The role of social interactions in conservation conflict: goose management across Scotland

Chris Richard John Pollard

December 2018

A thesis submitted for the degree of

Doctor of Philosophy

Faculty of Natural Sciences

The University of Stirling

SUMMARY ABSTRACT

Increasing anthropogenic influence has left no corner of the natural world untouched. As the negative impacts of people on the natural world have become more prominent, pro-conservation actions have been incentivised across scales, from individual to societal to intergovernmental. Clashes over conservation objectives, when there is a perception that one party is asserting its interests at the expense of the other, is termed Conservation Conflict, and causes negative outcomes for biodiversity and people. Conservation conflicts are complex problems, the successful management of which can rarely be undertaken unilaterally, for both practical and ethical reasons. Finding the best ways for encouraging social interactions and cooperative behaviours are therefore vital in managing conservation conflict.

I take a conservation conflict surrounding the damaging of crops by hyper-abundant flocks of wild geese across Scotland as a case study to explore the roles of social interactions in conservation conflict. In Chapter 2 I start at the network scale by modelling the interactions between individuals and organisations involved in the goose conflict at two locations. I test the networks for the prevalence of particular sets of network configurations which represent individuals forming interactions in response to either a coordination problem (where solutions are sought and implemented efficiently to tackle an agreed goal) or to a cooperation problem (where goals are not shared, and for which solutions must be sought through negotiation). I find that interaction networks in both locations were formed in response to, and have the function to tackle, coordination problems. This is useful for dealing with coordination problems such as the practical management of geese. Interaction networks formed in response to, and having the function to tackle, cooperation problems were less prevalent. This presents a problem when collective problem solving requires negotiation, such as for managing conservation conflict. Networks at both locations would benefit from forming certain types of interactions to strengthen the network for future cooperation problems.

To effectively manage conservation conflicts in-depth knowledge of the cooperative behaviours of the people involved is required. In Chapter 3 I use stakeholder interviews, to investigate how and why individual members of three important stakeholder groups (farmers & crofters, conservation managers, and shooters) cooperated with one another and what barriers to cooperation they faced. I identify three dimensions of cooperation in the goose conflict: i) that the lack of horizontal interactions (between actors who interact with others at a similar organisational scale, for example farmers communicating with other farmers or conservation project managers communicating with other conservation project managers) and vertical interactions (between actors across different organisational scales, for example farmers communicating with farming union representatives, or conservation project managers communicating with senior management) linking widely distributed actors meant both shared learning and the perception of fairness suffer. Building up horizontal and vertical interactions could bypass these scientific and political barriers; ii) a false belief in uniformity among stakeholder groups can be the source of poor system understanding, which can be prevented by developing wider or alternative stakeholder representation; and iii) for long-term, complex issues, identification and discussion of trade-offs is needed to avoid poor outcomes throughout the process, not just at the planning stages.

Laboratory experiments with volunteers 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. In Chapter 4, I test the effect of different sources of uncertainty on cooperative behaviour using a framed field experiment and interviews with crofters in Scotland. The experiment compared a baseline scenario of perfect certainty with scenarios including either: i) scientific uncertainty about the effectiveness of a conflict-reduction intervention; ii) administrative uncertainty about intervention funding; or iii) political uncertainty about the extent of community support. I find that crofters' intention to cooperate is high but lessened by uncertainty, especially over the commitment from other stakeholders to cooperate on goose management. I conclude that existing cooperation on goose management may be at risk if uncertainty isn't reduced outright or if commitments between parties are not strengthened. To avert this issue researchers and government advisers need to: i) determine how uncertainty will impact intention of stakeholders to cooperate; and ii) take steps (such as uncertainty reduction, communication, or acceptance) to reduce the negative impact of uncertainty on cooperation.

In Chapter 5 I use the findings from Chapters 2 to 4 in conjunction with a conservation conflict management tool to evaluate goose conflict management in Scotland. I find many existing structures and processes of goose conflict management in Scotland were successful, but in order to build on these successes I propose several practical interventions. Increasing interactions between disparate groups; building data commons for shared learning; identification, acknowledgement, discussion and inclusion of trade-offs as they emerge; and making commitments to balance and fairness across the system. Enacting these recommendations would give goose conflict management in Scotland greater ability to deliver positive outcomes in what is a highly dynamic issue.

This thesis uses mixed methods to investigate the role of social interaction in conservation conflict. The work succeeds in both identifying interventions specific for managing the goose conflict in Scotland and developing the theory of social interactions and cooperation in conservation conflict management more widely.

DECLARATION OF AUTHORSHIP

I, Chris R J Pollard, declare that this thesis has been composed by myself and that it embodies the results of my own research. Where appropriate, I have acknowledged the nature and extent of the work carried out in collaboration with others.

Signed…………………………………………

Date……………………………………………

ACKNOWLEDGEMENTS

I would like to begin by thanking NERC and IAPETUS DTP for funding my PhD and therefore for all the amazing experiences I've had whilst conducting my research. Similarly, thanks to Scottish Natural Heritage for their CASE partnership of my research and all the support they've provided throughout.

The biggest thanks go to my vast supervisory team, Juliette Young, Steve Redpath, Des Thompson, Aidan Keane, and Luc Bussière – but particularly to my principal supervisor, Nils Bunnefeld. Thanks Nils, for the ideas and the advice, and for continually supporting me and pushing opportunities my way (despite my lack of concrete output for the first three years); it's been great fun and that's the key right? My thanks also go to Ryan McAllister and CSIRO for hosting my time in Brisbane, from where I came home with fresh research ideas and an outstanding tan.

During my research I've had the opportunity to meet with a great many people, unbelievably generous with their time and experiences. Thanks to those working for SNH, RSPB, SAC, NFUS and SCF. Thanks so much to Johanne Ferguson who hosted me in the South Uist SNH office for three months. My unending appreciation goes to the people of the Uists and Orkney who put up with my questions and fed me scones and tea. It's such a privilege to have spent time in your wonderful islands.

There's a long list of new and not-so-new friends from Stirling who have made my PhD years hilarious and who have helped me out in numerous practical, emotional, domestic, and nutritional ways. Robbie, Izzy & Giles, Emma & Andrew, Kirstie, Bekah & Tom, Jeremy & Rocio, Kenneth, Tom, and Andy - you are all amazing people. Thanks to Stirling BES and assorted folk therein, for being a great department in which to work.

More people who I have only met through my PhD and who I now count as good friends. Flora, Kayleigh, and Katie (and Mel & Sue?) from Uist. The folk in Brisbane – Rob and Simon at CSIRO for truly inter-disciplinary lunchtimes and of course

Lisa, Liam, Schillo (you Reds!), Phoebe, the rest of the Hoyman 2017 Championship-winning trivia team (my greatest academic achievement to date and always). Big thank you also to Rollo, whom I love dearly even though he shit in my bed. Rollo is a dog.

Thanks to James, Chris, the Collinses, the Frances, the Parkeses, the Hedleys, and Paul & Steph – time spent with you is rejuvenating and never long enough.

Finally, thank you to my family, who have supported me greatly throughout this PhD and in pretty much everything I've ever done. I'm trying to think of times in which you haven't been supportive – maybe I just don't tell you the really bad things. Mum & Dad, Tim & Shereen, Fleur, John, Wesley & Oscar, I love you all very much.

TABLE OF CONTENTS

FIGURES

TABLES

Chapter 1

General introduction

1.1 CONSERVATION CONFLICT

1.1.1 What is conservation conflict?

Conservation conflict is defined by Redpath et al. (2013) as 'situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another.' The first part of the definition specifies conservation conflict occurs *regarding* wildlife, but *between* people. This differentiates conservation conflict from 'human-wildlife conflict' which occurs when the needs and actions of wildlife impact negatively on humans, or vice versa (Madden 2004; Woodroffe et al. 2005). Human-wildlife conflict is similar to the earlier concept of 'animal damage' (Conover 2001) where people suffer negative consequences from living with wildlife, but human-wildlife conflict repositions wildlife as an actor consciously in opposition to humans (Peterson et al. 2010). This can lead to people directing anger and frustration onto wildlife, allowing those who advocate on wildlife's behalf to be portrayed as rational representatives rather than individuals driven by values and subjectivity themselves (Peterson et al. 2010). By re-establishing the framing to have people embedded within an ecological system, conservation conflict concentrates on interactions between people, leaving 'biodiversity impacts' to describe the outcomes of human-biodiversity interactions (Young et al. 2010; White et al. 2009). The second part of the definition of conservation conflict, the requirement for a perception of one party asserting their interests at the other's expense, builds on the concept that all people involved in a conflict are driven by attitudes and values. It is a threat or imposition to these values which turns a disagreement into a conflict (Redpath et al. 2013).

1.1.2 The impacts of conservation conflict

Human pressure on the environment is unsustainable at current or even much reduced levels (Arrow et al. 1995). The global conservation response has led to increased incentives for governments and society to undertake pro-conservation actions, for example under the umbrellas of the UN Sustainable Development Goals (United Nations 2018) and the Intergovernmental Panel on Biodiversity and Ecosystem Services (Díaz et al. 2015). This has resulted in a tension between building social foundations for living a good life (such as social equality, clean water, food security, peace, and livelihoods) and limiting processes which cross planetary boundaries (such as biodiversity loss, climate change, and land conversion) (Raworth 2017). Conservation conflicts are the symptoms of these social-environmental tensions: legally protected Indian elephants damage crops and cause loss of life (Gubbi 2012), local people in Tanzania lack formal rights to sustainably access resources in protected areas, worsening livelihood insecurity (Vedeld et al. 2012), and active forest restoration in Latin America can cause net losses in tourism and livestock production revenue (Birch et al. 2010). Conservation conflicts negatively pervade all these social and environmental dimensions as well as being taxonomically (e.g. Johnson et al. 2015; Woodroffe & Redpath 2015; Simmonds & Brown 2010) and geographically (e.g. Woodroffe et al. 2005; Nyhus 2016; Lemly et al. 2000) widespread. Conflicts can have positive effects such as increased dialogue and creative problem solving (Young et al. 2010), but their severity and ubiquity present a major challenge in conservation science and practice (Redpath et al. 2015).

1.1.3 Types of conservation conflict

Conservation conflict is a social-ecological example of a wicked problem (Redpath et al. 2015; Mason, Pollard et al. 2018); an intractable issue emergent from a complex system, which is hard to define, and lacks clear solutions (Rittel & Webber 1973). The characteristics of a complex social-ecological system include non-linear dynamics with thresholds, multiple feedback loops, time lags, resilience, heterogeneity, and high levels and multiple sources of uncertainty (Liu et al. 2007). Conservation conflicts are thus hard to type based on their underlying cause, as they change and evolve over time. However, six broad categories of conflict have been outlined (Jones et al. 2005; Young et al. 2010) (Table 1). Conflicts will often overlap between several categories at any given time.

Table 1 - Typology of conservation conflict, adapted from Jones et al. (2005) and Young et al. (2010). Actors can be people, groups or organisations.

Category	**Source of conflict**
Conflict of interest	Actors want different things from the same habitat or system
Beliefs & values	Actors hold different normative perceptions on the value or use of wildlife
Process	Actors approach a problem favouring different methods
Information	Knowledge is missing, uncertain or perceived differently by different actors
Social structure	Actors interact within social, legal, economic and political arrangements, which harbour latent problems of their own
Interpersonal	Individual actors or groups have personal differences with one another, such as issues with trust or communication

1.1.4 Tackling conflicts and impacts

As conservation conflict is distinct from biodiversity impacts, so approaches to their respective management differ also. Management of biodiversity impacts focusses on technical fixes to reduce the incidence or intensity of impact, for instance scaring geese from crops (Simonsen et al. 2016), fencing elephants out of agriculture (King et al. 2017), culling badgers to prevent the spread of disease (Donnelly et al. 2006) and removal of an invasive seagrass (Lubell et al. 2017). Alternatively or additionally, compensatory instruments can be used to offset impacts on people (Nyhus et al. 2005, e.g. McKenzie 2014; Ogra & Badola 2008). The success of technical and compensatory methods may be limited for addressing conservation conflict as they do not confront the roots of underlying complexity (Table 1) (Young et al. 2010; Redpath et al. 2015). Overreliance on technical and compensatory approaches can lead to continuation or exacerbation of the conflict (Young et al. 2010; DeFries & Nagendra 2017).

1.1.5 Mapping and managing conflict

To tackle conservation conflict, rather than just biodiversity impacts, Redpath et al. (2013) proposed an iterative roadmap. Activities along the roadmap are split into mapping the conflict and managing the conflict, both of which rely on an interdisciplinary set of skills required to navigate the inherent complexity (Dickman 2010; Pooley et al. 2017). Mapping the conflict is about building an accurate picture of the situation, starting with the identity, circumstances, values, and goals, of stakeholders. Then, to provide the context in which stakeholders live and operate, ecological, political, economic and sociological data are gathered, including data gaps and uncertainties (Redpath et al. 2013).

Managing the conflict is about developing and implementing a mechanism for stakeholders to identify and test potential solutions. If a party has the power to develop and implement actions without inclusion of all stakeholders, the result can be top-down solutions imposed upon others (Reed & Sidoli Del Ceno 2015; Redpath et al. 2015; Kahane 2017). However, the more complex a problem the less likely it is that unilateral solutions exist, and the more likely that cooperation rather than imposition will result in more positive progress (Henmati 2002; Kahane 2017). A multi-stakeholder, participatory approach (MSPA) for managing complex conservation problems, which often involve conflict, uses cooperation rather than imposition to make progress (Henmati 2002; Kahane 2017). MSPAs enhance conservation conflict management by including diversity of viewpoints, increasing trust, generating shared learning, developing networks for future cooperation, and increasing perceived fairness (Henmati 2002; Reed 2008; Balint et al. 2011; Young, Jordan, R. Searle, et al. 2013; Bodin 2017). But no process is a panacea for complex social-ecological problems (Ostrom et al. 2007); MSPAs demand a high level of social resources (time, funding, and commitment) and as such can be easily derailed (Reed 2008; Balint et al. 2011; Young, Searle, et al. 2016). The conflict may be so severe that an MSPA is not possible (Henmati 2002). MSPAs having been shown to build cooperation during conservation conflict (Dickman 2010). For example, an MSPA including fishers, wildlife tourism operators, scientists and government cooperated to resolve a conflict surrounding the predation of commercially important salmon by seals in Scotland (Butler et al. 2015). Despite this, there remains a need to better recognise, understand and stimulate cooperative behaviours between stakeholders.

1.2 COOPERATION IN CONSERVATION CONFLICT

1.2.1 Cooperative behaviours

Cooperative behaviours include sharing information, exploring others' interests, needs and perspectives, working together on a problem, and actively seeking win/win solutions. Conversely, withholding information, arguing from fixed positions, attacking others' positions, and actively seeking purely self-winning solutions are adversarial behaviours (Pound 2015). Cooperation to tackle a complex problem requires individuals adopting cooperative behaviours on a scale to match the issue.

At the actor scale, researchers can simplify these behaviours into strategic 'cooperate or defect' behaviours. Analysis of these data via game theory has been suggested as a means to understand social interactions in conservation conflict (Frank & Sarkar 2010; Colyvan et al. 2011) and as a way to potentially identify win-win solutions (Redpath et al. 2013). Experimental economics can be used to test game theoretical predictions about cooperative behaviour in social-ecological systems. For example, Barrett & Dannenberg (2012) used volunteers in lab experiments to investigate decision making in the context of climate change negotiations, showing how uncertainty of the position of a carbon emission threshold resulted in less cooperation than uncertainty surrounding the impacts of exceeding that threshold. In the field Travers et al. (2011) played a game with stakeholders in Cambodia, showing how treatments that promoted cooperation between players through self-organisation had the greatest effect in reducing individual extraction of a valuable common-pool resource. These research methods are highly sensitive to experimental design and can be limited in their external validity (Redpath, et al. 2018), so richer data on the test system are required to draw system-wide conclusions.

At the system scale, social interactions between multiple pairs of actors combine to form network level structures. Networks have been used to study cooperation of orangutan conservation organisations in Borneo (Morgans et al. 2017), cross-scale cooperation of actors in a large-scale conservation restoration project in Australia (Guerrero et al. 2015), and to unpick the links between actors who hold opposing views in a hunting conflict in Malta (Veríssimo & Campbell 2015). The structure of a social interaction network can impact how well its actors can tackle certain types of problems (Berardo & Scholz 2010; Lubell et al. 2012). For instance, 'coordination problems' which are characterised by multiple actors holding broadly shared or non-competing goals, require efficient organisation of activities and rapid sharing of trusted information can be best approached by sparse networks, with well-connected central hubs (Figure 1 A). Whereas 'cooperation problems', characterised by actors with opposing or competing goals, require deliberation, negotiation, and the checking of unreliable information and actors, are better approached by dense networks, with many shared interactions (Figure 1 B) (Berardo & Scholz 2010). Interactions which directly link two actors who are otherwise already linked via one or more other actors, are known as 'redundant' interactions. Managing biodiversity impacts is more akin to a coordination problem with shared actor goals, whereas conservation conflict management is a cooperation problem of competing actor goals. A major challenge in collaborative conservation management is how to form and maintain networks which can simultaneously tackle complex cooperation problems and complete efficient coordination of relatively simple tasks (Bodin 2017). Due to its complexity, conservation conflict is highly context specific (White et al. 2009). To gain new understanding of cooperative behaviours at network scale and between individuals, compiling a detailed case study of a conservation conflict is required.

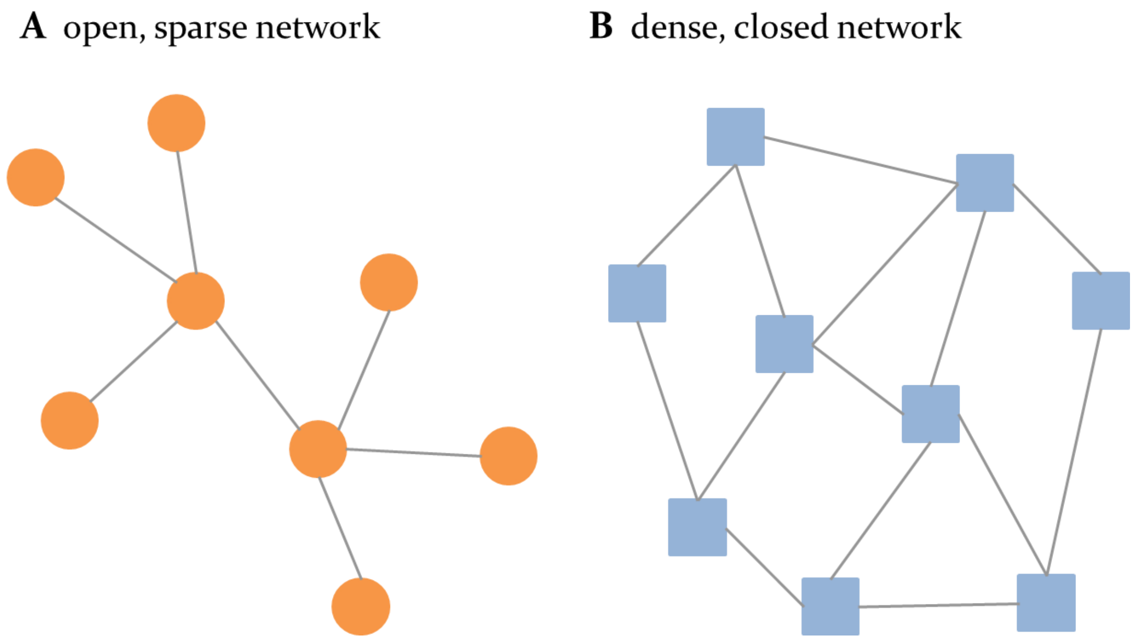


Figure 1 - Example network structures, show a sparse, open network with centralised hubs (A), and a dense closed network with many redundant links (B)

1.3 A CASE STUDY IN CONSERVATION CONFLICT MANAGEMENT: GOOSE CONFLICT IN SCOTLAND

1.3.1 The impacts & management of hyper-abundant geese

Wild goose populations are the source of a range of ecosystem services and disservices (Buij et al. 2017). Cultural services benefiting birdwatchers, conservationists, wildfowl hunters, and researchers are traded-off with provisioning disservices of crop damage for which they are regarded by farmers as a pest (Buij et al. 2017). Disagreements about how service and disservice trade-offs are managed can cause conservation conflict (Ceaușu et al. 2018). Goose population recoveries to hyper-abundance in Europe and North America are applauded as conservation success stories of habitat management and legislation, although much of the increase is attributable to abundant anthropogenic food sources and recent warming of breeding grounds due to climate change (Fox et al. 2017; Mason, Keane et al. 2018).

Some hyper-abundant populations are now viewed as too large (Lefebvre et al. 2017; Fox & Madsen 2017; Anderson et al. 2018). In Canada and the U.S. the greater snow goose *Anser caerulescens atlanticus* population grew from 3000 individuals in the early twentieth century to over 700,000 in the 1990s, with the resulting overpopulation responsible for habitat degradation in autumn and spring staging posts and damage to crops in both countries (Lefebvre et al. 2017). In Scandinavia and the Low Countries, the Svalbard population of pink-footed goose *Anser brachyrhynchus* increased at a rate of 3.6% per annum between 1965 and 2013, to reach 76,000. The large and growing population was degrading vulnerable tundra vegetation in the breeding grounds of Svalbard and causing conflict via crop damage in Norway (Madsen, et al. 2017; Fox & Madsen 2017).

There are four main tactics to manage geese and their impacts (reviewed by Fox et al. (2017)): population management, scaring, provision of alternative feeding areas, and payment of compensation to farmers. Population management requires coordinated shooting at an organisational level appropriate to the goose population (local, regional, national, international) and takes the form of culls (e.g. greylag geese in Scotland (Bainbridge 2017)) or changes in seasonal hunting (bag) limits (e.g. snow geese in North America (Lefebvre et al. 2017)). Scaring of geese through visual and / or audible stimuli is conducted to move geese away from crops. Efforts to scare geese are usually carried out by impacted individuals at the farm level, rather than via larger scale coordination. At the landscape scale, benefits accrued from individuals scaring geese become non-excludable, and people are impacted beyond the individual farm level as goose populations change in size and location (Zhang et al. 2007). Alternative feeding areas involve planting or maintenance of food sources more preferable to the geese than the crops to be protected (e.g. maintenance of high quality grassland for Greenland barnacle geese in Islay (McKenzie & Shaw 2017)). This requires agreement by people on whose land the geese are feeding, and can include compensation (McKenzie & Shaw 2017). Compensating farmers for lost crops (as opposed to provision of alternative feeding areas) has been effective in reducing economic impacts of goose damage (e.g. Svalbard pink-footed geese in Norway (Tombre et al. 2013a)). However, long-term payments, especially if they rise as goose populations continue to grow, maybe politically unpopular or economically impossible to maintain (Fox et al. 2017). None of these methods for decreasing the negative impacts of hyper-abundant geese can be successfully applied unilaterally, as even a single farmer scaring geese from their crops is affecting and affected by their neighbours.

1.3.2 Goose management in Scotland

In Scotland the impacts on agriculture of rising numbers of two goose species, Greenland barnacle geese *Branta leucopsis* and British greylag geese *Anser anser* resulted in the formation of the National Goose Forum by Scottish Government in 1997, subsequently replaced by the National Goose Management Review Group (NGMRG) in 2001. The NGMRG remains the national level body for goose issues in Scotland and includes representatives of Scottish Government, conservation organisations, shooting interests, and farming and crofting interests. Crofts are small-scale farms of typically 5 ha, culturally unique to the more remote and less productive areas of the Highlands and Islands of Scotland and legally distinct from farming at a more commercial scale. The multi-stakeholder NGMRG has three shared objectives: meet the UK's nature conservation obligations for geese, within the context of wider biodiversity objectives; minimise economic losses experienced by farmers and crofters as a result of the presence of geese; and maximise the value for money of public expenditure (Crabtree et al. 2010). The NGMRG receives scientific and technical guidance from the Goose Science Advisory Group (GSAG).

The NGMRG, aware of the importance of local context for goose management, distributed decision-making and responsibility to specially formed Local Goose Management Review Groups (LGMGs, Figure 2), which were responsible for implementing the NGMRG objectives in their respective contexts. Each LGMG is funded by Scottish Government and coordinated by the local Scottish Natural Heritage (SNH) office along with representatives from local stakeholder groups; mainly Scottish Government, conservation organisations, farmers and crofters, and wildfowl shooters. LGMGs construct their own schemes by blending methods to manage geese and their impacts, such as population reduction, scaring, and farmer payments for goose feeding areas. All LGMGs use annual goose counts and harvest data to model goose populations and set future targets for shooting.

Barnacle geese on Islay

The Greenland population of barnacle geese, overwintering in Islay, have increased from c. 3000 in 1952 to a peak of 46,000 in 2016, with agricultural damage increasing greatly in the past 20 years (WWT 2017; McKenzie & Shaw 2017). Greenland barnacle geese are Annex 1 listed under Article 9 of the EC Birds Directive, requiring member states to take measures to ensure survival of the species and prohibiting hunting unless under specific circumstances. Management in Islay involves scaring, population reduction, designated refuge areas, and payments to farmers for sacrificial land (Figure 2, Mckenzie 2014; McKenzie & Shaw 2017). Conservation NGOs Royal Society for the Protection of Birds (RSPB) and Wildfowl & Wetlands Trust (WWT) jointly lodged a complaint to the European Commission in contest to the population reduction of barnacle geese on

Islay (RSPB Scotland & WWT 2015) and withdrew their representatives from the NGMRG (Scottish Natural Heritage 2015). Local RSPB representatives are still involved in LGMGs at some locations. Payments to farmers account for £0.9m of the annual £1.6m goose management programme on Islay (Figure 2). The current Islay Sustainable Goose Management Strategy began in 2014 and runs until 2024 (McKenzie 2014).

Greylag geese across Scotland

There are several breeding populations of native greylag geese at year-round locations in Scotland. Greylag geese have recovered from c. 500 breeding birds in the 1930s which were mostly restricted to the Outer Hebrides, to breed at various locations totalling c. 40,000 (Mitchell et al. 2012; Bainbridge 2017). A number of local greylag populations of 1,000 – 25,000 have caused damage to standing crops during the spring and summer growing season and to pasture intended for livestock throughout the year (Crabtree et al. 2010). Greylag geese are amber listed in the UK due to breeding localisation, but are classified by IUCN as Least Concern globally (Eaton et al. 2015; IUCN 2016). All birds in the UK are protected by law while nesting, and greylag geese are named in assessments of protected areas such as the South Uist Machair and Lochs RAMSAR site in the Uists, meaning the Scottish government have a responsibility to maintain breeding populations of the species locally (Scottish Government, 2019). Conversely, several UK wildfowl species including greylag goose are legally hunted during the winter open season (September to February). Agricultural damage caused by British greylag geese has resulted in four adaptive management pilot schemes in the Orkney Islands, the Uists, Harris & Lewis, and Coll & Tiree (Figure 2). Adaptive management is an iterative method of testing and monitoring management options to guide future decision making (McCarthy & Possingham 2007). Each pilot scheme allows additional hunting periods for controlled population reduction outwith the open season, carried out by volunteers and or paid shooters. No payments are made to farmers for sacrificial land in any of the adaptive management pilots, unlike the case in Islay (Figure 2)

1.3.3 Current status of goose conflict management in Scotland

Management of geese in Scotland has key elements of conservation conflict management (Crabtree et al. 2010): National and local level participatory multi-stakeholder processes are in place, using formally agreed and shared goals to implement goose management actions (Reed & Sidoli Del Ceno 2015); actions are knowledge-based using scientific methods (e.g. population modelling) together with local experience to mould best-practice strategies to the local context (Young, Searle, et al. 2016); and adaptive management allows for flexibility of practice from year to year, and the freedom to test novel ideas (McCarthy & Possingham 2007).

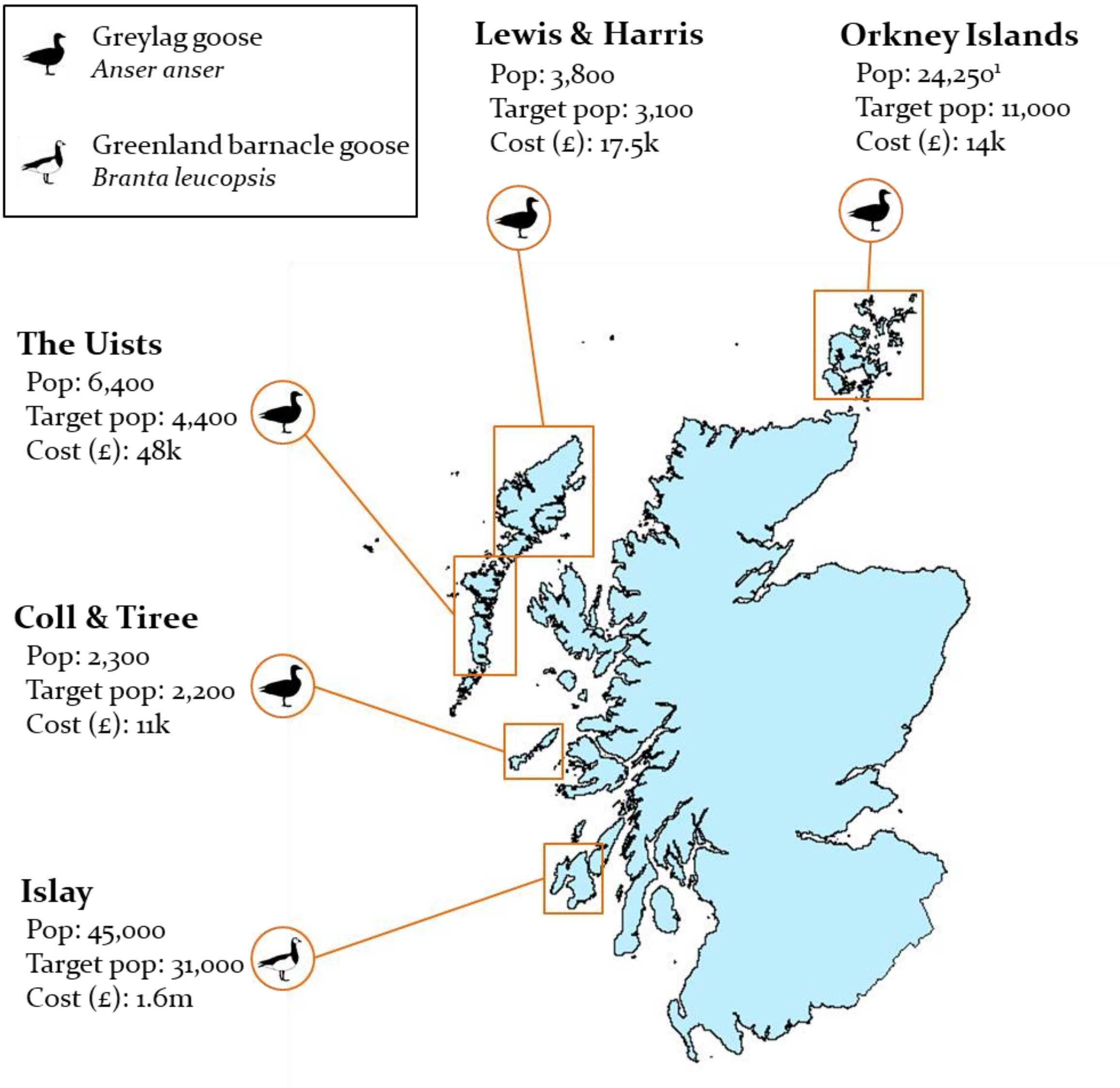


Figure 2 - Locations of goose conflict in Scotland. Label at each location shows species of goose for which the Local Goose Management Group LGMG is responsible for controlling. Greylag geese are resident, Greenland barnacle geese are overwintering migrants. Pop: goose population in 2016, Target pop: maximum value of the target population range in the respective LGMG plan, Cost: cost in £GBP allocated for 2016 (2014 for Islay). [1]Greylag goose population in Orkney increases to over 75,000 from November to February due to overwintering migrants. References: Islay (McKenzie 2014; WWT 2017), Coll & Tiree (SNH 2016), The Uists (Ferguson 2016), Lewis & Harris (MacFarlane 2016), Orkney Islands (Mitchell et al. 2016; Churchill 2016). Goose silhouettes produced by Tom Mason.

However, the conflict stubbornly persists. Lethal management of Greenland barnacle geese in Islay is still under legal challenge (RSPB Scotland & WWT 2015), and conservationists criticise the management project in the media for cruel shooting methods based on 'fundamentally flawed' science (Edwards 2018). In the Uists, community leaders use the media to hit out at goose managers for lack of funding (Howarth 2018), comparing the funding they receive (£48k (Ferguson 2016)) unfavourably with that of the Islay goose project (£1.6m (McKenzie 2014)).

Thus, goose conflict in Scotland as a case study is mature but still changing, with a high level of experience and knowledge available for analysis, and many years of forming and breaking collaborations between and within stakeholder groups.

1.4 THESIS AIMS

In this thesis I aim to assess the role of social interactions between actors in goose conservation conflict in Scotland. I will produce applied recommendations for managers and advance the understanding of the structures and processes of conservation conflict management more widely.

Chapter 2: Social network analysis of interactions between individual and organisational actors in two Scottish goose conflicts

Here, I use network modelling to see how the accumulation of interactions between individuals and organisations involved in the goose conflict shapes network scale function. I look to see if individuals are forming interactions in response to coordination and or cooperation problems, and how certain groups (e.g. organisations perceived as important), influence the formation of interactions.

Chapter 3: Understanding cooperation in conflict: learning from goose management in Scotland

In Chapter 3, I explore the circumstances, actions and goals of the three main stakeholder groups in the conflict: conservation managers, shooters, and farmers & crofters. Using a framework for understanding strategic interactions populated with detailed interview data, I ask how and why individuals cooperate towards management of the conflict and what they perceive as barriers to cooperation.

Chapter 4: The impact of uncertainty on cooperation intent in a conservation conflict

I examine how three realistic sources of uncertainty, that pertaining to scientific, administrative or political knowledge, impact cooperation. Using a game theory derived experimental economics scenario, I see how intention to cooperate between individual crofters' in the Uists is influenced by each type of uncertainty and what individual crofter characteristics are most important for describing cooperative behaviour.

Chapter 5: How do we successfully manage goose conflict?

Finally, I distil learning from Chapters 2, 3 and 4, through a conflict management tool to produce a set of policy interventions for building cooperation and preparing goose conflict management in Scotland for future surprises.

Chapter 2

Social network analysis of interactions between individual and organisational actors in two Scottish goose conflicts

Chris Pollard, Steve Redpath, Aidan Keane, Juliette Young and Nils Bunnefeld conceived the ideas and designed the methodology. CP collected the data with Kirsten Brewster. CP analysed the data and wrote the Chapter. Ryan McAllister contributed technical advice on network modelling. Drafts of the Chapter were commented on by SR, AK, JY, NB, RM, and Luc Bussière.

2.1 ABSTRACT

The pattern of interactions between actors in a policy network: i) reflects the type of problems faced by members of the network, and ii) regulates its function to tackle these problems, including conservation conflict.

We modelled policy networks to test for the prevalence of network configurations indicative of social processes associated with collective problem solving. Open / sparse network configurations represent a response to a coordination problem, where solutions are sought and implemented efficiently to tackle an agreed goal, whereas closed / dense network configurations represent a response to a cooperation problem, where goals are not shared, and for which solutions must be sought through negotiation. Network configurations indicative of each type of problem are not mutually exclusive, and can occur together in the same network. We interviewed 46 individuals involved in a conservation conflict surrounding the management of geese at two locations in Scotland, to determine their interactions with stakeholder organisations.

Networks at both locations showed significant overrepresentation of configurations indicative of individuals' responding to coordination problems. Additionally, network configurations indicative of individuals' responding to cooperation problems were significantly overrepresented at one location (to a lesser extent than the coordination configurations) but not at the other location. Interactions between individuals and organisations which were both members of the formal local goose management group (LGMG) were not significantly under- or overrepresented. Organisations in the group were perceived as significantly more important in managing geese by individuals at both locations, and at one location, perceived importance was a significant predictor for the formation of interactions between individuals and organisations.

Interaction networks in both locations were formed in response to, and have the function to tackle, coordination problems such as the practical management of geese. Interaction networks formed in response to, and having the function to tackle, cooperation problems were less prevalent. This may be a problem if

collective problem-solving requires negotiation, such as for managing conservation conflict. Networks at both locations would benefit from increasing interactions between individuals and organisations. This would prepare the network for future cooperation problems while additionally increasing creativity and knowledge sharing.

2.2 INTRODUCTION

Conservation conflicts occur where two or more actors with strongly held views clash over conservation management objectives and one actor is perceived to assert its interests at the expense of the other (Redpath et al. 2013). These typically wicked problems are widespread and damaging to conservation work and to the lives of people concerned. Ongoing efforts to develop conservation conflict management using social collaborative processes have yielded positive results (Dickman 2010; Colyvan et al. 2011; Butler et al. 2015; Fedreheim & Blanco 2017), although collaboration in the presence of large power disparities can result in tokenism (Redpath et al. 2015). Collaborative conflict management involves multiple actors working together to find and enact new ways of tackling issues, even though their respective objectives may be at odds. For example, a conflict surrounding the predation of commercially important salmon by seals in Scotland, was successfully resolved by engaging fishers, wildlife tourism operators, scientists and government in a multi-stakeholder process (Butler et al. 2015). The study of processes that regulate interactions between multiple actors is expanding rapidly in conservation science (Groce et al. 2018), but is underused in conservation conflict research.

For any given conservation problem there exists a range of actors whose perspectives each contribute to or undermine the functioning of collaborative efforts. These actors can include organisations such as residential communities, special interest groups, unions, businesses, non-governmental organisations (NGO), government, or individuals. For example, in a conflict surrounding conservation of raptors on grouse moors in Scotland, the key organisations involved are a representative body for the shooting industry, a government funded agency, and environmental charities, each advocating from different perspectives in the conflict (Hodgson et al. 2018).

Individuals represent their own specific interests within a conflict, but can also identify with one or more organisations, via for example, employment, registered membership, demographic similarity, or shared values (Tajfel & Turner 1979). Individuals and or organisations can come together to create a *policy forum*, an issue bound intermediary organisation made up of diverse actors who interact repeatedly (Fischer & Leifeld 2015). Individuals can form interactions with organisations, if it is in their interests to do so, inside or outside a policy forum and the combination of these interdependent interactions (for example between fishers and government, in the salmon conflict (Butler et al. 2015)) forms network level structure. It is possible to analyse network structure in a way that reveals both the social processes which cause interactions to form, and how well the network will perform collaborative functions such as problem solving (Lubell et al. 2012).

A useful approach for examining social processes, network structure and collaborative problem solving is the Risk Hypothesis, which states that an actor will make a rational decision to form an interaction if the risk of doing so does not outweigh the benefit (Berardo & Scholz 2010). The relationships between problem solving, social processes, network structure and conservation are summarised in Table 2. Benefits come as three forms of social capital – bridging, bonding and linking – that help the actor solve problems through access to information, influence and or resources (Lubell 2013; Woolcock 2001). Firstly, *bridging* social capital involves a network structure of sparse interactions with centralised "hubs." Holders of this type of social capital benefit from weaker interactions with lower transactional costs, whilst retaining high shared information and potential influence via interactions with a well-connected hub. Secondly, *bonding* social capital has stronger interactions and more clustered network structure. Information and influence flow through multiple redundant interactions (rather than from a central hub) so can be verified, enhancing trust and increasing ease with which defection (lying or breaking agreements) is detected and punished (Berardo & Scholz 2010). Thirdly, *linking* social capital involves preferentially forming interactions with organisations perceived as more important in the network (Woolcock 2001). This is beneficial for gaining access to resources, influence or information. Depending on the type of problem faced, actors will collaborate in different ways, forming or breaking interactions based on the risks and benefits of bridging, bonding and linking capitals.

Conservation problems involving unwanted impacts of biodiversity, where collaborating to meet agreed objectives is key, are examples of a coordination-type problem (Bodin 2017; Young et al. 2010). For instance, the successful management of invasive salt marsh cordgrass *Spartina alterniflora* in San Francisco Bay is partly the result of a collaborative stakeholder process centred around a small hub of experts responsible for coordinating most of the organisation and delivery of actions (Lubell et al. 2017).

Table 2 - Problem types in social-ecological systems and how they manifest in social networks.

	Coordination problem	**Cooperation problem**
Key attributes	Actors agree on a shared goal	Actors do not agree on a shared goal
	Progress requires activities to be organised efficiently	Progress requires negotiation and deliberation
Associated social capital	Bridging	Bonding
Associated network characteristics	Sparse, with centralised hubs	Dense, with redundant links
Equivalent conservation management issue	Biodiversity impacts	Conservation conflict

Individuals tackling coordination problems favour bridging social capital gained through a sparse, centralised network structure. Alternatively, conservation conflict is an example of a cooperation-type problem where actors have competing objectives which hinder progress, for example in the salmon conflict in Scotland fishers wanted to decrease the number of seals to protect their fishing opportunities and wildlife tourism operators wanted to keep seal numbers high for their customers to view (Butler et al. 2015; Redpath et al. 2013). Here there is a greater chance that actors will defect. Networks formed in response to cooperation problems are characterised by individuals seeking bonding social capital gained though a dense, closed network structure (Berardo & Scholz 2010).

In this chapter we investigate the social network of a conflict, which should (according to the Risk Hypothesis) be characterised by a preferentially closed network structure. We conceptualise our network as having two distinct levels (Wang et al. 2013), with one level comprising individual actors, and the other comprising interests. The pattern of interactions is generated by individuals interacting with organisations, with each organisation deemed to represent an organisational interest/perspective. How multiple interactions are structured together determines the network's ability to address associated coordination and cooperation problems. We focus on conflicts involving Greylag goose (*Anser anser*) populations in Scotland that have recovered from historic lows to local hyper-abundance, resulting in damage to arable crops and livestock pasture (Mitchell et al. 2010; Bainbridge 2017). The two broad viewpoints in the conflict are that agriculture should be protected from geese and that the geese and their habitat should be conserved. If an actor strongly holds one of these viewpoints over the other, they may find their objectives are competing with those of others when goose management is discussed. However, if they feel both viewpoints can be accommodated then non-competing or joint objectives may be possible. These are cooperation and coordination problems, respectively, both of which can occur simultaneously at network level (Berardo 2014).

In two island locations, the Uists of the Outer Hebrides and the Orkney Islands, Scottish Government-backed local goose management groups (LGMGs) were formed. LGMGs in both locations are multi-stakeholder policy forums including representatives of conservation organisations, farming unions, land owners, and government as well as individuals unaffiliated with particular organisations, such as wildfowl shooters and farmers. LGMGs are the formal mechanism of decision-making, giving them the greatest influence on goose management at their location. Membership of an LGMG is a characteristic of an individual or organisation that could influence the preference of interaction formation, as actors attending a policy forum have repeated opportunities to interact with one another. Many individuals and organisations are impacted by or involved in goose management but do not have the opportunities to interact afforded via LGMG membership. Such individuals must gain information or influence (should they so wish) from a position outwith the LGMG. Individuals may prefer to form interactions with organisations whom they perceive to be important players in the goose management, to build linking social capital (Nohrstedt 2018). Engaging individual farmers to collaborate with any goose management interventions, particularly coordinated shooting or scaring of geese, is vital to the adaptive management schemes devised by the LGMGs. Farmers share similar characteristics such as values, employment and social demographics so would be expected to share similar interaction formation behaviour, impacting collaboration potential.

To explore the processes that regulate interactions between actors in conservation conflict we ask two research questions. Firstly, are individuals forming interactions with organisations in response to coordination and or cooperation problems according to the risk hypothesis? Secondly, what influence do farmers, members of the LGMG, and organisations perceived as important have on the formation of interactions? We then discuss how the interaction network pattern of goose conflict in parts of Scotland impacts collaboration and suggest actions to tackle coordination and cooperation problems.

2.3 METHOD

2.3.1 Study areas

Both study areas are island groups in Scotland; North Uist, Benbecula, and South Uist (hereafter, the Uists), are part of the Outer Hebrides off the North-West of Scotland, whilst the Orkney Islands lie off the North-East coast. The Uists have a population of 4,839, with a strong tradition of the small-scale farming in Scotland known as “crofting” where 94% of holdings are under 20 hectares in size (National Records of Scotland 2013; Scottish Government 2017). The Orkney Islands have a higher population of 21,349 and farming is on a much larger, more commercial scale with only 63% of farms under 20 hectares (National Records of Scotland 2013; Scottish Government 2017).

Both sites have a resident population of greylag geese which cause damage to arable crop and pasture (Bainbridge 2017). Goose numbers have increased since the early 1980s in these areas and the resulting increase in damage triggered creation of Local Goose Management Groups (LGMGs) by Scottish Government. LGMGs are semi-autonomous from Scottish Government and are made up of a range of stakeholders selected locally including individuals affected by the geese directly and those representing groups or organisations. The individuals and organisations on the LGMG in each area are not identical to each other and have changed over time, but representatives include farmers, local government, conservation organisations, land managers, and recreational wildfowl shooters (Churchill 2016; Ferguson 2016). Farmers in the Uists and the Orkney Islands are represented on the respective LGMGs by local elected members of national agricultural unions, and by individual farmers unaffiliated to any national group. Adaptive management pilot schemes were started in 2012 in both areas. The pilots share the same objectives; to test if a level of shooting could be determined and implemented to successfully decrease goose damage (via population management) whilst maintaining the conservation status of the geese (Ferguson 2016). Pilots use local shooters (paid and volunteer in the Uist, volunteers only in the Orkney Islands) to carry out lethal and non-lethal scaring of the geese, reducing the population and protecting crops, respectively (Churchill 2016; Ferguson 2016).

2.3.2 Data collection

Network data were collected during semi-structured interviews (26 interviews in the Uists in 2016 and 20 interviews in Orkney in 2015), initially with key informants who represented members of the LGMG. Respondents were asked to name formal or informal groups (hereafter, organisations) which were involved or impacted by goose management locally and whether they thought each organisation was a “small player” or “large player” regarding decision making and how (if at all) goose management actions are ultimately applied (see Supporting information for interview guide). Respondents were then asked if they interacted with each named organisation to address one or more problem associated with goose management. Further respondents were selected via suggestion by those already interviewed (snowball sampling (Newing et al. 2011)). Social networks rarely have clear boundaries (Angst & Hirschi 2017), so saturation was deemed to have been reached when at least one person from all organisations named three times or more was interviewed. One organisation named four times ('international shooting tourists') was not interviewed as no representative of this organisation was suggested by respondents or that we could reliably identify. All interviews were audio recorded and transcribed later, except one in which extensive notes were taken. Respondents (hereafter, individuals) and organisations were coded as being farmers or not and as being members of the LGMG or not. Ethical approval for this study was granted by Biological and Environmental Sciences Ethical Review Committee, University of Stirling and respondents gave consent to their data being used.

To measure the perceived importance of each organisation, we produced a mean importance score. This was calculated for every organisation by assigning each small player response a score of 1 and each large player response a score of 2, then taking the mean score per individual interviewed.

2.3.3 Network data

We analysed interaction data via social network analysis, a set of methods used to understand system level social processes through patterns of nodes and edges. In this study, nodes are one of two types of actors: individuals and organisations, and edges are the interactions between the actors. An individual formed a connection to an organisation when they stated they interacted with that organisation regarding goose management. Interactions formed between individuals and the organisations for which they worked were included in the analysis. The presence or absence of interactions between a small number of actors creates network configurations with simple properties. For example, in Figure 3, configurations A1 and A2 are the two simplest examples of a bipartite configuration with a central hub, as three actors are connected with the fewest interactions possible. These are star (also known as open) configurations. A3 is a configuration which better illustrates a network hub, with many otherwise unconnected actors branching off a central actor. B1 and B2 of Figure 3 show cycle (also known as closed) network configurations; the simplest bipartite cyclic network, and a network with more actors, respectively. In closed configurations information can flow to every actor through more than one pathway. As networks get larger than a few of actors, the number and diversity of these network configurations also increases. The under- or overrepresentation of configurations such as those in Figure 3, are the outcomes of social processes. For example, any open configuration in a network is consistent with actors seeking bridging capital in response to a coordination problem. In contrast, the presence of many closed configurations is consistent with actors seeking bonding capital in response to a cooperation problem (Berardo & Scholz 2010).

Exponential random graph modelling (ERGM) is a statistical method used to assess the prevalence of a configuration of interest, compared to what would be expected to occur randomly (Robins et al. 2012). ERGM takes into account the lack of independence between configurations due to their nestedness (for example, configuration A1 and A2 of Figure 3 are present as part of B1) (Robins et al. 2012). We tested the network for prevalence of configurations indicative of three types of social capital (bridging, bonding and linking) and for configurations measuring the influence of actor characteristics (farmers and LGMG members). A significant positive model parameter value for a configuration means that configuration is significantly overrepresented in the sample network. A significant negative parameter value means the configuration is significantly under-represented in the network.

Initial analysis to determine network differences between the Uists network and the Orkney network indicated significant differences between the sites (see results). To learn about the influence of organisational actors common between the two locations, we modelled a third network in addition to the Uist and Orkney networks; a combined network including all actors at both locations.

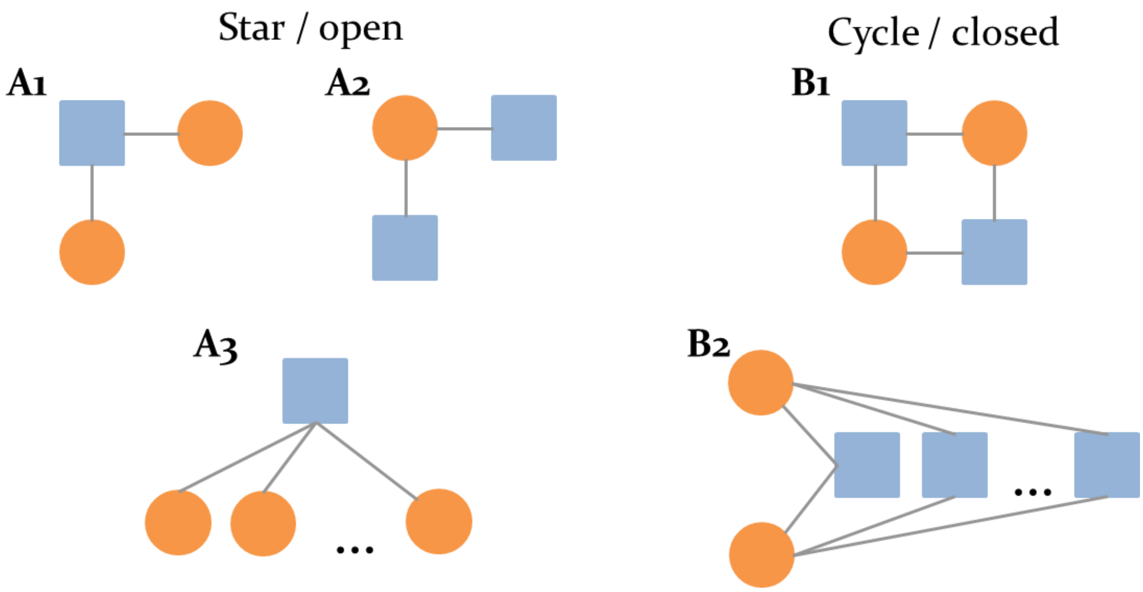


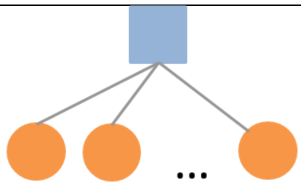
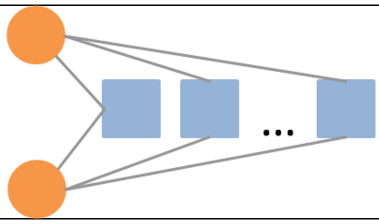
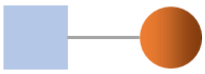
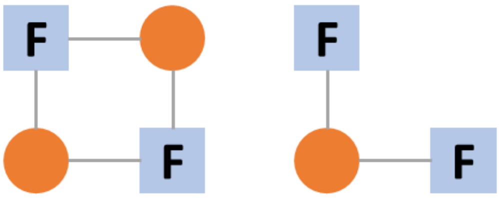
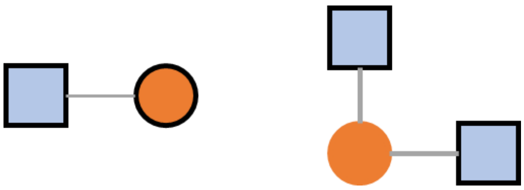
Figure 3 – Examples of bipartite network configurations, in which connections can only be formed between unlike nodes. A1 and A2 are the simplest open, bridging configurations containing three connected nodes. A3 illustrates a centralised hub node, connected to many otherwise unconnected nodes. B1 is a simple closed, bonding configuration. B2 is a configuration with a greater number of actors connected cyclically. Squares and circles represent two different types of actors, for example individuals and organisations

A model was fit for each of the three networks (Uist, Orkney and combined) using MPNet software (Wang et al. 2009; Wang et al. 2014). The software fixes the number of nodes in the model fit, but we chose not to fix the density (number of ties between nodes) of the network in order to maximise the amount of network space the modelling programme could explore. Models included the test configurations (Table 3) and additional single edge configurations (two nodes connected by one edge) to control for network density. All models included single edge configurations for any interaction, farmer interaction, and LGMG interaction. In the combined model, single edge configurations were also included to control for location of individual (either Orkney or the Uists). Models which converged were tested using the goodness of fit function in the MPNet software, which we set to create 10,000 random graphs using the parameter values from the model fit. The random networks were then compared to the source network for all configurations, not only those in the model, to assess if the model was a good fit. Parameter and significance values of the models indicate the prevalence of the test configurations in the networks.

2.3.4 Interactions & perceived importance

We ran two linear mixed effects models to determine if organisational actors were perceived as more important when either formally involved in the management of the geese or were a national organisation. The first analysis had the binary response variable as to whether an organisation was named as a stakeholder, or not, by individual respondents. The second analysis had the binary response variable as to whether named organisational actors were perceived as either lower or higher importance. Predictor variables used in both models were: organisation being a member of the local LGMG (binary; yes/no), organisation having a national presence rather than just a local presence (categorical; local only / local & national / national only), and location (the Uists or Orkney). Two random variables were included in both models to account for the grouping structure of the data. These were unique individual id, and organisation id. The area under the curve (AUC) of Receiver Operating Characteristic (ROC) plots was produced for both models to assess their ability to correctly discriminate between a randomly chosen positive response and a randomly chosen negative response. A value ≥0.7 was considered as having acceptable discriminatory ability (Sommerville et al. 2010).

Table 3 - Hypotheses tested using exponential random graph model (ERGM) and the respective network test configurations related to each hypothesis. Squares represent individuals, circles represent organisations, and shading represents the level of perceived importance attributed to organisations in the network (with darker shades representing more importance). F indicates the actor is a farmer, and an actor with solid black outline is a member of the local goose management group. Overrepresented and underrepresented configurations will be significantly more or less prevalent in the network than would be expected by chance, respectively.

Social process hypothesis	**Test configuration**	**Network model prediction based on the focal social process hypothesis**
Bridging social capital will be low as interactions are not formed to solve coordination problems		Configuration will be significantly underrepresented
Bonding social capital will be high as interactions are formed to solve cooperation problems		Configuration will be significantly overrepresented
Linking social capital will be high as individuals preferentially interact with organisations perceived as more important		Configuration will be significantly positively correlated with the mean importance score of the organisation
Farmers will **form similar interactions to each other** as they share a similar management objective		Configurations will be significantly overrepresented
LGMG individuals will **form interactions with each other or similar interactions to each other** as they participate together in a policy forum		Configurations will be significantly overrepresented

2.4 RESULTS

A summary of the 46 participants by location and stakeholder group is shown in Table 4. Farmers interviewed in Orkney were all self-employed, working on their own family farm. Three had been in paid or voluntary roles in private or public agricultural organisations. No farmers interviewed were employees or members of conservation organisations. Of the two conservation managers interviewed both had worked as employees for Scottish Natural Heritage and neither took part in shooting or farming. Four shooters who volunteered for the goose management pilot were interviewed. All had fulltime jobs around which they fit the volunteer shooting. One shooter worked in the sport shooting sector, but none of the remaining three were employed in any conservation or agricultural role associated with goose management.

In the Uists, four of the crofters interviewed relied on crofting for most of their income but all had sole control of their crofts. Eight crofters were members of the Scottish Crofting Federation. The two conservation managers interviewed had worked for Scottish Natural Heritage, one of whom was an active crofter. Of the six shooters interviewed, three were crofters, two were self-employed outside of the environmental sector and one employed within the environmental sector. Beyond employment as scarers through the LGMG, no shooters were employees of conservation organisations.

Table 4 - Number of interviewees by location, stakeholder group and membership of the local goose management group (LGMG)

Location	**Stakeholder group**	**Number of interviewees (formally involved via LGMG)**
Orkney	Conservation manager	2 (2)
	Farmer	9 (1)
	Shooter	4 (3)
	[1]Other	5 (2)
The Uists	Conservation manager	2 (2)
	Crofter	[2]12 (2)
	Shooter	[2]5 (3)
	[1]Other	9 (3)

[1]Other groups were butchers, government employees, conservation charity employees, Scotland's Agricultural College (SAC) and estate employees
[2]two informants were both crofters and shooters

The exponential random graph models we parameterised for the Combined, Uists and Orkney networks are shown in Table 5. The Single edge configurations were included in models to control for network density. All other configurations were included to test social process hypotheses, with under- and overrepresentation of the configurations indicated by negative and positive parameter values, respectively (Table 5). All interactions between individuals and organisations for the combined, Uists and Orkney networks are shown in Figure 4.

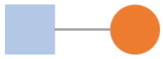
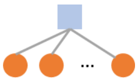
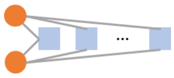
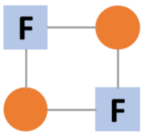
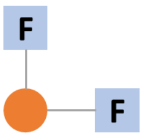
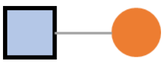
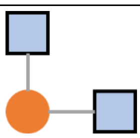
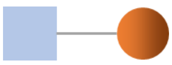
Open configurations were significantly overrepresented in all three models (parameter estimate combined: 0.709, P=0.002, Uists: 0.910, P=0.015, and Orkney: 1.277, P=0.010). This opposes our social process hypothesis (Table 3) that the networks would show low bridging social capital, indicating instead that individuals would seek interactions to address coordination problems. Closed configurations were significantly overrepresented in the combined and the Uists model (parameter estimate combined: 0.617, P<0.001, Uists: 0.242, P=0.002), supporting our hypothesis of individuals seeking bonding social capital to address cooperation problems. This was not significantly the case in Orkney where closed configurations were no more or less prevalent than would be expected by chance (parameter estimate: 0.065, P=0.699). The positive correlation of interactions and perceived importance of organisations, as per our hypothesis of individuals seeking linking capital, was significant in the Uists model (parameter estimate: 0.572, P=0.098) but not the combined (parameter estimate: 0.080, P=0.783) or Orkney model (parameter estimate: -0.054, P=0.887). Configurations representing interactions between individual members of the LGMG and organisational members of the LGMG were not under- or overrepresented in either the Uists or Orkney networks (parameter estimate Uists: 0.773, P=0.265, and Orkney: 0.439, P=0.495). The configuration representing shared interactions between LGMG individuals was underrepresented in the Uists model (parameter estimate: -0.977, P=0.074) but not the others (parameter estimate combined: -0.106, P=0.601, Orkney: -0.580, P=0.257). This rejects our hypothesis of preferential interaction formation between LGMG members. No configurations representing interactions shared between farmers were significantly under- or over represented, rejecting our hypothesis of farmers sharing similar patterns of interaction as each other.

Organisational actors which are members of their local goose management group (LGMG) had a significantly higher predicted probability of being named as stakeholders (P(named) = 0.10; 95%CI = 0.02-0.42) than those which were not members (P(named) = 0.02; 95%CI = 0.01-0.04) (Table 6A). When an organisational actor had been named, they had a significantly higher predicted probability of being perceived as more important in goose management if they were a member of the LGMG (P(important) = 0.38; 95%CI = 0.10-0.78) than if they weren't a member (P(important) = 0.20; 95%CI = 0.10-0.37) (Table 6B). There was no significant difference between organisational actors with a local only, local & national, or national only presence, in either model. The location (Uists or Orkney) had no significant effect in either model. The area under the curve value for receiver operating characteristic for the stakeholder and the importance models was 0.90 and 0.80, respectively, surpassing the acceptability threshold.

The perceived importance of specific organisational actors in the management of geese is shown in Table 7. In both locations SNH were perceived as the most important organisational actors but more so in the Uists (importance score of 1.81) than in Orkney (score of 1.45). In the Uists the next five most important organisational actors were farmers (1.46), Storas Uibhist (1.12), North Uist Estates

(0.96), SCF (0.73), and RSPB (0.73). Of these perceived important organisational actors, only North Uist Estates are not on the Uists LGMG. In Orkney, following SNH, the next five most important organisational actors were RSPB (1.15), farmers (1.10), NFUS (0.95), SAC (0.85), and SGRPID (0.85). Here, it is only the RSPB which is not represented on the Orkney LGMG.

Table 5 - Exponential random graph model (ERGM) models for combined, Uists and Orkney networks. Squares represent individual actors, circles are organisational actors, F indicates actor is a farmer, actor with solid black outline is a member of the LGMG, and light/dark shaded circle represents the level of perceived importance attributed to organisational actors, as a continuous variable. Underrepresented configurations are indicated by a negative parameter value, overrepresented configurations by a positive parameter value. P value indicates significance of difference of parameter from random networks with equal number of nodes. [a] Uists and Orkney networks only contain Uists and Orkney edges, respectively. [b] organisational actors not listed as LGMG in combined model, as LGMG membership different in Uists and Orkney.

Configuration		Combined		Uists		Orkney	
		Parameter	P value	Parameter	P value	Parameter	P value
Single edge		-2.946	<0.001	-3.454	<0.001	-3.239	<0.001
Open		0.709	0.002	0.910	0.015	1.277	0.010
Closed		0.617	<0.001	0.242	0.002	0.065	0.699
Single edge Uist only		-1.065	0.035	NA[a]	NA[a]	NA[a]	NA[a]
Single edge Orkney only		0.801	0.034	NA[a]	NA[a]	NA[a]	NA[a]
Farmer interactions		-0.095	0.804	0.587	0.343	0.143	0.809
		-0.035	0.776	0.778	0.273	0.122	0.824
		0.036	0.752	-1.055	0.112	-0.183	0.658
LGMG interactions		0.023	0.956	0.777	0.247	0.239	0.703
		NA[b]	NA[b]	0.773	0.265	0.439	0.495
		-0.106	0.601	-0.977	0.074	-0.580	0.257
Perceived importance		0.080	0.783	0.572	0.098	-0.054	0.887

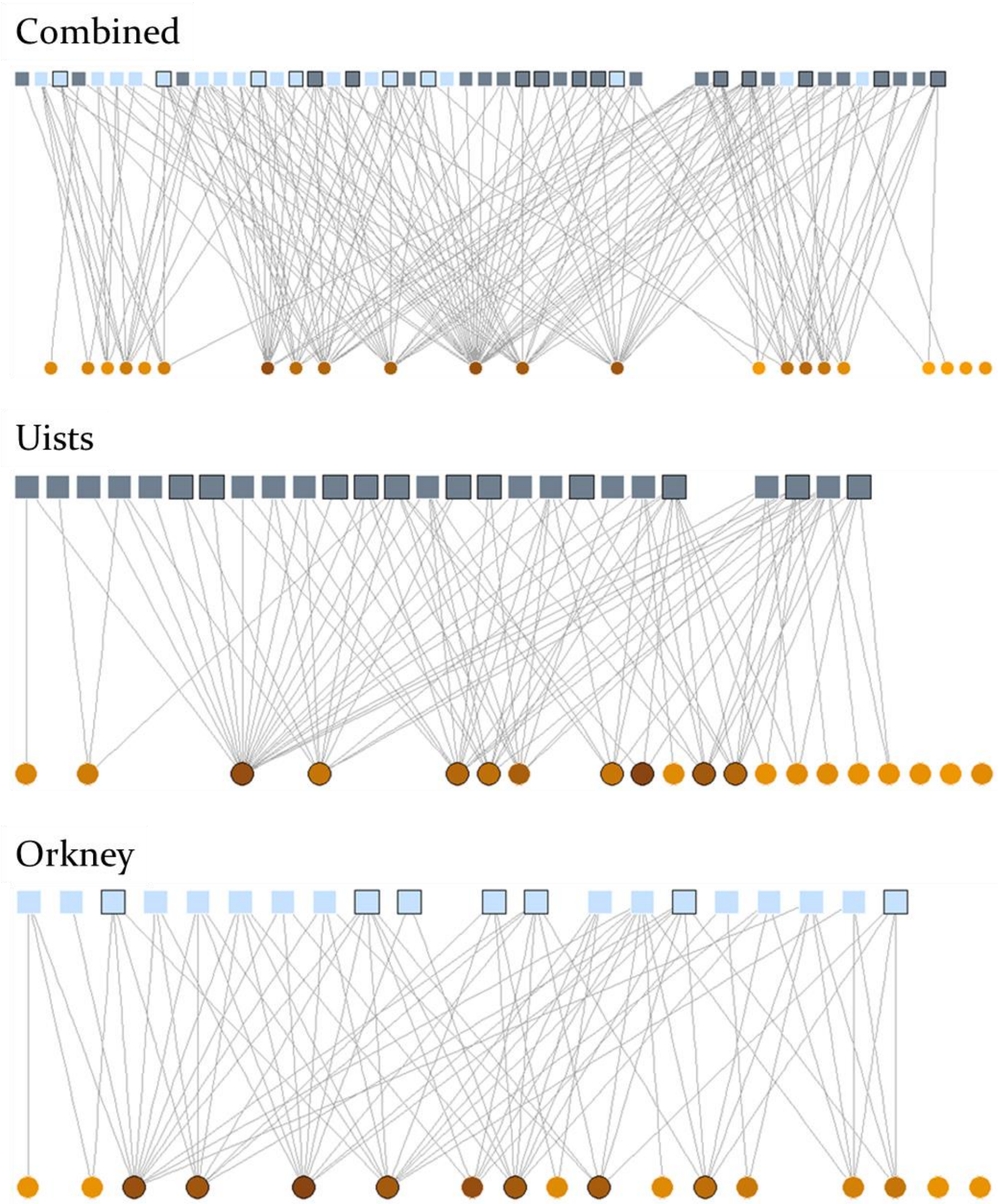


Figure 4 - Network diagram for the combined, Uists, and Orkney networks. Squares represent individuals, circles are organisations, darker circles are actors perceived as more important. A solid black line around a square/circle represents the actor as a member of the local goose management group, except in the combined network where membership is not shown for organisations.

Table 6 - Model output of two generalised linear mixed effects models to predict how membership of the local goose management group and scale of an organisation affects if organisational actors are: A. named as stakeholders, or B. classed as important players, or not. Variable coefficients in bold are significant to P<0.05

	Response variable			
	A. Organisational actors are named as stakeholders (binary; yes/no)		B. Organisational actors named as stakeholders are classed as important players (binary; yes/no)	
Predictor variable	**Coeff. (SE)**	**Pr(>|z|)**	**Coeff. (SE)**	**Pr(>|z|)**
Organisational actor is member of Local Goose Management Group	**1.92 (0.43)**	**<0.001**	**0.89 (0.45)**	**0.048**
Local and / or national presence of organisational actor (compared to local only)				
Local & national	1.32 (0.74)	0.07	0.68 (0.55)	0.213
National only	-0.09 (1.25)	0.94	0.75 (1.15)	0.513
Location	-0.09 (0.28)	0.76	-0.17 (0.29)	0.564

Random variables	**Variance**	**Variance**
Organisational actor identifier	1.46	0.60
Individual actor identifier	0.24	<0.001

Table 7 - Mean (±95% confidence interval) perceived importance of organisational actors in the Scottish goose conflict. Organisational actors got a score of 0 if they were not named as stakeholders, 1 if named as a less important stakeholder, and 2 if named as a more important stakeholder. Numbers in bold italics indicate the organisational actor is on the local goose management group in that location. NA indicates organisational actors not mentioned by any individual at that location.

Organisational actor	Combined	Uists	Orkney
Local butcher	0.37 (0.18)	0.31 (0.24)	***0.45 (0.27)***
Community council	0.13 (0.10)	0.19 (0.15)	0.05 (0.10)
Farmers	1.30 (0.19)	***1.46 (0.20)***	***1.10 (0.35)***
Livestock feed supplier	0.07 (0.07)	0.12 (0.13)	0.00
National government	0.07 (0.09)	0.08 (0.15)	0.05 (0.10)
Hotel	0.15 (0.10	0.04 (0.08)	0.30 (0.21)
National Farmers Union Scotland	0.46 (0.23)	0.08 (0.10)	***0.95 (0.41)***
National Goose Management Review Group	0.11 (0.11)	0.12 (0.17)	0.10 (0.13)
North Uist Estates	0.54 (0.23)	0.96 (0.33)	0.00
Other	0.07 (0.07)	0.00	0.15 (0.16)
Public	0.02 (0.04)	0.00	0.05 (0.10)
Private land owner (Uist)	0.04 (0.09)	0.08 (0.15)	0.00
Scottish Government Rural Payment Inspections Division	0.67 (0.24)	***0.54 (0.29)***	***0.85 (0.38)***
Royal Society for the Protection of Birds	0.91 (0.22)	***0.73 (0.30)***	1.15 (0.29)
SAC Consulting	0.59 (0.22)	***0.38 (0.27)***	***0.85 (0.36)***
Scottish Crofters Federation	0.43 (0.19)	***0.73 (0.28)***	0.05 (0.10)
Goose management shooters	0.59 (0.23)	***0.42 (0.27)***	***0.80 (0.39)***
Shooting supplies retailer	0.09 (0.08)	0.00	0.20 (0.18)
Scottish Natural Heritage	1.65 (0.18)	***1.81 (0.19)***	***1.45 (0.33)***
Storas Uibhist	0.63 (0.25)	***1.12 (0.35)***	0.00
Shooting tourists	0.22 (0.14)	0.12 (0.13)	0.35 (0.26)
Utilities	0.11 (0.09)	0.12 (0.13)	0.10 (0.13)

2.5 DISCUSSION

We found evidence of interaction networks formed to build bridging, bonding and linking social capitals. Configurations indicative of bridging social capital were significantly overrepresented in both the Uists and Orkney networks, whereas bonding social capital was only overrepresented in the Uists, and to a lesser extent than bridging capital. Based on the Risk Hypothesis, bridging structures are preferentially formed in response to coordination problems and bonding structures to cooperation problems (Berardo & Scholz 2010). Why would individuals favour interactions formed in response to coordination problems when conservation conflict (with its competing objectives and high risk of defection) is more akin to a cooperation problem?

Angst & Hirschi (2017) show patterns of interdependent interactions in a network can mature over time with 'nascent' bridging networks formed to solve simpler coordination problems growing into bonding networks to tackle cooperation problems. Without time-series network data it is not possible to confirm if goose management networks started forming in response to coordination problems or cooperation problems alone, or if both formed at the same time. However, interactions can be cultivated with formal participatory processes (Reed & Sidoli Del Ceno 2015) and the conception of LGMGs to specifically manage the conservation conflict (a cooperation problem) suggests that bonding interactions were prioritised via the policy forum of the LGMG. Bridging interactions would then have followed as the LGMGs made progress and the coordination problems associated with practical goose management, such as organising shooting, began to appear.

The bridging configurations in all networks suggest a low risk situation, where a sparse number of interactions is adequate for tackling the problem. LGMGs were started in 2012 and operated goose scaring and population management activities at both locations, with teams of volunteers or paid shooters (Churchill 2016; Ferguson 2016). Organising and carrying out a goose management activity such as shooting towards an agreed objective, is a coordination problem. Additionally, interacting with organisations which operate under familiar and trusted institutional rules is lower risk (Nohrstedt 2018). Individuals may have experience of LGMG managed pilot schemes over several years, and the organisations on the LGMG, such as Scottish Natural Heritage (SNH), farming or crofting unions, SAC Consulting (SAC) and Scottish Government each have a long history of working in rural Scotland. Existing network structures between these actors should be able to respond to coordination problems.

Network configurations indicative of bonding social capital were significantly overrepresented in the Uists, but not in Orkney. This suggests individuals in Orkney are not responding to a cooperation problem and see the level of risk as lower than individuals do in the Uists. In Orkney the conservation charity RSPB, resigned its representative from the LGMG in 2014, citing goose management as an agricultural issue rather than a biodiversity issue (Churchill 2015). RSPB at the national scale have strong views in support of goose conservation in Scotland to the point of lodging a complaint to the European Commission in contest to the management plan to shoot barnacle geese (*Branta leucopsis*) on Islay (RSPB Scotland & WWT 2015) and withdrawing their representative from the NGMRG (Scottish Natural Heritage 2015). The lack of an RSPB representative in Orkney will decrease the diversity of views on their LGMG leading on average to an increase in trust, decrease in transaction costs, and fewer bonding configurations required between the remaining members of the LGMG. The RSPB remain a member of the LGMG in the Uists, adding a different voice to the group potentially decreasing trust, increasing transaction costs and promoting more closed network configurations (Berardo & Scholz 2010). This may cause a future headache for goose management in Orkney should a cooperation problem arise and RSPB felt the need to act unilaterally. An emerging cooperation problem would by definition include competing objectives between stakeholders, and an increase in the risk of defection. A lack of bonding social capital through redundant interactions in the Orkney network would decrease both verification of information, and detection and punishment of defection (Berardo & Scholz 2010). Decreasing diversity itself narrows the breadth of knowledge available for problem solving and decreases legitimacy of processes (Reed & Curzon 2015; Mason, Pollard et al. 2018). Reforming interactions with RSPB or forming new interactions would come at a high transaction cost (Reed & Curzon 2015). All these factors together would result in goose conflict worsening in Orkney.

Individuals in the Uists (but not Orkney) preferentially formed interactions with organisations that were perceived to be more important in goose management supporting our hypothesis that linking social capital played a part in individuals forming interactions. Building linking social capital in this way can increase access to superior knowledge and resources (Woolcock 2001). Membership of the LGMG was the only significant predictor variable for perceived importance of an organisation. Location was not a significant predictor meaning organisations at one location did not have an average perception of importance greater than the other location. It is unsurprising that organisations on the LGMGs are perceived as important, as they may have been selected for membership of the LGMG for a reason which is also reflected in individuals' perception of importance, for example, political or financial authority, specialist skills (shooting or ecology), or land ownership (Reed et al. 2009). Membership of the LGMG may itself also have enhanced the perceived importance of an organisation. There are two prominent examples of organisations perceived as important but not on their respective LGMG (Table 7). In the Uists, North Uist Estates is the fourth highest ranked organisation out of a total of 19, ranking higher than five of eight LGMG members. In Orkney, RSPB has the second highest perceived importance out of a total of 18, ranking higher than six of seven LGMG organisations. Both of these organisations had previously been on the group but had decided to exit. On average, individuals perceive these two organisations to be important even though they are not formally involved in management of the geese. This could be because they gained importance as members of the LGMG previously, and individuals aren't aware of the change of circumstances, because they are formally involved with wider parallel issues such as wildfowling (North Uist Estates) or bird conservation (RSPB), or simply because they wield influence from outwith the LGMG. Our data cannot distinguish between these or other reasons for perceived importance. We can show that perceived importance of an organisation is not entirely due to formal participation in goose management and that in the Uists at least, this characteristic of organisations appears to influence the formation of the network.

Amongst individual members of the LGMG there was no evidence of preferred interaction with LGMG organisations. In the Uists configurations indicative of individual LGMG members sharing similar interactions as each other were underrepresented. We can therefore infer that LGMG members at this location are choosing not to form interactions with LGMG organisations, which was in opposition to our hypothesis. These results are surprising as the LGMG is an example of a policy forum designed to bring together individuals and organisations for interaction, often in person (Fischer & Leifeld 2015). Actors in a policy forum are assumed to be rational and instrumentalist in their actions and lobby for their preferred solution in a visible and legitimate venue (Fischer & Leifeld 2015). The results suggest that individuals who attend LGMG meetings do not feel they are forming interactions just because they are in the same room and perhaps participating in the same conversation with organisation representatives. Our results show that interactions do occur between individuals and organisations in the LGMG, just that they are not more or less prevalent than would happen by chance, even given the increased contact opportunities offered through the policy forum.

Our hypothesis of farmers sharing similar preferences for interactions was not supported by the analysis. Farmers are a diverse stakeholder group with a wide range of perspectives and behaviours on agricultural issues (Austin et al. 2001; Sok et al. 2018). This is reflected in our results even on the partisan topic of goose management.

Limitations of the study

Interactions between individuals may support or undermine the bipartite network investigated, providing coordination and cooperation problem solving ability. Social network analysis of natural resource management rarely includes causal analyses of the relationship between network structure and environmental outcomes, and typically lacks time series data (Groce et al. 2018; Nohrstedt 2018). This study does not address those gaps directly, but offers a comparison of two superficially similar networks, which have undergone the same interventions via establishment of a policy forum to manage conservation conflict.

2.6 CONCLUSION

Modelling of network structure helps us understand the connections between the social processes governing interaction formation and the collaborative problem-solving capability of a network. We found differences in network structure between two superficially similar conflicts which could result in distinct abilities to deal with emerging cooperation problems.

Over the recent years of the pilot adaptive management projects, collaboration between actors may have focussed on the coordination problem of practical goose management rather than the cooperation problem of conflict management. The policy forums of the LGMG did show the common interactions that might be expected, and organisations perceived as important drive interaction formation but are no longer formally involved. Geese damaging crops remains a problem in both locations, and across Scotland (Bainbridge 2017) so it may be time to stimulate the network for greater cooperative capacity, particularly in Orkney. Actively widening the boundaries of the network to introduce redundant interactions across locations would be beneficial by increasing creativity and knowledge sharing through diversity of views, but also through bonding social capital, verifying potentially unsatisfactory local interactions. The status of collaboration with important organisations which are not formally involved in goose management could benefit from re-evaluation. This could mean overcoming a very high transaction cost, particularly as previous streamlining of LGMG membership decreased diversity of viewpoints. Advantages of policy forums such as the LGMGs include legitimacy, transparency, engagement across society and access to quality information (Nohrstedt 2018). These strengths may risk being undermined if perceived importance lies elsewhere and individuals seek linking social capital outwith the LGMG.

2.7 SUPPORTING INFORMATION

Summary interview guide
Questions from which data included in the analyses of this chapter are shown in bold

Section 0 – Interview details
Location
Interview number
Date

Section 1 – Background
Age
Gender
Residence (current, previous)
Occupation / role (current, previous)

Section 2 – Views on geese
Describe your views on the geese
Describe the impacts of the geese on you and others

Section 3 – Stakeholder analysis
Please list all the stakeholders (including yourself, individuals, groups, and organisations) involved with or impacted by geese in [Orkney or the Uists]
For yourself –
Regarding management of geese:
• What is your goal and why?
• What actions do you take to achieve your goal?
• What additional actions could you take to achieve your goal?
• What stops you from taking these additional actions?
• Are you an important player in goose management and if so, how?

For each of the stakeholders listed, regarding management of geese:
• What is their goal and why?
• **Do you interact with this group and if so, how?**
• What actions do this group take to achieve their goals?
• What additional actions could they take to achieve better outcomes?
• What stops them from taking these additional actions?
• **Is this group an important player in goose management and if so, how?**

Section 4 – Opportunities & threats
Other than geese, list the major threats that you cope with in your occupation / role
Describe how these threats compare with the impacts of geese.
Describe how the future would be if management actions did not resolve the goose issue and the population increased significantly
Describe how the future would be if management actions did resolve the goose issue and the goose population decreased significantly

Section 5 – Additional information
Do you have any additional comments or information regarding what we've discussed today?

Chapter 3

Understanding cooperation in conflict: learning from goose management in Scotland

Chris Pollard, Steve Redpath, Aidan Keane, Juliette Young and Nils Bunnefeld conceived the ideas and designed the methodology. CP collected the data with Kirsten Brewster. CP analysed the data and wrote the Chapter. JY contributed technical advice on data analysis. Drafts of the Chapter were commented on by JY and NB.

3.1 ABSTRACT

To effectively manage conservation conflicts there is a need to gauge the prevalence of, and potential for, cooperative behaviours in the people involved.

Using in-depth stakeholder interviews, we investigated how and why individual members of three important stakeholder groups (farmers & crofters, conservation managers, and shooters) cooperated with one another and what barriers they faced to cooperation. We framed our research with Ostrom's Institutional Analysis and Development framework, which seeks to understand the cooperative and non-cooperative behaviour of individuals in a social-ecological system. Data are collected across seven framework criteria (actor, position, action, information, control outcome and payoff) to build a holistic picture of individuals' behaviour. We conducted 46 semi-structured interviews with people in two locations in Scotland, who were involved in a conservation conflict surrounding the management of geese.

We identified three important dimensions of cooperation in the conservation conflict: i) the formal structure of distributed decision-making for goose management in Scotland is welcomed but suffered from a lack of vertical and horizontal interactions; ii) members of a stakeholder group who superficially would share a similar goal, showed extensive heterogeneity not only in goal, but also their personal circumstances; iii) the complexity of the conflict resulted in emergence of novel trade-offs during management activities, affecting how stakeholders cooperate with one another. Stakeholders identified barriers to cooperation as political (the influence of important actors), knowledge (incomplete understanding of the natural system) or operational (due to legislation, high cost or low skill).

The lack of horizontal and vertical links between widely distributed groups meant shared learning and the perception of fairness suffered. Building up horizontal and vertical interactions could bypass political and knowledge barriers. A false belief in uniformity among stakeholder groups can be the source of poor system understanding, so developing wider or alternative representation is required to

prevent this. For long-term, complex issues, identification and discussion of trade-offs to avoid poor outcomes is needed throughout the process, not just during the planning stages.

3.2 INTRODUCTION

Conservation conflicts are complex and often result in negative outcomes for biodiversity and people (Redpath et al. 2015). Conflicts occur when two or more parties with strongly held beliefs clash over conservation objectives and when one party is perceived to assert their actions to the detriment of another (Redpath et al. 2013). Fostering cooperation within and between parties builds trust, facilitates learning, and develops networks for long-term problem solving; all of which can contribute to conservation conflict management (Reed & Sidoli Del Ceno 2015; Young, Searle, et al. 2016; Bodin 2017). Characteristics of cooperative behaviours include sharing information, exploring others interests and needs, working together on a problem, and actively seeking win/win solutions (Pound 2015). To manage conservation conflicts effectively there is a need to gauge the prevalence of and potential for, cooperative behaviours by the individuals involved.

The damage of crops by hyper-abundant geese is a well-characterised conservation conflict and there are multiple examples of goose conflict management schemes in Europe and North America (e.g. Tombre et al. 2013; Eythórsson et al. 2017b; Fox & Madsen 2017). In Scotland, greylag geese *Anser anser* have been increasing in number since the 1980s at several locations causing a corresponding increase in crop damage (Bainbridge 2017). Scottish Government have been involved with the conflict since the mid-1990s, but in 2012 committed to trialling participatory, multi-stakeholder processes for developing local goose management schemes (Bainbridge 2017). Throughout the history of formal goose management in Scotland, cooperative behaviours will have been promoted, discussed, implemented and rejected, both individually and collectively, formally and informally, shaping the conflict. To understand the role of cooperation in the goose conflict in Scotland and for lessons in conflict management more widely we ask the research questions:

- How and why do individuals cooperate towards the management of a conflict?
- What do people identify as the barriers to cooperation?

We focus on the three main stakeholder groups in two Scottish island locations which have greylag goose management schemes: farmers, conservation managers and wildfowl shooters. Our research was structured using the Institutional Analysis and Development (IAD) framework (Ostrom 2011). The IAD is a general framework developed for understanding the institutions governing common pool natural resource management (Orach & Schlüter 2016). The IAD's focus on cooperative interactions between individuals in a social-ecological context, make it a flexible framework useful for approaching a range of social-ecological policy issues, particularly at local scales, including adaptive co-management (Whaley & Weatherhead 2014). Individuals in the IAD are assumed to be boundedly rational fallible learners; that is, they make rational decisions (including honouring commitments and promises) under uncertain circumstances, sometimes making mistakes but potentially learning from the experience (Ostrom 2011; Orach & Schlüter 2016).

The IAD explicitly places those stakeholder interactions within a context of biophysical resources, community attributes, and rules (both formal and informal). The elements of the framework and how they relate to each other are designed to provide a logical method linking the exogenous biophysical, community and rules together with the endogenous person-person interactions, revealing cause and effect relationships (Ostrom, 2011).

This makes the IAD particularly relevant for studying conservation conflicts in which the person-person interactions can only be understood within the wider context of the biodiversity management in question. In the goose conflict system, major elements of the conflict fit into the building blocks of the IAD: wild geese, agriculture, geographical location (biophysical); farming culture, multi-scale conservation organisations, geographical location (community); and national hunting laws, local goose management plans, individuals' crop protection strategies (rules). The IAD can accommodate all explanatory variables of biophysical, community, and rule types by assigning them to one of a fixed number of defined criteria. This is the crucial first step in understanding a complex social-ecological system from what can seem a messy tangle of interacting variables and processes (McGinnis, 2011). The seven criteria together form an Action Situation; a description of interactions between individuals within their biophysical, community and rules context (Figure 5, Table 8) (Ostrom 2011). Many actions situations may arise from the description of a social-ecological system as described using the IAD.

Examples of IAD application to conservation problems include: conflict in multi-use forests (Wilkes-allemann et al. 2015); payment for ecosystem services (Barton et al. 2017); competing intercoastal zone management options (Ware 2017); and wildlife reserve management (Rastogi et al. 2014). In this chapter we construct a picture of cooperation in the goose conflict using action situations, then explore the interactions described to address our research questions.

Figure 5 – The Institutional Analysis and Development Action Situation (Ostrom 2011)

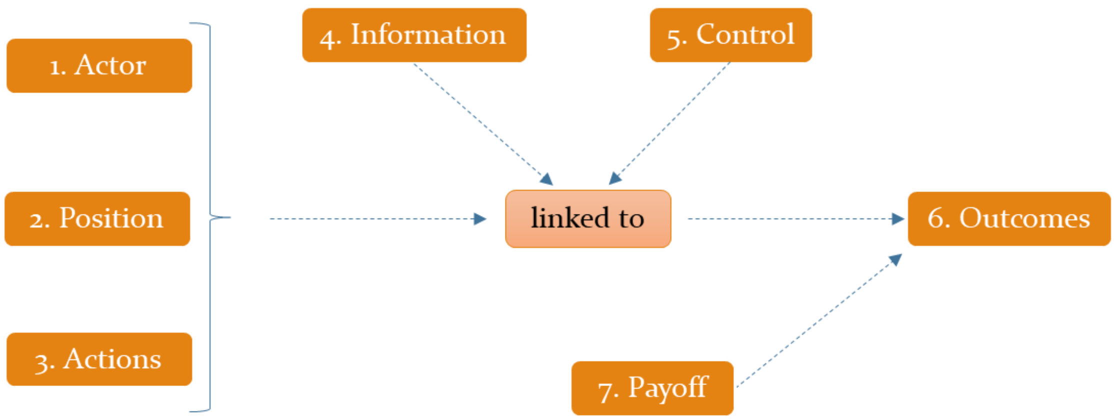


Table 8 – Summary description of the seven criteria of the Institutional Analysis and Development framework (Ostrom 2011)

1. Actor

A description of the individuals and stakeholder groups in the system. Cooperative interactions between people who are similar are different to those between people who aren't (Tajfel & Turner 1979). Within a stakeholder group, an individual may be more independent, choosing when and how to cooperate with similar people. Alternatively, their behaviour choices may be more restricted, for example as an employee following the rules of their employer. Outwith a stakeholder group, people may overlap between groups (for example, farmers who also shoot geese) or be firmly part of one stakeholder group.

2. Position

An actor's Position is the context of their role, describing what is satisfactory about their status quo, what is not satisfactory and why. An individual's perceptions of their own positions and positions of others determines what cooperative or non-cooperative actions an actor feels are realistically available.

3. Actions

Actors are aware of various cooperative and non-cooperative actions available to help them achieve their goals. Individuals have perceptions of whether specific actions are or will be successful and of the barriers associated with the action.

4. Information

Individuals are boundedly rational, fallible learners; the information available will influence their behaviour, but the information and their ability to process it are not perfect. People will use shortcuts such as trusted interactions with other people or groups, to process the information (Ostrom et al. 1994).

5. Control

Actors cannot always do what they want to do. Individuals are impacted by Controls, limiting or enhancing their choices of action. Controls which impact cooperative behaviour may take the form of formal laws, imbalances of actor influence, access to resources (including funding), or competing priorities.

6. Outcomes

Actors will make predictions about the results of their actions and the actions of others. These Outcomes and the cause and effect processes leading up to them, will influence choices made by actors. We explored the potential cause and effect processes and outcomes in the goose conflict through two scenarios; if goose damage was brought under control (i.e. the problem was resolved) and if the goose population continued to increase (unresolved).

7. Payoff

The balance of costs and benefits of an action are the Payoff. Individuals are assumed to be fallible learners who make rational decisions based on their own calculated payoffs, but also vary due to personal interactions such as keeping promises and reciprocity (Ostrom 2011). Cooperation between individuals may lead to a preferential payoff.

3.3 METHODS

3.3.1 Study areas

North Uist, Benbecula, and South Uist (hereafter, the Uists) make up part of the Outer Hebrides island chain situated of the North-West coast of Scotland. The Orkney Islands (hereafter, Orkney) lie off the North East of Scotland. The Uists are a crofting community, with a strong tradition of subsistence farming on small-scale farms known as crofts. Orkney is also highly agricultural, but with larger, more commercial farms. Holdings over 20 hectares account for 6% of all farms in the Outer Hebrides (which include the Uists) and 37% of all farms in Orkney. Improved grassland accounts for 9% and 61% of total grazing in the Outer Hebrides and Orkney, respectively (Scottish Government 2017). The Uists have a population of 4,839 whereas Orkney has a population of 21,349 (National Records of Scotland 2013).

Greylag geese (*Anser anser*) are amber listed in the UK due to breeding localisation and are named in assessments of protected areas such as the South Uist Machair and Lochs RAMSAR site in the Uists, meaning the Scottish government have a responsibility to maintain breeding populations of the species locally (Scottish Government, 2019) However, they are classified as Least Concern globally and can be legally hunted during the winter open season (September to February) (Eaton et al. 2015; IUCN 2016). In the Uists, counts of around 6,200 resident greylag geese were made in 2016, up from 1,100 in 1986 (Paterson 1987). In Orkney a count of over 24,000 resident geese was made in 2016 where no breeding was recorded in the 1980s (Mitchell et al. 2016). A larger population of Icelandic greylag geese overwinter in Orkney, increasing the population by an additional 60,000 – 90,000 from November to February (Brides et al. 2018). In the Uists there is also a small but growing population of migratory Greenland barnacle geese (*Branta leucopsis*).

Wild goose populations can cause a range of ecosystem services and disservices (Buij et al. 2017). Disagreements about how service and disservice trade-offs are managed can cause conservation conflict (Ceaușu et al. 2018). Geese in Orkney and the Uists afford predominantly cultural services of benefit to birdwatchers, conservationists, wildfowl hunters, and researchers. Provisioning disservices from geese are through crop damage where they are regarded by farmers as a pest. Goose management is like other common pool agricultural pest management. Preventing direct damage caused by geese at the field or farm level is in the interests of the private individual, but on the landscape scale benefits accrued from farmer actions are non-excludable, impacting people beyond the farm scale as goose populations change in size and location (Zhang et al. 2007).

To coordinate landscape scale goose management, Scottish Government created Local Goose Management Groups (LGMGs) in 2012 in several areas across Scotland including in Orkney and the Uists. Prior to and slightly overlapping this in the Uists was a four-year EU funded scheme led by the Royal Society for the Protection of Birds (RSPB) called Machair Life that aimed to improve conservation of the globally important machair habitat on the west coast of the islands (Machair Life+ 2014). This scheme included coordinated goose scaring by employees paid through the scheme to protect crofts, but no population reduction.

LGMGs are semi-autonomous, managed locally by Scottish Natural Heritage (SNH) and reporting via a central SNH coordinator to a National Goose Management Review Group (NGMRG). LGMGs consist of a range of local stakeholders including farmers or crofters affected by the geese directly and individuals representing groups or organisations. Groups represented on the LGMG in each area are not identical and have changed over time, but include farmers, local government, conservation organisations, land managers, and recreational wildfowl shooters (Churchill 2016; Ferguson 2016). Both LGMGs began pilot schemes in 2012 to control greylag geese using adaptive management. The goose management pilots had the same objectives; to test if a level of shooting could be determined and implemented to successfully decrease goose damage (via population management) whilst maintaining the conservation status of the geese (Ferguson 2016). Pilots use local shooters (paid and volunteer in the Uist, volunteers only in Orkney) to carry out lethal and non-lethal scaring of the geese to reduce the resident greylag population and protect crops (Churchill 2016; Ferguson 2016). Greylag geese are also shot during the open season and can be shot out of season only under licences issued in order to protect crops. There is no open season for Greenland barnacle geese due to their higher conservation status, a species that has caused conservation conflict via crop damage elsewhere in Scotland (McKenzie & Shaw 2017).

3.3.2 Recruitment and interviews

Semi-structured interviews were conducted between June and September 2015 in Orkney (n = 20), and between August and September 2016 in the Uists (n = 26) similar to the methodology set out in Young et al. (2018). For the interview guide, see 3.8 Supporting Information. We first identified key informants for interview at both locations, based on their formal association with goose management (for example as a member of the LGMG). Additional informants were identified by those already interviewed (snowball sampling (Newing et al. 2011)). Two informants in the Uists contacted CP following a request in the local newspaper for views on geese. During interviews we asked informants to list all stakeholder groups associated with goose management and determined data collection saturation as when at least one person from all stakeholder groups listed three times or more was interviewed. No-one from a stakeholder group named four times ('international shooting tourists') was interviewed as no member of this group could be identified. The first three interviews conducted were used as a pilot study, resulting in small alterations in the questions used (see 3.8 Supporting Information) and the data from the pilot interviews was included in the analysis. Orkney interviews were conducted in person (13) or by phone/Skype (7). CP led all interviews except one, which KB conducted alone. KB, NB and AK were present for 14, 10 and 5 interviews, respectively. Uists interviews were conducted solely by CP, in person (24) or by phone (2). Interviews lasted between 30 minutes and 2 hours, with a mean of 1 hour. Written notes were taken during interviews and all were recorded using Smart Recorder app (SmartMob v1.8.0), apart from one in which the informant declined recording, so more detailed notes were taken. All recordings were transcribed verbatim by CP. Ethical approval for this study was granted by Biological and Environmental Sciences Ethical Review Committee, University of Stirling and respondents gave consent to their data being used. The participant consent form is in 3.8 Supporting Information.

3.3.3 Interview structure and coding

In order to allow analysis of the conflict using the Institutional and Analysis Development (IAD) framework, we developed a semi-structured interview guide (interview guide in 3.8 Supporting information) in which each question was designed to collect information from the informant on one or more of the IAD criteria. Development of the final interview guide followed a short pilot study (see Section 3.3.2 above). The IAD framework was not discussed with informants during interview and instead the questions were grouped into five less abstract sections - Background, Views on geese, Stakeholder analysis, Opportunities & threats, and Additional information. Table 9 shows each of the five sections, a shortened version of the questions asked therein (full interview guide in Supporting information), and for which of the IAD criteria those questions were expected to provide data.

Data analysis was conducted in two sequential phases: firstly, we organised the responses using a pre-defined coding structure based on the IAD criteria; then secondly, thematic analysis was used to draw out themes of cooperation from the coding-structured data, both from within, and across the IAD criteria.

The first phase of analysis involved simplification by coding interview transcripts using a hierarchy of pre-defined nodes (Table 10). As we wished to ultimately describe the conflict in terms of the IAD criteria, the highest level of coding contained nodes for each of those criteria; Actor, Position, Actions, Information, Control, Outcomes, and Payoff. Below six of the seven parent nodes (the Actor node had no pre-defined sub-nodes) were nodes relating to the stakeholder groups about which informants were talking. We split these by our stakeholder groups of interest; Conservation manager, Farmer, and Shooter. We also included an Other group. Four IAD criteria (Position, Actions, Control, and Payoff) we used child nodes from each stakeholder group to separate responses from informants either talking about their own stakeholder group, or each of the other stakeholder groups. This was to allow us to compare how informants saw their own situation with how others perceived their situation to be. One IAD criterion, Information, contained pre-defined sub-nodes of Action and Payoff, followed by a split into nodes relating to each stakeholder group other than their own. This was to capture what informants perceived to be the practical options (actions) and ultimate goals (payoffs) available to stakeholder groups other than their own. Finally, one IAD criterion, Outcomes, had a pre-defined set of sub-nodes in which to code responses relating to how informants described the potential outcomes or a Resolved, or Unresolved, conflict.

The second phase of analysis involved thematic analysis, starting at the lowest level of the pre-defined coding structure in each IAD criteria, to draw out important themes in stakeholder perceptions of the conflict, focussing on cooperation within and between stakeholder groups. Ultimately three important themes were identified: Location & Scale; Heterogeneity of farmers & crofters; and Emerging shooter trade-offs. A number of barriers to cooperation were also found, which we described separately.

Interview transcriptions were coded using the IAD framework on NVivo11 software (QSR International 2017) by CP.

Table 9 – Questions (shortened questions shown here) were grouped into five sections during interviews. Each question aimed to collect information for one or more of the seven Institutional Analysis and Development (IAD) framework criteria (full interview guide in 3.8 Supporting information), shown here by ✓. Section 5 was not designed to provide data on a specific IAD criteria, but could capture information on any of the criteria, as shown by (✓).

		IAD criteria analysis nodes						
Interview section	**Questions**	**1 Actor**	**2 Position**	**3 Actions**	**4 Information**	**5 Control**	**6 Outcomes**	**7 Payoff**
1 Background	Age	✓	✓					
	Gender	✓	✓					
	Residence	✓	✓					
	Occupation / role	✓	✓					
2 Views on geese	Describe the impacts of geese on you and others		✓		✓		✓	
3 Stakeholder analysis	Please list the stakeholders (including self) involved or impacted by geese	✓	✓		✓			
	(then for each stakeholder in the list) What is your/their goal?				✓			✓
	How important and influential are you/they?		✓		✓	✓		
	How do you interact with them?			✓		✓		✓
	What actions do/could you/they take?		✓	✓	✓	✓	✓	
4 Opportunities and threats	Describe how you see the future if the goose issue is resolved/unresolved						✓	✓
	Comparing to issues of geese, what other threats do you have to deal with in your role?					✓		✓
5 Additional information	Any further comments or questions?	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)

Table 10 – Pre-defined node and sub-node structure of the first phase of interview analysis with number of sources and references. Following analysis of the Actor node, all other nodes were separated into sub-nodes based on the main stakeholder groups of interest (Conservation managers (CM), Farmers, Shooters). Sub-nodes were then split further, depending on the parent node.

Node	Sub-nodes			Sources	References
1 Actor				46	189
2 Position	CM	Self-stated		4	22
		Stated by others		40	123
	Farmers	Self-stated		24	239
		Stated by others		38	83
	Shooters	Self-stated		9	60
		Stated by others		28	62
	Others	Self-stated		16	126
		Stated by others		46	289
3 Actions	CM	Self-stated		3	43
		Stated by others		45	223
	Farmers	Self-stated		23	151
		Stated by others		41	168
	Shooters	Self-stated		9	54
		Stated by others		38	100
	Others	Self-stated		12	51
		Stated by others		45	253
4 Information	CM	Actions	Stated by farmers	9	46
			Stated by shooters	22	114
		Payoffs	Stated by farmers	6	11
			Stated by shooters	21	59
	Farmers	Actions	Stated by CM	4	28
			Stated by shooters	10	29
		Payoffs	Stated by CM	4	14
			Stated by shooters	1	13
	Shooters	Actions	Stated by CM	4	16
			Stated by farmers	18	42
		Payoffs	Stated by CM	4	5
			Stated by farmers	7	12
5 Control	CM	Self-stated		3	7
		Stated by others		44	140
	Farmers	Self-stated		21	120
		Stated by others		34	104
	Shooters	Self-stated		8	24
		Stated by others		21	48
	Others	Self-stated		16	61
		Stated by others		44	244
6 Outcomes	CM	Resolved		2	2
		Unresolved		5	10
	Farmers	Resolved		17	20
		Unresolved		21	39
	Shooters	Resolved		3	3
		Unresolved		7	16
	Others	Resolved		9	9
		Unresolved		16	32
7 Payoff	CM	Self-stated		5	22
		Stated by others		43	113
	Farmers	Self-stated		18	42
		Stated by others		39	98
	Shooters	Self-stated		7	21
		Stated by others		17	29
	Others	Self-stated		18	49
		Stated by others		45	246

3.4 RESULTS

The results are organised in turn by each of the Institute Analysis and Development (IAD) framework criteria.

3.4.1 Actor - a description of the individuals and stakeholder groups in the system

The majority of the 46 study informants were men (80.0% in Orkney, 80.8% in the Uists, 80.4% overall), with all the remainder of the sample being women. In Orkney, farmers were all self-employed, working on their own family farm. Three had been in paid or voluntary agricultural roles with Scottish Government Rural Payments and Inspections Division (SGRPID), SAC Consulting (SAC) or National Farmers Union, Scotland (NFUS). No farmers were employees or members of conservation organisations. Of the two conservation managers interviewed in Orkney both had worked as employees for SNH. None were either wildfowlers or farmers. Four shooters who volunteered for the goose management pilot were interviewed. All had fulltime jobs around which they fitted the volunteer shooting, including one who worked in the sport shooting sector. None of the remaining three shooters were employed in any conservation or agricultural role associated with goose management. In the Uists, four of the crofters relied on crofting for most of their income but all had sole control of their crofts. Eight crofters were members of the Scottish Crofting Federation (SCF). The two conservation managers interviewed had worked for SNH in the Uists, including one active crofter. Of the six shooters interviewed, three were crofters, two were self-employed outside of the environmental sector and one employed within the environmental sector. Beyond employment as scarers through the LGMG, no shooters were employees of conservation organisations. Informant codes by location, stakeholder group and membership of the local goose management group (LGMG) are shown in Table 11.

Table 11 – Informant codes by location, stakeholder group and membership of the local goose management group (LGMG)

Location	Stakeholder group	Number of informants (formally involved via LGMG)	Informant code
Orkney	Conservation manager	2 (2)	OC1-OC2
	Farmer	9 (1)	OF1-OF9
	Shooter	4 (3)	OS1-OS4
	[1]Other	5 (2)	OG1-OG5
The Uists	Conservation manager	2 (2)	UC1-UC2
	Crofter	[2]12 (2)	UF1-UF12
	Shooter	[2]5 (3)	US1-US5
	[1]Other	9 (3)	UG1-UG9

[1]Other groups were butchers, government employees, RSPB, SAC Consulting (SAC) and estate employees
[2]two informants were both crofters and shooters

3.4.2 Position - an actor's Position is the context of their role

Farmers & crofters

The main three challenges listed by farmers and crofters were (in no ranked order): uncertain weather, the high financial costs associated with farming in a remote location and the negative impacts of geese. The extent to which these challenges affected farmers and crofters varied between individuals, indicating heterogeneity of position of this stakeholder group. For example, on an individual level, farmers and crofters described high levels of uncertainty regarding goose damage on a day-to-day or even year-to-year basis. They knew however that damage was not totally random as improving their land through reseeding of rough grazing land or adding fertilizer attracted more geese. A Uist crofter who didn't receive any protection from the local goose management scheme said: "*every time you improve your land you get more geese, then it's worse than zero sum. And it's completely outwith my control.*" (UF1).

Traditional crofting practices in the Uists are vital to conservation of the machair habitat, a complex dune grassland habitat found only in Western Scotland and Ireland (Stewart 1999). Pride in traditional crofting practices was strong particularly as these practices are seen as unique to the location, having died-out elsewhere in Scotland. Goose damage was widely blamed for the ongoing move away from traditional methods towards increased mechanisation.

Conservation managers

The degree of success or failure, as defined by the objectives of the NGMRG and the individual LGMG in each location, are ultimately borne by SNH both at a local and national scale. SNH staff can find themselves in a position of having to navigate the space between local and national scales. For example, support for using goose meat sales to aid financial sustainability of goose management was unanimous amongst conservation managers at both locations, but the necessary legislative steps to make the meat sale scheme financially viable need to be taken at national level.

Shooters

In Orkney, volunteer shooter teams provide crop protection and population reduction alongside their fulltime jobs. Shooters were proud of being able to help farmers and felt that they and the project were successful.

Orkney is a popular tourism destination for wildfowl hunting and geese shot by paying customers contribute a large proportion of the population reduction targets. Several shooters explained how during the open season Orkney farmers would guarantee the shooting rights for their land to professional shoot guides in exchange for payment. This allowed shoot guides exclusive rights to take paying customers on those farms should geese congregate there. The volunteer shooters said this could often exclude them from locations they had shot throughout their lives. They then assigned high value on their opportunity to shoot as part of the goose management pilot as they had regained access to shooting.

In the Uists, informants emphasised how hard shooting was due to the adaptive behaviour of the geese and that other stakeholders have never appreciated the difficulty of implementing a successful shooting programme, always expecting to see success over an unrealistically short timeframe.

3.4.3 Actions - actors are aware of various actions available to achieve their goals

The themes of location & scale, heterogeneity of farmers & crofters, and emerging shooter trade-offs, and the barriers to cooperation, were evident throughout the informant responses on actions available to themselves and others.

Location & scale

The formal actions carried out by SNH in both locations included organising the LGMG meetings, set-up and coordination of shooting, monitoring and reporting of results, financial planning and communications. Locally, SNH were seen to act as the link between stakeholders in each location and the central goose management governance processes, in the form of the National Goose Management Review Group (NGMRG). There was sometimes tension between the local and national scale with respect to the actions which could or should be taken. For example, goose meat sales in both locations were seen as a success. SNH in Orkney spent 12 months organising the correct permissions to ensure the carcasses could be sold locally. Many shooters, farmers and conservation managers campaigned to allow sale of meat to consumers off-island. This would generate income locally, including for goose management. The same views were held in the Uists. Neither project currently has permission to sell meat beyond their local community, for example to mainland Scotland. A conservation manager believed previous efforts at lobbying had been successful in terms of agreement with national bodies to get "*geese put on the pest species list or more easily a generally licence issued for both shooting and for sale [of goose meat]*" (UC1), but that implementation quickly lost momentum and the agreed changed did not occur.

Farmer & crofter heterogeneity

One crofter in the Uists summarised how the varied positions of crofters meant that cooperative actions were difficult to coordinate; "*There's probably some people who aren't that fussed, if they're not necessarily relying on that crop to feed cattle, [protecting crops from geese is] not as important to them*" (UF3).

In Orkney however, informants perceived the problem that some farmers would not take action even though they did suffer negative impacts from geese. A typical criticism from one Orkney farmers was "*how many farmers complain about the geese problem and out of that many, how many of them phone the department? [They would] much rather sit at home complaining, than actually do something*" (OF7).

Emerging shooter trade-offs

Shooters in Orkney saw the actions of shoot tour companies paying farmers for exclusive shooting rights as putting their own recreational shooting opportunities under pressure. The demand for commercial goose shoot tourism during the open season has strong financial incentives, especially when geese are at a premium later in the open season. One shooter described how a market for shooting rights was created *"[shoot tour operators will] buy out all the farms on Orkney. So it's quite common to have competition because some will go to the farmers and offer them more money*" (OS4). In the Uists, shooters involved in the goose management pilot were under a different pressure when deciding on their actions. Shooters cannot achieve high numbers of geese shot without allowing a large flock to build up, but a larger flock can cause more damage to crops and so poses a greater danger for crofters. Shooters must first make a judgement call on the trade-off between leaving flocks to build and increased risk of crop damage, then communicate that judgement to potentially worried crofters. One shooter (US5) said that the "*stakes were high*" when making such decisions.

Barriers

Farmers in Orkney faced operational barriers to shooting more geese themselves, such the closed season, limited licenses and the high amount of paperwork required to own a gun, that prevented them shooting geese. Crofters in the Uists faced similar barriers. SNH allowing a widening of the open season was suggested as a low-cost action by farmers in both locations and shooters in Orkney. However, shooters in the Uists weren't confident there were enough skilled shooters to take advantage of such a legislative change. SNH had backed a drive to recruit more young shooters in principle but had not taken any actions (including providing funding) to increase capacity directly. In the Uists, one further barrier to more effective shooting was the knowledge gap caused by a difficulty in measuring offtake accurately. There is no requirement for shooters to record the number of geese shot during the open season, so SNH rely on voluntary submissions of bag data which wasn't always recorded, stored or accessible.

Farmers and crofters listed various practical actions to scare geese from their land including scarecrows, positioning farm vehicles in fields, kites which mimic birds of prey, goose rockets, and gas guns, or personally chasing the geese away. However, the ease of scaring geese decreases over time as geese become habituated. Farmers and crofters also described the agricultural adaptations they had already made wholly or in part to reduce the impact of the geese. Orkney farmers discussed switching to less vulnerable crops such as oats. A common practice was to add fertiliser to goose damaged grass fields to aid recovery. In extremis, farmers talked of reducing livestock numbers due to loss of winter feed and grazing to geese.

Scaring geese or adapting agricultural practices to accommodate or avoid goose damage requires overcoming operational barriers of cost and time, which are often borne solely by the individual farmer, even in the presence of the goose management pilots. One crofter sums up the task of having to constantly scare geese: "*I want it done, but I want someone else to do it*" (UF10). Thus, farmers and crofters in both locations justified inaction due political barriers of a lack of influence. One crofter/shooter from Uist described how "*most crofters are just fed up. You stop complaining. You stop getting in touch with agencies*" (US1). Political barriers caused Uist crofters to disengage from formal processes. For example, many crofters are members of the Scottish Crofting Federation (SCF) which had sent numerous letters to the press, organised a petition to Scottish Government, and taken a seat in the NGMRG. Individuals from the Uists then chose to leave the NGMRG, due to perceived lack of progress, with one prominent SCF representative summarising their reason for disengaging; "*Look, nothing's happening, you just feel like they're laughing at you*" (UF7).

3.4.4 Information - information available to actors will influence their behaviour

Location & scale

Informants across stakeholder groups and locations perceived inconsistencies in relationships between representatives of organisations involved in goose management locally, and those operating at a other scales and locations.

Most Orkney and Uist farmers perceived SNH as seeking a pragmatic balance between reducing goose damage and maintaining species population. Views of SNH not caring about farmers in Orkney were expressed either as the organisation prioritising geese over people or that their actions were purely performative to meet a government remit. An Orkney farmer said "*I don't actually know what [SNH] would want to achieve. I think they wanted to be seen to be doing something, now that we've got a cull they can sort of turn around and say you know "we've done something"*" (OF5). In the Uists the local SNH manager was seen in a positive light, but there were less positive feelings towards SNH. Crofters were typically cynical about the inconsistencies of goose management funding between locations, and that SNH at the national scale was responsible. One crofter said "*I'll expose [SNH]. Islay have been getting compensated to the tune of a million pounds for the last twenty years. We've been getting more geese here and doing farming as well. I would say that's a good case for discrimination.*" (UF2). The RSPB were also seen by many across stakeholder groups as a nationally influential organisation, which was driven by a mostly urban membership who did not have experience of the context of goose management in Scotland. It was felt that this would result RPSB acting to exert influence, to the detriment of a successful goose management pilot. One crofter summarised that "*there are so many birdy folk in the country nowadays, that are members of RSPB or whatever, that they could bring a lot of pressure to bear on RSPB to stop the cull because it just sounds such a barbaric way to do it*" (UF11).

Informants who had experience working for SNH agreed that they were indeed the link between local and national scales of goose management. Communication within the organisation mirrored this structure, with top-down sharing of information via a central coordinator. Direct communication between goose management scheme locations across Scotland was limited to occasional staff meetings which potentially lead to missed opportunities for shared learning. One conservation manager affiliated with the SNH noted "*It would be just as easy for [pilot goose management schemes across Scotland] to share information we don't do that, we're not in touch with each other really*" (UC1).

Beyond SNH, the lack of practical information being shared across locations and scales from those with technical experience to those without, meant enthusiasm for a management strategy could be misplaced. For example, egg-oiling or pricking was suggested as potentially useful by shooters and farmers in both locations. These practices involve finding the nest of the goose and either dipping the eggs in oil or pricking a hole in the shell, both of which prevent the embryo developing. Those who had actually had practical experience egg-oiling, were almost always less enthusiastic. An experienced shooter explained what they learnt from their own attempts at egg-oiling: "*First year it worked very well, there were no broods anywhere. The second year I did it they were all deserting*" (US3). This opinion of the method was rare amongst informants, even though experienced shooters were seen as having an expert role in the goose management pilots, suggesting that this type of crucial information was not being adequately shared.

Farmer & crofter heterogeneity

Conservation managers at both locations perceived farmers and crofters to share a single goal of achieving reduction in goose numbers. Conservation managers also felt that those farmers who had engaged with the project were pragmatic, having shown compromise on goose population targets. A conservation manager described their positive relationship with farmers on the Orkney LGMG: "*we are very lucky in the fact that the folk that are on the group you know will discuss and will listen*" (OC2). However, this was in contrast to interactions with Orkney farmers beyond the group, as farming representatives were expected to perform this role on behalf of the LGMG.

Shooters in both locations held negative perceptions of farmer and crofter goals and how they influence behaviour. A shooter in Orkney said "*Some farmers would* *like everything to be wiped out that's not cattle and anything that's [...] on their farm that's not paying them*" (OS3), and another in Uist perceived crofter's goal to be "*Getting other people to do their work. There is a whole lot more they could be doing themselves*" (US4).

Crofters themselves described their ongoing goal as being able to maintain their unique lifestyle. For example, one crofter indicated the importance of keeping cattle, rather than converting to keep sheep "*[crofters] don't want to stop crofting. It's their lifestyle. They don't keep many sheep here because they're cattle crofters, that's what they do best, that's what they enjoy doing. So, to grow their crops and feed their cattle over the winter, and have sheep as an aside, is ideal for them*" (UC2).

Several farmers in Orkney suggested that they would not share successful goose scaring tactics with farming neighbours if there was the incentive of geese staying away from their own crops. The majority of farmers, however, did talk with each other about damage suffered and potential scaring techniques, in person and on social media. In the Uists one crofter actively involved in many community activities, summarised how heterogeneity of views wasn't a problem within the island community, because of how families remain on the island for generations, "*you have to live here for hundreds of years and if you make a mistake, they'll be talking about it in three generations. I'm not sure if that helps, it makes the meetings much more civil*" (UF1).

Emerging shooter trade-offs

Shooters in Orkney want to be involved in the goose management pilot in order to increase their opportunities for shooting. One conservation manager said "*the reason [the shooters are] involved is because they love shooting and this is an opportunity, [...] them being involved in [the goose management pilot] means they get a chance to do goose shooting at times when other people can't*" (OC2). Relationships between farmers and particular shooting groups were described by both the farmers and the shooters as having a preference for exclusivity. One farmer described that "*we work with the one group [...] we know them, trust them*".

In the Uists, all stakeholders perceived shooters in the Uists as primarily aiming to contribute to the project via goose population control and crop protection. Many shooters in the Uists indicated their frustration that some crofters felt they didn't need to take responsibility for their own goose scaring and pushed all the responsibility onto the shooters and the pilot scheme. A typical Uist shooter comment was "*some of the crofters are unbelievable. They offer no protection for their crofts. It's mind boggling*" (US5). Another shooter indicated the difficulty of providing the service to the crofters: "*we try and keep them happy but just not sure it's possible sometimes*" (US3). This view of the relationship was sometimes confirmed by crofters also, for example one crofter described meeting a shooter on the machair "*they all listen, but that's it. No action. They just go with what the bosses say*" (UF9).

Barriers

Many stakeholders identified information barriers that impacted cooperation on goose management. Goose counts are used as the quantitative indicator at both locations to track success of population control and in modelling of goose population trends to dictate actions (Ferguson 2016; Churchill 2016). The uncertainty in the counts was acknowledged as a problem by all stakeholders, acting as a knowledge barrier to better management. Stakeholders critiqued both methods and results. In Orkney the Wildfowl & Wetlands Trust conduct a robust annual goose count, the data from which informs the subsequent year's goose management and published in a technical report e.g. Mitchell et al. (2016). Shooters and farmers were not involved with population data collection in Orkney and criticised timing the annual count during the cull period, as it interfered with shooting. In the Uists, practical difficulties led to less robust counting methods than Orkney and greater uncertainty in the population estimates. One Uist shooter disputed the figures from the goose count, "*[the Uist LGMG] say the number's reducing but I'm not so sure. Maybe in certain areas they are reducing. It all depends on the day you do the count, what the weather's like*" (US5). SNH in the Uists indicate that the counting method is the same every survey but acknowledge that there will be many uncounted geese. Count transects do not cover the entire area particularly on the less accessible east side of the islands. More accurate evaluations face a operational cost barrier. However, counts in the Uists are conducted collaboratively with crofters, conservation managers and shooters all taking part to produce the data together.

Despite criticism of the count data and the desire for more robust data, individuals from all stakeholder groups at both locations actually downplayed these sources of uncertainty in the goose management pilot as a whole, stating that the management plans were good, but the schemes needed to be scaled up. Barriers to success were based on number of skilled shooters and the amount of funding. One Uist crofter gave a common viewpoint that "*you need more of it. It's all you can do. [...] It takes money and resources to pay people to scare*" (UF2).

3.4.5 Control - individuals are impacted by Controls, altering their choices of action

Location & scale

Stakeholders generally agreed that organisations which spanned scales held much of the control. All stakeholders saw SNH as a major player in goose management in both Orkney and the Uists. One typical comment was from a Uist crofter: "*SNH are the biggest player, that's what's I'm getting at. They've got the most power, the most influence. They are an arm of government. They advise on the policy, they're the ones that feedback. They are absolutely central, absolutely key*" (UF8). The differences between the national scale influence of SNH and the local was emphasised repeatedly, with local representatives characteristically described as "*very helpful*" (OS1) by an Orkney shooter, and "*fantastic*" (UF1) by a Uist crofter.

Farmer & crofter heterogeneity

Orkney farmers felt that as a group they did not have as much influence on goose management as other actors "*[we are] likely important but not a big player*" (OF9). An Orkney conservationist felt farmers are important players as "*without their lobbying pressure nothing would have been done*" (OG4) and a shooter thought "*farmers are an important player as they have to give permission [to shoot]*" (OS3).

One informant who conducted had farmer surveys described how farmers individually had different amounts of control: "*there's lots of smaller farmers who just feel quite helpless about the situation*" (OG5).

In the Uists, crofters had mixed views on how important and influential they felt they were in goose management, with some saying crofters were a major player and others saying the opposite. One crofter summed it up "*Well crofters are the most effective [at goose management actions], but honestly in terms of influence [...] honestly in lots of ways, I'd say pretty low down the scale*" (UF8). Individuals from other stakeholder groups also had varied views on the potential for crofters to take control. One informant thought crofters had "*very little to do with goose management. They just suffer the consequences*" (UG4), but a non-farming LGMG member described some crofters as influential: "*They are fairly political savvy, they know how to motivate their local politicians to try and get things done and they are not afraid to influence people to try and get what they want*" (UG3).

A major source of control over crofters was seen to be their commitment to crofting culture, more so than in other areas in Scotland. One informant elaborated on how they are unlikely to be dissuaded from crofting, regardless of current or warnings of future hardships: "*if it's in your blood you can't see past it and you carry on regardless. Cos' we're always hoping for next year, this year's bad next year's going to be good. And if you listen to you accountants they will say "och!" You turn a deaf ear to that*" (UF10).

Emerging shooter trade-offs

Shooters themselves and people in other stakeholder groups all saw shooting expertise as very important to goose management in both locations. A shooter in the Uists said *"[the shooters] are the essential part. They are the foundation of it all*" (US4). An Orkney informant thought *"[shooters] are playing a key role in actually carrying out the shooting [and they] are professional folk out there who can do the management work*" (OG2).

Barriers

Farmers and crofters expressed that the challenges of high costs of a remote location and extreme weather, which act as operational barriers to engaging in the additional costs of goose management. They also perceive political barriers in the form of a lack of influence. One Orkney farmer commented "*[SNH] will listen, but they are up themselves like "we're SNH you aren't telling us what to do. We'll decide what we're doing"*" (OF8).

Shooters in the Orkney pilot are volunteers, whose level of shooting is controlled by time and cost implications. Potentially using the numerous sport-shooters to reduce the resident goose population during the winter open season faced a knowledge barrier of being able to preferentially target a resident bird over a migratory bird.

Time and money limitations are constraints for shooting in the Uists also, but there is also a knowledge barrier of a limited number of local individuals capable of performing the job. One older, more experienced shooter worried about who would take over duties as the current shooters grew older, "*Who's replacing? Because there isn't anybody else. Maybe one or two others, who are of similar age to us who would be able to continue.*" (US5).

3.4.6 Outcomes – the predictions actors make about the results of their actions

Farmer & crofter heterogeneity

A massive reduction in goose damage would result in little practical change for Orkney farmers, but considerably less stress. One said "*We'd carry on the same. I'd say we've carried on the same for a lot of years*" (OF9) another farmer felt "*It'd be one less worry in your mind. You lay in bed in the morning and you hear all these geese going over and you have to get up and have a look*" (OF8). However, an Orkney conservation manager wondered if a subset of farmers would still not be happy, with an older conflict replacing the current one "*if we ever managed to get the resident population down to the level that [...] is causing less damage, whether or not farmers would then just go back to complaining about the wintering geese or not?*" (OC2).

In the Uists, one crofter summarised the cause and effect process of a reduction in goose numbers "*Bring the numbers down, less geese, […] less damage, more crops harvested, […] less stress*" (UF3). Fewer geese could mark a return to traditional crofting, "*a lot of crofters together might only have twenty acres of corn, so if they do even one acre of traditional harvesting if would make a difference on the Machair*" (UF7).

Farmers in Orkney felt an increase in geese would force them to reduce barley production and as a result have to decrease livestock numbers. One farmer said, "*it'll get to the stage when it's not feasible to grow barley here*" (OF7). However, one Orkney farmer mentioned how many farmers had already adapted to continue farming: "*I don't think anybody would jack it in because of geese. I think folk have changed; I know a couple of farmers have just stopped growing crops now because they can't grow crops because of geese but they're still farming*" (OF2).

Stakeholder in the Uists noted the majority of crofters had stopped the more traditional practices in response to geese and offered a bleak picture if goose numbers continued to rise. One predicted that "*Crofting would more or less cease. It is not all that healthy at the moment. I think if the geese numbers are daft and go up any more it'll just be curtains for crofting*" (UF6). The unique machair habitat of the Uists was often mentioned as being a potential casualty of increased goose numbers. Specifically, the loss of cattle would impact biodiversity. One crofter described the cause and effect processes "*It's all one big circle that benefits the environment. So if people weren't keeping the cattle, which might be the case with a lot more geese, then the environment would suffer*" (UF4).

Emerging shooter trade-offs

Sport shooters were concerned with personal trade-offs of a successful population reduction scheme. One shooter from Orkney who ran a shoot tourism business said "*a lot of these businesses like myself would not want [geese], wiped out because that would obviously mean the end of business for all of us*" (OS3). In the Uists a goose population so low as to not require scaring was seen as advantageous to the local sport shooting industry by one shooter as the geese would be easier to shoot by paying customers: "*at the moment [the geese] never settle in one place enough to be able to shoot any numbers so [the scaring is] bit of a mixed blessing you know*" (US3).

Shooters in Orkney felt that increased goose numbers would not negatively affect them. One said "*I don't really think it would affect me personally*" (OS4). In fact, one shooter said there may be positive effects "*if it got worse it would get better for me basically, for the shooting side of things*" (OS2). One shooter described how sport shooters and a subset of farmers would also be happy "*There's so many guys making money from it you know the farmers are making money from the [shooters]*" (OS4).

3.4.7 Payoff – the balance of costs and benefits of an action

Location & scale

The stated pilot schemes objectives of reduced damage to agriculture and maintenance of the conservation status of the greylag geese are the primary goals of SNH in both locations (Ferguson 2016; Churchill 2016), as they are derived from those of the national scale project. However, there was tension between local and national when greater detail was required, for example on bag targets. An Orkney conservation manager said: "*people started to really apply for [shooting] licenses in the summer […] when there was about 7,000-10,000 resident geese [but] the national group didn't accept that, they have suggested that the target is 9,000-11,000. […] but my feeling is […] the figure that we go for is the one that can be maintained*" (OC2).

Practical aspects of what it takes to maintain the goose population, includes determination of where SNH's money is best spent to try and find resolutions that benefit all sides. A conservation manager described the importance of cooperation with local people, "*we want to be seen as an organisation who will try and help and compromise and find resolutions and while we do have regulatory roles as well that's one side of us and the other side is working with communities*" (OC1). In the Uists SNH also emphasised dual goals, one conservation manager said the SNH goal was "*basically to preserve the geese and preserve the benefits of crofting, side by side*"

(UC2). Another explained that they are satisfied with balancing outcomes between crofters at the local scale and scientists at the national scale, commenting "*I think we've come up with a fairly sensible solution there, that the crofters are mostly happy with and the scientists that are working on the population models are fairly happy* (UC1).

Farmer & crofter heterogeneity

Farmers interviewed in Orkney all wanted to see goose population reduction but disagreed on the ultimate goal. One farmer said "*there wouldn't be one single farmer who would say ach no, keep a few. Not one*" (OF2). Whilst another contradicted this sentiment "*There's not a farmer wanting to destroy wildlife, I can guarantee you that. I don't think any farmer want the geese at zero*" (OF8). Crofters in the Uists also responded with a range of goals: "*There's lots of crofters […] who have some kind of arable activity. And there are lots of crofters who keep […] sheep, they don't grow anything, […] the geese aren't a huge problem for them and they probably are sympathetic to other crofters but are ambivalent in themselves*" (UF8).

Those crofters who did want a reduction in goose numbers typically aimed to "*get them under control, or maybe move to a different habitat*" (UF5). Or more specifically "*to see them reduced by half*" (UF11).

Emerging shooter trade-offs

The volunteer shooters in Orkney like to engage in their pastime. One shooter said "*We want to see the geese here as well 'cause we enjoy going for a shoot you know it's a hobby as well*" (OS4). Those involved in shooting businesses indicated trading-off a commercial goal with sympathy to farmers: "*what we would generally like to see is shoot good numbers, keep the clients happy, keep the money coming in but at the same time have a population that is not doing too much harm to the crops*" (OS3).

In the Uists, shooters talked more of achieving the goose management pilot goals. One shooter said "*It's about covering [the area for shooting] effectively. One can't ask for more*" (US4). Compared to shooters in Orkney, the enjoyment Uist individuals got from the act of shooting geese was mixed. One older shooter said

"*I'm quite keen on geese. I'm getting a bit idle now in my old age, I don't go out now unless I'm sure I'm going to shoot well into double figures. […] No, I enjoy shooting geese, it's fun*" (US3).

3.5 RESULTS SUMMARY

3.5.1 Cooperation in Scotland's goose conflict

The bringing together of the seven criteria of the IAD into the descriptive action situation of goose management and conflict in Orkney and the Uists paints a picture of common themes and barriers to cooperative interactions.

Individuals took part in cooperative interactions across various locations and scales. Sharing of information between LGMGs was via interaction of the local SNH manager and a central SNH coordinator rather than directly between local individuals of all stakeholder groups. Issues were raised regarding differences in local and national goals. For example, in the case of the sale of goose meat all local actors wished to cooperate to expand the market for the geese, albeit to meet differing goals. The difficulties in accurately monitoring offtake of geese where there is greater market incentive to shoot illegally were perceived to be a legitimate concern for conservation organisations at the national level, who would strongly resist the changes in legislation needed. Crofters in the Uists were aware of the disparity in funding between their local LGMG and another in Scotland, causing resentment due to the perceived unfairness.

The independence of the farmers and crofters lacks the structure of organisations or multi-stakeholder processes such as the LGMG, which can be designed to foster cooperation. Many actors from different stakeholder groups agreed that cooperation by farmers and crofters would benefit goose management. Other stakeholder groups perceived farmers and crofters to have a universal goal of a massive reduction of geese, although this wasn't the whole story. Even where goals were similar, the heterogeneity of farmer and crofter positions made cooperation more difficult. For example, crofters growing crops with neighbours who kept only sheep may both want to decrease goose numbers but would have different motivation to spend valuable time and money cooperating with scaring activities. Information sharing on scaring tactics was common both through personal relationships and publicly on Facebook. Some suggested they withheld useful information if it meant they could make their land less desirable to geese compared to surrounding land. However, truthful, cooperative behaviour when communicating with others was seen as a necessity in the close community of the Uists, where defection would lead to long-term reputational damage. Cooperation for lobbying was successful. Orkney farmers and Uist crofters had achieved creation of the LGMGs to manage the geese in their respective locations. Individual Uist crofters had taken this further and represented crofting at national goose management meetings.

At each location, shooters felt under pressure from another group due to competing goals. In Orkney the positions, actions and goals of sport shooting companies and farmers align during the open season resulting in exclusive farm access sold to shooting companies. Local shooters felt that this exclusion controlled their opportunities to engage in their pastime. This resulted in enthusiasm for the access to shooting as part of the pilot scheme, benefitting the goose management pilot with a pool of highly skilled volunteer labour. In the Uists, shooters require a build-up of geese at one site in order to shoot the high numbers required for population control. Crofters want to protect their crops so many will scare any geese and are encouraged to do so. Scaring affected the behaviour of the geese making them less likely to build up in large numbers and warier of people.

3.5.2 Barriers to cooperation

Barriers described by informants were grouped into three broad categories: political barriers present due to the influence of important actors; operational barriers formed of legislation or cost; and knowledge barriers surrounding incomplete understanding of the natural system (Table 12).

Table 12 – Barriers to cooperation as described by informants in the goose conflict in Scotland, grouped into similar types

Political barriers (the influence of important actors)
• Farmers often felt that conservation managers heard their concerns but gave them low priority when decision-making • Crofters cooperating on the national goose group felt they were not listened to and disengaged with the process • Influential conservation interests were a limit to the locally supported expansion of goose meat processing and sale • More efficient methods of goose control may be unpalatable to the public and therefore would be unacceptable to elected representatives
Knowledge barriers (incomplete knowledge of the natural system)
• Lack of systematic testing for effective scaring techniques; • Goose counting methods with high uncertainty leading to lack of trust in population estimates; • Dissemination of experiences from those who had tried egg-oiling and pricking; • Indistinguishability of resident from migratory greylag geese in Orkney preventing targeted shooting during the open season.
Operational barriers (legislation, cost or skills)
• Increased crop protection or population control by farmers and crofters requires their valuable time and financial resources • Increased efficiency of shooting in the Uists was limited by the lack of shooting skills • Increased access to shooting requires licences (both for gun ownership and out of season bags) • Widening the open season, expanding goose meat sales or lowering the protected status of the geese would require legislation changes

3.6 DISCUSSION

Encouraging cooperative behaviours between people involved in a conservation conflict is a widely advocated approach for conflict management (Pound 2015), including those involving geese (Fox et al. 2017). Collecting data using the Institution Analysis and Development (IAD) framework gave us seven sets of interconnected data (as in Figure 5), one for each of the criteria. From these sets we identified three common themes of cooperation within the goose conflict that could be applicable to fostering cooperation in other conservation conflicts.

3.6.1 Location & scale

Goose management is decentralised allowing local stakeholders to devise management appropriate to the local context. Distributed decision-making is advantageous for conflict management as it allows adaptability of actions to the context and avoids the lack of ownership and low level of acceptance of a purely top-down approach (Reed & Sidoli Del Ceno 2015; Mason, Pollard et al. 2018). But no structure or process is a panacea for social-ecological problems (Ostrom et al. 2007). Opportunities for local stakeholders to engage in cooperative behaviours are influenced by external connections, both horizontal (across space) and vertical (e.g. different tiers of an organisation) (Armitage et al. 2009). Horizontal impacts on cooperation were seen when Uist crofters felt they were be treated unfairly compared to goose management schemes elsewhere in Scotland, as has been reported by others (Howarth 2018). Vertical impacts were present where a diverse range of local stakeholders agreed that expanding the market for goose meat sales would be a positive action, but it was perceived that national conservation organisations would not allow it to happen.

Information sharing within the formal goose management network travelled vertically up and down via a central SNH coordinator, rather than horizontally between LGMGs. Horizontal information sharing between other stakeholder groups was not seen. This meant that useful information would only be shared (if at all) via a network centred upon a conservation affiliated source at a national level. Information transfer through a central 'hub' in this way is efficient, but only desirable if the hub is trusted by the rest of the network (Berardo & Scholz 2010). Responses from farmers and crofters indicate this not to be the case. For example, we found support amongst many farmers, crofters and shooters to use the practice of egg-oiling in order to control geese, despite little experience of the method. The potential impact on the conflict of this is displayed as an action situation in Figure 6. Conservation managers also had little experience but did not agree with egg-oiling. Those who did have experience of egg-oiling (a small number of shooters) felt it was not a practical solution, agreeing with conservation managers. However, this information was only shared through the single conservation source rather than via the shooters and thus whether to conduct egg-oiling remained a point of debate. Contrastingly in a goose management scheme in Norway and Denmark, information spread by a network of lay individuals was seen as a likely contributor to positive hunter attitudes (Holmgaard et al. 2018). A network structure conducive to solving complex problems (denser and with more redundancy) is not mutually exclusive to an efficient network (built around centralised hubs) (Berardo & Scholz 2010). Management of conservation conflict is heavily context dependent (White et al. 2009; Young, Jordan, R. Searle, et al. 2013) and in long-running conflicts context will change with time. Developing horizontal and vertical network connections is valuable for coping with change.

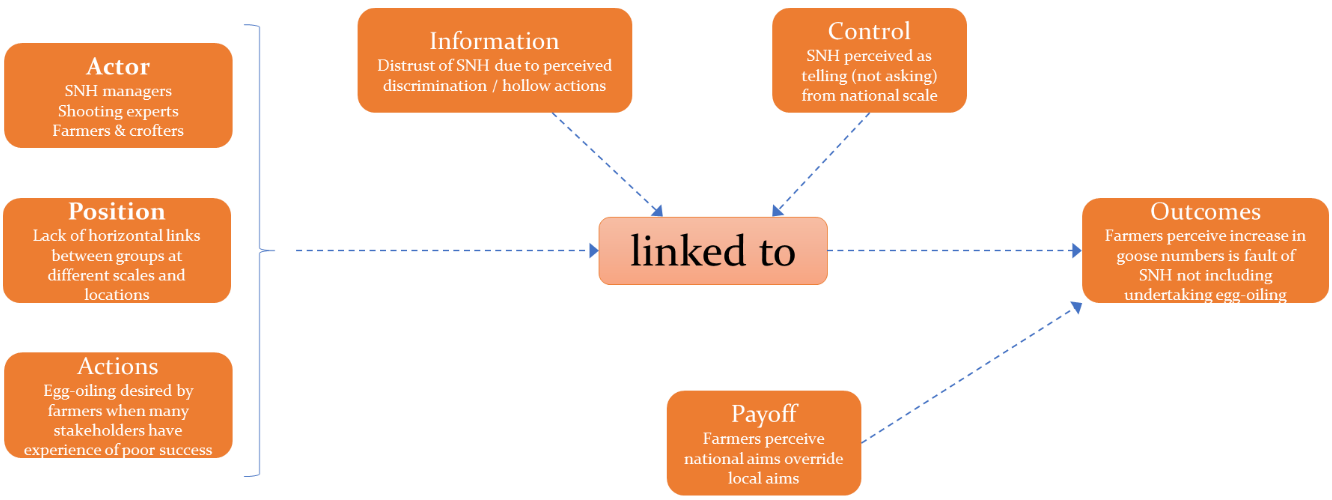


Figure 6 - Action situation describing how scale and location impacts the goose conflict using the example of disagreements over egg-oiling as a goose population control method

3.6.2 Farmer & crofter heterogeneity

It was perceived by most informants from other stakeholder groups, that farmers and crofters shared a common goal of achieving a large reduction in goose numbers. However, although farmers and crofters acknowledged themselves that this was their main goal, within those groups there was a wide spectrum of goals from total eradication to a sustainable population. This finding reflects findings of other researchers who have warned that the false belief in uniformity among stakeholder groups is partly responsible for continued poor understanding of socio-ecological systems (Ostrom et al. 2007). Some farmers and crofters indicated a preferred goal of personal crop protection which led to uncooperative behaviour when they said they would keep successful scaring tactics to themselves rather than share with others. At a landscape scale, pest protection becomes a common pool resource problem, as an individual who does no crop protection may benefit from the effort put in by an active neighbour (Zhang et al. 2007). In addition to variations in goals, farmers and crofters often held different positions. For example, they did not necessarily suffer the same impact. This led to farmers and crofters themselves perceiving that others in their stakeholder group would not cooperate with one another. The impacts of farmer heterogeneity on the conflict as shown as an action situation in Figure 7.

Our findings confirmed that farmers are a diverse stakeholder group with a complex range of perceptions regarding environmental management (Teixeira et al. 2018). Farmers and crofters are the most numerous stakeholder group directly involved in the goose conflict in Scotland, so their participation may be reliant on representative individuals or groups. Increasing diversity of group(s) involved with the participatory process, even within stakeholder groups, can produce benefits such as increased creativity for problem solving (Enayati 2002).

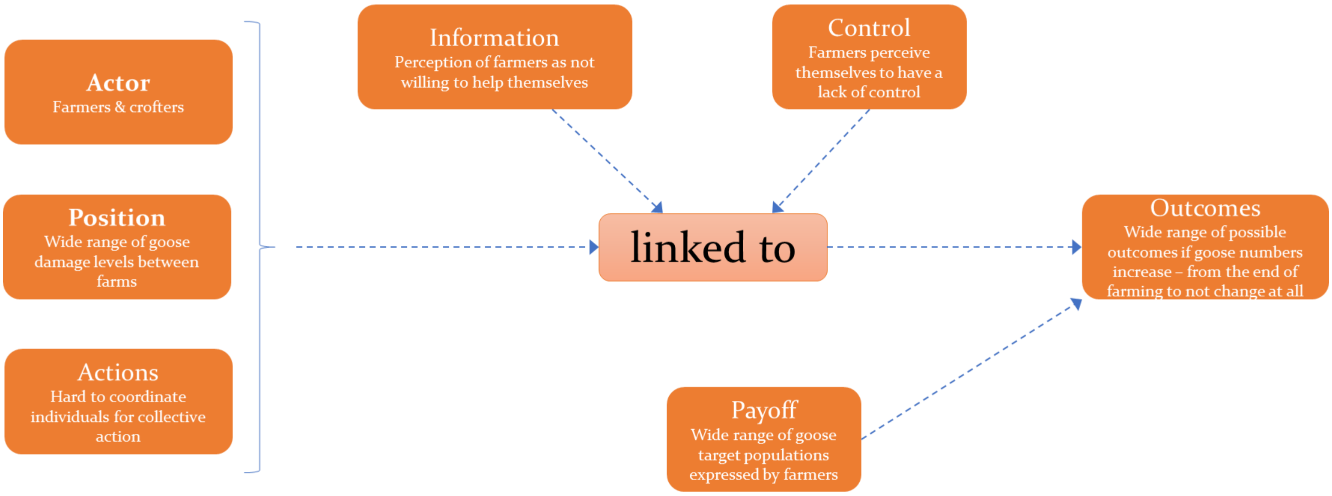


Figure 7 - Action situation describing how farmer and crofter heterogeneity impacts the goose conflict

3.6.3 Emerging shooter trade-offs

Actively seeking win-win outcomes is a cooperative behaviour promoted for conservation conflict management (Redpath et al. 2013; Pound 2015). It is well recognised in the conservation field that trade-offs between different stakeholder goals often prevent perfect win-win scenarios being realised; trade-offs are the norm (McShane et al. 2011). The three objectives set by the NGMRG acknowledge this, giving equal weighting to goose conservation, crop damage prevention and cost efficiency. Often trade-offs are discussed during the planning phase of a project, rather than throughout (Hirsch et al. 2011). This was apparent in both Orkney and the Uists where different trade-offs involving shooters have emerged. In the Uists, there was a trade-off between shooters who need flocks of geese to congregate so large hunting bags can be attained and crofters who need to protect their crops by scaring geese. The benefits of population reduction to the community and benefits of crop protection to the individual were in competition. Orkney shooters enthusiastically volunteered to be part of the scheme as their opportunities to shoot during the open season had diminished through farmers giving exclusive shooting access to paying companies. This seems like a potential win-win, but as circumstances change and expansion of the shooting is required (as is planned), shooters may become wary of losing their newly acquired shooting privileges to others, for example hired marksmen. If the shooters fought to maintain the status quo, the scheme could become locked-in to the current method of population reduction, potentially creating a conflict within a conflict and failure to meet scheme objectives. The impacts of this trade-off as displayed as an action situation in Figure 8.

Goose conflict management in Scotland has already approached trade-offs positively by establishing multi-stakeholder processes and working towards plural objectives. The capacity of conservation management systems to adapt to new challenges is not well understood (Mcleod et al. 2016) but many local individuals interviewed are fully aware of these emerging trade-offs which is a good starting point from which to approach adaptation. Participatory methods for this include scenario planning (Peterson et al. 2003) or games (Redpath, et al. 2018).

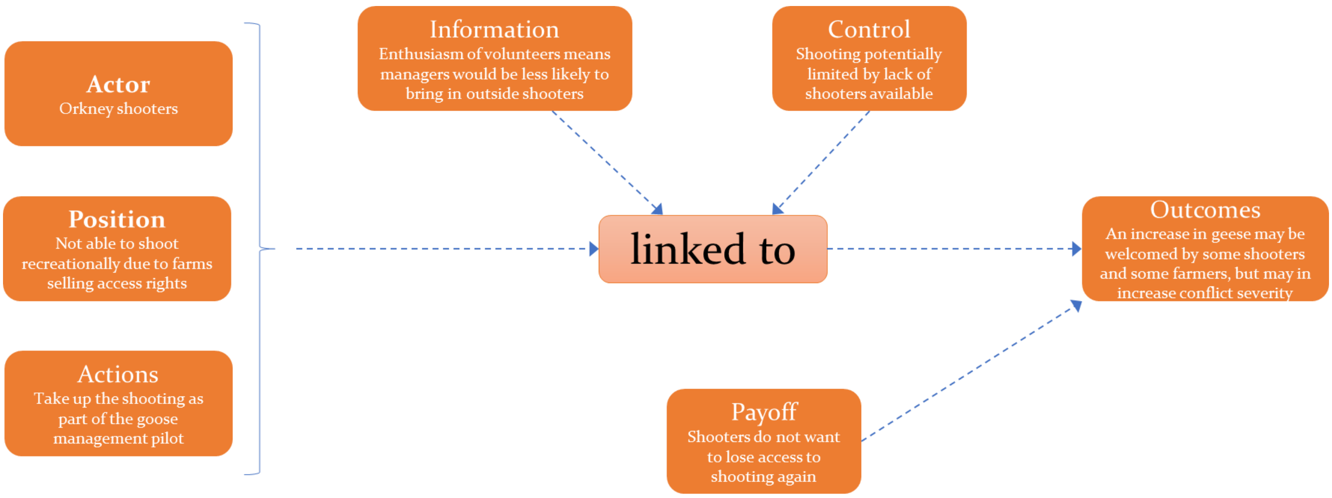


Figure 8 - Action situation describing how an emerging shooter trade-off impacts the goose conflict, using the example of volunteer shooters in Orkney defending their opportunity to shoot

3.6.4 Barriers to cooperation

Political barriers to cooperative behaviour existed due to the perception that some actors were more important and had more influence than others. Large organisations including government, have access to information and staying power that gives them considerable advantages over small, community organisations or individuals (Henmati 2002). Farmers and crofters accused larger organisations of tokenism, which can occur when there are large power disparities in participatory processes (Redpath et al. 2015). This indicated that for all the successes of the distributed decision-making of the LGMGs, many farmers and crofters do not (yet) feel engaged. This is not sufficient for truly participatory processes (Reed 2008).

Knowledge barriers are the result of incomplete understanding of the system. Uncertainty is inevitable and makes decision-making tougher (Polasky et al. 2011). The use of best-practice methods to deal with uncertainty can have undesirable outcomes in complex systems (Mason, Pollard et al. 2018) and this was seen in comparison of goose counting at the two locations. In the Uists, all stakeholder groups were involved in the goose counts which involved a count on a single day twice-yearly and missed out much of the geographical area of the islands. Many crofters questioned both the methodology and the outcome but agreed with SNH that the method was the best available for use in the management of the geese. Contrastingly, in Orkney the Wildfowl & Wetlands Trust produce a more accurate and robust count of the geese. Counting requires shooting to cease but is scheduled during a period of August when shooters are most active in population reduction. This resulted in conflict between shooters and conservation managers.

There were also several operational barriers which prevented stakeholder from carrying out practical cooperative actions, such as a skills shortage in shooting in the Uists. Inability to implement agreed tasks effectively can undermine decisions, hard won through cooperative behaviour (Agrawal & Gibson 1999).

3.6.5 Methodology and theoretical considerations

We concentrated on three main stakeholder groups involved in the goose conflict in Scotland. We did not include individuals who had not been directly involved in goose conflict in at least one of the locations. It is clear that regional or national scale actors have a large influence on the cooperative behaviours of individuals through vertical interactions. To address this, we decided to include their influence as externalities to the local conflicts, rather than expand data collection to 'off-island' informants. The snowball sampling used may have been biased by the social networks of the initial key informants (Reed et al. 2009). We were primarily concerned with cooperation around the LGMGs, which themselves have a low number of members and we interviewed representatives from all the groups consistently named by informants in the stakeholder identification.

Conservation conflict is a sensitive subject which can result in biased responses from face-to-face interviews (St. John et al. 2010). Informants can avoid certain questions or answer dishonestly to avoid losing face, revealing illegal activities or politically charged or socially unacceptable actions (St. John et al. 2010; Drury et al. 2011). To partially counteract this, we assured informants of confidentiality prior to interviews which is known to improve honest responses (Singer et al. 1995). Manipulation of researchers during interviews happened on several occasions as informants actively encouraged the interviewer to pass on sensitive comments specifically criticising other individuals and stakeholder groups (we did not) to try and affect change. This only occurred with farmers and crofters talking about conservation managers, suggesting that they viewed the researchers as having access to or influence over conservation groups.

The IAD framework we used was designed for the purpose of increasing understanding of the institutions surrounding natural resource management, so assumes a natural resource is the foundation of the system, then builds complexity upwards by adding individual behaviour (Ostrom 2011). We took advantage of framing conflict as a trade-off between ecosystem services and disservices (Ceaușu et al. 2018), to fit geese into the role of a natural resource about which individuals interact. This allowed us to answer our research questions by focusing data collection into seven specified criteria and then using the relationships between those criteria as proposed by Ostrom (2011) in the action situation (Figure 5), to draw out common themes. A general advantage to this framework is the ability to explore emergent themes in a consistent and therefore comparable way. More specifically it ensures that the criteria and relationships identified as common across systems of natural resource institutions are suitably investigated and important constituents of themes are not overlooked.

However, using the IAD for studying conservation conflict is not without limitations. Firstly, although the IAD is grounded in the individual scale, it is most often applied at aggregate level missing heterogeneity within groups (Orach &

Schlüter 2016). The reason for this became clear as we explored the variability between individuals, but due to resource constraints on data collection and analysis we did not explore upwards through institutional scales to fully understand the vertical relationships which were so often mentioned as important by our informants. Secondly, individuals in the IAD are boundedly rational, fallible learners, assuming individual learning through trial and error. The model of policy change in the IAD is gradual, stepwise and unidirectional, through learning and cooperation (Ostrom 2011; Orach & Schlüter 2016). These models of behaviour and change fit well for an IAD evaluation of local adaptive co-management (Whaley & Weatherhead 2014), but in conservation conflict, cooperative learning is plagued by complexities of perceived impartiality and trust (Redpath et al. 2015; Young, Searle, et al. 2016). If using the IAD for understanding conservation conflict, learning itself must be viewed as a value laden process.

3.7 CONCLUSION

This work adds to the literature regarding cooperation between stakeholders in conservation conflict in three ways. Firstly, distributed participatory processes still need to be considered as part of a whole, or may paradoxically risk the loss of cooperation at local scales. Evaluation of horizontal and vertical links between distributed groups can achieve gains through shared learning and avoid losses from perception of unfairness. Secondly, heterogeneity of stakeholder groups should be represented appropriately according to the level of the process – representation of farmers by, for example a union official, is appropriate at the national level, but the same strategy fails to include the diversity of stakeholder positions and goals at the local level, hindering cooperation. Finally, the propensity of stakeholders to cooperate will change with the emergence of new trade-offs. As adaptive management projects experiment and update to changing circumstances, so conservation conflict management should be encouraged to do the same. Conservation conflict is a complex problem and the structures and processes to manage it need to mirror this.

3.8 SUPPORTING INFORMATION

Pilot interviews

The first three interviews (all Orkney) were conducted on the same day and were used as a pilot for the interview guide. Questions additional to those on the pilot question list, were asked during the course of the pilot interviews as conversation developed and so small changes were made to the interview guide for the main study. Questions removed were: How would you describe resolution? How has the list of stakeholders changed over time? Is [stakeholder] making progress towards their goals? Are you part of [stakeholder] and do you have influence? Is [stakeholder] an important player regarding impact on you personally? How does [stakeholder] see the threats you have to cope with? Questions added were: What actions [stakeholder] take to achieve their goals? Do you interact with this group and if so, how? Data collected during the pilot were included in the final analysis.

Interview guide

Section 0 – Interview details
Location
Interview number
Date
Section 1 – Background
Age
Gender
Residence (current, previous)
Occupation / role (current, previous)

Section 2 – Views on geese
Describe your views on the geese
Describe the impacts of the geese on you and others

Section 3 – Stakeholder analysis
Please list all the stakeholders (including yourself, individuals, groups, and organisations) involved with or impacted by geese in [Orkney or the Uists]
For yourself –
Regarding management of geese:

- What is your goal and why?
- What actions do you take to achieve your goal?
- What additional actions could you take to achieve your goal?
- What stops you from taking these additional actions?
- Are you an important player in goose management and if so, how?

For each of the stakeholders listed -
Regarding management of geese:

- What is their goal and why?
- Do you interact with this group and if so, how?
- What actions do this group take to achieve their goals?
- What additional actions could they take to achieve better outcomes?
- What stops them from taking these additional actions?
- Is this group an important player in goose management and if so, how?

Section 4 – Opportunities & threats
Other than geese, list the major threats that you cope with in your occupation / role
Describe how these threats compare with the impacts of geese.
Describe how the future would be if management actions did not resolve the goose issue and the population increased significantly
Describe how the future would be if management actions did resolve the goose issue and the goose population decreased significantly

Section 5 – Additional information
Do you have any additional comments or information regarding what we've discussed today?

Participant Consent Form

I have been informed:

- Of the aim of the project;
- That my responses will be kept confidential within the research team and I will not be identified or identifiable in any report resulting from this research;
- I have the right to access the data files containing my responses at any time in the future.

Initial: __________

I agree to take part in this study:

______________________	____________________	_______________________
Name of participant	Date	Signature
______________________	____________________	_______________________
Name of investigator	Date	Signature

Chapter 4

The impact of uncertainty on cooperation intent in a conservation conflict

A version of this chapter has been accepted for publication as:

Pollard, C.R.J., Redpath, S.M., Bussière, L.F., Keane, A., Thompson, D.B.A., Young, J.C, and Bunnefeld, N. (2019) The impact of uncertainty on cooperation intent in a conservation conflict. *Journal of Applied Ecology,* (56), 1278–1288. doi: 10.1111/1365-2664.13361.

CP, SR, AK, JY, and NB conceived the ideas and designed the methodology. CP collected and analysed the data and led the writing of the manuscript. LB, AK, and NB contributed advice on statistical analyses and modelling. All authors contributed critically to the drafts and gave final approval for publication.

4.1 ABSTRACT

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.

We tested the effect 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: i) scientific uncertainty about the effectiveness of a conflict-reduction intervention; ii) administrative uncertainty about intervention funding; or iii) 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.

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.

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 isn't reduced outright or commitments between parties are not strengthened. This has wide applicability, supporting the need for researchers and government advisers to: i) determine how uncertainty will impact intention of stakeholders to cooperate; and ii) take steps (such as uncertainty reduction,

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

4.2 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. 2016). 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 et al. 1996). Rittel & 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 & Dannenberg (2012) used lab 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 lab 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 et al. 2006). In Northern Europe, reduction of agricultural yield due to grazing of wild geese is a well-documented problem (Cusack et al. 2018; Simonsen et al. 2017). Methods for reducing goose damage to crops include regulating population (e.g. shooting), non-lethal scaring, or providing sacrificial feeding areas (Fox et al. 2017). 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 as 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 there 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. (Mitchell et al., 2010; Bainbridge, 2017). 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 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.

4.3 METHOD

4.3.1 Study area

North Uist, Benbecula, and South Uist (hereafter, the Uists), are part of the Outer Hebrides; an island chain off the North-West 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 et al. 2016). Greylag geese can be legally shot during a winter open season (September to February). Out of season, geese can be shot under license 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 (Ferguson 2016). A five-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 (Ferguson 2016). The goose management 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 goose management pilot covers areas on the western side of the Uists where the arable crops are grown and uses population modelling of the geese to determine annual shooting targets (Ferguson 2016).

4.3.2 Crofter recruitment and data collection

In August 2016 a list of all crofts in Uist (N=1579) 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 conducted the data collection face-to-face 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 et al. 2011). For full recruitment, pilot and collection methods, see 4.7 Supporting Information. Ethical approval for this study was granted by Biological and Environmental Sciences Ethical Review Committee, University of Stirling.

4.3.3 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 et al. 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 willing to pay 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 willing to pay but could not specify an amount, the modal WTP amount identified during piloting (£50 year^{-1}) was used for C_{wtp}.

4.3.4 Cooperation scenario

We presented crofters with four scenarios, each detailing a hypothetical goose management plan, using summary cards (see Figure 10, Supporting information) 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 13). 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 $C_d + C_{mp} = C_{wtp} + 0 = C_{wtp}$. 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 13):

- 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}.
- 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 order in which the following three treatments were presented was randomised. The fixed annual costs remain the same so as time increases, the average payoffs for all four scenarios are equivalent (Table 13). 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 allows crofters to express confidence in their prediction, responding with the wager spread over a large or small range.

4.3.5 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 willingness to pay 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 14.

Table 13 – 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 19 (Supporting information) shows a worked example.

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

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.

Table 14 - 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)

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 criterion values (AICc) calculated using maximum likelihood. No interactions between variables resulted in a better fitted model, according to AICc. Best fitting models (ΔAICc<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 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 et al. 2010).

All model analyses were done in RStudio version 1.0.136, running R version 3.1.2., and using R packages lme4 (Bates et al. 2014), glmmADMB (Bolker et al. 2012) and pROC (Robin et al. 2011).

4.3.6 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 14): 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).

4.3.7 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 willing to pay 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 (Zuur et al. 2010).

4.3.8 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 14, IG7) and a binary predictor (cooperate / defect) variable indicating if the crofter had chosen to cooperate themselves under the equivalent scenario. We again used generalised linear mixed effects models (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.

4.4 RESULTS

Crofters had a mean (± SD) age of 58 (± 14) years and had been crofting for 32 (± 19) years. Of the crofters contacted (n=254), we interviewed 149. The remaining 105 either could not be contacted (49), were assessed as inappropriate for interview due to, ill health or on advice of family members (22) or declined to be interviewed

(34). All best fitted models had ΔAICc ≤ 2 (Tables 20 - 23 (Supporting information) for the output of all best fitted models). Results from the simplest (lowest number of predictor variables) of each best fitted model and predicted effect sizes are described below and in Table 16 and Table 17**.** Population level data for each predictor variable used in the models can be seen in Supporting Information.

4.4.1 Intention to cooperate

Most of the crofters who were interviewed (76.5%; 95%CI = 69.1-82.6%) were willing to pay for goose management. Reasons for crofters being unwilling to cooperate (UTC) are shown in Table 15. The most common reason under no uncertainty was that geese didn't 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 9, Table 16). 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 didn't (at mean time crofting (32 years), showing concern for others P(coop) = 0.86, no concern for others P(coop) = 0.63) (Table 17). Fixed effects accounted for 13% of total variation in the model but there was essentially no variation between locations. There was no significant difference (assessed by AICc) between models with and without the random variable. The area under the curve (AUC) of the receiver operating curve (ROC) was 0.72.

Under all treatments of the cooperation scenario, most crofters were willing to pay for goose management. Under the uncertainty scenarios, type of uncertainty was the only significant predictor variable for intention to cooperate (Figure 9, Table 16). In the absence of uncertainty (baseline), predicted probability of cooperation was >0.98 (Table 17). 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 17). 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.

4.4.2 Willingness To Pay - amount

The modal WTP amount was £50 year^{-1} and the mean £59.81 year^{-1}. Cost of goose scaring (time) and concern for others suffering damage were the two significant predictor variables for WTP amount (Figure 9, Table 16). A crofter who hadn't spent time scaring geese and wasn't concerned for others would pay £34.16 (Table 17), whereas those who had spent time scaring geese were willing to pay £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 17).

4.4.3 Perception of others' intention to cooperate

Individual cooperation, type of uncertainty, membership of SCF and perceived relative level of goose damage (Figure 9, Table 16) were all significant predictor variables for perception of others' cooperation. 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 17). 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 perceive 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 didn't 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.

Figure 9 - 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 20-23 (Supporting information), for plots A-D, respectively.

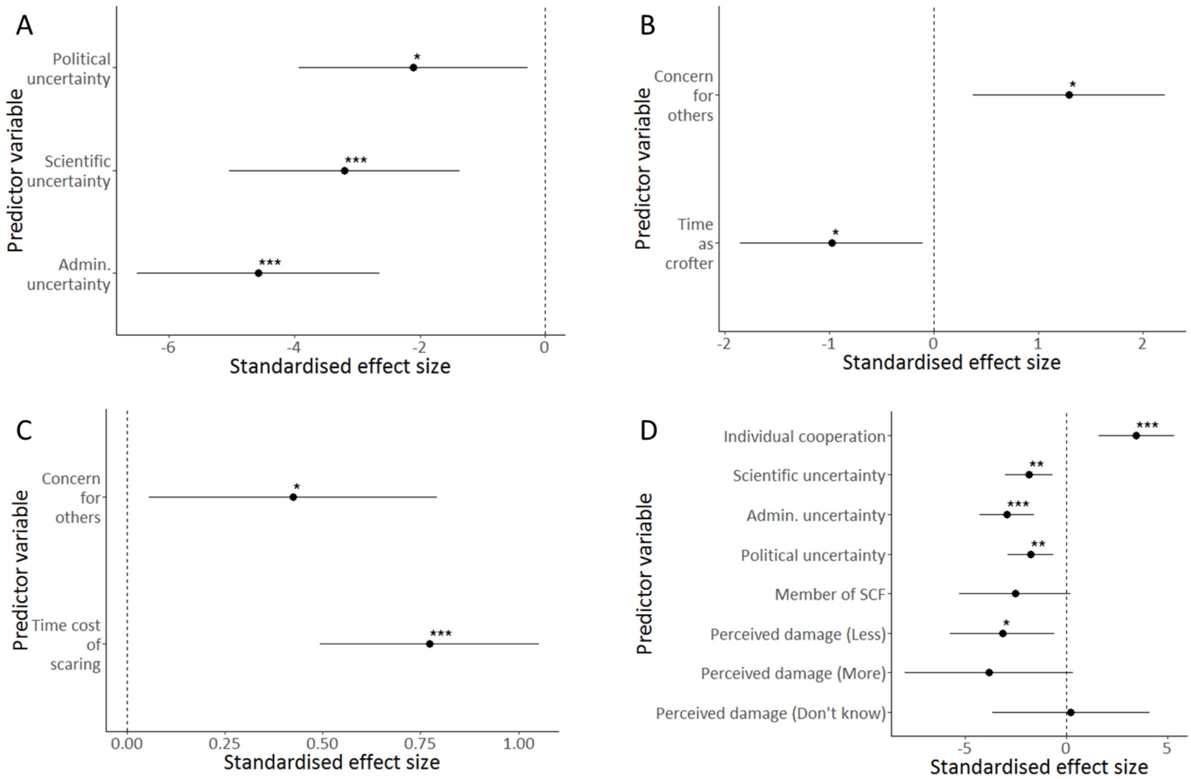


Table 15 - Reasons given by crofters for choosing not to cooperate in the willingness to pay (WTP) and in the three scenarios with uncertainty. n=138 for WTP and 97 for the other three scenarios. Crofters were asked if they were WTP for goose management and if they indicated they would, then they were 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%)

Table 16 - 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** Absence of uncertainty	**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

Table 17 – 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)
[1]32 years crofting - concern for others	0.63 (0.45-0.78)
[1]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:	
[2]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)

[1]32 years is the mean time crofting
[2]Baseline model for comparison: Goose damage wrt Uist (same) - uncertainty + Individual cooperation - membership of the SCF

4.5 DISCUSSION

4.5.1 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 et al. 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 toward 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 15). 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 be reacting to uncertainty directly (Table 15). 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).

4.5.2 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 wouldn't 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 2010a).

The mean WTP amount of £59.81 year^{-1} was similar to the £29.67 year^{-1} (£44.27, adjusted for inflation) which Hanley et al. (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 willing to pay 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.

4.5.3 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 et al. 1977).

4.5.4 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 et al. 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 et al. 2004) 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.

4.5.5 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. 2016). 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. 2017). 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 (Henmati 2002). Longer-term partnerships between managers and scientists are advantageous (Moore et al. 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 et al. 2014). Explicitly including multiple types of uncertainty in established participatory decision-making techniques (such as multicriteria 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, Pollard 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 five-year adaptive goose 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).

4.6 CONCLUSION

Our work illustrates the potential differences in stakeholders' response to uncertainty in the form of cooperation. Using a framed field experiment involving stakeholders who live in the locality of the conflict (rather than volunteers in lab experiments) meant that the experimental treatments applied were not just choices of payoff maximisation, but instead potentially evoked reasons for cooperative decision-making based on stakeholders' context. Reducing scientific uncertainty, at which conservation practitioners are likely to be most skilled, may not be the most important gap to fill if stakeholders do not perceive it as important. 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.

4.7 SUPPORTING INFORMATION

Crofter selection

In August 2016 there were 1579 crofts in the Uists (Registers of Scotland 2016). 1502 of the crofts had a named 'principal occupier'. Duplicates of individuals with the same name and residential address were excluded resulting in a population of crofters N=1149. Residential addresses not in the Uists were also excluded. The order of corfters in the list was then randomised and potential interviewees approached, starting at the top of the list. Of the crofters contacted (n=254), we interviewed 149. The remaining 105 either could not be contacted (49), were assessed as inappropriate for interview due to, ill health or on advice of family members (22), or declined to be interviewed (34). Crofters were most often interviewed alone, but where family members were present and some discussion occurred, the responses of the crofter named from the random sample were used. 79.2% of crofters in Scotland are aged between 41 and 80 years old (Crofting Commission 2017). The mean (±standard deviation) age of crofters sampled was 58.1 (±13.9) years, so 83.3% of those interviewed were between 41 and 80 years old.

An additional 11 crofters were randomly selected for a pilot prior to the main study, which resulted in alterations to the questionnaire to include a wider range of potential goose impacts, and to develop the communication materials explaining the cooperation scenario. The pilot data were not used in the final analysis.

Data collection sheet

Outer Hebrides– goose management data collection

Part 1 – Background

Name:		Age:		Male / Female	
Time living in Uists:		Time spent as crofter:			
Location of croft(s):		Landowner:			
Total area of croft(s):		Area of cropped croft(s):			
Geese on croft(s):	2009 Absent/present Nesting/damage	2013 Absent/present Nesting/damage		2016 Absent/present Nesting/damage	
Current level of goose damage compared to other crofts	Township	Less	Same	More	Don't know
	All of Uists	Less	Same	More	Don't know

List membership of:			
Farming / crofting (e.g. SCF, local):	Agri-environment schemes:	Conservation (e.g. RSPB, local)	Shooting (e.g. BASC, local)

Awareness of Uist Goose Management Group:	Yes / No					
Rate success of Uist Goose Management scheme:	1 poor	2	3	4	5 excellent	Don't know

Do geese impact you in any of these ways? (Tick all that apply)

☐ Eat seed
☐ Eat crop
☐ Soil fields
☐ Trample grass / increase wet area
☐ Force changes in your crofting practice
☐ Negative impacts on people you care about

☐ Costs to replace seed
☐ Costs to replace crop / buy feed
☐ Costs for scaring equip.
☐ Noise bothers you
☐ Risk of disease to livestock
☐ Stress

☐ Other: ______________

☐ Your time spent scaring
☐ Your time spent at meetings about geese
☐ Damage to natural habitat (Machair)
☐ Negative impact on other wildlife

☐ Other: ______________

Given the impacts listed above, if possible **would you pay a fee** to mitigate <u>all</u> of these impacts?	Yes / No
How much would you be prepared to pay each year to mitigate <u>all</u> of the impacts?	£

Part 2 – Scenario decisions

Decision	**Description**	**Sign up**	**Reasons**
1	Baseline	Yes / No	

0-5%	6-10%	11-15%	16-20%	21-25%	26-30%	31-35%	36-40%	41-45%	46-50%	51-55%	56-60%	61-65%	66-70%	71-75%	76-80%	81-85%	86-90%	91-95%	96-100%

2		Yes / No	

0-5%	6-10%	11-15%	16-20%	21-25%	26-30%	31-35%	36-40%	41-45%	46-50%	51-55%	56-60%	61-65%	66-70%	71-75%	76-80%	81-85%	86-90%	91-95%	96-100%

3		Yes / No	

0-5%	6-10%	11-15%	16-20%	21-25%	26-30%	31-35%	36-40%	41-45%	46-50%	51-55%	56-60%	61-65%	66-70%	71-75%	76-80%	81-85%	86-90%	91-95%	96-100%

4		Yes / No	

0-5%	6-10%	11-15%	16-20%	21-25%	26-30%	31-35%	36-40%	41-45%	46-50%	51-55%	56-60%	61-65%	66-70%	71-75%	76-80%	81-85%	86-90%	91-95%	96-100%

Table 18 - The mean cost of negative goose damage under uncertainty (Duc), mean cost of the management plan under uncertainty (Cuc), and mean threshold number of crofters choosing "cooperate" required for management plan to be enacted under uncertainty (Thuc) are equal to when no uncertainty is present, respectively. Thus, on average, all three treatment scenarios have equal costs and thresholds as each other and the baseline scenario.

Source of uncertainty per scenario	Mean uncertainty
Scientific	
D_{uc}	$= (P(D_{low})*D_{low}) + (P(D_{high})*D_{high})$
	$= 0.5*0.25C_{wtp} + 0.5*0.75C_{wtp}$
	$= 0.125C_{wtp} + 0.375C_{wtp}$
	$= 0.5C_{wtp}$
Administrative	
C_{uc}	$= (P(0)*0) + (P(C_{high})*C_{high})$
	$= 0 + 0.5*0.5C_{wtp}$
	$= 0.25C_{wtp}$
Political	
Th_{uc}	$= (P(Th_{low})*Th_{low}) + (P(Th_{high})*Th_{high})$
	$= 0.5*0.25N + 0.5*0.75N$
	$= 0.125N + 0.375N$
	$= 0.5N$

N, total population of crofters in the Uists; 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; $Th_{low} = 0.25N$, low threshold; $Th_{high} = 0.75N$, high threshold; P=0.5, probability of each alternative.

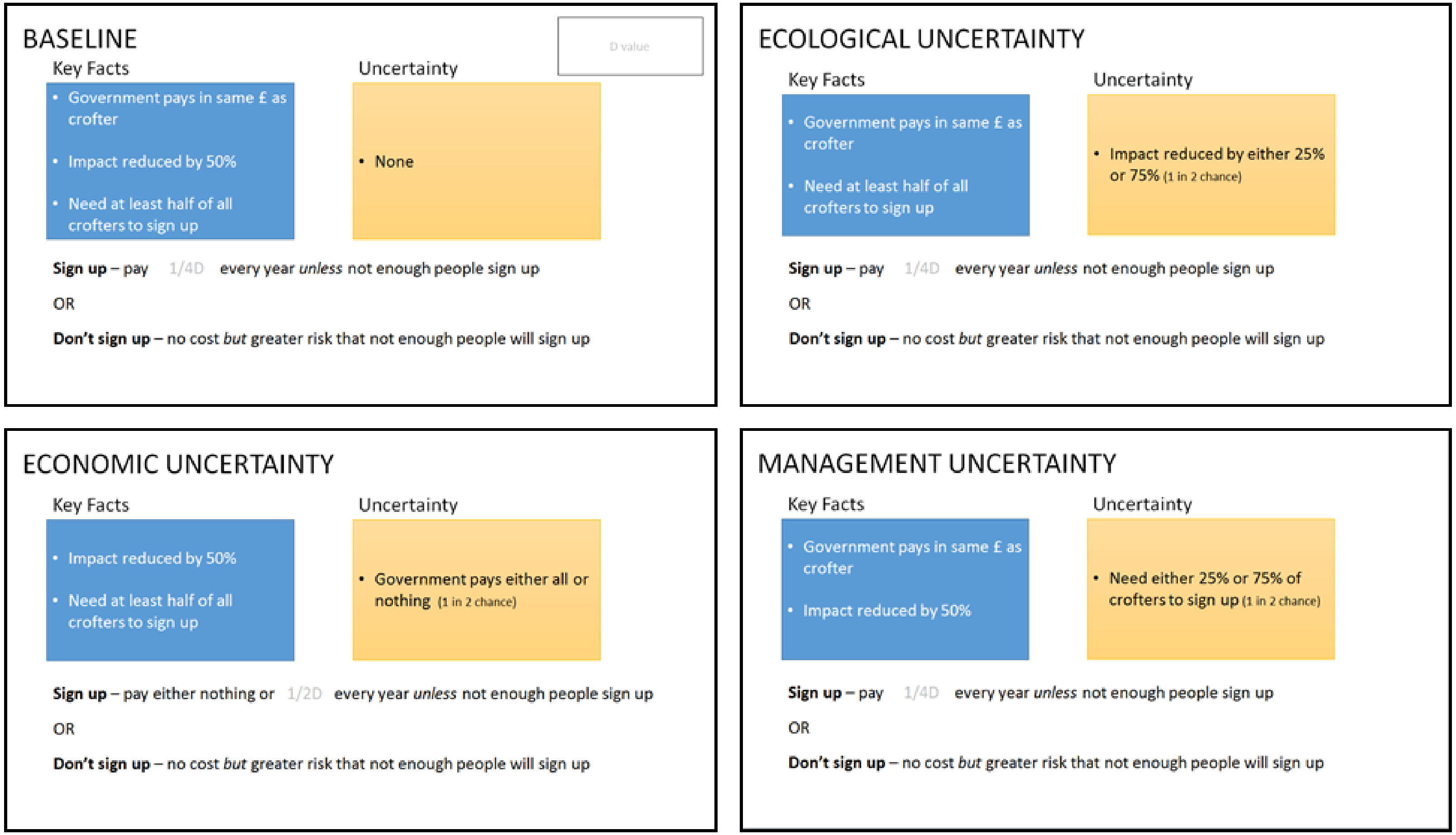


Figure 10 - Summary cards for cooperation scenario. Willingness to Pay (WTP) amount stated by crofter was recorded by the researcher in the box marked "D value" in the top right-hand side of the BASELINE card. The researcher then filled in the spaces on each card occupied with grey text, with the appropriate value. 1/4D for BASELINE, ECOLOGICAL UNCERTAINTY and MANAGEMENT UNCERTAINTY. 1/2D for ECONOMIC UNCERTAINTY. The BASELINE scenario card was always presented first, followed by the remaining three in a random order. The researcher would take the crofter through the scenario, describing the two choices and the potential outcomes and answering any questions. The reseracher would then ask for the crofter to make their choice and give their reason why. This was then repeated for the remaining scenarios. Uncertainty types were renamed to aid communication: ECOLOGICAL UNCERTAINTY is Scientific Uncertainty in this articlle, ECONOMIC UNCERTAINTY is Administrative Uncertainty and MANAGEMENT UNCERTAINTY is Political Uncertainty

Interview script guide

A. **Introduction script**

This short exercise is all about how and why crofters make decisions surrounding goose management. It involves a goose management scheme invented by me. As you will see, this management scheme is quite simple and is designed to find out about decision making rather than promote or suggest any particular solution.

Answers to the questions and any other interactions during the exercise are confidential and you can withdraw your participation at any time should you so wish.

There are two parts to the exercise. Part one starts with a few background questions about you followed by a tick box section about ways the geese on Uist impact you.

Part two presents four scenarios for a goose management scheme. The first scenario is the simplest "baseline" scenario and the following three are slight variations on that baseline. Once each scenario has been explained in turn, I will ask you to answer "Yes" or "No" to whether you would sign up to the scheme and why. I will also ask you to estimate how popular you think such a scheme would be.

Do you have any questions so far?

B. **Presentation of scenarios**

Baseline scenario

You've said that you think it's reasonable to pay £D for a 100% decrease in negative impact of the geese but imagine a more realistic scenario. In this potential project, crofters would pay in and the government would match that amount for every crofter. But the project wouldn't be able to guarantee 100% reduction of impact – only a 50% reduction. So because there's only half the reduction and the government is paying half of the cost, the crofter only pays a quarter of £D which is £0.25D per year.

Also, for the project to go ahead, at least half of all the crofters on the islands would need to sign up. That's North Uist, South Uist and Benbecula.

So the choice you have is either to sign up to the project, pay the £0.25D, add your name to the list to get over that threshold of half all crofters and potentially benefit from the 50% reduction. Or alternatively, don't sign up, which would cost you nothing. You may still get the benefit of the 50% reduction if enough other people sign up, but the project will have 1 fewer person towards meeting that "half all crofters" threshold.

What do you think? Would you sign up for the project or not?

So I want to know what you think other crofters would do in this scenario. If I gave you £20 to wager in pound coins, what percentage of crofters across the Uists do you think would sign up? You can split the £20 across more than block if you like; for example, if you thought it would be between 90% and 100% of people then you could put £10 on each block.

Ecological uncertainty scenario

Ok, this scenario is very similar. Again the government pays in the same amount as the crofters so it will again cost you £0.25D per year. Again at least half of all crofters are needed for the project to go ahead. But this time, there is ecological uncertainty in that a 50% reduction in the impact of the geese cannot be guaranteed.

The ecologists say there is a 1 in 2 chance that there will be a smaller, 25% reduction in impact and a 1 in 2 chance that there will be a larger 75% reduction in impact. It'll either be more than the baseline scenario or less.

Given that you don't know for sure which it will be year on year, would you still sign up (not sign up) in this scenario? Why?

Now, again, how many other crofters do you think would sign up to this project given that we won't know exactly how much the reduction in impact will be? Will it be similar to the previous scenario, more, less?

Economic uncertainty scenario

Ok the third scenario is slightly different again. This time we go back to guaranteeing a 50% decrease in the impact like the first scenario. This time though, there's uncertainty surrounding the amount of money the government can put in. Every year, there is a 1 in 2 chance that the government will be able to pay for the whole thing and crofters won't have to pay anything. But there is a 1 in 2 chance that they can't pay anything and crofters will have to make up the difference. So a 1 in 2 chance that you pay nothing and a 1 in 2 chance that you pay £0.5D.

Given that you don't know for sure how much it will cost year on year, would you still sign up (not sign up) in this scenario? Why?

And how many other crofters do you think would sign up to this project given that they don't know what the cost would be. How will it compare to the two previous scenarios?

Management uncertainty scenario

Ok, the final scenario is very similar again. This time there is a guaranteed 50% reduction in impact and the government is back to paying the same as the crofters, so you will be paying £0.25D per year again. This time though, there is uncertainty in how many crofters are required to sign up in order for the project to go ahead. It would either be 25% of all the crofters or 75% that would be needed.

Given that you don't know how many people are needed for it to happen, would you still sign up (not sign up) in this scenario?

And how many other crofters do you think would sign up to this project given that they don't know how many others are needed to make it happen. How will it compare to the other scenarios?

Table 19 - Example of equations in Table 13, if Willingness to Pay amount (C_{wtp}) = 50GBP

Scenario	Cooperation threshold	Cooperate		Defect	
Baseline	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp} = 50$	**= 50**		
	$N_c \geq 0.5N$	$C_{mp} = 0.25C_{wtp} = 12.5$ $C_d = 0.5C_{wtp} = 25$	**= 37.5**	$C_{mp} = 0$ $C_d = 0.5C_{wtp} = 25$	**= 25**
Scientific $D_{uc}=D_{low}$ or D_{high}, *where* $P(D_{low})=P(D_{high})=0.5$	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp} = 50$	**= 50**		
	$N_c \geq 0.5N$	$C_{mp} = 0.25C_{wtp} = 12.5$ $C_d = D_{uc} = 12.5$ or 37.5	**= 25 or 50**	$C_{mp} = 0$ $C_d = D_{uc} = 12.5$ or 37.5	**= 12.5 or 37.5**
Administrative $C_{uc}=0$ or C_{high}, *where* $P(0)=P(C_{high})=0.5$	$N_c < 0.5N$	$C_{mp} = 0$ $C_d = C_{wtp} = 50$	**= 50**		
	$N_c \geq 0.5N$	$C_{mp} = C_{uc} = 0$ or 25 $C_d = 0.5C_{wtp} = 25$	**= 25 or 50**	$C_{mp} = 0$ $C_d = 0.5C_{wtp} = 25$	**= 25**
Political $Th_{uc}=Th_{low}$ or Th_{high}, *where* $P(Th_{low})=P(Th_{high})=0.5$	$N_c < Th_{uc}$	$C_{mp} = 0$ $C_d = C_{wtp} = 50$	**= 50**		
	$N_c \geq Th_{uc}$	$C_{mp} = 0.25C_{wtp} = 12.5$ $C_d = 0.5C_{wtp} = 25$	**= 37.5**	$C_{mp} = 0$ $C_d = 0.5C_{wtp} = 25$	**= 25**

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.

Table 20 - Full range of response, predictor, study treatment, and random variables used in generalised linear mixed effects models

Response variable	**Description (units)**
Willing to cooperate	Willingness to sign up to a hypothetical goose plan (yes/No)
Willingness to pay	Amount willing to pay for a hypothetical goose plan (£ per year)
Prediction of crofters' response	Prediction of whether at least half of the population of crofters on Uist would sign up to a hypothetical goose plan (Yes/No)
Predictor variables	
Area of croft	Sum area of land worked, including rough grazing and apportionments of machair and hill grazing as reported by the crofter (Hectares)
Croft owner	The organisation from which the croft(s) is leased (North Uist Estates/Owner Occupier/ Scottish Government/Stòras Uibhist)
Membership of the Scottish Crofting Federation (SCF)	Membership of the crofters' representative organisation, SCF at the time of the interview (Yes/No)
Time as a crofter	Time active in crofting (years). If the crofter responded that they had been a crofter all their lifetime or since they had been a child, the value was calculated by subtracting 10 from the crofter's age
Township within LGMG shooting area	Resident in a township within the area covered by the LGMG goose management pilot (Yes/No)
Awareness of the LGMG	Awareness that there is a multi-stakeholder group on Uist which works to manage wild geese (Yes/No)
Extent of goose damage	Damage to land compared to perceived goose damage on an average Uist croft (less/same/more/don't know)
Goose damage suffered in 2016	Goose damage had occurred in the calendar year up to the interview (Yes/No)
Concern for natural habitats	Concern that geese are damaging or will damage natural habitats of the Uists (Yes/No)
Cost of goose damage (financial)	Money paid to replace damaged crops or seed (Yes/No)
Cost of goose scaring (financial)	Money paid for goose scaring equipment, such as rockets or kites (Yes/No)
Cost of goose scaring (time)	Spent time scaring geese themselves in person (Yes/No)
Concern with others suffering damage	Negative impact of goose damage on other people is an impact on them also (Yes/No)
Study treatments	
Uncertainty type	Type of uncertainty present during the treatment (Baseline (no uncertainty)/Ecological/Economic/Management)
Personal cooperation	Willingness to cooperate from Q3 (Yes/No). included as an interaction with Uncertainty type
Random variables	
Unique subject identifier	Accounting for repeated measurements for each crofter
Residential location	Accounting for similarities between crofters from the same township (township name)

Population level data for predictor variables

Crofters had a mean (± SD) age of 58 (± 14) years and had been crofting for 32 (± 19) years. Age and time crofting were strongly correlated (Spearman's rho = 0.627, $p<0.001$), so time crofting was chosen as the variable to be used in subsequent analysis. At least one interview was conducted in each of 70 townships across the Uists. The sample was split North Uist (40.3%), Benbecula (16.8%), and South Uist (43.0%). The primary croft owner for most crofters interviewed was either North Uist Estates (33.6%) or Stòras Uibhist (53.0%), with the remainder resident on a croft owned by Scottish Government (8.1%) or owner occupiers (5.4%). The mean total crofting area in use was 31.6 (± 48.2) ha. In 2016 (the year of interview) one or more geese were reported present on 89.9% (95%CI = 84.1-93.8%) of crofts across the Uists and 73.8% (95%CI = 66.2-80.2%) of crofters reported goose damage to their croft. 22.8% (95%CI = 16.8-30.2%) of crofters were members of the Scottish Crofting Federation (SCF) and 79.9% (95%CI = 72.7-85.5%) were aware that there is a local goose management group (LGMG) which runs a plan aiming to manage the geese. 27.5% (95%CI = 21.0-35.2%) and 25.5% (95%CI = 19.2-33.1%) of crofters interviewed had paid money to replace damaged crop or for goose scaring equipment, respectively. 41.0% (95%CI = 33.4-49.0%) had spent their own time scaring geese. 65.8% (95%CI = 57.8-72.9%) of crofters felt that geese are having a negative impact on the natural habitat in the Uists and 74.5% (95%CI = 66.9-80.8%) felt concern for crofters in the Uists other than themselves who suffer goose damage.

Table 21 - Model selection for Cooperation scenario. Top fitted (ΔAICc<2) generalised linear mixed effects models to determine what variables predict whether a crofter will be willing to pay for a hypothetical goose management plan under uncertainty. Full list of predictor variables see Table 14, only predictor variables which appeared in one or more of the top models are included here N=113. LGMG: local goose management group. Coefficients in bold are significant to $p<0.05$.

	Model label											
	2A		**2B**		**2C**		**2D**		**2E**		**2F**	
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
Crofting												
[1]Time as a crofter					-0.57 (0.56)	0.31			-0.41 (0.58)	0.49		
Township within LGMG shoot area							0.58 (0.73)	0.42			0.44 (0.72)	0.54
Experience of goose impact												
Cost of goose scaring (time)												
Formal organisations												
Awareness of LGMG			-1.14 (0.85)	0.18					-0.99 (0.86)	0.25	-1.07 (0.85)	0.21
Scenario treatment												
Uncertainty type:												
Scientific	**-3.20 (0.94)**	**<0.001**	**-3.21 (0.94)**	**<0.001**	**-3.22 (0.95)**	**<0.001**	**-3.20 (0.94)**	**<0.001**	**-3.22 (0.94)**	**<0.001**	**-3.20 (0.94)**	**<0.001**
Administrative	**-4.57 (0.99)**	**<0.001**	**-4.58 (0.99)**	**<0.001**	**-4.59 (1.00)**	**<0.001**	**-4.57 (0.99)**	**<0.001**	**-4.60 (1.00)**	**<0.001**	**-4.58 (0.99)**	**<0.001**
Political	**-2.10 (0.93**	**0.02**	**-2.10 (0.93)**	**0.02**	**-2.12 (0.94)**	**0.02**	**-2.10 (0.93)**	**0.02**	**-2.12 (0.94)**	**0.02**	**-2.10 (0.85)**	**0.02**
Random variable (variance)												
Location	3.50		3.28		3.45		3.39		3.26		3.23	
Participant number	1.30		1.32		1.24		1.30		1.29		1.29	
Model fit												
AICc	269.9		270.0		270.9		271.3		271.6		271.7	

[1] Effect sized standardised to allow direct comparison of coefficients throughout the model

	Model label			
	2G		**2H**	
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
Crofting				
[1]Time as a crofter				
Township within LGMG shoot area				
Experience of goose impact				
Cost of goose scaring (time)	**0.29 (0.61)**	**0.63**	0.30 (0.60)	0.62
Formal organisations				
Awareness of LGMG			-1.14 (0.85)	0.18
Scenario treatment				
Uncertainty type:				
Scientific	**-3.20 (0.94)**	**<0.001**	**-3.20 (0.94)**	**<0.001**
Administrative	**-4.57 (0.99)**	**<0.001**	**-4.58 (0.99)**	**<0.001**
Political	**-2.10 (0.93)**	**0.02**	**-2.10 (0.93)**	**0.02**
Random variable				
Location	3.36		3.16	
Participant number	1.33		1.34	
Model fit				
AICc	271.7		271.9	

Table 22 - Model selection for Willingness to pay. Top fitted (ΔAICc<2) generalised linear mixed effects models to determine what variables predict if a crofter will be willing to pay for a hypothetical goose management plan. Full list of predictor variables see Table 14, only predictor variables which appeared in one or more of the top models are included here N=138. SCF: Scottish Crofting Federation. LGMG: local goose management group.

	Model label											
	1A		**1B**		**1C**		**1D**		**1E**		**1F**	
Predictor variable	Coeff. (Std Err.)	Pr(>|z|)	Coeff. (Std Err.)	Pr(>|z|)	Coeff. (Std Err.)	Pr(>|z|)	Coeff. (Std Err.)	Pr(>|z|)	Coeff. (Std Err.)	Pr(>|z|)	Coeff. (Std Err.)	Pr(>|z|)
Crofting												
Area of croft	-0.75 (0.47)	0.11			-0.78 (0.47)	0.10	-0.80 (0.47)	0.09				
[1]Time as a crofter	**-1.08 (0.48)**	**0.03**	**-1.21 (0.47)**	**0.01**	**-1.28 (0.52)**	**0.01**	**-1.09 (0.49)**	**0.03**	**-1.39 (0.51)**	**0.01**	**-0.97 (0.45)**	**0.03**
Township within LGMG shoot area												
Experience of goose impact												
Damage suffered in 2016					0.74 (0.60)	0.22			0.67 (0.58)	0.25		
Concern for natural habitats							0.58 (0.48)	0.23				
Cost of goose scaring (financial)												
Concern for others	**1.24 (0.48)**	**0.01**	**1.24 (0.48)**	**0.01**	**1.05 (0.51)**	**0.04**	**1.09 (0.50)**	**0.03**	**1.07 (0.50)**	**0.03**	**1.30 (0.47)**	**0.01**
Formal organisations												
[1]Membership of SCF	**1.49 (0.75)**	**0.05**	1.04 (0.63)	0.10	1.45 (0.76)	0.06	**1.52 (0.76)**	**0.05**	0.98 (0.63)	0.12		
Awareness of LGMG												
Random variable (variance)												
Location	3.6E-15		7.7E-15		0.00		0.00		0.00		0.00	
Model fit												
AICc	134.5		134.8		135.2		135.3		135.7		135.7	

[1] Effect sized standardised to allow direct comparison of coefficients throughout the model

	Model label											
	1G		**1H**		**1I**		**1J**		**1K**		**1L**	
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
Crofting												
[1]Area of croft					-0.77 (0.47)	0.11	-0.76 (0.47)	0.11			-0.71 (0.47)	0.13
Time as a crofter	**-1.21 (0.48)**	**0.01**	**-1.20 (0.48)**	**0.01**	**-1.13 (0.49)**	**0.02**	**-1.11 (0.49)**	**0.02**	**-1.15 (0.48)**	**0.02**	**-1.04 (0.49)**	**0.03**
Township within LGMG shoot area					0.29 (0.49)	0.55						
Experience of goose impact												
Damage suffered in 2016			0.74 (0.57)	0.19								
Concern for natural habitats	0.51 (0.47)	0.28										
Cost of goose scaring (financial)									-0.38 (0.54)	0.48	-0.27 (0.56)	0.63
Concern for others	**1.10 (0.49)**	**0.02**	**1.12 (0.49)**	**0.02**	**1.15 (0.51)**	**0.02**	**1.21 (0.49)**	**0.01**	**1.32 (0.50)**	**0.01**	**1.30 (0.50)**	**0.01**
Formal organisations												
[1]Membership of SCF	1.05 (0.63)	0.10			**1.51 (0.75)**	**0.05**	1.47 (0.76)	0.05	1.10 (0.64)	0.08	**1.51 (0.75)**	**0.05**
Awareness of LGMG							0.33 (0.60)	0.58				
Random variable (variance)												
Location	0.00		5.5E-15		2.1E-15		0.00		0.00		6.0E-15	
Model fit												
AICc	135.8		136.2		136.4		136.4		136.5		136.5	

[1] Effect sized standardised to allow direct comparison of coefficients throughout the model

Table 23 - Model selection for Willingness to Pay – Amount. Top fitted (ΔAICc<2) generalised linear mixed effects models to determine what variables predict how much a crofter will be willing to pay for a hypothetical goose management plan. Full list of predictor variables see Table 14, only predictor variables which appeared in one or more of the top models are included here N=113. LGMG: local goose management group.

	Model label											
	3A		**3B**		**3C**		**3D**		**3E**		**3F**	
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
Crofting												
[1]Area of croft					0.10 (0.15)	0.50						
[1]Time as a crofter							-0.18 (0.16)	0.25			-0.11 (0.16)	0.48
Township within LGMG shoot area			-0.19 (0.18)	0.29								
Experience of goose impact												
Damage suffered in 2016	0.31 (0.21)	0.13	**0.41 (0.21)**	**0.05**	0.34 (0.21)	0.10						
Cost of goose damage (financial)												
Cost of goose scaring (financial)	**0.33 (0.18)**	**0.07**	**0.40 (0.19)**	**0.04**	0.34 (0.18)	0.07	**0.39 (0.19)**	**0.04**			**0.40 (0.19)**	**0.04**
Cost of goose scaring (time)	**0.48 (0.18)**	**0.01**	**0.45 (0.18)**	**0.01**	**0.45 (0.18)**	**0.01**	**0.60 (0.17)**	**<0.001**	**0.78 (0.14)**	**6.1E-8**	**0.59 (0.17)**	**<0.001**
Concern for others	**0.42 (0.18)**	**0.02**	**0.48 (0.19)**	**0.01**	**0.42 (0.18)**	**0.02**	**0.39 (0.19)**	**0.03**	**0.43 (0.19)**	**0.02**	**0.39 (0.19)**	**0.04**
Formal organisations												
[1]Membership of SCF												
Awareness of LGMG	0.20 (0.18)	0.26					0.31 (0.18)	0.09				
Random effect (variance)												
Location	0.12		0.13		0.14		0.11		0.13		0.12	
Model fit												
AICc	1023.8		1024.0		1024.6		1024.8		1025.0		1025.3	

[1] Effect sized standardised to allow direct comparison of coefficients throughout the model

	Model label											
	3G		**3H**		**3I**		**3J**					
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)				
Crofting												
[1]Area of croft			0.10 (0.15)	0.49								
[1]Time as a crofter												
Township within LGMG shoot area	-0.09 (0.17)	0.60										
Experience of goose impact												
Damage suffered in 2016												
Cost of goose damage (financial)					0.05 (0.17)	0.76						
Cost of goose scaring (financial)	**0.38 (0.19)**	**0.04**	0.33 (0.18)	0.07	0.35 (0.19)	0.06	**0.37 (0.19)**	**0.05**				
Cost of goose scaring (time)	**0.59 (0.17)**	**<0.001**	**0.58 (0.17)**	**<0.001**	**0.56 (0.18)**	**<0.01**	**0.58 (0.17)**	**<0.001**				
Concern for others	**0.44 (0.19)**	**0.03**	**0.42 (0.18)**	**0.02**	**0.40 (0.18)**	**0.03**	**0.40 (0.18)**	**0.03**				
Formal organisations												
[1]Membership of SCF							<0.01 (0.16)	0.99				
Awareness of LGMG			0.24 (0.17)	0.17								
Random effect (variance)												
Location	0.11		0.10		0.11		0.11					
Model fit												
AICc	1025.5		1025.6		1025.7		1025.8					

[1] Predictors standardised to allow direct comparison of coefficients throughout the model

Table 24 - Model selection for Perception of others' intention to cooperate. Top fitted (ΔAICc<2) generalised linear mixed effects models to determine what variables predict whether a crofter believes others will be willing to pay for a hypothetical goose management plan under uncertainty. Full list of predictor variables see Table 14, only predictor variables which appeared in one or more of the top models are included here N=113. LGMG: local goose management group. SCF: Scottish Crofting Federation. Coefficients in bold are significant to $p<0.05$.

	Model label									
	4A		**4B**		**4C**		**4D**		**4E**	
Predictor variable	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
Background										
[1]Time as a crofter	1.79 (1.10)	0.10	1.78 (1.09)	0.10			2.02 (1.13)	0.07		
Township within LGMG shoot area										
Experience of goose impact										
Cost of goose scaring (time)										
Concern for others			1.81 (1.40)	0.04					1.84 (1.42)	0.20
Goose damage wrt Uist average:										
Less damage	**-2.62 (1.28)**	**0.04**	-2.78 (1.37)	0.07	**-3.16 (1.32)**	**0.02**	**-2.60 (1.27)**	**0.04**	**-2.84 (1.30)**	**0.03**
More damage	-3.89 (2.08)	0.06	-3.91 (2.05)	0.06	-3.82 (2.11)	0.07	-4.10 (2.12)	0.05	-3.86 (2.08)	0.06
Don't know	0.50 (1.96)	0.80	0.32 (1.95)	0.87	0.22 (1.97)	0.91	0.76 (1.98)	0.70	0.03 (1.97)	0.99
Formal organisations										
Membership of SCF	**-2.76 (1.38)**	**0.05**	**-2.78 (1.37)**	**0.04**	-2.54 (1.40)	0.07	**-2.74 (1.38)**	**0.05**	-2.59 (1.39)	0.06
Awareness of LGMG							-1.45 (1.41)	0.30		
Scenario treatment										
Uncertainty type:										
Scientific	**-1.84 (0.60)**	**<0.01**	**-1.85 (0.60)**	**<0.01**	**-1.84 (0.60)**	**<0.01**	**-1.85 (0.60)**	**<0.01**	**-1.86 (0.60)**	**<0.01**
Administrative	**-2.94 (0.68)**	**<0.001**	**-2.95 (0.69)**	**<0.001**	**-2.94 (0.68)**	**<0.001**	**-2.95 (0.69)**	**<0.001**	**-2.95 (0.69)**	**<0.001**
Political	**-1.76 (0.58)**	**<0.01**	**-1.77 (0.59)**	**<0.01**	**-1.76 (0.58)**	**<0.01**	**-1.77 (0.58)**	**<0.01**	**-1.77 (0.59)**	**<0.01**
Individual cooperation	**3.51 (0.96)**	**<0.001**	**3.52 (0.96)**	**<0.001**	**3.45 (0.96)**	**<0.001**	**3.49 (0.96)**	**<0.001**	**3.47 (0.97)**	**<0.001**
Random variable										
Location	1.37E-13		0.00		0.00		-9.10E-14		-9.82E-15	
Participant number	16.35		16.14		16.96		16.35		16.95	
Model fit										
AICc	364.2		364.6		364.9		365.3		365.3	

[1] Predictors standardised to allow direct comparison of coefficients throughout the model

	Model label									
Predictor variable	**4F**		**4G**		**4H**		**4I**		**4J**	
Background	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)	Coeff. (SE)	Pr(>|z|)
[1]Time as a crofter	2.06 (1.06)	0.05	1.85 (1.09)	0.09	1.99 (1.12)	0.08	1.72 (1.10)	0.12	1.85 (1.10)	0.09
Township within LGMG shoot area			-1.10 (1.13)	0.33					-0.74 (1.11)	0.50
Experience of goose impact										
Cost of goose scaring (time)										
Concern for others	2.32 (1.36)	0.09	2.09 (1.43)	0.15	1.72 (0.13)	0.22				
Goose damage wrt Uist average:										
Less damage			**-2.69 (1.34)**	**0.05**	-2.28 (1.26)	0.07	-2.44 (1.30)	0.06	**-2.92 (1.37)**	**0.03**
More damage			-3.77 (2.04)	0.06	-4.09 (2.09)	0.05	-4.07 (2.12)	0.05	-3.80 (2.06)	0.07
Don't know			-0.06 (1.96)	0.97	0.57 (1.97)	0.77	0.33 (1.98)	0.87	0.34 (1.97)	0.86
Formal organisations										
Membership of SCF	**-2.85 (1.31)**	**0.03**	**-2.90 (1.37)**	**0.03**	**-2.77 (1.37)**	**0.04**	**-2.93 (1.42)**	**0.04**	**-2.84 (1.38)**	**0.04**
Awareness of LGMG					-1.32 (1.40)	0.35				
Scenario treatment										
Uncertainty type:										
Scientific	**-1.80 (0.58)**	**<0.01**	**-1.84 (0.60)**	**<0.01**	**-1.86 (0.60)**	**<0.01**	**-1.85 (0.60)**	**<0.01**	**-1.83 (0.60)**	**<0.01**
Administrative	**-2.87 (0.66)**	**<0.001**	**-2.93 (0.68)**	**<0.001**	**-2.96 (0.69)**	**<0.001**	**-2.95 (0.69)**	**<0.001**	**-2.93 (0.68)**	**<0.001**
Political	**-1.71 (0.57)**	**<0.01**	**-1.76 (0.58)**	**<0.01**	**-1.77 (0.59)**	**<0.01**	**-1.77 (0.58)**	**<0.01**	**-1.76 (0.58)**	**<0.01**
Individual cooperation	**3.45 (0.94)**	**<0.001**	**3.53 (0.96)**	**<0.001**	**3.50 (0.96)**	**<0.001**	**3.50 (0.96)**	**<0.001**	**3.51 (0.95)**	**<0.001**
Random variable										
Location	1.17E-13		9.38E-14		1.21E-13		5.16E-14		0.00	
Participant number	16.09		15.79		16.14		16.45		16.14	
Model fit										
AICc	365.6		365.8		365.8		365.9		365.9	

[1] Predictors standardised to allow direct comparison of coefficients throughout the model

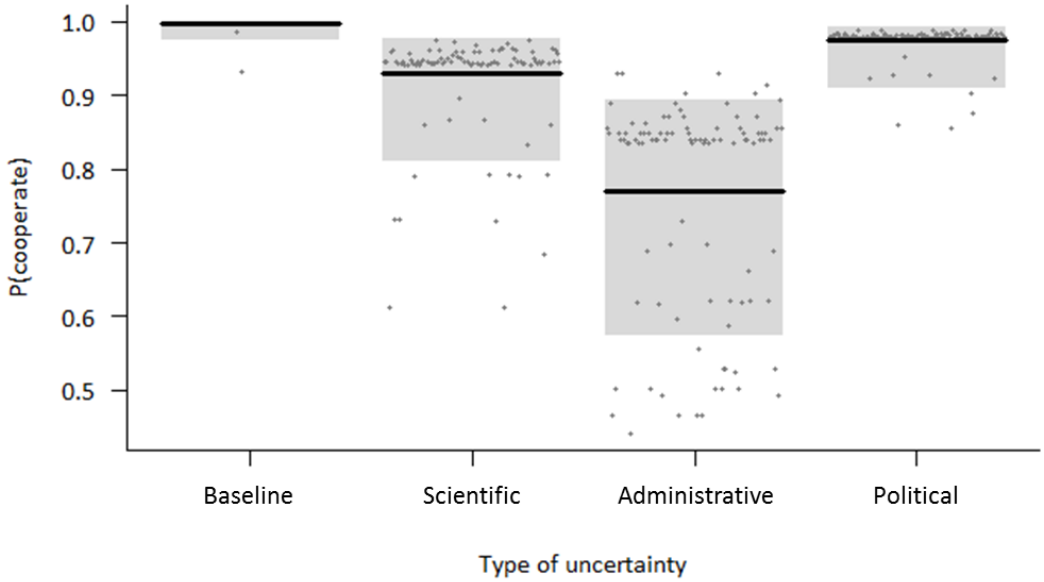


Figure 11 - Probability of cooperation (±95% confidence intervals) of significant predictor variables on intention to cooperate with other crofters on a cooperative goose management plan under different types of uncertainty. Dots are model residuals. Outputs are from the simplest, best-fitting models.

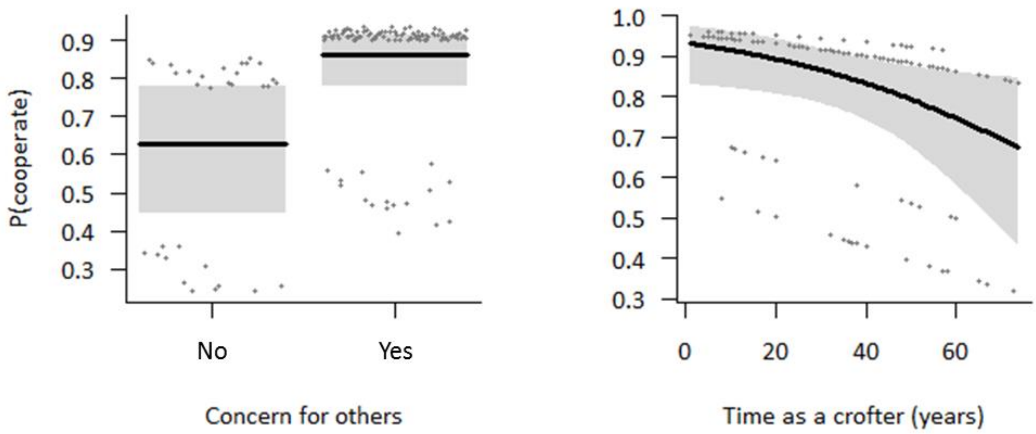


Figure 12 - Probability of cooperation (±95% confidence intervals) of significant predictor variables intention to cooperate with other crofters on a cooperative goose management plan (no uncertainty). Dots are model residuals. Outputs are from the simplest, best-fitting models.

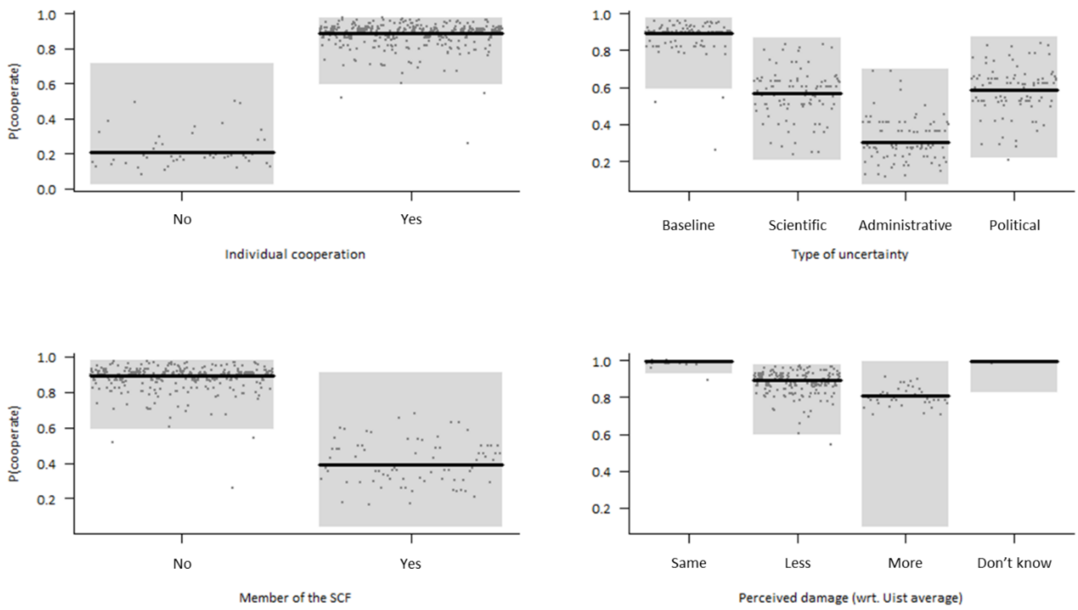


Figure 13 - Probability of cooperation (±95% confidence intervals) of significant predictor variables prediction of others to cooperate on a goose management plan. Dots are model residuals. Outputs are from the simplest, best-fitting models

Chapter 5

How do we successfully manage goose conflict?

Chris Pollard, Steve Redpath, Aidan Keane, Juliette Young, Des Thompson, Luc Bussière and Nils Bunnefeld conceived the ideas and designed the methodology. CP analysed the data and wrote the Chapter. Drafts of the Chapter were commented on by SR, AK, JY, DT, LB and NB.

5.1 ABSTRACT

In Scotland, geese and the conflicts surrounding their impacts on agriculture have been the focus of multi-stakeholder, collaborative management for over a decade. Yet the conflict persists. In light of the findings in Chapters 2 to 4 of this thesis and elsewhere, an appraisal of goose conflict management is appropriate.

Using a conservation conflict management tool for conservation agencies, we evaluatee goose conflict management in Scotland to identify successes and areas for improvement. We then draw on the conclusions made in this thesis and compared with other examples of goose conflict management from Northern Europe and North America, to recommend policy interventions applicable to the Scottish conservation conflict context.

Many existing structures and processes of goose conflict management in Scotland were successful. For example, multi-stakeholder groups at national and local level promoted participation; a set of three shared objectives built consensus between stakeholder groups; decision-making was distributed away from central forums to allow local stakeholders to find appropriate solutions to their context; and local expertise was coupled with scientific best practice to solve problems. Three areas for improvement were identified; i) limited horizontal and vertical interactions meant sharing of knowledge and perception of fairness suffered; ii) trade-offs involving data collection and management action implementation occurred, which exacerbated or have the potential to exacerbate the conflict; iii) multiple sources of uncertainty affect people in different ways and the heterogeneity of the system lacked balance between local and national levels.

In order to build on the successes of goose conflict management so far achieved in Scotland we propose several practical interventions. Increasing interactions between individuals and groups; building data commons for shared learning; identification, acknowledgement, discussion and inclusion of trade-offs as they emerge; and making commitments to balance and fairness across the system. Enacting these recommendations would give goose conflict management in

Scotland greater ability to deliver positive outcomes in what is a continually changing issue.

5.2 THE CHALLENGING CONFLICTS THAT ARISE FROM GOOSE HYPER-ABUNDANCE

Goose population recoveries are hailed as conservation successes but this has been accompanied by disagreements arising between parties supporting goose conservation (e.g. birdwatchers) and those who suffer the impacts of the damage (e.g. farmers) (Eythórsson et al. 2017; Tombre et al. 2013a; McKenzie 2014; Anderson et al. 2018). Disagreements can become conservation conflicts if the parties clash over conservation objectives and one party is perceived to pursue its interests to the detriment of the other (Redpath et al. 2013).

Conservation conflicts are complex, changing over time and subject to high levels of uncertainty from multiple sources (Redpath et al. 2013; Mason, Pollard et al. 2018). Actively managing conservation conflict is required to achieve both positive social and biodiversity outcomes. Use of multi-stakeholder participatory processes for complex conservation problems are potentially beneficial (Henmati 2002; Balint et al. 2011). They are used to enhance decision-making by including a diverse range of viewpoints, whilst also increasing trust, generating shared learning, and increasing perceived fairness (Reed 2008; Young, Jordan, R. Searle, et al. 2013). To achieve these positive outcomes, the structure and process of the approach require careful design. For example: analysis of stakeholder groups allows systematic and transparent representation; integrating both local and scientific knowledge helps tailor solutions to local context; embedding participation early in the process and not just relying on the existing methods used by stakeholders avoids the limitations of processes designed to solve other problems; and distributing responsibility to give stakeholders independence avoids disenfranchisement of marginalised groups (Reed 2008; Young, Jordan, R. Searle, et al. 2013).

Multi-stakeholder goose management in Scotland has been in place for over a decade which presents an ideal opportunity for an appraisal of the systems in place for managing the goose conflict. We make a distinction between 'goose management' (the practical tasks of controlling goose numbers and limiting crop damage) and 'goose conflict management' (addressing the conflict between stakeholders, related to the geese). We aim not to highlight best practice in goose management, as that is done elsewhere (e.g. Fox et al. 2016; Stroud et al. 2017), but rather to focus on the policy challenge of creating structures and processes suited to the complexity of goose conflict management in Scotland. We use a conflict management tool (Young, Thompson, et al. 2016) to systematically describe the successes of goose conflict management in Scotland and to explore areas for improvement. Then, comparing our findings to other goose conflicts in Northern Europe and North America, we compare successes and failures between case studies and identify policy interventions for strengthening goose conflict management in general.

5.3 BACKGROUND TO GOOSE MANAGEMENT IN SCOTLAND

In Scotland, two goose species, Greenland barnacle geese *Branta leucopsis* and greylag geese *Anser anser,* have seen a population recovery to levels of local hyper-abundance. The Scottish population of Greenland barnacle geese overwintering in Islay has risen from c. 3,000 in 1952 to 46,000 in 2016 (WWT 2017). Non-migratory greylag geese, were restricted to c. 500 breeding birds in the 1930s mostly in the Outer Hebrides, but now breed at various locations across Scotland numbering c. 40,000 (Mitchell et al. 2012; Bainbridge 2017). Population increases were due to decreased persecution, successful conservation interventions (practical and legislative), favourable climate change in breeding grounds, and promotion of farming practices such as improving grassland (Mason, Keane et al. 2018; Bainbridge 2017).

The impacts of rising goose numbers on agriculture led to the formation of the National Goose Forum by Scottish Government in 1997, subsequently replaced by the National Goose Management Review Group (NGMRG) in 2001. The NGMRG remains the national level body for goose issues in Scotland and includes stakeholders representing Scottish Government, conservation organisations, shooting interests, and farming and crofting interests. The NGMRG receives technical guidance from the Goose Science Advisory Group (GSAG). The NGMRG built consensus by having three shared objectives: meet the UK's nature conservation obligations for geese, within the context of wider biodiversity objectives; minimise economic losses experienced by farmers and crofters as a result of the presence of geese; and maximise the value for money of public expenditure (Crabtree et al. 2010).

Decision making for goose management was distributed to Local Goose Management Groups (LGMGs, Figure 14), which were responsible for implementing the NGMRG objectives in their respective contexts. Each locally tailored scheme is managed by the local Scottish Natural Heritage (SNH) office along with representatives from the important local stakeholder groups; mainly Scottish Government, conservation organisations, farmers and crofters, and wildfowl shooters. LGMGs use their own blend of actions to manage geese such as farmer payments for goose feeding areas, shooting, scaring, and population reduction. Funding comes from Scottish Government. However, the level of funding is based on the social and political history of each location rather than a costing linked to required management actions or damage incurred (Bainbridge 2017). All LGMGs use annual goose counts and harvest (bag) data to model goose populations and set future targets for shooting.

Barnacle geese on Islay

Greenland barnacle goose management on Islay involves scaring, population reduction, designated refuge areas, and payments to farmers for sacrificial land (Figure 2, Table 27, Mckenzie 2014; McKenzie & Shaw 2017). A range of goose scaring techniques has been tried on Islay, with limited success primarily due to goose habituation. Population reduction of the Annex 1 listed barnacle geese required derogation under Article 9 of the EC Birds Directive. Conservation NGOs Royal Society for the Protection of Birds (RSPB) and Wildfowl & Wetlands Trust (WWT) jointly lodged a complaint to the European Commission in contest to the population reduction of barnacle geese on Islay (RSPB Scotland & WWT 2015) and withdrew their representatives from the NGMRG (Scottish Natural Heritage 2015), although local RSPB representatives are still involved in LGMG at some locations. Payments to farmers make up the bulk £0.9m of the budgeted £1.6m goose management programme on Islay (Figure 14, Table 27). The current Islay Sustainable Goose Management Strategy began in 2014 and runs until 2024 (McKenzie 2014).

Greylag geese across Scotland

Conflict caused by British greylag geese has resulted in four adaptive management pilot schemes in Orkney, the Uists, Harris & Lewis, and Coll & Tiree (Figure 14, Table 27). Greylag geese can be legally hunted during the open season in winter (September – February) and each pilot scheme has one or two additional periods for controlled population reduction, carried out by volunteers and or paid shooters. No payments are made to farmers for sacrificial land in any of the adaptive management pilots, which resulted in the pilots all being an order of magnitude less costly than the barnacle goose scheme in Islay (highest cost greylag pilot £48k per year, compared to £1.6m per year to manage barnacle geese in Islay) (Figure 14, Table 27).

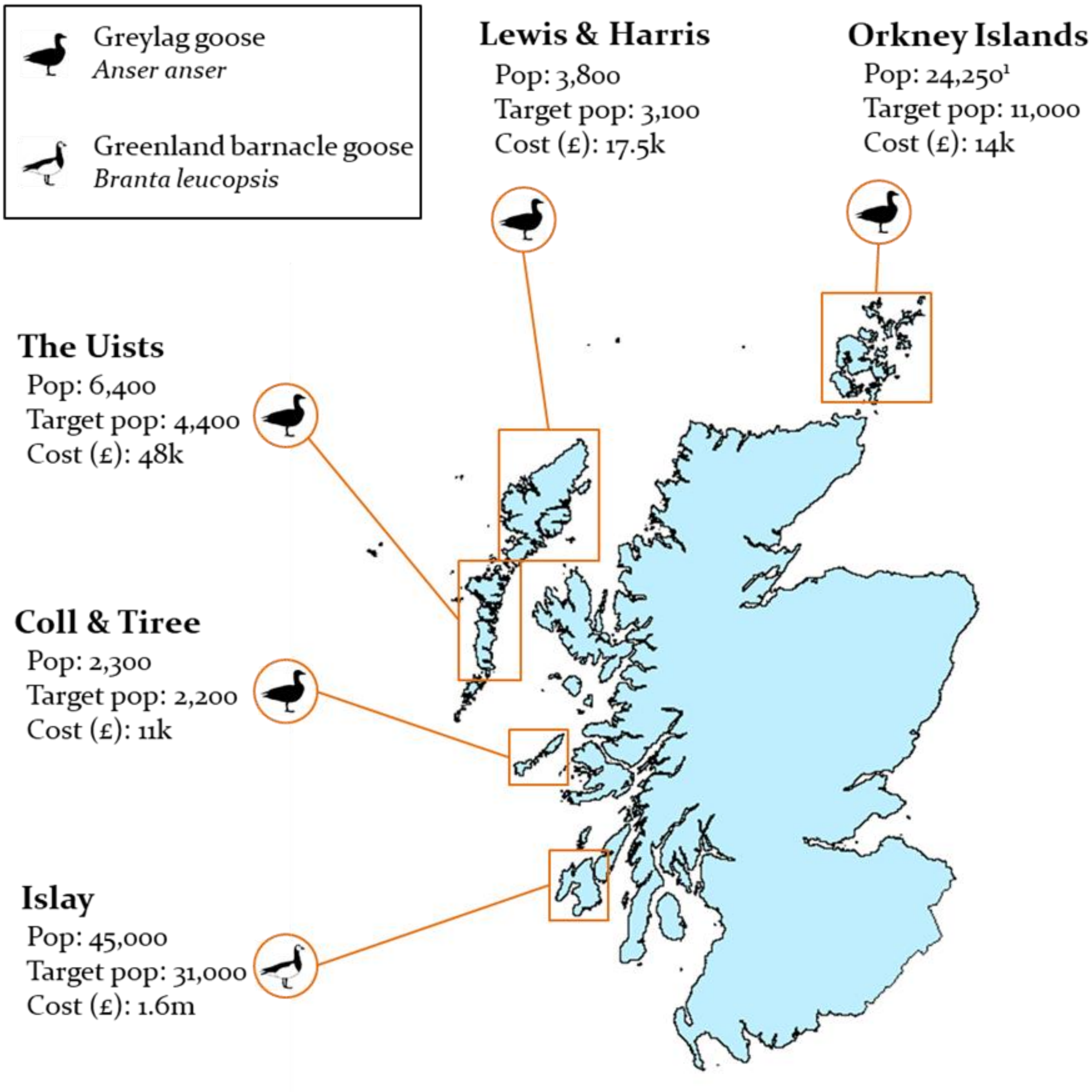


Figure 14 – Locations of goose conflict in Scotland. Label at each location show species of goose for which the Local Goose Management Group LGMG is responsible for controlling. Greylag geese are resident, Greenland barnacle geese are overwintering migrants. Pop: goose population in 2016, Target pop: maximum value of the target population range in the respective LGMG plan, Cost: cost in £GBP allocated for 2016 (2014 for Islay). [1]Greylag goose population in Orkney increases to over 75,000 from November to February due to overwintering migrants. References: Islay (McKenzie 2014; WWT 2017), Coll & Tiree (SNH 2016), The Uists (Ferguson 2016), Lewis & Harris (MacFarlane 2016), Orkney Islands (Mitchell et al. 2016; Churchill 2016). For further details see Table 27. Repeat of Figure 2, from Chapter 1. Goose silhouettes produced by Tom Mason.

5.4 CHALLENGES IN MANAGEMENT OF THE GOOSE CONFLICT IN SCOTLAND

To systematically explore areas for improvement we used a conflict management tool for conservation agencies (Young, Thompson, et al. 2016). This framework asks six stepwise questions to help design multi-stakeholder processes for conservation conflict management (Table 25).

Table 25 - Stages of a conflict management tool for conservation agencies, adapted from Young et al. (2016)

Stage of the conflict management tool
1. Is there a conflict?
2. Is the context of the conflict understood?
3. Is a multi-stakeholder process for conflict management required and / or how should it be structured?
4. Is there a joint understanding of the conflict and its evidence base?
5. Is there a shared goal and agreed process towards reaching this goal?
6. Is there long-term monitoring and management capable of adapting to a changing conflict?

5.4.1 Stage 1 – Is there a conflict?

Disagreements surrounding the management of geese has boiled over into conflict as parties broadly in favour of agriculture or goose conservation clash and perceive one another to be attempting to pursue their interests at the expense of the other. This includes farmers who shoulder the negative impacts of large numbers of geese feeling goose conservation is given greater priority than their livelihood and conservationists seeing farmers as single-mindedly pursuing profit at the expense of habitat and biodiversity. However, there is much more nuance and variability in these stances and in-depth discussions of competing goals and perceptions held by stakeholders are detailed in Chapter 3 of this thesis (for the Uists and Orkney) and in McKenzie & Shaw (2017) and Whitehouse (2009) (for Islay).

5.4.2 Stage 2 – Is the context of the conflict understood?

A wide range of stakeholders have formally contributed to the extensive ecological, economic, and political understanding of goose management in Scotland. For example: academic researchers have shown how ecological data can be better used for goose management in Scotland (Cusack et al. 2018) and the potential economic compensation required for the presence of hyper-abundant geese in Islay (Hanley et al. 2003); conservation charities have conducted robust ecological surveys of geese (e.g. WWT 2017) and challenged Scottish Government on the legality of their management plans (RSPB Scotland & WWT 2015); and Scottish Government have produced national level summaries (e.g. Crabtree et al. 2010). Additional contextual details of conflicts in the Uists and Orkney are in Chapter 3 and for Islay, in McKenzie & Shaw (2017) and Whitehouse (2009).

5.4.3 Stage 3 – Is a multi-stakeholder process for conflict management required and / or how should it be structured?

The structure of the NGMRG and the LGMGs have shown that multi-stakeholder processes are favoured by Scottish Government for goose management in Scotland. Using participatory multi-stakeholder processes for complex and contentious problems is not always feasible. Processes need to be acceptable to stakeholders, practical to implement, and technically, economically and politically possible. A successful multi-stakeholder process demands high level of social resources (time, funding and commitment) and as such can be easily derailed (Balint et al. 2011). Despite these challenges, distributed co-management has been successful at tailoring goose management methods for different locations using the expertise of local stakeholders. For example, in the Uists individual shooters are employed to actively patrol given areas of agriculture, whereas in the Orkney Islands shooting teams made up of volunteers reactively respond to requests from farmers. However, multi-stakeholder processes do not occur in a vacuum and issues of scale need to be considered (Reed 2008; Young, Jordan, R. Searle, et al. 2013). We showed in Chapter 3 that differences between LGMGs (Figure 14, Table 27) have caused anger in farmers in greylag control areas, who see fewer resources for their own LGMG than are made available for barnacle goose management on Islay where the species is different but the impact on crops is the same (Howarth 2018). The membership of national and local groups has changed over time, for instance with RSPB and WWT choosing to leave the NGMRG and the RSPB leaving the Orkney Islands LGMG. In the latter case RSPB felt goose management was a lower priority than their other conservation work locally and the LGMG members generally felt that more efficient coordination of the project could be achieved without formal RSPB input (Chapter 3). Losing a unique viewpoint from the multi-stakeholder processes could cause problems as interactions between stakeholders with diverse opinions and a dense network of individuals can both aid the solving of complex problems likely to arise in the future (Chapter 2). RSPB were also perceived as an important player in Orkney, should they choose to act unilaterally on goose management or if people preferentially interact with them because of their importance, the LGMG may be undermined (Chapter 2).

5.4.4 Stage 4 – Is there a joint understanding of the conflict and its evidence base?

LGMGs trust in the expertise of their members to implement goose control appropriate to the local context. The use of scientific evidence to guide decision making is overseen by Goose Science Advisory Group (GSAG), and technical advice on population modelling and efficacy of practical interventions is shared vertically between local managers and the central SNH coordinator. Scientific evidence on deciding between different management interventions and their efficiency, effectiveness and feasibility is rare (Tulloch et al. 2017; Mason, Keane et al. 2018). However, ideas discussed or tested at one location are not horizontally shared with individuals at another location. For example, in Chapter 3 we discovered how egg-oiling to decrease goose productivity was often seen by farmers, crofters and shooters as a potentially successful intervention even though technical advice shared by managers was to the contrary. This indicated a lack of trust in the technical advice or the reliability of its source. But if individuals tried the method themselves, they generally agreed egg-oiling was not feasible (Chapter 3). The information sharing network which currently relies on centralised coordination rather than horizontal interactions exacerbates any situation where individuals do not trust the source of the advice.

5.4.5 Stage 5 – Is there a shared goal and agreed process towards reaching this goal?

It is clear to stakeholders that they may have different goals to one another, but the NGMRG and LGMGs have successfully agreed on shared objectives (e.g. Ferguson 2016), meaning cooperative actions can be undertaken to manage geese. This includes agreed population targets for each goose management scheme. Still, shared goals alone are not sufficient for cooperation in goose conflict. Chapter 3 showed many farmers are positioned very differently (e.g. geographically, economically, agriculturally) and Chapter 2 suggested that individual farmers do not all interact with the same organisations involved in goose management. Heterogeneity of circumstances and connections makes actions such as cooperative goose scaring tough to achieve, even though individual farmers may all share the same goal of crop protection. Within the same stakeholder group there were also differences vertically, between local and national interests. For example, expanding the market for goose meat sales to help fund goose control was a potential goal shared locally across stakeholder groups in Orkney and the Uists (including conservationists), but there was a perception that steps required to access a larger market were not taken due to the lack of support from influential national conservation organisations (Chapter 3).

Practical implementation of goals can reveal emerging trade-offs between stakeholders (Chapter 3). For instance, shooters in the Uists wanting to efficiently reduce the number of geese require large flocks to gather, but crofters are encouraged to scare geese to protect their own crops. Scaring benefits short-term crop protection but harms efforts to reduce numbers over the longer-term.

5.4.6 Stage 6 – Is there long-term monitoring and management capable of adapting to a changing conflict?

Goose management in Scotland follows adaptive management principles, allowing actions to be changed as their effectiveness becomes apparent. Monitoring for effectiveness is both quantitative through goose counts and population modelling, and qualitative through formal and informal feedback from stakeholders. Producing better model predictions can help prevent disappointment and quell conflict. Cusack et al. (2018) showed that on Islay hunting targets are largely set using population data from the previous year rather than from the same year running the risk of under- or over-harvesting. In Orkney, however, there was no direct link between population and target bag since 2010. Additionally, achieving even a robustly set hunting target can be extremely challenging, and will result in under-harvesting. It is most likely that stakeholders therefore lose trust in the management process. We described in Chapter 3 how SNH in Orkney commission the Wildfowl & Wetlands Trust (WWT) to conduct a goose survey over a four-day period (e.g. Mitchell et al. 2016), but timing of the survey clashes with periods when shooters most want to be culling geese, causing conflict over the management process. Whereas in the Uists, counting is participatory with local crofters, shooters, and conservationists collaborating for a day to count geese. The uncertainty in the data provided by this method is high, but stakeholders accept the methods and appreciate the transparency.

We found in Chapter 4 that scientific uncertainty of goose ecology had less impact on Uist crofters' intention to cooperate with each other, than administrative uncertainty surrounding commitment of external funders. In Islay a 10 year plan has been agreed (McKenzie 2014) allowing a welcome length of certainty and commitment. In all other locations, adaptive management schemes were piloted with five years of government funding. Methods suggested to fund goose management beyond the five years included development of a market for the sale of goose meat in the Uists and Orkney and introducing a small levy on animals sold locally at market in the Uists, but a long-term replacement for government funding has yet to be found.

5.5 BUILDING SYSTEMS TO BETTER MANAGE GOOSE CONFLICT

Having highlighted some of the structures and processes in place for goose conflict management in Scotland, we now suggest improvements aimed at strengthening the Scottish system further. Our suggested system improvements are cross-cutting, each addressing challenges in more than one of the stages in the previous section. We also compare this to common challenges of European and North American goose conflict management and the current Scottish responses to these challenges (Table 26).

5.5.1 Building interactions

Increasing the interaction between currently unconnected stakeholders will help build a system more able to respond to forthcoming complex problems. For instance, Lefebvre et al. (2017) considered management of greater snow goose *Anser caerulescens atlanticus* populations in North America was successful due to interactions between wildlife managers and researchers made before overabundance became an issue. In Scotland, strengthening the network includes building stronger ties between major players such as the RSPB and those in the formal goose management process. Increasing diversity of viewpoints in this way may itself be challenging, but can foster creativity (Mason, Pollard et al. 2018) and build trust and legitimacy in the system (Henmati 2002). Madsen et al. (2017) describe how the adaptive management of the Svalbard pink-footed goose *Anser brachyrhynchus* population across Norway and Denmark was social-resource demanding but successful in achieving shared learning and transparency. The scheme well-documented the entire process (meetings, decisions, data, assessments) and made it all publicly available. In Scotland, ideas discussed or tested at one location by a particular stakeholder group or groups (e.g. experiences of egg-oiling) should be shared via direct interaction with individuals at other locations. Information is more likely to be trusted by a recipient if the source and recipient share characteristics (e.g. both farmers) and if it comes via more than one connection (Bodin 2017). Finally, beyond information sharing, denser networks with more redundant interactions (ties between actors who are otherwise tied) can aid problem solving in complex cooperation-type problems such as the Scottish organisations involved in goose conflict in Scotland may currently be better structured to solving coordination-type problems of efficiency (Chapter 2).

Recommendation - Develop networks of more diverse stakeholders and between individuals and organisations at different LGMG locations. Building data commons using an open-access list of ideas discussed and or tested at each site would aid shared learning in a transparent way.

5.5.2 Managing trade-offs

Stakeholder discussion is vital to make clear trade-offs for all parties (Mason, Pollard et al. 2018). There is an apparent trade-off when conducting goose counts between data quality and participation. This also shows the trade-offs between "goose management" and "goose conflict management," where choosing higher quality data over participation may favour the former but not the latter. Better data does lead to better modelled predictions including reduced uncertainty, but better models don't always help manage conflict. Eythórsson et al. (2017) report how a predictive model developed and used for distributing subsidy payments to farmers for pink-footed goose damage in Norway, was rejected by farmers as it rarely matched the reality of the damage. Instead, farmers favoured a simpler post-hoc compensation system based on monitored damage. In the Uists, trade-offs between scaring geese and population reduction emerged during implementation (Chapter 3). Trade-offs are widely acknowledged as important factors in conservation management, but tend to be front-loaded (e.g. during objective setting) rather than confronted later-on (e.g. during implementation) (Hirsch et al. 2011). In Scottish goose management, stakeholders are aware of these trade-off situations as they arise, but they remain hidden from the formal management processes and the wider network (Chapter 3).

Recommendation - It is not possible to foresee many trade-offs before they occur. Their identification, acknowledgement, discussion, and inclusion in formal plans and reports should be ongoing as a process of conflict management. Learning can then be shared centrally and between LGMGs.

5.5.3 Commitment and understanding

The NGMRG was formed in 2001, with the various goose management schemes following later, leading to an unavoidable top-down direction of institutional design. Distributed decision-making to the LGMG is a successful approach, but differing treatment of goose management schemes in different locations has fed conflict where those at one location feel they have access to fewer resources than those elsewhere (Howarth 2018). Clearly defined and real stakeholder involvement and recognition is required. For example management of pink-footed geese in Norway suffered from a vague compensation plan unequally skewed towards specific areas. Farmers were left to feel there was no real recognition of their economic burden and they lost confidence in the process (Tombre et al. 2013b). Following pressure from farming unions, stakeholders cooperatively developed a workable compensation scheme which the government then decided to fund on a permanent basis. Balancing local concerns at the national level is key to a managing conflict across Scotland rather than just at distinct locations within Scotland.

Multiple sources of uncertainty variably impact people in different ways. While some important elements of the system (e.g. funding) may be beyond the control of stakeholders, national level actors should make strong commitments towards the aims of multi-stakeholder processes (Henmati 2002). This would help alleviate the lower trust individuals in geographically and politically remote positions have in the process.

Recommendation - Stakeholders should indicate a high level of commitment, particularly to bring balance and fairness to the process of funding goose management in Scotland over the medium- to long-term. This acknowledges the uncertainty of the future but brings greater transparency and signals intention to cooperate equally with stakeholders across the locations.

5.6 CONCLUSIONS

Formal goose management in Scotland has evolved over the last two decades to successfully include processes and structures suitable for dealing with the conservation conflict. Creation of multi-stakeholder groups, distributed decision-making, creative solutions, regular formal interactions, and access to scientific support, have all helped to manage the negative aspects of the conflict. The complexity of conservation conflict however, means problems will inevitably change shape over time and persist in one way or another. System processes and structure must change, develop and experiment over time to tackle new aspects of the problem as they appear. Our recommendations aim to give stakeholders better opportunities to use their expertise collaboratively, both currently and to adapt to future problems. We've focussed on: increasing interactions between individuals locally and nationally, to share information and strengthen problem solving networks; capturing the unseen complexity of emerging trade-offs for management and learning; and showing commitment for developing long-term relationships. Applying these recommendations would help goose conflict management in Scotland to build on current successes and continue to deliver positive outcomes for people involved.

Table 26 – Summary of common goose conflict management challenges and the associated structure/process of goose management in Scotland

Common challenges	Example references	Associated structure/process of formal goose conflict management in Scotland
Promoting stakeholder participation	Holmgaard et al. 2018; Tombre et al. 2013b; Lefebvre et al. 2017	Multi-stakeholder groups formed at national and local level designed to include individuals representing major stakeholder groups: government, conservation, farming and crofting, shooting.
Building consensus on management objectives	Johnson et al. 2015; Lefebvre et al. 2017	The NGMRG has three shared objectives, each focussed on a major stakeholder group: farmers, conservationists, and government. LGMGs have adopted these objectives.
Shaping organisational structure	Eythórsson et al. 2017; Johnson et al. 2015	Decision-making is partially distributed away from the central NGMRG, allowing LGMGs to work with local stakeholders to find solutions appropriate for their context.
Bridging gaps between technical & local expertise	Johnson et al. 2015; Tombre et al. 2013b	LGMGs take best practice from central organisations (GSAG, partner organisations) and implement alongside local experts. For example, using centrally built population models to provide bag targets, then developing shooting methods with local shooters.
Coping with multiple sources of uncertainty	Johnson et al. 2015	Established multi-stakeholder groups at local and national levels have range of experience and history of collaborating to solve unexpected problems.
Maintaining momentum under pressure from alternative priorities	Johnson et al. 2015; Lefebvre et al. 2017; Madsen et al. 2017	Local and national groups hold regular meeting of their members and publish annual management plans. SNH maintain priority by employing part- and full-time staff for goose management.
Ensuing transparency and legitimacy of process and science	Johnson et al. 2015; Madsen et al. 2017; Eythórsson et al. 2017	Minutes of NGMRG meetings are available online and local SNH coordinators available for queries. Data collection methods for goose counts and hunting bags differ between locations. Model building is handled centrally.
Retaining collective learning	Tombre et al. 2013b	Feedback sessions between members of the LGMGs. Formal reporting of LGMG plans and outcomes to central coordinator.
Communicating	Tombre et al. 2013a; Eythórsson et al. 2017; Johnson et al. 2015	Regular meetings between stakeholders in local and national groups. Surveys conducted to collect farmer and crofter views. Communication with the public through press releases.

NGMRG, National Goose Management Review Group; LGMG, Local Goose Management Group; GSAG, Goose Science Advisory Group; SNH, Scottish Natural Heritage

Table 27 - Details of goose management schemes in Scotland with high levels of political activity.

Goose species	Greenland Barnacle *Branta leucopsis*	British Greylag *Anser anser*			
Location	Islay	Orkney	The Uists	Lewis & Harris	Coll & Tiree
Goose population	45,000 (McKenzie 2014; WWT 2017)	24,250 (Mitchell et al. 2016)	6,400 (Ferguson 2016)	3,800 (MacFarlane 2016)	2,300 (SNH 2016)
Target population	28,000 – 31,000 (McKenzie 2014)	9,000 – 11,000 (Churchill 2016)	3,600 – 4,400 (Ferguson 2016)	2,500 – 3,100 (MacFarlane 2016)	1,650 – 2,200 (SNH 2016)
Cost	£1.6m (2014) (McKenzie 2014)	£14k (2016) (Churchill 2016)	£48k (Ferguson 2016)	£17.5k (MacFarlane 2016)	£11k (SNH 2016)
Management actions	Counting in Islay & across range (Greenland, Iceland) Compensation per goose (no scaring). Amount based on payment rate for habitat & goose density Special Protected Areas (SPAs) reserved for geese (mainly outside of agricultural areas) Scaring to keep the geese inside the SPAs Scaring methods (McKenzie 2014): takes place on 15-20% of the 6-7k Ha of farmland included in the scheme – the rest is for the geese. Shooting to reduce numbers (controversial) using the Trinder Population Viability Analysis + simpler Excel	Adaptive management pilots: Counting Shooting during the open season Shooting during the closed season (Autumn only)	Adaptive management pilots: Counting Shooting during the open season Shooting during the closed season (Spring & Autumn) Scaring Damage monitoring (reporting from farmers and questionnaire).	Adaptive management pilots: Counting Shooting during the open season Shooting during the closed season (Spring & Autumn)	Adaptive management pilots: Counting Shooting during the open season Shooting during the closed season (Spring only)

	model (endorsed by GSAG). Measuring goose damage with exclosure cages to link goose numbers and goose damage				
Aims (beyond National Strategy Objectives)	Develop habitat management techniques to support Greenland white-fronted geese. Ensure large areas of suitable habitat are available to all species of geese as undisturbed roosting and feeding areas. Maintain a viable number of geese at a level which meets conservation obligations. Ensure there will be no adverse effect on site integrity of the SPAs by considering the conservation objectives of the sites. Reduce the damage to grass crops by reducing the number of barnacle geese on Islay, and therefore reducing the impact of geese on the agricultural economy.	To test whether local populations of resident geese can be managed effectively to maintain a stable population at levels that reduce the impacts of goose grazing on agriculture and retain the conservation interest. To test how effectively shooting levels can be managed, through setting agreed shooting levels and regular monitoring of population levels. This will protect populations from over exploitation, while at the same time reducing agricultural damage. In addition, the Project will be an important test of whether approaches to adaptive management which rely on voluntary recording of bag data are sufficiently robust to safeguard goose	To test approaches to adaptive management of geese and in particular to test whether local populations of geese can be managed effectively to maintain a stable population at levels that reduce the impacts of goose damage on agriculture and retain the conservation interest. To test how effectively shooting levels can be managed, through setting agreed shooting levels and regular monitoring of population levels. This will protect populations from over exploitation, while at the same time reducing agricultural damage. In addition the project will be an important test of whether approaches to adaptive management which rely on voluntary	The objective of the pilot is to test the approach to adaptive management of resident greylag geese on both islands. The pilot will test whether local populations of resident geese can be managed effectively to reduce agricultural damage whilst safeguarding the species conservation status and its geographical range.	The aim of the Project, as set out in the Project Agreement is to test whether local populations of resident greylag geese can be managed effectively to maintain a sustainable population at levels that reduce the impacts of geese on agricultural activity and retain their conservation interest. The project relies on the following underlying principles: To know goose numbers and life statistics, especially mortality from shooting; to have a degree of control over the numbers of geese being shot each year; to be able to assess population data and inform take each year; to have agreement and buy-in from local interests. The agreed objectives are:

	Ensure that farmer compensation payments to farmers for goose damage are targeted at the most appropriate management activities (i.e. those growing grass).	populations, while at the same time allowing co-ordinated effort, including scaring, to prevent agricultural damage. To meet our nature conservation obligations it is necessary to maintain both a sustainable and stable resident greylag goose population and its geographical range. To keep agricultural conflicts to an acceptable level. To have agreement and support from local interests.	recording of bag data are sufficiently robust to safeguard goose populations.		Maintain a sustainable resident greylag goose population and range. Keep agricultural conflicts to an acceptable level. Allow for recreational use that does not jeopardise the resident population.
Conflict management	Multi-stakeholder LGMG Consultations, open / public meetings, attendance at community events for public information.	Multi-stakeholder LGMG Objectives of minimising conflict (recording crop damage) and involving local people including the public and farmers who are not already on the LGMG. Farmer survey to investigate perceptions of scheme success.	Multi-stakeholder LGMG.	Multi-stakeholder LGMG Questionnaire of grazing clerks and farmers to investigate perceptions around geese and agriculture.	Multi-stakeholder LGMG Questionnaire of land managers to investigate perceptions around goose impacts and goose management.

Chapter 6

General discussion

6.1 History of goose populations and impacts

The negative impact of geese in Scotland was documented over 300 years ago when, visiting the Outer Hebrides of Scotland, Martin (1703) wrote "the wild geese are plentiful here, and very destructive to the barley, notwithstanding the many methods used for driving them away both by traps and gunshot." In the intervening three centuries, the fortunes of geese in Scotland have fluctuated with populations depleted in the first half of the twentieth century due to hunting for food and sport, systematic persecution and habitat disruption (Bainbridge 2017). Populations have been increasing from these historically (recorded) low numbers to again damage crops and compel the use of gunshot, if not traps. The modern-day goose in Scotland has support of national and international conservation organisations and legislation protecting them from persecution and securing their habitat (Williams et al. 2005; European Union 2009). Government support has led to the formation of collaborative multi-stakeholder goose management groups, both centrally and in the locations most affected (Bainbridge 2017). However, conflict has persisted (Howarth 2018; Edwards 2018), providing us with a mature yet dynamic case study for examining the role of social interactions in conservation conflict.

6.2 Cooperative interactions in goose conflict management in Scotland

6.2.1 Structure

The presence or absence of interactions between actors accumulate to form network structures through which information, influence and resources flow. Formal management of the goose conflict in Scotland, using participatory multi-stakeholder groups connected to a national coordinator had some success due to distributed decision-making, regular formal interactions, and access to scientific support (Chapter 5, Table 26). We recommended structural changes to increase the number and diversity of vertical interactions between local and national stakeholders and horizontal interactions between stakeholders in different locations or different fields (Chapter 5).

In Chapter 2 we showed how interaction networks in two goose management locations showed over-representation of configurations indicative of bridging social capital. Bridging social capital involves a network structure of sparse interactions with more centralised "hubs." This suggests that individuals formed interactions in response to coordination problems, where efficient identification and organisation of tasks to meet shared goals is important (Bodin 2017). The prevalence of bridging configurations also showed that the networks at both locations had the capacity to deal with coordination problems now and potentially increases capacity to do this in the future. We also discovered in the same networks, a lower prevalence of configurations indicative of bonding social capital. This type of social capital involves a network structure with more interactions and more closure. Multiple redundant interactions, rather than a central hub, mean information can be verified through more than one channel, enhancing trust in the information and increasing ease with which bad behaviour is detected (Berardo & Scholz 2010). The lower prevalence of configurations indicative of bonding social capital suggested that (at least in the Orkney Islands network) interactions were not formed in response to cooperation problems, where actors have competing goals requiring negotiation in order to find solutions and progress (Bodin 2017).

The lack of bonding social capital in the Orkney Islands may be due to the withdrawal of RSPB from the Local Goose Management Group. The RSPB were generally perceived as having a viewpoint contrary to many other stakeholders. The removal of a challenging voice would turn a cooperation problem into a coordination problem (i.e. turn negotiating with different goals, to organising with shared goals) allowing actors to form interactions better suited to the latter problem type (Chapter 2, Bodin 2017). This can be dangerous in three ways: firstly, when complex cooperation problems arise in the future, the current network would not have the capacity to respond and costly reorganisation of interactions must occur; secondly, that the context changes causing the unconnected party to act unilaterally; and finally, exclusion (whether mutually agreed or forced) of an organisation perceived to be one of the most important in the system, could push individuals seeking to preferentially form interactions with organisations perceived as more important (known as linking social capital (Woolcock 2001)), to bypass the LGMG altogether, potentially undermining the strength of the policy forum.

In Chapter 3 we revealed how the advantages of distributed decision-making were diluted due to isolation of local groups from shared learning opportunities and the perception of unequal distribution of resources by national level management across local goose management groups. Restricted structures for shared learning resulted in useful knowledge (e.g. experiences of egg-oiling) going to waste, as it was not disseminated through trusted pathways. The perception of unequal resource distribution caused conflict, potentially decreasing cooperative behaviour in crofters.

6.2.2 Process

Processes (the management and content of interactions) such as consensus building on management objectives, freedom to try creative solutions, and an adaptive management mindset for participatory testing of creative management options, all contributed to successful management (Chapter 5, Table 26). We recommended increasing the diversity of farmer and crofter representation at the local level, actively identifying trade-offs for acknowledgement, discussion and communication, and high-level commitment to fairness and transparency at the national level (Chapter 5).

Heterogeneity within the 'farmers & crofters' stakeholder group was not adequately included at the local level (Chapter 3). Perceptions of farmer and crofter goals by other stakeholders did not accurately describe the range of views on goose management which the farmers and crofters expressed themselves. Even individuals who stated similar goals as each other could be in different positions and have different barriers to cooperation. For example, an increase in crofters' intention to cooperative was not predicted by the impacts they suffered themselves from geese. Rather, concern for other people predicted greater cooperation, indicating the number of individuals willing to cooperate on the management of geese was underestimated. Additionally, the longer an individual had been crofting, the less likely they were to cooperate (Chapter 4).

Novel trade-offs were identified as impacting cooperative behaviours. In Chapter 3 we exposed three such examples which had emerged during implementation of goose management actions. Firstly, shooters were attempting to navigate the trade-off between population reduction to benefit the community on the one hand, and crop protection to benefit the individual crofter on the other. Secondly, shooters were potentially locking-in a suboptimal set of management actions to avoid the risk of losing out on their hard-won shooting rights. Thirdly, an increase in robustness of goose counting method was traded-off with decreased good-will of non-scientists. In Chapter 4 we showed experimentally how crofters' intention to cooperate changed under scenarios with different types of uncertainty. On average the presence of uncertainty decreased cooperative behaviours as measured, but different sources of uncertainty affected the trade-off between cooperating and defecting differently. Administrative uncertainty regarding the commitment of external funding for goose management had the greatest negative effect on cooperation.

6.3 Research approach to mapping and management of conservation conflict

In a mature, well-studied conflict such as that of our goose case study, much useful ecological, social, economic and political knowledge is available for mapping and management (see Chapter 5). We used mixed-methods (qualitative and quantitative) to triangulate our results and gain a holistic view of the conflict context. We approached our conflict case study using the Institutional Analysis and Development (IAD) framework (Ostrom 2011), to re-map from the perspective of cooperative behaviours and assess the management actions already taken. The IAD framework has the individual at the local level as its unit of analysis, which can then be scaled to draw system wide conclusions (Ostrom 2011; Orach & Schlüter 2016). This framework fit our system well, as we sought to understand cooperation between individuals and between individuals and organisations, and the IAD captured the importance of scale effects such as the value of horizontal and vertical interactions. Understanding heterogeneity of stakeholders at the scale of analysis is important for design of conflict management processes (Henmati 2002; Reed 2008) and using the IAD framework we identified variability between individuals which impacted cooperation (Chapter 2 and 3). However, the extent of data collection and analysis required to uncover and understand the variation using this framework resulted in a high resource cost (Chapter 3).

The IAD assumes actors to be boundedly rational fallible learners (Ostrom 2011). The framework fit our research needs allowing us to map a stakeholder's objective or goal, as defined in conservation conflict (Redpath et al. 2013), to the payoff criterion in the IAD (Ostrom 2011). On the other hand, fallible learning assumes imperfect but stepwise use of knowledge, but in conservation conflict knowledge and learning are themselves value laden and associated with impartiality and trust (Redpath et al. 2015; Young, Searle, et al. 2016). This was confirmed in Chapter 4 where information about the source of uncertainty resulted in changes in intention to cooperate, even though the statistical likelihood of alternative outcomes in each treatment was identical. Overall, the IAD framework was suitable for understanding cooperation in conservation conflict, particularly at the individual user scale. However, researchers should be cautious about using the IAD due to underlying assumptions of rational learning behaviour and the limitations of the data collection required to gain understanding of individual behaviours at multiple scales and locations.

Our assessment of goose conflict management focussed on the formal structure of the Local Goose Management Groups (LGMGs) in two locations in Scotland. We judged our sampling for social network analysis (Chapter 2) and semi-structured interviews (Chapter 3) to have reached saturation when at least one person from all organisations named more than twice was interviewed (with one exception, see Chapter 2; Method). Sampling of crofters to take part in the experiment in Chapter 4, was via random selection from a registered list. Clear boundaries of social-ecological systems are rare (Angst & Hirschi 2017; Balint et al. 2011) and this was evident from our findings. We focussed on the local situation of the interviewees, which was geographically unambiguous given the island locations of the study sites. Perhaps because of this focus, important external ('off-island') interactions were identified (see Structure and Process sections, this chapter), and their evaluation formed the basis of several of our main conclusions and recommendations (Chapters 2, 3, 4 and 5).

6.4 Dealing with complexity in conservation conflict

The goose conflict in Scotland confirms the complex nature of conservation conflict, as we observed instances of all six types of conflict (Table 28). It would be expected that some of these conflict types are more important in driving the conflict than others at any one time, however a feature of complex systems is that of constant dynamic change (Liu et al. 2007). White et al. (2009), Redpath et al. (2013) and Young et al. (2016) all allude to this in their respective conservation conflict frameworks, by illustrating a cyclic flow of mapping and management activities suggesting that assessments should be repeated to check what has changed.

To address complexity in managing the impacts of the geese, multi-stakeholder LGMGs in Scotland have embraced adaptive management. Adaptive management is the cyclic, iterative method of testing and monitoring management options to guide future decision making (McCarthy & Possingham 2007). Together, the recommendations made in this thesis point towards a similar approach to goose conflict management: building the *adaptive capacity* of collaborating individuals and groups. Adaptive capacity is the ability of a system to take advantage of opportunities or to respond to consequences (Mcleod et al. 2016). Folke et al. (2003) give four dimensions of adaptive capacity; i) learning to live with change and uncertainty; ii) nurturing diversity for resilience; iii) combining different types of knowledge; and iv) maintaining opportunity for self-organisation. Our findings mirror these dimensions: we highlighted the importance of learning to live with uncertainty, due to the different effects specific sources of uncertainty had on intention to cooperate (Chapter 4); we found the representation of within group diversity was lacking at the local level, and that emerging trade-offs will cause changes in cooperative behaviour (Chapter 3); and we discussed horizontal interactions for combining and sharing knowledge and how preferential self-organisation of interactions in networks influences the function of coordination and cooperation problem solving (Chapter 2).

We found that cooperative behaviours can improve adaptive capacity via both problem-solving network structures and knowledge sharing; and that adaptive capacity can improve cooperative behaviours via embracing uncertainty and identifying trade-offs (Figure 15). Tuvendal & Elmberg (2015) report that a goose management group in Sweden maintained the adaptive capacity to deal with evolving goose conflict using cooperative behaviours such as seeking shared solutions, exploring the perspectives of one another, and sharing information. The goose management group in Sweden was bottom-up / self-organised and had no formal or legal authority, unlike our case study. Given the theoretical literature together with the Swedish and our own case studies, further research on the interplay between cooperative behaviours and the adaptive capacity is warranted.

Table 28 – Application of a typology of conservation conflict to the goose conflict in Scotland, adapted from Jones et al. (2005) and Young et al. (2010). Actors can be people, groups or organisations.

Category	**Source of conflict**	**Example from goose conflict in Scotland**
Conflict of interest	Actors want different things from the same habitat or system	Broadly, farmers and crofters need to make a living from the land, but conservationists prioritise the same land to support biodiversity (Chapter 3).
Beliefs & values	Actors hold different normative perceptions on the value or use of wildlife	Some stakeholders perceived that conservationists and government valued wildlife more than the people working in agriculture. In reverse, some stakeholders saw farmers and crofters as favouring habitat destruction for financial gain (Chapter 3).
Process	Actors approach a problem favouring different approaches	Crofters who attended the National Goose Management Review Group chose to disengage from the process feeling their voices were not adequately heard (Chapter 3).
Information	Knowledge is missing, uncertain or perceived differently by different actors	Source of uncertainty (e.g. scientific or administrative) impacted the intention to cooperate of crofters, even though the stated outcomes were the same (Chapter 4).
Social structure	Actors interact within social, legal, economic and political arrangements	Local individuals and organisations, and their national equivalents did not share the same positions, goals and barriers, impacting cooperative behaviours in the system (Chapter 3).
Interpersonal	Individual actors or groups have personal differences with one another, such as issues with trust or communication	A conservation organisation leaving the local goose management group was seen as positive by some other stakeholders, based partly on the perception that the conservationists would always block required actions (Chapter 2, 3).

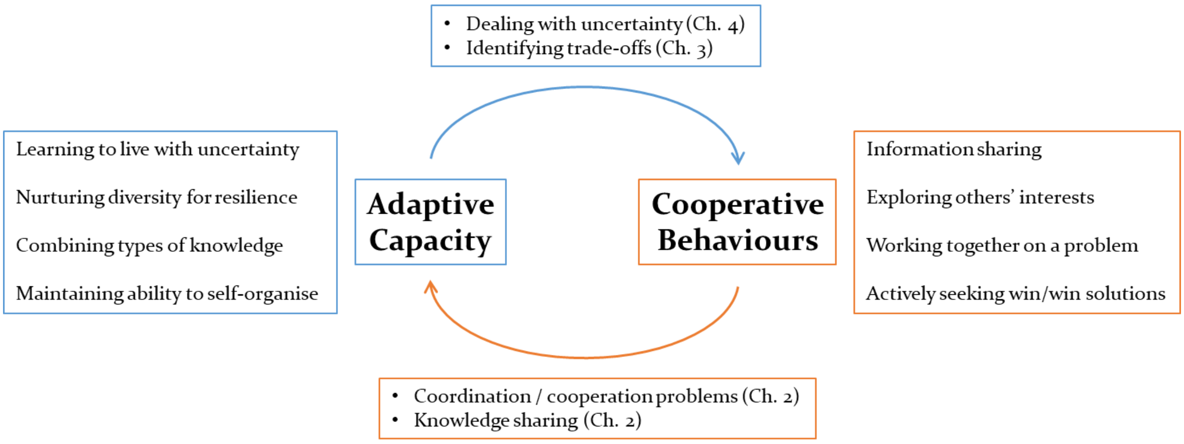


Figure 15 - The reinforcing relationship between adaptive capacity and cooperative behaviours in conservation conflict, with examples from the goose conflict case study referenced by thesis chapter. Adaptive capacity dimensions from Folke et al. (2003), cooperative behaviours from Pound (2015)

6.5 Cooperation across scales

Aligning conservation management activities (including those for conflict management) with the scale as perceived by stakeholders, is more likely to be successful (Young, Jordan, Searle, et al. 2013). The goose conflict in Scotland permeates between local and national scales. Goose flyways elsewhere in the world introduce an international scale, for example greater snow goose *Anser caerulescens atlanticus* populations are managed between Canada and the U.S. (Lefebvre et al. 2017) and pink-footed goose *Anser brachyrhynchus* populations across Norway, Denmark, the Netherlands and Belgium (Madsen, et al. 2017).

Conflict in environmental management and conservation scaled to the global level are increasingly prominent and important as the world wakes up to the global environmental challenges we face in the 21st century. The crossing of planetary boundaries including biodiversity loss, land conversion, and climate change, will cause a shift from the hospitable conditions of the Holocene into a new regime with disastrous consequences for people (Scheffer et al. 2001; Rockström et al. 2009). Planetary boundaries are tightly coupled to one another so efforts to tackle one without considering the trade-offs will result in failure (Rockström et al. 2009). To add further complexity, whilst staying within these limits it is both ethically correct and politically necessary to simultaneously build and maintain the foundations of life quality such as social equality, clean water and food security (Raworth 2017). It is increasingly likely that critical planetary thresholds will be crossed faster than previously predicted (Xu et al. 2018), with climate change triggering a series of regime shifts such as dieback of the Amazon rainforest and permafrost thawing, which will accelerate warming through additional carbon release (Steffen et al. 2018). The size of the collective action problem requires global collaborative action involving deep transformations in how we live (Steffen et al. 2018). Cooperation of governments to design and enact policy instruments is required to meet the problem, although actions which conflict with the requirements of power and privilege are rarely successful (Chomsky 1992). However, global policy instruments are not the only mechanisms for achieving big goals. Ostrom (2010) champions the capacity of bottom-up, self-organising polycentric systems for achieving direct benefits (e.g. lower greenhouse gas emissions) whilst facilitating learning and experimentation across diverse policies. Our suggestions for learning and experimentation for goose *conflict* management by, for example, sharing knowledge gained from learning and experimentation for goose management is the application of Ostrom's nested polycentric solutions. Conservation researchers have taken Ostrom as an inspiration for capturing the advantages of both bottom-up and top-down conflict management (Redpath et al. 2017). In this thesis we have recommended actions specific to the context of the goose conflict in Scotland and added to the burgeoning theory regarding the role of social interactions in conservation conflict management for use at any scale.

References

Agrawal, A. & Gibson, C.C., 1999. Enchantment and Disenchantment : The Role of Community in Natural Resource Conservation. , 27(4), pp.629–649.

Anderson, M.G. et al., 2018. The migratory bird treaty and a century of waterfowl conservation. *Journal of Wildlife Management*, 82(2), pp.247–259.

Angst, M. & Hirschi, C., 2017. Network Dynamics in Natural Resource Governance: A Case Study of Swiss Landscape Management. *Policy Studies Journal*, 45(2), pp.315–336.

Armitage, D.R. et al., 2009. Adaptive co-management for social-ecological complexity. *Frontiers in Ecology and the Environment*, 7(2), pp.95–102.

Arrow, K. et al., 1995. Economic Growth , Carrying Capacity , and the Environment. *Science*, 268, pp.520–521.

Arroyo Mina, J.S. et al., 2016. Economic behavior of fishers under climate-related uncertainty: Results from field experiments in Mexico and Colombia. *Fisheries Research*, 183, pp.304–317.

Austin, E.J., Deary, I.J. & Willock, J., 2001. Personality and intelligence as predictors of economic behaviour in Scottish farmers. *European Journal of Personality*, 15(S1), pp.S123–S137.

Bainbridge, I., 2017. Goose management in Scotland: An overview. *Ambio*, 46(s2), pp.224–230.

Balint, P.J. et al., 2011. *Wicked Environmental Problems: Managing uncertainty and conflict*, Island Press.

Barrett, S. & Dannenberg, A., 2012. Climate negotiations under scientific uncertainty. *PNAS*, 109(43), pp.17372–17376.

Barton, D.N. et al., 2017. Payments for Ecosystem Services as a Policy Mix:

Demonstrating the institutional analysis and development framework on conservation policy instruments. *Environmental Policy & Governance*, 421, pp.404–421.

Bates, D. et al., 2014. Fitting Linear Mixed-Effects Models using lme4. *Journal of Statistical Software*, 67(1), pp.1–48.

Berardo, R., 2014. The evolution of self-organizing communication networks in high-risk social-ecological systems. *International Journal of the Commons*, 8(1), pp.236–258.

Berardo, R. & Scholz, J.T., 2010. Self-Organizing Policy Networks: Risk, Partner Selection, and Cooperation in Estuaries. *Political Science*, 54(3), pp.632–649.

Birch, J.C. et al., 2010. Cost-effectiveness of dryland forest restoration evaluated by spatial analysis of ecosystem services. *Proceedings of the National Academy of Sciences*, 107(50), pp.21925–21930.

Bodin, Ö., 2017. Collaborative Environmental Governance: Achiving Collective Action in Social-Ecological Systems. *Science*, 357, eaan1114.

Bolker, B. et al., 2012. Getting started with the glmmADMB package. *R package ver. 2.0–8*, p.12.

Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), pp.77–101.

Brides, K. et al., 2018. *Status and distribution of Icelandic- breeding geese: results of the 2017 international census.*, Wildfowl & Wetlands Trust Report, Slimbridge.

Buij, R. et al., 2017. Balancing ecosystem function, services and disservices resulting from expanding goose populations. *Ambio*, 46, pp.301–318.

Butler, J.R.A. et al., 2015. Evaluating adaptive co-management as conservation conflict resolution: Learning from seals and salmon. *Journal of Environmental Management*, 160, pp.212–225.

Cárdenas, J.C. & Ostrom, E., 2004. What do people bring into the game? Experiments in the field about cooperation in the commons. *Agricultural*

Systems, 82(3), pp.307–326.

Ceaușu, S. et al., 2018. Governing trade-offs in ecosystem services and disservices to achieve human-wildlife coexistence. *Conservation Biology,* 33(3), pp.543–553.

Chomsky, N., 1992. *Deterring Democracy*, Macmillan Publishers Limited.

Churchill, G., 2015. Orkney Resident Greylag Goose Adaptive Management Pilot 2012 to 2015 Annual Report for 2014 Season, Scottish Natural Heritage.

Churchill, G., 2016. Orkney Resident Greylag Goose Adaptive Management Pilot 2012 to 2015 Annual Report for 2015 Season. Scottish Natural Heritage.

Colyvan, M., Justus, J. & Regan, H.M., 2011. The conservation game. *Biological Conservation*, 144(4), pp.1246–1253.

Conover, M., 2001. *Resolving Human-Animal Conflicts - The science of wildlfie damage management*, Lewis Publishers.

Crabtree, B. et al., 2010. 2010 Review of Goose Management Policy in Scotland. *British Trust for Ornithology Scotland*, p.302.

Crofting Commission, 2017. *Crofting Commission Annual Report and Accounts 2016-2017.* Crofting Commission.

Cusack, J.J. et al., 2018. Time series analysis reveals synchrony and asynchrony between conflict management effort and increasing large grazing bird populations in northern Europe. *Conservation Letters*, p.e12450.

DeFries, R. & Nagendra, H., 2017. Ecosystem management as a wicked problem. *Science*, 356(6335), pp.265–270.

Díaz, S. et al., 2015. The IPBES Conceptual Framework - connecting nature and people. *Current Opinion in Environmental Sustainability*, 14, pp.1–16.

Dickman, a. J., 2010. Complexities of conflict: The importance of considering social factors for effectively resolving human-wildlife conflict. *Animal Conservation*, 13(5), pp.458–466.

Donnelly, C.A. et al., 2006. Positive and negative effects of widespread badger culling on tuberculosis in cattle. *Nature*, 439(7078), pp.843–846.

Drury, R., Homewood, K. & Randall, S., 2011. Less is more: the potential of qualitative approaches in conservation research. *Animal Conservation*, 14(1), pp.18–24.

Eaton, M. et al., 2015. Birds of Conservation Concern 4: The population status of birds in the UK, Channel Islands and Isle of Man. *British Birds*, 108(12), pp.708–746.

Edwards, R., 2018. Mass killing of geese on Islay must cease , say scientists | The Ferret. *The Ferret*, pp.17–20.

Enayati, J., 2002. The Research: Effective Communication and Decision-making in Diverse Groups. In M. Hemmati, ed. *Multistakeholder processes for governance and sustainability; Beyond deadlock and conflict*. Routledge, pp. 73–95.

European Union, 2009. *Directive 2009/147/EC of The European Parliament and of The Council*.

Eythórsson, E., Tombre, I.M. & Madsen, J., 2017. Goose management schemes to resolve conflicts with agriculture: Theory, practice and effects. *Ambio*, 46, pp.231–240.

Fedreheim, G.E. & Blanco, E., 2017. Co-management of protected areas to alleviate conservation conflicts: Experiences in Norway. *International Journal of the Commons*, 11(2), pp.754–773.

Ferguson, J., 2016. *Uist Greylag Goose Adaptive Management Pilot - Annual report 2015-16*. Scottish Natural Heritage.

Fischer, M. & Leifeld, P., 2015. Policy forums: Why do they exist and what are they used for? *Policy Sciences*, 48(3), pp.363–382.

Folke, C., Colding, J. & Berkes, F., 2003. *Synthesis: building resilience and adaptive capacity in social-ecological systems* C. Folke, J. Colding, & F. Berkes, eds., Cambridge University Press.

Fox, A.D. et al., 2017. Agriculture and herbivorous waterfowl: A review of the scientific basis for improved management. *Biological Reviews*, 92, pp.854–877.

Fox, A.D. & Madsen, J., 2017. Threatened species to super-abundance: The unexpected international implications of successful goose conservation. *Ambio*, 46(s2), pp.179–187.

Frank, D. & Sarkar, S., 2010. Group Decisions in Biodiversity Conservation: Implications from Game Theory. *Plos One*, 5(5), p.e10688.

Gelman, A., 2008. Scaling regression inputs by dividing by two standard deviations. *Statistics in Medicine*, 27, pp.2865–2873.

Groce, J.E. et al., 2018. Using social-network research to improve outcomes in natural resource management. *Conservation Biology*, 33(1), pp.53–65.

Gubbi, S., 2012. Patterns and correlates of human-elephant conflict around a south Indian reserve. *Biological Conservation*, 148(1), pp.88–95.

Guerrero, A.M., Mcallister, R.R.J. & Wilson, K.A., 2015. Achieving Cross-Scale Collaboration for Large Scale Conservation Initiatives. *Conservation Letters*, 8(2), pp.107–117.

Hanley, N. et al., 2003. Economics and the design of nature conservation policy: A case study of wild goose conservation in Scotland using choice experiments. *Animal Conservation*, 6(2), pp.123–129.

Hausman, J., 2012. Contingent Valuation: From Dubious to Hopeless. *Journal of Economic Perspectives*, 26(4), pp.43–56.

Hemmati, M., 2002. *Multi-stakeholder processes for governance and sustainability*, Routledge.

Hirsch, P.D. et al., 2011. Acknowledging conservation trade-offs and embracing complexity. *Conservation Biology*, 25(2), pp.259–264.

Hodgson, I.D. et al., 2018. Fighting talk: Organisational discourses of the conflict over raptors and grouse moor management in Scotland. *Land Use Policy*, 77(May), pp.332–343.

Holmgaard, S.B., Eythórsson, E. & Tombre, I.M., 2018. Hunter opinions on the management of migratory geese: a case of stakeholder involvement in adaptive harvest management. *Human Dimensions of Wildlife*, 23(3), pp.284–292.

Howarth, A., 2018. Future of crofting on Outer Hebrides 'threatened by geese.' *The Scotsman*.

IUCN, 2016. *Anser anser. The IUCN Red List of Threatened Species 2016*. International Union for the Conservation of Nature.

Johnson, F.A. et al., 2015. Multilevel Learning in the Adaptive Management of Waterfowl Harvests : 20 Years and Counting. *Wildlife Society Bulletin*, 39(1), pp.9–19.

Johnston, R.J. et al., 2017. Contemporary Guidance for Stated Preference Studies. *Journal of the Association of Environmental and Resource Economists*, 4(2), pp.319–405.

Jones, S., Young, J. & Watt, A., 2005. *Biodiversity conflict management: A report of the BIOFORUM project*.

Kahane, A., 2017. *Collaborating with the Enemy*, Berrett-Koehler.

Kahneman, D. & Tversky, A., 1979. Prospect Theory : An Analysis of Decision under Risk. *Econometrica*, 47(2), pp.263–292.

King, L.E. et al., 2017. Beehive fences as a multidimensional conflict-mitigation tool for farmers coexisting with elephants. *Conservation Biology*, 31(4), pp.743–752.

Lefebvre, J. et al., 2017. The greater snow goose Anser caerulescens atlanticus: Managing an overabundant population. *Ambio*, 46, pp.262–274.

Lemly, A.D., Kingsford, R.T. & Thompson, J.R., 2000. Irrigated agriculture and wildlife conservation: Conflict on a global scale. *Environmental Management*, 25(5), pp.485–512.

Levitt, S.D. & List, J.A., 2007. What Do Laboratory Experiments Measuring Social Preferences Reveal About the Real World ? *Journal of Economic Perspectives*, 21(2), pp.153–174.

Liu, J. et al., 2007. Complexity of coupled human and natural systems. *Science*, 317(5844), pp.1513–6.

Lubell, M., 2013. Governing institutional complexity: The ecology of games framework. *Policy Studies Journal*, 41(3), pp.537–559.

Lubell, M. et al., 2012. Testing Policy Theory with Statistical Models of Networks. *Policy Studies Journal*, 40(3), pp.351–374.

Lubell, M., Jasny, L. & Hastings, A., 2017. Network Governance for Invasive Species Management. *Conservation Letters*, 10(6), pp.699–707.

Lundhede, T. et al., 2015. Incorporating outcome uncertainty and prior outcome beliefs in stated preferences. *Land Economics*, 91(2), pp.296–316.

MacFarlane, C., 2016. *2015-16 annual report - Lewis and Harris greylag goose management pilot*. Scottish Natural Heritage.

Machair Life+, 2014. *Machair Life - Final technical report*.

Madden, F., 2004. Creating Coexistence between Humans and Wildlife: Global Perspectives on Local Efforts to Address Human–Wildlife Conflict. *Human Dimensions of Wildlife*, 9(4), pp.247–257.

Madsen, J., Williams, J.H., Johnson, F.A., et al., 2017. Implementation of the first adaptive management plan for a European migratory waterbird population : The case of the Svalbard pink-footed goose Anser brachyrhynchus. *Ambio*, 46(s2), pp.275–289.

Martin, M., 1703. *A Description of the Western Islands of Scotland Circa 1695: A Voyage to St Kilda: with A Description of the Occidental I.E. Western Islands of Scotland* 2014 Edition., Birlinn Ltd.

Mason, T.H.E., Keane, A., et al., 2018. The changing environment of conservation conflict: Geese and farming in Scotland. *Journal of Applied Ecology*, 55(2), pp.651–662.

Mason, T.H.E., Pollard, C.R.J., et al., 2018. Wicked conflict: Using wicked problem thinking for holistic management of conservation conflict. *Conservation Letters*, (October 2017), pp.1–9.

McCarthy, M. & Possingham, H.P., 2007. Active adaptive management for conservation. *Conservation biology : the journal of the Society for Conservation Biology*, 21(4), pp.956–63.

McGinnis, M. D., 2011. An introduction to IAD and the language of the Ostrom Workshop: A simple guide to a complex framework. *Policy Studies Journal*, 39(1), pp.169-183.

McKenzie, R., 2014. Islay sustainable goose management strategy october 2014 – april 2024. Scottish Natural Heritage.

McKenzie, R. & Shaw, J.M., 2017. Reconciling competing values placed upon goose populations: The evolution of and experiences from the Islay Sustainable Goose Management Strategy. *Ambio*, 46(s2), pp.198–209.

Mcleod, E. et al., 2016. Conservation Organizations Need to Consider Adaptive Capacity: Why Local Input Matters. *Conservation Letters*, 9(5), pp.351–360.

McShane, T.O. et al., 2011. Hard choices: Making trade-offs between biodiversity conservation and human well-being. *Biological Conservation*, 144(3), pp.966–972.

Mitchell, C. et al., 2010. *The population size of breeding greylag geese Anser anser in Scotland in 2008/09*. Scottish Natural Heritage.

Mitchell, C., Hearn, R. & Stroud, D., 2012. The merging of populations of Greylag Geese breeding in Britain. *British Birds*, 105(9), pp.498–505.

Mitchell, C., Leitch, A. & Meek, E., 2016. The abundance and distribution of British Greylag Geese in Orkney, August 2016. Wildfowl & Wetlands Trust Report, Slimbridge.

Moore, J.L. et al., 2017. Implementing Decision Analysis for Invasive Species Management. In N. Bunnefeld, E. Nicholson, & E. J. Milner-Gulland, eds.

Decision-Making in Conservation and Natural Resource Management. Cambridge University Press, pp. 125–155.

Morgans, C.L. et al., 2017. Not more, but strategic collaboration needed to conserve Borneo's orangutan. *Global Ecology and Conservation*, 11, pp.236–246.

Murphy, J. et al., 2004. A meta-analysis of hypotheticalbias in stated preference valuation, Department of Resource Economics. *University Of Massachusetts*.

National Records of Scotland, 2013. 2011 Census: First Results on Population and Household Estimates for Scotland - Release 1C (Part Two)., 4(August), pp.1–14.

Newing, H. et al., 2011. *Conducting Research in Conservation: A social science perspective*, Routledge.

Nohrstedt, D., 2018. Bonding and Bridging Relationships in Collaborative Forums Responding to Weather Warnings. *Weather Climate and Society*, 10(3), pp.521–536.

Nyhus, P.J. et al., 2005. Bearing the costs of human – wildlife conflict : the challenges of compensation schemes. In R. Woodroffe, S. J. Thirgood, & A. Rabinowitz, eds. *People and Wildlife; Conflict or Coexistence?*. pp. 107–121.

Nyhus, P.J., 2016. Human–Wildlife Conflict and Coexistence. *Annual Review of Environment and Resources*, 41, pp.143–171.

Ogra, M. & Badola, R., 2008. Compensating human-wildlife conflict in protected area communities: Ground-Level perspectives from Uttarakhand, India. *Human Ecology*, 36(5), pp.717–729.

Orach, K. & Schlüter, M., 2016. Uncovering the political dimension of social-ecological systems: Contributions from policy process frameworks. *Global Environmental Change*, 40, pp.13–25.

Ostrom, E., 2010a. Analyzing collective action. *Agricultural Economics*, 41, pp.155–166.

Ostrom, E., 2011. Background on the Institutional Analysis and Development Framework. *The Policy Studies Journal*, 39(1), pp.7–27.

Ostrom, E., 2010b. Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), pp.550–557.

Ostrom, E., Gardner, R. & Walker, J., 1994. *Rules, Games and Common-pool Resources*, The University of Michigan Press.

Ostrom, E., Janssen, M.A. & Anderies, J.M., 2007. Going beyond panaceas. *Proceedings of the National Academy of Sciences*, 104(39), pp.15176–15178.

Park, K. & Lee, S.S., 2015. The Role of Beneficiaries' Group Identity in Determining Successful Appeal Strategies for Charitable Giving. *Psychology & Marketing*, 32(12), pp.1117–1132.

Paterson, J.W., 1987. The status and distribution of Greylag Geese Anser anser in the Uists , Scotland The status and distribution of Greylag Geese Anser. *Bird Study*, 34(3), pp.235–238.

Pe'er, G. et al., 2014. Towards a different attitude to uncertainty. *Nature Conservation*, 8, pp.95–114.

Pearce, D., Ece, O. & Özedemiroglu, E., 2002. Economic valuation with stated preference techniques Summary Guide. Department for Transport, Local Government and the Regions.

Peterson, G.D., Cumming, G.S. & Carpenter, S.R., 2003. Scenario Planning: a Tool for Conservation in an Uncertain World. , 17(2), pp.358–366.

Peterson, M.N. et al., 2010. Rearticulating the myth of human-wildlife conflict. *Conservation Letters*, 3(2), pp.74–82.

Polasky, S. et al., 2011. Decision-making under great uncertainty: Environmental management in an era of global change. *Trends in Ecology and Evolution*, 26(8), pp.398–404.

Pooley, S. et al., 2017. An interdisciplinary review of current and future approaches to improving human–predator relations. *Conservation Biology*, 31(3), pp.513–523.

Pound, D., 2015. Designing and facilitating consensus-building - keys to success. In

S. M. Redpath et al., eds. *Conflicts in Conservation*. Cambridge University Press, pp. 240–253.

QSR_International, 2017. NVivo 11.

Rapoport, A., Sundali, J.A. & Seale, D.A., 1996. Ultimatums in two-person bargaining with one-sided uncertainty: Demand games. *Journal of Economic Behavior and Organization*, 30(2), pp.173–196.

Rastogi, A. et al., 2014. Understanding the local socio-political processes affecting conservation management outcomes in Corbett Tiger Reserve, India. *Environmental Management*, 53(5), pp.913–929.

Raworth, K., 2017. *Doughnut Economics - Seven ways to think like a 21st century economist*, Random House.

Redpath, S.M. et al., 2015. *Conflicts in conservation: Navigating towards solutions* First edit., Cambridge University Press.

Redpath, S.M. et al., 2017. Don't forget to look down – collaborative approaches to predator conservation. *Biological Reviews*, 92(4), pp.2157–2163.

Redpath, S.M., Keane, A., Andrén, H., Baynham-herd, Z., et al., 2018. Games as Tools to Address Conservation Con fl icts. , 33(6), pp.415–426.

Redpath, S.M. et al., 2013. Understanding and managing conservation conflicts. *Trends in ecology & evolution*, 28(2), pp.100–9.

Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. *Biological Conservation*, 141(10), pp.2417–2431.

Reed, M.S. et al., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, 90(5), pp.1933–1949.

Reed, M.S. & Curzon, R., 2015. Stakeholder mapping for the governance of biosecurity : a literature review. *Journal of Integrative Environmental Sciences*, 12(1), pp.15–38.

Reed, M.S. & Sidoli Del Ceno, J., 2015. Mediation and conservation conflicts: from top-down to bottom-up. In J. C. Y. Stephen M. Redpath, Ralph J. Gutiérrez, Anna Evely, Kevin A. Wood, ed. *Conflicts in Conservation*. Cambridge University Press, pp. 226–236.

Registers of Scotland, 2016. The Crofting Register. www.crofts.ros.gov.uk.

Rittel, H.W.J. & Webber, M.M., 1973. Dilemmas in a General Theory of Planning. *Policy Sciences*.

Robin, X. et al., 2011. pROC: an open source package for R and S+ to analyze and compare ROC curves. *BMC Bioinformatics*, 12, p.77.

Robins, G., Lewis, J.M. & Wang, P., 2012. Statistical Network Analysis for Analyzing Policy Networks. *Policy Studies Journal*, 40(3), pp.375–401.

Rockström, J. et al., 2009. A Safe Operating Space for Humanity. *Nature*, 461(24).

Ross, L., Greene, D. & House, P., 1977. The "false in social consensus perception effect": An egocentric bias and attribution processes. *Journal of Experimental Social Psychology*, 13(3), pp.279–301.

RSPB Scotland & WWT, 2015. *Complaint To The Commission Of The European Communities Concerning Failure To Comply With Community Law*.

Scheffer, M. et al., 2001. Catastrophic shifts in ecosystems. *Nature.*, 413(6856), p.591.

Scottish Government, 2016. Crofting in Scotland - Support for Crofting. www2.gov.scot/Topics/farmingrural/Rural/crofting-policy/support-for-crofting.

Scottish Government, 2017. *Economic Report on Scottish Agriculture 2017 Edition (Census Year 2016)*. www2.gov.scot/Topics/Statistics/Browse/Agriculture-Fisheries/PubEconomicReport/2017docs.

Scottish Government, 2019. *Implementation of Scottish Government policy on protecting Ramsar sites*. www.gov.scot/publications/implementation-of-scottish-government-policy-on-protecting-ramsar-sites/

Scottish Natural Heritage, 2015. *Minutes of the National Goose Management Review Group meeting - 24 March 2015*. Scottish Natural Heritage.

Simmonds, M.P. & Brown, V.C., 2010. Is there a conflict between cetacean conservation and marine renewable-energy developments? *Wildlife Research*, 37(8), pp.688–694.

Simonsen, C.E. et al., 2016. Is it worthwhile scaring geese to alleviate damage to crops? – An experimental study. *Journal of Applied Ecology*, 53(3), pp.916–924.

Simonsen, C.E., Tombre, I.M. & Madsen, J., 2017. Scaring as a tool to alleviate crop damage by geese: Revealing differences between farmers' perceptions and the scale of the problem. *Ambio*, 46, pp.319–327.

Singer, E., Von Thurn, D. & Miller, E.R., 1995. Confidentiality Assurances and Response. *Public Opinion Quarterly*, 59(1), pp.66–77.

SNH, 2016. *Tiree and Coll Greylag Goose Adaptive Management Pilot annual Report for 2016*. Scottish Natural Heritage.

Sok, J. et al., 2018. Perceived risk and personality traits explaining heterogeneity in Dutch dairy farmers' beliefs about vaccination against Bluetongue. *Journal of Risk Research*, 21(5), pp.562–578.

Sommerville, M. et al., 2010. Impact of a community-based payment for environmental services intervention on forest use in Menabe, Madagascar. *Conservation Biology*, 24(6), pp.1488–1498.

St. John, F.A.V. et al., 2010. Testing novel methods for assessing rule breaking in conservation. *Biological Conservation*, 143(4), pp.1025–1030.

Steffen, W. et al., 2018. Trajectories of the Earth System in the Anthropocene. *Proceedings of the National Academy of Sciences*, 115(33), pp.8252–8259.

Stewart, A., 1999. De Tha Machair ? Towards a Machair Definition. *System*, 1992(1979), pp.7–22.

Stroud, D.A., Madsen, J. & Fox, A.D., 2017. Key actions towards the sustainable management of European geese. *Ambio*, 46(s2), pp.328–338.

Sutherland, L.A. & Burton, R.J.F., 2011. Good farmers, good neighbours? The role of cultural capital in social capital development in a Scottish farming community. *Sociologia Ruralis*, 51(3), pp.238–255.

Tajfel, H. & Turner, J., 1979. An integrative theory of conflict analysis. In Austin & Worchel, eds. *The Social Psychology of Intergroup Relations*. Burnham Inc Pub, pp. 33–47.

Teixeira, H.M. et al., 2018. Farmers show complex and contrasting perceptions on ecosystem services and their management. *Ecosystems Services*, 33(August), pp.44–58.

Tombre, I.M., Eythórsson, E. & Madsen, J., 2013a. Stakeholder involvement in adaptive goose management; case studies and experiences from Norway. *Ornis Norvegica*, 36, pp.17–24.

Tombre, I.M., Eythórsson, E. & Madsen, J., 2013b. Towards a Solution to the Goose-Agriculture Conflict in North Norway, 1988–2012: The Interplay between Policy, Stakeholder Influence and Goose Population Dynamics. *PLoS ONE*, 8(8), p.e71912.

Travers, H. et al., 2011. Incentives for cooperation: The effects of institutional controls on common pool resource extraction in Cambodia. *Ecological Economics*, 71(1), pp.151–161.

Treves, A. et al., 2006. Co-managing human–wildlife conflicts: A review. *Human Dimensions of Wildlife*, 11(6), pp.383–396.

Tulloch, A.I.T., Nicol, S. & Bunnefeld, N., 2017. Quantifying the expected value of uncertain management choices for over-abundant Greylag Geese. *Biological Conservation*, 214(May), pp.147–155.

Tuvendal, M. & Elmberg, J., 2015. A Handshake between Markets and Hierarchies: Geese as an Example of Successful Collaborative Management of Ecosystem Services. *Sustainability*, pp.15937–15954.

United Nations, 2018. The Sustainable Development Goals Report 2018.

Vedeld, P. et al., 2012. Protected areas, poverty and conflicts. A livelihood case study of Mikumi National Park, Tanzania. *Forest Policy and Economics*, 21, pp.20–31.

Veríssimo, D. & Campbell, B., 2015. Understanding stakeholder conflict between conservation and hunting in Malta. *Biological Conservation*. 191, 812–818.

Vlaev, I., 2012. How different are real and hypothetical decisions? Overestimation, contrast and assimilation in social interaction. *Journal of Economic Psychology*, 33(5), pp.963–972.

Vohs, K.D., Mead, N.L. & Goode, M.R., 2008. Merely activating the concept of money changes personal and interpersonal behavior. *Current Directions in Psychological Science*, 17(3), pp.208–212.

Wang, P. et al., 2009. Exponential random graph (p *) models for affiliation networks. *Social Networks*, 31(1), pp.12–25.

Wang, P. et al., 2013. Exponential random graph models for multilevel networks. *Social Networks*, 35(1), pp.96–115.

Wang, P. et al., 2014. MPNet: Program for the Simulation and Estimation of (p*) Exponential Random Graph Models for Multilevel Networks USER MANUAL.

Ware, D., 2017. Sustainable resolution of conflicts over coastal values : a case study of the Gold Coast Surf Management Plan study of the Gold Coast Surf Management Plan. *Australian Journal of Maritime and Ocean Affairs*, 0(1), pp.1–13.

Whaley, L. & Weatherhead, E.K., 2014. An Integrated Approach to Analyzing (Adaptive) Comanagement Using the “Politicized” IAD Framework. *Ecology and Society*, 19(1).

White, R.M. et al., 2009. Developing an integrated conceptual framework to understand biodiversity conflicts. *Land Use Policy*, 26(2), pp.242–253.

Whitehouse, A., 2009. 'A Disgrace to a Farmer': Conservation and Agriculture on a Nature Reserve in Islay, Scotland. *Conservation and Society*, 7(3), p.165.

Wilkes-allemann, J. et al., 2015. Conflict situations and response strategies in urban forests in Switzerland. *Scandinavian Journal ofForest Research*, pp.1–13

Williams, G., Pullan, D. & Dickie, L., 2005. The European Birds Directive-Safeguarding special places for people and wildlife. RSPB, pp.1–28.

Woodroffe, R. & Redpath, S.M., 2015. When the hunter becomes the hunted. *Science*, 348(6241), pp.1312–1314.

Woodroffe, R., Thirgood, S.J. & Rabinowitz, A., 2005. *People and Wildlife, Conflict Or Co-existence?*, Cambridge University Press.

Woolcock, M., 2001. The Place of Social Capital in Understanding Social and Economic Outcomes. *Canadian Journal of Policy Research*, 2(1), pp.11–17.

WWT, 2017. *Goose & Swan Monitoring Programme: survey results 2016/17 Greenland Barnacle Goose Brant leucopsis.*, Wildfowl & Wetlands Trust Report, Slimbridge.

Xu, Y., Ramanathan, V. & Victor, D.G., 2018. Global warming will happen faster than we think. *Nature*, pp.6–8.

Yamagishi, T., 2005. Separating Trust from Cooperation in a Dynamic Relationship: Prisoner's Dilemma with Variable Dependence. *Rationality and Society*, 17(3), pp.275–308.

Young, J.C., Thompson, D.B.A., et al., 2016. A conflict management tool for conservation agencies. *Journal of Applied Ecology*, 53(3), pp.705–711.

Young, J.C. et al., 2018. A methodological guide to using and reporting on interviews in conservation science research. *Methods in Ecology and Evolution*, 9(1), pp.10–19.

Young, J.C., Jordan, A., R. Searle, K., et al., 2013. Does stakeholder involvement really benefit biodiversity conservation? *Biological Conservation*, 158, pp.359–370.

Young, J.C., Jordan, A., Searle, K.R., et al., 2013. Framing scale in participatory biodiversity management may contribute to more sustainable solutions.

Conservation Letters, 6(5), pp.333–340.

Young, J.C. et al., 2010. The emergence of biodiversity conflicts from biodiversity impacts: characteristics and management strategies. *Biodiversity and Conservation*, 19(14), pp.3973–3990.

Young, J.C., Searle, K., et al., 2016. The role of trust in the resolution of conservation conflicts. *Biological Conservation*, 195(March), pp.196–202.

Zhang, W. et al., 2007. Ecosystem services and dis-services to agriculture. , 4, pp.0–7.

Zuur, A.F., Ieno, E.N. & Elphick, C.S., 2010. A protocol for data exploration to avoid common statistical problems. *Methods in Ecology and Evolution*, 1(1), pp.3–14.