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Agricultural damage following the recent expansion of wild boar (*Sus scrofa*)—farmer perceptions and preconditions

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ABSTRACT

The wild boar (*Sus scrofa*) population has recently increased in Fennoscandia, leading to increasing interactions with humans, e.g. in the form of hunting opportunities or property damages. These experiences may shape the attitudes towards wild boars and affect their population management. We studied attitudes among 165 farmers towards wild boar by means of survey data. We also made preliminary estimates of wild boar damage costs in Finland. Our analysis revealed three attitude groups among farmers, emphasizing various perspectives: "hunting resource", "pest-of-concern", and "ambivalent". The benefits, costs, feelings, and perceived wild boar population development partly explained the division. The direct annual damage costs in southeast Finland were broadly estimated to be circa 990,000€ and mitigation costs circa 350,000€. Reconciling differing opinions and goals into a widely accepted management strategy is a key precondition for sustainable coexistence. While the level of economic loss is so far not substantial, monitoring of crop damages is vital. Our results provide a valuable baseline for future evaluations, as the wild boar population is expected to grow.

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Wild boar; human–wildlife conflict; management; crop damage cost; attitudes

1. Introduction

Globally, the wild boar (*Sus scrofa*) is one of the most wide-spread terrestrial mammals, and their populations can attain considerable local densities (Meijaard, d'Huart, and Oliver 2011). As large-bodied omnivorous animals, wild boars are often considered "ecosystem engineers" (Jones, Lawton, and Shachak 1997) that are capable of imposing various, often dramatic, effects on local ecosystems (Barrios-Garcia and Ballari 2012; Risch, Ringma, and Price 2021). Such effects may, in some cases, be beneficial to communities of humans and other species. However, more often than not, the impacts of wild boar are regarded as negative for both humans and other wildlife. Examples of such negative effects include reductions in the diversity of native flora and fauna, the spread of zoonoses and other diseases (especially African swine fever, ASF), vehicle collisions, along with agricultural and silvicultural damage (Barrios-Garcia and Ballari 2012; Gavier-Widén et al. 2015; Massei and Genov 2004; Schley and Roper 2003).

In Northern Europe, wild boars have spread and increased rapidly during recent decades (Danilov and Panchenko 2012; Kukko, Pellikka, and Pusenius 2018; Markov et al. 2022; Massei et al. 2015). This increase is due to several intrinsic and external factors, such as high reproductive capacity and ecological plasticity (Meijaard, d'Huart, and Oliver 2011), a warming climate at the northern edge of the species' distribution range (Markov, Pankova, and Filippov 2019), a scarcity of predators (Nores, Llaneza, and Álvarez 2008), and active supplemental feeding (Cellina 2008). Climate is the most important factor limiting the wild boar distribution (Markov, Pankova, and Morelle 2019), whereas hunting efforts appear to be inefficient in managing expanding wild boar populations (Gortázar and Fernandez-de-Simon 2022; Keuling, Strauß, and Siebert 2016; Massei et al. 2015). Wild boar populations are expected to continue growing and dispersing over wider areas in northern regions.

Wild boars appeared in Finland in the 1950s, after which they occurred at very low densities for several decades (Erkinaro et al. 1982).

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The population has experienced a notable increase in density and distribution range in the past 20 years (Kukko, Pellikka, and Pusenius 2018). The most recent population size estimate indicates that the median number of wild boars in Finland was slightly over 2500 individuals in January 2023 (90%c.i. 1630–4002; Ruha and Kunnasranta 2023). Currently, the main segment of the population lives in the southeastern part of the country, along the border with Russia, an area from which the current population mainly originates (Erkinaro et al. 1982; Kukko, Pellikka, and Pusenius 2018; Markov et al. 2022, Miettinen et al. 2023). Living conditions in the boreal zone of Northern Europe have not been as favourable for the species as in more southern regions (Rosvold and Andersen 2008), due to harsh winters with limited access to food resources. However, global climate change affects this species and contributes to its northward population expansion (Markov et al. 2022). Supplementary winter feeding may also play a major role in maintaining the local population and facilitating the transboundary immigration of wild boars from Russia.

Typically, increases in wildlife population size lead to increased rates of human–wildlife interactions. Such interactions are not equally positive and negative for everyone, or similar in various situations (Bhatia et al. 2020; Dickman 2010; Dressel, Sandström, and Ericsson 2015; Kansky, Kidd, and Knight 2014): Attitudes are typically influenced by socio-demographic factors, such as age, gender, and education, together with experiences of damage and damage risk. Tolerance to wildlife encounters may be affected by levels of recent exposure and the number of meaningful experiences (Kansky, Kidd, and Knight 2016). In addition, opinions and attitudes toward a species are shown to vary with its novelty (Cranston, Crowley, and Early 2022; Houston, Bruskotter, and Fan 2010) and underlying emotions felt toward the species (Jacobs, Vaske, and Roemer 2012, McLean et al. 2021). Wildlife experiences, beliefs, and feelings typically shape the attitudes and behavioural responses of humans and may vary spatially (Bruskotter and Wilson 2014; Caplenor et al. 2017; Eriksson et al. 2020).

In the case of wild boar, humans may experience worries related to potential property damage or personal safety, but on the other hand, the species may also provide some value and benefits, particularly in the form of hunting and meat (Bevins et al. 2014). Given the potentially strong impacts of wild boars, the contrast in attitudes may likewise be strong (Adams et al. 2005; Harper et al. 2016; Li et al. 2010; Storie and Bell 2017) and may potentially lead to elevated conflicts requiring mitigation measures.

Here we introduce an empirical case of wild boar emergence in a novel region from the perspective of farmers, based on survey data. In this study, we aim to determine: (1) whether the recent spread of wild boar has led to the formation of attitude groups among farmers, and, if yes, (2) is belonging to a specific attitude group explained by various perceived impacts of the species (comprised of experienced damage, perceived harm, feelings associated with personal encounters, and benefits from hunting). Finally, we aimed (3) to provide a rough first estimate of the magnitude of economic wild boar agricultural damage in Finland. These results may have implications for wild boar management procedures and policies (e.g. related to damage compensations) and for the management of other controversial species appearing in new areas. Identifying interest groups and their views is a key premise in finding widely accepted solutions to mitigate human–wildlife conflict.

2. Materials and methods

2.1. Study area

The study was conducted with farmers of southeastern Finland, in regions covering most of the Finnish wild boar population and therefore experiencing the highest level of impact (Figure 1). These regions cover the provinces of Eastern Uusimaa, Kymenlaakso, South Karelia, South Savo, and North Karelia. According to the national agricultural organization ProAgria, the area contains 3870 farms with full-time outdoor crop farming. Cereal crops (including oil seeds) are the most common farming product in the study area (Supplement 1).

2.2. Pilot interviews and survey

To recognize the relevant categories for damage, mitigation, and opinions, and to develop the content of the subsequent online survey, 14 farmers were engaged in a face-to-face pilot interview in the regions of South Karelia and Kymenlaakso during June–August 2020 (Figure 1). Those interviewed were purposefully chosen to represent both hunting and non-hunting farmers operating in areas with abundant wild boar populations. The open and semi-open questions focused on farmers' experiences and opinions considering wild boars and their impacts. The questions provided us with response alternatives for the following online survey.

The online survey form was constructed by the authors. The form consisted of questions regarding background information, local wild boar abundance,

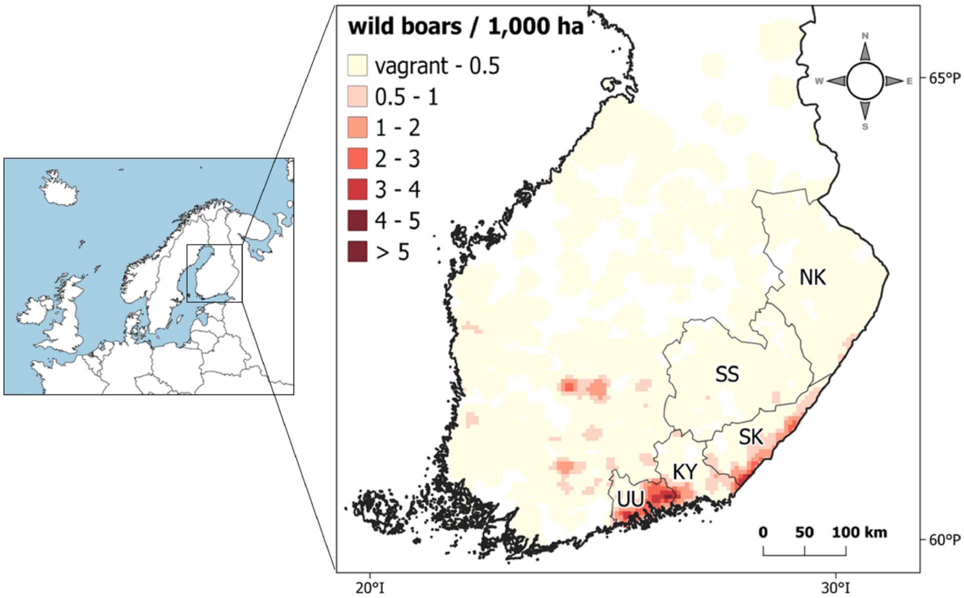

Figure 1. Regions of the study area (UU: Uusimaa; KY: Kymenlaakso; SS: South Savo; SK: South Karelia; NK: North Karelia) and wild boar density in 2020 according to the annual population abundance estimate by Natural Resources Institute Finland (Ruha and Kunnasranta 2023).

experiences, obtained benefits and incurred damages, mitigation measures, emotions experienced during encounters, and opinions concerning management alternatives (Supplement 2). The questions were aimed to cover the costs, attitudes, and possible factors explaining the attitudes (based on prior interviews and literature (e.g. Bhatia et al. 2020; Dressel, Sandström, and Ericsson 2015; Kansky, Kidd, and Knight 2014). An invitation to participate in the survey was distributed to the farmers *via* e-mail, using the ProAgria newsletter. The survey was open from mid-December 2020 to mid-January 2021. A reminder email was sent in late December. The survey was conducted using the Webropol online survey tool (Webropol 2023), which, by default, mainly adheres to the principles of survey design (e.g. Dillman, Smyth, and Christian 2009).

The protection of any personal data was ensured. Respondents were informed about the data anonymity, usage, and storage before deciding to enter the survey. According to national legislation, no ethical approval is required for this type of survey.

2.3. Clustering of attitude groups

We assumed attitudes as latent constructions that can be measured by using a set of manifest variables (here categorical survey responses to the desired population trends and attitude claims related to the desired management alternatives, see Figure 2). We first fitted a series of standard latent class models (LCA) with six manifest variables without any covariates to select several latent classes for use in the consequent analyses. We evaluated the model fit for alternative models with 1–5 classes (LL, AIC, BIC; Supplement 3), and the identified model with the smallest BIC and good separation was selected. The assumption of local independence of the manifest variables was sufficiently met in the selected model, based on the bivariate correlation estimates that were calculated between the manifest variables separately within each class (defined by posterior modal assignment, showing absolute Pearson r values <0.438 in each class). We continued the testing of model fit for the model structures that included random intercept (nonparametric multilevel LCA; MLCA) with either two or three clusters (consisting of province clusters). The better-fitting model was then used as the model to which we added respondent-level (1) covariate variable blocks with the one-step method, first separately and then together (see Table 1). The idea was to test whether social demography, context, feelings arising from an encounter, and perceived benefits or costs predict belonging to specific attitude groups with and without adjusting for the effect of other predictors. All LCA analyses were carried out without survey weights in R software (v4.0.2; R Core Team 2021) with the glca package (v1.3.3; Kim and Chung 2021).

2.4. Calculating economic costs

Respondents were asked to report their total costs of wild boar damages and mitigation measures non-specifically or by specifying repair and mitigation expenses and associated work time (Supplement 2). In national agriculture and horticulture viability accounting (Natural Resources Institute Finland

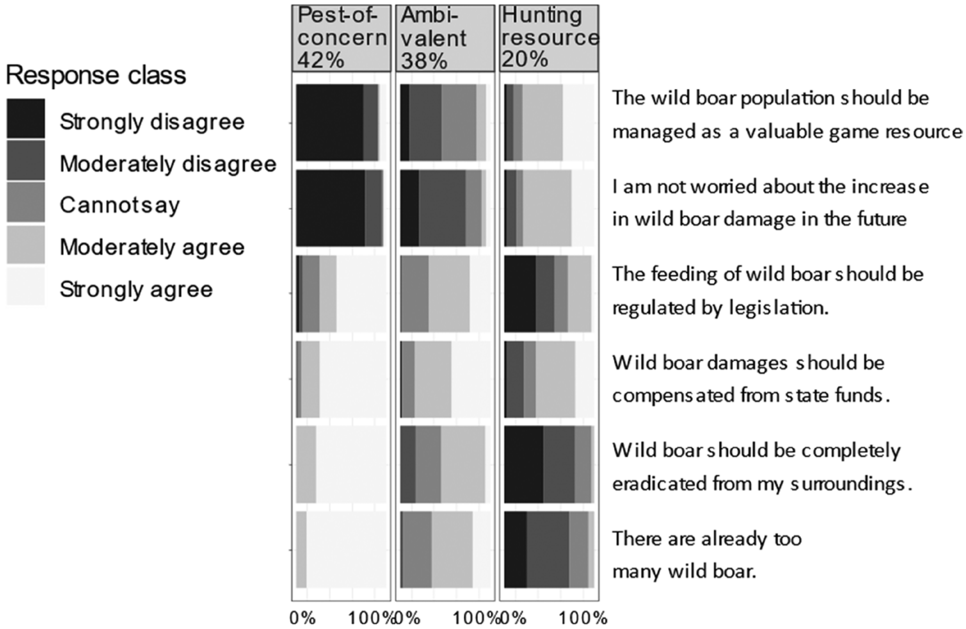

Figure 2. Three attitude groups based on the LCA analysis. The frequencies describe item–response conditional probabilities for a specific response class by each manifest variable (summing to 100%).

Table 1. Predictors of belonging to the three attitude classes.

	Variables included as separate blocks:			All the blocks included:		
	"Pest-of-concern" group	"Hunting resource" group	"Ambivalent" group	"Pest-of-concern" group	"Hunting resource" group	"Ambivalent" group
Social demography						
Year of birth	Ref. class	1.00$^{ns.}$	1.00$^{ns.}$	Ref. class	1.00^{ns}	1.00^{ns}
Gender (female)		1.68***	2.45***		0.997***	2.06***
Wild boar context (the perc. pop. trend)						
Has increased	Ref.	0.18***	0.73***	Ref.	0.15***	0.31***
Has decreased		3.87***	0.42***		4.72***	2.08***
Is stable		1.16***	3.72***		0.68***	0.70***
Cannot say		Ref. level	Ref. level		Ref. level	Ref. level
Benefits (self-reported):						
Farmer had wild boar hunting opportunities (yes)	Ref.	1.50***	2.28***	Ref.	5.26***	1.40***
Farmer received meat (yes)		16.1***	1.89***		4.64***	1.45***
Feelings associated with encountering tracks, or when hearing or seeing animals:						
Negative feelings (yes—fear, anger, or disgust)	Ref.	0.06***	0.11***	Ref.	0.10***	0.19***
Positive feelings (yes—joy)		21.25***	1.02$^{ns.}$		1.33***	0.98$^{ns.}$
Damages (self-reported):						
In agriculture (yes)	Ref.	0.11***	0.65**	Ref.	0.41***	0.41***
In forestry (yes)		0.86$^{ns.}$	0.26***		2.37***	1.55***
Mitigation measure(s) taken (yes)	Ref.	0.64$^{ns.}$	0.29***	Ref.	1.47**	0.73***

The numbers are variable-specific odds ratio (OR) estimates of the multinomial regression analysis that includes 1 level covariate variables in the MLCA model as either separate blocks (middle column) or as multiple blocks (right-side column).
Statistical significance: $^{ns.}p > 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

2020), the hourly income claim of farming entrepreneurs is 16€, which is also used here for estimating the total costs. The specified costs are used primarily when estimating total damage and mitigation costs. Non-specified costs are used only when specified values are not given.

Even though other factors, such as topic interest and accessibility of the online survey, may cause bias in questionnaire responses, we base our broad estimate of total costs on the assumption that the damages reported in the survey represent a truly random sample from each of the five regions. Hence, we weighted each respondent's cost value with the number of farmers the respondent represents in his/her region. Using bootstrapping (Hesterberg 2011), we simulated 10,000 datasets by resampling (with replacement) the weighted values. This way we obtain a value estimate, with 95% confidence intervals (C.I.), of wild boar damages in the study area in 2020.

3. Results

3.1. Survey response rate

Of the 3870 full-time farmers in the research area, 2048 opened the survey invitation and 334 farmers proceeded to the survey (Supplement 1). A total of 165 farmers responded fully to the survey. No significant differences in response class frequencies were observed between early and late responses (Supplement 4). The auxiliary information of the persons who opened the invitation letter or survey form (the latter contains respondents) indicates only small deviations from the farmer population in the study region (Supplement 1).

3.2. Interactions

Most respondents were aware of wild boars occurring in their vicinity. Of the 165 respondents, 87% claimed that wild boars have been observed in their home municipality and 63% reported sows with piglets. The median year of the first observations was 2005 (varying from 1972 to 2020) and 2010 for the first piglets (1980–2020). The perception of change in local wild boar numbers during the last five years varied: increased (62%), unchanged (23%), and decreased (6%), while some respondents (9%) could not say.

In addition, 64% of respondents also reported their own personal observations of wild boars. Observed tracks were reported by 52%, sightings of wild boars by 45%, and auditory observations by 8% of all respondents. Emotions among respondents regarding the observations varied. Anger was the most common emotion regarding track observations, while sightings and auditory signals most often resulted in surprise (i.e. a neutral emotion). Negative emotions (anger, sadness, disgust, fear, and anxiety) represented 53% of all reported emotions, while 10% were positive (joy, interest). The remaining emotions were neutral (e.g. surprise).

3.3. Effects of wild boars

Forty-four percent of respondents stated that wild boar had affected their livelihoods during the preceding year. Small effects were reported by 27%, moderate effects by 10%, and major effects by 7% of respondents. While positive wild boar effects were also reported, they were outweighed by negative effects. The reported negative effects of wild boars occurred mostly in farming, as 38% of respondents reported agricultural damages. This percentage was highest in South Karelia (65%) and lowest in North Karelia (17%) and South Savo (23%).

Most often agricultural damages focused directly on cultivated plants (92% of respondents reporting damage). The forms of damage to crops and crop quality, in order of frequency, were soil digging (20%), trampling (15%), foraging (11%), trails (7%), and faeces (5%), while 64% did not specify the form of damage. Affected crops were most often cereals (57%), of which oat (*Avena sativa*; 26%) and wheat (*Triticum aestivum*; 26%) were most affected. Damages to cereals with longer awns, i.e. barley (*Hordeum vulgare*) and rye (*Secale cereale*), were reported less frequently (16 and 3%, respectively). After cereals, forage plants were the second most frequently affected (25%) group in the questionnaire replies, followed by caraway (*Carum carvi*; 18%), pea (*Pisum sativum*; 7%), potato (*Solanum tuberosum*; 5%), oil seeds (*Brassica* spp. 5%), and broad bean (*Vicia faba*; 2%). For the most common crops, the reported damage per farmer for specific crops was calculated as follows: for wheat, 30% (95% C.I.: 18–44); for oats, 16% (9–25); for forage plants, 16% (9–25); and for barley, 11% (6–20). In addition to direct crop damage, flooding due to blocked drains and damages to protective structures (e.g. fences) were also reported in the survey (30 and 10%, respectively).

Forest damage by wild boars was rare, having been reported by 13% of respondents practising forestry activities ($N = 157$). Damage consisted mostly of soil digging (which may damage tree roots; 95% of respondents reporting forestry damage) and, to a lesser extent, damage to trunks or saplings (38%). One respondent reported a forest flooding risk due to drain blockages caused by wild boars.

The reported positive effects were strictly related to wild boar hunting and meat. Benefits were reported by 14% of respondents, all of whom received meat or hunting opportunities for themselves, guests, or clients. Twenty percent of respondents stated that hunting and/or game management was their leisure activity.

3.4. Mitigation methods

Mitigation measures for wild boar damage were reported by 20% of respondents. Sixty-five percent of those reporting mitigation reported hunting (by themselves or others) as a way of mitigating damage. Other mentioned measures (reported by 38% of respondents reporting mitigation) included fencing, repellents (scent, sound, and light), earlier crop harvesting, avoiding the planting of vulnerable crops, and prohibiting supplemental wildlife feeding in winter. Fencing and repellents were used only by respondents who also reported damage, while 30% of those considering hunting as mitigation did not have damage experiences.

3.5. Attitude groups of farmers

The data indicate that farmers are not a homogeneous group with respect to wild boar management. The most parsimonious LCA model assumed that respondents belonged to three notable attitude groups. This model had a better fit to the data than corresponding models assuming two, four, or five groups (Supplement 3).

The three attitude groups were named, based on the pattern of item–response conditional probabilities (see Figure 2), as the "Hunting resource" group (20% of respondents), "Pest-of-concern" group (42%), and "Ambivalent" group (38%). Farmers who were classified primarily into the "Hunting resource" group did not regard the current wild boar population as too large or its increase to be worrying. They also strongly resisted the idea that wild boars should be eradicated or that supplemental feeding of the species should be regulated. Instead, they most commonly perceived that the species should be managed as beneficial—a valuable hunting resource. The "Pest-of-concern" group showed a clearly distinctive attitude pattern compared to the other groups, with strong views that the species already is an excessively abundant pest animal, which should not be maintained by feeding nor managed as a species that mainly benefits hunters. This group also showed the highest support for compensating damages from state funds. The "Ambivalent" group was divided internally regarding every attitude item, although they tended to regard the species as primarily raising concern.

The LCA model fit improved when a two-level structure (province ID as a random intercept) was added to the model. The resulting nonparametric MLCA model assumed that the prevalence of the attitude groups may vary within the study region and form clusters of provinces. Among the alternative models with varying numbers of modelled clusters, the MLCA, which assumed measurement invariance and had two regional clusters, showed the highest fit with the lowest BIC and AIC (Supplement 3). Farmers from the other provinces, apart from those in North Karelia, exhibited a similar farmer classification pattern at level 1.

We then added farmer-specific (level 1) covariates to the MLCA model, which enabled us to analyse the factors predicting inclusion into the attitude groups. The most parsimonious model (lowest BIC and AIC) only included the reported positive and negative feelings of observations as predictors. This and the high effect sizes (odds ratio coefficients, Table 1) of both negative and positive feelings of belonging to certain attitude groups indicate the major role of the affective component within attitudes. The variable coefficients varied to some extent between the block and all-blocks models while always remaining statistically significant, indicating that beliefs and feelings are shaping the attitude constructs. The perceived benefits realized damages, population trend perceptions, and specific feelings of encountering wild boars strongly separate the attitude groups.

3.6. The economic costs of damages and mitigation

The median economically affected farmer suffered damages worth 224€ (0.5–5320€, $N = 58$) in the year preceding the survey. A third of these responses did not include specified costs, in which case non-specified (total) costs were taken into account. All the used non-specified costs fit within the scope of the specified costs. Individual non-specified costs to the extent of 20,000€ were reported, but these were excluded due to the provided specified costs. The median crop damage area reported by respondents ($N = 59$) was 2000 m^2, with a minimum of 2 m^2 and a maximum of 300,000 m^2. Median values are used as a measure of central tendency, as mean values were greatly affected by considerably high individual values (potential outliers).

Assuming that respondents represent a random sample of their region, estimated damage costs extrapolate to total damages of 987,840€ (95% C.I.: 511,140–1,593,500€) in the research area in 2020. The highest estimated costs were incurred in North Karelia (39% of all costs) and South Karelia (38%), along the eastern border of the research area. These were followed by Kymenlaakso (15%), Eastern Uusimaa (5%), and South Savo (2%).

The costs of mitigation measures (materials and work time) varied between 16 and 4200€, with a median of 337€, among the 24 farmers reporting above-zero costs in the questionnaire. The total extrapolated cost of mitigation in the research area in 2020 is 349,540€ (95% C.I. 131,680–641,430€).

4. Discussion

Our survey of southeastern Finnish farmers revealed that while most respondents have wild boars in their vicinity, the majority have not experienced damages caused by them. The incurred damages were mainly focused on crop fields in the regions with the highest wild boar densities. The experienced benefits from the species were solely related to hunting, which was also the main mitigation method reported. Three attitude groups were identified among the surveyed farmers: “Hunting resource”, “Pest-of-concern”, and “Ambivalent”. In addition to experienced damage, specific beliefs and feelings explained this division into groups. Respondents who have experienced damages reported median costs of 224€ per farm, with estimated yearly costs of damages in the whole research area being circa 990,000€ and mitigation costs circa 350,000€.

4.1. Adaptation

Direct experiences of wild boar were abundant among the surveyed farmers and their surroundings. However, the recent settling history, experienced recent increase of the species, implemented mitigation measures, and seizing of hunting opportunities revealed that the process of adapting to the new species is dynamic in nature (see also Howard 2019) and currently only in its early stages in many regions of Finland. Due to the dispersal history and Russian origin of the wild boar population (Kukko, Pellikka, and Pusenius 2018; Markov et al. 2022), the damage experiences and related costs are concentrated in South Karelia. North Karelia was also highlighted as a province with notable damage costs, but it did not show high rates of damage experiences. This may suggest a denser, but spatially more restricted population (Ruha and Kunnasranta 2023), the expansion of which is likely limited by a more northern and continental climate in that region.

Individual experiences with a species determine people’s perceptions of risks relative to benefits as well as their tolerance (Kansky, Kidd, and Knight 2016). In our case, so far, a minority of farmers have had strong meaningful experiences: While most respondents had already had some encounters with the species, less than half of the respondents reported wild boars affecting their livelihoods in any way. This also suggests the ongoing process of farmer adaptation, as the increasing density of wild boars presumably increases the number and severity of damage experiences related to the species (Bleier et al. 2012; Frackowiak et al. 2013).

The reported negative effects outweigh the positives, which also explains the mostly negative emotions related to wild boar observations. Most of these negative effects were associated with crop damage, which is in line with previous literature from Western and Eastern Europe (Barrios-Garcia and Ballari 2012; Schley and Roper 2003; Tarvydas and Belova 2022) and the United States (Adams et al. 2005), as is the high proportion of damage to cereals (Gren et al. 2019; Schley et al. 2008). Forestry damage experiences were rare in our study. Despite some exceptions (Fern et al. 2020), forestry damages by wild boars are often regarded as insignificant, especially in North European studies (Gren et al. 2019; Haaverstad, Hjeljord, and Wam 2014; Tarvydas and Belova 2022).

Although the survey targeted farmers and not hunters, hunting stands out in the responses as the most significant source of benefits for farmers as well as the main damage mitigation method. The minor role of other mitigation methods (e.g. fencing, repellents, and changes to production) may be partially due to the novel presence of the species and lack of damage experiences. However, the cost-effectiveness of alternative methods is generally considered low in core areas of the wild boar’s distribution (Geisser and Reyer 2004; Laguna et al. 2022; Massei, Roy, and Bunting 2011; Storie and Bell 2017), indicating that hunting will likely retain its status as the main control method.

4.2. Mixed attitudes of farmers

The observed farmer attitude groups demonstrate that farmers are not a unanimous group regarding their opinions towards wild boar management. Few publications measure benefits when analysing perceptions in large mammal conflicts, and even fewer detect their importance in explaining attitudes (Kansky and Knight 2014). In addition to benefits and mitigation, the hunting perspective also stands out in the formation of the attitude groups. Personal hunting and livelihood-related interests would presumably increase incoherence in attitude formation but generally seem to manifest in rather favourable attitudes toward wild boars. In contrast, adverse attitudes are mainly driven by concern and even fear regarding the negative effects associated with the recent population increase. Positive feelings regarding wild boar encounters and perceived benefits are experienced almost solely by farmers in the “Hunting resource” group. Hunting farmers showed attitudes that went beyond those indicating “tolerance”, even implying “stewardship”, highlighting the internal conflicts among farmers regarding wild boar management strategies. Similar damage *vs.* hunting benefit contrast has also been observed elsewhere in settled, non-native wild boar ranges (Adams et al. 2005; Jaebker et al. 2022; McLean et al. 2021; Storie and Bell 2017). As one possible source of bias, farmers with topic interest (i.e. related to damage prevention, compensations, and/or promoting hunting benefits) may be more likely to respond to the survey (Groves, Presser, and Dipko 2004). Thus, farmers with ambivalent attitudes towards wild boars, and therefore towards the survey, may be underrepresented in the responses.

The hunting aspect seems to simultaneously unify and divide opinions on management strategies depending on the subject: damage control by hunting may serve as a common goal (Cromsigt et al. 2013; Jaebker et al. 2022; McLean et al. 2021) and, for a farmer, build an increased sense of control in a situation. Conflicts may arise within farmer communities constituting various attitude groups when discussing the issue and defining shared management goals and supporting actions, such as eradicating or maintaining the local wild boar population. As a case example, the legislative control of supplemental feeding divides opinions between the attitude groups. Feeding sites enable effective bait hunting (Cellina 2008; Geisser and Reyer 2004) and, in some cases, even divert wild boars from crop fields (Calenge et al. 2004; Cellina 2008; Muthoka et al. 2022). On the other hand, supplemental feeding may maintain and even increase the local wild boar population (Cellina 2008; Geisser and Reyer 2004). Supplemental feeding along with population management goals are apparent themes in the conflict between hunting and incurred damages also in more established areas of the wild boar distribution (Storie and Bell 2017). Interestingly, farmers in the “Hunting resource” attitude group often considered wild boar population trends differently than farmers in other attitude groups. This difference between hunting and non-hunting farmers may be partly explained by local knowledge exchange among these subgroups and differences in information availability in the media (including hunter magazines). Overall, growing environmental, media, and social contacts (e.g. neighbouring farmers) may play a role in shaping these attitudes (Caplenor et al. 2017; Cullen et al. 2020; Hosaka, Sugimoto, and Numata 2017; Wang and Mumby 2022). The production and provision of accurate monitoring information on the trends is probably useful for building more shared perceptions of wild boar population goals.

Experienced crop damage correlated with belonging to the “Pest-of-concern” attitude group, and thus with more negative attitudes. Past research has shown that tolerance towards ungulates is often proportional to the damage probability (Kansky, Kidd, and Knight 2014) and that past experiences may explain the formation of attitudes (Conejero et al. 2019; Dressel, Sandström, and Ericsson 2015; Hosaka, Sugimoto, and Numata 2017). This, along with the research by Basak et al. (2022), suggests that an increase in the wild boar population may result in an increasing prevalence of negative attitudes towards the species. Farmer attitudes are most often negative, at least in the non-native range of the species (Adams et al. 2005; Harper et al. 2016).

4.3. Economic effects

The damage costs in the research area are supposedly quite close to the total costs experienced in Finland due to the area having the highest wild boar densities in the country. However, due to the relatively low number of respondents (4% of full-time farmers in the research area), we can only broadly estimate the magnitude of yearly costs incurred due to wild boar. Due to the possible topic interest bias (Groves, Presser, and Dipko 2004), farmers with damage experiences may be overrepresented in the survey, and therefore, the true damage costs may be lower than the estimated costs (990,000€). Based on the estimate, the reported costs are smaller compared to those in other countries with more settled and denser wild boar populations. In Sweden, Gren et al. (2019) estimated annual damages of circa 2759€ (including protection costs of <28%) in 2022 per farm, while our estimates translate to 250€ of damages and 90€ of mitigation costs per farm. In Luxembourg, Schley et al. (2008) used paid compensations to calculate the mean cost of individual damage cases to be 396€. The economic effects of wild boars have not been estimated previously in Finland. As climate models predict increasingly favourable conditions for wild boars in the north, it is highly probable that damages will increase. Therefore, even this broad estimate provides a valuable baseline for future estimates.

When dealing with pests, the need for action depends on the amount of harm caused by the species (Carpio, Apollonio, and Acevedo 2021). Considering the high individual cost values (up to 20,000€) reported by a few respondents, it appears that while median costs in Finland are still low due to the restricted wild boar population, damages may occasionally be locally substantial. This, combined with the expected population increase, may facilitate the need to include wild boar damages in the national compensation scheme. Such a scheme is in place for other ungulates but does not cover wild boar damages (Game Animal Damages Act 105/2009 2009). In comparison, collective damages in 2020 by moose (*Alces alces*) and white-tailed deer (*Odocoileus virginianus*) were compensated with over four million euros in Finland and with more than half a million euros within our study area, according to the game animal damage register (Ministry of Agriculture and Forestry of Finland n.d.). These costs are at a similar level compared to estimated wild boar damage costs in the study area. The call for compensation was the most unanimous opinion among the attitude groups, and this is not unique to our research area (Frank, Monaco, and Bath 2015).

4.4. Conclusions

Several theories from various disciplines describe the general phases of increasing human adaptation in problematic situations. Few, however, have focused on the process in the context of wild boar novel wild boar presence (for an exception, see Frank 2012), despite the global spread of wild boars and the severity of damages the species may cause to farmers, which calls for attempts to manage their impacts. In Finland, adapting to wild boar presence has manifested as, e.g. intensified hunting and use of other mitigation measures and as increasing demands for damage compensation. Experiences with and costs of wild boars, while not yet extensive, are likely to increase as the warming climate accommodates the increase in abundance and the geographical spread of the species (Markov et al. 2022). Our results demonstrate that farmers are not unified in their attitudes towards the novel pest species. This highlights the importance and challenge of jointly accommodating farmer knowledge and multiple interests and values to find widely accepted management strategies. Management and policymaking also require population trend monitoring and efficient information sharing concerning the species' current status. In addition, a transdisciplinary approach is needed to focus more broadly on interactions that connect animal population processes and impacts and farmers' practical capacities to adapt to the presence of a hard-to-control pest, such as wild boar. Also, the continuous monitoring of the damage caused by pest species is vital for assessing the need for support and the effectiveness of management actions.

Geolocation information

This study was conducted in southeastern Finland (centre: 61.5 N, 28.5 E).

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Data availability statement

The data generated and analysed during the current study are available at a Luke data repository upon a reasonable request *via* email from the corresponding author.

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