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RESEARCH ARTICLE

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The impact of uncertainty on cooperation intent in a conservation conflict

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Abstract

1. Stakeholder cooperation can be vital in managing conservation conflicts. Laboratory experiments show cooperation is less likely in the presence of uncertainty. Much less is known about how stakeholders in real-life conservation conflicts respond to different types of uncertainty.
2. We tested the effects of different sources of uncertainty on cooperative behaviour using a framed field experiment and interviews. The experiment compared a baseline scenario of perfect certainty with scenarios including either: (a) scientific uncertainty about the effectiveness of a conflict-reduction intervention; (b) administrative uncertainty about intervention funding; or (c) political uncertainty about the extent of community support. We applied these scenarios to a conservation conflict in the Outer Hebrides, Scotland, involving the management of geese to simultaneously meet both conservation and farming objectives. We asked 149 crofters (small-scale farmers) if they would commit to cooperate with others by helping fund a goose management plan given the three sources of uncertainty.
3. On average, intention to cooperate was highest (99%) in scenarios without uncertainty, and lowest under administrative uncertainty (77%). Scientific uncertainty and political uncertainty both had less of an effect, with over 95% of crofters predicted to be willing to cooperate in these scenarios. Crofters who indicated concern for other crofters suffering the impact of geese were more likely to cooperate. The longer an individual had been a crofter, the less likely they were to cooperate.
4. *Synthesis and applications*. Crofters' intention to cooperate is high but lessened by uncertainty, especially over the commitment from other stakeholders such as government, to cooperate on goose management. Existing cooperation on goose management may be at risk if uncertainty is not reduced outright or commitments between parties are not strengthened. This has wide applicability, supporting the need for researchers and government advisers to: (a) determine how uncertainty will impact intention of stakeholders to cooperate; and (b) take steps (such as

uncertainty reduction, communication or acceptance) to reduce the negative impact of uncertainty on cooperation.

KEYWORDS
conflict, conservation management, decision-making, experimental economics, goose, public goods game, uncertainty

1 | INTRODUCTION

Conflicts in conservation are ubiquitous around the globe and are damaging to both conservation efforts and people's lives (Redpath et al., 2013). Fostering cooperation between stakeholders with conflicting values is a priority of conservation conflict management as it builds trust and reduces conflict, both under experimental conditions and in real-life (Yamagishi, 2005; Young et al., 2016b). One important factor that reduces the chances of achieving cooperation in conflict is uncertainty, which will generally decrease the tendency to trust and cooperate (Rapoport, Sundali, & Seale, 1996). Rittel and Webber (1973) describe three broad sources of uncertainty in social ecological systems (SES): scientific uncertainty from incomplete knowledge of the research system; political uncertainty regarding power relationships and values; and administrative uncertainty surrounding cost and responsibilities.

Experimental economics methods have been used to test cooperation in collective-action problems (Cárdenas & Ostrom, 2004), including in the presence or absence of uncertainty. For example, Barrett and Dannenberg (2012) used laboratory experiments with volunteers to investigate decision-making in the context of climate change negotiations, showing that uncertainty of the position of an emission threshold resulted in lower cooperation than uncertainty surrounding the impacts of exceeding that threshold. However, volunteers in a laboratory setting will act differently to stakeholders in a real-world situation (Levitt & List, 2007). Working with stakeholders involved in a conservation conflict (rather than with volunteers) and framing the experiment in a way which reflects a real collective-action problem, allows real-life aspects of the conflict such as knowledge of the system, underlying values and perceptions of others, to be taken into account. Here, we use an experimental economics method to explore how three types of uncertainty (scientific uncertainty, administrative uncertainty and political uncertainty) influence the intention to cooperate, of people in a real-life conservation conflict.

Conservation conflicts involving the damage of crops by wildlife are widespread globally (Treves, Wallace, Naughton-Treves, & Morales, 2006). In Northern Europe, reduction of agricultural yield due to grazing of wild geese is a well-documented problem (Cusack et al., 2018; Simonsen, Tombre, & Madsen, 2017). Methods for reducing goose damage to crops include regulating population (e.g. shooting), non-lethal scaring or providing sacrificial feeding areas (Fox, Elmberg, Tombre, & Hessel, 2016). Stakeholders involved in a goose conflict can include those who: suffer directly from goose damage; wish to maintain the conservation status of the geese and their habitat; are responsible for scientific support of management; are required to fulfil practical management activities; and, provide funding or practical support. Mapping the specific stakeholders and uncertainties has been identified an important step in understanding the context for conservation conflict management (Redpath et al., 2013); however, less is known regarding how cooperative behaviour of stakeholders in a conflict is affected by different sources of uncertainty.

In this paper, we test how scientific, administrative and political uncertainties impact on stakeholders' willingness to cooperate on goose management in the Outer Hebrides, Scotland. Resident greylag goose (*Anser anser*) numbers have been increasing steadily from historic low points in the mid-twentieth century, to record highs. While this is seen by many as a conservation success story, the geese are responsible for damage to arable crops and to pasture intended for livestock. (Bainbridge, 2017; Mitchell, Griffin, Trinder, & Newth, 2010). The majority of agricultural activity in the Outer Hebrides takes place on crofts; small-scale farms of typically 5 ha, culturally unique to the more remote and less productive areas of the Highlands and Islands of Scotland. Crofting is regarded historically and legally as a distinct category of farming in Scotland and is recognised by the Scottish Government as being vital in maintaining the population of remote areas, supporting local businesses and managing important natural habitats (Scottish Government, 2016). Crofters (farmers of croft land) impacted by geese essentially take part in a form of public goods game, where they each choose whether to voluntarily contribute to the maintenance of a non-excludable, non-rivalrous public good (cooperate with goose management by contributing to scaring actions) or not (defect). Defection is less costly in the short term where benefits of the public good can be obtained without contribution (elsewhere called free-riding) but runs the risk of losing the benefits should enough others do the same.

Presenting crofters with a set of four public goods scenarios for goose management—a baseline with no uncertainty and three treatments with differing sources of uncertainty—we aimed to:

1. examine how crofters' intention to cooperate was influenced by different types of uncertainty
2. determine which variables (e.g. crofting location, time spent as a crofter, experiences of goose damage) were most important for describing cooperative behaviour.

2 | MATERIALS AND METHODS

2.1 | Study area

North Uist, Benbecula and South Uist (hereafter, the Uists), are part of the Outer Hebrides; an island chain off the northwest coast of Scotland, UK. The Uists provide year-round habitat for greylag geese which damage both arable crop and pasture (Bainbridge, 2017). Non-lethal goose scaring methods have limited success (Simonsen, Madsen, Tombre, & Nabe-Nielsen, 2016). Greylag geese can be legally shot during a winter open season (September to February). Out of season, geese can be shot under licence only.

Goose management efforts had been ongoing for over a decade, but in 2012, a new multi-stakeholder local goose management group (LGMG), funded by the Scottish Government was created in the Uists. Stakeholders include crofters, government, conservation organisations, croft owners and recreational wildfowl shooters (SNH, 2016). A 5-year adaptive management pilot was designed to test if shooting levels could be managed to decrease goose damage whilst maintaining the conservation status of the geese (SNH, 2016). The pilot uses a mixture of volunteer and paid shooters who spend several hours a day in designated areas, carrying out lethal and non-lethal scaring throughout August and September. The pilot covers areas on the western side of the Uists where the arable crops are grown and uses population modelling to determine annual shooting targets (SNH, 2016).

2.2 | Crofter recruitment and data collection

In August 2016, a list of all crofts in Uist (*N* = 1,579) was obtained (Registers of Scotland, 2016). Potential interviewees were sequentially approached down a randomised copy of the list, until the end of the data collection campaign in November 2016. This resulted in 149 crofters agreeing to be interviewed. We used face-to-face interviews to ensure crofters' understanding of the questions and to capture qualitative responses accurately. Information from crofters on themselves, their crofting and their experiences of goose impact was collected using a structured questionnaire, to allow statistical analyses on the data collected (Newing, 2011). For full recruitment, pilot and collection methods, see Supporting Information. Ethical approval for this study was granted by Biological and Environmental Sciences Ethical Review Committee, University of Stirling.

2.3 | Willingness to pay

Crofters were asked if they would be willing to pay (WTP) an annual fee along with other crofters, for a project which would completely mitigate all the negative impacts of the geese, using a contingent valuation technique (Pearce, Ece, & Özedemiroglu, 2002). Those who were unwilling to pay were asked to give reasons. The responses were then coded post-hoc using theoretical thematic analysis (Braun & Clarke, 2006). Those who responded that they would be WTP were then asked to indicate how much they would pay annually into a fund with other crofters for 100% mitigation of the negative goose impacts (hereafter, the WTP amount or C_{wtp}). The primary aim was to identify a WTP amount for each individual which could then be used in the subsequent cooperation scenario. This was done to account for individual differences in value placed on goose impact reduction. The stated WTP amount was then repeatedly used in each cooperation scenario (see below). Where crofters were WTP but could not specify an amount, the modal WTP amount identified during piloting (£50 per year) was used as C_{wtp}.

2.4 | Cooperation scenario

We presented crofters with four scenarios, each detailing a hypothetical goose management plan, using summary cards (see Figure S1). Crofters could choose to either support the plan (intention to cooperate), or not (intention to defect). Both choices incurred a cost to the crofter, a resulting reduction in goose impact, and a threshold number of crofters that would be required for the management plan to be enacted. This choice is akin to a public good game, where the crofter's payoff (a utility function made up of the sum of the level of goose impact and cost of joining a goose management plan) is dependent on their own course of action as well as the actions of others (to meet the threshold number required) (Table 1). The goose management plan outlined in the baseline scenario resulted in a decrease of negative goose impact (C_d) down to half the current impact levels. The WTP amount (C_{wtp}) previously stated by the crofter was for 100% reduction in negative goose impact. Therefore, the cost to each crofter (C_{mp}) of a management plan which achieved half that reduction as is the case in the baseline scenario, was $0.5C_{wtp}$. The management plan was presented as receiving partial payment from government funds equal to $0.25C_{wtp}$, so a cooperating crofter would receive a 50% reduction in goose impact for a $C_{mp} = 0.25C_{wtp}$. This resulted in a total payoff to the crofter of $C_d + C_{mp} = 0.5C_{wtp} + 0.25C_{wtp} = 0.75C_{wtp}$. However, the hypothetical management plan needed the number of crofters signing up (N_c) to be at least half of all the crofters in the Uists (N). If this threshold (N_c/N) was not reached, crofters did not pay anything ($C_{mp} = 0$) but there was no goose impact reduction ($C_d = C_{wtp}$), so total payoff is $C_d + C_{mp} = C_{wtp} + 0 = C_{wtp}$. Choosing to defect always set $C_{mp} = 0$. The crofter then suffered the full negative impact if the threshold was not reached (as above), or if the threshold was reached the crofter received the benefit of impact reduction without paying for the cost.

Three other scenarios were the same as the baseline, but each contained a single type of uncertainty (Table 1):

- The 'Scientific' scenario was described to crofters as representing managers' incomplete knowledge of goose ecology resulting in uncertainty to impact reduction, C_d.
- The 'Administrative' scenario was described as representing managers' incomplete knowledge of public funding for the management plan resulting in uncertainty to the cost of the plan to the crofter, C_{mp}.

TABLE 1 Crofter payoff (per year) matrices under four treatments of varied uncertainty. Here, payoffs are costs to the crofter, so rational behaviour seeks to minimise total costs under each treatment. Total cost to the crofter in bold, is the sum of the respective cost of management plan (C_{mp}) and the cost of the negative goose impacts (C_d). Table S2 shows a worked example

Scenario	Cooperation threshold	Cooperate		Defect	
Baseline	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**	$C_{mp} = 0$ $C_d = C_{wtp}$	**$= C_{wtp}$**
	$N_c \geq 0.5N$	$C_{mp} = 0.25C_{wtp}$ $C_d = 0.5C_{wtp}$	**$=0.75C_{wtp}$**	$C_{mp} = 0$ $C_d = 0.5C_{wtp}$	**$=0.5C_{wtp}$**
Scientific $D_{uc} = D_{low}$ or D_{high}, *where* $P(D_{low}) = P(D_{high}) = 0.5$	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**
	$N_c \geq 0.5N$	$C_{mp} = 0.25C_{wtp}$ $C_d = D_{uc}$	**$=0.25C_{wtp}+D_{uc}$**	$C_{mp} = 0$ $C_d = D_{uc}$	**$=D_{uc}$**
Administrative $C_{uc} = 0$ or C_{high}, *where* $P(0) = P(C_{high}) = 0.5$	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**
	$N_c \geq 0.5N$	$C_{mp} = C_{uc}$ $C_d = 0.5C_{wtp}$	**$=C_{uc} + 0.5C_{wtp}$**	$C_{mp} = 0$ $C_d = 0.5C_{wtp}$	**$=0.5C_{wtp}$**
Political $Th_{uc} = Th_{low}$ or Th_{high}, *where* $P(Th_{low}) = P(Th_{high}) = 0.5$	$N_c < Th_{uc}$	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**	$C_{mp} = 0$ $C_d = C_{wtp}$	**$=C_{wtp}$**
	$N_c \geq Th_{uc}$	$C_{mp} = 0.25C_{wtp}$ $C_d = 0.5C_{wtp}$	**$=0.75C_{wtp}$**	$C_{mp} = 0$ $C_d = 0.5C_{wtp}$	**$=0.5C_{wtp}$**

N_c, total number of crofters choosing "cooperate"; N, total population of crofters in the Uists; C_{mp}, cost of management plan; C_d, cost of negative goose impacts; C_{wtp}, crofter WTP to eliminate all current negative goose impact; C_{uc}, cost of management plan under uncertainty; $C_{high} = 0.5C_{wtp}$, high cost; D_{uc}, cost of negative goose impacts caused under uncertainty; $D_{low} = 0.25C_{wtp}$, low level of damage; $D_{high} = 0.75C_{wtp}$, high level of damage; Th_{uc}, threshold number of crofters choosing "cooperate" required for management plan to be enacted under uncertainty; $Th_{low} = 0.25N$, low threshold; $Th_{high} = 0.75N$, high threshold.

- The 'Political' scenario was described as representing managers' incomplete knowledge of how much support would be needed for the plan to be initiated, resulting in uncertainty to the threshold of cooperation required from crofters, Th_{uc}.

The baseline was always presented to crofters first, and the following three treatments were randomised. The fixed annual costs remain the same so as time increases, the average payoffs for all four scenarios become equivalent (Table S1). To evaluate the crofters' beliefs about how others would behave in the same scenario, we used a wager method. After each decision, crofters were asked to estimate what percentage of all the crofters in the Uists would cooperate, by splitting a hypothetical £20 wager between 20 equal cells each representing a 5% block of the population. For example, if the crofter thought that between 46% and 55% of others would cooperate, they would write '10' in each of the '46%–50%' and '51%–55%' cells. If the crofter felt they could not estimate or they felt there was an equal chance of all outcomes, they would write '1' in each of the 20 cells. A fixed wager allowed crofters to express confidence in their prediction, responding with the wager spread over a large or small range.

2.5 | Statistical analyses

To examine how uncertainty affects the intention to cooperate, as well as which background and impact experience characteristics most strongly predict intent to cooperate, we ran four linear mixed effects models. Analyses were focused on how intention to cooperate and WTP for goose management were influenced by three groups of variables. Firstly, the value a crofter places on cooperation may depend on their current situation including size of their croft, the extent of their crofting experience or their existing access to goose management support via the croft owner or LGMG. Secondly, intention to cooperate may stem from wanting to mitigate personal impacts of geese such as time and money costs. We also include variables to capture crofters wishing to mitigate goose impacts on their community or on natural habitats. Finally, crofters who are aware of existing goose management through formal organisations may support cooperation with other crofters, or conversely believe that responsibility lies elsewhere. The individual variables for each of the groups are shown Table 2.

Firstly, for each analysis a 'global' model was built containing the predictor and random variables thought relevant to that analysis. The function 'dredge' (R package MuMIn) was then used on the global models to build and rank models by finite-sample corrected Akaike information criteria values (AIC_c) calculated using maximum likelihood. No interactions between variables resulted in a better fitted model, according to AIC_c. Best-fitting models ($\Delta AIC_c < 2$) were retained and were then standardised by dividing the continuous fixed variables by two standard deviations allowing direct comparison of coefficients between continuous and binary variables (Gelman, 2008).

The area under the curve (AUC) of receiver operating characteristic (ROC) plots was calculated for all models with a binary output

TABLE 2 Variables measured for modelling intention to cooperate and willingness to pay for goose management. Not all predictor and random variables were included in all models

Groups of variables	Variables measured (units)
Crofting experience *Representing individuals' connection to crofting and access to support*	CE1: Time spent as a crofter (years) CE2: Area of crofting land (Hectares) CE3: Croft owner identity (North Uist Estate, Storas Uibhist community estate, Scottish Government or owner occupier) CE4: Township in Local Goose Management Group area (yes or no)
Impact of geese *Representing the range of direct impacts geese have on crofters*	IG1: Goose damage on their croft (yes or no) IG2: Incurring of financial costs due to crop loss (yes or no) IG3: Incurring of financial costs from scaring geese (yes or no) IG4: Incurring of time costs from scaring geese themselves (yes or no) IG5: Personal concern about damage to natural habitats by geese (yes or no) IG6: Personal concern about damage to other crofters' crops (yes or no) IG7: Damage suffered compared to other crofters in the Uists (less, similar, more or unsure)
Formal organisations *Representing engagement with formal groups involved in goose management*	FO1: Member of the Scottish Crofting Federation (yes or no) FO2: Awareness of the existing goose management plan (yes or no)
Random variables *Included to account for the structure of the data*	R1: Location of crofter (township) R2: Crofter identification (unique study identification number)

variable to assess the ability of each model to correctly discriminate between a randomly chosen positive response and a randomly chosen negative response. A value of 0.7 or greater was considered as having acceptable discriminatory ability (Sommerville, Milner-Gulland, Rahajaharison, & Jones, 2010).

All model analyses were done in RStudio version 1.0.136, running R version 3.1.2. and using R packages LME4 (Bates, Mächler, Bolker, & Walker, 2014), GLMMADMB (Bolker, Skaug, Magnusson, & Nielsen, 2012) and PROC (Robin et al., 2011).

2.6 | Intention to cooperate

Two global models were built to investigate intention to cooperate. The first willingness to pay (WTP) global model included all crofters, whereas the second only included those advancing to the cooperation scenario. Both models have a binary response variable (Cooperate/Defect), so we used generalised linear mixed effects models (GLMMs) with binomial error structure and a logit link. For predictor variables included in the WTP global model (see Table 2): CE1-4, IG1-6 and FO1-2. Following simplification of the first global model, only predictor variables which were significant in at least one of the best-fitting models were included in the global model for the cooperation scenario (CE1, CE4, IG3-4, IG6, FO1-2). Residential location (R1) was included as the random variable for both models, and unique identifier (R2) was included in the cooperation scenario model only, as it contained repeated measurements from individuals. The cooperation scenario model also included the study treatment predictor variable, uncertainty type (scientific, administrative, political or baseline/no uncertainty).

2.7 | Willingness to pay – amount

The WTP amount global model used the same predictor and random variables as the WTP global model above. The response variable was amount WTP in British Pounds. We used a zero-inflated mixed effects model with a negative binomial distribution, which accounts for the large difference between mean and variance of the responses and the high number of zeros in the data caused by those unwilling to cooperate (UTC; Zuur, Ieno, & Elphick, 2010).

2.8 | Perception of others' intention to cooperate

Predictor variables included in this global model were the same as for the cooperation scenario, with the addition of the measure of how crofters compared their own goose damage with that of others (Table 2, IG7) and a binary predictor (cooperate/defect) variable indicating if the crofter had chosen to cooperate themselves under the equivalent scenario. We again used GLMMs with binomial error structure and a logit link. Data were collected as a wager. Crofters readily engaged with this method, however responses were mostly constrained to a narrow numerical range, and models with continuous responses failed to converge. Consequently, we converted these data into a binary output. If the wager ≥£10 across the range 51%–100%, we recorded that the crofter believed that the threshold of Uist crofters required to initiate the goose management plan would be passed.

3 | RESULTS

All best fitted models had $\Delta AIC_c \leq 2$ (Tables S4–S7 for the output of all best fitted models). Results from the simplest (lowest number

TABLE 3 Standardised effect size of predictor variables on: intention to cooperate with other crofters on a cooperative goose management plan under different types of uncertainty (a) or with no uncertainty (b); amount willing to pay into a cooperative goose management plan (c); and crofters' prediction of others to cooperate (d). Outputs are from the simplest, best-fitting models. Effect sizes have been standardised *(p < 0.05); **(p < 0.01); ***(p < 0.001)

Predictor variable	(a) Cooperation scenario	(b) Willingness to pay	(c) Willingness to pay – amount	(d) Perception of others
Goose damage wrt Uist average				
Less damage				−3.16*
More damage				−3.82
Don't know				0.22
Membership of SCF				−2.54
Time as a crofter		−0.97*		
Cost of goose scaring (time)			0.78***	
Concern for others		1.30*	0.43*	
Uncertainty type				
Scientific	−3.20***			−1.84**
Administrative	−4.57***			−2.94***
Political	−2.10*			−1.76**
Individual cooperation				3.45***
Random effects included	Location; participant	Location	Location	Participant
Receiver operating characteristic; area under curve	0.96	0.72	NA	0.99

of predictor variables) of each best fitted model and predicted effect sizes are described below and in Tables 3 and 4. Population level data for each predictor variable used in the models can be seen in Supporting Information.

3.1 | Intention to cooperate

Most of the crofters who were interviewed (76.5%; 95% CI = 69.1%–82.6%) were WTP for goose management. Reasons for crofters being UTC are shown in Table 5. The most common reason under no uncertainty was that geese did not affect them enough. In the presence of each type of uncertainty, the most common reason given for UTC behaviour was the unsatisfactory risk of a worse outcome compared to the baseline scenario.

Crofters' concern for others and their time as crofters were the two significant predictor variables (Figure 1, Table 3). The longer an individual had been a crofter the lower the predicted probability of cooperation (e.g. 10 years of crofting P(coop) = 0.75; 50 years of crofting P(coop) = 0.51) and crofters who showed concern for others had a higher predicted probability of cooperation than those who did not (at mean time crofting (32 years), showing concern for others P(coop) = 0.86, no concern for others P(coop) = 0.63) (Table 4). Fixed effects accounted for 13% of total variation in the model but there was essentially no variation between locations (Table S4). There was no significant difference (assessed by AIC_c) between models with and without the random variable. The AUC of the ROC was 0.72.

Under all treatments of the cooperation scenario, most crofters were WTP for goose management. Under the uncertainty scenarios, type of uncertainty was the only significant predictor variable for intention to cooperate (Figure 1, Table 3). In the absence of uncertainty (baseline), predicted probability of cooperation was >0.98 (Table 4). The presence of each of the three types (scientific, administrative and political) significantly decreased the predicted probability of cooperation compared to the baseline. The greatest effect was seen in the administrative scenario (P(coop) = 0.77), followed by small but significant effects with scientific (P(coop) = 0.93) and political (P(coop) = 0.98) (Table 4). Fixed variables accounted for 26% of the total variation and variation due to random variables accounted for 44% (R_m^2 = 0.26, R_c^2 = 0.70). The AUC of the ROC for this model was 0.96.

3.2 | Willingness to pay – amount

The modal WTP amount was £50 per year and the mean £59.81 per year. Cost of goose scaring (time) and concern for others suffering damage were the two significant predictor variables for WTP amount (Figure 1, Table 3). A crofter who had not spent time scaring geese and was not concerned for others would pay £34.16 (Table 4), whereas those who had spent time scaring geese were WTP £73.98 and those indicating concern for others would pay £52.27. The model variance attributable to crofter location (random variable) was 0.13 (Table S4).

3.3 | Perception of others' intention to cooperate

Individual cooperation, type of uncertainty, membership of SCF and perceived relative level of goose damage (Figure 1, Table 3) were all significant predictor variables for perception of others' cooperation.

TABLE 4 Example model predictions to illustrate how combinations of significant predictor variables affect: Probability of intention to cooperate, P(coop) (models a, b and d) or willingness to pay amount, £ (model c). Only the simplest, best-fitting models are shown. All values in parentheses are 95% confidence intervals

Selected model structure	Model prediction
(a) Cooperation scenario	P(coop)
Baseline	0.98 (0.97–1.00)
+Scientific Uncertainty	0.93 (0.81–0.98)
+Administrative Uncertainty	0.77 (0.58–0.89)
+Political Uncertainty	0.98 (0.91–0.99)
(b) Willingness to pay	P(coop)
[a]32 years crofting − concern for others	0.63 (0.45–0.78)
[a]32 years crofting + concern for others	0.86 (0.78–0.92)
10 years crofting − concern for others	0.75 (0.45–0.92)
50 years crofting − concern for others	0.51 (0.10–0.91)
(c) Willingness to pay − Amount	Willingness to pay amount (£)
−cost of goose scaring − concern for others	34.16 (24.22–48.18)
−cost of goose scaring + concern for others	52.27 (31.60–86.48)
+cost of goose scaring − concern for others	73.98 (47.51–115.18)
(d) Perception of others	P(coop)
Goose damage wrt Uist	
[b]Baseline	0.93 (0.64–0.99)
−same damage + less damage	0.35 (0.11–0.71)
+Scientific Uncertainty	0.63 (0.34–0.85)
+Administrative Uncertainty	0.36 (0.16–0.65)
+Political Uncertainty	0.65 (0.35–0.86)
−Individual cooperation	0.10 (0.19–0.43)

[a]32 years is the mean time crofting. [b]Baseline model for comparison: Goose damage wrt Uist (same) - uncertainty + Individual cooperation - membership of the SCF.

Compared to a baseline (of individual cooperation, no uncertainty, no membership of SCF and a perceived average level of goose damage, P(coop) = 0.93), the presence of each type of uncertainty had a negative effect on predicted probability of cooperation (Table 4). Again, the greatest effect was seen with administrative uncertainty (P(coop) = 0.36), followed by scientific (P(coop) = 0.63), and then political (P(coop) = 0.65). Compared to the baseline model those who perceived they have suffered less than average damage were less likely to predict others as cooperating (P(coop) = 0.35). Having the perception of suffering more damage than others or a 'don't know' response had no significant impact, compared to those who had a perception of average damage. Compared to the baseline model, crofters who did not cooperate themselves were less likely to predict others would cooperate also (P(coop) = 0.10). Fixed variables account for 27% of the total variation and variation due to random variables accounted for 62% (R_m^2 = 0.27, R_c^2 = 0.88). The AUC of the ROC was 0.99.

4 | DISCUSSION

4.1 | How uncertainty affects crofters' intention to cooperate

When faced with a choice of discrete courses of action, people generally select those with lower uncertainty (Kahneman & Tversky, 1979; Lundhede, Jacobsen, Hanley, Strange, & Thorsen., 2015). This expectation is supported by our findings, with the presence of scientific uncertainty (from incomplete knowledge of the research system), administrative uncertainty (surrounding cost and responsibilities) and political uncertainty (regarding power relationships and values) each significantly decreasing the predicted probability of cooperation compared to a baseline scenario with no uncertainty.

Administrative uncertainty causes the largest decrease in terms of probability of cooperation. The administrative treatment was presented as uncertainty about whether public funding would be able to either pay all the cost of the management plan (thus, free for the crofter) or pay nothing towards the plan (doubling the cost to the crofter compared with other treatments). A view of shared responsibility was evident under the scenario of administrative uncertainty as the second most given reason for defecting was that others should contribute to goose management (Table 5). In this case, administrative uncertainty caused crofters to question the commitment of another stakeholder group, causing defection.

The negative effect of scientific uncertainty on probability of cooperation was small but statistically significant. Scientific uncertainty was framed as full enactment of management actions but with ecological uncertainty of how actions would affect the geese and the resulting level of damage caused. Here, defecting crofters did not mention other stakeholders (as with administrative uncertainty), so seemed to

TABLE 5 Reasons given by crofters for choosing not to cooperate in the willingness to pay (WTP) and in the three scenarios with uncertainty. n = 138 for WTP and 97 for the other three scenarios. Crofters were asked if they were WTP for goose management and if they indicated they would, then they were given four further choices (cooperation scenarios). The baseline treatment is not included in the table as there were no non-cooperation responses. Sum of percentages may be greater than 100% as crofters could give more than one reason

	Scenario type (number of non-cooperation responses)			
		Cooperation scenario		
Reason	WTP (34)	Scientific (13)	Admin. (29)	Political (7)
The issue doesn't affect me enough	12 (35.3%)	1 (7.7%)	3 (10.3%)	1 (14.3%)
I will be leaving crofting soon	7 (20.6%)			
Goose management is not possible	3 (8.8%)			
Non-crofting groups should (also) contribute funding	8 (23.5%)		12 (41.4%)	
Crofters should be individually responsible	4 (11.8%)			1 (14.3%)
Not enough other crofters will cooperate		2 (15.4%)	1 (3.4%)	3 (42.9%)
There is too much risk		9 (69.2%)	15 (51.7%)	3 (42.9%)
Uncertainty gives excuse for poor management		1 (7.7%)		1 (14.3%)

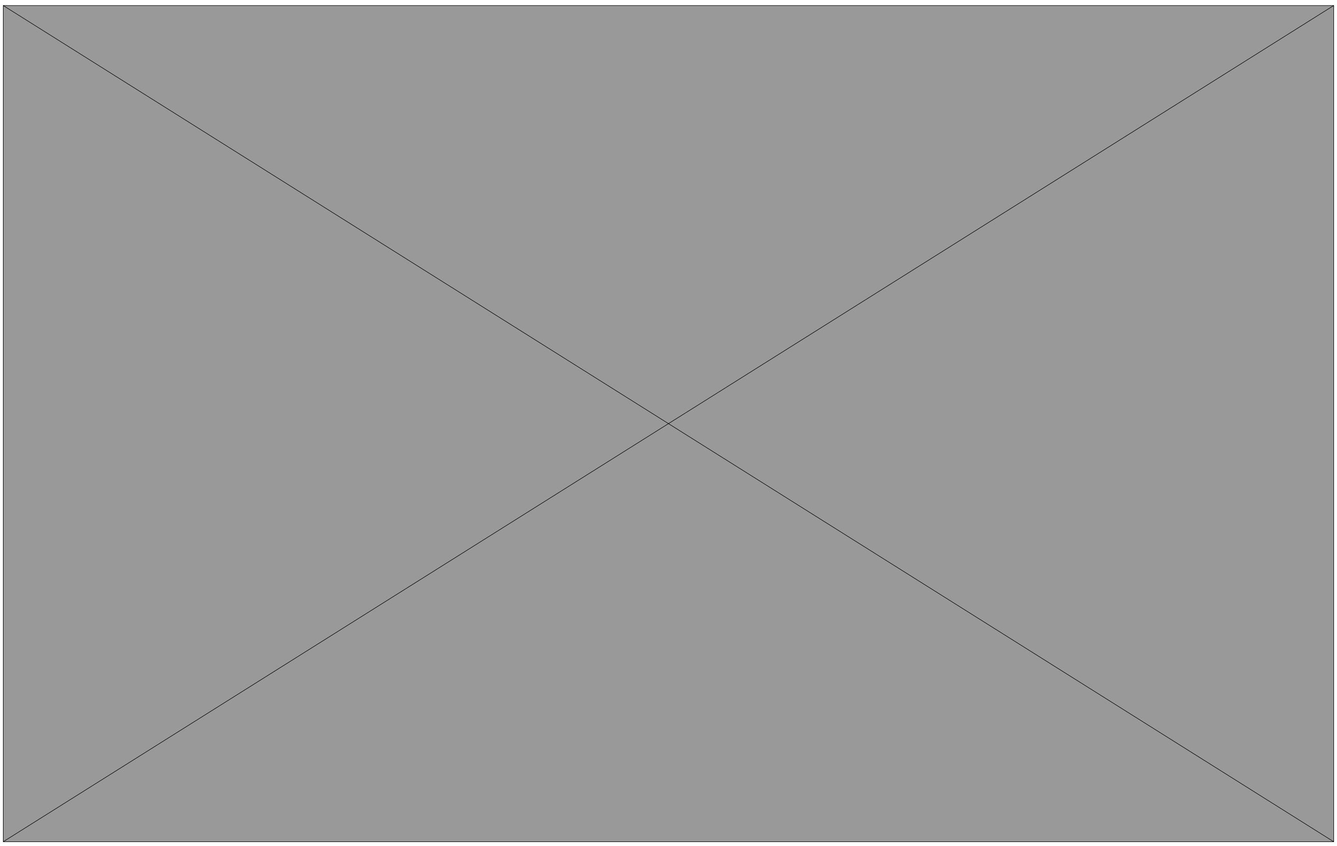

FIGURE 1 Standardised effect size (±95% confidence intervals) of predictor variables on: intention to cooperate with other crofters on a cooperative goose management plan under different types of uncertainty (a) or with no uncertainty (b); amount willing to pay into a cooperative goose management plan (c); and crofters' prediction of others to cooperate (d). Outputs are from the simplest, best-fitting models. Effect sizes have been standardised *(p < 0.05); **(p < 0.01); ***(p < 0.001). Full model outputs in Tables S3–S6, for plots a-d, respectively

be reacting to uncertainty directly (Table 3). In this scenario, general aversion to uncertainty may be contributing to much of the decrease in intention to cooperate (Lundhede et al., 2015).

Compared to the baseline scenario, the decrease in effect size under political uncertainty was very small but significant. The uncertainty in this scenario affected how many other people crofters thought might need to get involved, but also changed the conditions for accessing benefits without contribution. The small effect size means we cannot separate decreased probability of cooperation under political uncertainty from the general negative utility experienced from any type of uncertainty (Lundhede et al., 2015).

4.2 | Describing crofters' cooperative behaviour

Financial loss via goose damage was not a significant predictor variable for any model. Crofters were more likely to cooperate on a goose management plan and would pay more into such a plan when they indicated concern for others suffering from goose impacts. This pattern of cooperation would be expected if goose management payments were seen more as a charitable donation than self-serving (Park & Lee, 2015). The probability of cooperation decreased with increased time as a crofter. This result may be driven by crofters approaching retirement as 20% of crofters who chose to defect gave the reason that they were exiting crofting soon.

Many crofters chose to defect but not one crofter indicated that they were aiming to gain benefits without contributing. Crofters may not want to gain benefits this way because they see it as unfair, or they would not want to be seen as being unfair by their community. Small agricultural communities have strong reciprocal relationships between individuals (Sutherland & Burton, 2011), which can decrease behaviour perceived as unfair (Ostrom, 2010).

The mean WTP amount of £59.81 per year was similar to the £29.67 per year (£44.27, adjusted for inflation) which Hanley, MacMillan, Patterson, and Wright (2003) showed in a willingness to accept study for hypothetical goose population increase in Islay, Scotland. Those who have spent their own time scaring geese were WTP more into a cooperative goose management plan. Successful goose scaring is resource-intensive, as the geese repeatedly become accustomed to the methods used which then must be changed (Simonsen et al., 2016). Our results indicate that the opportunity costs associated with scaring geese are important enough to significantly increase WTP amount in the Uists.

4.3 | Predicting others behaviour

The largest predictor of whether crofters thought others would cooperate with each management scheme was their own preference to cooperate or defect. All types of uncertainty were also significant in the same direction and in the same rank order as with crofters' own choices. Individual crofters believed other crofters in the Uists would act similarly to themselves and did not indicate they thought others would attempt to gain benefits without contributing. Both these crofter predictions are consistent with the false consensus effect, where people project their own behaviour onto others (Ross, Greene, & House, 1977).

4.4 | Limitations of the method

The use of contingent valuation methods to accurately value goods and services has been criticised. For example, WTP suffers from hypothetical biases, differences between willingness to pay and willingness to accept values for similar goods, and assumptions about how goods may be embedded in one another (Hausman, 2012). Hypothetical bias can be reduced by offering payments based on decisions made in the experiment, but it can unrealistically incentivise individualistic behaviour (Vohs, Mead, & Goode, 2008). Using the WTP amount from this study would not be appropriate for costing of a Uist goose management funding scheme. Where good, independent, data are available for goose management costs, a discrete choice experiment between alternative management actions could elicit a more accurate value than our contingent valuation (Johnston et al., 2017). The WTP variables in our modelling did not include a measure of personal wealth or income, which may be expected to have a significant influence on WTP amount (Pearce et al., 2002). The aim of identifying an individual WTP amount for each crofter to use in the cooperation scenario was achieved with our method.

We focused on the predictor variables that significantly affect cooperation and on the difference between the treatments. However, people also tend to overestimate WTP amount when responding to scenario questions compared to real-life situations (Murphy, Allen, Stevens, & Weatherhead, 2005) and without social interaction people overestimate theirs and others' propensity to cooperate (Vlaev, 2012). Steps were taken to minimise biases of methodological origin, such as by discussing the scenarios in a neutral way. Crofters predicted that others would make very similar choices to themselves, which suggests any bias towards wanting to appear in a good light extended beyond themselves to promoting the community as a whole. Separating bias from the social norms which we are trying to study is an ongoing challenge in field studies such as this.

4.5 | Management implications of multiple system uncertainties

The three sources of uncertainty affected crofters' intention to cooperate in different ways. In the presence of administrative uncertainty, defecting crofters indicated that other groups should shoulder some of the burden caused by uncertainty. In the presence of scientific uncertainty, no actions by any other group were mentioned as being involved in crofter cooperation. In the presence of political uncertainty (and in general), cooperating crofters were confident that others would act like them and not try to gain benefits without contributing. Prior to management actions being developed, an important step is for managers to understand the societal dimensions of a conflict, including stakeholder roles and actions (Young et al., 2016a). Our study shows that managers should also include an assessment of how stakeholders' actions may change under different sources of uncertainty, especially if sources are associated with particular stakeholder groups.

Once relationships are better understood, steps can then be taken to cope with uncertainty. Firstly, uncertainty could be reduced by filling scientific research gaps such as the relative efficacy of scaring techniques or goose crop selectivity (Fox et al., 2016). But the application of increased ecological knowledge alone may have suboptimal impact on conflict if other types of uncertainty are not also addressed. Reducing reliance on uncertain external funding by increasing local fundraising may then decrease the administrative uncertainty which caused the greatest decrease in intention to cooperate. Secondly, in addition to technical solutions for uncertainty reduction, stakeholders should indicate a high level of commitment to the process (Hemmati, 2002). Longer-term partnerships between managers and scientists are advantageous (Moore, Pascoe, Thomas, & Keatley, 2017) and transparent communication of commitment could lessen the effect that associated uncertainties can have on intention to cooperate. Finally, embracing the inevitable uncertainty can bring positive benefits, such as opportunities for learning, increased stakeholder engagement and adaptability (Pe'er, Mihoub, Dislich, & Matsinos, 2014). Explicitly including multiple types of uncertainty in established participatory decision-making techniques (such as multi-criteria decision-making or scenario planning) may decrease the negative impact of uncertainty on levels of cooperation, even though the calculated level of uncertainty has not reduced (Mason et al., 2018).

Cooperation in the Uists over goose management has been established through formation of the multi-stakeholder LGMG and previous commitment to the 5-year adaptive management pilot. The current level of cooperation between stakeholders may be at risk if future goose management plans cannot reduce administrative uncertainty (for example, by securing funding) nor demonstrate commitment to the project (for example, by enshrining another multi-year plan).

5 | CONCLUSIONS

Our work illustrates the potential differences in stakeholders' response to uncertainty in the form of cooperation. Reducing scientific uncertainty, at which conservation practitioners are likely to be most skilled, may not be the most important gap to fill. Variation in behavioural response to uncertainty can be taken into account throughout the conflict management process to target the most effective ways to either preferentially reduce uncertainty itself or increase the acceptance of uncertainty amongst stakeholders. Both tactics mark a way forward to reducing the impacts that uncertainty can cause.

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AUTHORS' CONTRIBUTIONS

C.R.J.P., S.R., A.K., J.Y. and N.B. conceived the ideas and designed the methodology; C.R.J.P. collected and analysed the data and led the writing of the manuscript; L.F.B., A.K. and N.B. contributed advice on statistical analyses and modelling. All authors contributed critically to the drafts and gave final approval for publication.

DATA ACCESSIBILITY

The data used in this study are available via the Dryad Digital Repository https://doi.org/10.5061/dryad.gk44j56 (Pollard et al., 2019).

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