Mitigating measures in wildlife management: testing lethal and non-lethal scaring on crop-foraging geese

INGUNN M. TOMBRE[1]*, GØRLI ELIDA BRUUN ANDERSEN[2,3] & BÅRD-JØRGEN BÅRDSEN[1]

[1]Norwegian Institute for Nature Research (NINA), Fram Centre for High North Research, P.O. Box 6606 Langnes, N-9296 Tromsø, Norway.
[2]Inland Norway University of Applied Sciences, P.O. Box 400, N-2418 Elverum, Norway.
[3]Romsveien 35 A, N-3114 Tønsberg, Norway.
*Correspondence author. E-mail: ingunn.tombre@nina.no

Abstract

Managing geese (*Anser* and *Branta* spp.) is challenging but mitigation measures are available that can reduce adverse impacts, such as crop loss from grazing geese. Both non-lethal and lethal scaring offer mechanisms to reduce such impacts, although the latter is often criticised on animal welfare grounds. Conversely, an argument used for shooting some geese is that it acts as a deterrent to others in the flock, so potentially is more effective than non-lethal scaring for moving birds from particular fields. This study therefore compares the effects of lethal scaring (by a person shooting with a shotgun) and non-lethal scaring (someone approaching the geese on foot), as two treatments in an experiment conducted from mid-May to mid-June 2016 in Tønsberg municipality, Norway, an area significantly affected by geese foraging on cultivated fields throughout the growing season. Experimental scaring was conducted at one large property, imposing alternate lethal and non-lethal scaring in nine treatment blocks. Total numbers of geese on the fields, distances between different goose flocks and the scaring field, and flock sizes did not differ significantly between the two treatments in days after scaring. Following application of both scaring methods, geese returned to the scaring field the same day; hence, both methods appeared equally ineffective at reducing the number of geese and their potential to cause crop damage. It should, however, be noted that this study was conducted at just one site in a single season, and more extensive studies are required on this sensitive issue. Meanwhile, lethal scaring implemented in accordance with applicable rules and regulations (*e.g.* with evidence of economic loss) may have a conflict-mitigating effect, although conflict resolution should not in itself be used to justify lethal scaring.

Key words: conflict mitigation, crop protection, goose distribution, goose grazing, lethal scaring, wildlife management.

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Protecting crops from foraging geese (*Anser* and *Branta* spp.) is challenging. Although a range of tools are available to displace the birds (Fox *et al.* 2017; Tombre *et al.* 2019), conflicts between geese and agriculture are significant in many regions and present major management challenges (Eythórsson *et al.* 2017; Eriksson *et al.* 2020). Accordingly, goose management plans commonly include objectives to reduce crop losses and conflicts with agriculture. In 2016, the European Goose Management Platform (EGMP) was established under the auspices of the Agreement of the Conservation of African-Eurasian Migratory Waterbirds (AEWA), developed under the United Nations Environment Programme's Convention on Migratory Species (CMS). The platform addresses the conservation and management of several goose populations in Europe through a coordinated flyway approach involving relevant Range States. While the primary aim is to manage and conserve geese effectively throughout their migratory range, reducing crop damage and thus conflict with farmers is also a fundamental objective of the EGMP (Madsen & Williams 2012; Jensen *et al.* 2018; Powolny *et al.* 2018). As geese increasingly favour farmland over natural habitats (Fox & Abraham 2017), and since many populations continue to increase both in numbers and distribution (Fox & Madsen 2017; Heldbjerg *et al.* 2025), crop protection remains an ongoing problem and hence a source of concern for farmers, further challenging successful wildlife management (Eriksson *et al.* 2024).

Responses to grazing and crop-foraging geese by the agricultural community occur at different scales and take different forms, from a local farmer response to organised actions or schemes at the regional or national level (see *e.g.* Eythórsson *et al.* 2017; Koffijberg *et al.* 2017, 2024; Seltmann *et al.* 2025). Farmers may chase foraging geese away from the fields (human scaring), but this is resource intensive (Vickery & Summers 1992), often with limited effects (Simonsen *et al.* 2016; Månsson *et al.* 2024). Alternatively, scaring devices (*e.g.* scarecrows, kites and lasers) can be employed, but these too generally provide only a short-term deterrent, and require significant effort to implement (Blackwell *et al.* 2002; Werner & Clark 2006; Clausen *et al.* 2019; Elbers & Gonzales 2021; Månsson *et al.* 2024; Robai *et al.* 2024). Experience suggests that combining different scaring techniques is most effective (Holevinski *et al.* 2007).

Lethal scaring is practised outside the hunting season, when permission has been sought and granted to shoot geese causing damage to agricultural crops, on the basis that lethal scaring results in the flock abandoning the field (Heldbjerg *et al.* 2022). Goose abundance may be reduced for several days at the targeted field (Månsson 2017; Aarseth 2023). Conservationists argue that non-lethal scaring methods have displacement effects similar to lethal scaring and support their use from an animal welfare perspective (Hadidian 2002), although shooting was found to be more successful for disturbing Mallard *Anas platyrhynchos* (Dooley *et al.* 2010). In a recent study, Sørensen *et al.* (2026) compared several scaring techniques, both lethal and non-lethal, and brought farmers' experiences into the evaluation. Lethal scaring appeared

to be most effective combined with other methods and, given farmers' needs to safeguard crops and pasture grass, such a legally sanctioned measure (subject to granting of permits) is generally acknowledged by farmers as an important management option. Reducing conflicts between geese and agriculture is an important objective in the EGMP management plan for the European Northwest/Southwest population of Greylag Goose *Anser anser* (Powolny *et al.* 2018) and, whilst conflict reduction cannot be the sole reason for implementing lethal scaring or derogations (which should include the provision of evidence of crop damage and the limited effectiveness of using other non-lethal scaring techniques), their implementation commonly has an alleviating effect.

In general, shooting must be practised under controlled conditions, with special permits and target the so-called culprits, *i.e.* the birds actually doing the damage (Conover 2002). In Norway, a specific regulation to reduce damage caused by game species provides the legal basis for the lethal scaring of geese ("The Game Regulations"; Lovdata Foundation 2020). Granting of permission for lethal scaring is conditional upon the following: (i) that damage caused by geese exceeds a certain level of economic loss; (ii) that other non-lethal methods should previously have been practised and failed; (iii) that only culprit species should be targeted; and (iv) the activity should not have any adverse effects on the size of the population in question, although at what scale the population is assessed (*i.e.* the local population size) is open for interpretation by the municipality. According to farmers, lethal scaring is the most efficient method for reducing goose abundance in the fields as well as crop damage, and hence for mitigating the goose-agriculture conflicts.

In response to the different arguments for using lethal *versus* non-lethal scaring in the goose-agriculture conflict, we here present results from an experimental field study quantifying goose responses to both methods: lethal scaring and scaring by an approaching human who chases the geese off the fields. To our knowledge, no studies have directly compared the effects of these methods (but see Månsson *et al.* 2024 for some related perspectives). We quantified goose responses to scaring (lethal *vs.* non-lethal) in terms of: (1) total goose numbers on the field before and after scaring, (2) flight distances of the different flocks (*i.e.* the distance between the scaring field and fields where the geese subsequently settled) after being exposed to either human or lethal scaring, and (3) goose flock sizes before and after scaring treatments. Our aim is to provide useful information to the toolbox of different measures available for farmers challenged by goose foraging on crop and pasture fields.

Methods

Study site

The study was conducted from mid-May to mid-June 2016 in the municipality of Tønsberg, southern Norway (Fig. 1). During this period the flocks consist primarily of young geese and non-breeders (breeders and families being still mainly at their nest sites on islands further out in the fjord), foraging on cultivated fields where lethal scaring is

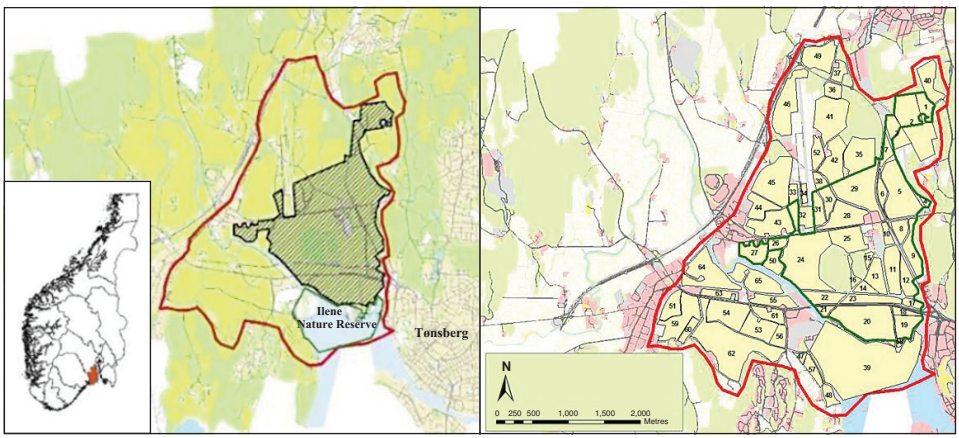


Figure 1. Study area in southern Norway (small, inserted map), where Greylag Geese and Barnacle Geese utilise farmland fields during the growing season (within the red lines). Scaring treatments and goose responses were monitored within the black shaded area (left map, outlined in green on right map). Their roosting site (the Ilene Nature Reserve), also used for foraging, is shown within the green line (left map) and by location number "39" (right map), whilst fields where scaring took place are coloured in darker yellow (right map).

practised by farmers under permits issued by the municipality. A permit to apply lethal scaring was also provided for the present study (see later). Greylag Geese and Barnacle Geese *Branta leucopsis* forage on cereal and pasture fields, as well as *e.g.* lettuce, bean and pea fields in the region. The study area comprised mostly cereal fields. Greylag Geese were the dominant species and were the ones shot by lethal scaring. However, since Barnacle Geese also are exposed to the disturbance, both species were included in the study.

The study was conducted at Jarlsberg Hovedgård (59°17.43'N, 10°23.08'E), the largest farm in Tønsberg municipality with 370 ha of cultivated fields, where wheat is grown as the dominant crop. Proximity to the roosting site used by geese – the Ilene Nature Reserve (a Ramsar site; Fig. 1) – means that the farm is seriously challenged by goose grazing during the growing season. A significant number of other waterfowl and waders also use the reserve, which hosts 270 different species (Visitor Centre Wetland Ilene 2026). Most fields at Jarlsberg Hovedgård have foraging geese from March through to October. The landowner organises successful autumn goose hunts on the property, where 30–40% of Greylag Geese in the municipality are harvested (from totals of 580 and 790 Greylag Geese harvested across Tønsberg during autumn recreational hunting in 2023/2024 and 2024/2025, respectively; Statistics Norway 2026). Lethal scaring is practised before the regular hunting season (which opens on 21 July in Tønsberg), and in the present study it was organised by the project. No other scaring was undertaken, and the landowner

received modest funding to compensate for some of the extra loss incurred by being involved in the study. There is no open season for Barnacle Geese, but lethal scaring of this locally breeding population was initiated in southern Norway in 2017. Permission to implement lethal scaring for Greylag Geese was granted by Tønsberg municipality and the County Governor of Vestfold, and the local police were informed before all shooting events took place, which is mandatory under the Norwegian legislation.

Field protocol and experimental design

Although none of the geese were individually marked or tracked, we assumed from observations made over many years (see *e.g.* Andersen & Tombre 2018) that the same individuals flew up to 1.5–2.0 km from their roost site each morning to forage on nearby cereal fields during the day. Consequently, we considered that roughly the same flocks were exposed to sequential scaring. Geese were observed using binoculars (Swarovski 10×32) and a spotting scope (Swarovski ATS 80 HD), from vantage points (car or bird tower) in the nature reserve. Systematic monitoring was undertaken daily, and flock sizes and field locations were marked on maps. The lethal or non-lethal scaring measures were undertaken between 04:00–06:00 h, on fields determined from goose distribution mapping the previous evening (because geese commonly return to foraging fields used the previous evening the following morning; Jensen *et al.* 2016). This enabled targeted scaring on the field with potentially the largest flocks, whilst at the same time also mimicking a farmer's behaviour. Non-lethal scaring was performed by the same person running towards the flock, while clapping hands and shouting. Flight distances (*i.e.* the distances between the person scaring and the geese when they flew) were measured using a Nikon camera with a built-in range-finder function. This measure was not possible (for safety and practical reasons) for lethal scaring because the hunter cannot run, shoot and quantify the escape distance all at the same time. Most lethal scaring was conducted by local, skilled goose hunters who used a shotgun at distances of 30–50 m and targeted individuals to avoid crippling birds. No decoys were allowed. When shooting started, the flock left the field immediately, and number of geese shot and shots fired were recorded as a measure of scaring intensity. On occasions when it was not possible to shoot at the geese because of poor visibility or if the birds were > 50 m away, shots were directed towards the ground for security reasons, mimicking the farmers' behaviour in similar situations. After scaring in the morning, geese were monitored in all nearby fields the following afternoon and for the next two mornings, as described below.

Although not measured directly, observations indicated that the geese flew back to the roost site or to fields farther away immediately after being scared. Distances (in metres) between the centre of the scaring field and fields where geese were subsequently observed were measured using ESRI Arc Map software.

As scaring was conducted at only one large property, for practical and local topographical reasons, the length of the study period limited by the number of

scaring incidents possible at a single site. Lethal scaring was conducted on five occasions whereas non-lethal scaring was conducted four times. To obtain sufficient and independent scaring incidents, three days were chosen at the time as the shortest interval between the scaring treatments. While we have no evidence to support this, we assumed that no effects of the previous scaring activity remained on day three, and that a new scaring treatment therefore could be undertaken (in practice > 60 h after the previous scare) without compromising the results of the study. Scaring therefore was conducted at three-day intervals, except for a period in the middle of the study period when fewer geese were observed in the fields used for scaring (geese sometimes used fields where shooting was impossible for security reasons), resulting in intervals of six and seven days between scaring. When there were three days between each scaring, the day before scaring and the third day after are the same day and we assume that the treatments are independent of each other.

Statistical analyses

We analysed responses to the treatments using four response metrics: (1) local abundance (total number of geese in the study area: N); (2) changes in total goose numbers post-treatment relative to pre-treatment (growth: $\log_e(\lambda) = \log_e(N_t)/\log_e(N_{-1})$, where t is days relative to treatment); (3) distribution in the landscape (minimum distances based on the coordinates of the observations in relation to the mid-point of the scaring field); and (4) flock size (N_{flock}). Flock size and spatial distribution were individual survey records for each field, whereas local abundance was calculated from daily aggregated sums of N_{flock}. Observations of the two species were aggregated to daily case-level summaries based on the day (evening) before manipulation ("–1"), the afternoon on the day when manipulation occurred in the morning ("0"), the morning of the day after manipulation ("1", between 04:00–06:00 h), and the mornings two ("2") and three ("3") days after manipulation. In the analyses of N and N_{flock}, we $\log_e$-transformed the response (λ was already $\log_e$-transformed) to approximate a normally distributed response. We did not make a direct statistical comparison between lethal and non-lethal scaring because the interventions were not conducted simultaneously, so were partly confounded with time. Instead, we therefore estimated the effect of each intervention within its respective period and compared the direction, magnitude and uncertainty of the effect estimates descriptively.

Statistical analyses and plotting were performed in Program R (R Core Team 2024). All tests were two tailed with $\alpha = 0.05$. We used Wald statistics to assess parameter significance and checked model assumptions using standard diagnostic plots (not shown; see Zuur *et al.* 2009). We fitted a set of regular linear models (*e.g.* Fox 2002; Pinheiro & Bates 2000; Zuur *et al.* 2009), using R's statistical package, to represent competing biological hypotheses. Three different main predictors (all included as categorical variables, using treatment contrasts, with each level compared with the predictor's baseline level), were included to explain the outcome of our manipulations: (1) Treatment Day, to analyse multi-level treatment-day effects (using treatment day with –1 as the

baseline, and days 1, 2 and 3 as the other levels); (2) Treatment Category – a simpler version in which days ≥ 2 were pooled together ("2+"); and (3) Treatment Simple, with pre- (baseline) and post-manipulation as two levels. As population change (the "growth" response defined above) was defined relative to population size the day before treatment, including Treatment Simple as a predictor was redundant in these analyses. In these analyses we therefore only fitted an intercept-only model to test whether mean post-manipulation growth was negative (with no differences across days). These models were fitted to a subset of the data excluding the day before manipulation. As there was a significant correlation between Treatment Day and abundance (across all scaring occurrences: $F_{5,142} = 7.377$, $R^2 = 0.206$, $P < 0.001$), we did not include candidate models with both abundance and Treatment Day as predictors in the analyses. We performed model selection using the second-order Akaike Information Criterion (AICc; Burnham & Anderson 2002). For each candidate model (i), we calculated the AICc, the Δ_i difference from the model with the minimum AICc, and Akaike's weights (w_i), using the AICcmodavg package (Mazerolle *et al.* 2023; see Supporting Materials Table S1). Models with $\Delta_i \leq 2$ were considered to be supported by the data and, among the supported models, the simplest (*i.e.* with the fewest estimated degrees of freedom; Anderson 2008) was taken as the best fit.

Results

Scaring incidents were carried out where goose abundance was highest, and six of nine incidents were performed at the same field. Over the study period, a total of 25 shots were fired, and seven Greylag Geese killed. For the non-lethal scaring incidents, escape flight distances were 100, 100, 70 and 95 m, respectively (average = 92 m).

Change in the numbers of geese after lethal scaring. The intercept-only model, applied to the analyses of changes in numbers (growth), showed that the decrease in goose numbers, post-manipulation relative to pre-manipulation, was statistically significant (Intercept = –0.355, s.e. = 0.151, $P = 0.033$; Fig. 2). This change was, however, mostly driven by lower goose numbers on day 3, which we interpret as an artefact (confounded with temporal trends; Supporting Materials Fig. S1), rather than an effect of the treatment – we had no *a priori* reason to expect scaring to have lagged effects. In the analyses of abundance, the model with Treatment Simple as the only predictor was the best supported mode ($\Delta_i = 0$, $w_i = 0.893$; Supporting Materials Table S1), but it did not have a statistically significant effect on *N* (Table 1a).

Change in the numbers of geese after human scaring. In the human scaring manipulation, post-manipulation growth was not statistically significant from zero (Intercept = –0.109; s.e. = 0.109; $P = 0.336$; Fig. 2). Again, as for the lethal scaring analysis, we selected the model with Treatment Simple as the only predictor in the abundance analyses ($\Delta_i = 1.423$, $w_i = 0.490$; Table S1), but it did not significantly affect *N* (Table 1b, Fig. 2).

Distances between geese and scaring fields after lethal scaring. We selected the model with Treatment

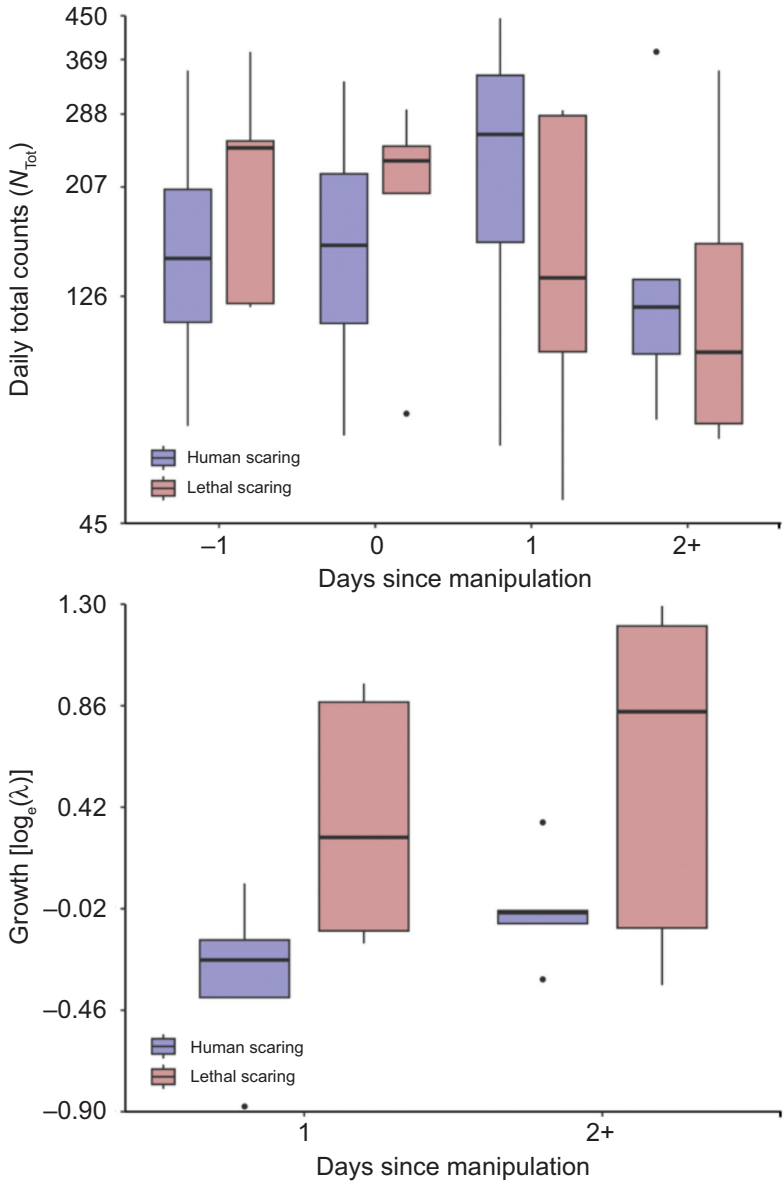


Figure 2. Daily total counts of geese (top) and the growth (total number of geese counted on the study fields) on: (–1) the day before scaring treatments; (0) the evening following the treatments; and (1 and 2+) the following mornings. The latter category represents days 2 and 3 after the treatment. Blue = non-lethal (human) scaring; red = lethal scaring. Vertical lines represent minimum and maximum values, the boxes are interquartile ranges, and horizontal lines are median values. Black dots are extreme values ("outliers"). See text for statistical details.

Table 1. Selected models from analysis of goose abundance (*N*) in the study area, before *vs.* after: (a) lethal scaring, and (b) non-lethal (human) scaring. Intercept refers to the pre-manipulation (baseline); Treatment Simple is a two-level factor (control = pre-manipulation; post-manipulation covers all days after manipulation); *P* values indicate no significant difference in abundance following both scaring treatments. Model selection was based on the second-order Akaike's Information Criteria (AICc) across the linear regression analyses (see Supporting Materials Table S1).

	Estimate	s.e.	*t*	*P*
a) Lethal scaring				
Intercept	5.32	0.23	19.20	< 0.001
Treatment Simple (post-manipulation)	–0.34	0.32	–1.08	0.30
$F_{1,19} = 1.157$; $R^2 = 0.057$; $P = 0.30$				
b) Human scaring				
Intercept	5.03	0.34	14.83	< 0.001
Treatment Simple (post-manipulation)	0.05	0.39	0.13	0.90
$F_{1,15} = 0.016$; $R^2 = 0.001$; $P = 0.90$				

Simple as a covariate as the model used for inference ($\Delta_i = 0$, $w_i = 0.818$; Table S1). Nonetheless, the difference between pre- and post-manipulation was not statistically significant (Table 2a, Fig. 3).

Distances between geese and scaring fields after human scaring. We selected the model with Treatment Simple for inference ($\Delta_i = 0$, $w_i = 0.859$; Table S1), and the difference between pre- and post-manipulation was not statistically significant (Table 2b, Fig. 3).

Flock sizes after lethal scaring. We selected the model with Treatment Simple as the model used for inference ($\Delta_i = 0$, $w_i = 0.472$; Table S1), but again not statistically significant (Table 3a, Fig. 4).

Flock sizes after human scaring. Lastly, we selected the same model (*i.e.* with Treatment Simple as the only predictor: $\Delta_i = 0$, $w_i = 0.870$; Table S1), and the difference between pre- and post-manipulation was significantly positive, with an effect size of 0.680 (s.e. = 0.332, $P = 0.045$) on a log-scale (Table 3, Fig. 4). On a normal scale, average size almost doubled from before to after scaring; pre- (intercept = 18.345) *vs.* post-manipulation (intercept + effect = 36.201).

Discussion

Wildlife management can be challenging, and the increasing abundance of several European goose populations has led to management plans that are valid across multiple range states (Madsen & Williams

Table 2. Selected models from analysis of the distances (m) between the geese and the scaring fields in the study area, before *vs.* after: (a) lethal, and (b) non-lethal (human) scaring treatments. Intercept refers to the pre-manipulation (baseline); Treatment Simple is a two-level factor (control = pre-manipulation; post-manipulation covers all days after manipulation); *P* values indicate no significant different in distances recorded following both scaring treatments.

	Estimate	s.e.	*t*	*P*
a) Lethal scaring				
Intercept	715.56	168.12	4.26	< 0.001
Treatment Simple (post-manipulation)	214.33	188.26	1.39	0.30
$F_{1,77} = 1.296$; $R^2 = 0.017$; $P = 0.26$				
b) Human scaring				
Intercept	1087.50	176.62	9.96	< 0.001
Treatment Simple (post-manipulation)	–283.77	213.66	1.33	0.199
$F_{1,58} = 1.764$; $R^2 = 0.030$; $P = 0.19$				

2012; Jensen *et al.* 2018; Powolny *et al.* 2018). One important objective of these plans is to minimise conflicts between geese and agriculture, for which a range of mitigating tools are available (Fox *et al.* 2017; Tombre *et al.* 2019). Motivated by this, goose responses to two different scaring techniques were tested as repellents: non-lethal scaring by an approaching person and lethal scaring by shotgun fire. The geese were scared and abandoned the fields regardless of the method used, but geese were observed at the scaring field later the same day. It was not possible to distinguish between the methods in terms of effectiveness, as there were no significant differences between lethal and non-lethal scaring nor in the total number of geese before and after scaring, nor in the distances between the scaring field and the fields where geese were observed after scaring, although they were on average further away after lethal than after non-lethal scaring. Flock sizes were, however, larger after human scaring. Results should be interpreted with caution and in the context of this study area; we were able to conduct the experiment based on only nine scaring trials at a single farm. As we implemented a three-day interval between the scaring treatments, a method aiming for independence between treatments, the season length limited the number of treatments in each category. Scaring at shorter intervals may have been more effective, although it is uncertain whether this would have changed the results. In our study, the geese were also unmarked, which in combination with the limited sample in

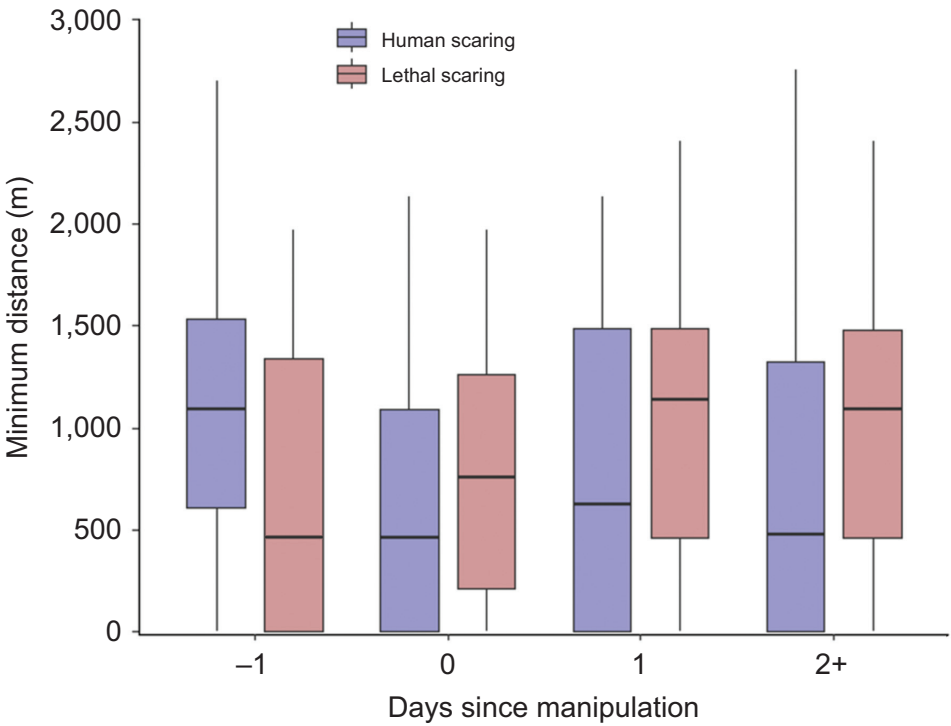


Figure 3. Minimum distances between the observed goose flocks and the mid-point of the scaring field on: (–1) the day before scaring treatments; (0) the evening following the treatments; and (1 and 2+) the following mornings. The latter category represents days 2 and 3 after the treatment. Blue = non-lethal (human) scaring; red = lethal scaring. Vertical lines are minimum and maximum values, the boxes are interquartile ranges, and horizontal lines are median values. See text for statistical details.

one particular season, at a single farm, means that results cannot be generalised as such. An improved study design, as adopted in other studies where behavioural responses to crop protection measures are observations based on individually marked geese, will give information about more specific effects (Nolet *et al.* 2016; Månsson *et al.* 2024; Nilsson *et al.* 2024; Seltmann *et al.* 2025).

Although we do not know whether we observed the same birds after scaring, this is the situation typically experienced by farmers in this area. It illustrates how difficult it can be to keep geese off cultivated fields for extended periods. In a Swedish study, where geese were scared by an approaching human or a drone, the birds were GPS-tagged and could be traced individually (Månsson *et al.* 2024). As in our study, their results showed that scaring effects levelled off (after 24 h), despite the immediate displacement effect of scaring. The outcome of scaring may however depend on the scaring technique, the local conditions, goose species, the number of birds in the area, food availability and the availability of non-disturbed fields

Table 3. Selected models from analysis of goose flock sizes ($N_{\text{flock size}}$) in the study area, before *vs.* after: (a) lethal, and (b) non-lethal (human) scaring treatments. Intercept refers to the pre-manipulation (baseline); Treatment Simple is a two-level factor (control = pre-manipulation; post-manipulation covers all days after manipulation); *P* values indicate no significant different in flock sizes following lethal but a significant increase following human scaring.

	Estimate	s.e.	*t*	*P*
a) Lethal scaring				
Intercept	3.74	0.30	12.59	< 0.001
Treatment Simple (post-manipulation)	–0.57	0.33	–1.70	0.09
$F_{1,77} = 2.904$; $R^2 = 0.036$; $P = 0.09$				
b) Human scaring				
Intercept	2.91	0.28	10.60	< 0.001
Treatment Simple (post-manipulation)	0.68	0.33	2.05	0.05
$F_{1,58} = 4.187$; $R^2 = 0.067$; $P = 0.05$				

(Baxter & Allan 2008; Clausen *et al.* 2019; Aarseth 2023; Nilsson *et al.* 2024; Robai *et al.* 2024). For example, studies of Greylag Geese on farmland islands in northern Norway showed significant effects of lethal scaring on numbers of geese using pasture fields (Aarseth 2023), as some geese left the islands and foraged elsewhere because opportunities for grazing nearby were limited. In this situation, lethal scaring may have been an effective method to keep foraging geese away from agricultural fields. Lethal scaring was also effective in reducing the number of Greylag Geese in cultivated fields in Sweden, although the effects were, as in our study, short-term (Månsson 2017). There the lethal scaring was conducted on a different scale to that in our study, with more geese shot and more geese disturbed. Scaring intensity therefore appeared to be greater, but the geese still returned after a few days.

Scaring geese by an approaching human can have positive effects on the grazing pressure if scaring is performed intensively. This has been demonstrated for Pink-footed Geese *Anser brachyrhynchus* spring-staging in Mid-Norway (Simonsen *et al.* 2016). Based on dropping counts, goose densities were reduced after scaring, but only for significant scaring levels. From a farmer's perspective, scaring represents a cost-benefit trade-off: the time (and other resources) needed for chasing geese during spring (a busy time in the farming year) must be balanced against the reduced crop damage. Less resource-demanding tools may therefore be prioritised, for instance using a laser to repel geese, as they can be displaced at long

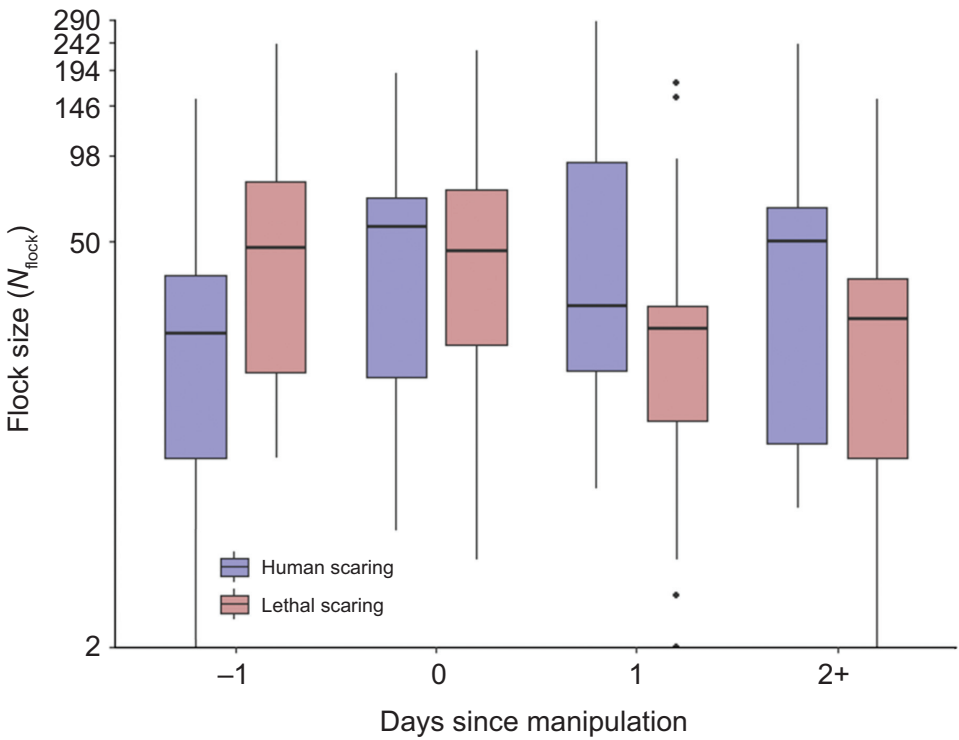


Figure 4. Flock sizes (log scale) of geese in the study area before and after scaring on: (–1) the day before scaring treatments; (0) the evening following the treatments; and (1 and 2+) the following mornings. The latter category represents days 2 and 3 after the treatment. Blue = non-lethal (human) scaring; red = lethal scaring. Vertical lines are minimum and maximum values, the boxes are interquartile ranges, and horizontal lines are median values. Black dots are extreme values ("outliers"). See text for statistical details.

distances with minimal effort (Clausen *et al.* 2019).

The larger flock sizes after human scaring compared to the lack of such an effect after lethal scaring is difficult to explain. We assume this to be an artefact and not a response of the treatment as such. Lethal scaring is expected to have similar (or larger) effects compared to non-lethal human scaring as flocking behaviour is a common anti-predator behavioural response (Lazarus 1978).

Scaring geese also represents a "tragedy of the commons" (see *e.g.* Næss 2017 for perspectives) as scaring at one field may simply displace the problem to neighbouring landowners (Månsson *et al.* 2024). In terms of goose management, where there is a need to reduce crop damage and agricultural conflicts, scaring geese should be combined with other measures such as accommodation fields, sacrificial crops or areas where geese can forage without disturbance while having access to food (Koffijberg *et al.* 2019;

Nilsson *et al.* 2024). Hence, goose scaring will presumably not be sufficient on its own as a tool to reduce crop damage (Robai *et al.* 2024).

Few studies have addressed numerical responses on comparing different goose scaring techniques (but see Robai *et al.* 2024) and the number of trials and sample sizes were limited in the present study, a result of the design being constrained by one large property and the length of the season. The main aim was to compare the effects of lethal scaring and non-lethal scaring by an approaching person, motivated by discussions about animal welfare and the potentially differential effects of the two methods. Results indicate that, in this case, the farmer may gain the same in terms of reduced crop damage regardless of the method applied. However, while lethal scaring serves a more effective psychological function (restoring a sense of control and reducing frustration to the farmer), such alleviation of conflict cannot be used as a justification for its implementation. Both methods are nevertheless legally accepted within goose management. Lethal scaring is practised not only for geese, but also for other bird species (*e.g.* gulls and corvids) causing crop losses (Baxter & Allan 2008). It may also be used to address challenges posed by invasive species, as shown for example for the invasive Rose-ringed Parakeet *Psittacula krameri* on the Hawaiian Islands (Klug *et al.* 2019). In goose management plans within the EGMP, the objective of minimising crop damage caused by geese also includes reducing conflicts with farmers as a component (Madsen & Williams 2012; Jensen *et al.* 2018; Powolny *et al.* 2018; Madsen *et al.* 2017), and regulating goose populations by hunting will presumably reduce crop loss as a result of fewer geese (Madsen *et al.* 2017). These plans follow an adaptive management approach (Rist *et al.* 2012) where including stakeholder perspectives and views are central parts of the process. Accordingly, conflict mitigation is important when implementing the plans locally, and this appears to be a spin-off effect of their implementation. If practising lethal scaring is a tool farmers prefer, despite the potentially limited advantage compared to non-lethal scaring, these mitigation measures are legally acceptable if they are implemented in accordance with the applicable rules and regulations, and if potential exposure to crippling is minimised. The present study contributes to other studies on displacement methods to reduce agricultural damage caused by geese (Simonsen *et al.* 2016; Clausen *et al.* 2019; Månsson *et al.* 2024; Nilsson *et al.* 2024; Robai *et al.* 2024). Reducing conflicts between geese and agriculture is an important objective in several European goose management plans, and a combination of several actions is likely to be needed to fulfil this objective.

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Photograph: Greylag Goose families on spring-sown cereals, by Gørli Elida Bruun Andersen.