Identifying Conflicts and Opportunities for Collaboration in the Management of a Wildlife Resource

A Mixed-Methods Approach

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Identifying conflicts and opportunities for collaboration in the management of a wildlife resource: a mixed methods approach

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Abstract

Context. The sustainable management of many common-pool ecological resources can be strengthened through collaboration among stakeholder groups. However, the benefits of collaborative management are often not realised due to conflicts of interest among stakeholders. Effective strategies for enhancing collaborative management require an understanding of the trade-offs that managers make between different management outcomes and an understanding of the socioeconomic and location-specific differences that drive these preferences. Approaches based on quantitative or qualitative methods alone often fail to reveal some of the underlying factors inhibiting collaboration.

Aims. Our aim was to understand the relative importance that private-sector deer managers attach to changes in three outcomes of deer management: deer numbers, deer-related road traffic accidents (RTAs) and deer impacts on conservation woodlands.

Methods. We used a mixed methods approach, combining choice experiment methodology with qualitative analysis of focus group discussions from 10 study regions throughout Britain.

Key results. Our results show that most of the private sector stakeholders responsible for deer management decisions at the local level would prefer to see a future with fewer deer-related RTAs but do not want to see a future with lower deer population levels. This is especially the case for those stakeholders managing for sporting purposes and those that rely on deer as a financial resource.

Conclusions. The preferences of many private sector stakeholders responsible for deer management are at odds with those of private landowners currently experiencing economic and conservation damage from deer, and with the aims of government and

non-government bodies seeking to reduce grazing and browsing damage through lower deer densities. Similar barriers to collaborative management are likely to exist in any situations where ecological resources deliver an unequal distribution of benefits and costs among stakeholders.

Implications. Overcoming barriers to collaboration requires enhanced understanding of how different collaborative mechanisms are viewed amongst the stakeholder community and how collaborative management can be promoted. More holistic approaches to deer management, which include greater public awareness, additional road traffic speed restrictions and appropriate fencing, or perhaps include deer population reduction as only one of a suite of mechanisms for delivering multiple benefits from the land, are likely to gain more support from private sector stakeholders. Mixed-methods approaches can provide an important first step in terms of both quantifying preferences in relation to the management of ecological resources and enabling detailed insights into the motivations and behaviours underlying them.

1. Introduction

Collaboration can enhance the sustainable management of common-pool ecological resources as a result of stakeholders agreeing on common practices, engaging in conflict resolution and sharing information to build a common knowledge base (Bodin and Crona 2009). Collaboration may be particularly beneficial for the management of ecological resources such as wildlife species, which are mobile across ownership boundaries, and where actors may have competing objectives for the use and management of the resource (Keough and Blahna 2006; Bodin and Crona 2009). For species which confer costs as well as resource benefits to society, the conflicting interests of different stakeholder groups can present significant barriers to collaborative management. Understanding the preferences for, and drivers behind, different management outcomes and the constraints surrounding current management can help to identify areas of conflict and common interest between and within stakeholder groups. Such information is essential for informing the development of future collaborative management strategies, which rely on acceptance by resource managers and stakeholders for their success.

The inclusion of stakeholder participation in environmental decision-making is increasingly recognised as helping to identify some of these barriers and contributing to decisions that are better adapted to local socio-cultural and environmental conditions (Yearley *et al.* 2003; Reed 2008). This in turn may lead to policies that have a greater rate of adoption among target groups and an enhanced capacity to meet local needs and priorities (Martin and Sherington 1997; Lynam *et al.* 2007). A number of participatory research methods have been developed recently which investigate the role which stakeholders, both private and public, play in the process of environmental decision making. Quantitative methods include, amongst others, the use of participatory mapping approaches (Austin *et al.* 2009; Irvine *et al.* 2009; Jankowski 2009), Bayesian belief networks (Henriksen and Barlebo 2008) and Q-methodology (Raadgever *et al.* 2008) for stakeholder participation. Choice experiment methodology, which was originally developed to determine consumer preferences for multi-attribute goods (Louviere and Woodworth 1983), has more recently been developed to assess stakeholder preferences for recreation and environmental management (Hearne and Salinas 2002; Othman *et al.* 2004) and to examine the tradeoffs which stakeholders make between competing natural resource priorities (Breffle and Rowe 2002; Xu *et al.* 2003; Horne *et al.* 2005; Smyth *et al.* 2009). Qualitative methods for stakeholder participation involve the analysis of structured, semi-structured and open discussion conducted during interviews or focus group settings. Both the quantitative and qualitative approaches have advantages in certain situations. However, used in isolation, each approach may fail to provide a complete picture regarding the underlying factors inhibiting more collaborative management. Mixed-methods approaches, employing both quantitative and qualitative elements, have the potential to overcome these problems. Focus groups have been used in order to inform choice experiment procedure (Christie *et al.* 2006) or evaluate their implementation (Powe *et al.* 2005), but such qualitative information has rarely been used in tandem with choice experiment analysis to support the quantified preferences or inform the motivations behind decisions on trade-offs in the management of common-pool natural resources.

Wild deer species in Britain are considered by many stakeholders as a common-pool resource. While alive they belong to no one, but the right to shoot deer rests with the landowners, or deer managers acting on their authority when they are resident on their land (Parkes and Thornley 2000). Most deer species are mobile across the landscape and will therefore range across areas of different land ownership, often subject to disparate and conflicting management objectives. Deer produce a range of values for society. Revenue is produced from hunting, venison production and tourism-related activities (Gordon *et al.* 2004; Macmillan and Phillip 2008), whereas costs can arise from deer-related road traffic accidents (Putman 1997; Malo *et al.* 2004) and grazing or browsing impacts on sites managed for agriculture, forestry and conservation (Putman and Moore 1998). In order to address the current expansion of both deer numbers and distributions (Ward 2005) while sustainably managing populations in order to maximise benefits, collaborative management at a landscape level has become the preferred strategy among governing organisations (English Nature 2003; Wilson 2003c). Such collaboration can entail the co-ordination of information and effort for managing deer across the whole range of a population, in order to share the responsibility, costs and benefits derived from this management (Mayle 1999). While there are a number of formal and informal deer management groups established across Britain for the collaborative management of deer, there remain places where such schemes do not exist and even where they do, management conflicts may still persist.

In order to understand the barriers to collaboration and develop effective strategies to enhance the collaborative management of wild deer, there is a need to understand the trade-offs that deer managers make between the benefits and costs arising from current management and the socioeconomic and geographical differences that drive these preferences. While such knowledge does exist in the stakeholder community, it is used only infrequently to inform future policy making regarding the collaborative management of deer. This is particularly the case regarding the motivations and behaviours of private-sector stakeholders, yet this stakeholder group form the largest sector of owners and managers across the wild deer range in the UK and it is therefore essential to understand their motivations and behaviours when developing policies for effective collaboration in deer management.

In this paper, we use a mixed-methods approach to examine the tradeoffs which private-sector deer managers in Britain make between different outcomes of deer management. Specifically we examine the relative importance that the deer managers attach to changes in deer numbers, incidence of deer-related road traffic accidents (RTAs) and deer impacts on conservation habitat. These attributes were identified as nationally important direct and indirect outcomes of deer management during two stakeholder consultation meetings with representatives from environmentally-related statutory organisations, nature conservation groups and the deer hunting community. We use choice experiment methodology to quantify the deer managers' relative preferences for these management outcomes and to examine how these preferences differ with socio-economic and geographical differences among manager groups. We supplement this with qualitative analysis of focus group discussions to identify some of the motivations underlying the expressed preferences.

2. Material and methods

2.1. Study area survey approach

We conducted the combined choice experiment and focus group discussions in ten study regions across Britain (Figure 1). These regions were chosen in order to cover a wide range of habitats and areas with different resident deer species, both managed and unmanaged (Table 1). We held the events in locations central to each study region and invited those private sector landowners and land managers who were responsible for making the decisions regarding deer management within each region. Information regarding these stakeholders was obtained from personal contacts within local interest groups established during fieldwork in each area. The number of final attendees at each event varied from 7 to 19, with a total of 128 participants nationwide (Table 1).

Approximate location of Figure 1

Approximate location of Table 1

2.2. Choice experiment design

Participants at the focus group events were asked to complete a choice experiment which featured three attributes; deer-related RTAs, deer population size and deer impact on conservation woodland regeneration. The choice experiment design featured two levels of each attribute: a level representing a noticeable increase from the current *status quo* (SQ) level, and a level representing a noticeable decrease from the SQ (Table 2). The experiment used a full factorial design featuring the three attributes at two levels. Two potential future scenarios (options A and B) which delivered different combinations of the increased and decreased attribute levels, relative to the levels present in the SQ, were presented on each choice card. A composite SQ combination containing the current levels of each attribute was also included on each choice card (Figure 2). Appropriate foldover generators were used to produce the option B levels from the levels present in option A on each card (Street and Burgess 2007) to enable all main effects and all first order interaction effects to be estimated independently. Duplicate option pairs were removed, leaving a set of eight choice cards in total. All participants were presented with all eight choice sets and asked to select their single preferred option (A, B or SQ) on each card.

Approximate location of Figure 2.

Approximate location of Table 2

2.3. Data collection

At each event, participants were first shown a brief presentation concerning the aims of the project, and then given a simple explanation of choice experiment methodology, including the attribute levels represented on the choice cards. After an initial discussion in which participants were given the opportunity to ask questions regarding the project and the methodology, participants were then asked to complete the eight choice cards, selecting their one preferred option from the three available options on each card. After the choice cards were completed, a semi-structured discussion was conducted and recorded with permission of the participants. The recordings were later transcribed for use in the qualitative analysis (section 2.4.4).

In addition to the choice experiments and group discussion, socio-economic information was requested from each participant, usually at the beginning of each event. This information included: the age of the participant; the area of land managed and a brief description of the landscape; whether they were a landowner, a land manager (or both); the primary purpose of their deer management (sporting, pest control or both); the percentage of business income derived from deer management (participants could choose from one of four categories: 0-25%, 25-50%, 50-75% or 75-100%). At this stage, participants were also asked to complete a consent form and indicate how they wanted the data to be treated in terms of confidentiality and archiving.

The choice experiment and focus group events took place between November 2007 and January 2009. All preliminary results from the choice experiments and the group discussions were summarised into one-page reports specific to each site, which were posted to each participant within two months of the event. Every participant was then given the opportunity to comment on the report and provide further details if not covered within the summary.

2.4. Data analysis

2.4.1. Conditional logit model

We used a basic conditional logit (CL) model (McFadden 1974) in order to determine the preferences associated with each main attribute within a pooled dataset containing choice data from the ten study sites. Dummy codes were used to represent the 'increase' level for each attribute (Table 3). Due to missing data, nine participants were removed from the dataset and therefore the analysis was conducted on the responses of 119 individuals. A respondent marked each card just once, to indicate a preference for one of three future deer management outcomes: option A, option B or the status quo (which remained constant on all cards and represented a combined attribute bundle for current levels of deer population size, woodland regeneration and RTAs. We specified the model so that the probability of selecting future deer management options A or B was expressed as a function of preferences for an increase (as opposed to a decrease) in any of the attributes present in those options. We also included a separate alternative specific constant (ASC), to represent any inherent preference for the status quo.

Approximate location of Table 3

2.4.2 Conditional logit model with interactions

The CL model assumes that preferences are homogenous across respondents. Although all of the participants were landowners or land managers (or both) responsible for making decisions regarding deer management in the study areas, they differed regarding the purpose for which they managed the deer and also the level of business income that they derived from deer management. It was possible that there would also be differences in preferences according to geographical region. These forms of heterogeneity are likely to provide important indications of why preferences for management outcomes might differ among different groups of managers. We therefore included dummy variables to represent these respondent-specific factors and location-specific factors (Table 4) as interaction terms in the preferences for the choice-specific attributes (Table 3) and also with the alternative specific constant (ASC) representing the status quo in the CL model.

Out of a total of 119 participants who provided complete information, 107 (90%) were land managers but only 28 (24%) participants were landowners, therefore, we included a landowner interaction term in the model. In addition, 65 (55%) participants managed deer for sporting purposes and 79 (66%) participants managed deer for pest control objectives. These variables were not mutually exclusive, with some participants managing deer for both objectives. Therefore, management for sport and management for pest control were also included as interaction terms in the model, along with region (Scotland or England and Wales) and dummy variables for each individual site. We did not include the percentage of business income derived from deer as an interaction term due to the large amount of missing data associated with this variable. All possible model combinations were tested and the final model was selected based on improvements in log-likelihood using backwards selection of variables.

Approximate location of Table 4

All models were estimated using LIMDEP 8.0 NLOGIT 3.0 and the overall fit of the models was assessed using McFadden's Pseudo-R^2. The Pseudo-R^2 value in multinomial logit models is similar to the R^2 value in a linear regression model, however, significance occurs at lower levels, with a Pseudo-R^2 of 0.3 representing an R^2 value of approximately 0.6 (Hensher *et al.* 2007). A Pseudo-R^2 value of between 0.2 and 0.4 is considered to be a good fit (Louviere *et al.* 2000).

2.4.3. Latent class model

As an alternative method of accounting for heterogeneity in preferences, we employed a latent class model (LCM) to the choice experiment data. In a LCM, the population consists of an identifiable number of groups (segments) that differ significantly in their preference structure. The identification of different segments is probabilistic and determined endogenously by the data, but the segments can then be related to identifiable socio-demographic or location-specific characteristics of the participants (Birol *et al.* 2006). This analysis may therefore provide additional information on the potential drivers and motivations underlying preference structures.

Here, we used models which included the three main deer management attributes without socio-demographic and geographical attribute interactions but specified different numbers of segments each time we ran the LCM. Model fit was determined by examining the log likelihood and the AIC and BIC statistics, in addition to the Pseudo-R^2 value and the number of parameters included in each model (Boxall and Adamowicz 2002). As stated in much of the choice experiment literature (Birol et al. 2006; Colombo et al. 2009; Ruto and Garrod 2009), there is no set way of deciding on the appropriate number of segments in a latent class model. Most authors look for a significant reduction in AIC or BIC, but other authors emphasise the importance of parsimony and consider the trade-off between sequential decreases in AIC or BIC and increases in Pseudo-R^2 on one hand and an increase in the number of parameters on the other as the number of segments increases (Birol et al. 2006; Ruto and Garrod 2009). These variations in approaches to model selection can be important in terms of the application of the results, since a model which is highly statistically-significant but reliant on a large number of segments and parameters may be less straightforward to interpret for management purposes. In a relatively small dataset there is also the risk that the inclusion of a large number of segments may attach undue importance to uncommon or irregular preference structures. Because the focus of our work was identifying the main preference structures for deer management and their underlying drivers, we attached the greatest importance to parsimony in interpreting our LCM results. We therefore followed the approach of Birol et al. (2006) and Ruto and Garrod (2009) for model selection.

Once the LCM with the optimal number of segments was identified, we estimated the relative size of each segment in the LCM and the probability of each respondent belonging to each segment. We ran a posterior analysis on these membership probabilities to determine whether any participant socio-demographic or location-specific characteristics were associated with the probability of LCM segment membership (Bucklin and Gupta 1992). This entailed introducing the participant-specific probabilities of segment membership as the dependent variables in binary and multinomial logit regressions with the participant-specific factors which had been used previously as interaction terms in the CL model as the potential explanatory variables.

2.4.4. Focus group qualitative analysis

For this analysis, we were interested in whether the main preferences for deer management outcomes that were estimated with the CL models were reflected in the group discussion. However, we also wanted to identify other factors which were expressed by participants as influencing their preferences. In particular, it was important to identify the underlying motivations driving any regional or socioeconomic differences in preference structure to better understand why such conflicting management preferences occurred. This information could not be gathered or assessed using the quantitative methodology alone and therefore it was necessary to use a qualitative analysis. The transcripts from each group discussion were therefore coded according to these underlying themes using the software package Atlas.ti version. 5.2 (Altas.ti Scientific Software Development GmbH, Berlin, Germany) and the results were entered into a matrix to enable comparisons between the different sites.

3. Results

3.1. Main preferences for deer management attributes

The conditional logit model for all sites, based on the three main deer management attributes, was a good fit, with a Pseudo-R^2 value of 0.308 (Table 5). Preferences for all the attributes were statistically significant and of the expected polarity. The estimated preferences for ‘RTA increase’ had the largest absolute coefficient, indicating that the participants have a strong aversion towards future increases (as opposed to decreases) in deer-related RTAs. Estimated preferences for the ‘Wood increase’ and ‘Deer increase’ attributes were significant and positive, indicating a preference for future increases in woodland regeneration and deer populations, as opposed to decreases. However, the preference for increasing deer populations was much weaker than that for increasing woodland regeneration. The positive and significant ASC coefficient implies an aversion to a move away from the status quo.

Approximate location of Table 5

3.2. Interactions between preferences and socio-demographic and location-specific factors

The results of the CL model for all sites which included the three main deer management attributes and interactions between those main attributes, showed that preferences for the three deer management attributes and the status quo option were similar to the simple CL model (Table 5). However, by including attribute interactions and accounting for socio-demographic characteristics as sources of preference heterogeneity the model fit improved, with Pseudo-R^2 increasing to 0.355.

The negative interaction between the ‘RTA increase’ and ‘Deer increase’ attributes indicates an overall aversion to a simultaneous increase, as opposed to a decrease, in both deer-related RTAs and deer numbers, whereas a positive preference was expressed for an increase in deer numbers decoupled from an increase in deer-related RTAs. Several socio-demographic factors were found to significantly influence preferences for the main deer management attributes. Landowners as well as landowners who are also land managers (‘Owner’) had a significantly stronger preference for increasing, as opposed to decreasing, woodland regeneration (‘Wood increase’) when compared to land managers *per se*. However, participants managing deer for sporting purposes (‘Sport’) had a significantly weaker preference for increasing, as opposed to decreasing, woodland regeneration. (This dichotomy is also evident in the latent class analysis below). Three regional and site-specific interaction effects were also significant. Participants from the Dorset study site (‘Dorset’) displayed a significantly stronger preference for the status quo situation than respondents from other sites. Respondents from Scotland displayed a stronger preference for increasing, as opposed to decreasing, deer numbers (‘Deer increase’) compared to respondents in England and Wales, but participants from the Suffolk study site (‘Suffolk’) were unique in displaying an aversion to increasing deer numbers.

Qualitative analysis of the focus group discussions supported the findings from the quantitative CL models. The aversion to increasing deer numbers demonstrated by the participants from the Suffolk study site is likely to be a consequence of the perceived economic impact that fallow deer have in this region. The majority view at this site was captured by a comment made by one of the participants: ‘we are probably majority driven by the economic impact, it’s the damage that is done to our crops, that is done to our woodlands… the economic impact to our businesses and the responsibility we have to the landowners and whoever else that we are managing the deer with’ (Long Melford, Suffolk). The strong preference identified for increasing deer numbers at the Scottish study sites when compared to the English and Welsh sites was also evident in the group discussions. The majority of participants at one Scottish site remarked on how deer are a key economic resource on privately-owned land in their region but that they did not perceive this to be the case in other areas or on neighbouring, publicly-owned land holdings: ‘…We need the deer, we see them as a natural resource, an income, [deer are] important to us - they are not important to this body that is funded by public money, they are not dependent on it’ (Ullapool, Ross-shire).

The qualitative analysis supported the CL model results but also revealed new information regarding the perceived relationships between management outcomes. Many participants stated that there are a number of other factors influencing the relationship between deer numbers and RTAs and therefore a direct correlation between the two was unjustified. Deer-related RTAs were not considered common in all study areas, but where they were considered an issue, factors mentioned in influencing their occurrence included increased public access and fencing resulting in a redistribution of deer to roadside areas as well as road salting and roadside planting as important factors in attracting deer to roadside areas: ‘In the case of the RTAs, there’s lots of factors to be taken into consideration as to why the deer are there on the roads. We had fencing channelling them down onto the road, we had fenced their winter grounds… Is it down to the salt that’s on the road, could we recreate that further out on the hill to keep them off the road?’ (Ullapool, Ross-shire). The majority of participants voiced strong concerns that deer-related RTAs were linked to inappropriate driving speeds in rural areas, and therefore deer-RTAs could be reduced accordingly: ‘I think there needs to be more emphasis on people driving more carefully through areas where there are known to be high populations of deer… I think that’s far more important than just saying… “Deer are being involved in accidents, therefore shoot more.” I think we need to look at people’s driving habits.’ (Monmouth, Lower Wye Valley).

3.3. Distinguishing groups based on preferences

Applying the method of Birol et al. (2006) to the results of our LCM, we found that as more segments were added to the LCM, the AIC and BIC statistics decreased and the Pseusdo-R^2 value increased (Table 6). However, this was at the expense of a considerable increase in the number of parameters included. The increase in Pseudo-R^2 value and the decrease in the AIC and BIC statistics relative to the increases in parameters were much greater when the second segment was introduced than when subsequent segments were added. We therefore selected the 2-segment model as the providing the most parsimonious fit. As before, all models were estimated using LIMDEP 8.0 NLOGIT 3.0.

Approximate location of Table 6

The 2-segment LC model (Table 7) shows that a significant aversion to increases, as opposed to decreases, in deer-related RTAs and a preference for increasing, as opposed to decreasing, woodland regeneration are common to both segments. However, based on the coefficient value and relative to the other preferences held, segment 2 expressed a stronger preference for increases in woodland regeneration than segment 1. Segment

2 also expressed no significant preference for an increase, as opposed to a decrease, in deer numbers, in sharp contrast to segment 1 who hold a strong relative preference for increasing deer numbers alongside their weaker but still significant relative preference for increased woodland regeneration.

Approximate location of Table 7

Posterior analysis of latent class membership probabilities (Table 8) showed that while the 'Control' and the 'Scotland' variables were not significantly associated with membership of either segment, land owners were more likely to be members of segment 2 and those managing deer for sporting purposes were more likely to be members of segment 1.

The preference structure associated with segment 1 was confirmed by comments made during focus group discussions at several sites. In particular, there was a demonstrated preference for more deer in conjunction with a preference for increases in woodland regeneration and decreases in deer-related RTAs and this 'conflict' was clearly demonstrated by participants managing deer for sporting purposes: 'I think there is a conflict…because I think whilst the group to which I belong [attach priority to] natural regeneration and reducing accidents, the conflict is that we want to have deer because we enjoy the sport and I guess if everybody's truthful around this table, we enjoy the sport of going stalking.' (Okehampton, Devon).

Approximate location of Table 8

4. Discussion

Our results reveal a complex picture in which private land owners and managers cannot be partitioned neatly into conservation and sporting interest groups. In many cases a preference for both higher deer levels and increased woodland regeneration was expressed amongst the same set of stakeholders. The choice experiment analysis and the qualitative information both support this preference structure and suggest that this is not inconsistent with the preference for a reduction in deer-related RTAs. Importantly, as a result of our qualitative analysis, we can reveal that deer managers do not consider that reductions in deer density are the solution to reducing this major cost which deer impose on society, indicating that other strategies should be supported. It is important however to emphasise that the consistency underlying these preferences would not have been identified without the use of the mixed-methods approach, where qualitative data were examined along with the quantitative findings.

Most choice experiment studies aim to collect quantitative information in order to determine statistical preferences for attributes and sometimes to relate these preferences to socio-economic characteristics of respondents. Rarely do they achieve any further, detailed explanations or interpretations of the attitudes and motivations behind the observed preferences. Such information can be derived from further stakeholder participation and is essential for more informed environmental management decisions. This is especially the case regarding the (collaborative) management of common-pool natural resources which are often the source of conflicting management objectives. Any management policies relating to such resources will benefit from an improved understanding of these conflicting interests, particularly whether they relate to specific groups or characteristics of stakeholder and whether they introduce further barriers to the effective management of the resource in question.

The Scottish sites in our study showed a stronger preference for increasing deer numbers when compared to sites in England and Wales. Individual land holdings (estates) are typically much larger in Scotland, ranging in size from 1,000 to over 10,000 hectares (MacMillan and Leitch 2008), and they are often unfenced, allowing deer to roam across large areas. Many contemporary sporting estates have their origins in the early nineteenth century but still make significant contributions to the rural economy. The income and employment generated due to stalking and the sale of venison, as well as wildlife-related tourism, is thought to be worth £105 million to the Scottish economy each year (Macmillan and Phillip 2008). Indeed, our qualitative analysis inferred that private sector Scottish deer managers see deer as an important natural resource which they are 'dependent' upon. These stakeholders are therefore likely to manage deer populations to maintain high densities in order to provide this hunting resource, an objective that may conflict with those of neighbouring sites which are publicly owned. In Scotland, there has been an increase in the amount of land owned by government agencies and non-governmental organisations which aim to keep deer densities low to reduce grazing impacts (Irvine *et al.* 2009). This has contributed to the increasing conflict over red deer management in this region, particularly concerning the movement of deer from high density to low density areas (Smart *et al.* 2008), ensuring that a preference for increasing deer numbers is particularly strong amongst private sector deer managers in Scotland when compared to other regions.

The CL and LC model results show that a strong overall aversion to increasing deer-RTAs is common to all regions and socioeconomic groups. This is not surprising given that the annual number of deer-related RTAs lies within the range of 20,000-60,000 for the UK and between 12,500-54,000 for England, with associated damage costs thought to be around £10.5 million per annum in England alone (Wilson 2003a). However, the absence of a causal link between deer numbers and the level of RTAs perceived by participants was identified through the qualitative analysis. This supports their inclusion as independent attributes in the choice experiment and also helps to explain why, rationally, participants could express both a preference for increasing deer numbers and for decreasing RTAs, as demonstrated in the CL models and segment 1 of the LC model.

Our results indicate that the Suffolk study region is the only area to show a significant aversion to increasing deer numbers. As a result of qualitative analysis, we confirmed that this preference is likely to be a consequence of the economic impacts associated with deer in the region. Just over 1.5 million hectares of land are managed for agriculture in the East of England, playing a key role in the economy of the region (Environment Agency 2009). The annual cost of deer impacts on agriculture in England is thought to be around £4.3 million (Wilson 2003b). In the East of England, damage to crops has largely been attributed to the impact of fallow, red and roe deer on cereals and grass (Putman and Moore 1998) with the total cost of deer damage to agriculture in the region estimated at £3.11 million (White *et al.* 2004). Such costs are highly variable, often depending on many factors including deer densities, winter conditions, and the type of crop affected (Ward *et al.* 2004; Macmillan and Phillip 2008). However, our results show that fallow deer are strongly perceived to be causing economic damage in this region and this is one of the main factors behind the expressed preference amongst mangers for a reduction in current deer population levels here.

By using a LC analysis, we were able to identify two groups of participants that differed significantly in their preference structure across all areas in this study. One group, who were statistically more likely to be landowners, displayed a strong relative preference for an increase as oppose to a decrease in woodland regeneration, a relationship that was also identified in the CL model. This group did not display any significant preference for either an increase or a decrease in deer numbers. Landowner motivations are shaped by economic, conservation, traditional and aesthetic goals (Church and Ravenscroft 2008) and here, the strong preference for woodland regeneration is likely to be influenced by all of these motivations. In particular, many of these landowners may be receiving grant aid in order to manage for successful regeneration of their woodland as a result of schemes such as the English Woodland Grant Scheme (Forestry Commission England 2009). Such landowners are therefore likely to display the preference structure revealed here regarding woodland regeneration and deer numbers. The second group identified in the LC analysis were statistically more likely to manage deer for sporting purposes and displayed a strong preference for increasing as oppose to decreasing deer numbers. Using qualitative analysis we confirmed that this preference, coupled with a preference for decreasing deer-related RTAs and increasing woodland regeneration, was common amongst those participants who manage deer for sporting purposes. These motivations highlight the difficulties inherent in developing future deer management policy based on population reductions.

Management implications

While the stakeholders surveyed would prefer to see a future with fewer deer-related RTAs, they perceived many factors apart from deer numbers to be important in influencing deer movement and RTA occurrence. This will need to be considered in future deer management policies, as a policy aim of reducing deer-related RTAs through more intensive deer population control is likely to be unpopular with the majority of deer managers. More holistic approaches to deer management, which include public awareness, additional road traffic speed restrictions and appropriate fencing, or perhaps include deer population reduction as only one of a suite of mechanisms for delivering multiple benefits from the land, are likely to gain more support.

Most of the private sector stakeholders responsible for deer management decisions at the local level do not want to see a future with lower deer population levels. Most managers want to see more deer, especially those managing for sporting purposes and those that rely on deer as a resource which makes an important contribution to the rural economy, as demonstrated by a stronger preference for more deer expressed by managers in Scotland when compared to England and Wales. However, in some areas these preferences may be at odds with those of private landowners currently experiencing economic and conservation damage from deer, as well as with the aims of government and non-government bodies seeking to reduce grazing and browsing damage through reduced deer densities.

Conclusion

The mixed methods approach we have used, combining quantitative choice experiment methodology with qualitative analysis, has delivered more detailed insights into the motivations which underlie expressed preferences than would have been possible using choice experiment methodology alone. With respect to wild deer in Britain, further understanding is needed regarding how different collaborative mechanisms are viewed amongst the stakeholder community, further barriers which may exist to these forms of management and the mechanisms by which collaborative management can be promoted among the different stakeholder groups, given the restrictions which have been identified here.

In this study, our mixed-methods approach has highlighted a number of barriers that exist in relation to the collaborative management of deer. Similar barriers are likely to exist in relation to the management of deer populations worldwide and in any situations where mobile ecological resources act as a source of both benefits and costs which are distributed unequally among stakeholders. Overcoming these barriers presents a major challenge to researchers, policy makers and resource managers. However, mixed-methods approaches can provide an important first step in terms of both quantifying preferences in relation to the management of ecological resources and delivering more detailed insights into the motivations and behaviours which underlie these preferences.

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Table 1. Study area information and participant group size for each choice experiment.

Choice experiment location	Number of participants	Main habitats	Deer species present
Balquhidder, Perthshire	12	Large forest blocks, open hills and moorland.	Red* and roe
Long Melford, Suffolk	10	Arable and mixed woodland.	Fallow*, roe, muntjac and red
Ullapool, Ross-shire	19	Woodland, open hills and moorland.	Red* and roe
Wareham, Dorset	12	Mixed woodland, heathland and marshland.	Sika* and roe
Monmouth, Lower Wye valley	12	Mixed-wooded valley and farmland.	Fallow* and roe
Kendal, Cumbria	19	Mixed woodland, open hill and heather moorland.	Red* and roe
Okehampton, Devon	14	Deep wooded valleys, arable, grassland and urban fringe areas.	Red*, roe* and fallow*
Hemel Hempstead, Hertfordshire	12	Arable, woodland and urban fringe areas.	Fallow*, roe*, muntjac* and Chinese water deer*
Ludlow, Shropshire	11	Woodland and arable.	Fallow*, roe* and muntjac
Kingussie, Cairngorms	7	Large forest blocks, open hills and moorland.	Red* and roe
Total	128		

*Those species managed by members of the focus group

Table 2. Summary of attributes and levels used in the choice experiment.

Attribute		Attribute levels		
Name	Description	Status quo (present in SQ option only)	Decrease (present in Options A or B)	Increase (present in Options A or B)
Deer population	The deer population level within the management area for the species which is the focus of active management.	No change from current deer population level within the management area.	A noticeable decrease in the deer population level within the management area.	A noticeable increase in the deer population level within the management area.
Woodland regeneration	The regeneration of ‘conservation’ woodlands. i.e. woodlands designated for protection by a statutory body, not plantation woodlands managed for harvesting.	No change from current woodland regeneration levels within the management area	A noticeable ‘deterioration’ in regeneration of conservation woodlands within the management area.	A noticeable ‘improvement’ in regeneration of conservation woodlands within the management area.
Deer-related RTAs	The number of deer-related RTAs taking place within the management area. This includes all collisions at all levels of severity.	No change from current numbers of deer-related RTAs within the management area	A noticeable decrease in the number of deer-related RTAs within the management area.	A noticeable increase in the number of deer-related RTAs within the management area.

Table 3. Main variables tested in the conditional logit model

Variable name	Description	Coding
RTA increase	An increase in the number of deer-related RTAs observed	1 = Increased RTA occurrence in choice bundle 0 = Decreased RTA occurrence in choice bundle or SQ *
Wood increase	An increase in the woodland regeneration levels	1 = Increased woodland regeneration present in choice bundle 0 = Decreased woodland regeneration present in choice bundle or SQ*
Deer increase	An increase in the deer population level observed	1 = Increased deer population level present in choice bundle 0 = Decreased deer population level present in choice bundle or SQ*

*Further details regarding the attribute levels can be found in Table 2.

Table 4. The interaction factors and variable units tested in the conditional logit model

Variable	Coding and description
Owner	1 = Land owners, some of whom were also land managers. 0 = Land managers only
Control	1 = Participants who managed deer for control purposes, some of whom also managed for sporting purposes. 0 = Participants who managed deer for sporting purposes only.
Sport	1 = Participants who managed deer for sporting purposes, some of whom also managed for control purposes. 0 = Participants who managed deer for control purposes only.
Scotland	1 = Participants from the Scottish study sites 0 = Participants from the English and Welsh study sites
Site	10 separate variables. For each variable: 1 = Participant was from the site tested (for list of sites see Table 1). 0 = Participant from all other sites.

Table 5. Results from a conditional logit model, and a conditional logit model with interactions, of discrete choice data from a choice experiment featuring deer-related RTAs; deer population size and woodland regeneration attributes as outcomes of management

	Conditional logit model	Conditional logit model with interactions
Attributes and interactions	Coefficient (± s.e)	Coefficient (± s.e)
ASC	1.33 ± 0.14***	1.43 ± 0.16***
RTA increase	-2.75 ± 0.17***	-2.32 ± 0.26***
Wood increase	1.68 ± 0.14***	2.12 ± 0.19***
Deer increase	0.80 ± 0.13***	0.87 ± 0.17***
RTA increase*Deer increase	-	-1.01 ± 0.35**
Wood increase*Owner	-	0.90 ± 0.23***
Wood increase*Sport	-	-0.96 ± 0.19***
Deer increase*Scotland	-	0.83 ± 0.21***
Deer increase*Suffolk	-	-1.06 ± 0.40**
ASC*Dorset	-	0.68 ± 0.16*
Log-likelihood	-662.690	-617.825
Pseudo-R^2	0.308	0.355
Sample size	944	944

***significance level ($P< 0.001$) **significance level ($P< 0.01$) *significance level ($P<0.05$)

Table 6. Latent class model information for determining optimal number of segments

No. of segments	Log likelihood (LL)	Pseudo-R^2	Parameters (P)	AIC	BIC
1	-662.69	0.308	4	1333.38	676.39
2	-571.61	0.403	9	1161.23	602.44
3	-547.94	0.428	14	1123.88	595.89
4	-525.66	0.451	19	1089.32	590.74

Sample size is 944 choices (N) from 119 individuals.
AIC (Akaike Information Criterion) is calculated using -2(LL-P)
BIC (Bayesian Information Criterion) is calculated using -LL+[(P/2)*ln(N)]

Table 7. Two-segment latent class model for deer management attributes

	Segment 1	Segment 2
Attributes	Coefficient (± s.e)	Coefficient (± s.e)
ASC	3.48 ± 0.69***	0.82 ± 0.12***
RTA increase	-4.43 ± 0.82***	-2.68 ± 0.12***
Wood increase	0.96 ± 0.33**	2.38 ± 0.12***
Deer increase	3.24 ± 0.67***	0.17 ± 0.10

Log likelihood = -571.61

Pseudo-R^2 = 0.403

***significance level (P< 0.001) **significance level (P< 0.01) *significance level (P<0.05)

Table 8. Posterior analysis of factors affecting probability of membership of segment 1 of the latent class model

Factor	Probability of membership: Segment 1
Attribute	Coefficient (± s.e)
Constant	-0.90 ± 0.70
Control	0.067 ± 0.59
Sport	1.37 ± 0.54*
Owner	-1.02 ± 0.52*
Scotland	-0.28 ± 0.50

***significance level (P< 0.001) **significance level (P< 0.01) *significance level (P<0.05)

Figures

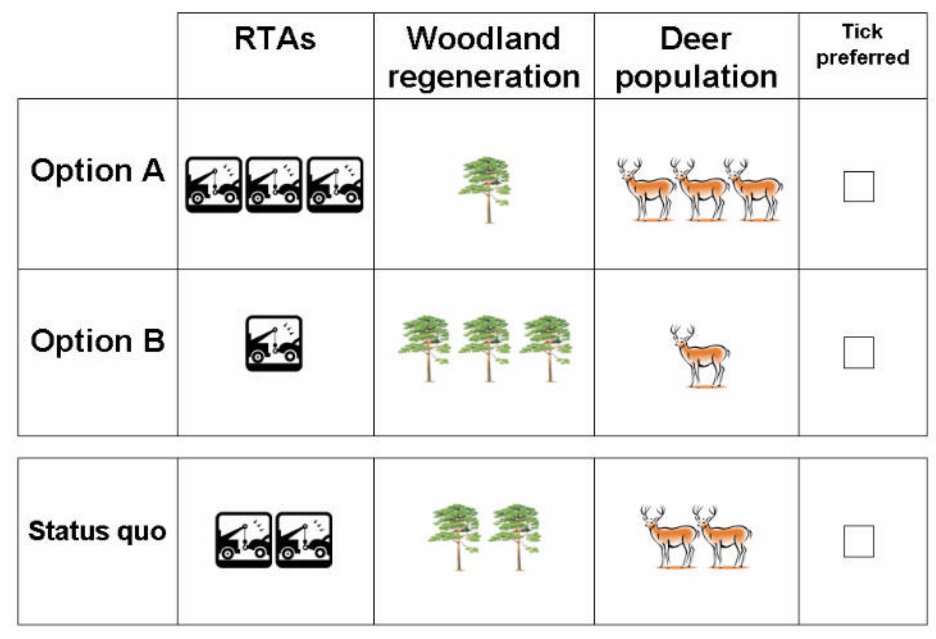
Figure 1. Map of choice experiment locations across Britain

Figure 2. An example of one of the eight choice cards used in the choice experiment.

Figure 1.


N
Ullapool
Kingussie
Balquhidder
Kendal
Ludlow
Long Melford
Monmouth
Hemel Hempstead
Okehampton
Wareham

Figure 2.


RTAs
Woodland regeneration
Deer population
Tick preferred
Option A
Option B
Status quo

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Authors' response to reviewers' comments

Our responses to the comments are below in italics. The original comments are shown in normal type.

Associate Editor
I agree with the assessment of the referees that this is a nice contribution to the wildlife management literature.

I ask the authors in a revision to carefully consider and address the comments of both referees. In particular, please address Reviewer 1's concerns about context basis for 'status quo', and both referees criticism, which I share, of the mixing of info-theory and H-testing paradigms, and the inappropriate use of P-values as measures of relative hypothesis support.

Reviewer 1

Comments

Q1. In the choice experiment, woodland regeneration could improve or deteriorate, relative to the status quo. This assumes that it is possible for regeneration problems to deteriorate. I have limited experience with deer abundance and forest conditions in Scotland but wonder whether that is possible. When I stopped counting >300 red deer on a hillside and could see regeneration 'explode' out of the heath when fenced I really wonder if the status quo is partly a 'context' issue. That is, if hunters or landowners are used to forests that have been exposed to heavy browsing pressure for decades there is reduced ability to assess browsing impacts because what is 'normal' is really a degraded environment.

So my question for the authors is whether the status quo is context dependent and how does that influence their interpretation of results. Moreover, how do environmental conditions vary spatially and could that explain some results. The authors address this somewhat in the context of agricultural areas (Suffolk region) but could more subtle spatial variation exist? Would some discussion of forest regeneration problems (in an absolute sense) be of value to readers?

A1 – We agree with the reviewer's point here that the status quo is context-dependent. In our original discussions with representatives of various stakeholder groups, which helped to formulate the design of the choice experiment, we discussed whether we should include some quantified data on current states and targets for deer management, whether in terms of the deer population or in terms of regeneration rates of native trees. However, it was apparent that what would be considered desirable (or achievable) would vary considerably from one region to another. Since one of our aims was to compare preference structures across the country, this would have made this much more difficult. The other reason that we did not go down the route of quantifying targets was that these are not actually identified in quantitative terms in most cases. For example, a 'desirable' conservation state or rate of regeneration would vary between a conservationist and a deer manager, and even within these groups. The reviewer is quite right that people's perceptions of good conservation condition are formed by their experience, and that their view of a desirable state may in fact be considerably different from some optimal conservation state. Indeed, the nature of a 'desirable' conservation state for European temperate woodlands and how this relates to the history of woodland development, is itself the subject of a separate literature (see review by Soepboer & Lotter 2009), which we consider to be beyond the cope of this paper.

What the participants are responding to when they make their choice on the cards between the status quo, a noticeable increase or a noticeable decrease is entirely dependent on their experience and their own perceptions. This will vary between respondents, but in the deer world, as in much practical conservation, management decisions, especially where these involve negotiations between different interest groups, are based largely on perceptions. So, we agree that the status quo and the other choices are context-dependent, but do not consider this to be a shortcoming of the approach. In fact, it is the only approach that would have *worked and allows for generalisation and comparisons across regions that a more specific, quantified approach would have precluded.*

Q2. The authors freely mix information theoretic methods and hypothesis testing statistics (P values) for model selection and interpretation of results. My review of the literature suggests this is common but makes it difficult to identify whether the authors are making decisions for selecting the best model based on objective measures or not. For example, the argument the authors present for choosing a 2 segment LC model is suspect. In the methods they indicate they used AIC and BIC and then in the results indicate because the change between the 1 and 2 segment models was greater than the 2 and 3 segment models they went with the 2 segment model. However, the difference in AIC between the 2 and 3 segment models declined by almost 40 points (Table 6). This is a huge difference and would suggest that the 2 segment model is not even competitive to the 3 segment model. The AIC model weight for the 4 segment model is nearly 1.0 (the sum of the weights of the other 3 models is <0.000001). This leads me to wonder if the authors could really only interpret the 2 segment model even though statistically there is evidence for a greater number of segments.

A2. As stated in much of the choice experiment literature (Birol et al., 2006; Colombo et al., 2009; Ruto & Garrod, 2009) there is no set way of deciding on the appropriate number of segments in a latent class model. Many authors look solely for a significant reduction in AIC or BIC, but this can result in over-complicated models, which can reduce their usefulness for management. Other authors therefore stress the importance of parsimony and consider reductions in AIC or BIC (or increases in pseudo-R^2) alongside concurrent increases in the number of parameters. Because of the applied nature of our work, we attached the greater importance to parsimony, and hence followed the method used in Birol et al., 2006 and Ruto & Garrod (2009), where decreases in BIC and AIC were considered as well as the increase in pseudo-R^2 when selecting the optimal number of segments. The authors in this paper also, crucially, looked at the size of the changes in these statistics between models. We have amended our Methods section on the LCM analysis to clarify our approach here in relation to that of others (p. 13 line 11 – p. 14 line 16).

Q3. The authors seem to use P values as a way to assess strength of associations. In a hypothesis testing framework one selects a rejection level and then decides whether the statistic is different to warrant rejection of the null hypothesis. P values of 0.04 or 0.0001 have the same meaning (if rejection is set alpha = 0.05). Consequently, the statement on page 15, line 7 'attributes were strongly significant' is misleading if that statement is based on the P values of <0.001 in Table 5. Similarly, I find the P values presented in Table 7 of little use because I am assuming the authors selected the 2 segment model using an information theoretic approach. The 2 segment model was chosen because it was parsimonious (but see my comment #2 above) so it is important to have all four variables in the model regardless of their P values.

A3. We agree that the wording used on page 15, line 7: 'attributes were strongly significant' is misleading. The wording on this line has now been changed to: ‘attributes were statistically significant’. Regarding Table 7, the strength of the preferences was largely based on the coefficient values and not p-values. They are in the table simply to show statistical significance and not strength of association. Some text has been added on page 19, lines 24-25 to emphasise this.

Q4. Minor points

a. 'between' is oftentimes used when I think 'among' would be correct.

A4a. We have gone through all of the ‘betweens’ in the document. Where these relate to interactions among groups, for example in relation to collaboration, the ‘betweens’ have been changed to ‘amongs’.

b. I don't think the acronym 'CE' is defined before it is first used on page 12, line 25 ? I assume it means 'choice experiment'

A4b. Thank you for spotting this. CE does stand for ‘choice experiment’. However, we do not use this acronym again in the paper apart from in the titles of Tables 1 and 5. We have therefore changed these three ‘CEs’ to ‘choice experiment’ in the text.

Review 2
Comments

The article 'Identifying conflicts and opportunities for collaboration in the management of a wildlife resource: a mixed methods approach' represents a very exciting step in human dimensions of wildlife management, because it is focused on a critical problem (finding agreement among diverse stakeholders) using state of the art social sciences research methods. Too much ?human dimensions? research is conducted by natural scientists largely ignorant of social research methodology, and the present manuscript is a breath of fresh air in this regard. As someone who has worked on trying to find agreement among groups of people regarding a natural resource, I found the work presented to be extremely exciting - it will have a real impact on how I go about doing things in the future. My comments are few, and related primarily to increasing the clarity of some of the methodological steps which may be unfamiliar to readers of wildlife research.

Line 12 'deer' is repeated

A1. The extra 'deer' has now been removed – see page 2, line 12. Thank you for spotting this.

Pg 11 line 6 - it might be helpful to show examples of how the three different responses on the example card (Fig 2) would be coded - I'm finding it particularly difficult to visualize the ASC - I think the explanation here is correct, but given that an application of this sort to human choice (as opposed to habitat selection) might be unfamiliar to WR readers a bit of extra clarity would go a long ways.

We have re-worded this explanation of the mode structure to clarify it. The new text can be found on p. 11 line 3 – p. 11 line 10.

Pg 12 line 24+ Why were models up to 4 segments the only ones considered? Why not consider more? This affects your interpretation of what the 'optimal' number of segments is (see below), so your choice needs further justification.

A3. We have explained and justified our modelling approach more fully in the revised paper (p. 12 line 23 – p. 14 line 2). The emphasis of our work was on parsimony (following the approach of Birol et al. 2006). With 3 segments, there were already 14 parameters in the model. Using 5 or more segments would have led to further increases in the number of parameters, well beyond what we would consider to be a parsimonious model.

Pg 18 line 12 - this use of AIC/BIC is somewhat at odds with approaches commonly used in wildlife ecology (e.g. Burnham and Anderson 2002). Looking simultaneously at the whole set shows that a 4 segment model has the lowest AIC, and the evidence ratio between that model and the 2 segment model is on the order of 10^-16; even the 3 segment model is 3 million times less evidence in favor than the 4 segment model. Small differences in AIC represent large differences in the weight of evidence. Why were models up to 4 segments the only ones considered? Why not consider more? Eventually the AIC/BIC will start to increase again because of the large number of parameters.

A4. As stated in much of the choice experiment literature (Birol et al., 2006; Colombo et al., 2009) there is no set way of deciding on the appropriate number of segments in a latent class model. Most authors look for a significant reduction in AIC. In an effort to choose the most parsimonious model, we followed the method used in (Birol et al., 2006) where decreases in BIC and AIC were considered as well as the increase in pseudo-R^2 when selecting the optimal number of segments. The authors in this paper also, crucially, looked at the size of the changes in these statistics between models. Going by this method, we found that the two segment model provided the best fit as now stated in the paper – page 19, lines 10-18. Our methodology is now more fully explained in the paper – see also response to reviewer 1 above.

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