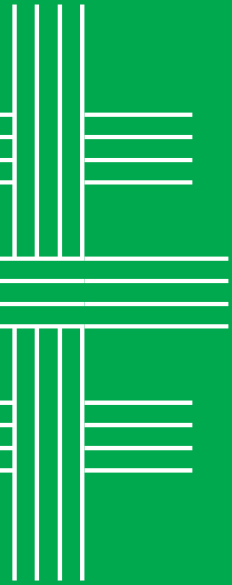
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SUPPORTING INFORMATION

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3



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Large carnivores give rise to strong public engagement and have proven to be especially controversial and challenging to conserve. Increasingly, managers rely on scientific knowledge and evidence-based policy to guide decision-making and increase legitimacy in management policies. Given the challenges society face when it comes to trust in scientific knowledge and science communicators, the goal for this thesis was to assess the trust in large carnivore science and large carnivore scientists. I wanted to provide a better understanding of the characteristics that describe people with low trust in large carnivore science, thus potentially helping communicators to identify needs leading to more efficient science communication.

Through a geographically stratified survey covering all of Norway, I examined how trust in large carnivore science varied across participants depending on how they are influenced by the presence of large carnivores. The results showed that elderly men, people with lower education, having experienced losses of livestock to carnivores, being a big game hunter, and having fear of wolves (*Canis lupus*) was associated with lower trust. One out of four participants perceived research statements as manipulation, indicating that not all find policies guided by large carnivore science to be legitimate. In a systematic review of peer-reviewed articles on attitudes towards wolves globally, covering the last four decades, respondents living in areas where wolves have been continuously present were observed to hold more negative attitudes compared to other respondents.

In summary, the results of this thesis highlight that trust and attitudes vary across people and is associated with their experience of living with large carnivores. A better understanding and further monitoring of social trust and trust in large carnivore science, and the linkages to attitudes and, ultimately, behavioral intention to support management, will help to tailor trust-building outreach.