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Broad support for lethal control of wild deer among subscribers of nature organisations in England and Wales

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Abstract

1. Wild deer populations are increasing across the northern hemisphere, posing challenges to the environment and people. Deer impacts can be managed using lethal and non-lethal practices, but research suggests lethal control receives mixed support. Differences in perspectives towards management practices may hinder collaborative, landscape-scale strategies required to achieve resilient ecosystems and tree cover targets. Thus, understanding human-deer relationships is crucial for sustainable deer management.

2. To investigate perceptions towards deer and their management in England and Wales, we designed a questionnaire measuring the level of support for different actions to manage deer impacts and beliefs regarding the aesthetic and existence, environmental, economic and cultural-symbolic value of deer. Targeting actors within and outside the land management, the questionnaire was distributed to subscribers of five national organisations, three focussing on wildlife management and two on woodland management.

3. We collected data from 3936 people and, using cluster analysis, characterised groups of respondents based on their beliefs towards deer. We assessed variations between groups by socio-demographic characteristics and support for lethal and non-lethal management practices.

4. Lethal control was the most supported and most used deer management practice, followed by tree guards and deer fencing. Our cluster analysis grouped respondents into 4 clusters. The cluster composed predominantly of deer stalkers (47%) held the most positive perceptions of deer and registered the highest support for lethal control and the highest opposition to deer fencing. Conversely, the cluster

with the highest proportion of farmers (27%) and lowest proportion of stalkers (16%) expressed more neutral and negative opinions towards deer.

5. There was no evidence of column clusters, indicating that beliefs did not cluster according to value dimensions (e.g. economic, environmental), suggesting that deer were valued similarly across all value dimensions. Differing opinions on deer and land management goals make it difficult for neighbours to collaborate on managing deer.

6. Lethal control received strong support, which could ease concerns about recommending its use by nature organisations and decision-makers who depend on public backing.

KEYWORDS

attitudes, beliefs, collaborative management, deer management, lethal control, management practices, perceptions, values

1 | INTRODUCTION

In recent decades, the densities and distributions of wild deer species have increased throughout the northern hemisphere (Côté et al., 2004). Whilst deer promote dynamic natural ecosystem processes such as seed dispersal (Ramirez et al., 2018), and generate income through tourism, hunting and venison (MacMillan & Phillip, 2008), they can negatively impact anthropocentric interests. Intensive grazing and browsing by deer can threaten tree regeneration and woodland resilience (Gill, 2000; Gill & Fuller, 2007) and impact biodiversity (Dolman et al., 2010; Eichhorn et al., 2017; Gill, 2000; Putman, 1996). Deer can damage food crops and strip bark from mature trees in woodland-agricultural landscapes, including established timber crops (Putman, 1996). Elevated deer densities are also a concern for deer-vehicle collisions and disease transmission to livestock and humans (Böhm et al., 2007; Putman et al., 2011). It is therefore essential that people involved in woodland management in temperate regions plan for and mitigate deer impacts.

Increasing deer densities present a challenge to UK government policies aiming to expand woodland cover and transition to net zero by 2050 (HM Gov, 2021). Effective mitigation of deer impacts to new and existing woodlands will be crucial in achieving these targets (Climate Change Committee, 2024). Options to mitigate deer impacts include non-lethal practices, such as deer fencing and tree guards (Gill, 1999), and lethal control, which in the UK involve the regulated shooting of deer (Barton et al., 2022; Deer Act, 1991). Since deer are highly mobile, the most effective deer management strategies are implemented at the landscape scale (e.g. Fattorini et al., 2020), requiring cooperation between landowners and widespread support from diverse actors (e.g. Austin et al., 2010).

Lethal control of deer is one of the most cost-effective forms of impact control (Bowker et al., 2003). However, whilst studies provide evidence of support for lethal control (e.g. Fulton et al., 2004; Green et al., 1997b; Kilpatrick & Walter, 1997; Loker et al., 1999; Stewart, 2011; Urbanek et al., 2012), preference for non-lethal measures is often reported (Dandy et al., 2009, 2011; Green et al., 1997a; Martínez-Jauregui et al., 2020; Stout et al., 1997; Whitefield et al., 2021). Evidence suggests that support for lethal control is higher among those directly affected by deer impacts (e.g. Siemer et al., 2004; Urbanek et al., 2015), and those more familiar with deer, including people in the land management sector (Whitefield et al., 2021) and rural residents (Loker et al., 1999; Sijtsma et al., 2012). Indeed, interest in woodland planting and regeneration likely increases awareness of the need to reduce deer numbers in some areas (Bunce et al., 2014; Gullett et al., 2023; Logan et al., 2025). Frequent contact with deer or higher risk of deer-related damage has been linked to more negative attitudes towards them (e.g. Stinchcomb, 2022; Valente et al., 2020; West & Parkhurst, 2002). Furthermore, attitudes towards deer may vary with age, with older individuals being more aware of potential negative impacts (Valente et al., 2020; Whitefield et al., 2021).

Lethal control may be opposed by those who are unaware of deer impacts or deem impacts as acceptable (Dandy et al., 2009, 2011). For example, Dandy et al. (2011) showed that peri-urban communities in Scotland preferred non-lethal measures, such as deer fencing and vehicle speed limits to reduce deer-vehicle collisions. Lethal control may also be opposed due to the aesthetically pleasing nature of deer (Dandy et al., 2009, 2011). People believing wildlife and humans should hold similar rights (i.e. "mutualism") may be less likely to support lethal control compared to those believing wildlife exists to benefit humans (i.e. "domination") (e.g. Sijtsma et al., 2012; Teel & Manfredo, 2010). Previous studies examining differences in attitudes towards wild deer and their management often involved broad respondent groups, such as professionals versus the public (e.g. Dandy et al., 2012) or rural versus urban residents (e.g. Hare et al., 2021; Sijtsma et al., 2012). Many studies focussed on specific communities and local areas of interest (e.g. Dandy et al., 2011; Lauber & Knuth, 2000; Urbanek et al., 2015; Whitefield et al., 2021), whilst fewer conducted quantitative research at the national scale (Hare et al., 2021; Jacobs et al., 2014;

Martínez-Jauregui et al., 2020; Sijtsma et al., 2012) or on more diverse respondent categories (Ehrhart et al., 2022; Stewart, 2011; Stinchcomb, 2022; Valente et al., 2020). Furthermore, past research often relied on relatively small samples, with few exceeding 1000 respondents (Diefenbach et al., 1997; Hare et al., 2021; Stewart, 2011).

In Britain, research on human-deer relations has mostly focussed on Scotland (Dandy et al., 2009, 2011; Hare et al., 2021; Holland et al., 2017; MacMillan & Leitch, 2008; Whitefield et al., 2021). However, perspectives in England and Wales could differ due to variations in deer species densities and distributions, landownership, governance structures, land management objectives and national deer management strategies (The Deer Initiative, https://thedeerinitiative.co.uk/; NatureScot, https://www.nature.scot/). Deer management across much of Scotland often takes place on large, private estates by a relatively small number of landowners (Putman, 2010). In England and Wales, deer management generally takes place across mosaics of smaller-scale landownership (The Deer Initiative, https://thedeerinitiative.co.uk/), requiring cooperation between larger numbers of individuals to affect landscape-scale deer management. Different opinions between neighbouring landowners regarding deer and their management may hinder landscape-scale collaborations (Austin et al., 2010, 2013). Land access also differs across Britain. In England and Wales, access is more restricted (Countryside and Rights of Way Act, 2000), whereas in Scotland, the Land Reform (Scotland) Act (2003) grants statutory rights of access for any form of non-motorised outdoor recreation excluding hunting, fishing and shooting. Finally, nature organisations might also be reluctant to publicly discuss and campaign for deer management, fearing negative impacts on member retention. Such reluctance may hinder efforts toward sustainable deer management and, ultimately, resilient woodlands benefitting people and wildlife.

In this study, we used a national-scale questionnaire to survey subscribers of five nature organisations in England and Wales: three focussing on wildlife management, two on woodland management. We chose these organisations to capture a range of visions and perspectives towards wild deer and their management drawing from wildlife value orientation frameworks and structuring our questionnaire to assess and cluster diverse values of deer, from conservation to ecological sustainability, to reveal broader beliefs about their management. Whilst some of these organisations focus predominantly on the management and sustainable use of game animals, including deer, others emphasise the importance of resilient woodlands and restoration of biodiversity. Our objectives were to: (1) characterise the beliefs held by a range of actors towards wild deer, including farmers (people working their own or leased land), land managers (people employed to manage farms and estates) and individuals with no involvement in land management; (2) investigate differences in these beliefs in relation to involvement in land management, age, subscription to wildlife management or woodland management-focussed organisations, and their support for lethal and non-lethal deer management practices. Our study assesses perceptions towards wild deer and management approaches across a

large sample of respondents in England and Wales, offering insights to facilitate collaboration among different actors and informing the design of strategies that will help mitigate deer impacts on tree planting targets, which are a key component of the UK transition to net zero (HM Gov, 2021).

2 | METHODS

To investigate people's perceptions towards deer and their management in England and Wales, we designed a questionnaire which was distributed online (LimeSurvey GmbH, n.d.; Qualtrics, 2005) by five national organisations, three focussing on wildlife management (British Association for Shooting and Conservation (BASC); British Deer Society (BDS); Game and Wildlife Conservation Trust (GWCT)) and two on woodland management (Sylva Foundation; The Woodland Trust). This enabled us to collect data from different groups of people residing in England and Wales: farmers, land managers, deer stalkers, game keepers, foresters, conservation practitioners/advisors and people not involved in managing land, but with an interest in woodland or wildlife. Our focus on England and Wales was driven by similarities in deer management regulations in these nations (The Deer Initiative, https://thedeerinitiative.co.uk/) and the paucity of existing research.

2.1 | Questionnaire design

The questionnaire contained eleven sections (Supporting Information S1). We collected information on respondents' involvement in land management, deer species on their property, and types of deer damage experienced, and then presented them with 17 statements measuring beliefs towards deer. These were informed by existing literature measuring wildlife value orientations (e.g. Fulton et al., 1996; Jacobs et al., 2014; McCance et al., 2015; Teel & Manfredo, 2010) and human perceptions of deer (e.g. Dandy et al., 2009; Valente et al., 2020), and developed to ensure coverage of a range of dimensions, including the aesthetic and existence, environmental, economic and cultural-symbolic values of deer (Table 1). For example, to explore beliefs regarding the perceived economic value of deer, participants reported their level of agreement or disagreement with: "Wild deer are valuable for the venison market". Answers were provided on a five-point Likert-type scale (1=strongly disagree, 5=strongly agree). Statement order was randomised to eliminate order effects.

Next, respondents indicated their level of support (1=strongly oppose, 5=strongly support) for different actions to manage deer impacts. These included non-lethal practices, such as deer fencing and tree guards and lethal control. To distinguish lethal control from recreational hunting, the following definition was provided: "Lethal control is performed with the aim of reducing wild deer numbers and their impacts". Here we sought to adopt a neutral tone and avoid emotive words. Respondents also rated 16 statements designed to

TABLE 1 Statements on beliefs toward deer that were scored by questionnaire respondents.

Values	Explanation	Statements on values towards deer	Statement abbreviation
Aesthetic and existence	Wild deer are physically appealing and need to be protected and cared for	• It is important to know deer exist in my local area • Seeing deer connects people with nature • Hunting deer connects people with nature • Consuming wild venison connects people with nature • Deer are an important part of nature	• Local existence value • Deer-nature connection • Hunting-nature connection • Venison-nature connection • Part of nature
Environmental	Wild deer are important for the environment and ecology—for example browsing, seed dispersing, expression of healthy environment	• Deer contribute to the health of forests and the ecosystem • Deer presence is an indicator of a healthy environment • Deer are a key element of biodiversity • Hunting deer allows people to access more sustainable, locally sourced meat	• Ecosystem health • Environmental health • Biodiversity • Sustainable meat
Economic	Wild deer holds economic value through tourism, shooting, venison	• Deer are important for tourism • Hunting deer generates economic value • Wild deer are valuable for the venison market • Deer are important for the economy	• Tourism economy • Hunting economy • Venison economy • General economy
Cultural and symbolic	Wild deer are seen as a symbol of national identity, community, cultural heritage	• Deer are an expression of our cultural heritage • Deer are important symbols of our nation • Hunting deer is an important tradition to people • Consuming wild venison connects people with their local roots	• Cultural heritage • National symbol • Hunting tradition • Venison tradition

Note: The table displays the 17 statements with their abbreviation.

assess perceptions towards lethal control (1=strongly disagree, 5=strongly agree). The statements were grouped into two blocks: one containing eight statements in support of lethal control, another including eight statements opposing it. The order of these two blocks, and the statements within them, was randomised. Finally, respondents involved in land management were asked how easy or difficult it was for them to work with their neighbours to control wild deer and their impacts, with a follow-up question examining reasons for difficult collaboration.

2.2 | Questionnaire distribution

The questionnaire was reviewed by project partners prior to piloting and distribution. The five distributing organisations used newsletters or dedicated emails to share the questionnaire with their subscribers in England and Wales. Data was collected between November 2023 and September 2024. Free, prior and informed consent was sought from all respondents, who were 18 years or older and could drop out before questionnaire completion by closing their browser. The questionnaire was anonymous, and research was approved by Bangor CoESE Ethics Committee (Approval Number: COSE2023ECiDeer02A).

2.3 | Statistical analysis

We used cluster analysis to characterise groups of respondents based on their beliefs towards wild deer and assessed the variation between groups in relation to respondents' involvement in land management, age and support for different deer management practices. The dataset comprised a matrix of ordered categorical responses (i.e. Likert-type data), with a row for each respondent and a column for each of the 17 belief statements. We also incorporated additional covariates for each respondent: involvement in land management (deer stalker, farmer, forester, game keeper, conservation practitioner/advisor, other involvement, no involvement), source organisation (wildlife management-focussed or woodland management-focussed) and age group (18–34, 35–44, 45–54, 55–64, 65+). We used model-based clustering with a proportional-odds model structure, suitable for ordered categorical variables (Matechou et al., 2016). This approach was selected over commonly used Exploratory Factor Analysis (EFA) (Furr, 2011) because cluster analysis allows us to group both respondents and belief statements, whilst EFA combines variables into simpler structures (i.e. clusters of belief statements only). Moreover, the highly asymmetric belief scores (Table L, Supporting Information S2) were not suitable for parametric analyses inherent to EFA (Watkins, 2018). Importantly,

the model-based clustering approach provides parameter estimates that allow us to determine important covariates that drive the clustering of beliefs.

Model-based clustering can be used to find groups of respondents (rows) that contain individuals with similar patterns of responses whilst simultaneously finding groups of correlated belief statements (columns). We chose to use a specific model-based clustering method that can also incorporate additional covariates that may affect the responses (Preedalikit et al., 2024). A priori, we expected covariates for respondents to influence their responses to the belief statements. We therefore compared the fit of different model structures that varied in the number of row and column clusters and tested the inclusion of covariates.

Initially, we fitted 15 combinations of two to six row clusters and two to three column clusters to explore the feasibility of clustering both rows (respondents) and columns (belief statements) simultaneously. We selected the solution with four clusters of respondents and two clusters of belief statements (Supporting Information S3) based on a combination of parsimony in the number of clusters and the criteria ICL, AIC and BIC (Lezhnina & Kismihók, 2022). We decided to fit four further models with this cluster configuration, one without covariates and three with different covariates: involvement in land management, source organisation and age group. Since involvement in land management was partially nested within source organisation and age group, covariates were not fitted in a single model together (Supporting Information S3).

The maximum-likelihood-based clustering method (Matechou et al., 2016) yields probabilities for each statement indicating their likelihood of belonging in each cluster and assigns each statement to the cluster it has the highest probability of membership for. Although our best-fitting model without covariates had two clusters of belief statements, one of those clusters had no belief statements assigned to it, suggesting that column clustering was not supported and that there was little evidence of any structure among belief statements. Therefore, we proceeded to only cluster the observations (i.e. "row clustering") and not the belief statements. We constructed the following four models, each comprising four row clusters:

1. **Model A**: row clustering without covariates
2. **Model B**: row clustering with involvement in land management as covariate
3. **Model C**: row clustering with source organisation as covariate
4. **Model D**: row clustering with age group as covariate

AIC and BIC were used to identify the model with the best fit, from which we explored variation in cluster composition according to respondents' scoring of belief statements, the nature of their involvement in land management, source organisation, age group and support for the three main management practices: lethal control, deer fencing and tree guards.

It is likely that deer stalkers consistently supported lethal control and strongly agreed with belief statements related to deer due to

their role in deer culling. To ascertain whether clustering patterns were primarily driven by the inclusion of deer stalkers, we performed a sensitivity analysis by removing the 2914 stalkers from the dataset before repeating the cluster analysis and examining if findings differed from the full dataset ($N = 3936$). All analyses were conducted in RStudio (R version 4.2.3) (RStudio Team, 2020). Cluster analysis was done using the "clustord" package version 1.2.1 (Matechou et al., 2016; McMillan et al., 2024).

3 | RESULTS

3.1 | Sample description

After discarding 134 responses from outside England and Wales, we retained 3936 usable responses (97%). Most responses came from England (94%, $n = 3709$), with few from Wales (>5%, $n = 208$) and border areas (<1%, $n = 19$) where partial postcodes overlap between England and Wales (Figure 1). These counts are proportional to the total population in England and Wales (57.7 million and 3.2 million, respectively; Office for National Statistics (ONS), 2023).

Most respondents (73%, $n = 2858$) subscribed to wildlife management-focussed organisations and the remainder to woodland management-focussed organisations (27%, $n = 1078$). Most respondents (59%, $n = 2334$) were involved in land management (Tables A1 and A2, Supporting Information S2) and were aged 55 or over (73%, $n = 2869$) (Table B, Supporting Information S2).

3.2 | Deer impacts

Most respondents reported having deer on the land they manage, or where they live (92%, $n = 3607$); others reported they had no deer (6%, $n = 231$) or were unsure of their presence (2%, $n = 98$). Among respondents involved in land management and reporting deer presence on their land ($n = 2245$), most stated that deer damaged tree saplings (83%, $n = 1874$), established trees or hedges (72%, $n = 1615$) and ate crops or pasture (71%, $n = 1594$). Only 4% ($n = 94$) reported no deer damage (Table C, Supporting Information S2).

3.3 | Support for deer management

Across all respondent types, support for deer management practices was the highest for lethal control (85% supported or strongly supported the practice, $n = 3359$), followed by tree guards (82%, $n = 3245$) and deer fencing (69%, $n = 2727$) (Table D, Supporting Information S2). Deer stalkers were the most supportive (98%, $n = 1000$), followed by game keepers (96%, $n = 92$) and foresters (93%, $n = 81$). Most respondents not involved in land management also supported lethal control (73%, $n = 1170$) (Table E, Supporting Information S2). Across all respondents, high levels of agreement with our eight statements supporting lethal control, and low
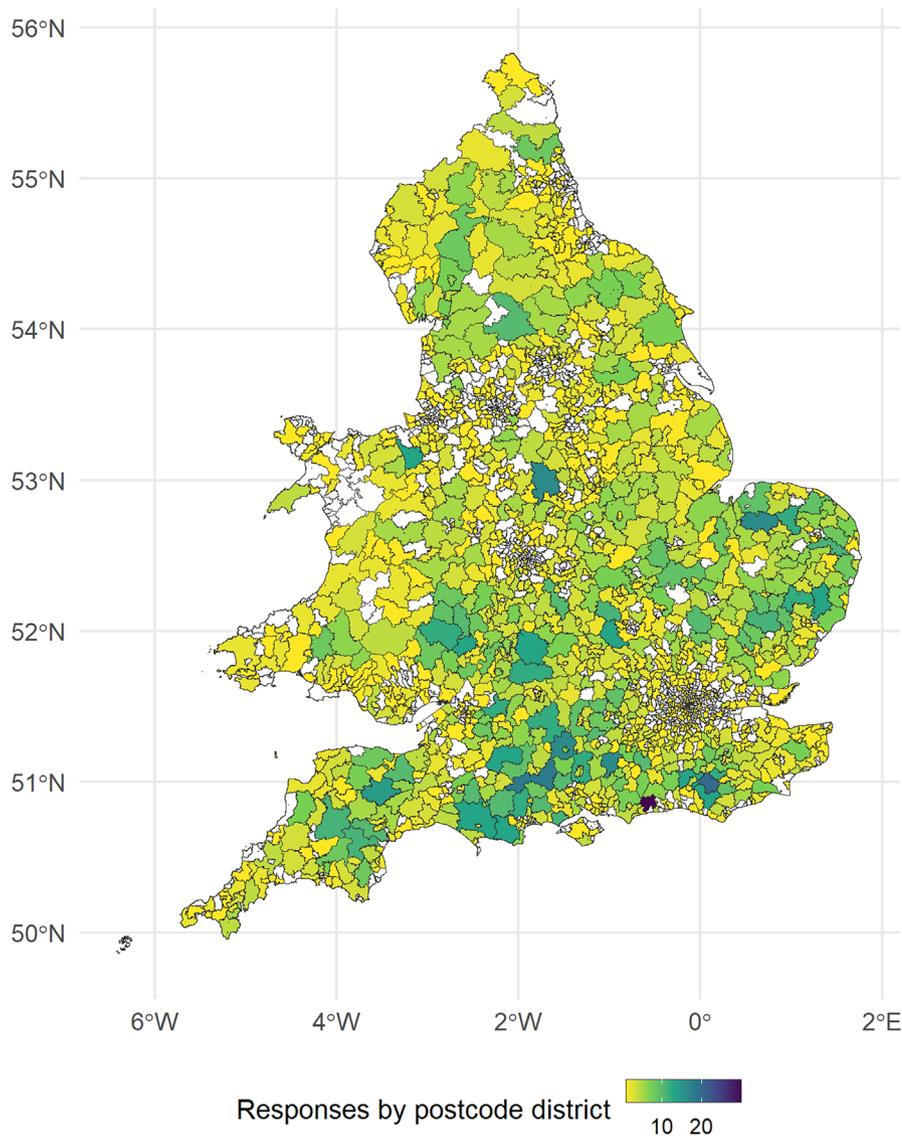
FIGURE 1 Distribution of responses by postcode district. Districts are coloured according to the quantity of responses received. Districts with no responses are blank. A total of 27 responses were discarded due to insufficient postcode information, and one respondent provided two postcodes; therefore, the number of responses mapped was 3910 from 3909 respondents. The two highlighted districts in the top-right partly cross the Scottish border due to shared postcode areas, though all responses originated from districts within England.

agreement with eight statements opposing lethal control, provide further evidence of strong support for this practice across the sample (Tables F–G, Supporting Information S2).

The most common approaches that respondents reported using to minimise deer damage were lethal control (71%, $n = 1019$), tree guards (65%, $n = 928$) and deer fencing (38%, $n = 557$); other management practices were used by less than 6% (Tables H–I, Supporting Information S2). Most respondents with management control of their land did not incorporate the risk of deer damage into their land use decisions (76%, $n = 1085$), for example by avoiding planting crops palatable to deer (Table J, Supporting Information S2). Further, 31% ($n = 435$) stated it would be difficult to collaborate with their neighbours to control deer and their impacts. The most selected reasons were different views on deer and their impacts (51%, $n = 220$) and differences in land management objectives (48%, $n = 210$). Lack of funding was reported less frequently (19%, $n = 82$) (Tables K1 and K2, Supporting Information S2).

3.4 | Respondent groupings according to their beliefs towards wild deer

Deer were valued for aesthetic and existence reasons, as well as their environmental role. They were also considered culturally significant and economically valuable through hunting and venison (Figure 2; Table L, Supporting Information S2).

When comparing models with different combinations of row and column cluster quantities, the model with four row clusters provided the best fit to the data (Table D, Supporting Information S3). There was no evidence of column clusters, suggesting that belief statements, despite representing different value dimensions, did not cluster into multiple groups (Table 1). This means respondents did not distinguish between value dimensions (e.g. economic, environmental) when rating statements; deer were valued similarly across all dimensions.

Once covariates were incorporated, model C, which included source organisation as a covariate (i.e. wildlife management- or

Percentage of agreement with statements
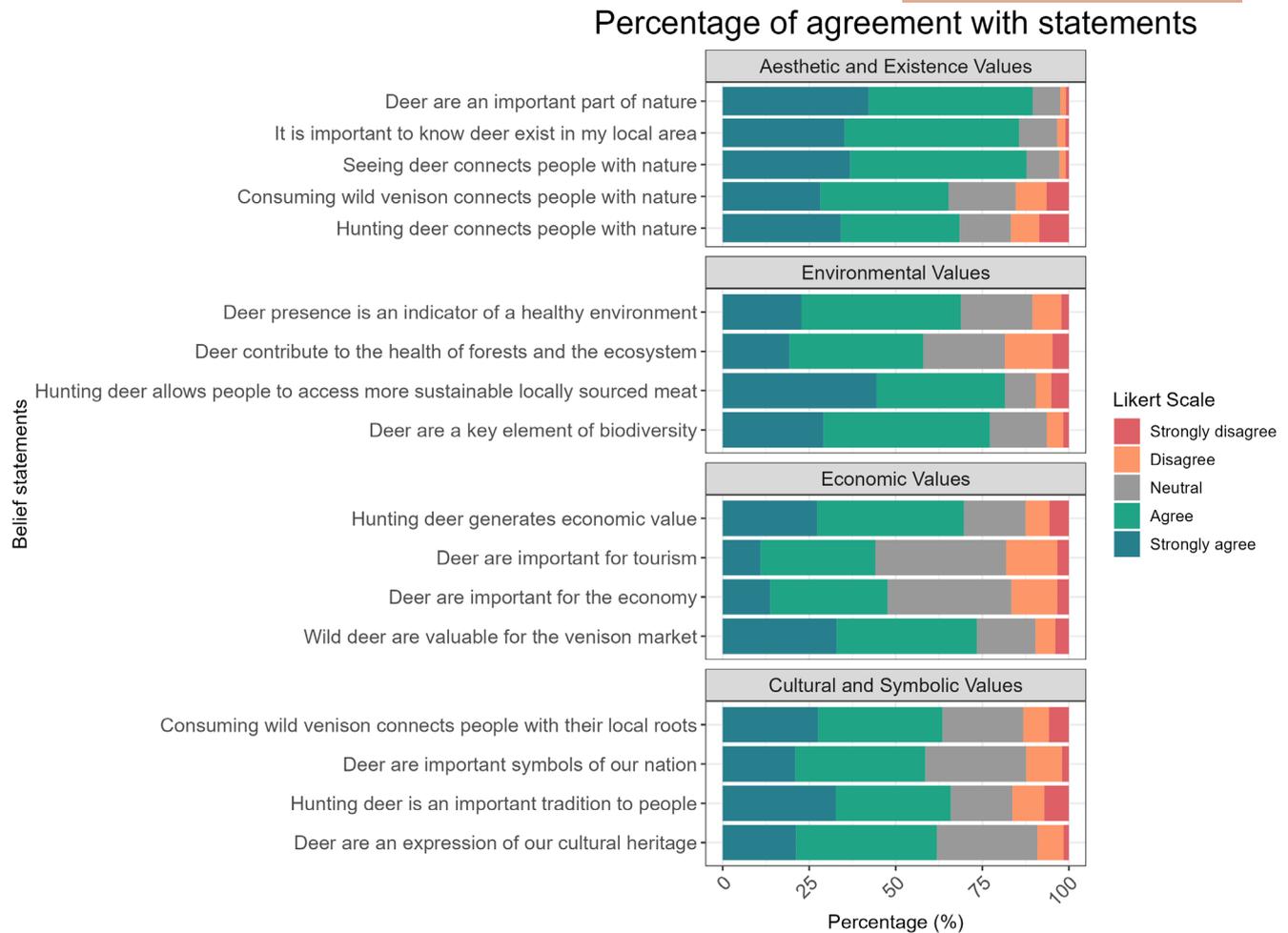
FIGURE 2 Respondents' level of agreement with statements on beliefs towards deer. Statements were grouped a priori by four value dimensions. $N = 3936$.

TABLE 2 AIC and BIC of models with four row clusters.

Model	Covariate	ICL	ΔICL	AIC	ΔAIC	BIC	ΔBIC
Model C	Source organisation	165201.4	0	163108.9	0	163209.1	0
Model B	Involvement in land management	165497.4	296.0	163341.7	232.8	163496.6	287.5
Model D	Age group	165670.0	468.6	163688.0	579.1	163815.6	606.5
Model A	None	165721.0	519.6	163809.3	700.4	163900.4	691.3

Note: Models are ordered from the lowest to the highest ICL, AIC and BIC. The best model is model C. ΔICL, ΔAIC and ΔBIC (i.e. the difference between each model and the best model) are also reported.

woodland management-focussed), was the best-fitting model (i.e. with the lowest ICL, AIC and BIC) compared to the others (Table 2; Figure A, Supporting Information S3). Cluster composition and cluster effect are detailed in Table 3. The cluster effect, corresponding to the α_r coefficient in the proportional-odds model (see Matechou et al., 2016; Preedalikit et al., 2024), changes the likelihood that individuals in that cluster will answer more positively or negatively to statements. Positive cluster effects increase the probability that individuals will answer more positively to the belief statements, and negative cluster effects increase the probability of them answering more negatively. These effects

combine additively with the effect of the covariates in the overall model. Source organisation provides information on the value of responses; the "woodland" category returned a negative coefficient (–1.14). This result suggests that respondents subscribed to woodland management-focussed organisations are more likely to provide negative responses to the belief statements than respondents from wildlife-focussed organisations.

Cluster A was predominantly composed of deer stalkers (47%, Figure 3; Table E, Supporting Information S3) and had the most strongly positive cluster effect (Table 3): people belonging to this cluster strongly agreed with 16 of 17 statements on beliefs

TABLE 3 Results of the fitted cluster model incorporating source organisation (wildlife management- or woodland management-focussed) as a covariate.

Cluster	Cluster effect	Respondents per cluster	
		Count	Percentage (%)
A	2.56	576	14.63
B	0.59	1593	40.47
C	−0.70	1601	40.68
D	−2.45	166	4.22

Note: Clusters are ordered by the relative strength and direction of their effect; positive effect values make individuals in the cluster more likely to give positive responses to statements, whilst negative effect values make individuals in the cluster more likely to give negative responses to statements. $N = 3936$.

towards deer, indicating they strongly believed deer are an important part of nature, a healthy environment and the economy (Figure 4; Table K, Supporting Information S3). This cluster included a lower proportion of respondents aged 65+ and a greater proportion of respondents between 18 and 44 years compared to the other clusters (Table G, Supporting Information S3). Cluster A also registered the highest proportion of respondents from wildlife management-focussed organisations (88%, Table F, Supporting Information S3), the highest support for lethal control and the highest opposition to deer fencing across all clusters (Tables G and H, Supporting Information S3).

Cluster B primarily consisted of people not involved in land management (43%, Figure 3; Table E, Supporting Information S3) and had the lowest proportion of respondents from wildlife management-focussed organisations of all clusters (67%, Table F, Supporting Information S3). They strongly agreed with 2 of 17 belief statements and agreed with the rest, suggesting people in this cluster also regarded deer as important (Figure 4; Table K, Supporting Information S3). Cluster C was also dominated by people not directly involved in land management (43%, Figure 3; Table E, Supporting Information S3) and together with cluster D, had the highest proportion of people aged 65+ of all clusters (51%; Table G, Supporting Information S3).

Cluster C registered the lowest level of support for lethal control, although 47% of respondents in this cluster still strongly supported it (Table H, Supporting Information S3). Moreover, respondents in clusters B and C showed strong support for non-lethal management approaches, with the highest support for deer fencing (Tables I and J, Supporting Information S3). People belonging to cluster C agreed with 10 belief statements and reported neutral responses to the rest (Figure 4; Table K, Supporting Information S3).

Finally, cluster D had the highest proportion of farmers (27%), lowest proportion of deer stalkers (16%, Figure 3; Table E, Supporting Information S3) and lowest proportion of respondents aged 18–34 years across all clusters (1%; Table G, Supporting Information S3). Cluster D had the lowest cluster effect value (Table 3), indicating respondents in this cluster scored the lowest of all clusters across belief statements. Indeed, they reported

neutral answers to 10 belief statements and disagreed with the rest (Figure 4; Table K, Supporting Information S3). They also registered the lowest support for tree guards and deer fencing (Tables I and J, Supporting Information S3). Lastly, whilst deer stalkers consisted of 26% of the sample ($n = 1024$), results from the sensitivity analysis revealed that removing them from the dataset did not impact our findings (Figures A–D, Table L, Supporting Information S3).

4 | DISCUSSION

Our study used a questionnaire distributed across England and Wales to subscribers of woodland management- and wildlife management-focussed organisations to understand perspectives towards wild deer and their management. The results provide evidence that lethal control is the most commonly supported form of deer management across all types of respondents, agreeing with several studies that surveyed different communities and counties across the US (Fulton et al., 2004; Green et al., 1997b; Kilpatrick & Walter, 1997; Loker et al., 1999; Stewart, 2011; Urbanek et al., 2012). Most of our respondents reported having deer on their property, and experiencing deer impacts, such as damage to tree saplings and established trees and hedges. As found by others (e.g. Lauber & Knuth, 2000; Whitefield et al., 2021), the strong support for lethal control observed in our sample may result from awareness of the potential negative impacts of deer among respondents.

Past studies involving diverse actors have sometimes reported low support for lethal control (e.g. Dandy et al., 2009, 2011; Stout et al., 1997). For example, in Scotland, focus groups and workshops with small groups of participants from peri-urban communities, including land managers, demonstrated low support for lethal control (Dandy et al., 2009), as did a questionnaire surveying over 100 community members (Dandy et al., 2011). However, another questionnaire with 184 residents reported much greater agreement with lethal control to reduce deer impacts (Whitefield et al., 2021), and it has been shown that residents in Scotland would support an increase in lethal control if it helped reduce the spread of Lyme disease, prevented overwinter starvation of deer, or aided forest recovery (Hare et al., 2021), particularly when other methods fail (Dandy et al., 2011), or when welfare is considered (Dandy et al., 2012). Therefore, context is crucial when evaluating opinions toward lethal control (e.g. Dandy et al., 2012; Martínez-Jauregui et al., 2020), including, for example, specific geographical areas, cultural differences and country laws, which could influence people's familiarity with wild deer and thus opinions towards their management. In our questionnaire, we explicitly defined lethal control as a strategy to reduce deer numbers and mitigate their impacts, which may have allayed ethical concerns. Additionally, we avoided emotive words such as "killing" and "shooting" used in other studies (e.g. Hare et al., 2021; Jacobs et al., 2014), as negative emotions tend to be more influential on human cognition (Jing-Schmidt, 2007). Our use of neutral language may partly explain the high level of support observed across our sample.

Cluster characteristics
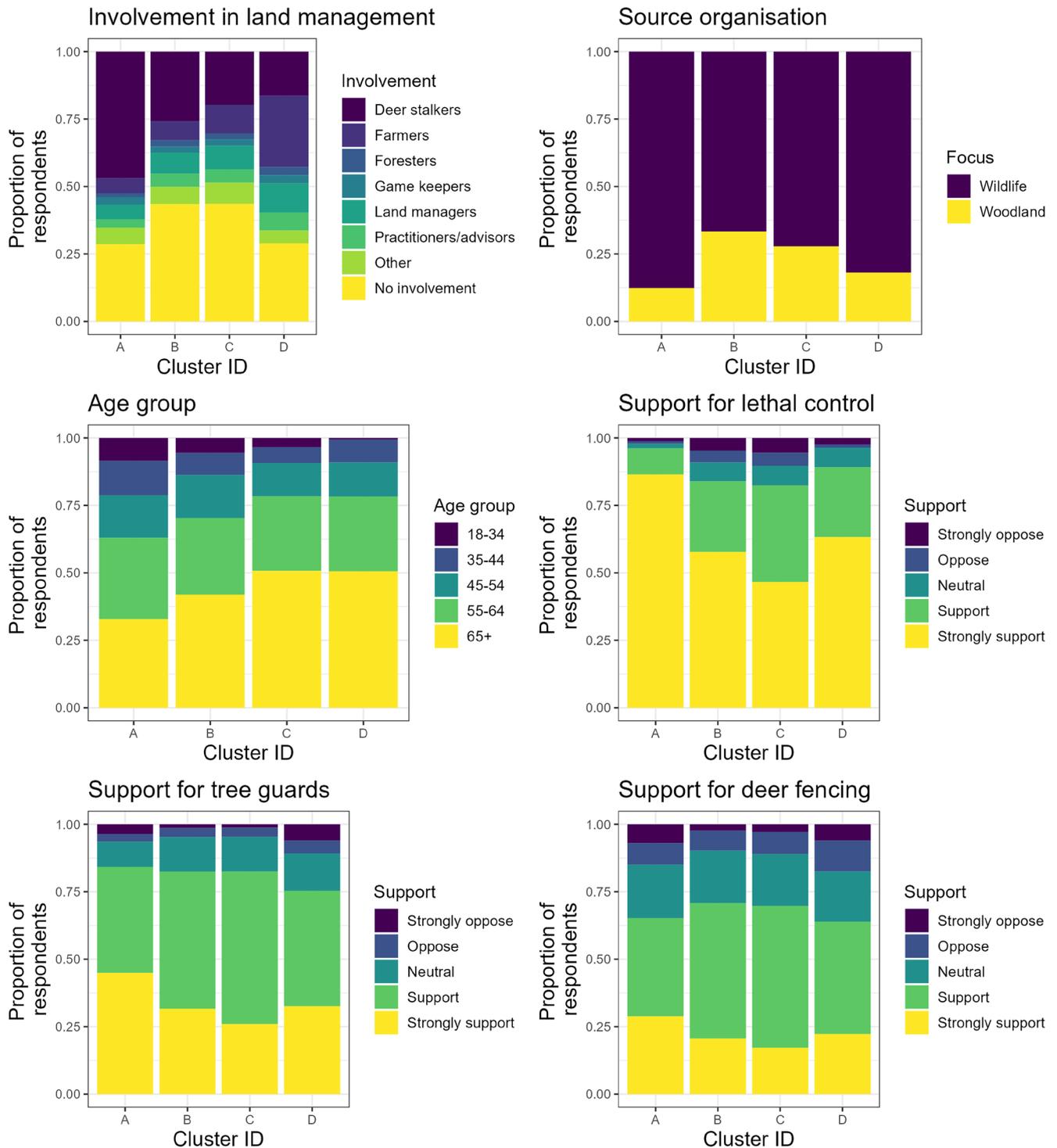
FIGURE 3 Characterisation of clusters according to involvement in land management, source organisation, age group and support for management practices. Agreement is scaled such that the higher the value, the greater the level of agreement with belief statements. *N* = 3936.

In our sample, strong regard for the aesthetic and existence, and cultural values of deer did not coincide with low support for lethal control or a preference for non-lethal management. Respondents with more favourable beliefs about deer valued them for connecting people to nature and maintaining ecological integrity, whilst also recognising their economic and cultural importance as game species.
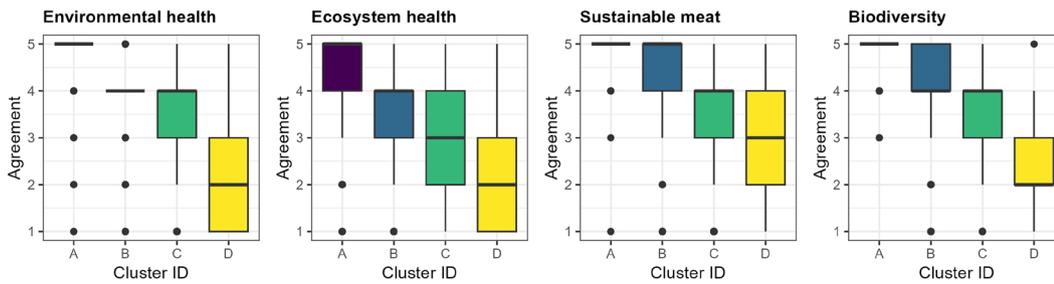
Clusters and beliefs toward deer

Clusters ▮ A ▮ B ▮ C ▮ D
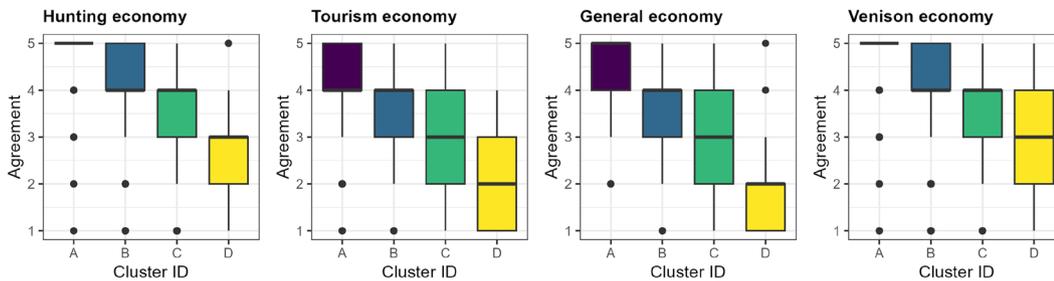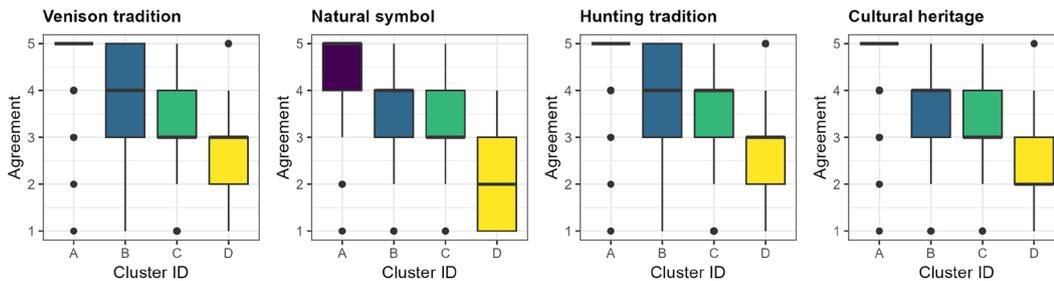
Aesthetic and Existence values
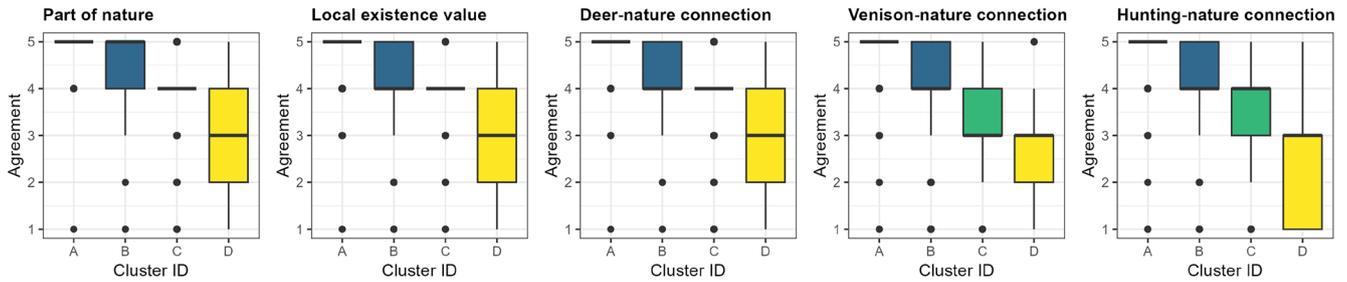
Environmental values

Economic values

Cultural-symbolic values

FIGURE 4 Level of agreement with belief statements for four clusters of respondents. Respondents reported their level of agreement with statements using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). The bold line represents the median, the lower and upper edges of the box are the first and third quartiles, and the whiskers are the maximum and minimum points. $N = 3936$.

Most respondents agreed that deer are a sustainable meat source and generate economic revenue through hunting and venison, illustrating close connections between admiration for and acceptance of the sustainable use of nature. Interestingly, our belief statements did not cluster into value dimensions as anticipated a priori.

The impacts of deer on ecosystem services are complex and context-dependent, with positive values attributed to venison production, existence and cultural values juxtaposed against declines in woodland biodiversity, woodland structural complexity and timber production when deer are at higher densities (Garcia et al., 2025). Our results are perhaps consistent with a growing appreciation of these complexities and acceptance among those affected that deer population control is often an integral part of plans to achieve multiple-use aims for a deer-impacted landscape (Logan et al., 2025). Previous research capturing people's views on the use and care of wildlife has proposed that values are oriented by two contrasting ideologies, domination and mutualism and that these orientations result in different attitudes and behaviours towards wildlife and acceptability of lethal control (Manfredo et al., 2009). For example, among a sample of residents in the Netherlands, respondents who held beliefs associated with human domination of nature were more likely to support lethal control than those holding more mutualistic beliefs (Sijtsma et al., 2012). The lack of distinctive value dimensions in our data might stem from our exclusive focus on wild deer; in developing statements for our questionnaire, we paid particular attention to research on human perspectives toward deer and their management, rather than broader wildlife value orientations (Teel & Manfredo, 2010).

Personal experiences shape beliefs and attitudes towards wildlife (Manfredo, 2008), and our respondents may be familiar with deer due to their subscription to nature organisations and deer presence on their properties. This may explain why they can simultaneously tolerate lethal control and revere deer for their aesthetic, cultural and existence values. Importantly, our cluster analysis detected associations between the nature of respondents' involvement in land management, and their beliefs towards deer. Interestingly, the cluster dominated by deer stalkers held the most positive perceptions of deer across all belief statements, whilst the cluster with the highest proportion of farmers reported more neutral and negative scores. Such findings align with studies from other locations. For example, hunters in Portugal associated deer with greater benefits (e.g. existence, economic, ecological values) than non-hunters, whilst farmers recognised fewer benefits (Valente et al., 2020). Evidence suggests that greater exposure to deer damage reduces tolerance and fosters negative perceptions of deer (e.g. Stinchcomb, 2022; Valente et al., 2020). Our findings support this notion.

We found that non-lethal measures, including deer fencing and tree guards, received lower levels of support than lethal control. Deer fencing is expensive to maintain (Dolman et al., 2010; Trout & Brunt, 2014), can reduce landscape connectivity for other wildlife and is a welfare concern, as wildlife can get entangled (Harrington & Conover, 2006). Fencing can also displace deer impacts to other areas, shifting the problem rather than resolving it (Dolman et al., 2010). In comparison, tree guards do not alter landscape connectivity or reduce

accessibility for walkers (Gill, 1999; Trout & Brunt, 2014). However, they are expensive to use over large areas, require frequent maintenance and are generally not reusable (Trout & Brunt, 2014).

Our study also explored the challenges of collaborative deer management. Thirty-one percent of respondents with land management responsibilities stated it would be difficult to collaborate with their neighbours. Different views on deer and land management objectives were the primary reasons behind such difficulty. Among them, 97% believed that communicating with neighbours would be beneficial, confirming the perceived importance of collaborations across neighbouring lands. Since wild deer hold "res nullius" status, belonging to no one and crossing landownership boundaries (Davies & White, 2012), management practices on one property can affect neighbouring properties (Bullock, 1999). As a result, landscape-scale partnerships among landowners are necessary for effective deer impact mitigation (The Deer Initiative, https://thedeerinitiative.co.uk/). Given the financial costs of collaborative management (e.g. Davies & White, 2012; Holland et al., 2017), we expected funding availability to be a prominent concern of respondents reporting difficulties in working with neighbours, yet it was the sixth reason reported. Funding for deer partnership officers is crucial to developing collaborative management initiatives, but it would not go to land managers. As such, its importance may not have been picked up by our questionnaire.

Finally, our data were collected from subscribers of wildlife management- and woodland management-focussed organisations. Expanding the study to subscribers of wildlife conservation organisations, or indeed, a large random sample of residents in England and Wales would offer a more comprehensive perspective on opinions toward deer and their management, beyond individuals subscribed to the organisations involved in this study. It would be particularly valuable to explore whether perceptions vary across different geographical contexts and levels of deer presence and to investigate what drives such beliefs to help identify the underlying rationale shaping them. Moreover, our study was a collaboration between academics and conservation practitioners. Such partnerships are mutually beneficial: practitioners gain insights into subscribers' perspectives to inform decision-making, whilst academics gain access to otherwise hard-to-reach participants. Each organisation involved in this study chose how to engage their subscribers, distributing the questionnaire through newsletters or dedicated emails. This approach enabled us to reach a large audience but prevented us from calculating a response rate.

5 | CONCLUSIONS AND RECOMMENDATIONS

Understanding perceptions of wild deer and their management across different actors is key to the design of effective deer management strategies. Our findings shed light on how people's beliefs towards deer are influenced by factors including involvement in land management, age group and the type of organisation they are subscribed to. A high level of support for lethal control observed

across respondents may alleviate concerns of widespread opposition toward the use of lethal deer management by organisations and decision-makers that rely on public support and membership.

Engaging directly with those affected by deer, valuing their experiences and fostering dialogue can build trust and consensus for effective management (Logan et al., 2025). Demonstrating the benefits of deer management to local communities through monitoring programmes may also enhance support (Kilpatrick & LaBonte, 2003). Further research into factors driving support for lethal control of deer across different groups could help build even broader acceptance of the practice. Finally, we emphasised the importance of communication and collaborations between neighbours to achieve deer management benefits and address potential conflicts. To identify the strengths of collaborative management that could encourage wider adoption, future research should explore characteristics of successful collaborations, which were not investigated in our questionnaire. Respondents indicated that funding is not among the primary barriers to collaboration; instead, knowledge exchange opportunities among land managers should be prioritised to address differing perceptions of deer and their management. Facilitating collaboration does require funding, which may not always be available. Policy makers should ensure that opportunities for people to come together and develop mutual trust continue to exist by supporting initiatives that foster dialogue and cooperative efforts.

AUTHOR CONTRIBUTIONS

Elena Cini, Rebecca Spake, Freya A. V. St John, Christopher P. Nichols, Paul Orsi, Graeme Shannon and Amy Gresham conceived the study idea. Louise McMillan, Rebecca Spake, Freya A. V. St John and Elena Cini designed the methodology; Elena Cini, Freya A. V. St John, Christopher P. Nichols and Paul Orsi collected the data; Elena Cini, Rebecca Spake and Louise McMillan analysed the data; Elena Cini led the writing of the manuscript. All authors contributed critically to the interpretation of the results and manuscript drafts and gave final approval for publication.

CONFLICT OF INTEREST STATEMENT

All authors declare no competing interests.

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REFERENCES

Austin, Z., Raffaelli, D. G., & White, P. C. L. (2013). Interactions between ecological and social drivers in determining and managing biodiversity impacts of deer. *Biological Conservation*, 158, 214–222. https://doi.org/10.1016/j.biocon.2012.09.021

Austin, Z., Smart, J. C. R., Yearley, S., Irvine, R. J., & White, P. C. L. (2010). Identifying conflicts and opportunities for collaboration in the management of a wildlife resource: A mixed-methods approach. *Wildlife Research*, 37(8), 647–657. https://doi.org/10.1071/WR10057

Barton, O., Gresham, A., Healey, J. R., Cordes, L. S., & Shannon, G. (2022). The effects of population management on wild ungulates: A systematic map of evidence for UK species. *PLoS One*, 17(6), e0267385. https://doi.org/10.1371/journal.pone.0267385

Böhm, M., White, P. C. L., Chambers, J., Smith, L., & Hutchings, M. R. (2007). Wild deer as a source of infection for livestock and humans in the UK. *The Veterinary Journal*, 174(2), 260–276. https://doi.org/10.1016/j.tvjl.2006.11.003

Bowker, J. M., Newman, D. H., Warren, R. J., & Henderson, D. W. (2003). Estimating the economic value of lethal versus nonlethal deer control in suburban communities. *Society & Natural Resources*, 16(2), 143–158. https://doi.org/10.1080/08941920309197

Bullock, C. H. (1999). Environmental and strategic uncertainty in common property management: The case of Scottish Red Deer. *Journal of Environmental Planning and Management*, 42(2), 235–252. https://doi.org/10.1080/09640569911235

Bunce, R. G., Wood, C. M., Smart, S. M., Oakley, R., Browning, G., Daniels, M. J., Bunce, R. G. H., Ashmole, P., Cresswell, J., & Holl, K. (2014). The landscape ecological impact of afforestation on the British uplands and some initiatives to restore native woodland cover. *Journal of Landscape Ecology*, 7(2), 5–24. https://doi.org/10.2478/jlecol-2014-0013

Climate Change Committee. (2024). Reducing UK emissions. 2024 Progress Report to Parliament. https://www.theccc.org.uk/publication/progress-in-reducing-emissions-2024-report-to-parliament/

Côté, S. D., Rooney, T. P., Tremblay, J.-P., Dussault, C., & Waller, D. M. (2004). Ecological impacts of deer overabundance. *Annual Review of Ecology, Evolution, and Systematics*, 35(1), 113–147. https://doi.org/10.1146/annurev.ecolsys.35.021103.105725

Countryside and Rights of Way Act (2000). https://www.legislation.gov.uk/ukpga/2000/37/contents

Dandy, N., Ballantyne, S., Moseley, D., Gill, R., Peace, A., & Quine, C. (2011). Preferences for wildlife management methods among the peri-urban public in Scotland. *European Journal of Wildlife Research*, 57(6), 1213–1221. https://doi.org/10.1007/s10344-011-0534-x

Dandy, N., Ballantyne, S., Moseley, D., Gill, R., & Quine, C. (2009). The management of roe deer in peri-urban Scotland. *Forest Research*. https://cdn.forestresearch.gov.uk/2022/02/management_of_roe_deer_in_peri-urban_scotland_final_report_may_2009.pdf

Dandy, N., Ballantyne, S., Moseley, D., Gill, R., Quine, C., & van der Wal, R. (2012). Exploring beliefs behind support for and opposition to wildlife management methods: A qualitative study. *European Journal of Wildlife Research*, *58*(4), 695–706. https://doi.org/10.1007/s10344-012-0619-1

Davies, A. L., & White, R. M. (2012). Collaboration in natural resource governance: Reconciling stakeholder expectations in deer management in Scotland. *Journal of Environmental Management*, *112*, 160–169. https://doi.org/10.1016/j.jenvman.2012.07.032

Deer Act (1991). Chapter 54. https://www.legislation.gov.uk/ukpga/1991/54/contents

Diefenbach, D. R., Palmer, W. L., & Shope, W. K. (1997). Attitudes of Pennsylvania sportsmen towards managing white-tailed deer to protect the ecological integrity of forests. *Wildlife Society Bulletin*, *25*(2), 244–251. https://www.jstor.org/stable/3783438

Dolman, P., Fuller, R., Gill, R., Hooton, D., & Tabor, R. (2010). Escalating ecological impacts of deer in lowland woodland. *British Wildlife*, *21*(4), 242–254. https://www.researchgate.net/publication/286292050_Escalating_ecological_impacts_Of_deer_in_lowland_woodland

Ehrhart, S., Stühlinger, M., & Schraml, U. (2022). The relationship of stakeholders' social identities and wildlife value orientations with attitudes toward red deer management. *Human Dimensions of Wildlife*, *27*(1), 69–83. https://doi.org/10.1080/10871209.2021.1885767

Eichhorn, M. P., Ryding, J., Smith, M. J., Gill, R. M. A., Siriwardena, G. M., & Fuller, R. J. (2017). Effects of deer on woodland structure revealed through terrestrial laser scanning. *Journal of Applied Ecology*, *54*(6), 1615–1626. https://doi.org/10.1111/1365-2664.12902

Fattorini, N., Lovari, S., Watson, P., & Putman, R. (2020). The scale-dependent effectiveness of wildlife management: A case study on British deer. *Journal of Environmental Management*, *276*, 111303. https://doi.org/10.1016/j.jenvman.2020.111303

Fulton, D. C., Manfredo, M. J., & Lipscomb, J. (1996). Wildlife value orientations: A conceptual and measurement approach. *Human Dimensions of Wildlife*, *1*(2), 24–47. https://doi.org/10.1080/10871209609359060

Fulton, D. C., Skerl, K., Shank, E. M., & Lime, D. W. (2004). Beliefs and attitudes toward lethal management of deer in Cuyahoga Valley National Park. *Wildlife Society Bulletin*, *32*(4), 1166–1176. https://doi.org/10.2193/0091-7648(2004)032[1166:BAATLM]2.0.CO;2

Furr, R. M. (2011). *Scale construction and psychometrics for social and personality psychology*. SAGE Publications Ltd. https://doi.org/10.4135/9781446287866

Garcia, F., Alves da Silva, A., Freitas, H., Sousa, J. P., & Alves, J. (2025). The essential, but complex, role of red deer as an ecosystem service provider: A comprehensive review across Europe. *European Journal of Wildlife Research*, *71*(3), 1–14. https://doi.org/10.1007/s10344-025-01922-7

Gill, R. (1999). Deer management to protect forest vegetation—A British perspective. In: *Proceedings of the cedar symposium* (pp. 59–68). https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=9cc64c6c98aa29806b14a408d05653ca900680bd#page=66

Gill, R. (2000). The impact of deer on woodland biodiversity (No. 36, pp. 1–6). https://cdn.forestresearch.gov.uk/2000/01/fcin036.pdf

Gill, R., & Fuller, R. J. (2007). The effects of deer browsing on woodland structure and songbirds in lowland Britain. *Ibis*, *149*(s2), 119–127. https://doi.org/10.1111/j.1474-919X.2007.00731.x

Green, D., Askins, G. R., & West, P. D. (1997a). Developing urban deer management plans: The need for public education. In: *Proceedings of the Eighth Eastern Wildlife Damage Management Conference*. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1014&context=ewdcc8

Green, D., Askins, G. R., & West, P. D. (1997b). Public opinion: Obstacle or aid to sound deer management? *Wildlife Society Bulletin*, *25*(2), 367–370. https://www.jstor.org/stable/3783456

Gullett, P. R., Leslie, C., Mason, R., Ratcliffe, P., Sargent, I., Beck, A., Cameron, T., Cowie, N. R., Hetherington, D., MacDonell, T., Moat, T., Moore, P., Teuten, E., & Hancock, M. H. (2023). Woodland expansion in the presence of deer: 30 years of evidence from the Cairngorms connect landscape restoration partnership. *Journal of Applied Ecology*, *60*(11), 2298–2308. https://doi.org/10.1111/1365-2664.14501

Hare, D., Daniels, M., & Blossey, B. (2021). Public perceptions of deer management in Scotland. *Frontiers in Conservation Science*, *2*, 781546. https://doi.org/10.3389/fcosc.2021.781546

Harrington, J. L., & Conover, M. R. (2006). Characteristics of ungulate behavior and mortality associated with wire fences. *Wildlife Society Bulletin*, *34*(5), 1295–1305. https://doi.org/10.2193/0091-7648(2006)34[1295:COUBAM]2.0.CO;2

HM Gov (2021). Net zero strategy: Build back greener. https://www.gov.uk/government/publications/net-zero-strategy/

Holland, J., McMorran, R., Morgan-Davies, C., Bryce, R., Glass, J., Pollock, M., McCracken, D., Glass, R., Woolvin, A., & Thomson, S. (2017). Meeting the challenge of wild deer research to support delivery of sustainable deer management in Scotland. *Scottish Natural Heritage Commissioned Report*, *963*, 1–150. https://www.nature.scot/sites/default/files/2017-09/Publication%202017%20-%20SNH%20Commissioned%20Report%20963%20-%20Meeting%20the%20challenge%20of%20wild%20deer%20research%20to%20support%20delivery%20of%20sustainable%20deer%20management%20in%20Scotland.pdf

Jacobs, M. H., Vaske, J. J., & Sijtsma, M. T. J. (2014). Predictive potential of wildlife value orientations for acceptability of management interventions. *Journal for Nature Conservation*, *22*(4), 377–383. https://doi.org/10.1016/j.jnc.2014.03.005

Jing-Schmidt, Z. (2007). Negativity bias in language: A cognitive-affective model of emotive intensifiers. *Cognitive Linguistics*, *18*(3), 417–433. https://doi.org/10.1515/COG.2007.023

Kilpatrick, H. J., & LaBonte, A. M. (2003). Deer hunting in a residential community: The community's perspective. *Wildlife Society Bulletin*, *31*(2), 340–348. https://www.jstor.org/stable/3784312

Kilpatrick, H. J., & Walter, W. D. (1997). Urban deer management: A community vote. *Wildlife Society Bulletin*, *25*(2), 388–391. https://www.jstor.org/stable/3783460

Land Reform (Scotland) Act (2003). https://www.legislation.gov.uk/asp/2003/2/2021-02-24

Lauber, T. B., & Knuth, B. A. (2000). Communicating about suburban deer management: Tailoring the message to the stakeholders. In: *The Ninth Wildlife Damage Management Conference Proceedings.* Paper 33. https://digitalcommons.unl.edu/icwdm_wdmconfproc/33/?utm_source=digitalcommons.unl.edu%2Ficwdm_wdmconfproc%2F33&utm_medium=PDF&utm_campaign=PDFCoverPages

Lezhnina, O., & Kismihók, G. (2022). Latent class cluster analysis: Selecting the number of clusters. *MethodsX*, *9*, 101747. https://doi.org/10.1016/j.mex.2022.101747

LimeSurvey GmbH. (n.d.). LimeSurvey: An open source survey tool/ LimeSurvey GmbH, Hamburg, Germany. http://www.limesurvey.org

Logan, T. W., Ward, A. I., & Hopkins, C. R. (2025). Stakeholder solutions to human-wildlife conflicts: Co-created adaptive impact management for wild red deer, *Cervus elaphus*, in the English Lake District. *Biological Conservation*, *310*, 111380. https://doi.org/10.1016/j.biocon.2025.111380

Loker, C. A., Decker, D. J., & Schwager, S. J. (1999). Social acceptability of wildlife management actions in suburban areas: 3 cases from New

York. *Wildlife Society Bulletin*, 27(1), 152–159. https://www.jstor.org/stable/3783952

MacMillan, D. C., & Leitch, K. (2008). Conservation with a gun: Understanding landowner attitudes to deer hunting in the Scottish highlands. *Human Ecology*, 36(4), 473–484. https://doi.org/10.1007/s10745-008-9170-9

MacMillan, D. C., & Phillip, S. (2008). Consumptive and non-consumptive values of wild mammals in Britain. *Mammal Review*, 38(2–3), 189–204. https://doi.org/10.1111/j.1365-2907.2008.00124.x

Manfredo, M. J. (2008). Who cares about wildlife? In *Who cares about wildlife?* (pp. 1–27). Springer US. https://doi.org/10.1007/978-0-387-77040-6_1

Manfredo, M. J., Teel, T. L., & Henry, K. L. (2009). Linking society and environment: A multilevel model of shifting wildlife value orientations in the western United States. *Social Science Quarterly*, 90(2), 407–427. https://doi.org/10.1111/j.1540-6237.2009.00624.x

Martínez-Jauregui, M., Delibes-Mateos, M., Arroyo, B., & Soliño, M. (2020). Addressing social attitudes toward lethal control of wildlife in national parks. *Conservation Biology*, 34(4), 868–878. https://doi.org/10.1111/cobi.13468

Matechou, E., Liu, I., Fernández, D., Farias, M., & Gjelsvik, B. (2016). Biclustering models for two-mode ordinal data. *Psychometrika*, 81(3), 611–624. https://doi.org/10.1007/s11336-016-9503-3

McCance, E. C., Campbell, M. M., & Baydack, R. K. (2015). Identifying how human behavior influences urban White-tailed deer movement patterns in a Canadian metropolitan area. *Human Dimensions of Wildlife*, 20(6), 471–483. https://doi.org/10.1080/10871209.2015.1046094

McMillan, L., Fernández Martínez, D., Cui, Y., & Matechou, E. (2024). Clustord: Clustering ordinal data using proportional odds model, ordered stereotype model or binary model. https://vuw-clustering.github.io/clustord/

Office for National Statistics (ONS) (2023). Population estimates for the UK, England, Wales, Scotland, and Northern Ireland: mid-2023. Statistical bulletin. Released 8 October 2024. https://www.ons.gov.uk/

Preedalikit, K., Fernández, D., Liu, I., McMillan, L., Nai Ruscone, M., & Costilla, R. (2024). Row mixture-based clustering with covariates for ordinal responses. *Computational Statistics*, 39(5), 2511–2555. https://doi.org/10.1007/s00180-023-01387-9

Putman, R. (1996). Ungulates in temperate forest ecosystems: Perspectives and recommendations for future research. *Forest Ecology and Management*, 88(1–2), 205–214. https://doi.org/10.1016/S0378-1127(96)03878-9

Putman, R. (2010). A review of the various legal and administrative systems governing management of large herbivores in Europe. In *Ungulate management in Europe: Problems and practices* (pp. 54–79). Cambridge University Press. https://doi.org/10.1017/CBO9780511974137.004

Putman, R., Langbein, J., Green, P., & Watson, P. (2011). Identifying threshold densities for wild deer in the UK above which negative impacts may occur. *Mammal Review*, 41(3), 175–196. https://doi.org/10.1111/j.1365-2907.2010.00173.x

Qualtrics (2005). Provo, Utah, USA. https://www.qualtrics.com

Ramirez, J. I., Jansen, P. A., & Poorter, L. (2018). Effects of wild ungulates on the regeneration, structure and functioning of temperate forests: A semi-quantitative review. *Forest Ecology and Management*, 424, 406–419. https://doi.org/10.1016/j.foreco.2018.05.016

RStudio Team (2020). *RStudio: Integrated development for R*. RStudio, PBC. http://www.rstudio.com

Siemer, W. F., Lauber, T. B., Chase, L. C., Decker, D. J., McPeake, R. J., & Jacobson, C. A. (2004). Deer/elk management actions in suburban environments: What will stakeholders accept? In: *Proceedings of the 4th International Symposium on Urban Wildlife Conservation* (pp. 228–237). Tucson, Arizona, USA. https://cales.arizona.edu/pubs/adjunct/snr0704/snr07042t.pdf

Sijtsma, M. T. J., Vaske, J. J., & Jacobs, M. H. (2012). Acceptability of lethal control of wildlife that damage agriculture in The Netherlands. *Society and Natural Resources*, 25(12), 1308–1323. https://doi.org/10.1080/08941920.2012.684850

Stewart, C. M. (2011). Attitudes of urban and suburban residents in Indiana on deer management. *Wildlife Society Bulletin*, 35(3), 316–322. https://doi.org/10.1002/wsb.30

Stinchcomb, T. R. (2022). Beyond Bambi and Big Bucks: Exploring the social complexity of deer management in Indiana (Doctoral dissertation, Purdue University). https://doi.org/10.25394/PGS.19330589.v1

Stout, R. J., Knuth, B. A., & Curtis, P. D. (1997). Preferences of suburban landowners for deer management techniques: A step towards better communication. *Wildlife Society Bulletin*, 25(2), 348–359. https://www.jstor.org/stable/3783454

Teel, T. L., & Manfredo, M. J. (2010). Understanding the diversity of public interests in wildlife conservation. *Conservation Biology*, 24, 128–139. https://doi.org/10.1111/j.1523-1739.2009.01374.x

Trout, R., & Brunt, A. (2014). Protection of trees from mammal damage. For Res Best Pract Guid Land Regen, 12, 1–7. https://cdn.forestresearch.gov.uk/2022/02/lru_bpg12.pdf

Urbanek, R. E., Nielsen, C. K., Davenport, M. A., & Woodson, B. D. (2012). Acceptability and conflict regarding suburban deer management methods. *Human Dimensions of Wildlife*, 17(6), 389–403. https://doi.org/10.1080/10871209.2012.684196

Urbanek, R. E., Nielsen, C. K., & Woodson, B. D. (2015). Perceived and desired outcomes of suburban deer management methods. *Journal of Wildlife Management*, 79(4), 647–661. https://doi.org/10.1002/jwmg.871

Valente, A. M., Acevedo, P., Figueiredo, A. M., Martins, R., Fonseca, C., Torres, R. T., & Delibes-Mateos, M. (2020). Dear deer? Maybe for now. People's perception on red deer (*Cervus elaphus*) populations in Portugal. *Science of the Total Environment*, 748, 141400. https://doi.org/10.1016/j.scitotenv.2020.141400

Watkins, M. W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology*, 44(3), 219–246. https://doi.org/10.1177/0095798418771807

West, B. C., & Parkhurst, J. A. (2002). Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. *Wildlife Society Bulletin*, 30(1), 139–147. https://www.jstor.org/stable/3784647

Whitefield, A. C. E., McMorran, R., Paterson, J. S., & Warren, C. R. (2021). Public perceptions of deer management in Scotland: The impact of place of residence, knowledge and demographic factors. *Scottish Geographical Journal*, 137(1), 67–83. https://doi.org/10.1080/14702541.2021.1920048

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Supporting Information S1. Questionnaire.

Supporting Information S2. Descriptive statistics.

Supporting Information S3. Clustering analysis.

Supporting Information S4. R Code.