



# Habitat monitoring in the wider countryside: A case study on the pursuit of innovation in red deer management



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## ARTICLE INFO

### Article history:

Received 3 December 2012

Received in revised form

5 June 2013

Accepted 12 June 2013

Available online 13 July 2013

### Keywords:

Diffusion of innovations

Red deer management

Private land

Habitat monitoring

Wildlife management

## ABSTRACT

Policy frameworks for protected areas, such as the EU habitats directive, ensure that environmental monitoring takes place to assess the condition of these sites. However, this monitoring rarely extends to the wider countryside, and there is no obligation for private landowners to detect trends in habitat condition. Using the diffusion of innovations model as an analytical framework we conducted a series of semi-structured interviews to consider the uptake of habitat impact assessment methods throughout a community involved in private land use pursuits in Scotland. It was found that although the community as a whole recognises the benefits of habitat impact assessments there are a number of barriers to their uptake, including the complexity of data gathering and interpretation, and uncertainty around who should be responsible for the conduct of assessments. Analysing the uptake of an innovation at an early stage, rather than retrospectively as is commonly done, highlights the potential for non-adoption and could therefore inform the reinvention of the innovation. In this instance reinvention could lead to more appropriate monitoring methods, which, if taken up, could reduce the need for legislative intervention in situations where both public and private interests need to be considered.

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## 1. Introduction

Since the early 1900's a growing proportion of the Earth's land surface has been conserved under national and international legislation (Chape et al., 2005). Currently, over 12% of all terrestrial environments are designated as protected areas (IUCN and UNEP-WCMC, 2011). These areas are monitored using a range of scientific methods in an effort to assess the condition of the habitat, and to catalogue the abundance of species within them.

The wider countryside that neighbours designated sites is rarely subject to statutory monitoring as there is generally no obligation for private landowners to assess habitat condition or trends therein. This is despite the neighbouring wider countryside often

being comprised of similar habitats to those found within protected areas. In order for nature conservation objectives within designated sites to be met it may be necessary to consider the sites as components of the wider countryside, not in isolation (Adams et al., 1992, 1994; Ostermann, 1998). This necessitates ecological monitoring schemes that are flexible to cope with different land use contexts (Adams et al., 1992). In many instances the introduction of such ecological monitoring schemes could be perceived as an innovation, as they are new and unfamiliar tools in more traditional forms of land management.

The introduction of an innovation, whether it is an idea, theory or product, has formed the basis of a broad volume of research catalogued under the 'diffusion of innovations' theoretical framework (Rogers, 2003). The framework was originally developed from research into the adoption of agricultural innovations in America during the 1950s. Today, the diffusion of innovations model continues to be commonly used in agricultural research, as well as in, for example, marketing, medical sciences and renewable energies research (see Haider and Kreps, 2004; Greenhalgh et al., 2005 for examples).

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Here, we apply the diffusion of innovations model as a theoretical framework to analyse the introduction of habitat assessment as a land management tool, using the deer management community in Scotland as a case study. By doing so we aim to: 1) understand current perceptions towards habitat assessment across the deer management community; and 2) highlight some of the potential barriers to the more widespread uptake of habitat assessment as a method to evaluate grazing impacts of deer on privately owned land. In the following sections we provide the necessary context to these issues, present an overview of the theoretical framework adopted and introduce the case study itself along with the research methodology.

## 2. Context – protected areas and wider environmental monitoring issues

Conservation goals for landscapes continually face issues when they are considered alongside other land use objectives (Lindenmayer et al., 2008), and legislation is often employed as a tool to address conservation conflicts (Redpath et al., 2013). In North America, the land trust movement followed an incentivised conservation easement strategy, where permanent legal development restrictions were placed on private land in exchange for tax benefits (See Merenlender et al., 2004). Although apparently successful it was warned that tension existed between the public and private benefits that the movement promoted (Cheever, 1995; Merenlender et al., 2004). In some instances it was even suggested that significant government intervention would be required to regulate management on private areas in order to realise benefits on public ones (Wear et al., 1996). In Europe, designated Natura 2000 sites frequently fall on privately owned land. These sites are part of a network of protected areas that has been developed over the last 20 years to “assure the long-term survival of Europe’s most valuable and threatened species and habitats” (European Commission, 2012). Whether located on privately owned land or not the sites are periodically monitored by regulatory bodies.

Across all of Europe, Scotland has the highest concentration of private land ownership (Wightman, 1996). While there is clear recognition that privately owned land can provide a wide range of public benefits (Smout, 2000), it must also be recognised that private ownership presents a patchwork of autonomous objectives and land management practices across the landscape (Phillip et al., 2009). Private ownership of land commonly includes sporting pursuits, such as salmon fishing, grouse shooting and the most widespread, deer stalking (Wightman, 1996; MacMillan, 2004; MacMillan et al., 2010). As deer have a recognised impact on different habitats the management required for deer stalking often conflicts with management for other land uses.

In recent years there have been several attempts to address the conflict between deer management and management for other land uses. The latest is a voluntary code of practice that has been introduced under the *Wildlife and Natural Environment (Scotland) Act 2011* (hereafter *WANE (Scotland) Act*). Experience from around the world has demonstrated that conservation objectives are not realised when top-down approaches are used to try and reconcile conflict with other land uses (Redpath et al., 2013). However, voluntary codes of practice are often seen as a way to introduce initiatives without pursuing government regulation (Webb and Morrison, 2004). In this instance the voluntary code promotes management methods outlined in the *Best Practice Guidance on the Management of Wild Deer in Scotland* (Scottish Natural Heritage, 2011), which was developed in close collaboration with the deer management community. It is the first instance where a piece of legislation in the UK has encouraged private landowners to voluntarily conduct habitat impact assessments in the wider

countryside. As such, the habitat monitoring methods advocated should be perceived as an innovation that is new and unfamiliar to deer management (Scottish Natural Heritage, 2011).

## 3. Theoretical framework

To analyse the introduction of habitat monitoring methods to deer management in Scotland we used the diffusion of innovations model as a theoretical frame. According to Rogers (2003) there are four key dimensions to this theoretical frame (Fig. 1a–d), which are: a) the characteristics of the innovation; b) how it is communicated; c) the temporal dimension within which the decision to adopt an innovation is made; and d) the role of the social system within which an innovation is being evaluated by potential adopters. These dimensions influence adoption over time (Fig. 1e) and among different types of adopters (Fig. 1f). Although the figures suggest linear progression, they should only be considered as representative of the diffusion of innovations model as a whole, with each having elements of recursive learning and debate within them.

Innovation (Fig. 1a) forms the primary focus of this study. It refers to five factors that affect the successful adoption of an innovation, but it should be considered with reference to the remaining three areas of the model. Potential adopters must be able to see the *relative advantage* that adopting a certain innovation will have over the current system; the system must be *compatible* with the potential adopter’s current practices; it must be simple (*complexity*) to use; a potential adopter must also be able to *trial* an innovation before completely adopting it, and they must be able to *observe* positive responses to the innovation from other users.

Communication around an innovation (Fig. 1b) can be understood as being conducted through either ‘mass’ or ‘interpersonal’ channels. Mass channels of communication are often associated with the media (see Lowery and DeFleur, 1995), and have a recognised importance in initiating interest in an innovation. However, it is deemed more likely that interpersonal ‘word-of-mouth’ channels will propel the adoption of an innovation (Valente, 1996; Wejnert, 2002).

In deer management in Scotland both mass and interpersonal communication channels are utilised to a greater or lesser extent by environmental organisations (Toogood, 2003). Here, we argue that mass communication channels (best practice guidance) are being used to promote habitat assessments. However, it is less clear what influence interpersonal communication channels have on the diffusion of this innovation. Studies in other disciplines have demonstrated that key individuals in such networks (identified as opinion leaders within the diffusion of innovations model) can have a direct impact on how or whether innovations are broadly accepted, due to their credibility among other members of the community (Valente and Davies, 1999; Deroian, 2002). In light of this, we hypothesise that opinion leaders across the deer management community will similarly have a large influence on the adoption of habitat assessment.

Interpersonal networks and opinion leaders therein will have an overall bearing on the *time* taken for an innovation to be adopted or rejected (Fig. 1c). Five stages have been recognised within the innovation decision period: *knowledge, persuasion, decision, implementation* and *confirmation*. All of the five stages of the innovation decision period (Fig. 1c) can operate at both the individual and the community level. Here we apply the innovation decision period at the community level and consider the deer management community as a whole. It is hypothesised that the deer management community is currently operating within the first two stages of the innovation decision period: *knowledge* and *persuasion*.

The social system (Fig. 1d) that an innovation is introduced into will strongly influence the rate of adoption throughout the community. Three types of social system are recognised as influencing the uptake of an innovation. In an authoritarian system decisions are

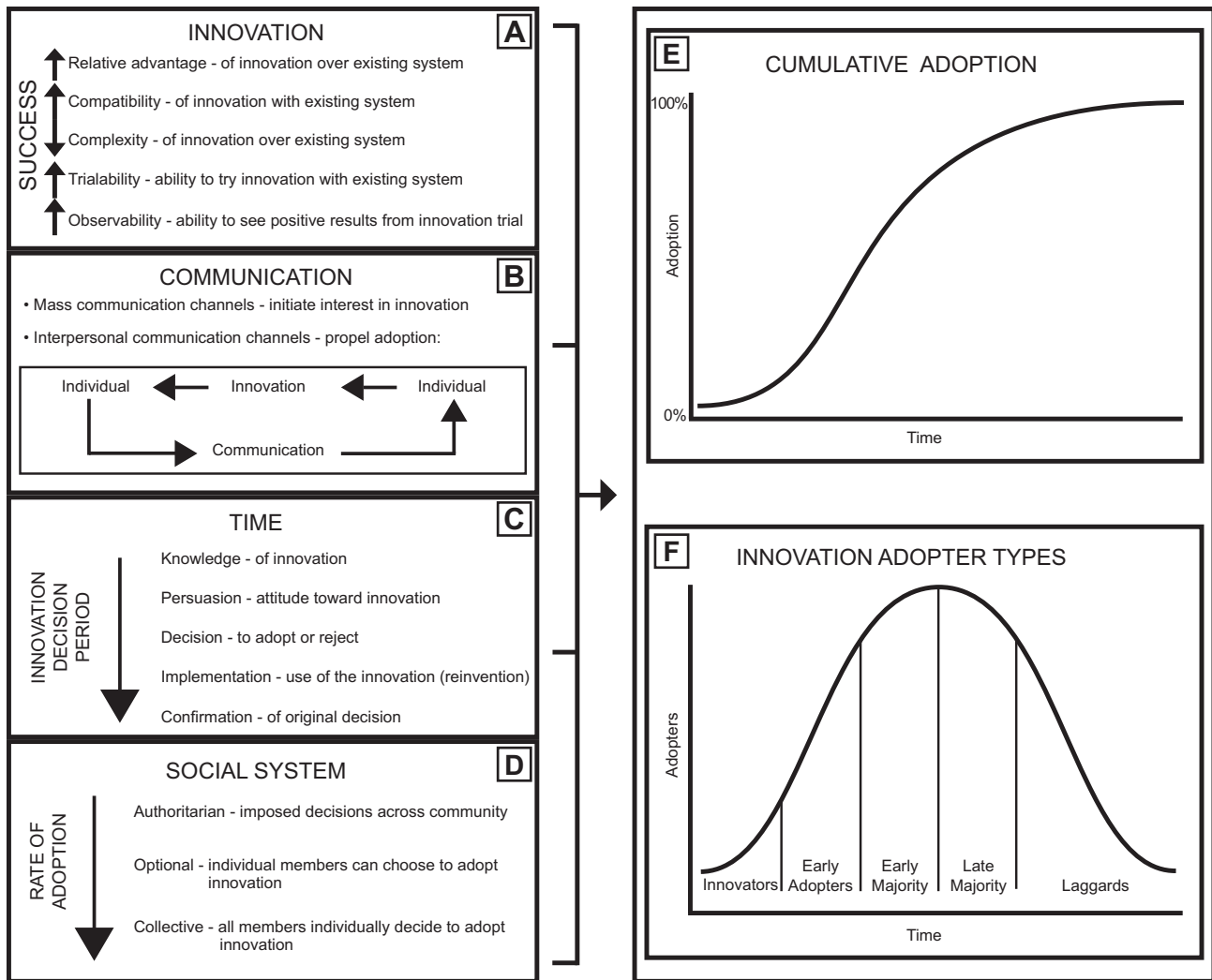


Fig. 1. Simplified diagram highlighting the key components of the diffusion of innovations model.

imposed upon the community, making adoption more rapid than an optional social system in which individuals can choose whether to adopt the innovation or not. Adoption is predicted to be slowest in a collective social system where all its members need to choose to adopt an innovation. Deer management operates across a complex amalgamation of these three systems. Although legislation around habitat assessments currently exists (authoritarian), it operates under a voluntary principal (optional); yet for habitat assessments to become a standard management tool on estates there needs to be adoption across the whole community (collective).

It should be considered that in much of the literature, the diffusion of innovations model is used either retrospectively or in relation to computer-based modelling systems to describe the adoption of an innovation. For this reason, there is a bias towards studies of successful innovation adoption (Rogers, 2003). Here we fill this hiatus and explore the deliberation around a potential adoption by the deer management community of an innovation that is both controversial and in the early stages of the innovation decision period.

#### 4. Case study and methodology

Red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) are recognised by Scottish residents as the most important species in

Scotland (Stewart, 2006). Both species have a significant role in recreational activities and rural economics across the country (MacMillan et al., 2010). Yet the management, notably of red deer, is a contentious topic due to the acknowledged impact that deer have on different habitats, especially woodland and heather moorland (Albon et al., 2007; DeGabriel et al., 2011; Putman et al., 2011a). For centuries deer have retained a *res nullius* status, literally meaning 'nobody's property', and are free to roam between different land units. However, landowners do have the right to shoot deer on their property, and many privately owned estates are run for the pursuit of sporting interests (Wightman et al., 2002). Sporting estates became increasingly popular during the Victorian era (Wightman et al., 2002; Toogood, 2003; MacMillan et al., 2010). More recently there has been an increase in Non-Governmental Organisation and community owned estates (Wightman, 1996), which commonly have a conservation focus. This ever divergent land use has resulted in the familiar dichotomy where: "conservationists argue that there are too many deer, whereas landowners argue that fewer deer will undermine traditional stalking" (MacMillan and Leitch, 2008:482).

Deer management groups (DMGs) were established in the 1960's and are now used as forums to reconcile deer stalking objectives (private) with natural heritage objectives (public) at a regional scale (see Fiorini et al., 2011 for a comprehensive

explanation). In an effort to address these divergent interests at a national scale the deer management community has worked with policy makers to develop a legislative approach to management in The WANE (Scotland) Act and associated Code of Practice on Deer Management. At present the Code of Practice on Deer Management still relies on voluntary compliance, however a lack of compliance with the Code could be used to justify intervention by public bodies in deer management on private estates. This increases the pressure on estates to begin to incorporate tools such as habitat impact assessment methods from the Best Practice Guidance on the Management of Wild Deer in Scotland into their standard management practice. Adoption of 'best practice guidance' may reduce the need for state intervention and any subsequent legislation that would increase statutory obligations on land owners regarding the management of habitats on private land.

To investigate perceptions of habitat assessment among members of the deer management community in Scotland, semi-structured, in-depth interviews were conducted with twelve individuals from across this community. The interviewees were selected on the basis of their active involvement in the deer management community, using heuristics such as attendance at deer management group meetings and involvement in previous research or through involvement in policy development. As such interviewees embodied and represented "meaningful experience-structure links" (Crouch and McKensie, 2006:493) across deer management and provided a cross-section of views, ranging from those who are familiar with and instrumental in legislative issues to those whose roles are fundamental to the daily workings of estates (although these roles are not necessarily mutually exclusive). Twelve participants were interviewed and due to the participants' high level of experience and engagement with the deer management community, saturation of themes and issues emerging from the interviews was apparent early on in the process (see Guest et al. (2006) for further discussion on theoretical saturation). Participants represented: practitioners (including land managers and gamekeepers); researchers; representatives of government funded bodies, non-governmental organisations and voluntary groups; and lecturers (colleges). Interview questions covered topics relating to habitat assessments, including how interviewees perceived the methods and the data produced from assessments, how people learnt about habitat assessment methods and whether assessments were being actively conducted at present.

The interviews were transcribed verbatim, and analysis of the interviews was undertaken in two steps. The initial analysis took an inductive approach; the interviews were systematically read and relevant text coded (Thomas, 2003), using the software program NVivo 9. Following this initial inductive analysis the codes were re-analysed and re-coded under themes that were appropriate within the context of the adopted theoretical framework (Fereday, 2006).

## 5. Results

Seven key themes were identified from the semi-structured interviews (Table 1) that collectively demonstrate the range of issues and views around habitat assessments. These themes capture textual data on how habitat assessments are conducted (*methods*) and interpreted (*interpretation*), who interviewees feel should be responsible for conducting habitat assessments (*responsibility*), what factors influence their adoption (*drivers*), how individuals learn about habitat assessment methods (*information*) and what potential role the age structure of the deer management community played in their uptake (*age*). The final identified theme (*landscape management*) captured interview material on the role of habitat assessments and deer management within the wider context of the countryside. Quotes are used throughout the results section to reflect views from across the deer management

**Table 1**  
Definitions of the themes identified from the interview data.

Themes	Definition
Habitat assessment methods	How habitat assessments are currently being conducted
Interpretation of habitat assessment data	How habitat assessment results are currently interpreted and how they could be in the future
Responsibility for conducting habitat monitoring	Who individuals feel are or should be responsible for conducting habitat assessments
Drivers in habitat assessment adoption	Who or what individuals feel is influencing the uptake of habitat assessment
Information on habitat assessments	The role of available information in promoting habitat assessment methods (notably through best practice guidance)
People's age across the deer management community	The influence of the age structure of the deer management community on the uptake of habitat assessment methods
Landscape management	Consideration of deer management alongside other land uses

community; the numbers (1–12) that follow each quote denote which interviewees are being quoted.

### 5.1. Habitat assessment methods

Practices that were identified as being used to assess habitat condition ranged widely: from formal procedures with a scientific methodology to informal "personal observation"(4) on the estate. This informal assessment, or "institutional memory"(2), as one participant put it, were instances where estate staff were always monitoring the environment due to the nature of being "on the ground all the time"(4). Scientifically recognised habitat monitoring was generally perceived to be used by estates that had "designated sites or because their policies are taking them in that direction"(3).

Some participants also referred to previous situations where habitat assessments had been conducted. They explained how management had been adjusted in response to habitat assessments to reach specific management goals, and that once these had been reached assessments were no longer continued. One advocate of habitat assessments noted that many estates did not conduct them as they did not link habitat monitoring to their own management objectives. The interviewee indicated that when visiting an estate "[the] first thing I need to see is [the estate's] deer management objectives, then I know what [the estate] want to monitor against"(6). However, this link was not clearly stated by other interviewees.

### 5.2. Interpretation of habitat assessment data

A major barrier to the adoption of habitat assessments appeared to be the interpretation of the data once it has been collected. Applying uniform habitat assessment methods across deer management was seen as a way to ensure that the community had "greater ownership"(1) over the data. However, this argument was weakened by confusion over how the data could be used before or after interpretation. Whereas some individuals expressed an interest in being able to see their own, or even regional, data, others stated that the potential of such information entering the public domain would mean that it was "available for someone to thrash [them] with"(2). As one participant put it: "all these impacts, they're impacts in somebody's view, some detrimental, but to others they're an [management] objective"(7).

It was felt that the current presentation of results from habitat assessments was somewhat detached from the social context of a

local area. For example, the negative association that comes with red colouration currently used to denote areas of habitat assessed as being in poor condition was viewed as potentially generating misunderstanding around the impact that deer were having in the area, without accounting for practices such as stalking. When one interviewee spoke about overgrazing by red deer they said, “that’s what the habitat should be like because that’s an area that supports a lot of deer”(2). On top of this there was also the view that deer are automatically, and often unnecessarily, seen as the main cause of negative habitat impact, with an interviewee noting: “where there’s vegetation heavy grazing at an unsustainable level people always say it’s the deer. Well it’s usually more complicated than that”(5). It was thought that such associations often result in “political or emotional bias”(2) that can find its way into scientific reports. These negative associations made it difficult for some members of the deer management community to see clear benefits of incorporating habitat assessments into their management practice.

In particular there was a lack of trust in surveys conducted and reports written by statutory agencies on designated sites. One interviewee said that this was “because [statutory agencies] have had difficulty in establishing good relations with land managers”(5). Another interviewee went further to explain that stalkers “feel they haven’t been invited”(6) to go and check habitat assessment plots, and that it would help understanding if stalkers could “come at the same time, or even go and check”(6) plots themselves to increase their confidence in the data obtained.

### 5.3. Responsibility for habitat monitoring

Who interviewees felt should be responsible for conducting habitat assessments varied widely, from statutory agencies and scientists to estate owners and their staff. Interviewees acknowledged the importance of discussions “round the table”(1, 7, 10) between different stakeholders on the topic of habitat assessment. One representative in particular talked about the general, but not absolute, perception among the deer management community that “habitat assessments are a scientist’s job, and managing the deer is a gamekeeper’s job, and actually those two need to come more closely together”(5).

These feelings of responsibility often appeared to be strongly linked to economics. Funding was identified as a “driving force”(1) behind conducting habitat assessments, with the notion of “public interest”(2, 5, 6) commonly being invoked alongside this. Some interviewees felt that there was a “lack of communication and justification for the expense and maintenance”(3) required to carry out these management practices. Essentially, underpinning the notion that if someone is “required to do something for the public good then the public should be paying for it really”(2).

### 5.4. Drivers in habitat assessment adoption

A key factor influencing the uptake of habitat assessments was specific individuals who play a role in raising awareness and interest in habitat assessments. Specific individuals tended to be viewed as those who are recognised as holding a position of authority in the sense that they are well placed within the deer management community to influence how practices develop.

Alongside key individuals the ADMG and, in particular, DMGs were recognised as important forums to disseminate and discuss information and changes in management practice. Interviewees spoke about them as a place for “pooled resources”(11), where data and interpretation can be collated that is relevant for individual groups. One interviewee felt though that to help move forward DMGs would need additional support beyond voluntary membership “given the demands that the Scottish government is going to place

on DMGs through the [WANE (Scotland) Act] and other things that might be coming down the line”(3).

Attitudes towards DMGs were largely positive, but their limitations were also noted. It was felt that “the expectation for collaboration is far greater than the people on the ground actually engage in”(3). Those groups where the majority of individuals had similar management objectives were perceived to be more successful than those where individuals all had conflicting management objectives. It was also warned that DMG decisions are dependent on “one, what the chairman is thinking for a start; two, you have one to two stalkers within the group who have bought into [the topic of discussion] who others look up to or respect”(6).

Previous research projects (notably HILLDEER – a software package developed by The Macaulay Land Use Research Institute – now The James Hutton Institute) were seen as a “stepping stone”(1) in the development of habitat assessment methods. However, it was legislation and other policies that were identified as having real influence on the uptake of such methods. In particular individuals noted the potential impact that the WANE (Scotland) Act and its associated Code of Practice on Deer Management could have in the future.

### 5.5. Information on habitat assessments

The availability of information on habitat assessments was regarded as an important factor in breaking down the perceived complexity of their methods. As one interviewee put it, once people had been taken “hand in hand, step by step through the whole [habitat assessment] process”(6) there was a realisation of competence: “Oh, I can do this”(6). Gamekeeping college courses were seen to teach vital skills to “the new cohort of stalkers”(5), with the hope that as these keepers “progress through their career they’ll be able to disseminate these practices to the next generations”(8).

Overall, it was best practice guidance for deer management that was seen as the main “vehicle”(11) for providing information on habitat assessment methods. The guidance was referred to as both a “well respected”(3) and “handy”(8) point of reference that ensures that “this information [from habitat assessments] is verifiable”(6) due to the use of uniform methodologies. The workshops and associated materials cover a number of different topics including habitat assessments, and one interviewee stated that there are “over 1000 people that have subscribed”(11) to best practice guidance. Interviewees also referred to best practice guidance being endorsed by the Scottish Gamekeepers Association, North Highland College and the British Association for Shooting and Conservation.

However, despite this positive attitude towards the best practice guidance, it was more difficult to determine which parts of it are commonly used or to say “how many people are actually carrying [habitat assessments] out routinely”(11). One interviewee summarised that there is essentially a gap between the information that is available on habitat assessments and the actual adoption of the methods, saying: “some folk are happy with what is in the best practice as a guide but they wouldn’t put their name to it saying, well I did that and this is what I’m finding”(7).

### 5.6. Age across the deer management community

Interviewees often talked about the “older”(6, 7, 8) and “younger”(4, 8, 9) generations of gamekeepers and stalkers. Although both generations could access information on habitat assessments through best practice guidance events and college courses, the older generations were seen as being more reluctant to take up new management practices. This reluctance was generally felt to be because of the older generation’s perceived expertise that came through the hands-on experience of working on the land. In



addition one interviewee did note that these assessments are for “a long term benefit”(6) beyond the older generation’s career “so why buy into it?”(6) A contrasting but more common view, however was that “the newer breed, the newer generation of gamekeepers”(1) would likely be more “comfortable”(1, 8, 9) with habitat assessments with “it becoming common practice to use these [habitat assessment] tools”(8) in future estate management.

The changing role of gamekeeping for the younger generations was also discussed in relation to deer management: “[so] they had [stalking] skills to a very high level but now we’re asking them to do a whole lot of other things, and also to possibly begin to have some qualifications”(5). However, one interviewee did warn that newly qualified keepers could be trained out of college learnt habits due to the influence of more senior stalkers; this could potentially have a negative impact upon the uptake of new management practices to future generations of stalkers.

### 5.7. Landscape management

Throughout the interviews a common vision of referring to deer management within a “bigger”(6, 7), “wider”(8, 9) or more “holistic”(1, 6) picture was raised. Although there was recognition that deer management in itself has a single species focus, there was a strong desire to consider the socio-economic factors of deer within a broader “modern land management”(12) context as “upland management has become a more public kind of vision”(7). One participant spoke in particular of how it would be good to take a pilot area of land to “develop a plan that covered the whole of the natural resources, including living resources and vegetation so that we could develop a way of looking at nature and sustainability that is way beyond where we are at the moment”(5).

Despite the idea of landscape scale management being prevalent in nearly all of the interviews, there were also concerns that any plans to “incorporate other land management strategies [would] be too complicated”(2). However, it is apparent that, on a whole, deer management is moving away from “a single species management”(5, 7) focus towards one that “give[s] the wider countryside equal attention”(9) and addresses the complexity of weighing deer management and its impact against other land management practices. As one interviewee put it “I think there’s a real expectation now following the Wildlife and Natural Environment bill that deer managers will show their merits [and] show that they are working in a way that is sustainable and inclusive”(10); but others recognised that these kinds of shifts are part of “a long slow process”(12).

## 6. Discussion

The themes that emerged from the interviews collectively provided a representation of the deer community’s attitude towards habitat assessments. At the individual estate scale concerns around the necessity and practicality of habitat assessments were raised in relation to current management practice. Individuals highlighted problems such as resource provision, time commitment and the interpretation of results. However, there was recognition that, as a community, deer managers would benefit from being able to objectively support management decisions using data from habitat assessments. In light of this we discuss the results within the context of the diffusion of innovations model to explore whether habitat assessments are likely to be adopted into future deer management practice, without additional legislation.

We consider how the seven themes identified in the interview data relate to the innovation area of the diffusion of innovations model (Fig. 1a), making reference to other elements of the model where appropriate. Our interviews clarified that the deer management community currently operates in the initial stages of the

innovations area with the majority of the themes identified relating to the *relative advantage*, *compatibility* and *complexity* of habitat assessment as an innovation.

### 6.1. Relative advantage

It is clear from the interviews that individuals recognised the relative advantage of the uniform application of habitat assessments as a way to increase data ownership across the deer management community. However, it is apparent that this attitude has not filtered through to practical action on estates. In 1999 Bullock warned that it could not be assumed that stalkers followed scientific models as presented in software such as HILLDEER. This is echoed in the interviews with suspicion around how such habitat assessment data would be interpreted, and how the results could be used to justify or contest existing management practices.

There were also concerns among estate owners as to where additional resources to conduct habitat assessments would come from, how their data would be used and whether such data would be stored in the public domain. Dandy et al. (2012) have also demonstrated that practicality and cost can be the most prominent concerns when considering wildlife management methods. While these concerns continue it can be questioned what relative advantage there is for individual estates to adopt scientifically recognised methodologies beyond deer management group interaction (Toogood, 2003; Fiorini et al., 2011). The answer may lie in part with the training of younger generations of gamekeepers through college courses. These courses demonstrate how scientific methodologies can be used in conjunction with management plans to meet estate objectives. It was warned in the interviews that some newly qualified keepers could be influenced by more senior stalkers to adopt practices that were not learnt at college. This highlights the importance of the continued promotion of best practice guidance if the deer management community wants to address the generational divide in the use of habitat assessment.

### 6.2. Compatibility

The compatibility of habitat assessments with current management practices was widely contested throughout the interviews. The origins of habitat assessment methods as an ecological construct, and continued monitoring by professional field staff on designated sites, has made some members of the deer management community question who should be conducting these assessments and who will benefit from them. There were also additional concerns with regards to whether the current presentation of habitat assessment data accounts for the social context and private benefits of estate management practices. In some situations it was felt that habitat assessments attributed high deer density to negative environmental impact, without incorporating the perceived social and economic contribution of stalking to an area (MacMillan, 2000; MacMillan and Leitch, 2008; MacMillan and Phillip, 2010).

Despite this conflict there was a recognised desire throughout the interviews to visualise deer management within a landscape scale approach to management. This would ensure that “in the next five to six years everybody who manages deer will be able to also not just look at the animal but look at what it’s living off”(5). Putman et al. (2011b) presented a similar rhetoric and concluded that deer density alone is not a good indicator of the species’ ecological impact on the environment. They urged that long-term management strategies involving deer required habitat studies as well. This emphasises the need to link habitat assessment with deer management objectives and planning to provide a clearer indication of the industry’s impact alongside other land uses (MacMillan, 2000).

In considering deer management within a landscape context it would likely raise further questions around resource provision. Interviewees highlighted that for DMGs to help move deer management forward they would require additional support (Davies and White, 2012). This links in with the economic argument put forward by interviewed estate owners asserting that if the public are the primary beneficiaries of habitat assessments then public funding should support assessments. Although this is a legitimate argument, MacMillan and Phillip (2010) point out that financial incentives for modifying deer management to achieve conservation goals may not be successful because profit maximisation (or cost reduction) is not necessarily the primary goal of estate management. Financial incentives have also been criticised in other conservation management schemes due to the tension they create between public and private benefits (Cheever, 1995; Merenlender et al., 2004; Newburn et al., 2005; Rissman et al., 2007). Instead, considering the long-term benefits of habitat maintenance on individual estates may be a more appropriate avenue to meet both public and private agendas (Adams et al., 1992; Knight, 1999; Norton, 2000).

### 6.3. Complexity

It was recognised throughout the interviews that best practice guidance events and college courses have contributed to simplifying the methods used in habitat assessments. However, they still tend “not to be a part of the job [gamekeepers] find all that attractive” (11), and some individuals do not feel confident in their data collection or its interpretation. This complexity is likely to be one of the key sticking points in the adoption of habitat assessments, as without a firm connection between management objectives, data collection and interpretation it is difficult to view the overall process. Interviewees noted that in previous situations where these links have successfully been made, habitat assessments were seen as a necessary tool for estates to attain their management objectives.

By further simplifying or reinventing habitat assessment methods, and shifting the focus from the methods themselves to the results they produce, it may become clearer how these tools can help individual estates meet management goals. This in turn would have ramifications for communication around habitat assessment as a management tool. Increased communication through interpersonal networks would further help to determine whether habitat assessments will be rejected altogether, if and where they require reinvention, or whether once trialled responses are sufficiently positive to prompt adoption across a majority of the community (Valente, 1996; Wejnert, 2002).

Mass communication channels (best practice guidance) have been well utilised to promote habitat assessment across the deer management community. In a study by Morris et al. (2000) on the uptake of agri-environment schemes among farmers, it was felt that although mass media channels were relevant for creating awareness of an innovation, it was participant farmers who were the best advocates for promoting the adoption of an innovation. It is likely that the multiple interpersonal networks within deer management are also affecting communication flow through this social system. Future research should focus on topics surrounding interpersonal networks, and notably the role of opinion leaders within them, to better understand the importance of reinforcing legislative agendas.

## 7. Conclusion

It is recognised that previous research on the diffusion of innovations has a bias towards retrospective studies where the successful adoption of an innovation has already taken place (Rogers,

2003). By investigating the diffusion of a specific innovation in its early stages we have identified fundamental barriers that may prevent the innovation's uptake altogether; this is despite the realisation of benefits for the community as a whole associated with adoption. These barriers demonstrate the importance of considering the relative advantage, the compatibility and the complexity of the innovation that is being introduced. It has been suggested that it is during the implementation stage of the innovation decision period (Fig. 1c) that reinvention of the innovation is most likely to occur (Rice and Rogers, 1980; Hays, 1996). However, our findings also highlight the potential need for reinvention earlier in the innovation decision period.

The innovation studied here considers habitat assessment in the wider countryside. It is not an example of a top-down approach (which are largely felt to be unsuccessful – Redpath et al., 2013), but instead reflects the deer management community's own attempts to reconcile deer management with other land uses, primarily those associated with nature conservation objectives. While it is recognised that the data collected from environmental monitoring could be used to objectively support management decisions on the ground, there is fear that it could simultaneously be used to question management practices. This problem of data ownership, interpretation and access also underpins who should be responsible for conducting, and ultimately who should be paying for, habitat monitoring in the wider countryside. Applying habitat assessment outside of designated areas explicitly demonstrates the difficulty of incorporating environmental monitoring into an area where social factors and economic objectives also need to be considered.

In order to address the delivery of nature conservation objectives in the wider countryside, flexibility may be required to allow the reinvention of this innovation in its initial stages of introduction. Without addressing the identified barriers through reinvention it is likely that the innovation will be rejected. This, in turn, may prompt further intervention at a legislative level that could increasingly attempt to dictate management conduct in the wider countryside to realise nature conservation goals in protected areas. Working with individuals at this initial stage of an innovation's introduction provides an opportunity for open dialogue on the contested notion of land ownership, as well as querying the role of stewardship within it. Pursuing innovation and thereby limiting legislation may be a way of ensuring that public and private interests no longer remain on opposite sides of the fence.

## Acknowledgements

This research was supported through dot.rural, RCUK Digital Economy Research. We would like to thank the interviewees for taking the time to impart their breadth of experience and knowledge on deer management. We would also like to thank Rosalind Bryce, Althea Davies, Annie McKee, Chris Mellish and three anonymous referees for their constructive comments on earlier drafts of this manuscript.

## References

- Adams, W.M., Bourn, N.A.D., Hodge, I., 1992. Conservation in the wider countryside: SSSIs and wildlife habitat in eastern England. *Land Use Policy* 9, 235–248.
- Adams, W.M., Hodge, I.D., Bourn, N.A.D., 1994. Nature conservation and the management of the wider countryside in eastern England. *J. Rural Stud.* 10, 147–157.
- Albon, S.D., Brewer, M.J., O'Brien, S., Nolan, A.J., Cope, D., 2007. Quantifying the grazing impacts associated with different herbivores on rangelands. *J. Appl. Ecol.* 44, 1176–1187.
- Bullock, C.H., 1999. Environmental and strategic uncertainty in common property management: the case of Scottish red deer. *J. Environ. Plann. Man.* 42, 235–252.
- Chape, S., Harrison, J., Spalding, M., Lysenko, I., 2005. Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. *Philos. T. R. Soc. B.* 360, 443–455.

- Cheever, F., 1995. Public good and private magic in the law of land trusts and conservation easements: a happy present and a troubled future. *Denver U. Law Rev.* 73, 1077–1102.
- Crouch, M., McKensie, H., 2006. The logic of small samples in interview-based qualitative research. *Social Sc. Inform.* 45, 483–499.
- Dandy, N., Ballantyne, S., Moseley, D., Gill, R., Quine, C., Van der Wal, R., 2012. Exploring beliefs behind support for and opposition to wildlife management methods: a qualitative study. *Eur. J. Wildl. Res.* 58, 695–706.
- Davies, A.L., White, R.M., 2012. Collaboration in natural resource governance: reconciling stakeholder expectations in deer management in Scotland. *J. Environ. Manage.* 112, 160–169.
- DeGabriel, J.L., Albon, S.D., Fielding, D.A., Riach, D.J., Westaway, S., Irvine, R.J., 2011. The presence of sheep leads to increases in plant diversity and reductions in the impact of deer on heather. *J. Appl. Ecol.* 48, 1269–1277.
- Deroian, F., 2002. Formation of social networks and diffusion of innovations. *Res. Policy* 31, 835–846.
- European Commission, 2012. [online] Available: <[http://ec.europa.eu/environment/nature/natura2000/index\\_en.htm](http://ec.europa.eu/environment/nature/natura2000/index_en.htm)> (12 August 2012).
- Fereday, J., 2006. Demonstrating rigour using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Int. J. Qual. Meth.* 5, 80–92.
- Fiorini, S., Yearley, S., Dandy, N., 2011. Wild deer, multivalence, and institutional adaptation: the "deer management group" in Britain. *Hum. Organ.* 70, 179–188.
- Greenhalgh, T., Robert, G., Macfarlane, F., Bate, P., Kyriakidou, O., Peacock, R., 2005. Storylines of research in diffusion of innovation: a meta-narrative approach to systematic review. *Soc. Sci. Med.* 61, 417–430.
- Guest, G., Bunce, A., Johnson, L., 2006. How many interviews are enough? an experiment with data saturation and variability. *Field Method* 18, 59–82.
- Haider, M., Kreps, G.L., 2004. Forty years of diffusion of innovations: utility and value in public health. *J. Health Commun.* 9, 3–11.
- Hays, S.P., 1996. Influences on reinvention during the diffusion of innovations. *Polit. Res. Quart.* 49, 631–650.
- IUCN and UNEP-WCMC, 2011. *The World Database of Protected Areas*. (Cambridge, UK).
- Knight, R., 1999. Private lands: the neglected geography. *Conserv. Biol.* 13, 223–224.
- Lindenmayer, D., Hobbs, R.J., Montague-Drake, R., Alexandra, J., Bennet, A., Burgman, M., Cale, P., Calhoun, A., Cramer, V., Cullen, P., Driscoll, D., Fahrig, L., Fischer, J., Franklin, J., Haila, Y., Hunter, M., Gibbons, P., Lake, S., Luck, G., MacGregor, C., McIntyre, S., Mac Nally, R., Manning, A., Miller, J., Mooney, H., Noss, R., Possingham, H., Saunders, D., Schmiegelow, F., Scott, M., Simberloff, D., Sisk, T., Tabor, G., Walker, B., Wiens, J., Woinarski, J., Zavaleta, E., 2008. A checklist for ecological management of landscapes for conservation. *Ecol. Lett.* 11, 78–91.
- Lowery, S., DeFleur, M.L., 1995. *Milestones in Mass Communication Research: Media Effects*, third ed. Longman Publishers, USA.
- MacMillan, D.C., 2000. An economic case for land reform. *Land Use Policy* 17, 49–57.
- MacMillan, D.C., 2004. Tradeable hunting obligations – a new approach to regulating red deer numbers in the Scottish highlands? *J. Environ. Manage.* 71, 261–270.
- MacMillan, D.C., Leitch, K., 2008. Conservation with a gun: understanding landowner attitudes to deer hunting in the Scottish highlands. *Hum. Ecol.* 36, 473–484.
- MacMillan, D.C., Phillip, S., 2010. Can economic incentives resolve conservation conflict: the case of wild deer management and habitat conservation in the Scottish highlands. *Hum. Ecol.* 38, 485–493.
- MacMillan, D.C., Leitch, K., Wightman, A., Higgins, P., 2010. The management and role of highland sporting estates in the early twenty-first century: the owner's view of a unique but contested form of land use. *Scot. Geog. J.* 126, 24–40.
- Merenlender, A.M., Huntsinger, L., Guthey, G., Fairfax, S.K., 2004. Land trusts and conservation easements: who is conserving what for whom? *Conserv. Biol.* 18, 65–75.
- Morris, J., Mills, J., Crawford, I.M., 2000. Promoting farmer uptake of agri-environment schemes: the countryside stewardship arable options scheme. *Land Use Policy* 17, 241–254.
- Newburn, D., Reed, S., Berck, P., Merenlender, A., 2005. Economics and land-use change in prioritizing private land conservation. *Conserv. Biol.* 19, 1411–1420.
- Norton, D.A., 2000. Editorial conservation biology shifting the focus and private land. *Conserv. Biol.* 14, 1221–1223.
- Ostermann, O.P., 1998. The need for management of natural conservation sites designated under Natura 2000. *J. Appl. Ecol.* 35, 968–973.
- Phillip, S., Dandy, N., Gill, R., MacMillan, D.C., 2009. Is legislation a barrier to the sustainable management of game species? A case study of wild deer in Britain. *J. Environ. Plann. Man.* 52, 993–1012.
- Putman, R., Langbein, J., Green, P., Watson, P., 2011a. Identifying threshold densities for wild deer in the UK above which negative impacts occur. *Mammal Rev.* 41, 175–196.
- Putman, R., Watson, P., Langbein, J., 2011b. Assessing deer densities and impacts at the appropriate level for management: a review of methodologies for use beyond the site scale. *Mammal Rev.* 41, 197–219.
- Redpath, S.M., Young, J., Evely, A., Adams, W.M., Sutherland, W.J., Whitehouse, A., Amar, A., Lambert, R.A., Linnell, J.D.C., Watt, A., Gutiérrez, R.J., 2013. Understanding and managing conservation conflicts. *Trends Ecol. Evol.* 28, 100–109.
- Rice, R., Rogers, E.M., 1980. Reinvention in the innovation process. *Sci. Commun.* 1, 499–514.
- Rissman, A.R., Lozier, L., Comendant, T., Kareiva, P., Kiesecker, J.M., Shaw, M.R., Merenlender, A.M., 2007. Conservation easements: biodiversity protection and private use. *Conserv. Biol.* 21, 709–718.
- Rogers, E.M., 2003. *Diffusion of Innovations*, fifth ed. Free Press, New York.
- Scottish Natural Heritage, 2011. *Best Practice Guidance on the Management of Wild Deer in Scotland*. Scottish Natural Heritage, Inverness.
- Smout, T.C., 2000. The fragile hill. In: *Nature Contested: Environmental History in Scotland and Northern England since 1600*, first ed. Edinburgh University Press, Edinburgh, pp. 116–141.
- Stewart, D., 2006. Scottish Biodiversity List Social Criterion: Results of a Survey of the Scottish Population. Social Research Environment Group, p. 26.
- Thomas, D.R., 2003. *A General Inductive Approach for Qualitative Data Analysis*. School of Population Health, University of Auckland.
- Toogood, M., 2003. Decolonizing highland conservation. In: Adams, W., Mulligan, M. (Eds.), *Decolonizing Nature: Strategies for Conservation in a Post-Colonial Era*. Earthscan publishing, London, pp. 152–171.
- Valente, T.W., 1996. Network models of the diffusion of innovations. *Comput. Math. Organ. Th* 2, 163–164.
- Valente, T.W., Davies, R.L., 1999. Accelerating the diffusion of innovations using opinion leaders. *Ann. Am. Acad. Polit. SS.* 566, 55–67.
- Webb, K., Morrison, A., 2004. The law and voluntary codes: examining the "tangled web". In: Webb, K. (Ed.), *Voluntary Codes, Private Governance, the Public Interest and Innovation*. Carleton University, Ottawa, pp. 105–174.
- Wear, D., Turner, M.G., Flamm, R.O., 1996. Ecosystem management with multiple owners: landscape dynamics in a southern Appalachian watershed. *Ecol. Appl.* 6, 1173–1188.
- Wejnert, B., 2002. Models of diffusion of innovations: a conceptual framework. *Annu. Rev. Sociol.* 28, 297–326.
- Wightman, A., 1996. *Who Owns Scotland*. Canongate Books, Edinburgh.
- Wightman, A., Higgins, P., Jarvie, G., Nicol, R., 2002. The cultural politics of hunting: sporting estates and recreational land use in the highlands and islands of Scotland. *Culture, Sport Soc.* 5, 53–70.
- Wildlife and natural environment (Scotland) Act 2011, 2011. *Wildlife and Natural Environment (Scotland) Act 2011 (asp 6)*. (Edinburgh).