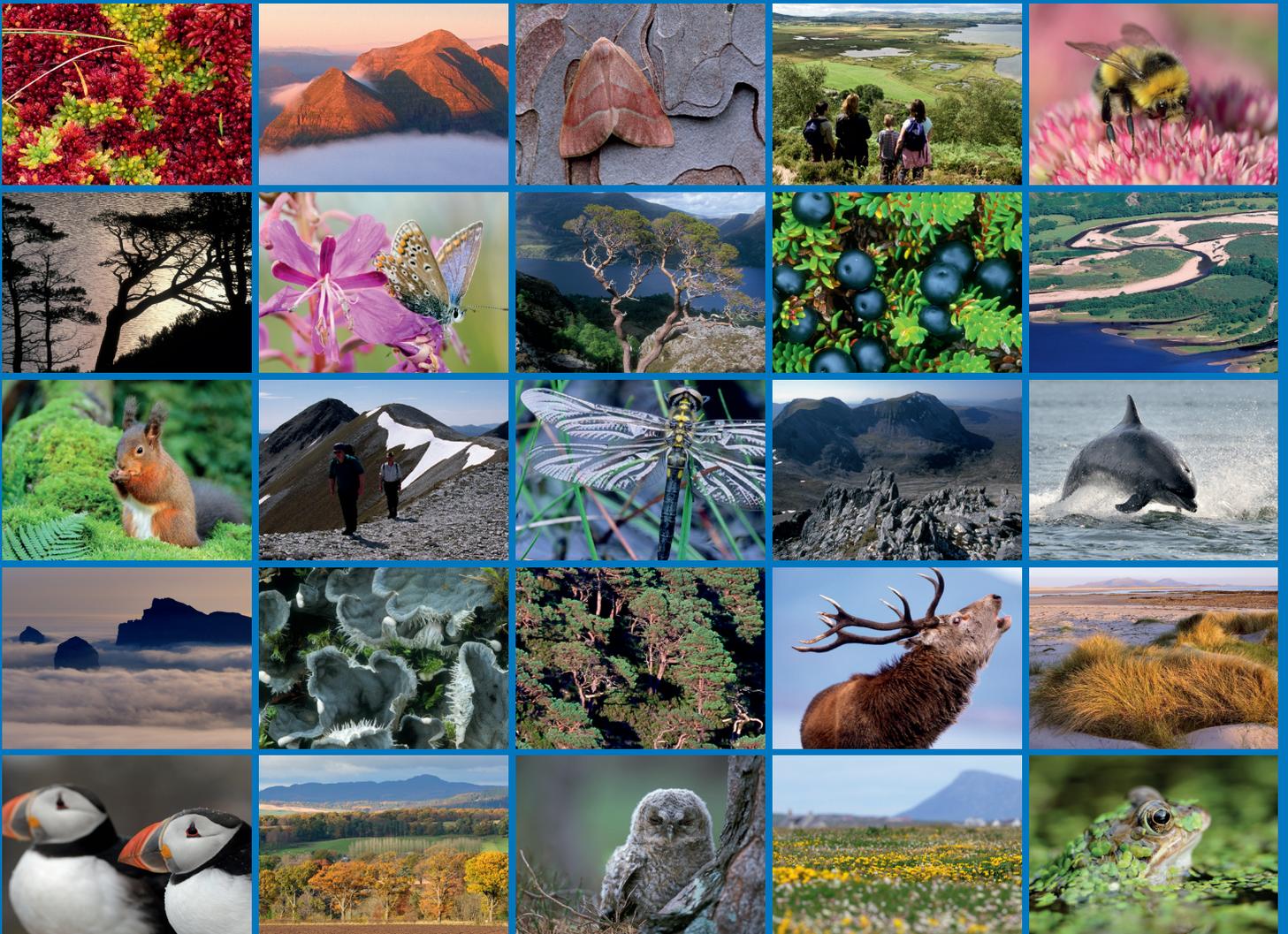


Meeting the challenge of wild deer research to support delivery of sustainable deer management in Scotland





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Forestry Commission Scotland

COMMISSIONED REPORT

Commissioned Report No. 963

Meeting the challenge of wild deer research to support delivery of sustainable deer management in Scotland

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COMMISSIONED REPORT

Summary

Meeting the challenge of wild deer research to support delivery of sustainable deer management in Scotland

Commissioned Report No. Report No. 963

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Deer; research; WDNA; Scotland's Wild Deer: A National Approach.

Background

The aim of this project was to analyse existing wild deer research and identify specific research and evidence gaps which need to be addressed in order to meet the challenges for each of the five priorities outlined in [Scotland's Wild Deer - A National Approach \(WDNA\)](#). The project was developed to facilitate more effective exchange of knowledge and provide a fuller understanding of the issues involved in deer management and therefore help deliver targeted, informed *and sustainable deer management in Scotland*. This report complements the recently published [Deer Management in Scotland: Report to the Scottish Government from Scottish Natural Heritage 2016](#).

Gaps in the existing knowledge-base were identified by gathering the views of stakeholders at a series of workshops, through an online survey of researchers and policy makers, and through a review of published and un-published research material. Workshops were run across Scotland, including four regional stakeholder workshops, one workshop for trainers, and one for researchers/policy makers. The uptake of research by stakeholders was also examined through the use of an on-line survey of researchers and policy makers. The information gained from the workshops, online survey and literature review were analysed to determine the key research and knowledge transfer gaps associated with each of the five WDNA priorities.

As part of the project a web-based deer research resource was created that provides an online database of deer research relevant to the five WDNA priorities (www.deerscotland.info).

Main findings

Cross Cutting Themes: A number of themes and issues identified were relevant across all the WDNA priorities:

- Improved communication, information sharing and conflict management are required in order to overcome challenges and mistrust, and facilitate understanding between the different perspectives of the many stakeholders. Building trust will improve the uptake of research and strengthen collaboration.

- Knowledge exchange of existing research and best practice is often more important and more relevant than undertaking new research.
- Improved public engagement and education is needed in order to better inform the public's perception of deer management.
- Upland, lowland, peri-urban and urban areas have their own issues and gaps, but there are also common issues across these areas.
- There is a need to carry out research at a range of spatial and temporal scales.

WDNA 1 - Collaboration and Effective Deer Management Planning and Implementation: Identified gaps tended to be linked to a need for improved knowledge transfer rather than new research. A wider understanding of different stakeholder perspectives and cultures is required to underpin conflict management processes and the future management of deer management groups. Sharing of knowledge and data is necessary for improved deer management planning and this depends on overcoming mistrust between stakeholders. Understanding deer movements and habitat utilisation and how this is influenced by management activities emerged as a key research gap. A lack of available data on local trends and patterns was considered a barrier to improving this evidence base.

WDNA 2 - Healthy Ecosystems: The gap analysis identified a range of both research and knowledge transfer gaps associated with the Healthy Ecosystems priority. Although a considerable amount of research has been carried out on the impacts of deer and other herbivores on habitats and species, there remain knowledge gaps in this area. Most of the key research gaps relate to a need for a better understanding of herbivore impacts and interactions across a range of temporal and spatial scales, and more knowledge on the influence that deer and deer management have on ecosystem services. One of the main knowledge transfer gaps relates to the need to facilitate understanding of the herbivore impact assessment methodology and the practical use of HIA data within the deer management planning process, through the provision of skills training.

WDNA 3 - Lowland and Urban Deer: Gaps tended to be more related to issues of knowledge transfer than to new research needs. Research gaps that did emerge as important for the lowland and urban deer context tended to reflect those that are also pertinent in the uplands. There is a need to understand the effectiveness of existing collaborative structures and linked to this are more context specific knowledge transfer challenges related to incentivising and involving stakeholders in lowland and urban areas e.g. local authorities and the public, and ensuring that decision making incorporates multiple perspectives. A further research gap concerns the relationship between deer population dynamics and habitat impacts in lowland and urban areas. There are related knowledge transfer needs for improved gathering and sharing of information about local deer populations.

WDNA 4 - Economic and Community Development: In this particular challenge, the approach used showed that nearly all the gaps identified were research gaps rather than knowledge transfer or exchange gaps, contrary to the other challenges. The key research gaps related to a need for more studies on socio-economic impacts at local and site level, the venison supply chain and the potential for diversification, as well as cost-benefit analysis on alternative deer management models, both for upland and lowland wild deer. Unlike the other challenges, the gap analysis also identified a particular policy gap, to gain improved clarity as to what the vision for wild deer management should be at the national level. Clearly the WDNA was designed to fulfil this role, which suggests stakeholders either feel it is not providing the vision or they are not fully engaged with the process.

WDNA 5 - Training and Wild Deer Welfare: In this theme gaps predominantly related to knowledge transfer gaps and/or gaps in uptake of training and/or practice - communicating knowledge and facilitating knowledge uptake as opposed to carrying out new research. The enhancement of data driven management processes is a strong cross-cutting theme within WDNA 5, particularly in relation to improved accuracy and coverage in cull records as a basis for welfare assessments and wider sustainable deer management processes. A second critical cross-cutting theme which has emerged as a key priority knowledge transfer opportunity is the further professionalisation of deer management through enhanced training provision and uptake in key areas; participatory approaches, Information Technology and Habitat Impact Assessment. Increasing the uptake and direct relevance of habitat assessment and management to all deer managers represents a cornerstone of WDNA 5.

Research priorities

WDNA 1 - Collaboration and Effective Deer Management Planning and Implementation:

- Understanding the dynamics of deer movements and habitat utilisation in response to management.
- Development of improved deer count techniques.
- Understanding the effectiveness of collaborative structures. Research is needed to better understand the factors that influence collaboration and conflict.

WDNA 2 - Healthy Ecosystems:

- Improved understanding of the impacts of deer and other herbivores on different habitats and species.
- Improved understanding of the responses of habitats and species to changes in deer grazing pressure across a range of spatial and temporal scales.
- Improved understanding of the interactions of different herbivores, including deer and domestic livestock, and how these interactions affect different habitats and species.
- More studies on the influence of deer and deer management on ecosystem services, including carbon sequestration and greenhouse gas emissions.

WDNA 3 - Lowland and Urban Deer:

- Understanding how collaboration and decision making in lowland and urban areas can incorporate a range of values and impacts.
- Understanding population dynamics of deer in lowland and urban areas and relationships with habitat impacts.

WDNA 4 - Economic and Community Development:

- Improved understanding of the socio-economic impact and value of deer management.
- Fuller understanding of the direct and indirect impacts of alternative models of deer management (conservation, community stalking groups, private sporting etc.).
- More market research on alternative forms of income related to deer management (e.g. wildlife and deer watching, hind stalking, alternative hunting (i.e. any form of hunting that has an economic and/or environmental/social rationale which is different to the traditional model of deer stalking on sporting estates)).
- Marketing research into the venison supply chain and incentives (both for upland and lowland deer).
- Better consideration of specific mitigation measures required at deer vehicle collision hotspots.

WDNA 5 - Training and Wild Deer Welfare:

- Further research on the impacts of recreational disturbance on deer welfare, including impacts on feeding habitat and variation of impacts seasonally and in relation to wider environmental factors.

- Improved understanding through research of Deer Vehicle Collisions and the identification of suitable collision avoidance mechanisms in different contexts (peri-urban, lowland and rural) with potential for incorporation of citizen science approaches through DVC reporting.
- Review and investigation of key future disease risks and risk factors for wild deer populations in Scotland in relation to climate change and potential disease transmission from European ungulate populations.
- Further investigation of the link between deer management intensity and rates of over-wintering mortality in wild deer populations.

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1. INTRODUCTION

This is the final report for the Scottish Government, Scottish Natural Heritage and Forestry Commission Scotland funded project SCL/025/15 “Meeting the challenge of wild deer research to support delivery of sustainable deer management in Scotland”. The aim of this project was to analyse existing research and identify specific research and evidence gaps which require to be addressed in order to meet the challenges outlined in **Scotland’s Wild Deer - A National Approach (WDNA)** and other Scottish Government land-use policies. The recently published SNH report, [Deer Management in Scotland: Report to the Scottish Government from Scottish Natural Heritage 2016](#), is also highly relevant in setting out the evidence base on densities of deer and impacts of herbivores on the natural heritage.

The research objectives for this project were as follows:

1. Review existing research and its utility in wild deer management to help achieve key Scottish Government land, habitat and wildlife management policies and strategies as represented by the WDNA 2015-2020 Challenges and including the developing land reform proposals;
2. Identify gaps in the knowledge required to meet the challenges raised by the Rural Affairs Climate Change and Environment Committee (RACCE) towards the end of 2013 and endorsed by the Minister in relation to deer management;
3. Assess how to apply existing research to the priorities and challenges for 2015-2020 as set out in the WDNA;
4. Establish an accessible and comprehensive ‘deer data resource’;
5. Gather stakeholder views on deer research and facilitate knowledge exchange.

A number of principal Scottish Government policies are highly important drivers behind the need for further work on deer and their management. The policy with the most direct linkages is **Scotland’s Wild Deer: A National Approach (WDNA)**. This sets out the Scottish Government’s strategic vision for wild deer in Scotland using a collaborative approach. First published in [2008](#) it underwent its first 5 year review in 2014 with a revised version being published in April [2015](#). This revised version includes a set of challenges for 2015-2020. These recognise the significant contribution which deer can make to Scotland along with the negative impacts they can have on the environment, agriculture and forestry. The associated [2015 - 2018 WDNA Action Plan](#) sets out a broad range of activities which will contribute to the delivery of the WDNA priorities, which are based around: collaboration and effective deer management planning and implementation; healthy ecosystems; lowland and urban deer; economic and community development; training and deer welfare. This research project was designed to strengthen the already existing collaborative approach of the WDNA. The report **identifies some of the specific research needed to meet the WDNA priorities and challenges.**

There were eight key stages to the research project:

1. [Stakeholder workshops](#) - A series of stakeholder workshops were run across Scotland, including four regional workshops, one trainers’ workshop and one researchers’/policy makers’ workshop. These workshops were used to obtain information from a range of stakeholders on what they considered to be the main knowledge and research gaps relating to deer management. (Objectives 2 and 5).
2. [Literature review](#) - A review of the published and unpublished research relevant to the five WDNA priorities was carried out. This review identified areas where research had already been carried out and where gaps existed. (Objective 1).
3. [Review of research uptake](#) - An on-line survey of deer researchers and stakeholders in deer management policy was used to review the uptake of research by stakeholders. (Objective 3).

4. [Gap analysis](#) - The information gained from the workshops, online survey and literature review were analysed to determine the key research and knowledge transfer gaps associated with each of the five WDNA priorities (see Figure 1.1 below for the methodology used in the gap analysis). (Objective 2).

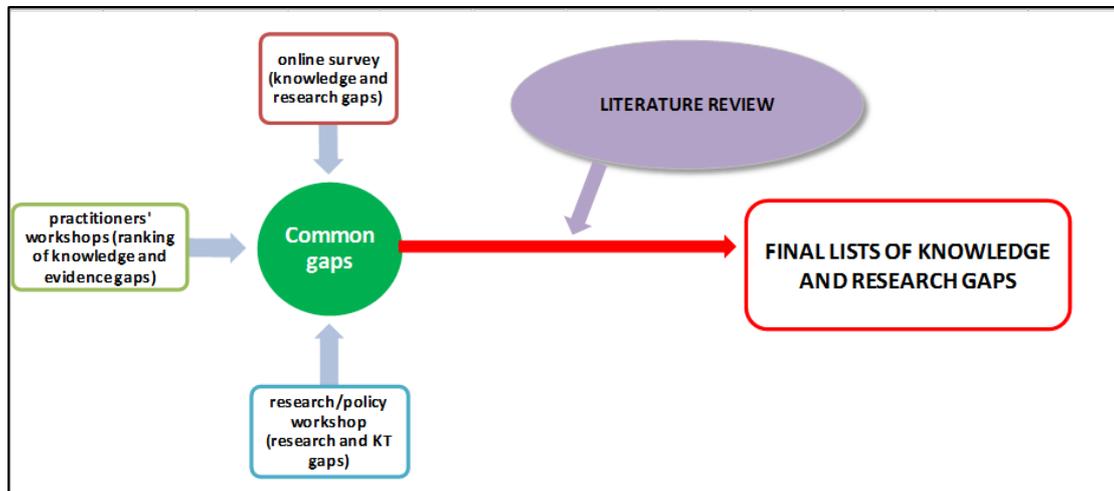


Figure 1.1 - Gap analysis methodology

5. [Key findings](#) - A synthesis of the key findings for each of the WDNA priorities was produced. (Objective 2).
6. [Research priorities](#) - A list of the main research priorities and potential research projects were developed from the gap analysis. (Objective 2).
7. [Production of a web-based deer research resource](#) - A website was developed which provides public access to the literature database. (Objective 4).
8. Final stakeholder seminar - A final stakeholder seminar was held on 23rd November 2016 at SNH Battleby where the results of the project were disseminated. Over seventy people attended the seminar. (Objective 5).

This report contains the results from the workshops; the literature review; the online survey results; the gap analysis; the key findings; and a list of identified research priorities.

2. STAKEHOLDER WORKSHOPS

2.1 Introduction

A key project requirement was to gather views on knowledge and research gaps relating to deer management and facilitate knowledge exchange amongst stakeholders involved in deer management. To deliver this four regional workshops and one specialist trainers' workshop were planned and carried out, with a final researchers'/policy-makers' workshop carried out as the final stage of the process.

Four regional workshops were carried out to access knowledge on deer management issues and views on knowledge and evidence gaps at a regional level. A wide range of relevant stakeholders, including deer and land managers, Deer Management Group (DMG) representatives, landowners and public agency and NGO representatives were invited. These were carried out in:

- Boat of Garten (Monadhliath and the Cairngorms region - 20th April 2016)
- Crianlarich (Central Highlands and Argyll - 27th April 2016)
- Ullapool (NW Scotland - 11th May 2016)
- Strathclyde (Central Belt and Southern Scotland - 18th May 2016)

The Strathclyde workshop was specifically focused on lowland and peri-urban areas (with participants from the Central Belt area and Southern Scotland). This was to allow for recognition of lowland and peri-urban specific challenges and knowledge gaps. A trainers' workshop was also carried out in Perth on June 1st 2016 to discuss knowledge gaps specific to training. The final researchers'/policy-makers' workshop was carried out on July 6th 2016 to review regional workshop findings and facilitate a synthesis of identified knowledge gaps into key research priorities for sustainable deer management.

2.2 Workshop Methodology

The methodology used for the workshops is given in [Appendix 1](#).

2.3 Workshop Attendance

In total, 114 participants attended five workshops (Table 2.1), with an average attendance of 19 and both the Ullapool and Strathclyde workshops hosting 23 participants. Figure 2.1 illustrates the overall breakdown of attendees by stakeholder type. A total of 31% of attendees represented the private estate/hunting sector, including gamekeepers (7%), estate owners and factors (15%) and hunting/estate NGOs (9%). The hunting/estate NGO category includes respondents from BASC, Scottish Land and Estates and the British Deer Society. Public bodies represented the largest group overall, although this includes local authorities and a range of government agencies, with Forestry Commission Scotland and Scottish Natural Heritage the most frequently represented public bodies. Environmental NGOs represented included the RSPB, NTS, John Muir Trust and Trees for Life. The 'other' category included representatives of community bodies, community landowners, a deer farmer, conservation director and some individuals who were active volunteers within Deer Management Groups (e.g. as secretaries) but did not fit into any of the other seven categories. The majority of participants were members of a Deer Management Group, including 19 DMG chairs and seven secretaries.

Table 2.1 - Number of attendees at deer research workshops

Workshop	Cairngorm/ Monadhliath	Central Highlands /Argyll	North West	Low- lands	Trainers	Research/ Policy
No. of Attendees	16	21	23	23	14	17 (+ 7 email responses)

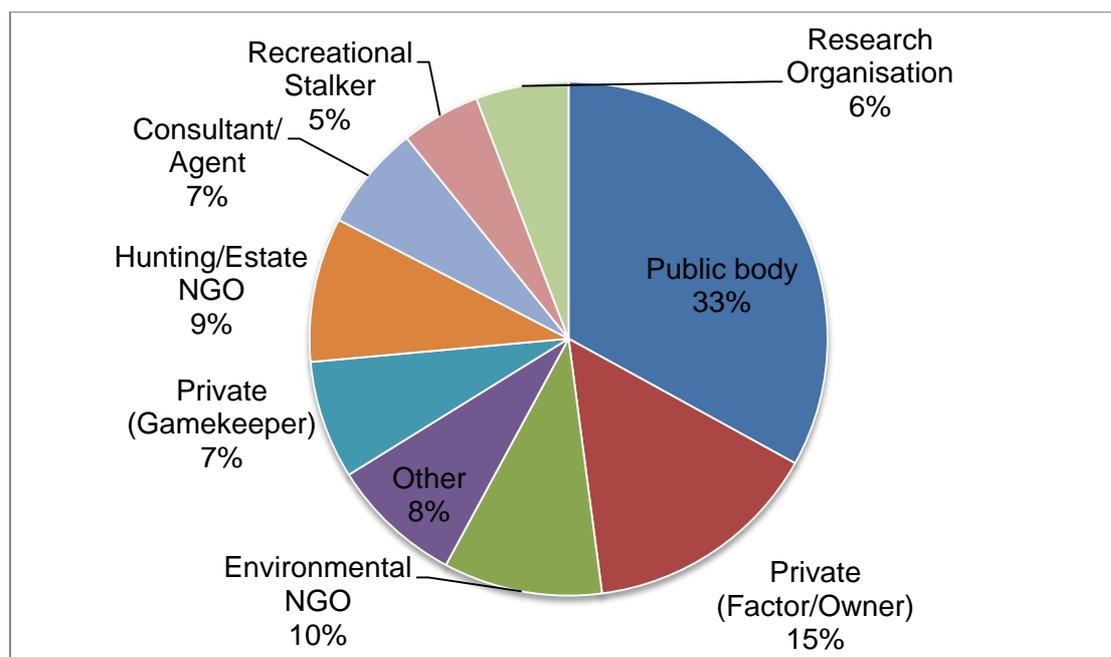


Figure 2.1 - Breakdown of workshop attendees by stakeholder type across all six workshops

Figure 2.2 shows the breakdown of stakeholder types across the five workshops. The four regional workshops show a reasonably good spread of stakeholder types with public body and private estate participants making up a significant proportion of participants in most cases. The lowland workshop included a larger proportion of public bodies, due in part to the inclusion of a number of local authority representatives, as well as FCS and SNH participants. The trainers' workshop had a lower attendance (14) and both the lowland and trainers' workshop had no environmental NGO participants. Notably, Figure 2.1 and 2.2 include seven respondents who participated in the researchers'/policy makers' workshop process by reviewing the workshop presentation by email and completing the entry and exit questionnaires by email. This option was pursued due to a low turnout at this (researchers'/policy makers') workshop relative to the numbers actually confirming that they would attend (with 18 cancellations from the original 35 who accepted the invitation to attend). Research organisations only attended the final synthesis workshop, with this workshop also hosting a higher number of consultants and low numbers of estate managers/gamekeepers, although four hunting/estate NGO representatives attended, with only one environmental NGO attendee.

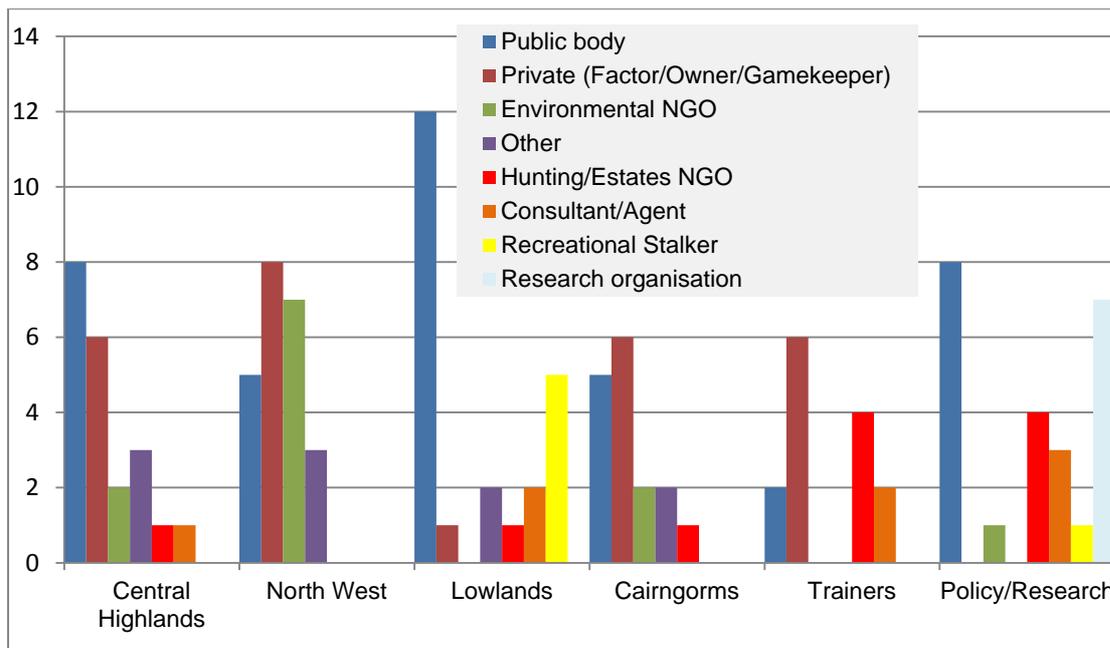


Figure 2.2 - Breakdown of workshop participants by stakeholder type and workshop location

2.4 Pre-workshop Entry Questionnaire

2.4.1 Key Challenges

In the entry questionnaire workshop participants were asked (an open ended question) to identify up to five barriers to delivering sustainable deer management in their region in order of importance. Responses were coded into twenty one separate challenge themes. The total number of comments identified under each theme is shown in Figure 2.3, which also shows the order of importance of comments. The conflicting objectives/cross boundary challenges theme was the most frequently mentioned challenge overall, followed by operational constraints and public/political awareness (lack of awareness/misunderstanding) of deer management. The coded themes were broad in some cases, with the conflicting objectives/cross boundary theme for example including comments on lack of information sharing, insufficient participation in DMGs, trust building and the need for involvement of wider stakeholders. The operational constraints theme also included comments on costs, staff limitations, time constraints, closed seasons, seasonal challenges and accessibility.

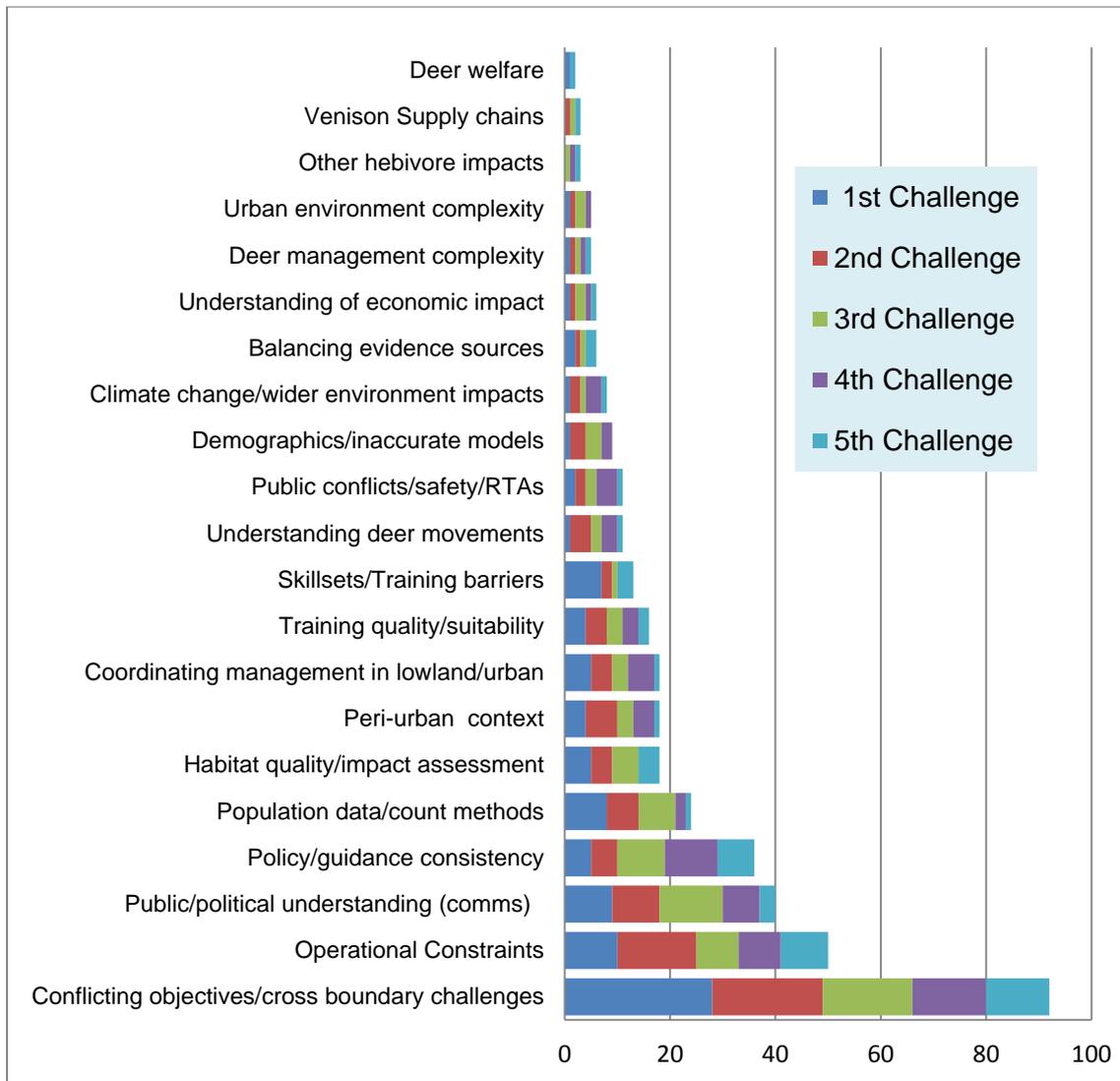


Figure 2.3 - Challenges identified by survey participants (all workshops combined) by order of importance

Figure 2.4 shows the challenges identified by order of importance at the synthesis (researchers'/policy makers') workshop. The relative importance of key challenges is similar to those identified in the other five workshops, with conflicts and cross boundary challenges the most common first and second ranked challenge. Policy and guidance was the second most common challenge overall, perhaps representing the policy-level representation at the workshop, with deer movement and habitat impacts and impact assessment also consistent as challenges with the wider workshops.

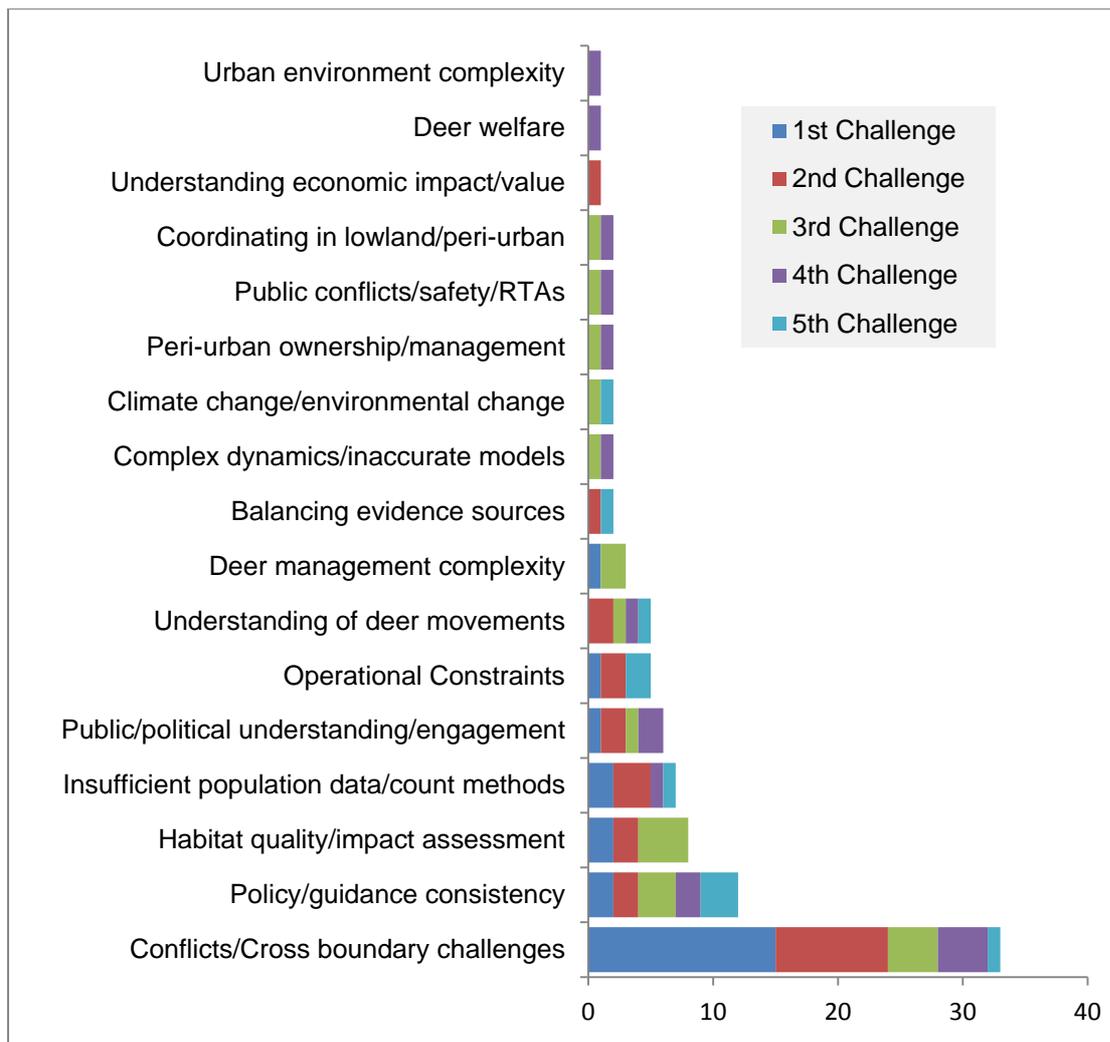


Figure 2.4 - Challenges identified by researcher/policy maker workshop participants ranked by level of importance

Figure 2.5 shows the challenges identified by workshop survey participants by stakeholder type. All stakeholder types emphasised the challenge of conflicting objectives/cross boundary issues, with recreational stalkers also recognising the challenge of coordinating management in lowland settings (due to a lack of established collaborative structures and a complex land use/ownership setting). Private estates and public bodies both recognised the challenges of operational constraints and public/political understanding; although public bodies placed a greater emphasis on population data/count techniques and habitat impact data and assessment techniques than private estate participants. Public body responses generally show a wider spread across a broad range of challenges, while a large number of private estate comments are bunched within the top four challenges. Challenges relating to policy/guidance were more frequently raised by private estate, environmental NGO and 'other' respondents. Insufficient understanding of deer movements was also identified by public and environmental NGO respondents as a challenge.

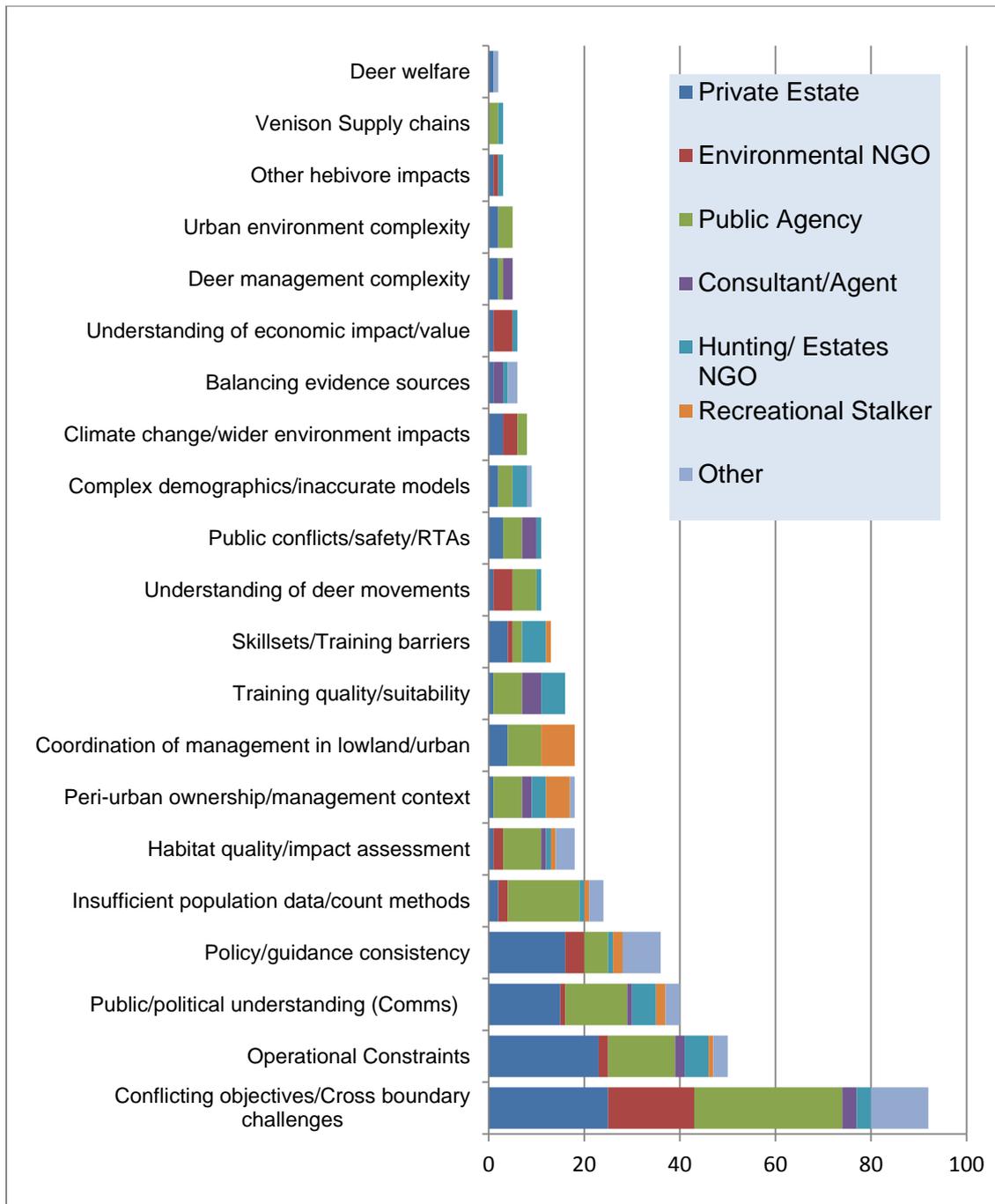


Figure 2.5 - Challenges identified by workshop survey participants by stakeholder type

2.4.2 Where Participants Obtain Information

Workshop participants (not including the synthesis workshop) were asked a closed question on where they obtained information to help them address deer management challenges. Peer to peer communication and personal observation/experience were selected by most respondents. Training courses and reports were each selected as sources by 72 respondents and academic sources was selected by 55 (Table 2.2). The other category included organisational magazines (e.g. the BDS Journal), communication with scientists and public bodies (e.g. SNH), Scottish Government legislation and plans, and best practice guidance documents/events.

Table 2.2 - Information sources used by workshop participants to inform their management

	Peer communication	Personal observation/experience	Training courses	Reports	Academic sources	Popular Media	Other
Total	90	86	72	72	55	16	14

Figure 2.6 further breaks down the choice of information sources by workshop type. Sources used varied slightly between regions but were relatively consistent overall. The use of reports and academic sources varies somewhat by workshop although peer communication, training and experience are consistently used across the five workshops.

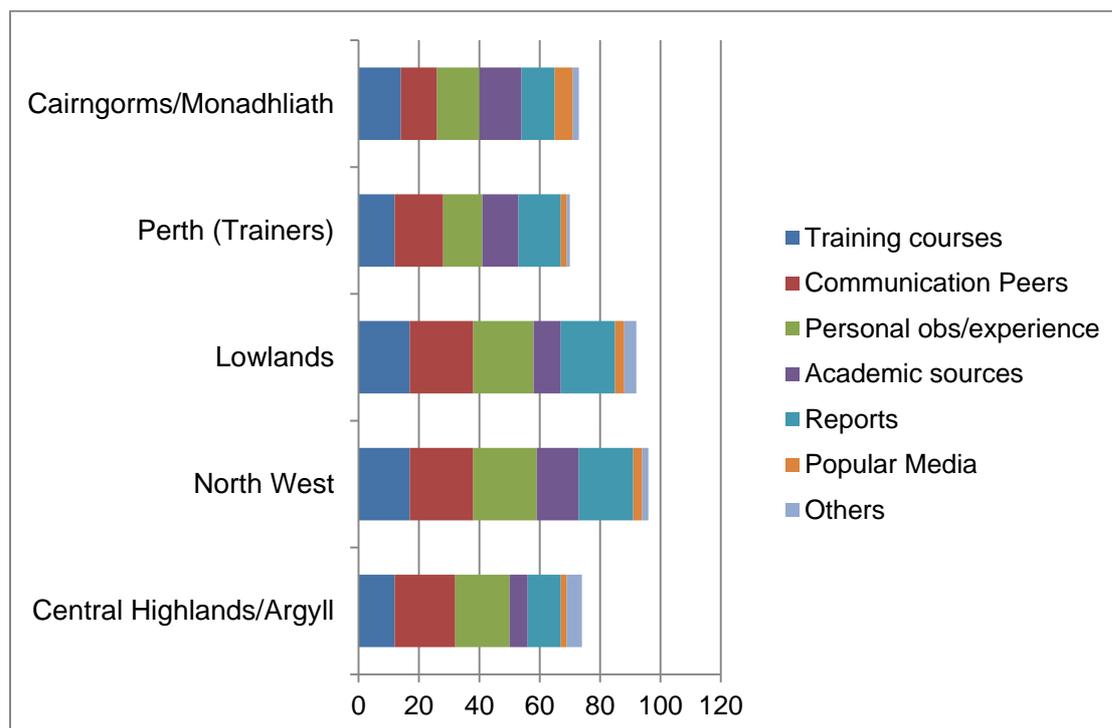


Figure 2.6 - Information sources used by respondents to inform management by workshop location

2.4.3 Knowledge Gap Identification

The workshop questionnaire also asked respondents to identify up to three knowledge or evidence gaps (in order of importance) which made it difficult to address the previously identified barriers. Responses were coded into twenty two separate themes. Figure 2.7

shows the total number of comments relating to evidence/knowledge gaps and their relative order of importance. Habitat quality data and HIA (Habitat Impact Assessment) techniques was the most frequently mentioned code overall, followed by collaborative working/conflict management, both of which were identified as the most important gap by the same number of respondents (10). Deer population count data and evidence of economic impacts and valuation of deer management were the third and fourth most frequently recognised knowledge gaps overall.

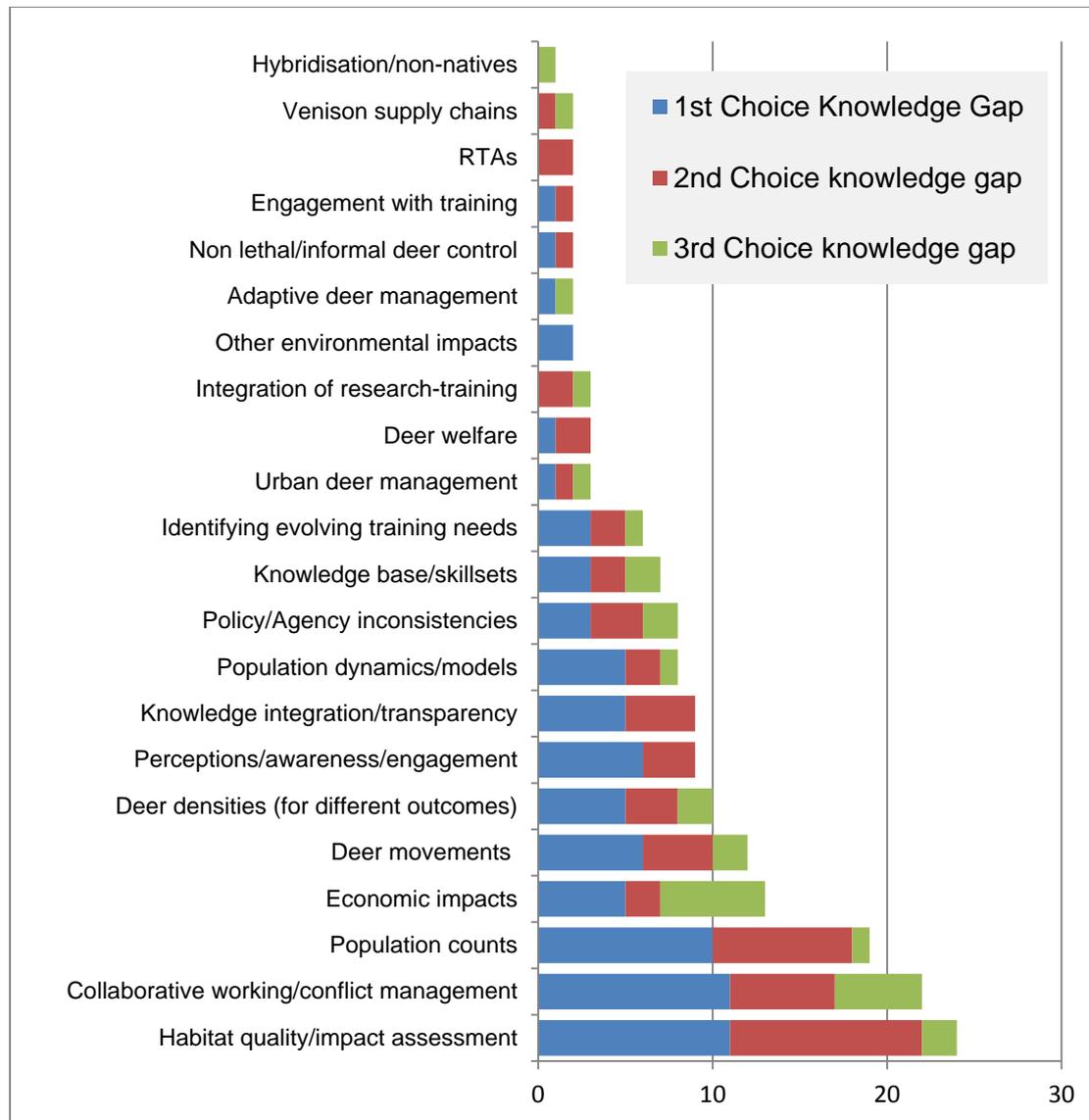


Figure 2.7 - Knowledge/evidence gaps identified by survey participants (all workshops combined) by order of importance

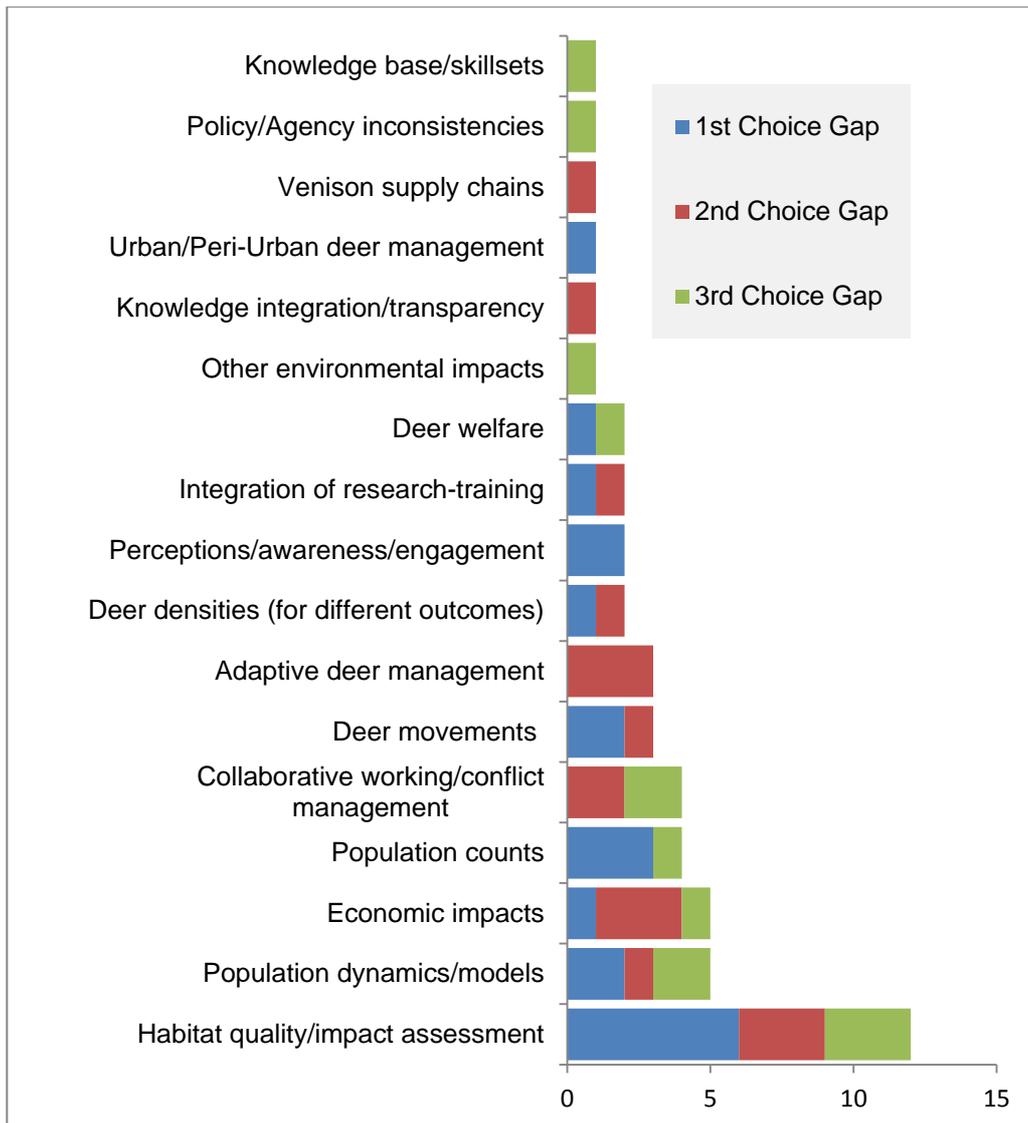


Figure 2.8 - Knowledge/evidence gaps identified by survey participants from the researchers'/policy makers' workshop by order of importance

Figure 2.8 shows the knowledge gaps identified by order of importance at the synthesis (researchers'/policy makers') workshop. As for the regional workshops, evidence of habitat quality and HIA techniques was the most frequently mentioned gap code overall (including assessing impacts at different scales, higher quality data on impacts and enhanced HIA techniques and skillsets). However, collaborative working and conflict management was not as highly recognised as a knowledge gap in the synthesis workshop (relative to earlier workshops which consistently recognised it as a key gap). This indicates that synthesis workshop participants differentiated conflict and collaborative aspects as practical challenges or policy/practice gaps, as opposed to consistently viewing them as clear gaps in knowledge. Population count information was also slightly less frequently referred to as a gap within the synthesis workshop relative to wider workshops. Adaptive deer management (data/monitoring driven management) was referred to explicitly more frequently as an overall proportion of responses in the synthesis workshop (although some of the comments in earlier workshops reflected an adaptive approach). In contrast to earlier workshops training was not specifically referred to as a gap, with deer related RTAs and hybridisation also not referred to specifically as gaps within the synthesis workshop entry survey responses.

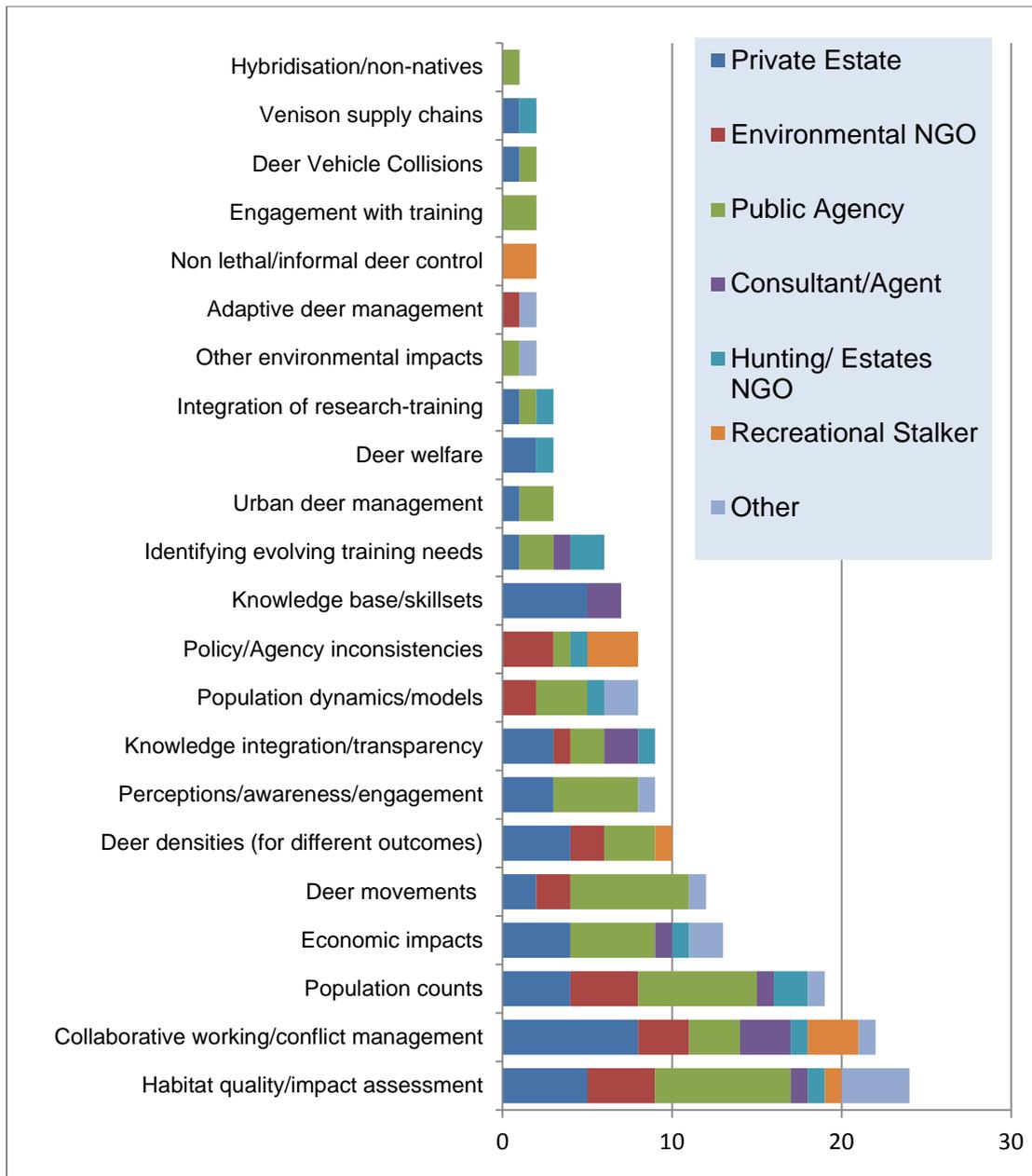


Figure 2.9 - Knowledge/evidence gaps identified by workshop survey participants by stakeholder type

Figure 2.9 shows the knowledge/evidence gaps identified by workshop survey participants by stakeholder type. Overall, different stakeholder groups all recognise a variety of knowledge gaps and there is some agreement evident between stakeholder types. Public agencies identified habitat impacts/impact assessment as a knowledge gap more frequently than other stakeholder types, with private estate respondents more frequently identifying collaborative working/conflict management as a gap. Public bodies also more frequently identified evidence on population counts and deer movements than private estates, with private estates more frequently identifying the ability to match deer densities to specific outcomes as a knowledge gap. Knowledge on the economic impact/value of deer and deer management was recognised as a gap by most stakeholder types, with knowledge of public perceptions of management and mechanisms of public engagement recognised by public and private estate respondents.

2.5 Knowledge/Evidence Gaps Identified Through Workshop Discussion

2.5.1 Workshop results format

Tables 2.3-2.7 present the summarised findings of the qualitative workshop discussions by WDNA priority. The themes presented in the tables have been developed through coding and merging discussion themes recorded in all six workshops for the respective WDNA priority. Where themes are indicated with a tick (✓) within a workshop column this indicates they were discussed as a knowledge/evidence gap for the respective workshop. Where two ticks occur beside a theme, the theme was discussed more than once and in relation to different sub-themes/specific aspects (i.e. where more than one tick occurs the theme was discussed in greater depth and detail). Where the tick box for a theme is also shaded dark, this indicates that workshop participants (at the end of the workshop) also ranked the theme as one of the most important themes discussed across the workshop as a whole (i.e. darker shading indicates themes of greater significance). The final two columns in each table present the key findings from the synthesis workshop discussions which are also ticked and shaded according to order of importance (with red boxes showing themes where the greatest emphasis was placed overall).

2.5.2 Collaboration and effective deer management planning and implementation

The key knowledge gap sub-themes discussed and emphasised within the collaboration and deer management planning (DMP) theme (Table 2.3) related to knowledge and guidance on conflict management (including conflict management tools) and understanding of trust building mechanisms. This theme was further developed in relation to the need for knowledge and guidance on effective governance and leadership of collaborative processes (DMGs). Facilitating understanding of different perspectives was a key challenge linked to collaborative management processes. Collectively these conflict management/cross boundary challenges sub-themes represented one of the most discussed and emphasised set of themes across the workshops as a whole (excluding the lowland workshops where the emphasis was slightly different – see Table 2.6). This reflects the general trends evident in the workshop survey responses presented earlier.

The synthesis workshop discussion also identified trust building processes and understanding the drivers of conflicts as a key research theme; however, the synthesis discussion also highlighted how many of the sub-themes relating to conflict and cross-boundary issues¹ represented knowledge transfer gaps or gaps in practice or challenges (as opposed to actual evidence gaps). This is further supported by the entry survey analysis which indicated that synthesis workshop participants differentiated conflict and collaborative aspects as practical challenges or policy/practice gaps, as opposed to consistently viewing them as research gaps. The potential value of some further research on conflict drivers and trust building was recognised by some synthesis workshop participants; however, translating and communication of existing theory and research to facilitate development of conflict management tools or frameworks was more specifically recognised as a gap in knowledge transfer or practice. Survey responses in all workshops perceived cross-boundary challenges as the greatest challenge for the sector; it is possible therefore, that in some cases this same theme is rated as a key knowledge gap due to its general overriding importance, as opposed to an actual clear need for further research on the topic.

Within the detail of workshop survey responses it is also apparent that while answers relating to the theme of conflict/cross boundary challenges were often listed as research priorities, the detail of many answers actually related to factors which more accurately represented knowledge transfer gaps or gaps in practice e.g. sharing of management

¹ Cross-boundary issues largely result from differences in land management practices between adjacent management units or differences in management ideology.

experiences, building useful applied tools, conflict mediation processes. Issues relating to trust building, governance and leadership skills and those relating to the remit and scope of DMGs, were differentiated within the synthesis workshop as more related to training needs (e.g. in engagement or meeting management) or representing policy/management challenges than actual research gaps. Knowledge transfer gaps were also highlighted at DMG-level, with synthesis workshop participants recognising the need for developing stronger DMG evidence bases through data gathering and sharing to facilitate adaptive management approaches.

The synthesis workshop highlighted issues of effective translation and uptake of existing research on deer population dynamics and density dependence (i.e. impacts of hind management on stags). This was linked to the need for clear guidance and the use of straightforward population dynamics models to facilitate cull target setting within Deer Management Plans, with a number of examples of existing tools noted, which have not been further developed or utilised following the end of specific research projects (e.g. SWARD, HillDeer, DeerMap).

Understanding of deer movements/migration (between landholdings/at landscape scales) repeatedly emerged as a knowledge gap across the regional workshops. From the synthesis workshop it was noted that some research had been conducted on deer movements; however, further research on deer movements (e.g. in response to disturbance) was generally seen as being of value due to the complexity of the issue and place specific variations in deer movement and migration (although not all synthesis workshop participants agreed on this point).

Development of improved deer count techniques, including remote sensing methods, was discussed as a gap across three regional workshops. While synthesis workshop participants recognised that deer count data was not always adequate or widely available or up to date, count methods and research on deer numbers was not overly emphasised as a research priority (with greater emphasis placed on movement and impacts).

Understanding of public perceptions of deer management and public/community engagement mechanisms also emerged repeatedly across regional workshops, with the synthesis workshop identifying this more specifically as a gap in engagement and transfer of knowledge to the wider public.

Table 2.3 - Discussion themes (by workshop) on knowledge gaps relating to collaboration and effective deer management planning and implementation (WDNA 1)

Discussion theme	Cairngorms	Argyll	North West	Trainer	Policy / Researchers	
					KT Gap	Res Gap
Conflict Management/Cross-boundary challenges						
Conflict management frameworks/tools/processes (mediation/facilitation); translation of theory into practice	✓	✓	✓		✓	✓
Trust building processes and understanding differing objectives and pressures/drivers; (on different owners/managers e.g. stockmanship vs. management for impacts); knowledge sharing and role of communication processes; effect of timescales on pressures.	✓✓	✓	✓	✓✓	✓	✓
Governance expertise and leadership development within cross-boundary management; Participation of empowered decision makers in DMGs	✓✓	✓	✓		✓	
Future remit/scope of DMGs (DMG resourcing - costs of DMPs/developing long term approach); Considering area specific context and role/inclusion of wider stakeholders/ other herbivores control etc.		✓	✓✓	✓✓	✓	
Assessing value of local/manager knowledge and experience against scientific knowledge.			✓	✓		
Deer counts/movement/population models						
Understanding deer movement/migration at landscape scales; winter movement; evidence for/against vacuum effect; impacts of management/disturbance on movement	✓	✓✓	✓			✓✓
Insufficient deer counts/over emphasis on counts or misleading data (due to count timing)/need for wider consideration of impacts/movements/fencing			✓✓			✓
Improvement of deer count techniques (funding, professionalism, scale); woodland count techniques (remote sensing/communicating best practice)	✓	✓✓				
Improved population models – achieving some agreement with deer counts/HIA; long term datasets; improving understanding of density-dependence/population dynamics and integration within DMP process. Application of existing models (e.g. SWARD) and decision support tools			✓		✓✓	
Establishing agreed robust baselines for sustainable culls and levels of habitat impacts			✓			
Public awareness/ engagement						
Understanding public perception/awareness of deer management; improving public education/engagement with deer management	✓✓	✓		✓	✓✓	
Other factors/themes						
Impact of closed seasons on achieving objectives	✓	✓				
Agreeing and quantifying public interest	✓					
Investigating relevance of European models of deer management			✓			

2.5.3 *Healthy ecosystems*

An over-arching theme related to healthy ecosystems discussed from different perspectives in the regional and trainers' workshops was the need for reliable evidence on habitat impacts and adaptable, robust HIA methodologies (Table 2.4). In contrast, synthesis workshop participants placed greater emphasis on the need for improved uptake of HIA and the building of understanding and trust in the HIA process and the end use of HIA data. In particular, synthesis workshop participants noted the need for greater integration of impact assessment data with the DMP process and cull target setting. HIA methodologies were therefore emphasised at the synthesis stage as a gap in knowledge transfer, skills training and practice, as opposed to an evidence gap. Improving understanding of links between deer densities and habitat impacts (for different habitat types) was identified as a research gap at the synthesis workshop, despite a lack of consistent emphasis in earlier workshops.

The need for the development of longer-term and larger-scale datasets (on deer populations and impacts) was also recognised as necessary for understanding longer term ecosystem change; this was highlighted more as a site-specific (rather than national) gap at the synthesis stage. Notably, the issue of longer term or larger scale data was related specifically at the synthesis stage to the need for wider adoption of regular HIA monitoring (and data collation) across DMGs and the use of specific techniques such as remote sensing to identify habitat change over time. These measures were viewed as necessary for providing DMGs with an evidence base, in combination with population assessments, to inform DMP decision making processes (e.g. cull target setting) and develop adaptive management plans.

Developing agreed definitions of degraded habitat, the need for further data on habitat impacts outside of designated sites and evidence on non-native deer populations were also all raised less frequently at the regional workshops. The synthesis stage highlighted the need for developing clear definitions as a specific knowledge transfer gap, requiring more effective interpretation of relevant research on ecological condition for different habitat types. Evidence and data on the impacts of other herbivores (sheep, hare, goats etc.) also repeatedly emerged as an evidence gap across four separate workshops (and potential changes to grazers linked to changes to CAP etc.), with this theme also recognised as a research gap at the synthesis stage.

An additional theme emphasised in the Argyll workshop and raised in some of the other workshops was the need for improved understanding of the impact of deer management on ecosystem services, with peatland dynamics and carbon stores repeatedly discussed. The need for greater understanding of the impacts of climate change on deer management was also raised in the Argyll and Ullapool workshops. The opportunity for research on deer and ecosystem services (and specifically carbon storage and peatland ecosystem dynamics) and strategic approaches to managing deer in peatlands was also recognised to some extent at the synthesis stage. This theme was also discussed as a knowledge transfer issue, with an increased need for information on ecosystem services to be communicated to land managers and a requirement for effective markets to be developed for trading carbon credits. Synthesis workshop participants also noted the existence of considerable research on non-native deer species, which has not been effectively communicated more widely.

Table 2.4 - Discussion themes (by workshop) on knowledge gaps relating to healthy ecosystems (WDNA 2)

Discussion Theme	Cairngorms	Argyll	North West	Trainer	Policy / Researchers	
					KT Gap	Res Gap
Habitat impacts/assessment/density						
Increased usability/reliability of HIA for different habitat types (data analysis, interpretation)	✓	✓	✓✓		✓	
Increased understanding of HIA and attitudes towards use of HIA; relating HIA data to cull planning					✓✓	
Improved understanding of link between deer densities and deer impacts			✓			✓
Understanding population trends and impacts over larger spatial and temporal scales (e.g. remote sensing)	✓					✓
Impacts of other herbivores on ecosystems/habitats and herbivore interactions	✓	✓✓	✓	✓		✓
Definitions/criteria for degraded habitat and good ecological condition (for multiple habitat types)	✓		✓		✓	✓
Assessing habitat impacts outside of designated sites	✓	✓				✓
Consistency of data collection/long term datasets						
Consistency, availability of data collection and data analysis (count, culls, recruitment etc.); understanding change over time - long term habitat data collection		✓✓	✓	✓	✓	
Role/effectiveness of fencing						
Fencing effectiveness and impacts of fencing removal on other objectives (improving effectiveness for woodland habitats); fencing costs		✓	✓			
Wider environment/ecosystem services/climate change						
Peatland dynamics and herbivory (Impacts of deer and other herbivores on peatland condition, peatland recovery and wider factors impacting peatland habitat)	✓		✓			✓
Understanding influence of management on ecosystem services; carbon - strategic approaches to managing deer in peatland ecosystems; ecosystem services/mapping and understanding of long term ecosystem dynamics	✓	✓✓✓		✓	✓✓	✓
Impacts of climate change on deer management (flooding and access, habitat condition, changing timing of rut)		✓✓	✓			✓
Non-native deer populations						
Non-native deer species (potential spread, long-term impacts, management approaches); value				✓	✓	✓

2.5.4 Economic and community development

A key sub-theme discussed repeatedly under the socio-economic theme (Table 2.5) was the need for greater understanding of the full economic value of deer and deer management, including the downstream (multiplier) effects of management, local community economic impacts and differentiation of private and public economic benefit streams. This theme was further developed in the Ullapool and trainers' workshops in relation to the need to assess the relative full economic impact/value of different deer management models (e.g. traditional sporting; conservation management; community stalking groups). While recognising existing research demonstrating the economic impacts of deer and deer management, synthesis workshop participants concurred on the identification of economic valuation and costs/benefits associated with alternative models as a research gap.

A further theme discussed at all four regional workshops was the need for a fuller understanding of venison supply chains and existing supply chain capacity (including in lowland contexts). This theme also emerged at the synthesis stage, although marketing and supply chain development (e.g. larder availability in lowland areas) was articulated more as a sectoral constraint than a key research gap. Nevertheless, the synthesis stage also recognised that supply and demand levels and monetary flows relating to venison were often not fully understood, particularly in lowland areas.

Exploring opportunities for added value and longer-term diversification (e.g. hind stalking, nature tourism) was also discussed at the Argyll and Ullapool workshops. This was also discussed as a research gap at the synthesis stage, although the majority did not rank it as being of high importance as a research priority overall.

Knowledge of public perceptions and engagement mechanisms emerged within socio-economic discussions across all five workshops. The synthesis stage also highlighted this theme, with workshop discussions and survey responses differentiating it as a knowledge transfer gap as opposed to a priority for research. Specific related opportunities for improved public awareness of deer management noted at the synthesis stage included citizen science (e.g. recording deer in urban areas, reporting deer related road traffic accidents), educational initiatives (e.g. through the curriculum), targeted projects (e.g. the Deer on Your Doorstep initiative) and public events communicating the role and history of deer and deer management.

Policy mechanisms including suitability of designation and subsidy systems were discussed in a smaller number of workshops. The synthesis stage identified these gaps as gaps in policy (as opposed to knowledge), with a further discussion point raised at the synthesis stage relating to the need for improved clarity of the 'vision' for deer management at the policy/national level in Scotland.

Table 2.5 - Discussion themes (by workshop) on knowledge gaps relating to economic and community development (WDNA 3)

Discussion Theme	Cairngorms	Argyll	North West	Trainer	Policy / Researchers	
					KT Gap	Res Gap
Socio-economic impact/valuation/local and down-stream impacts						
Socio-economic impact/value of deer management (full impact, downstream benefits); local and regional economic impact; multiplier effects of investment, activity, employment (public/private benefits)	✓		✓✓	✓✓	✓	✓
Understanding socio-economic impacts (costs/benefits) of alternative models of management (conservation; stalking groups); true economic cost			✓	✓	✓	✓
Venison supply chain development, added value/diversification and branding						
Venison supply chain development and added value; processing and marketing capacity ; linking supply and demand (addressing cost and seasonality of venison); whole supply chain business model	✓✓	✓	✓		✓✓	✓
Adding value to venison products ; addressing hygiene/regulatory challenges; awareness of how to add value		✓	✓			
Supporting/exploring market (local economic) diversification (capturing income): wildlife/deer watching; hind stalking; alternative hunting ²		✓	✓✓✓		✓	✓✓
Understanding public perceptions/awareness and engagement						
Understanding public perception/awareness of deer management and improving public education/engagement with deer management (on impacts and positive role of deer); link between management and community councils	✓	✓	✓	✓✓	✓✓✓✓	
Policy mechanisms						
Suitability/relevance of current designation system		✓				
Suitability of subsidy system (potential for an outcome based system linked to objectives)			✓			
Improved clarity of policy guidance/vision and collective purpose					✓	

² Alternative hunting is defined as any form of hunting that has an economic and/or environmental/social rationale which is different to the traditional model of deer stalking on sporting estates. For example, hind stalking at lower rates to get non-typical people involved in hunting; roe stalking; the hunting of other species such as wild boar; and different approaches to stalking (e.g. wilderness stalking where you walk out and carry the carcass back; the community approach (e.g. North Harris Trust); and hunting groups, where organised groups of keen hunters come into areas and undertake stalking).

2.5.5 *Lowland and urban deer*

The lowland and urban deer theme was primarily discussed in the Strathclyde (lowland/urban) workshop (Table 2.6) and as a distinct theme within the trainers' and synthesis workshops. The development and enhancement of processes of landowner/manager/stakeholder collaboration and cooperation also represented the most frequently mentioned theme in a lowland context. The low involvement of local authorities in lowland deer management processes in particular was repeatedly identified as a weakness. The synthesis stage also discussed this aspect repeatedly as a knowledge transfer gap, requiring greater sharing of knowledge and experience between local authorities and involvement in the deer management process in lowland and peri-urban areas. The development of a database of land managers and skilled deer stalker contacts within local authorities also offers potential for increasing awareness of utilising the deer management resource effectively when required. Releasing the potential of the volunteer deer management resource in lowland areas through coordination, facilitating new stalking entrants and potential use of 'citizen science' were also discussed within the lowland workshop.

The actual mechanisms of establishing cooperation were emphasised, as opposed to a continual focus on conflicts (as in many lowland areas collaborative management was in a very early stage of development relative to many upland regions). The focus was therefore on how to effect collaboration as opposed to how to manage conflict and govern collaborative structures already in place (as was the case in the uplands). As highlighted at the synthesis workshop potential therefore existed to transfer knowledge on existing successful collaborative approaches in lowland and peri-urban areas through development of case studies, stakeholder events (including local authorities) and training.

Lowland workshop participants highlighted the importance of differentiating lowland deer management from the upland deer management context. Specific requirements included improved understanding of lowland deer dynamics, deer impacts in diverse habitat/land use contexts, improved data on roe deer and non-native deer species and determining the importance of disease transmission (from deer to livestock). The synthesis workshop also identified this area as the main actual research/evidence gap relating to the lowland theme, with less research evidence available on roe deer dynamics to inform lowland-specific deer population models.

Improved understanding of public perceptions of deer in lowland contexts and the public safety challenges of deer management in an urban context was also identified as a gap within the lowland workshop (as in all other workshops), with the synthesis discussion stage emphasising this more as a gap in awareness or knowledge transfer. Overall, the discussion themes from the lowland workshop (Table 2.6) include a range of themes which may more accurately reflect management challenges or constraints (e.g. enabling new entrants, venison supply chain development) or gaps in transfer or interpretation of wider deer knowledge to a lowland context.

Table 2.6 - Discussion themes (by workshop) on knowledge gaps relating to lowland and urban deer (WDNA 4)

Discussion Theme	Low-land	Trainer	Policy / Researchers	
			KT Gap	Res Gap
Collaboration/cooperation and stakeholder communication				
Improved understanding of functioning of existing management models and collaborative deer management mechanisms between landowners, agencies and local authorities; (cross boundary approaches); in lowland/peri-urban settings; Constraints and opportunities for cooperative action (deer groups)	✓✓✓	✓✓✓	✓✓	✓
Local Authority (LA) involvement/prioritisation of deer management; understanding of barriers to LA involvement; sharing of knowledge between LAs.	✓✓		✓✓✓	
Venison supply chain development; access to shared processing infrastructure/marketing opportunities	✓	✓	✓	
Utilising (volunteer) deer management resource				
Lack of awareness/database of competent stalkers/accessing local deer management resource	✓		✓✓	
Capturing existing deer management resources (deer groups) - resourcing lowland groups and creating awareness of their potential role	✓			
Enabling new entrants to stalking/accessing stalking resource/mentoring	✓			
Use of citizen science in recording deer occurrence	✓		✓	
Public perception/awareness/engagement				
Understanding public perception/awareness of deer management and improving public education/engagement with deer management process and deer managers	✓	✓	✓	✓
Challenge of maintaining low profile approach to urban deer management (public safety/perception)		✓		
Lowland deer dynamics/population data				
Differentiating lowland dynamics and issues (habitat/land use diversity in lowland context); lowland deer population and impact models		✓	✓	✓✓
Understanding deer movement/migration and disturbance impacts; development impacts on Lowland deer dynamics; fencing effectiveness	✓			
Improving deer count techniques in lowland/woodland settings; Knowledge/data on deer in urban/peri-urban areas; awareness of suitable planting scheme designs	✓		✓	
Habitat impacts/habitat impacts assessments				
Increased understanding and adoption of HIA; spatial variability in impacts; carrying capacity of lowland habitats	✓	✓	✓	✓
Roe and non-native deer populations				
Non-native deer species (potential spread, impacts, management approaches)	✓	✓		
Understanding roe deer populations/dynamics (Densities, impacts, territoriality, recruitment, predation on calves, culling versus trophy stalking)	✓✓	✓		✓✓
Disease transmission				
Understanding/managing disease transmission between deer and livestock; Lyme disease transmission	✓		✓	
Best practice (lowland management)				
Identifying and communicating shared experience/best practice in lowland and urban deer management (case studies)	✓	✓	✓	

2.5.6 *Training and deer welfare*

Key sub-themes which emerged from discussions under the training and deer welfare theme included the expansion of deer qualifications to include habitat management and assessment training, incorporating the underpinning science and role of HIA in cull planning (emphasised in three workshops). This theme was further confirmed as a priority training gap at the synthesis workshop (Table 2.7). An increasing emphasis on management which delivers private and public benefits was recognised as requiring an evolution in new training opportunities, including welfare concerns, public engagement, DMG governance and administration, population models, welfare and disease concerns (e.g. Chronic Wasting Disease) and Deer Vehicle Collision (DVC) management. Training in engagement, dialogue and governance techniques offers opportunities to address a number of key gaps identified in earlier themes (including conflicts and cross boundary challenges and public awareness of, and engagement with, deer management). Stakeholder events, knowledge sharing and training were also recognised as offering opportunities to build trust between landowners and across stakeholder groups. This is reinforced further by the recognition in Section 2.6.2 that many gaps identified under the broad theme of conflict and cross-boundary challenges reflected gaps in knowledge transfer or practice as opposed to purely research gaps.

A further point raised in two regional workshops and the training workshop and reinforced as a knowledge transfer gap in the synthesis workshop is the opportunity for further aligning tertiary education with WDNA themes. In particular the development of new higher level qualifications beyond DSC1 and DSC2 which are targeted at deer managers. In this respect, a requirement was identified for future training to be relevant and linked to current and future directions for rural land use, recognising the growing importance of community engagement in land use decision making, multifunctional and integrated land management and rural business diversification.

Deer welfare considerations were recognised as requiring the development of clear criteria for defining welfare and improved data gathering on carcass numbers, mortality events, breeding success and ageing, to facilitate effective monitoring of deer welfare. Evidence gaps were also highlighted in relation to the impacts of habitat conditions, night shooting and climate change in deer welfare. Specific gaps relating to different aspects of DVCs (national mapping, public cost and assessment of avoidance mechanisms) were also identified. These welfare related themes were also identified in the synthesis – as knowledge transfer gaps, as opposed to research priorities, with the exception of DVC risk factors and avoidance where some participants perceived a research gap.

Table 2.7 - Discussion themes (by workshop) on knowledge gaps relating to training and wild deer welfare (WDNA 5)

Generic Codes	Cairngorms	Argyll	North West	Lowland	Trainer	Policy / Researchers	
						KT Gap	Res Gap
Enhancing best practice							
Updating Best Practice guidance (and linking to existing evidence)	✓✓				✓	✓	
Identifying and communicating best practice in lowland and urban deer management (case studies); developing urban stalking skillsets	✓			✓	✓✓		
New mechanisms for Best Practice at DMG level	✓		✓				
Availability of deer management tools/models ; dissemination of advances in technology (apps, thermal imagery etc.)					✓		
Expanding relevant qualifications/training							
Expansion of deer qualifications to include habitat management training; uptake of HIA training; improving HIA training; density related impacts; understanding of underpinning science and role of HIA in cull planning	✓	✓			✓✓	✓✓✓	
Raising of training standards for deer managers /fostering a continual CPD approach (reassessments)	✓	✓	✓		✓✓	✓	
Developing place-based education - apprenticeships, visits, placements; capturing sector practical experience	✓	✓	✓	✓✓			
Specific skills development: stockmanship; roadside kills management; population models.	✓	✓			✓✓✓		
Development of communication/engagement training (deer managers); DMG operations skills					✓✓	✓	
Aligning of tertiary education with WDNA; Integrated land use Qualification (training beyond DSC1/2)	✓	✓			✓	✓	
Public perceptions/awareness/engagement							
Understanding public perception/awareness of deer management and improving public education/engagement			✓		✓		
Public awareness of Lyme disease		✓		✓			
Improved interpretation and communication of science	✓	✓		✓			
Awareness around urban deer best practice	✓				✓		
Deer welfare							
Defining (indicators) and assessing deer welfare (carcass numbers/ mortality, breeding success, ageing); integration with training	✓✓	✓	✓		✓	✓✓	
Welfare impacts of night shooting; poaching; and cruelty		✓			✓✓	✓	
Impacts of different habitats/ conditions on welfare; disturbance timing	✓					✓	
Climate change impacts on welfare			✓				
Deer Vehicle Collisions							
DVCs reporting mechanisms/unreported incidents; risk factors and avoidance		✓	✓			✓	✓
Integrated assessment/national mapping DVCs (extent; mortality; welfare impacts)	✓			✓✓			
Public cost/economic impact DVCs				✓			

2.6 Summary and Initial Conclusions from the Workshops

This section has produced a summary of the perceptions of workshop participants relating to knowledge gaps around deer management. It is therefore a summary of stakeholder perceptions, as opposed to an objective statement of knowledge transfer, training and research gaps. Different stakeholders can prioritise different gaps, as apparent from regional workshop stakeholder responses differentiated by stakeholder type. Different stakeholder groups may perceive specific areas of research (e.g. evidence of habitat impacts or evidence of economic impacts of deer management) as more likely to produce results in support of their specific agendas, which may influence their prioritisation of gaps. The regional workshops identified a very broad range of undifferentiated knowledge gaps.

Overall levels of interest and participation in workshops were generally high, with positive feedback from participants, including in relation to the usefulness and impact of the workshops. Participants represent a diverse cross section of deer management stakeholders, although participation of community council/rural community representatives was limited and deer managers were skewed towards estate factors/managers, with gamekeeper representation arguably low by comparison. The challenges identified in the workshops questionnaire are reflected in the gaps subsequently identified in the survey and through the detailed workshop discussions. Importantly, challenges and corresponding evidence gaps, vary spatially and most specifically in relation to the upland-lowland-urban divides, requiring a regionally specific policy and research response.

As apparent from the actual detail of the proposed gaps and subsequently from the analysis of the synthesis workshop discussions and survey responses, some undifferentiated gaps may in fact represent challenges facing the deer sector or gaps in knowledge transfer or training needs as opposed to actual gaps in evidence/research. Based on the amalgamated analysis of the six workshops presented in this section the most frequently discussed and most prioritised perceived gaps are summarised below as: i) potential research gaps; and ii) knowledge transfer and training gaps.

2.6.1 Key perceived research gaps/priorities

1. Further research on the **mechanisms of trust building** within collaborative processes and understanding of the underlying drivers of land use/management conflicts was perceived consistently as being of potential value; however, other measures relating to training and knowledge transfer (below) may offer greater potential for contributing to addressing this gap/challenge.
2. Further improved **understanding of deer movements** (e.g. response to disturbance) and migration at landscape scales, including movements in winter and development of further evidence for or against the vacuum effect in different contexts and regions. A linked opportunity for research includes the development of an adaptive management learning project on cross-boundary conflict management. This could incorporate the development of a buffer zone between two areas managed for different objectives with stag recruitment assessed on one side and regeneration success on the other, through long-term monitoring with GPS tracking of a selected group of deer to monitor movement over time.
3. Improved understanding of **the links between deer densities and habitat impacts** (for different habitat types) may offer some potential for further research; however, a number of habitat impact related gaps also represent knowledge transfer or training gaps (see below).
4. Evidence and data on the **impacts of other herbivores** (sheep, hare, goats etc.) and herbivore interactions repeatedly emerged as an evidence gap (and potential changes to grazers linked to changes to CAP etc.).
5. Improved understanding of the socio-economic impact and value of deer management, including local and regional economic impacts, the multiplier effects of investment, employment impacts and true costs/benefits of management in relation to public and private benefit streams. Potentially including a fuller understanding of the **direct and indirect impacts of alternative models of deer management** (conservation; stalking groups etc.) and the development of a transferable economic outputs model (decision support tool) for application on a case by case basis.
6. Determining the **impacts of deer and other herbivores on peatland habitat condition**, peatland recovery and wider factors impacting peatland habitats.
7. Enhanced **understanding of lowland deer populations and lowland-specific deer management issues**. To include enhanced understanding of roe deer population dynamics and the development of lowland deer models, evidence on lowland deer population densities, impacts, territoriality and recruitment.

2.6.2 Key perceived knowledge transfer gaps/priorities

1. Improved **knowledge and guidance on conflict management** and translation of existing conflict management research into effective and useable frameworks and tools; to include the availability of trained, **independent mediators and facilitators** within DMG/DMP processes.

2. Trust building and knowledge sharing and awareness of differing stakeholder perspectives (e.g. sporting estate management, conservation management, community land management). **Sharing of knowledge and perspectives through well designed events** at local and regional level, including exchange trips, visits and placements. To include open days in different ownership/management formats and events arranged in conjunction with interested bodies based around: i) technical, operational and wildlife issues; and sustainable economic development and sports tourism opportunities. Design of events to include opportunities for structured discussion across sectors to share knowledge, practices and different perspectives in neutral settings.

3. **Sharing of information (e.g. stakeholder events and development of case studies)** to improve understanding of the functioning (barriers/success stories) of existing management models and collaborative deer management mechanisms (cooperative deer groups) and DMP development between landowners, agencies and local authorities **in lowland/peri-urban settings**.

4. The development of longer-term and larger-scale datasets (on deer populations and impacts), particularly at **DMG-level**, incorporating habitat and deer population data gathering and sharing to facilitate adaptive management approaches. To include in parallel increased understanding of HIA techniques and **enhanced integration of habitat impact assessment data with DMP processes and linking HIA data with cull target setting** within DMG management plans. This theme reflects both a site-specific research/evidence gap and relates to a gap in transfer and uptake of knowledge and skills relating to HIA and deer counts.

5. Improved availability of **decision support tools and services to support Deer Management Groups**. To improve readily available and understood (user friendly) population dynamics modelling tools and mapping tools, to aid management and foster increased collaborative communication and understanding of deer population dynamics. Provision of advice and training to support DMGs in robust data collection (population counts and HIA), to include availability of independent trained mediators where required and (potentially) oversight of deer counts.

6. Effective translation and uptake of existing research on deer population dynamics and density dependence. To include the transfer of **existing knowledge from past/existing projects (to support previous point)** including: i) DeerMap (GIS based model to predict deer movement across a landscape); ii) Larder data project (JHI and Forest Research) to develop method of collecting useful larder data; iii) SWARD (grazing model); iv) HillDeer (population model). Wider access to research should be fostered to provide practitioners with direct access to findings.

7. **Improved and wider engagement of the general public and local communities in relation to deer management**, potentially including citizen science (e.g. recording deer in urban areas, reporting deer related RTAs), educational initiatives, targeted engagement projects (e.g. the Deer on Your Doorstep initiative) and public events relating to deer.

8. **Developing agreed definitions of degraded habitat/good habitat condition** based on effective interpretation of relevant research on ecological condition for different habitat types.

9. Translation of research and **dissemination of relevant information on the influence of deer management on the provision of key ecosystem services** (e.g. carbon) and the link between deer management and long term ecosystem dynamics.

10. Alignment of WDNA with tertiary education and the expansion of formal training for deer managers beyond existing qualifications (DSC1/2). To include specifically **the expansion of deer management qualifications to incorporate habitat impact assessment** (HIA) and habitat management training which incorporates the underpinning science and role of HIA in cull target setting within DMPs. To include potentially the development of an integrated land use qualification at 3rd level.

11. Further areas of future training development which offer potential for addressing multiple gaps and challenges include: **training in: i) community engagement; ii) mediation and positive/focused meeting management** for DMG chairs and secretaries (governance and leadership expertise) to promote open dialogue and conflict resolution; and iii) in ecosystem dynamics and approaches to integrated land management.

3. LITERATURE REVIEW

This literature review of published (refereed and “grey”) and unpublished research work on deer and deer management is structured around the challenges identified for the five WDNA priorities (1 - Collaboration and effective deer management planning and implementation; 2 - Healthy ecosystems; 3 - Lowland and urban deer; 4 - Economic and community development; and 5 - Training and Wild deer welfare). It is not intended to be a comprehensive review of all deer related research, but specifically focuses on the five high-level priorities for 2015-2020 set out in the WDNA.

The information and knowledge gained from the literature review has been used in the gap analysis ([Section 5](#)) to determine whether the gaps identified by the stakeholders, at the workshops and through the online survey, are real research gaps or knowledge transfer gaps.

Open access reports and other documents published by government agencies can be accessed via the hyperlinks.

Scottish Natural Heritage’s report to the Scottish Government on Deer Management in Scotland ([SNH, 2016](#)) was published after the literature review had been completed and therefore information from this comprehensive report is not included in the review.

3.1 Priority 1 - Collaboration and Effective Deer Management Planning and Implementation

3.1.1 Introduction

Wild deer are a common resource and they do not respect ownership or jurisdictional boundaries. This makes their management a complex issue that needs to be carried out at the landscape scale, rather than on a site-by-site basis. Deer interact with an increasingly large number of stakeholders, with those with an interest in how deer are managed extending beyond those involved directly in management of the species. Collaboration (joint-working between stakeholders) is therefore essential to manage wild deer populations as a common property resource (Bullock, 1999; Maffey *et al.*, 2013). Collaboration can take many forms, including: co-ordinated land management; discussion and planning meetings; government consultation exercises; development of ‘Best Practice’ advice; strategic partnerships; personal interaction between individuals; and bilateral research contracts ([Forest Research, 2010](#)). In Scotland, a collaborative approach to deer management has been developed through the formation of voluntary Deer Management Groups (DMGs) which are run by representatives of the landholdings in the area to manage the local deer population as a common resource ([Rose, 2010](#)). In this review, the focus is on collaborative mechanisms such as DMGs, which are particularly suited to implementing the WDNA priorities in Scotland.

3.1.2 Challenge 1: Build on work to develop conflict management tools

There are a range of stakeholders with an interest in deer, their impacts on the environment and the management of these impacts. Stakeholders with an interest in wild deer have been mapped by researchers in the wide-ranging Rural Economy and Land Use Programme (RELU) funded project that studied wild deer management, identifying key individuals, groups and organisations, and understanding the communication links between them (Reed *et al.*, 2009; [RELU, 2010](#)). In trying to understand the relationships between stakeholders, it was found that the majority of organisations interested in deer management are concerned with environmental issues (particularly public agencies and NGOs/charities). Public agencies play a key role in the provision and exchange of information related to deer management, with stakeholders preferring social interactions over consulting publications/emails. Notably,

there is a lack of interaction between organisations with divergent objectives (e.g. professional bodies and NGOs/charities), while there is better social networking between organisations that share objectives (White and Davies, 2012).

Trying to develop shared understandings of a 'problem' (or 'consensus') is a common feature of collaborative processes, with a range of tools existing to enable collaborative deer management. Understanding the **preferences for (and drivers behind) deer management decisions has been a key consideration of research, in order to understand the factors affecting management decisions, identify areas of conflict, and inform the design of conflict management processes** (e.g. MacMillan and Leitch, 2008; Austin *et al.*, 2010; RELU, 2010). A specific focus has been on agreeing suitable deer numbers, recognising the local, regional and national variations in stakeholder preferences, as related to management outcomes. Participatory approaches have been widely used to engage with deer stakeholders, with methods such as choice experiments, interviews, workshops (some in the field) and group discussions yielding a large amount of information about the values and views of a wide group (RELU, 2010). Structured approaches such as decision modelling, whereby participants are able to identify specific criteria for assessing management practices and then assign weightings or preferences to them, have proved particularly successful ([Scott *et al.*, 2002](#)).

Progress has also been made with participatory approaches to **combine ecological understanding and data with stakeholder knowledge and attitudes**, in order to improve the information available for management and facilitate communication and consensus. By combining local knowledge and experience of deer locations and movements with predictions generated from formal scientific understanding and ecological spatial data, it is possible to improve the accuracy of predictions of the suitability of terrain for deer populations in uplands (Austin *et al.*, 2009). In one case, combining deer managers' knowledge with existing deer distribution data led to an increase from 50% to 80% accuracy of a modified model for predicting upland areas highly suitable for deer (Irvine *et al.*, 2009). Conflicting interpretations of evidence have been found to limit stakeholders' willingness to collaborate (RELU, 2010). Therefore, these types of approaches that seek to combine different understandings and perspectives have allowed neighbouring landowners to explore their views of what is happening to the local resources, as well as check their ideas against agreed evidence from GIS maps.

Some steps have been taken to evaluate the effectiveness of collaborative management of deer and how collaboration is perceived by individual landowners. In a case study in the east of England, the ecological impacts of deer were widely recognised amongst landowners, with many management decisions based on observations of site ecology in the first instance (Austin *et al.*, 2013). Social factors were also found to provide insight into deer management decisions. No evidence was found in this study to suggest that deer management focussed at the individual site-level is effective for achieving ecological management objectives, finding that **collaborative management with neighbouring landowners helped to reduce conservation impacts, especially in relation to larger deer species**³.

Several **barriers to collaboration have also been identified** by researchers. Dandy *et al.*, (2014) considered how wild deer and their impacts (damage to natural environments, human health and safety, disease risk) tend to be presented as a 'problem' or a 'pest' rather than a resource (Nugent and Fraser, 1993; Decker *et al.*, 2004), creating a negative basis for collaboration processes. Collaborative management is not typically constructed around positive interactions with wild deer, such as their economic value as a game species, their

³ This study recognised that smaller species (e.g. muntjac) still have the potential to impact on conservation interests and should be accounted for if conservation objectives are to be met in the areas that these species inhabit.

value as cultural icons, or positive contributions to biodiversity. How 'problems' are identified and defined is affected by two factors: the debate over deer numbers/impacts, and the status and interpretation of 'science'. 'Problems' have also been the main stimulus for the formulation of DMGs and collaboration in general (Davies and White, 2012). Macmillan and Leitch (2008), based on results of a survey and interviews with land owners and managers of land predominantly used for deer stalking, called for greater collaboration between landowners and conservationists to create a 'positive context' which would allow more joint initiatives and activities for managing wild deer. In this context, it is perhaps also important to note that management conflicts are generally resolved when it is possible to focus on shared knowledge and objectives. Therefore, taking steps to understand managers' priorities and what motivates them to collaborate is important for addressing collaboration barriers (RELU, 2010).

Recent research has suggested that **the most appropriate mechanism to encourage collaboration depends on the contexts within which management decisions are made.** In the majority of regions across the UK, deer managers would regard a mandatory collaboration scheme as undesirable, as compared to the current voluntary system (Austin *et al.*, 2014). However, managers included in this particular study had positive responses to financial incentives for taking part in mandatory collaboration, particularly in regions where stakeholders had prior experience of existing payment schemes for modifying land use and wildlife management. In general, though, collaboration is resisted on the grounds that managers value their independence, with scepticism towards financial incentives for collaboration seen as too unreliable to compensate the perceived loss of independence (RELU, 2010). There is perhaps a need to understand in more detail how effective and accepted potential financial incentives might be in practice (Phillip *et al.*, 2009)⁴.

There is **a need to understand how different collaborative approaches are viewed and promoted** (Austin *et al.*, 2010). Effective collaboration requires a strong leader who is sufficiently motivated to overcome challenges, and enough time is needed for engagement to take place, allowing trust and an understanding of others' perspectives to develop (RELU, 2010). Power relationships between stakeholders are a key challenge: if substantial power has been wielded in advance of a collaborative or conflict management process, the capacity of subsequent processes to share power among stakeholders may be severely limited (Dandy *et al.*, 2014). Using collaboration to bring in a range of diverse and interdependent stakeholders has been found to have the potential to create more balanced power structures (Booher and Innes, 2002). The growth of sustainability and nature conservation policies has also had a critical impact on the agendas of collaborative processes. In three cases (in the USA, England and Scotland) considered by Dandy *et al.* (2014), nature conservation was a key objective that drove the formation of collaborative forums. As these types of policy are within the remit of public agencies, power rests with these organisations with respect to these agendas, and these agendas are often set before the collaborative process starts. As a result, challenges were revealed when stakeholders try to redefine an issue or look for innovative management options, particularly due to a lack of resources for generating and organising information and/or persuading others. Consequently, non-state stakeholders can feel that they cannot significantly affect this agenda-setting mechanism, even in collaborative settings, and weaker or new stakeholders can be left without power.

Key points (conflict management):

- Relationships between stakeholders are quite well-understood, and there is a lack of interaction between organisations with divergent objectives;

⁴ Options for financial incentives for modifying deer densities have also been considered by Smart *et al.* (2008).

- Understanding the preferences (and drivers) for different management outcomes is important for identifying conflicts and designing conflict management processes;
- Progress has been made to combine ecological data and stakeholder attitudes, generating more accurate spatial models and aiding mutual understanding of perspectives;
- Collaboration with neighbouring landowners helps to reduce conservation impacts, especially in relation to larger deer species;
- There are many barriers to collaboration, including how deer are presented negatively as 'pest' or 'problem', rather than positively as a resource;
- The most appropriate mechanism to encourage collaboration depends on how management decisions are made (most deer managers would see mandatory collaboration as undesirable);
- Better understanding is required of how different collaborative approaches are viewed and promoted.

3.1.3 *Challenge 2: Ensure robust deer management planning and implementation; Promote and implement the deer code*

Deer management **planning requires the active involvement of different individuals and groups with an interest in how deer are managed**, and plans need to be agreed with neighbours, working out what should be achieved and agreeing on a set of actions. In Scotland, a number of groups, networks and partnerships (e.g. DMGs; Lowland Deer Network) exist to enable collaboration and manage conflicts between neighbours and others who have differing management objectives about how best to manage wild deer. While there are increasing numbers of stakeholders involved with DMGs and general support for them as a concept ([Rose, 2010](#)), there are varying levels of collaboration within these groups (Fiorini *et al.*, 2011). The [Code of Practice on Deer Management](#) and the [Association of Deer Management Groups Benchmark](#) set out guiding principles for effective deer management planning, which include considering the public interest and developing a list of actions that deliver the collective objectives of DMG members. In a Scottish case study in the Cairngorms, studied by Dandy *et al.* (2014), stakeholders were in the process of developing a collaborative plan, in order to reflect the range of land management priorities in the area. A shift away from discussing deer numbers towards focussing on habitat impacts was found, particularly due to the diverse types of landowners represented on the DMG (including conservation organisations and private owners with conservation interests). However, an interest in deer numbers remained and it was found that open discussion about numbers was often difficult due to a reluctance by DMG members to disclose commercially sensitive data. In a situation like this, bringing a broad set of stakeholders around the table can bring in alternative perspectives and help to redefine issues/norms.

Due to the different expectations and agendas among stakeholders, **establishing shared goals presents a real challenge**. In an evaluation of collaboration within DMGs, Davies and White (2012) found that there tends to be little clear or direct incentive for taking part in collaborative initiatives, due to a mismatch in the distribution of costs and benefits relative to each stakeholder's priorities and values (Davies and White, 2012). In this study, it was found that some estates choose not to engage with DMGs in their area, preferring to respond to decisions, rather than take a proactive role in planning. Reasons for this include the cost of collaboration (time and money), as well as a perceived 'limited influence' due to the tendency for DMG members to seek individual benefits, despite the direction/content of group discussions. However, in one case study where diverse interests were represented, there was more equitable representation and consideration of the range of management objectives within the group. Shared leadership of the group may also be productive for addressing collaboration challenges and representing multiple interests. Phillip *et al.* (2009) also found that DMGs can be restricted by a lack of support, or only superficial support by a small minority of landowners.

The scientific community has a role to play in facilitating the use of decision-support tools to assist transparent deer management planning. The complexity of management systems and the large amount of information that needs to be considered presents a challenge for deer managers and researchers alike, particularly when stakeholders are required to show transparency in their decision-making processes and to evaluate trade-offs publicly (Tremblay *et al.*, 2004). Decision-support tools (computer-based systems that provide information by forecasting, using GIS or other databases) can be used, for example, to model forest gaps, simulating disturbance caused by browsing, simulate ecosystems and interactions between plants and herbivores, and integrate stakeholder knowledge in 'bottom-up' models, similar to the example outlined in Section 3.1.2 when local knowledge was used to improve GIS models of deer habitat suitability. Spatial agent-based models have also been used to understand how ecological dynamics influence collaboration in landscapes comprising mainly land owned for sporting, in comparison to landscapes where biodiversity management objectives dominate (Touza, 2013).

Effective deer management planning **requires collaboration to go beyond 'stakeholder input' to sharing responsibility between organisations and community stakeholders.** In the USA, research has revealed that community involvement with deer management in suburban areas has increased, leading to both challenges and opportunities for collaboration between different stakeholder groups in New York and Massachusetts (Raik *et al.*, 2003; 2004; 2005). Decker *et al.* (2005) also studied the importance of US wildlife management agencies working to increase the capacity of local community stakeholders to be involved with wildlife management decisions on the ground. Igot and Suzuki (2008) explored the potential of community-based collaboration with a non-governmental organisation to manage the increasing sika deer population in the Hokkaido region of Japan, where the hunter population is declining. In the Japanese case, the aim was to generate community-level economic benefits by attracting visiting hunters and developing a hunter education programme. While some community-level deer management collaboration exists in Scotland (the community stalking group in North Harris is a good example, Mc Morran *et al.* 2014), there is potential to involve local communities more in deer management planning, in order to increase public awareness of the need for deer management and the role that local people can play (see [Economic and Community Development](#) section of the literature review).

Key points:

- Deer management planning requires the active involvement of different individuals and groups with an interest in how deer are managed;
- Establishing shared goals presents a real challenge;
- The scientific community has a role to play in facilitating the use of decision-support tools to assist transparent deer management planning;
- Effective deer management planning requires collaboration that goes beyond 'stakeholder input' to sharing responsibility between organisations and community stakeholders.

3.1.4 Challenge 3: Establish a shared, trusted and high quality knowledge base associated with wild deer; Raise awareness of the need for effective deer management

Deer management stakeholders have been found to be cautious when engaging with the overarching habitat impacts agenda, due to a lack of common understanding of the different data available. Different types of knowledge (related to earlier points made about combining scientific and ecological knowledge) have been found to compete in a way that can have a negative impact on the work of DMGs. For example, while systematic DMG records are often kept of population harvest and animal condition, formal 'scientific' habitat monitoring needed to assess deer impacts is often not necessarily a part of a DMG's agenda

(Dandy *et al.*, 2014). Instead, gamekeepers make decisions primarily based on observational or traditional ecological knowledge and there can be mistrust about how scientific data are used to drive changes in management (perhaps when negative impacts of deer on habitat trigger intervention from public agencies). Similarly, deer managers have demonstrated a lack of trust in surveys and reports led by statutory agencies on designated sites (Maffey *et al.*, 2013). It has also been noted that scientific data are used by national organisations but not at the local level, raising questions about the role that government agencies should play in communicating science to those managing deer on the ground (RELU, 2010).

As a potential remedy to this issue, it has been found that **interactions between stakeholders during collaborative processes provide a substantial opportunity for learning** (Daniels and Walker, 2001; Raik *et al.*, 2005). Learning can potentially lead to stakeholders developing shared or overlapping objectives, as well as potentially improve understanding of the perspectives of others (and tolerance of those perspectives) and the data presented to/by them. Collaborative processes to discuss wild deer may also improve stakeholders' understanding of legislation, as well as the steps that local officials need to take to implement it on the ground (Dandy *et al.*, 2014). 'Culture' has been found to be important as stakeholders draw on shared values and accepted practices in order to include or exclude stakeholders from collaborative processes and/or management options from the process. Two contrasting cultures tend to prevail in the deer management context: a 'traditional' management approach and a 'public' perspective (the latter characterised by scepticism of the acceptability of established management methods). Dandy *et al.* (2014) found that those from the 'traditional' culture were effective in setting the collaborative agenda by referring to their shared culture. In Germany, researchers found similar groupings of people interested in wild red deer management, identifying three groups: 'process protectors', displaying a positive attitude to free roaming red deer; 'game keeping', consisting of more than 70% hunters; and 'game damage', perceiving expected damage as the greatest obstacle to free roaming deer (Gerner *et al.*, 2012). However, this research team suggested that grouping people like this may neglect more subtle reasons for differences in perspectives and difficulties experienced in reaching consensus (Gerner *et al.*, 2011). While discussions between these groups may assist in finding collaborative solutions, the length and nature of the experiences of members of the three groups with the national park and its administration had impacts on their attitudes.

Despite frustrations aired about the effectiveness of DMGs, research has found that, **in general, stakeholders feel the DMG process has improved mutual understanding** (Davies and White, 2012). **Building trust and increasing information sharing is therefore important for increasing collaborative management of wild deer at both local and regional levels** (RELU, 2010). It has been widely recognised in research that policy makers and those implementing policies and best practice should aim to: engage with local managers from the outset and include all those with a stake; give voice to outsiders who may be able to improve collaboration; use face to face meetings (or field workshops, discussion groups, etc.) where possible; and develop flexible ways to combine scientific and local knowledge (e.g. participatory GIS). A mistrust of scientific data also presents a challenge for building trust as this can restrict the willingness of stakeholders to share information or engage more with different people's perspectives (Davies and White, 2012). DMGs may help land managers to work collaboratively, despite these issues, if the group aims to allow consensus on the legitimacy of the range of objectives that exist within the group (Fiorini *et al.*, 2011).

Key points:

- There is a lack of common understanding among deer management stakeholders of the different data available about habitat impacts;

- To tackle this, it has been found that interactions between stakeholders during collaborative processes can provide an opportunity for learning and understanding available data;
- Deer management group processes have improved mutual understanding, and building further trust and increasing information sharing is a priority.

3.1.5 General observations on research gaps (Priority 1)

It is clear that successful collaboration can increase the overall benefits derived from wild deer (RELU, 2010). An increase in the number and diversity of stakeholders involved leads to more communication and to stakeholders gaining a wider perspective of management of deer by sharing understanding and knowledge. Similarly, policy development that includes local managers' insights from the outset is more likely to lead to local collaboration.

Nevertheless, gaps in understanding remain that point towards the need for more consideration of some key issues and/or application of findings that could be put into practice more widely. These include:

- There has been limited research evaluating the effectiveness of collaborative management of deer, particularly when power relationships are taken into account;
- Work to integrate scientific and local/ecological knowledge has yielded positive results and the use of spatial and decision support tools could be rolled out more widely;
- More attention needs to be given to multi-level collaboration efforts (not just DMG or national policy forum) – at the very least, effective and streamlined communication to share knowledge between stakeholders - at best, cross-scale institutional processes with the aim of redressing power imbalances;
- Linked to the previous point, there is the need for increased connectivity and mutual understanding between 'traditional' and 'conservation' cultures – one solution may be to ensure that collaborative processes build in time *and resources* to provide opportunities for stakeholders to express and experience different cultures (although this may be difficult to do at the DMG scale as it may challenge the dominant culture and/or issues that led to the establishment of the DMG in the first place);
- Government agencies need to develop better ways to communicate scientific data to practitioners, addressing the issue of mistrust of scientific data within the sector;
- The potential effectiveness and acceptance of financial incentives for collaboration is not well-understood – there are potential sensitivities here with regards to revealing cull data, etc. and there is the opportunity to scope out how effective and accepted potential financial incentives might be in practice.

3.1.6 Priority 1 - References

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3.2 Priority 2 - Healthy Ecosystems

3.2.1 Introduction

There is a wide breadth and long history of research on the ecology of deer in the UK and their impacts on habitats and other species, much of which has relevance for deer management and the maintenance of healthy ecosystems. This section gives an overview of some of this research that is relevant to the main WDNA challenges identified under the “Healthy Ecosystems” priority. It is not intended to be a comprehensive review of deer ecology. Many additional relevant references that are not directly cited in this review are included in the reference list at the end of this section and on the online deer research resource, which can be accessed at www.deerscotland.info (see [Appendix 8](#)).

3.2.2 Challenge 1: Contribute to the 2020 challenge for Scotland's biodiversity

Agreeing and achieving appropriate levels of deer grazing that reduce their negative impacts and benefit different habitats is a key challenge. There are many studies that have looked at the impacts of deer grazing on semi-natural habitats that can help address this challenge.

A vast amount of research on red deer has been carried out over the last 58 years on the Isle of Rum (<http://rumdeer.biology.ed.ac.uk/>). This has included research on the ecology, reproductive physiology, behaviour (including grazing and foraging behaviour), population dynamics, genetics and management of red deer. The research has involved more than thirty scientists based at the Universities of Edinburgh, Cambridge and Imperial College London, the James Hutton Institute and several other universities and institutes. The full range of deer research generated by the Isle of Rum Red Deer Project, which includes over 150 peer reviewed papers, 17 PhD theses and 3 books, can be found at <http://rumdeer.biology.ed.ac.uk/publications>. Much of the research has management implications that are relevant for deer managers across Scotland. An SNH publication by [Pemberton et al. \(2015\)](#) provides a summary of the Isle of Rum research relating to red deer management and contains a number of recommendations for deer managers that have arisen from this research.

Some of the early research on deer ecology that is relevant to the management of red deer in Scotland is reviewed in [Mitchell et al. \(1977\)](#). This comprehensive review gives some background on the taxonomy, biology and status of red deer in Britain at that time, as well as looking at factors affecting their distribution, their impacts on habitats, and their population dynamics and management.

Foster *et al.* (2014) assessed the peer-reviewed literature on the effects of large native herbivores on other animals. Their aim was to synthesise current knowledge, identify gaps and limitations in the literature and highlight priorities for future research. They found that the literature was dominated by short term studies that compared only two levels of herbivory. They identified a number of key knowledge gaps including:

- The nonlinear responses to herbivore pressure
- How do responses differ between different herbivores
- How do responses vary spatially and temporally
- How do the effects of herbivores interact with other land management practices
- What are the mechanisms driving cascading effects through ecosystems

Minimising the further spread of sika and preventing the establishment of other non-native deer species, in particular muntjac, are other key challenges that need to be addressed. Various studies have looked at the habitat selection, and impacts of sika (Mann and Putman, 1989a; 1989b; Chadwick *et al.*, 1996; Hannaford *et al.*, 2006; Uzal *et al.*, 2013; Pérez-

Espona *et al.*, 2009) and muntjac (Chapman *et al.*, 1985; 1993; Hemami *et al.*, 2004; Dolman and Wäber, 2008, Fuller and Gill, 2010). [Ward and Lees \(2011\)](#) produced a report for Scottish Natural Heritage looking at the cost of preventing the establishment of muntjac in Scotland. They estimated that in 2011 the costs of eradicating an outbreak of muntjac are likely to range from £3,683 to £60,625 per outbreak for populations of up to 200 animals; and that the costs of managing an established muntjac population are likely to range from £457,821 to £1,915,411 per year.

Impacts on native woodland habitats and species

Browsing, primarily by red deer, can and often does prevent the regeneration of native woodlands in the uplands (Palmer and Truscott, 2003a; Miller *et al.*, 1998; Andrews *et al.*, 2000). The likelihood of saplings being browsed is governed by a complex interaction of factors including the physical and chemical characteristics of the tree, alternative food sources, season, deer density and soil conditions (Miller *et al.*, 1998). Instances of regeneration of birch have however sometimes been observed in the presence of livestock and deer (Pollock *et al.*, 2005). Excessive grazing and browsing by deer can have negative impacts on ground vegetation and the fauna that relies on it ([Gill, 2000](#)). Baines *et al.*, (1994) found un-grazed exclosures in pinewoods had less grass and more ericoid shrubs, and many more insects, than the adjacent grazed forest.

Fencing to exclude deer and allow regeneration to take place can however be problematic. For example, fatalities of birds such as red and black grouse and capercaillie through collisions with deer fencing have been observed (Baines and Summers, 1997). In some cases, the dense vegetation that develops when all large herbivores are excluded using deer fencing can have negative effects on communities of cryptogams (liverworts and lichens) of conservation importance (Moore and Crawley, 2014; Moore and Crawley, 2015).

In a study by Miller *et al.* (1982) looking at the impact of red deer browsing on tree saplings in the Scottish Highlands, they found that the extent to which saplings were browsed varied according to their location and species. Saplings that were tall and visible were more liable to browsing than smaller more obscured plants. They found that pine was the species most liable to browsing, with juniper and birch being browsed the least (Miller *et al.*, 1982).

In Atlantic oak woodlands tree regeneration often fails through a combination of browsing by red and roe deer, sheep and insects (Palmer *et al.*, 2004). Palmer *et al.* (2004) recommend that management plans are written on a site-specific basis and incorporate both the woodland area and the adjacent open ground that deer range over.

Work carried out by Harrison and Bardgett (2003) at Creag Meagaidh NNR on how browsing by red deer impacts on litter decomposition in a native regenerating birch woodland found that litter of un-browsed trees decomposed faster than that from browsed trees. Their results indicate that deer browsing has a negative impact on rates of litter decomposition in native regenerating birch woodland, ultimately retarding nutrient cycling rates.

Tanentzap *et al.* (2013) used a spatially explicit model to predict the responses of birch to red deer browsing and land management in the Scottish Highlands. Their results show that in order to maximise tree regeneration, managers cannot simply reduce deer densities but must also improve ground cover for seedling establishment. They stress the need for land managers to consider the impacts of red deer rather than just their densities.

There have been a number of reviews looking at the impact of deer on woodland habitats (e.g. Dolman *et al.*, 2010). Gerhardt *et al.* (2013) carried out a systematic literature analysis of the determinants of deer impacts in European forests. They identified 80 distinct factors determining the browsing, bark stripping and fraying impact of deer. Most of the factors were

related to the properties and structure of the forest, but disturbance and site features were also relevant.

Mitchell and Kirby (1990) carried out a review of the impact of large herbivores on the conservation of semi-natural woods in the British uplands. They identified a number of possible options for managing upland woods in relation to conservation objectives; these included rotational grazing, seasonal grazing and reducing the overall levels of grazing.

Scott *et al.* (2002a; 2002b) produced two reports for the DCS on management of deer in woodlands. They carried out literature reviews on practical woodland design to facilitate deer control; techniques for assessing deer populations and damage; and how decisions are influenced by management objectives, scale of ownership, deer species present, available resources and information on woodland damage and deer populations.

In April 2000, the Forest Ecology Group of the British Ecological Society held a meeting on 'Ecological Impacts of Deer in Lowland Woods'. Fuller and Gill (2001) summarised the main issues that emerged from the meeting. The abundances of a wide range of taxa and the overall community composition of woodlands can be strongly modified by increasing numbers of deer. Sustained heavy grazing and browsing results in a reduction in species richness, however, there are considerable differences in the responses of species to heavy grazing and it is not always detrimental. The responses of many species are non-linear, and in many cases intermediate levels of deer pressure are beneficial.

Gill and Beardall (2001) reviewed the effect of deer browsing on woodland vegetation. They analysed the results from 13 studies on the effects of deer browsing on species richness and tree diversity. Their results showed that deer tend to reduce the diversity of seedlings, and that the effect is greater at higher deer densities. There were differences in the susceptibility of tree species to deer browsing, with some species being depleted at all sites, whereas others declined in some sites but increased in others. The effects of deer browsing on the amount and composition of tree regeneration appear to depend on the characteristics of the site, including the light regime and the composition of the ground flora (Gill and Beardall, 2001).

Gill and Morgan (2010) found that seedling densities in lowland woodlands were negatively correlated with deer densities, with seeding and sapling regeneration unlikely to be adequate at deer densities over 14 deer km⁻². High densities of deer can have undesirable impacts on woodland field layer vegetation, with grass species increasing at the expense of woodland herbs (Corney *et al.*, 2008) and a decrease in the cover of bramble (Kirby, 2001).

Several studies have documented undesirable impacts of high deer densities on woodland birds (Fuller, 2001; Fuller *et al.*, 2005; Palmer *et al.*, 2015; Newson *et al.*, 2012; Gill and Fuller, 2007). For instance, habitat quality for blackcap, a species that is dependent on dense understory vegetation, declined in areas that were unprotected from deer (Holt *et al.*, 2013). Perrins and Overall (2001) observed declines in populations of blackcap, chiffchaff, garden warbler and willow warbler following increases in the deer population in Wytham Wood, Oxfordshire. Understorey vegetation, particularly bramble, also reduced in Wytham Wood (Morecroft *et al.*, 2001). A study that collated national data (Newson *et al.*, 2012) found nightingales and willow tits, both species of conservation concern, to be most at risk from high deer densities in woodlands. In an enclosure experiment in woods in eastern England, several species of birds were found to benefit from the increased understory vegetation where deer were absent, and none were negatively affected (Holt *et al.*, 2014). It should be noted that small-scale enclosure experiments do not necessarily represent what would occur if deer were completely excluded from a larger area of woodland.

There is a group of bird species that are strongly characteristic of pasture woodlands in western Britain, that probably benefit from the habitat structures created by high levels of grazing (Fuller, 2001). These species are the pied flycatcher, redstart, wood warbler and tree pipit. A research priority highlighted by Fuller in his review of the responses of woodland birds to increasing numbers of deer (Fuller, 2001), is to understand how bird communities respond to different densities of deer.

High deer populations and their impacts on ground vegetation and understory shrubs are thought to have a negative effect on populations of small mammals (Flowerdew and Ellwood, 2001); reductions in rodent populations are likely to lead to reduced breeding success of avian predators like tawny owls. The reductions in small mammal populations may be reversible when deer are controlled and understory vegetation recovers, especially if relict populations from protected areas survive (Bush *et al.*, 2012).

Deer can have profound impacts on the communities of insects within lowland woodlands (Stewart, 2001). **Many of the impacts are negative** (e.g. Pollard and Cooke, 1994), but at **light browsing intensities, deer promote insect community diversity** by maintaining some open areas and providing food for dung-eating insects (Stewart, 2001).

Deer grazing is important for many key butterfly habitats in the UK (Feber *et al.*, 2001). The impacts of deer grazing on butterfly populations occur at a range of scales from effects on the local availability of larval food-plants or nectar sources, to larger-scale changes in habitat structure and management (Feber *et al.*, 2001). Many of the lowland woodland butterflies in the UK have historically relied on clearings in coppiced woodland, but high deer numbers are a major disincentive to the maintenance of this traditional form of management (Feber *et al.*, 2001). However, in some woodland habitats deer grazing is beneficial to particular butterfly species, for example most of the Scottish colonies of the threatened pearl-bordered fritillary (*Boloria euphrosyne*) rely to some degree on deer grazing, to maintain open bracken (*Pteridium aquilinum*) habitats within woodland (Feber *et al.*, 2001). The fencing out of deer and other grazing animals can lead to rapid loss of these crucial open woodland habitats (Feber *et al.*, 2001).

There is the potential for deer to perform an **important ecological function by dispersing plant propagules in their dung**. Eycott *et al.* (2007) looked at the number and species composition of viable seeds found in the dung of four deer and two lagomorph species in a forest in eastern England. One hundred and one plant species germinated from the dung they collected, of which more than a third had no other known means of dispersal. The seed dispersal function of the four different deer species varied, with red deer and fallow deer dispersing the most seeds and most species and muntjac dispersing the fewest seeds (Eycott *et al.*, 2007). In a study looking at the potential of mammalian herbivores as seed dispersal vectors in ancient woodland fragments, Panter and Dolman (2012), found that there were few dispersal benefits for the woodland plant community. They found that rather than dispersing the seeds of woodland plants the deer transported large volumes of seed of ruderal agrarian and open-habitat species from surrounding habitats into the ancient woodland fragments.

Impacts on upland habitats and species

[Milne *et al.* \(1998\)](#) produced a review for SNH on the impact of vertebrate herbivores on the natural heritage of the Scottish uplands. This report contains a wealth of information and research on the impacts of deer and other herbivores on upland habitats and species.

A number of studies have been carried out on the impact of red deer grazing on heather moorland. Grant *et al.* (1981) found that old heather was less able to withstand grazing than young heather, and that heather cover was reduced where the stocking rate exceeded 2

hinds ha⁻¹. Moss *et al.* (1981) found that grazing by mountain hares and red deer was invariably associated with a decrease in the crude fibre content of heather. Grazing of current year's growth by red deer was heaviest at patches of heather rich in nitrogen (Moss *et al.*, 1981).

There have also been a number of studies looking at the foraging behaviour and utilisation of heather by red deer and sheep in heather/grass mosaics (Clarke *et al.*, 1995a; 1995b; Hester and Baillie, 1998; Hester *et al.*, 1999; Oom and Hester, 1999; Cuartas *et al.*, 2000; Palmer and Hester, 2000; Palmer *et al.*, 2003; DeGabriel *et al.*, 2011). Palmer *et al.* (2003) studied the influence of proximity to preferred grass patches on the utilization of less preferred heather by red deer and sheep at a range of spatial scales in the Cairngorm Mountains. They found that heather utilization declined sharply with increasing distance from the edges of grass patches. Moore *et al.* (2015) looked at how landscape-scale vegetation patterns influenced small-scale grazing impacts. They tested the effects of proximity of a preferred plant community on the grazing impact of red deer on four plant communities that have conservation value. They found that grazing impacts on heaths were higher when there was more species-rich grassland present within 1km. The density of herbivores was found to be only weakly correlated to grazing impacts.

Work carried out on the Isle of Rum by Gordon (1989a; 1989b; 1989c; Gordon and Illius, 1989) looking at vegetation community selection by ungulates found that red deer preferentially selected mesotrophic grassland communities throughout the year.

Recent changes in livestock numbers, particularly in the uplands ([Holland *et al.*, 2011](#)), are likely to have significant impacts on deer movements and foraging patterns. In a study carried out by Pollock *et al.* (2013) looking at the consequences of reduced sheep grazing on upland habitats, it was found that deer tended to be more abundant where sheep grazing had been reduced, compared to adjacent areas where sheep grazing levels had been maintained. The reduced competition and lower levels of disturbance that result when livestock are removed from hill ground are likely to lead to changes in the population density and distribution of red deer and other wild herbivores.

Albon *et al.* (2007), looking at the grazing impacts associated with different herbivores on Scottish hill vegetation, found that the presence of sheep was associated with the largest increase in grazing and trampling impact, and that cattle had the second largest impact, while the presence of red deer was associated with a significantly lower impact than sheep. They suggest that the limited ranging behaviour and greater aggregation of sheep may be reasons for the higher impact associated with the presence of sheep. They suggest that further declines in sheep numbers may limit the extent of their impact, but not necessarily the local magnitude. Growing evidence also suggests that a reduction in competition with sheep may lead to increases in deer densities, and although deer impacts are more diffuse, they may have a greater impact on heather dominated habitats (Albon *et al.*, 2007; Clutton-Brock and Albon, 1989).

DeGabriel *et al.* (2011) found that mixed grazing with both sheep and deer appeared to be beneficial by increasing both alpha and beta plant diversity and minimising damage to heather in the uplands. They suggest that the absence of sheep is likely to result in an expansion in the deer population and greater impact on heather. Their results indicate that reductions in livestock may alter the impacts of wild grazers resulting in changes in plant diversity, whereas mixed grazing can enhance habitat quality and maintain plant diversity.

In a study using spatial and temporal information of red deer winter counts carried out across Scotland, Pérez-Barbería *et al.* (2013) found that winter habitat niche breadth in red deer has widened with increasing population density. They found that increasing density favoured the selection of grassland, rather than heather moorland. When temperature

increased, the selection of heather and grassland decreased, while the selection of montane and peatland habitats increased (Pérez-Barbería *et al.*, 2013).

Milner *et al.* (2002) looked at deer management on three upland estates in Wester Ross, with the aim of finding an optimal deer management strategy for the area. The study was set up to estimate the number of deer on the estates, assess the level of their impact on the habitat, look at the performance and condition of the herd, and explore future management options (Milner *et al.*, 2002).

Impacts on lowland semi-natural habitats and plantations

From the literature search there is a **significant amount of published scientific information available on the impacts of red deer in upland semi-natural woodlands and on roe deer and non-native species in lowland semi-natural woodlands, but there appears to be very little literature on deer impacts in lowland semi-natural non-wooded habitats**. Putman and Moore (1998) reviewed deer impacts in the lowlands and stated that deer impacts on heathland, grassland and wetland habitats of conservation interest in England and Wales were generally welcomed as they slow succession to scrub. Even in situations where deer provide conservation benefits, through browsing and grazing, their management may still present problems, especially where habitats of high conservation value are located close to arable farmland (Dolman *et al.*, 2010).

The impacts of deer on commercial forestry plantations have been extensively studied (e.g. Welch *et al.*, 1987; 1988; 1991; 1992; Welch and Scott, 1997; 1998; Ward *et al.* 2004; 2008; Scott, 1998; Scott *et al.*, 2009). There are also a number of studies looking at the feeding ecology and population dynamics of deer in plantation forests (e.g. Moore *et al.*, 2000; Ratcliffe, 1984; Latham *et al.*, 1996; Latham *et al.*, 1999).

Methodologies for assessing deer numbers and impacts

Estimates of deer population density are important for helping to guide deer management decisions. In 1999 the Forestry Commission published a field guide entitled "How many deer? - a field guide to estimating deer population size" ([Mayle *et al.*, 1999](#)). This publication describes the **range of methods available for determining how many deer** are utilising particular areas of land, both wooded and open. Monitoring can be carried out directly, using observations of animals, and indirectly, by observing dung or impacts created. Monitoring woodland deer population size and change is important, but difficult to do because unlike in open habitats, the animals are not readily visible. One of the methods described in the field guide, which is appropriate for use in both woodlands and open habitats, is the use of faecal pellet counts (Bailey and Putman, 1981). This method relies on estimating the rates of deposition and decomposition of faecal pellet groups. Estimating animal densities using indirect methods like dung counts gives results with wide confidence intervals (Campbell *et al.*, 2004), with faecal accumulation rate giving more robust information than faecal standing crops.

More recent studies, carried out by Strath Caulaidh Ltd., in collaboration with FCS, have shown that methods based on pellet counts obtained in two successive visits in marked plots could be more effective than the initial technique described by Mayle *et al.* (1999), particularly in upland environments (Campbell *et al.*, 2004). The Forestry Commission have produced a Bulletin (No. 28) (Swanson *et al.*, 2008) that gives a full description and justification of the combination plot technique developed by Strath Caulaidh Ltd., and provides a comprehensive overview of how to assess deer density using dung counts.

Thermal imaging equipment has been used to estimate deer population density in woodland habitats (Gill *et al.*, 1997; Hemami *et al.*, 2007). Thermal imagers are able to detect the radiant heat energy emitted from warm-bodied animals; and can detect large mammals at

distances of up to 2 km. The term 'distance sampling' refers to a group of methods for estimating animal density or abundance by counting the numbers of animals seen from a point or transect and making an assumption that nearby animals are more likely to be seen than those further away (source: Wikipedia). Distance sampling using thermal imaging has been found to be an effective method for estimating deer density (Wäber and Dolman, 2015) when compared with drive counts, especially if patches of thicker vegetation, (where deer are harder to see, even with a thermal imaging camera) are taken into account. However Smart (2004) predicted that thermal imaging would not improve estimates compared to indirect methods. Thermal imaging can however also provide information on the species of deer, the size of groups and habitat use.

Scott *et al.* (2002a) carried out a review of techniques used to assess deer populations and damage in woodlands. They suggest that direct counts are not suitable for woodland and that indirect methods should be used. They recommend the use of faecal pellet group counts. They considered static census, aerial census, spotlighting and index counts to be unreliable for estimating deer populations in woodlands, and that drive counts and thermal imagery were at that time too costly to be used in most situations.

Morellet *et al.* (2007) argue that to manage populations effectively, both population size and ecological indicators (animal performance, population abundance, habitat quality and/or herbivore habitat impact) need to be monitored, with management being continually adapted according to the results of monitoring. Monitoring both population size and impacts is wise, given that the impacts of a given density of deer vary depending on the habitat they are in (Putman *et al.*, 2011a). To be effective, monitoring and management also need to occur at a landscape scale (Putman *et al.*, 2011b), since deer move from areas with high population densities (sources) to areas with low population densities (sinks) (Wäber *et al.*, 2013; Putman *et al.*, 2005).

Key points:

- A vast amount of research on the ecology and biology of red deer has been carried out, particularly on the [Isle of Rum](#), and much of this research has relevance for deer management and the maintenance of healthy ecosystems across Scotland;
- The impacts of deer grazing and browsing have been widely studied in upland and lowland semi-natural woodlands, plantation forestry and upland habitats (particularly grass-heather mosaics);
- There are relatively few studies on the impacts of deer on lowland non-wooded habitats;
- Most of the impacts of deer on habitats and other species are seen as negative, and there are few examples of positive impacts of deer grazing/browsing/trampling;
- There are a range of well developed, tested and utilised methods for monitoring deer populations. These methods continue to be developed. New technology may improve the accuracy or reliability of existing methods or lead to the development of new methods.

3.2.3 Challenge 2: Carry out work to mitigate against, reduce and adapt to the effects of climate change

Deer and the management of deer have both **direct and indirect impacts on greenhouse gas emissions**. Deer emit methane through the process of enteric fermentation, and methane is also released from their manure. The trampling and erosion by deer of peatlands and other carbon rich soils may cause the release of carbon dioxide, while browsing and grazing may prevent the growth of vegetation that could absorb carbon dioxide.

Changes to the climate will also have an impact on wild deer both directly and indirectly. The **productivity** and **health** of wild deer may be affected by climate induced changes in the **spread of tick-borne and other infectious diseases** (Dobson and Randolph, 2011; Randolph, 2004; Gilbert, 2010); as well as changes in the **type, distribution and productivity of vegetation**.

Tanentzap and Coomes (2012) looking at the impact of herbivores on carbon storage in terrestrial habitats suggest that herbivores can reduce above- and below-ground carbon stocks across habitats, however given sufficient time for the systems to respond to the herbivory, reductions in carbon stocks may approach zero. They suggest that the removal of herbivores, through management, might be an important strategy towards increasing terrestrial carbon stocks at local and regional scales within specific habitats.

Post *et al.* (1997) found that red deer born following warm winters were smaller than those born after cold winters, and that this variability persisted into adulthood. They suggest that phenotypic variation among red deer influenced by climate change may pose consequences for the fitness of cohorts since body size and condition contribute to their reproductive success and survival. They suggest that the trend towards increasingly warm winters in northern Europe may lead to reduced body size and fecundity of red deer.

While the response of woodland vegetation to high densities of deer has been well studied, there is far less known about the impacts of deer on peatland habitats. Pellerin *et al.* (2006) studied the impact of white-tailed deer (*Odocoileus virginianus*) on peatland habitats in eastern North America. They found that white-tailed deer had no long-term impact on the plant species assemblages in ombrotrophic bogs, however they did find reduced lichen cover and increased cover of sedges, grasses and bare peat. In contrast, the floristic composition of minerotrophic fens differed significantly between sites where deer were present or absent. In undisturbed fens plant species diversity was greater, particularly for shrubs, sedges and liverworts. Their results suggest that the impacts of white-tailed deer on the vegetation of peatlands were important and that they could be harmful for the long-term conservation of peatland plant diversity (Pellerin *et al.*, 2006).

The way that animal populations respond to climate change will depend on the interplay between their life history, the availability of resources, and the scale of the change (Gaillard *et al.*, 2013). Gaillard *et al.* (2013) looking at the influence of climate change on the demographic processes of two roe deer populations found that woodland roe deer cannot currently cope with increasingly early springs. They hypothesise that with the earlier onset of spring, roe deer should shift their distribution during the critical rearing stage, to richer, more heterogeneous landscapes (Gaillard *et al.*, 2013).

[Natural Capital Ltd. \(2009\)](#) produced a report for Scottish Natural Heritage on the life cycle assessment of Scottish wild venison, which was the first attempt at establishing a carbon footprint for wild venison in Scotland. The analysis indicated that the carbon footprint of venison was 38% lower than beef and 49% lower than lamb. Methane emissions from enteric fermentation and manure were estimated to be responsible for 76% of total emissions associated with wild venison. The report also looked at how to reduce the carbon footprint of venison through deer management activities such as sharing deer larders and the collection of carcasses.

Key points:

- Deer have both direct and indirect impacts on greenhouse gas emissions and carbon sequestration;
- Changes to the climate will have an impact on the productivity, population dynamics and health of wild deer;

- Deer are likely to be affected by climate induced changes in the spread of tick-borne and other infectious diseases;
- Climate induced changes in the type, distribution and productivity of vegetation are likely to have an impact on wild deer;
- There appears to be relatively little information on the impacts of deer on peatland habitats;
- The carbon footprint of wild venison has been shown to be 38% lower than beef and 49% lower than lamb.

3.2.4 Challenge 3: Contribute to achieving favourable condition status for designated features

SNH published a two volume **guide to surveying land management impacts in the uplands** in 1998, and this has been used extensively by vegetation surveyors in the monitoring of upland habitats particularly in terms of **Habitat (Herbivore) Impact Assessments (HIA)** (MacDonald *et al.*, [1998a](#); [1998b](#)). SNH have published many survey reports on the impacts of herbivores on designated sites using this guidance (e.g. Strathglas SAC - [O'Hanrahan, 2005](#); Ben Hope SSSI - [Maier, 2012](#); [MacKenzie and Clifford, 2010](#); Cairngorms - [Horsfield, 2009](#); Caithness and Sutherland peatlands SAC - [Headley, 2006](#); Ben Vorlich SSSI - [Headley, 2008](#); [Doherty, 2015](#); Drummochter Hills SAC - [Dayton, 2008](#); Torridon Forest SSSI - [Campbell and Marchbank, 2013a](#); Monadhliath SAC - [Campbell and Marchbank, 2013b](#)). There have also been numerous unpublished SNH reports on the impacts of herbivores on other designated sites. In addition to HIA monitoring, the Common Standards Monitoring (CSM) guidance for upland habitats produced by JNCC provides a methodology for monitoring the condition of notified features on designated sites ([JNCC, 2006](#)). The information provided by **HIA and CSM not only provide evidence of the current condition of notified features within designated sites but also help inform management in order to achieve or maintain favourable condition for these features**. Although the HIA and CSM were designed principally for designated sites, the monitoring of habitats outwith these sites is vitally important in order to meet the challenges of the WDNA. The [Best Practice Guidance](#) website has a range of guides to help deer managers establish habitat impact assessment monitoring schemes for different habitats on the land they manage, much of which will be outside designated sites. A case study by Maffey *et al.* (2013) looked at the uptake of HIA methods on private land. They found that although the benefits of HIA to support management decisions were recognised, there were a number of barriers preventing its uptake, including the complexity of collecting and interpreting the data, and uncertainty around who should be responsible for doing the assessments.

English Nature's "The Upland Management Handbook" contains a wealth of information on upland habitats and species and their management ([Backshall *et al.*, 2001](#)), and is a useful aid to upland land managers.

[Holland *et al.* \(2010\)](#) carried out a research project for SNH looking at developing guidance for managing extensive upland grazing where habitats have differing requirements. The aims of the project were: to explore existing site condition monitoring and herbivore impact assessment data from upland designated sites in order to review the evidence for conflicts between the grazing requirements of nearby habitats; and to develop principles as decision support tools that could be used to help manage these conflicts. The report also contains a short literature review on plant-herbivore interactions. The main findings from the project were used to develop a [Management Guide](#). The guide provides practical information for land managers who are undertaking upland habitat management particularly on designated sites where habitats have different management requirements.

[Armstrong *et al.* \(2014\)](#) have developed a **Herbivore Impact Assessment method for woodlands** which is a subjective method of assessing and monitoring the impact of large

herbivores on wooded habitats. In addition to this, a [Woodland Grazing Toolbox](#) has been produced that is designed to help woodland managers, who want to achieve biodiversity and/or cultural heritage objectives using livestock as a management tool, to develop a woodland grazing plan.

Key points:

- There are well developed and established methods of Habitat (Herbivore) Impact Assessment and Site Condition Monitoring that are widely used on upland designated sites;
- There remain a number of barriers preventing the uptake of HIA by private land managers on land outside designated sites;
- HIA monitoring methods are now available for woodland habitats;
- There have been numerous survey reports produced on the impacts of herbivores on upland designated sites using the HIA guidance. The information in these reports, on the impacts of grazing and trampling by wild deer and other herbivores, not only provides evidence of the current condition of notified features within designated sites but also helps inform management in order to achieve or maintain favourable condition for these features.

3.2.5 Challenge 4: Differentiate between herbivore impacts

The diet selection and foraging behaviour of different herbivores varies, resulting in different impacts on the vegetation. However distinguishing damage caused by different species can be difficult.

Herbivore **diet selection** is determined by a **range of plant and animal factors**, but is largely dependent upon what is available and the requirements of the animal (Gordon and Iason, 1989). Plant factors that affect diet selection include, the species composition and structure (e.g. height and density) of the vegetation, and the spatial distribution of the different species and plant parts within the vegetation, in particular the distribution and availability of more preferred species (Milne, 1991). An array of grazing related plant attributes also influence diet selection, including the digestibility, nutritional value, fibre content and silica content, and the levels of plant secondary metabolites within the plant material (Arnold, 1964; Hughes *et al.*, 1964; Reichardt *et al.*, 1987). There are also a number of animal functional attributes that affect diet selection and foraging behaviour, including body size; the morphology, size and function of the digestive tract; the size, shape and structure of the mouthparts; and the method of biting (Gordon and Illius, 1988; Illius and Gordon, 1993).

Small animals have relatively higher metabolic energy requirements per unit body weight than larger animals, and require higher quality (lower fibre content) diets in order to survive. Larger herbivores tend to have bigger mouthparts and are therefore less able to select individual species, live material, or the more nutritious plant parts, than smaller herbivores (Gordon and Illius, 1988). Large ruminants also have larger rumens and longer food retention times within the gut, than small ruminants, which allows them to utilise a more fibrous diet (Demment and van Soest, 1985; Gordon and Illius, 1988). Large animals also have higher foraging costs than small animals, and may therefore need to be less selective in order to contain these costs (Murray, 1991).

The herbage intake rates of ruminants are also dependent upon a range of factors, including the digestibility of the vegetation (Allison, 1985; Armstrong *et al.*, 1986); the time of year; the vegetation height and structure; the physiological state and body condition of the animal; and the time spent foraging.

The **grazing distribution patterns** of free-ranging ruminants are **affected by abiotic factors** such as slope, distance to water, exposure and disturbance; and by **biotic factors** such as the distribution and proportion of different vegetation types, and the quantity and quality of forage within these different vegetation types (Bailey *et al.*, 1996; Hester *et al.*, 1999). In heterogeneous environments grazing ruminants have been shown to use a range of available food resources, rather than just the single source that provides the highest daily intake rate. Herbivores also show seasonal patterns in the grazing utilisation of different vegetation types, and these seasonal patterns of use differ between species (Osborne, 1984; Gordon, 1989b).

Key points:

- The diet selection and foraging behaviour of different herbivores varies, depending on a range of biotic and abiotic factors, which results in different impacts on the vegetation.
- Despite these differences distinguishing between different herbivore impacts remains challenging.
- Although there are a number of research studies looking at the grazing impacts of sheep and deer a better understanding of the response of habitats to changes in grazing pressure from different herbivores is required

3.2.6 *General observations on research gaps (Priority 2)*

The impacts of deer grazing, browsing and trampling on different habitats and ecosystems have been widely studied and monitored. However, there still appear to be gaps in our knowledge that need addressing that would help achieve some of the challenges highlighted by the WDNA under the 'Healthy Ecosystems' priority; these include:

- More information on the impacts of deer on peatlands and non-wooded lowland habitats.
- Improved understanding of the responses of habitats and species to changes in grazing pressure from different herbivores (spatial and temporal responses)
- Improved understanding of the interactions of different herbivores, including domestic livestock and deer, and how these interactions affect different habitats and species.
- A better understanding of the effects of different herbivores and how they interact with other land management practices.
- More information on the ecological impacts of introduced deer and their potential interactions with native deer species.
- More information on the implications of intensified deer browsing on the biodiversity of wooded and non-wooded habitats, taking into account both the effects of different deer densities and different assemblages of deer.
- Better understanding of the potential conflicts that arise between different habitats of conservation value in relation to their grazing requirements, and the role deer grazing and management affects these potential conflicts.
- A better understanding of the mechanisms underlying spatial and temporal variation in the sensitivity of upland plant communities to increasing disturbance.
- The further development of spatially explicit decision support tools to aid the management of heterogeneous grazing systems.

3.2.7 Priority 2 - References

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3.3 Priority 3 - Lowland and Urban Deer

3.3.1 Introduction

There is increasing recognition of the need to manage deer populations in lowland areas of Scotland including peri-urban and urban areas. There is much habitat suitable for roe deer in lowland areas where land-use is predominantly forestry/woodland or agricultural and increases in woodland plantings and other green areas are thought to be leading to increased deer numbers. The 'peri-urban' environment was described by Dandy *et al.* (2009) as being an important area for deer management. Peri-urban is defined as the transitional area between rural and fully urban zones where land-use may be a mix of housing, woodland, transport infrastructure and agriculture. Interactions between deer and people in such areas can be particularly frequent. From these areas, deer incursions into more fully urban areas are common.

Research on lowland, peri-urban and urban deer is relatively scarce with fewer studies than for upland deer, particularly in the UK. Urban, peri-urban and lowland deer management, however, is often regarded as a growing issue and challenge for deer managers due to the increasing numbers of deer within these areas (Ballantyne, 2012). Deer management in lowland Scotland involves a particular focus on the impacts of deer on lowland land uses such as forestry and agriculture, but as for upland and peri-urban/urban deer management it has in common the challenge of achieving effective collaborative management structures. Deer management groups are a less well established mechanism in lowland and peri-urban environments and stakeholders tend to be more numerous, due to the smaller size of landholdings with variable levels of interest in managing deer. Perceptions of deer may be quite different in the lowland and urban context; for example they are less likely to be viewed as an economic resource and more frequently an agent of damage. However their presence can be also be highly valued by those who like to see deer in the countryside and in proximity to towns and villages. Some of the issues discussed as part of the other WDNA challenges need particular attention in lowland and urban areas due to more frequent interaction with people e.g. deer-vehicle collisions and different environmental and habitat impact. There have been numerous studies on urban deer carried out in the USA which may inform management approaches in Scotland.

3.3.2 Challenge 1: Improve understanding of deer population dynamics

As the most abundant cervid, national population estimates and harvest data suggests that the population of **European roe deer over a large part of Europe has substantially increased since the 1980s** (Burbaite and Csányi, 2009). The authors highlight the potential for populations to continue growing and encourage future research to focus on socio-economic and cultural factors which influence roe deer population management. However, despite evidence of a general expansion of deer population in lowland areas, there is far less certainty over densities and trends in specific areas (Putnam and Moore, 1998). **Accurate population estimates are more challenging to achieve in lowland and peri-urban areas** due to the fragmented nature of the habitat and the logistic barriers associated with collaboration. Lowland deer management groups are not as well established as those in the uplands and with improved collaboration in the future, regional population estimates may improve.

Putnam *et al.* (2011) provide useful insights on the relationships between deer densities and the likely impacts on land uses such as forestry, agriculture and conservation. There can be problems with scale when implementing management based on regional density estimates, as local impacts can depend on habitat preference and utilisation which is more strongly influenced by local landscape features rather than deer density. Indirect measures of density (e.g. faecal counts) may also be more indicative of local habit use than true density which may make their use in population assessment less reliable. Putnam *et al.* (2011) go on to

suggest that **there is a non-linear relationship between deer density and levels of damage** and therefore threshold densities for management are not straightforward. Assessments of deer density and of habitat impacts therefore need to be considered together to inform management. While there are not clear thresholds of deer density that can be related to increased levels of damage, Putnam *et al.* (2011) does indicate densities, above which damage may be expected to occur and where targeted monitoring would be beneficial.

Evidence suggests that roe deer tend to have lower impacts on lowland woodland environments than red deer in the uplands. Birch and oak regeneration is found to be little affected by roe deer in lowland areas even when densities are relatively high (25/km²) (Putman, 2012). Studies of fallow deer on farm woodland scheme plantations in Suffolk found a high variation in damage to terminal shoots and considerable differences in the susceptibility of tree species with cherry *Prunus avium*, rowan *Sorbus aucuparia* and lime *Tilia cordata* being the most preferred and damaged. Important determinants of damage are species composition, degree of cover and plantation size. Larger plantations that either had good cover or were adjacent to areas with good cover were found to be more prone to damage (Putman, 2012). Coppice management appears to be particularly vulnerable to damage by deer in relation to effects on ground flora, damage to fences and reduced coppice regrowth in sites in England; again this is more associated with site area and cover rather than deer density alone (Putman *et al.*, 2011). A study by Cooke (2006) found that muntjac deer densities of 100/km² or greater had severe impacts on coppice regrowth, tree regeneration, and ground flora homogenisation. Gill and Morgan (2010) investigated how deer density influenced woodland regeneration across lowland woodlands in England, finding a negative relationship between deer density and seedling density. Higher densities of deer were generally associated with arable sites with drier and more fertile soils, a pattern which has been observed elsewhere in Europe. Woodland damage was less where deer made use of adjacent fields and this depended on the deer species in question i.e. fallow deer are larger and able to utilise less digestible forage than muntjac and roe deer and are therefore more likely to use these areas. Sage *et al.* (2004) monitored vegetation in experimental exclosures in small farm woodlands and reported reduced cover in grazed plots and some change in species composition over a four year period including an increase in grass cover. However Putnam and Moore (1998) highlight the importance of grazing to maintain characteristics of certain ecosystems and caution against referring to all herbivory impacts as 'damaging' as grazing reduction may also have negative impacts on ecosystems. Conservation damage tends to be more associated with woodlands where ground flora may be impacted and regeneration suppressed. They recommend that impacts be assessed in relation to management objectives e.g. conservation, economics.

In his report on the economic costs and benefits of deer, Putman (2012) reviews the impacts of deer on agriculture in Scotland and highlights the lack of existing data. This follows an in depth review of the impacts of deer in lowland Britain on agriculture, forestry and conservation habitat (Putman and Moore, 1998). Studies have shown that damage can be caused to arable and root crops and the productivity of grass crops grown for hay and silage can be reduced. Roe deer in particular can impact on orchards, soft fruit and nurseries and the smaller-scale nature of such ventures can mean damage is more likely to be significant. Putman (2012) explains that the 'patchiness' or localised nature of agricultural impacts means that it is difficult to predict economic losses at scales larger than individual holdings. Overall, studies seem to suggest that damage caused in lowland areas is usually not considered an important issue. In National Nature Reserves, a survey of managers found that 18% experienced problems with meeting management objectives as a result of deer damage and most of those managing open sites (e.g. grassland, heathland), viewed the presence of grazing deer as positive for the habitat. While damage to crops can be quite apparent, crops often completely recover, and winter and spring grazing on cereals can actually have positive impacts on yields (Scott and Palmer, 2000). Similarly, the timber

quality of woodlands may be reduced by browsing, but evidence suggest that the economic implications are relatively small (Putman and Moore, 1998).

A survey of Deer Management Groups in Scotland conducted by Scott and Palmer (2000) found that agricultural damage was mostly associated with red deer, and where roe deer caused damage it was usually perceived to be in combination with red deer. The authors describe evidence that damage is related to the distance of crops from woodland cover and this is supported by studies of habitat use on farmland. Studies in Scotland, as in the rest of the UK have tended to look at damage at the scale of individual land holdings or fields. Studies from other countries suggest the extent of damage to agriculture is seasonal and dependent on the timing in the crop cycle.

Key points:

- There is not a linear relationship between deer density and levels of damage to forestry, agricultural and conservation interests. Deer density and damage assessments should be made side by side;
- Agricultural impacts are often localised and dependent on landscape features, crop type and season;
- Roe deer are not considered to have major economic impacts on timber and crop production in lowland areas. However, impacts are spatially variable and therefore economic losses are also likely to be spatially variable.

3.3.3 *Challenge 2: Co-ordinate, make available and use current data on lowland and urban deer*

There is less data for deer populations in lowland and peri-urban areas than for upland areas. Ballantyne (2012) conducted a study on deer density in Central Scotland as part of a socio-ecological study to understand the relationship between deer density figures and perceptions of deer presence. Deer densities were estimated using night-time thermal imaging of deer along farm road transects ([Dandy et al., 2009](#)). Deer densities in the study areas were relatively low, ranging from 0.8km² to 3.3km². Focus groups and questionnaires were used to gather data from communities and land managers and found that there was little perception of deer-related habitat damage and that deer prevalence was not considered as high. Overall, deer were perceived as representing a **positive aspect of local nature with benefits for human wellbeing**. As discussed in the previous section, the combined use of deer density estimates and impact monitoring will help inform suitable management interventions. Gill *et al.* (1997) suggested that the **wider use of thermal imaging methods has the potential to improve population estimates** in lowland areas.

The **growing incidence of Road Traffic Accidents involving deer** is a key challenge for lowland and urban deer managers (WDNA, 2014) due to the impact on public safety and the implications for deer welfare. A study of deer manager preferences across Britain, found a strong aversion to a potential rise in deer-related road traffic accidents as part of an evaluation of future management options (Austin *et al.*, 2014).

The Deer Vehicle Collisions in Scotland Project has been collecting data on incidents across Scotland since 2008 ([Langbein, 2011](#)). A new phase of the project is about to be initiated to maintain and develop the long term dataset to further understand collision trends. This followed the National Deer-Vehicle Collisions Project conducted in England which developed a national database of road traffic collisions involving deer in Britain ([Langbein, 2007](#)). A North American study found a correlation between deer density and the frequency of deer-vehicle collisions (Gkritza *et al.*, 2010); the percentage of cropland in the area also increased collisions. Lagos *et al.* (2011) detected patterns in the frequency of deer-related road accidents in north-west Spain that were related to temporal factors. Accidents involving roe

deer were most frequent during the breeding season in April and May and during the rut in July. They were also more common at dawn and dusk. The peak of accidents in April/May was thought to be due to the dispersal of yearling roe deer as they establish new home ranges, through an increase in road-crossing behaviour. During the rut, an increased level of activity among male roe deer also causes increased road crossing but the peak may also be partly explained by the greater summer day length. The authors recommended a campaign to **increase public awareness of the increased risk of collisions at certain times** including the use of seasonal signage and warning lights on roads. Putnam *et al.* (2011) explain that, as for habitat impacts, road traffic accidents are not only related to deer density but also to road density and the speed and volume of traffic, suggesting that these parameters should be considered simultaneously.

Key points:

- Accurate population estimates do not exist for many lowland, peri-urban and urban areas of Scotland;
- More extensive use of thermal imaging could improve accuracy of population estimates;
- There are certain factors that increase the frequency of road traffic accidents involving deer and an increased awareness of these may improve public safety and deer welfare.

3.3.4 Challenge 3: Develop a range of options for deer management planning

Deer management planning in lowland areas is less well advanced than for the uplands. Lowland deer management groups are less well established than their upland counterparts and there is less agreement over where the responsibility for deer management lies. There has been little research on deer management in lowland and peri-urban areas. However there is some general guidance for identifying deer impacts and management measures in lowland rural areas in the UK ([Mayle, 1999](#)) and some best practice guidance for deer in towns ([SNH, 2008](#)). A guidance document about managing urban roe deer was developed by [Quarrel \(2012\)](#) with the support of two Scottish lowland deer management groups. This provides in-depth practical information about managing roe deer from the author's professional experience of working in urban deer management and includes local observations about the behaviour of urban roe deer and how this differs from the rural environment. He suggests that an increase in de-industrialised areas at the edge of towns has led to an increase in scrub cover and a greater influx of roe deer. [Dandy *et al.* \(2009\)](#) explains that increasing woodland planting in and around urban areas has also contributed to this. Indeed the thermal imaging research carried out by the same author indicated that the largest numbers of deer were found in and around woodland areas.

[Dandy *et al.* \(2009\)](#) used a **GIS mapping approach to demonstrate how land cover, natural heritage, thermal imaging of deer locations and road traffic accident data could be combined to spatially characterise people-deer interactions**. This is a potentially useful tool for peri-urban deer management planning in the future. As is apparently the case in rural areas, habitat configuration is likely to influence densities of deer in urban areas. Urbanek and Nielsen (2013) found that landscape characteristics such as density of agricultural 'patches' and presence of forests were related to higher densities of suburban white-tailed deer in North America.

Guidance for managing suburban deer is more developed in North America. DeNicola *et al.* (2000) provide a detailed technical guide for managing white-tailed deer in North American suburban environments where human-deer conflicts have increased over recent years. They explain the practicalities of using a range of management measures such as fencing, deterrents, fertility control and culling. The authors indicate that conflicts involving deer are

not usually resolved using non-lethal methods, but as in the UK, culling is often not favoured as a management measure by suburban communities. The authors also highlight the potential transmission of Lyme disease, Bovine Tuberculosis and Chronic Wasting Disease between deer and the associated human health risk where deer are over abundant in populated areas.

Collaborative deer management has a range of particular challenges in lowland and urban settings and there is a **clear requirement for effective community engagement** in planning. There is a significant body of literature and guidance from the North American context which may usefully inform urban collaborative management in Scotland. For example the urban ungulate conflict analysis by Hesse (2010) provides a detailed discussion of the human-ungulate interactions in British Columbia and recommends community-based, co-management processes as more efficient and equitable than traditional authoritative approaches. **Management may receive more community support if there are perceived community benefits.** For example, hunting of urban deer gained greater support in a North American residential community following a reduction in damage to landscape plantings and the number of Lyme disease cases observed after population reduction (Kilpatrick and LaBonte, 2003). This would require good communication between managers and community representatives.

Key points:

- Collaborative management in lowland areas is less well established than in the uplands. The distribution of stakeholder roles and responsibilities is less well acknowledged.
- Tools for mapping human deer interactions may be useful for peri-urban management planning;
- Evidence from North American studies illustrates the importance of good community engagement with peri-urban/urban deer management.

3.3.5 Challenge 4: Understanding public perception of urban and lowland deer

A substantial research project was carried out entitled 'The Management of Roe Deer in Peri-urban Scotland' between 2007 and 2009. This made some significant progress in understanding the interactions, both positive and negative, between people and deer in peri-urban environments. This has been recognised as a significant knowledge gap in urban deer management in Scotland. The project investigated the extent of impacts such as road-traffic accidents involving deer, garden and horticultural damage and the potential transmission of tick-borne diseases.

[Dandy et al. \(2009\)](#) identified **a range of positive values for deer in the peri-urban environment**; deer hold **considerable cultural value** as they do in the uplands, they have a recognised role in providing ecological services (e.g. biodiversity), there is economic value derived from recreational stalking and tourism, and deer are valued as a source of venison. The values most recognised in a survey of peri-urban communities were associated with seeing deer and knowing that deer exist in the local environment. Cultural value was also expressed but there was less awareness of the economic and ecological dimensions. The authors explained that community members do not perceive roe deer as over-abundant and that management measures to reduce numbers may detract from the main source of value they have for communities. Ballantyne (2012) discusses plans for 'green corridors' to bring biodiversity including deer into urban and peri-urban areas to increase awareness and encourage positive perceptions of nature.

A study, reported to be the first to investigate attitudes to wildlife management methods among UK peri-urban communities found that the perceptions of deer in lowland and peri-urban areas differs substantially from in the uplands (Dandy et al., 2011). A survey of

communities in Central Scotland revealed a **preference for non-lethal methods of control in peri-urban areas** (Dandy *et al.*, 2011), culling was only supported if other methods failed and was completely unsupported by two thirds of respondents. Preferences for management responses to different impacts were considered (road-traffic accidents involving deer, woodland damage, garden damage and incidents of cruelty towards deer) and these were analysed in relation to socio-demographics of respondents including gender, age-class and familiarity with deer. Few differences were observed between the attitudes of different groups. Fencing and changing human behaviour (e.g. speed limits, increased policing to reduce incidents of cruelty) were the preferred interventions. The potential use of 'scarers' was also a popular option. The lack of support for culling is thought to be partly due to cultural factors but this may also be related to the fact that there are not the perceived economic benefits for deer management in peri-urban areas as there are in rural areas. Attitudes towards lethal management methods have tended to be more positive in North America, especially among those who have experienced negative impacts associated with suburban deer (Kilpatrick *et al.*, 2007; Messmer *et al.*, 1997).

Another challenge related to perceptions of urban deer is related to their welfare in such environments. They are reportedly **targets of poaching and inhumane treatment** by criminals ([Quarrel, 2012](#)) and this problem may grow if populations continue to increase.

Key points:

- Deer are of great cultural value in peri-urban areas and recognised as an important part of nature;
- Communities in lowland/peri-urban areas are more supportive of non-lethal deer management methods.

3.3.6 General observations on research gaps (Priority 3)

It is apparent that there is growing awareness of the increase in wild deer populations in lowland, peri-urban and urban areas alongside acknowledgment of human-deer conflicts, e.g. deer-vehicle collisions, potential disease transmission and damage to woodlands and arable land. As a result, there is increased interest in establishing a better understanding of the links between deer populations and their impacts on people and habitats so that management interventions may be improved.

Knowledge and research gaps identified from the literature include:

- Understanding of regional deer densities and how these relate to impacts across different habitats in lowland and peri-urban areas. This involves improving population estimates and monitoring deer at the landscape scale;
- [Dandy *et al.* \(2009\)](#) set out a clear set of research recommendations in the context of their research project on peri-urban deer. These include both socio-cultural aspects such as enhancing our understanding of how the public experience values and impacts associated with deer across urban and rural localities and deepening our knowledge of the cultural and existence values that are held for wildlife including deer;
- [Dandy *et al.* \(2009\)](#) recommend research into ecological differences between wild deer in urban, peri-urban and rural landscapes and into the causes of road traffic accidents involving deer;
- There is evidence of a need for further research on effective decision-making tools which incorporate values and impacts, to ensure that stakeholder views are adequately represented leading to more robust decisions;
- Putman and Moore (1998) highlight the increase of roe deer populations in the UK and the potential for increasing levels of damage to be caused to woodlands, conservation areas and adjacent agricultural land. The increase in farm woodland plantings across

the UK and general increase in forest cover in Scotland raises the question of what the future impacts will be on deer populations and habitats. [Putman \(2012\)](#) also highlights the lack of data concerning the impacts of deer on agriculture in Scotland.

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3.4 Priority 4 - Economic and Community Development

3.4.1 Challenge 1: Understand the costs and benefits of deer management

Wild deer management is an **important facet to the economic and community** development of rural areas and of Scotland. [PACEC \(2006\)](#) undertook a study to look specifically at the contribution of deer management to the Scottish economy. They looked at both sporting and non-sporting management, and reported on the direct and indirect contribution, such as employment, income and expenditure these activities incurred. However, the study only focused on grossed up results. A follow-up study in 2014 (PACEC, 2014) was more extensive, and looked at the economic contribution, but also at the environmental and social contribution of shooting sports in the UK. However, there has been some criticism of the 2006 and 2014 PACEC reports. In a detailed and critical review of the reports by Cormack and Rotherham (2014) for *The League Against Cruel Sports*, the authors criticised the methodology used and concluded that it was not possible to accept the estimates of Gross Value Added (GVA) of the sporting shooting sector given in either report.

[PACEC \(2016\)](#) published findings from the 2013/14 sports shooting survey for Scottish wild deer. The 186 Scottish deer managers that responded to the survey were responsible for 1.8 million hectares (**25% of Scotland's land mass**). Two thirds of respondents were members of DMGs with formal written management plans in place. Over 80% of respondents were involved in deer counts and monitoring and assessment of deer habitat was being undertaken in their DMG. Deer management on landholdings was mostly carried out by the landowner (57% of cases) although employed professional stalkers were often used (36%). Those in the Lowland Deer Network Scotland undertook deer management to protect agricultural crops (74%) and reduce risks of road traffic accidents (47%).

[PACEC \(2016\)](#) estimate that the total expenditure on deer management in Scotland in 2013/14 was £43.1m - with £7.7m spent on capital expenditure, £15.2m on staff wages, and £20.2m on other operational expenditure. Income partially offset the costs, with £12.5m income from deer management (with 53% coming from carcass sales – considerably more than Putman's (2012) estimated of £2 million generated from venison sales). There were an estimated 2,532 jobs in deer management in Scotland (including full-time, part-time and seasonal workers) that accounted for 845 FTEs (722 paid, 124 unpaid). PACEC suggest that the **total impact of deer management on the Scottish economy in 2014**, including economic impacts from associated hospitality and the wider supply chain within Scotland, **was £140.8m** with a total of 2,520 FTE paid jobs supported in Scotland. These impacts were measured by the numerical questions from their survey and extrapolated to provide estimates for the whole of Scotland. They were considered to be representative of activity in Scotland as a whole, although the relatively small lowland sample supported a lower level of confidence than that for the Highlands. It was also estimated that over 90% of primary suppliers of equipment, rifles, vehicles, etc. to the deer management sector were located in Scotland.

MacMillan and Phillip (2008) conducted an extensive review of the contribution wildlife makes to the rural economy; finding it generated jobs, income and profits from food and sporting enterprises, and contributed in less direct ways by bringing pleasure from viewing and learning. The review focused on UK studies published in peer-reviewed journals and official web-based sources in the last 20 years. They found that traditional activities such as deer stalking remained an important source of wealth and employment, but their overall contribution was declining relative to non-consumptive uses such as wildlife tourism.

Another major review commissioned by SNH (Putman, 2012), looked specifically at Scotland and wild deer. They highlighted notably the **significant contribution to the economy in many rural areas that wild deer management bring in Scotland, whether for private**

enjoyment by the landowners and their guests or through leased hunting. He also found, like PACEC (2006; 2014; 2016) that estates were major employers in some rural areas. Putman (2012) also discussed the significant contribution of red deer to the capital value of sporting estates. He estimated deer underpinned rural estate values to around £450 million in 2000 - with the capital value of stags reportedly around £22,000 with hinds at around £2,200 (Deer Commission Scotland (2000) in Putman, 2012).

Putman (2012), however, concluded there were a **wide range of impacts that must be assessed to provide an accurate cost/benefit analysis for wild deer** in Scotland. He provided initial estimates of costs and benefits and identified other data sources that could contribute to our overall understanding of the true costs of both deer impacts and deer management. He nonetheless recognised that although most information was currently available at a national scale, the costs and impacts may be better understood at local or site level.

Putman (2012) reviewed the **economic cost that wild deer had on the forestry sector**, citing damage to commercial and naturally regenerated afforestation through browsing on young trees. Attempts to minimise such damage can lead to significant costs for land owners through fencing, tree guards, or through culling. Putman (2012) highlighted the paucity of up-to-date data regarding the costs of deer damage and control in forestry, and Edwards and Kenyon (2013) referred to the government's response to Parliamentary Questions where it was stated that "no figures are available for the overall cost of deer damage to the forestry sector, however surveys on the national forest estate indicate that 15-20% of young trees have suffered some deer damage" (Scottish Parliament, 2013, reported in Edwards and Kenyon, 2013). Putman (2012) did, however report that the net cost (expenditure minus sales) of forest protection (primarily deer control) in the Forestry Commission estate was some £9.4 million in 2009/10, with £2 million grant aid to private woodlands over 2009-2013 to reduce deer impacts, figures that do not take into account reduced timber yield. Putman suggested that **more work is required to establish the full economic costs of deer on forestry**, accounting for all aspects, beyond deer control.

Putman (2012) also reported an **extreme paucity of data on the impact of deer on agricultural production**, whilst acknowledging that deer can damage crops and reduce productivity of grasslands through reduced hay and silage yields, or reduced forage availability for livestock. It is also highlighted that actual damage is often highly localised (often to individual fields) making it difficult to record and therefore make estimates at regional or national level.

Putman (2012) highlighted the costs of restoration of SSSIs or SACs that were classified as being in unfavourable condition due to deer grazing. He estimated that over the 2005 -2010 period the annual financial cost to SNH/DCS for 12 Section 7 agreements covering 9,887 ha was £2.63 per ha, and on all 62 Joint Working Sites this had an annual cost of £250,000 or £1.68 per ha.

Finally, it is crucial to also understand the **relative socio-economic importance of deer in certain localities** (e.g. importance socially for schools, doctors' surgeries, local shops etc.). In remote areas, where there are fewer job opportunities, deer can bring social benefits that go beyond the immediate local community (Putman, 2012) and provide relative **economic local multiplier effects** (that may be higher than farming), as also highlighted previously in the USA by Loomis (1995).

Key points:

- The contributions that shooting (including wild deer) provide are very important to the economy, in terms of local employment and gross added value;

- It is not always easy to obtain information on fee-paying stalking in the private sector, so contribution to the economy is potentially underestimated;
- The economic impact analyses that have been carried out tend to be dated and do not cover the whole of the UK;
- Most of these studies are based on a straight quantification of the contributions and are not detailed cost-benefit analyses;
- There seems to be a need for more local or site-level detailed studies of the range of impacts and benefits that wild deer management can offer;
- There is a need to better understand the relative socio-economic importance of deer in certain localities and the relative economic local multiplier effects.

3.4.2 Challenge 2: Encourage diverse economic opportunities associated with wild deer

Despite this economic importance, it seems difficult to understand how to encourage diverse economic opportunities associated with wild deer. [Maffey *et al.* \(2015\)](#) highlighted many references to the **economic potential for venison in the UK**, linked, for example, to the health benefits venison can provide, and a rise in popularity in recipes and promotion of venison meat. They looked at actions to overcome barriers to such economic opportunities linked with venison production, however, this was limited to deer farming, and did not focus on wild deer. The extensive review of MacMillan and Phillip (2008) also highlighted that wild meat provides a niche in the contemporary food market, but that although demand was growing, growth was handicapped by a **fragmented supply chain and lack of marketing**. Interestingly, they also found that in comparison with other rural resources such as farming, the contribution made by wild mammals to the rural economy appears small, even in relatively remote regions, but this may partly reflect gaps in the literature regarding their contribution via less formal markets, hobby activities, and in supporting ecosystem services.

White *et al.* (2004) highlighted the **potential for ecotourism in terms of deer viewing or deer safaris among wild populations, as well as potential for obtaining revenue from venison**. They advocated the need (in 2004) to investigate the potential for the development of large-scale venison production in the South East of England. MacMillan and Phillip (2010) investigated the potential role of market incentives to increase venison production, as a mechanism to resolve conflicts over wild red deer management in the Scottish Highlands. They found that such an approach is unlikely to be effective because investments in venison production would bring **conflict** with more important non-pecuniary objectives of landownership such as 'sporting quality' and 'exclusivity'.

MacGregor and Stockdale (1994) emphasised the notion that **most estate owners' motivation to management was private enjoyment**. Likewise, in Europe, Martinez-Jauregui *et al.* (2014) found that non-market values and social factors (such as cultural heritage or self-consumption associated with hunting) must be estimated to better explain society priorities and therefore to efficiently guide future conservation or management policies, as the current market apparently does not justify maintaining hunting in some European mountain systems.

Key points:

- Although there is a growing demand for venison, the supply chain appears to be fragmented and lacking, despite the diverse economic opportunities that have been identified in the literature;
- The literature showed a lack in marketing efforts to meet the demand for venison;
- Market incentives for venison and economic development may not be effective due to the values and motivations of some of the estates' owners. Private enjoyment and exclusivity were found to be often more important than income and wealth;

- Cultural heritage and motivations should be taken into account when trying to encourage economic opportunities for wild deer management.

3.4.3 Challenge 3: Develop appreciation and understanding between access and deer management

Unlimited **access** and freedom to roam in Scotland mean that there can be **conflicts between recreational, conservation and deer management activities**. Bullock *et al.* (1998) looked at deer management and conservation objectives. They reported that deer management was largely in the hands of private estates, who may have little incentive to reduce deer numbers because of the influence of deer numbers on capital values. In terms of access, MacMillan *et al.* (2010) also highlighted that although estate owners are sympathetic to nature conservation interests, attitudes to public access are shaped by their potential to conflict with sporting activities and personal privacy. Mountain biking, camping and canoeing were found to be least tolerated. White *et al.* (2004) found in England, that there was a need to understand that deer management to enhance biodiversity would almost certainly include the culling of deer.

However, **few studies were found concerning public views on deer management**, despite red deer being an iconic touristic figure. Bullock *et al.* (1993) looked at the effect of disturbance by visitors on public and private deer parks on deer survival, where routine activities of deer are altered to such an extent that feeding time is reduced and individual deer are chased by dogs. Likewise, Huxley (1993) looked at the effects of tourism in Scotland in terms of its impact: on animals such as deer, highlighting possible actions that could be carried out to reduce these impacts, and the economic costs of pursuing such policies, and the particular importance of educating the public. Dandy *et al.* (2011) also highlighted the considerable controversy of wildlife management amongst many stakeholders, particularly where culling is used. White *et al.* (2004) in their review in England, also pointed out that with the increasing interest and participation of the general public in decision making on wildlife issues, management was being driven more and more by societal perceptions. As a consequence, there was a growing requirement to justify management actions and any deer management needed to be based on a proper understanding of the causes of the perceived problem. **Mitigation methods should not only be cost-effective and environmentally acceptable, but also ethically acceptable to society**. This may be a significant problem where culling was envisaged, especially with regard to reducing deer impacts on Nature Reserves.

Key points:

- Estate owners' attitudes to public access are linked with their perceived attitudes to conflicts with sporting activities, and perhaps more education is needed to resolve any issues;
- There is an increase in access to the countryside by the public and societal perception (especially regarding culling) must be better understood;
- Educating and encouraging the public to be involved in deer management is becoming an important and urgent issue.

3.4.4 Challenge 4: Build on work to address deer vehicle collisions and human disease risks

The attitudes of the public and wider stakeholders to deer management must also encompass the issues around deer vehicle collisions (DVCs) and human disease risks.

The economic costs and risks to public safety resulting from DVCs must be considered. Some studies have been done in Canada (Found and Boyce, 2011) to model the incidence and factors that increase DVCs. They found that the type of vegetation,

landscape and groomed width of road side were very important factors. In the USA, Gonsler *et al.* (2009) equally found that DVCs were not randomly located, and that habitat type and structure probably played an important role in the location of DVCs.

[Dandy *et al.* \(2009\)](#) stated that **DVCs are one of the most important negative interactions between deer and people**. In the UK, the National Deer Collisions Project (Langbein and Putman, 2005) recorded information on deer collisions and incidents. They found that concerns over this issue went beyond the deer welfare and population size and should include the costs to the wider economy (human health and vehicle damage), with [Putman \(2012\)](#) estimating the cost of DVCs in Scotland to be around £9.4 million per annum. The AA (2009) suggest that UK insurance claims for DVCs could amount to between £59 million and £103 million per year in the UK, at an average cost of £1,400⁵ corroborating Putman's figure at the lower end (around 20% of DVCs in UK occur in Scotland).

White *et al.* (2004) also identified this issue for the South East of England. Solutions proposed by Langbein and Putman (2005) to **reduce collisions were: provide safer crossing points for deer (e.g. overpasses); increase driver awareness; and prevent or control crossing**. A follow-up of this study, the DVC Scotland 2008-11 Monitoring Project ([Langbein, 2011](#)), commissioned by SNH, was carried out to re-establish the DVC database built up during 2003 to 2005. The DVC Scotland Database included more than 12,500 DVC records for the ten year period 2001 to 2010. The peak period for collision occurrences was in May-June (60% on motorways and 35% on 'A' roads). They also found an average of 7000 DVCs annually in Scotland, with 65-70 human injuries per year, leading to an economic cost of £75,000 per incident with human injury, and an annual cost of £4.9 million. In SNH's 2016 report to Scottish Government on Deer Management in Scotland ([SNH, 2016](#)) it was estimated that total DVC costs (adjusted for 2016) were at least £13.8 million per year. The high spring-time collision occurrence was also highlighted in Spain (Lagos *et al.*, 2012) with roe deer, which coincided with the breeding season for the animals, and at the week-ends, when there is an increase in human activities and travel, as seen in the previous priority (WDNA 3). White *et al.* (2004) also showed that DVCs seemed to be in specific hotspots of risk, suggesting that it was these particular areas in which mitigation measures would be most usefully employed.

As well as DVC risks, wild deer are connected with **human diseases**, with tick bites and the risk of **Lyme borreliosis** associated with areas used by deer (Robertson *et al.*, 2000). White *et al.* (2004) in their review also identified a correlative link between the incidence of Lyme disease and deer density. However, they pointed out that deer were just one component of the disease-host system for tick-borne diseases. A study on the potential economic costs of Lyme disease for Scotland by Joss *et al.* (2003) found that the estimated annual costs for diagnosis, treatment and loss of time through illness were approximately £331,000 (1999 prices; equivalent to over £500,000 in 2016), based on an estimated 368 Lyme disease patients per year ([SNH, 2016](#)). [Putman \(2012\)](#) cites research from a USA study from 1998 that estimates the average cost of illness (including both direct medical and indirect costs) from each case to be around \$36,000 (£24,000), equivalent to £39,000 in 2016 ([SNH, 2016](#)). This would equate to an annual cost in Scotland in 2016 of over £23 million ([SNH, 2016](#)). The healthcare costs are likely to be considerably higher in the US meaning this figure is likely to be high, nevertheless, the costs of impacts on any sector that involves human health or livelihood can be considerable and the situation should therefore be monitored closely.

More recently in Norway, Mysterud *et al.* (2016) also showed that **a high spatial and temporal population density of deer increase the incidence of Lyme disease**. They suggested that managing deer populations will have some effect on the disease incidence,

⁵ http://www.theaa.com/motoring_advice/news/aa-insurance-warns-of-cost-of-deer-collisions.html

but that Lyme disease may nevertheless increase as multiple drivers are involved. Further, a modelling study by Li *et al.* (2014) also showed that reducing local deer densities could not effectively reduce tick abundance if woodland patches were well-connected, controlling deer grazing intensity in grassland may not be an effective tick control strategy, local extinction of deer could decrease tick abundance considerably but deer reintroduction could lead to fast tick upsurge, and controlling human disturbances may reduce the tick density at landscape-level, as well as tick "hotspots" (i.e. areas with unusually high tick density).

[Dandy *et al.* \(2009\)](#) report that increased people-deer interactions in peri-urban areas can lead to greater risk of contraction of tick-borne diseases, higher risk of DVCs, and more public safety issues from risks around poaching and the use of firearms in public places, etc.

Key points:

- DVCs have an important economic and social impact, both in terms of human and animal welfare;
- DVCs have been widely studied and some mitigation measures have been proposed, such as providing safer crossing points for deer, increasing drivers' awareness, preventing or controlling crossing;
- Mitigation measures should be targeted at identified collision hotspots;
- Tick-borne diseases have a major impact on human health due to risks of Lyme disease, however, recent studies found reducing deer density and/or grazing intensity may not be an effective way of controlling the risk to human health. Reducing human disturbance and understanding the wider drivers to Lyme disease should also be encouraged.

3.4.5 Challenge 5: Improve understanding of deer impacts on agriculture and forestry

Wild deer are also seen to have impacts on other land use sectors, such as agriculture and forestry. MacMillan and Phillip (2008), in their extensive review of wild deer impacts, found that **much of the literature focuses on the negative impacts of mammals on commercial activities such as agriculture and forestry, even though these impacts were considered to be relatively insignificant** in economic terms at both regional and national levels. White *et al.* (2004) found that because of their potential economic significance and the relative paucity of data, quantifying damage-density relationships within the agriculture and conservation sectors should be the priority for further research on the impacts of deer in the South East of England.

Gill *et al.* (2000) looked at the **economic implications of deer damage in forests**, with various forms of deer damage, the effects of damage on growth and timber quality and the consequences of damage to timber yield and ultimately revenue losses. Estimates of revenue loss suggested that browsing was likely to be a more serious form of damage than bark stripping. However, there was a lack of data directly relating growth loss, survival and poor stem form to timber yield loss. As a result, estimates of revenue loss from browsing remained speculative. They also stated that efforts taken to limit revenue loss through deer management were likely to be only partially effective and that culling appeared to be a far more cost effective option than fencing. Estimates of the cost of browsing on Sitka spruce suggested that fencing was unlikely to be a cost-effective measure for preventing damage, unless it is to be applied in an area where little or no deer control can be carried out.

Scott and Palmer (2000), in a report commissioned by the Deer Commission for Scotland, also looked at deer damage in woodlands and found that **more data were required on the economic costs of damage both for more tree species and from a wider selection of forests**. This review also encompassed damage to agriculture by deer. At the time, damage was found to be confined to fields immediately adjacent to woodland or other suitable cover.

Furthermore, most damage occurred on the boundary edges of fields close to woodland. Within fields damage tended to be patchy and within a distinct 'zone' of utilisation. The timing of damage dictated the seriousness of economic loss. In Scotland, marauding red deer came down off open hill ground in winter and spring to raid crops. A closer monitoring of the "agricultural cull" was found to be useful for estimating the "size" of the "agricultural problem".

Putman and Moore (1998), in lowland Britain, found that because of fundamental differences in ecology and distribution, **different species of deer were implicated in different types of damage**, depending on feeding habit and distribution in relation to geographical patterns of crop-type. Despite the apparent severity of damage caused to agriculture or forestry, the actual economic significance of such damage would appear in many cases to be negligible or small. Field crops frequently recovered completely from such damage, and although woodland crops may be checked and quality of the timber may be reduced as a consequence of earlier browsing damage, losses may be far less than they first appear. **This whole question of the true economic cost of deer damage needs further research.**

[Dandy et al. \(2009\)](#) and [Putman \(2012\)](#) also suggest that increasing roe deer numbers mean that there is a higher level of damage occurring to crops, woodlands, private gardens and public spaces, such as golf courses, graveyards and public parks.

Key points:

- Economic costs of deer damage for more tree species and from a wider selection of forests are needed;
- The studies on agricultural damage by red deer are somewhat dated, but showed that the extent of the damage was very dependent on timing and the locations of agricultural fields.

3.4.6 General observations on research gaps (Priority 4)

The economic and community development priority for wild deer management encompasses a range of issues, which have been reviewed or studied extensively in the literature over the past 20 years. However, there still seem to be gaps in knowledge or understanding, and better consideration or more research on key issues could include:

- The need for more detailed research on cost-benefit analysis and economic impact analysis of wild deer management at a range of scales (i.e. national, regional, local and site level);
- The need for more knowledge of the economic and social benefits from different deer management strategies, including forest lease values and rural employment;
- More marketing research could be done, especially on how to provide adequate incentives to estates owners that would make the supply chain for venison and other benefits more effective;
- More attention on how to involve and educate the public in wild deer management would be beneficial, as well as trying to better understand and hopefully resolve conflicts between public access and deer management;
- Although research on DVCs has been carried out extensively, better consideration of specific mitigation measures in hotspot risks would be helpful. GIS based approaches should be used to identify and record such mitigation measures. The impact of DVCs on the rail network is also unknown;
- Although there has been some recent research on the causes, effects and risks of Lyme disease in humans, in relation to deer management, there are still gaps in our understanding of the precise role that deer play in the spread of Lyme disease;

- Although there has been some research which has looked at the economic costs of deer damage to forestry and agriculture at a national level, damage is generally highly localised making it particularly challenging to assess at the national scale.

3.4.7 Priority 4 - References

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3.5 Priority 5 - Training and Wild Deer Welfare

3.5.1 Challenge 1: Ensuring a strong skill base in deer management

Training of deer managers and enhancing the skills base across the sector is a WDNA theme often more strongly related to management practice and knowledge transfer than research. Nevertheless, a number of key studies have been carried out which highlight important themes and opportunities relating to addressing key skills gaps, measuring and enhancing stalker competence, improving uptake of training in key practices (e.g. habitat management) and integrating action learning within collaborative deer management. An SNH commissioned study ([Pound, 2012](#)) of the wildlife management sector which assessed existing skills and training capacity and the ability of the sector to deliver any required skills uplift in deer management in Scotland, identified a range of key findings. Based on a survey completed by 250 game and wildlife managers, [Pound \(2012\)](#) identified that a concentration of game and wildlife management involvement exists in the central belt area of Scotland, the sector is highly male dominated and volunteers represent an important element of the workforce. Overall, 95% of respondents possessed a relevant qualification and 86% recognised the importance of wildlife management qualifications, with the DSC2 representing the highest level of qualification for 45% of respondents, with only 4.5% holding no qualification. **The sector workforce is highly skilled; although these skills are commonly developed through non-accredited training and knowledge transfer activities** rather than full-accredited qualifications. Enrolments in relevant FE courses were identified as having increased year-on-year, with short specialist courses (which are widely available) and on the job skills development the most favoured forms of training. [Pound \(2012\)](#) identified gaps and opportunities for improvements in a number of key areas, including: i) improving links between organisations representing wildlife managers and training providers; ii) raising public awareness of the game and wildlife sector; **iii) improved availability of higher level training relating to Information Technology and**

conservation/habitat management; iv) agreeing industry wide minimum standards and running events to promote careers in the sector including for female entrants.

The competence of deer managers and assessment and monitoring of competence represents a key theme relating to the sectoral skills base and specific deer welfare concerns. [Daniels and Findlay \(2007\)](#) identified a lack of comprehensive monitoring and data on competence as a key challenge to assessing stalker competence. The Deer Stalking Certificate (DSC1 and DSC2) qualifications are currently the main mechanism of assessing stalker competence, with deer managers wishing to control deer under specific authorisation (e.g. at night or during the close season) also required to register under the competency register as 'fit and competent' (with competency demonstrated by completing the DSC2, or the DSC1 combined with evidence from suitable referees, one of whom must hold a DSC1). **Higher levels of stalker competence are commonly linked to enhancing deer welfare** (e.g. [Findlay, 2007b](#); Aebischer *et al.*, 2014).

The Wild Deer [Best Practice Guides](#) were launched in 2008. Leading up to this a series of reports focusing on welfare and training were undertaken by the Deer Commission for Scotland. These reports assimilated and analysed data, at the time, on different aspects of welfare in relation to wild deer and the relationship between welfare and training. In 2007 [Daniels and Findlay \(2007\)](#) identified key gaps in existing methods for assessing competence, including: **i) a lack of formal training in, or assessment of, 'night shooting' skills; ii) a lack of assessment or demonstration of competence in the open season** and for those circumstances and individuals who are exempt (owner, employees etc.) from having to apply for authorisations (e.g. landowners and employees of landowners); **iii) an absence of formal training or skills demonstration in specialist skills** (e.g. use of dogs, pony extraction, collaborative culling etc.); and **iv) inconsistencies between existing methods of assessment**. These authors identified the need for a system capable of addressing these (and future) gaps, which demonstrates competence for all those who shoot deer and applies a consistent approach to assessing competence for all stalkers.

The 2007/08 reports identified a lack of an agreed, clear and meaningful definition of competence as a particular challenge. [Findlay \(2007b\)](#) positions competence within a broader context of 'responsibility of care', which requires a degree of competence to implement. In 2007 as per [Findlay \(2007b\)](#) **competence was linked directly to three key aspects: public safety, deer welfare and public confidence in venison** as a product. Practitioner competence was seen as being related to both theoretical knowledge and practical application of knowledge, with experience recognised as instrumental in building competence. **Identifying specifically what is required for competence to be developed includes the scope of required skills (e.g. where to shoot), standards of competence (e.g. National Occupational Standards) and measures of competence (e.g. the ability of a manager to pass an assessment such as DSC1)**. A consistent definition of competence is recognised as necessary to facilitate assessment of competence, with standards required which are capable of responding to future changes in legislation and industry needs ([Findlay, 2007b](#)).

Smiths Gore (2008a) reviewed methods of assessing and monitoring the competence of hunters in other countries using phone surveys. This study found that tests for competence (for hunters to be allowed a licence to hunt) were commonplace in the surveyed countries, with competency requirements varying in terms of their stringency and scope. The authors concluded that **the type and scope of competency tests needs to be tailored to their specific purpose (why competency is being assessed)**. For example, short focused training often leads to improvements in hunter safety; in contrast, training and assessment of welfare, food safety and ethics related competencies requires greater time and cost commitments. In a further study, [Smiths Gore \(2008b\)](#) stressed that **any system for monitoring competence must have a clear purpose and be straightforward to**

administer (e.g. monitoring specific measurable components of competence). They identified key factors for monitoring of competence which included: i) extent of public safety incidents (using data from law enforcement authorities); ii) safeguarding of deer welfare (by assessing correct shot placement and wounding); and iii) ensuring food safety (through data gathering from game dealers and vets on the number of deer correctly and incorrectly shot and handled). They also highlighted that any potential monitoring system requires reliable and accurate data, with monitoring at sectoral level potentially reducing the data gathering burden on hunters and ensuring progress is being observed rather than hunters being under permanent scrutiny (thereby facilitating greater support from the industry/sector).

The background to much of this work on the relationship between deer welfare and the competence of those who shoot deer is in part based on research on shot placement. The correct placement of shots (shooter accuracy) can minimise the suffering of the animal. [Putman \(2008a\)](#) suggested that wounding rates for deer in the UK are in the order of 'around 10%' i.e. in 10% of cases a second shot is fired because the animal did not immediately fall. This reflects a study by Urquhart and McKendrick (2003) on red deer, where they found that 14% of culled animals had received more than one shot. Bateson and Bradshaw (1999) also suggested that some 2% of all deer shot may escape wounded. Training can have a direct impact on shooter accuracy and therefore on deer welfare. Aebischer *et al.* (2014) for example, found that the probability of a shot hitting its target was higher for stalkers who had a DSC2 or an Advanced Stalker Certificate (93%), while it was lower (87%) for stalkers with a DSC1 or no qualification (i.e. wounding rates were higher). Stalkers who practiced at least once a week had the highest probability of a shot hitting its target, with this figure falling to 91-92% for those practicing at least once a year and to 79% for those who practiced less than once a year.

Urquhart and McKendrick (2003) suggest that carcass examination (for wound tracts) at the point of processing offers specific potential as a method for monitoring shooter competency. As Smiths Gore (2008a) identified in a review relating to competence in Europe, the U.S. and Canada, a number of countries monitor shooting accuracy and shot placement by monitoring wounding through game dealers and veterinarians rejecting carcasses. Urquhart and McKendrick (2003) suggest that carcass data collection, as a means of competency assessment, should incorporate a wide range of submitting deer managers and sampling days, to ensure the influence of wider variables can be accounted for when assessing wound site variability. However, as Smiths Gore (2008a) note, poorly shot deer may not be presented if the hunters know their competence is being assessed, which may affect the accuracy of such a system for assessing shot placement.

Limited availability of training on certain aspects of management, combined with the complexity of implementing [Best Practice Guidance](#) in key areas, represents a barrier for sustainable deer management. As Maffey *et al.* (2013) note, implementing Best Practice relies upon collective adoption of agreed practices across the entire deer management community; however, the reality of deer management operating under the voluntary principle in Scotland requires that deer managers choose to adopt an innovation, which can result in slow uptake of new management practices. Maffey *et al.* (2013) identified a number of **specific challenges limiting the uptake and implementation of Habitat Impact Assessment (HIA), including the complexity of data gathering and subsequent data analysis and uncertainty around who should be responsible for carrying out HIA.** These barriers existed despite wide recognition across the deer management sector of the potential benefits of HIA. As Maffey *et al.* (2016) recognised, HIA practices have often failed to adequately link local management requirements with the data provided by the monitoring process. Maffey *et al.* (2016) piloted hosting HIA on a mobile phone platform in an effort to remove barriers. This approach addressed some barriers; however, it also revealed key underlying concerns relating to the end use and purpose of HIA, indicating friction between

scientific and management perspectives which needs to be addressed if monitoring is to become more widely accepted as a tool to inform management (Maffey *et al.*, 2016).

More broadly, Dinnie *et al.* (2015), through an investigation of the perspectives of land managers, concluded that long standing management practices based on experience and ties to the land, can often run counter to social change, new governance arrangements and changes in public policy. This further highlights the friction between scientific and land management perspectives which can impact on uptake of both training and best practice in certain aspects of deer management.

Wider research, including the RELU project in Collaborative Frameworks in Deer management (see Section 3.1), directly incorporated support and training to facilitate development of participatory frameworks and engagement between land managers to foster collaboration over public and private objectives. Action learning approaches were utilised to facilitate skills development among managers essential to collaborative processes, including: i) participatory techniques; ii) collating knowledge relevant to the landscape scale using GIS; iii) analysing the knowledge to inform management issues ([RELU, 2010](#)). These initiatives highlight the potential **future importance of training beyond conventional land management practices, towards wider skills development in engagement and collaborative governance processes.**

Key Points:

- Key skills gaps are evident, including in relation to information technology, habitat management and assessment and specialist skills. Training provision has failed to fully address the gaps which have emerged in relation to the evolving requirements for delivering sustainable deer management;
- This review suggests that, to be widely effective, a consistent and straightforward approach to the assessment and monitoring of competence is required, which is capable of demonstrating competence for all those who shoot deer.
- There is a need to ensure that existing management practices are supported by adequate training provision and that the development of Best Practice Guidance helps facilitate the evolution of these management practices.
- Increasing emphasis on public engagement in deer management and collaborative deer management processes requires enhanced skills development by deer managers in related areas. This includes skills relating to facilitation and conflict management, critical thinking, communication and presentation skills, and project management.

3.5.2 Challenge 2: Understand, promote and deliver deer welfare

Deer welfare is a complex concept, with a wide range of factors relevant to welfare within a deer management context, including the legal status of welfare, impacts of management (e.g. timing of culling, culling techniques) on welfare, impacts of natural mortality and disease, the role of monitoring and data gathering in welfare assessment, and wider considerations (e.g. the role of disturbance). Welfare is also a rapidly evolving topic. This section attempts to chart the main developments and changes over the years based on the available research.

An important early driver of our understanding (and definition) of animal welfare in the UK was the 1965 report of the UK Government's Committee to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Systems - known as the 'Brambell Report'. The committee concluded that negative impacts on animal welfare could be avoided where animals are kept free from: i) hunger, thirst or inadequate food; ii) thermal and physical discomfort; iii) injuries and diseases; iv) fear and chronic stress; v) and are free to display normal, species-specific behavioural patterns. Notably, these freedoms were

developed primarily in relation to avoiding negative welfare states in farm animals, with potentially less relevance when applied to wild animals (managed or otherwise).

More recent reviews have identified that an animals' welfare status occurs on a continuum and that consideration must be given to factors which may assist in promoting positive welfare, as well as those which simply avoid negative welfare states (Dawkins, 2008, Yeates and Main, 2008). In particular, an increasing emphasis has been placed on the link between positive animal welfare states and the freedom of the animal or animals to react to changing environmental circumstances (Korte *et al.*, 2007; Ohl and van der Staay, 2012). [Ohl and Putman \(2013a\)](#) explain in relation to the welfare of wild animals, welfare issues can arise where an animal or group of animals have insufficient freedom to respond appropriately to welfare 'challenges' by adaptation and behavioural change. Assessment of welfare therefore requires a focus more on whether or not the animal has the capacity to react appropriately, as opposed to a focus on the immediate challenges an animal faces. **In relation to deer, welfare assessments need to consider the presence of unexpected or atypical behaviours, as well as factors relating to physical condition** (e.g. weight, kidney fat, parasite loads etc.) ([Ohl and Putman, 2013a](#)).

In 2007 [Findlay \(2007a\)](#) identified the existence of a wide range of stakeholder perceptions of what exactly constitutes deer welfare. In practice, the implicit rather than explicit definition of welfare in legislation has resulted in a lack of prescriptive protective measures for wild deer welfare in Scotland ([Findlay, 2007a](#)). Clearly defining the parameters of wild deer welfare offers potential for countering these multiple perceptions and developing a consistent approach to safeguarding welfare. Following this and other reviews (e.g. [Ohl and Putman, 2013a](#), [Ohl and Putman, 2013b](#)) and reflecting an increasing organisational focus on welfare in recent years, SNH developed a Position Statement on Wildlife Welfare in 2014, which established a series of key principles as a benchmark for wildlife welfare. These included: i) taking welfare into account in management plans which are likely to have an impact on wildlife; ii) considering the welfare implications of the manner of how an animal dies; iii) basing welfare considerations on current scientific knowledge; iv) considering public opinion and values in relation to wildlife welfare; and v) taking into account the dynamic and adaptive characteristics of wildlife welfare ([SNH, 2014](#)).

Consideration of perceptions and legal status of welfare outside of Scotland has also occurred, with [Putman \(2008a\)](#) reviewing deer welfare considerations across a range of international models. [Putman \(2008a\)](#) highlighted that **no single defining welfare or hunting model exists, although many countries have hunting associations and codes of practice, with welfare considerations commonly addressed indirectly through regulations on seasons and weapon types**. More recently [Green \(2016\)](#), in a report for Scottish Natural Heritage, proposed a set of practical indicators for assessing welfare of wild deer in Scotland. [Green \(2016\)](#) suggested that indicators be used in combination and over a period of time and proposed nine specific indicators divided into indicators to assess physical body condition (e.g. body condition of yearlings, normal mobility, fat deposits in yearlings) and indicators of behaviour (e.g. social interaction, foraging, tolerance of close approach).

A limited number of studies have been conducted on the links between stalker competence and welfare, with shooting accuracy and wounding rates in particular attempted to be linked to welfare outcomes for wild deer. Aebischer *et al.* (2014) (see previous sub-section for additional findings) identified a number of key factors which offer potential for enhancing shooting success, including i) a comfortable stalking position; ii) use of a gun rest; iii) targeting of the chest area; iv) use of bullets heavier than 75 grains; v) avoidance of rushed, obscured and moving target shots; vi) take care when the ground is unfamiliar; and vii) undertaking regular shooting practice.

Studies of the impacts of different culling methods for red deer on behaviour and post mortem measurements of physiological characteristics (e.g. blood chemistry related to stress factors) have also occurred. In a comparative study of a range of culling methods (including night time and helicopter assisted culling) Cockram *et al.* (2011) identified culling by a single stalker during the day as the most accurate method of placing a single shot in a target area. Nevertheless, there was **no evidence that any particular culling method was more associated with an increased risk of accidental or pre-culling injury/wounding**. Where helicopters are used to assist culling, deer are more likely to be disturbed before they are shot and measures should be undertaken to reduce disturbance. Bateson and Bradshaw (2000) assessed the welfare implications of different culling methods through analysis of cortisol levels, with no link apparent between cortisol levels and wound site location.

A perceived deer welfare issue relates to the shooting of pregnant hinds. Close seasons originated primarily as a resource protection measure while also offering a measure of protection to female deer and their young. Best Practice Guidance on culling during the close season exists to ensure close season culling occurs as humanely as possible. Nevertheless, some stakeholders view close season culling as unethical due to the potential for dependent young to be orphaned. Findlay (2007c), in a review of females culled in close season, noted that collated data indicated that **most culling out of season occurs under owner/occupier rights and is therefore not subject to any external scrutiny of the welfare implications, with monthly breakdowns of venison returns indicating some deer are being culled in the sensitive period (1st May-31st August)**. It is unclear therefore whether the welfare of dependent young in these cases is compromised. More specifically, in relation to unborn calves, Mellor (2003) concludes that the **evidence suggests that when a pregnant hind is culled the foetus is unlikely to suffer**.

In 2012 the exemption which gave landowners and occupiers the right to cull deer out of season to prevent damage to agriculture and enclosed woodland was removed⁶. Instead, SNH now issues a general authorisation permitting owners and occupiers to cull male deer during the close season to prevent damage to crops and woodland. Close season culling authorisations for female deer can be obtained in specific circumstances where deer are known to be causing significant damage to agricultural or forestry/woodland interests. SNH assesses individual applications for culling of female deer and ensures that appropriate mitigation of welfare issues is carried out, with site visits being carried out in some cases (SNH, 2016).

Natural mortality and particularly overwinter mortality represents a further welfare concern for wild deer in Scotland. Putman (2008b) carried out a review of available data on natural mortality of red and roe deer populations. In managed populations of deer the natural mortality (i.e. from disease/starvation) range lies between 2.7% and 5.0% of total recorded mortality for red deer and between 2.4% and 10.8 % for roe (Putman, 2008b). The limited available evidence suggests that **for red deer over-winter mortality may account on average for up to 3.9% of total spring population size; levels can be much higher in certain years and between 10.0 and 22.7% of total recorded mortality (Putman, 2008b)**. From a welfare perspective, selective culling based on age and condition represents an opportunity to enhance deer welfare at an individual and population level. Targeting animals in the poorest condition can prevent eventual natural mortality and therefore reduce individual suffering. Despite this fact, Putman (2008a) found **no clear evidence that higher cull levels on specific landholdings result in lower winter mortality**. Nevertheless, Guinness *et al.* (1978) determined that calf winter mortality is higher in areas of higher deer

⁶ As a result of measures under the Wildlife and Natural Environment (WANE) Act (Scotland) 2011. For further detail on Authorisations for culling during the close season and the role of SNH see: <http://www.snh.gov.uk/protecting-scotlands-nature/species-licensing/deer/authorisations/>

densities and changes in winter mortality were correlated with increasing population density of hinds. This indicates a relationship between deer density and winter mortality rates. However, as [Putman \(2008a\)](#) notes, in deer populations in predator free environments and/or where culling rates are not 'sufficiently intense' to maintain populations below habitat carrying capacity culling levels would need to have very significant impacts on deer densities (e.g. major reduction culls) to result in any perceptible changes in mortality which outweigh that of winter weather conditions. In practice therefore, the potential for altering natural mortality levels through active management may be limited.

Detecting physical and behavioural traits indicative of animal condition requires considerable skill and is a key component of herd management. A review of characteristics used for selecting animals for culling demonstrated that **no single characteristic is capable of differentiating age and condition of animals, with assessments always based on a combination of characteristics** ([Putman, 2005](#)). Condition assessments are particularly difficult in woodland situations and are inaccurate, with a number of indicators being used (e.g. animal size, head length, timing of coat change etc.), with no direct correlation between these factors and age (beyond an estimate of age class).

Wild deer carry a number of diseases and parasites, which can affect the condition and welfare of individual animals and deer herds. A number of disease studies in wild deer populations have been carried out. *Böhm et al. (2007)* concluded that increasing deer numbers (across all deer species in the UK) and range expansion are likely to impact directly on the potential for the persistence of disease and transfer of disease to both humans and livestock. **Changes in key climatic factors** are also likely to influence the presence and abundance of pathogens and vectors, suggesting that **exotic diseases may become an increasingly important concern in both wildlife and livestock disease management in the UK, due to the potential of deer to act as a source of disease transmission for livestock (and humans) in the UK** (*Böhm et al., 2007*).

Specific diseases which represent possible threats to Scottish deer populations and which currently do not occur in Scotland, include Bluetongue Virus (BTV) and Chronic Wasting Disease (CWD), a transmissible spongiform encephalopathy. The UK is currently free from BTV, with the last outbreak in 2007. *Falconi et al. (2011)* highlight concern around the changing distribution of BTV in Europe in relation to climate change and the role unvaccinated wild ungulates (e.g. deer) may play in the spread of BTV across Europe, which may complicate the control of BTV in domestic ungulates. CWD represents a relatively new threat in Europe, with recent cases diagnosed in Scandinavia in reindeer and moose, with the disease causing devastation of many populations of farmed and wild deer in North America (*Roberts, 2016*). **CWD is highly infectious and with no known treatments or vaccines it has the potential to result in major losses in deer populations** should it become established in Scotland ([BDS, 2016a](#); [BDS, 2016b](#); *Williams et al., 2002*).

These findings indicate that **a monitoring strategy represents an important aspect of protecting Scottish wild deer populations from high-risk diseases** (*Roberts, 2016*; *Böhm et al., 2007*). Notably, such a strategy may not require an active disease monitoring programme of wild deer populations; education and awareness raising of symptoms among deer managers also offers potential for aiding early identification of the occurrence of key diseases. In a study of red and sika deer *Böhm et al. (2006)* identified deer health as being linked to key endoparasites (*Sarcocystis* spp. and *Elaphostrongylus* spp.). Results from *Böhm et al. (2006)* suggest that a combination of key indicator parasite species and non-specific signs of disease may offer scope for monitoring the health of wild deer populations at a national scale. Long term, landscape-scale monitoring offers the potential for improving understanding of disease distribution and potential transmission risks for humans and livestock and represents a potentially important future aspect of deer management in Scotland.

The importance of **data collection and reporting on deer culls is identified in the literature in relation to the potential for more comprehensive and accurate cull records to provide traceability for disease monitoring, assist in sustainable deer management and to link cull records to stalker competence** ([Daniels, 2008a](#)). Currently, all systems of cull data recording are prone to under reporting and inaccurate or non-submission of cull returns. Cull data in Scotland is therefore currently inaccurate with a requirement for the development of a more unified and comprehensive system ([Daniels, 2008b](#)). As [Putman \(2008c\)](#) notes, current systems yield only partial data on numbers of animals culled, which in themselves are of limited utility unless cross referenced to a defined management objective. Notably, **the degree of regulation around cull recording and deer management is considerably higher in many European countries than in Scotland** ([Putman, 2008c](#)).

Additional welfare concerns in Scotland include the potential impacts of supplementary feeding on wild deer. Supplementary feeding is common in Europe and North America, with the aim of maintaining high deer densities and improving body condition and reducing damage to crops and habitats (diversionary feeding). In a study of supplementary feeding of deer on the open range Putman and Staines (2004) **determined that feeding has limited effects on body weight, breeding success and survival**. To be effective in reducing mortality feeding needs to occur early in the season (not just during challenging periods). Furthermore, the **evidence was inconclusive as to whether supplementary feeding is effective in negating environmental damage**. From a welfare perspective, deer may develop a reliance on the food supplement provided and lose condition due to the food not always being available. High concentrations of animals around feed stations may also increase the risk of infection and lead to the development of high parasite burdens.

Some studies have also been carried out on the effect of human disturbance on deer welfare. Jarkody *et al.* (2011) for example, identified nutritional benefits for deer of reducing disturbance near open grassland due to a requirement for greater vigilance in open ground habitats. Sibbald *et al.* (2011) in a study of deer movement responses to regular disturbance by high numbers of hill walkers demonstrated that even where deer are habituated to disturbance, they will alter their behaviour in their home range and potentially their diet composition in response to regular increased disturbance. **Disturbance represents an issue of potentially growing importance due to the rapidly increasing visitor numbers in key hill walking areas.**

A final area of wider welfare concern relates to the use of lead ammunition and lead poisoning, which has been recognised as a source of heavy metal contamination in terrestrial systems (Knott *et al.*, 2009). Lead in game meat also has the potential to impact on humans, with the Food Standards Agency advising that frequent consumption of lead shot game can expose consumers to potentially harmful levels of lead, with key groups (toddlers, children, pregnant women and women trying to conceive) identified as particularly vulnerable due to exposure potentially harming the development of the brain and nervous system ([FSA, 2012](#)). Research by the Swedish National Food Agency identified that lead fragments from bullets and shot were abundant in game carcasses and occurred in meat intended for consumption ([SNFA, 2014](#)). This research identified a clear relationship between number of shots fired by surveyed hunting families over the previous six months and blood lead levels, with 70% of males, 30% of the females and 40-50% of children that consumed game meat exhibiting blood lead levels above the reference points established by the European Food Standards Authority ([SNFA, 2014](#)).

Lead fragments in the thoracic region of culled deer are likely to be small enough to be ingested by scavengers and birds causing sub lethal and lethal effects (Knott *et al.*, 2010). Some of the potentially most vulnerable species represent high priority raptors such as the white-tailed sea eagle and golden eagle, which have been subject to costly reintroduction

and/or conservation management measures. The likelihood of poisoning is high, with limited studies of raptors and scavenging species suggesting that 2-9% of those that have died may have done so as a result of exposure to lead ammunition ([Lead Ammunition Group, 2015](#)). The extent to which these and other species of raptors are impacted by lead poisoning is currently largely unknown due to an insufficient number of studies having been conducted in the UK to evaluate poisoning levels and potential impacts on population levels ([Lead Ammunition Group, 2015](#)). As there is no known significant difference in accuracy and killing power between lead and copper bullets, wider use of copper ammunition represents an environmentally friendly alternative to lead ammunition.

Key points:

- Welfare is a complex concept and a direct link between the competence of deer managers and the welfare of deer at individual and population levels is apparent (to some extent) across a reasonably broad range of literature;
- It is apparent that data availability and clear codes of practice on cull techniques and cull recording represent important elements of the supporting framework for enhancing deer welfare;
- Comprehensive research on key disease risks for wild deer populations is limited. Expanding deer populations and deer ranges combined with other factors (e.g. climate change) suggest disease within wild deer populations (and transmission to humans and livestock) represents a concern of growing importance.

3.5.3 General observations on research gaps (Priority 5)

The training and wild deer welfare priority for wild deer management is relatively complex and incorporates a range of specific relevant elements. A considerable amount of the research and reports in this theme relate to identifying opportunities for enhancing stalker competence and developing a more comprehensive system of cull recording to provide a stronger basis for sustainable management, including welfare assessments.

Specific knowledge and research gaps identified from the literature include:

- Specific practical skills and knowledge gaps, including in relation to habitat impact assessment and skills development in engagement and collaborative management for deer managers.
- Some research exploring barriers to uptake of training and best practice is evident; however, this area is limited and improved understanding of uptake barriers may offer potential for improving knowledge transfer in relation to key areas of management.
- Cull data is not comprehensively gathered. This makes population modelling difficult.
- Disease (including exotic/new threats) in deer populations represents a growing threat linked to climate change impacts, with limited existing research available in relation to identifying key threats and potential specific mitigating measures.
- Reasonable evidence of overwinter mortality impacts on deer and the relationship between deer management and overwinter mortality exists; however, exchange and application of this knowledge across the sector remains limited.
- Additionally, existing research in supplementary feeding is inconclusive with respect to whether such approaches reduce environmental damage.
- The accuracy and usefulness of condition scoring/criteria for assessing animal health is poorly understood and could be investigated further through field trials, comparing estimated age/condition of culled animals from visual observation before the shot is taken, with age and condition of the same animal determined in the larder.

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4. REVIEW OF RESEARCH UPTAKE

4.1 Understanding How Knowledge and Evidence is used in Sustainable Deer Management - Online Survey

4.1.1 Rationale

In order to evaluate the use of research and evidence in deer management policy and practice, an online survey was designed and disseminated to deer researchers and stakeholders in deer management policy.

The survey was structured around the five high level priorities for sustainable deer management and their associated challenges for 2015-2020 as identified in the policy document *Scotland's Wild Deer: A National Approach (WDNA)*. The aim of the survey was to understand how evidence from research relevant to these priorities has been taken up and used in policy and practice, and the factors that have influenced this. Knowledge gaps which need to be addressed to more effectively deliver sustainable deer management in Scotland were also identified for each priority and were considered in the gap analysis in [Section 5](#).

4.1.2 Survey design and implementation

The survey was designed using the SurveyMonkey online software. The survey was organised in two parts. The first part was about the background of the respondents; their occupation, place of work and role regarding research and policy development. The second part dealt with the five priority areas for deer management. Respondents were asked to select the priority area they were most familiar with. For this priority, respondents were asked to assess in their personal view, the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice using Likert-scale responses. Respondents were then asked to give an example of relevant knowledge/evidence that in their view had been taken up in policy and/or practice and one example where uptake had been limited or non-existent. Finally, respondents were asked whether they were aware of key knowledge gaps relevant to the priority which should be addressed by further research. Responses to these three questions were open-ended in free text boxes so answers could be explained. After completing questions for one priority, respondents were asked whether they wished to repeat the questions for a second priority before finishing the survey. The survey questions are shown in [Appendix 7](#). An email invitation to complete the online survey was sent out to 115 stakeholders identified as having a role in research or policy relevant to deer management. This was based on the same stakeholder identification used for the project workshops.

4.1.3 Survey responses

Invitations were sent out on the 13th June 2016 with a follow up reminder on 22nd June 2016 and participants in the researcher/policy workshop were also reminded to take part. The survey remained open until mid-July.

By the 26th August 2016, 74 respondents had opened the survey; forty five completed surveys were returned and a further 29 were partially completed. Figure 4.1 shows respondent occupation (by percentage response).

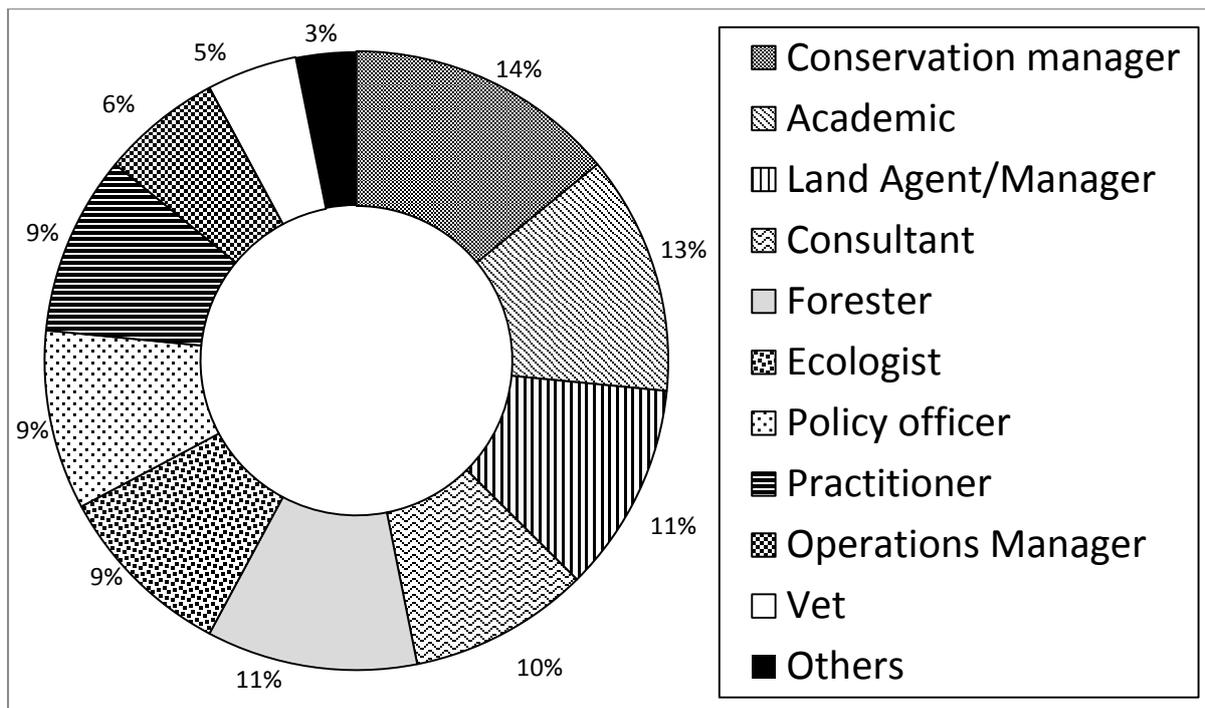


Figure 4.1 - Occupation of respondents (by percentage response)

4.1.4 Survey results

Respondents were found to be most familiar with Priority 1: Collaboration and effective deer management planning and implementation (37.5%) and Priority 2: Healthy Ecosystems (33.9%) (Figure 4.2). The majority of respondents only answered the questions for a single priority.

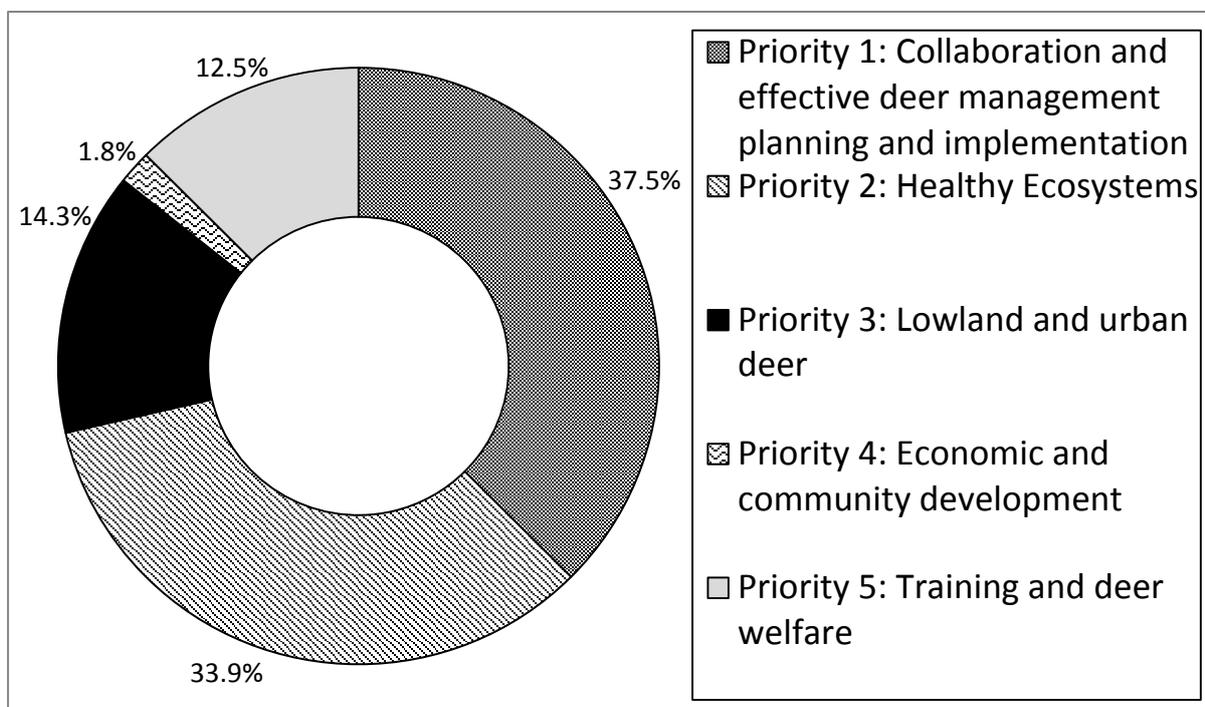


Figure 4.2 - WDNA priority area that respondents were most familiar with

A summary of the results is given for each of the five priorities.

Priority 1 - Collaboration and effective deer management planning and implementation (25 respondents)

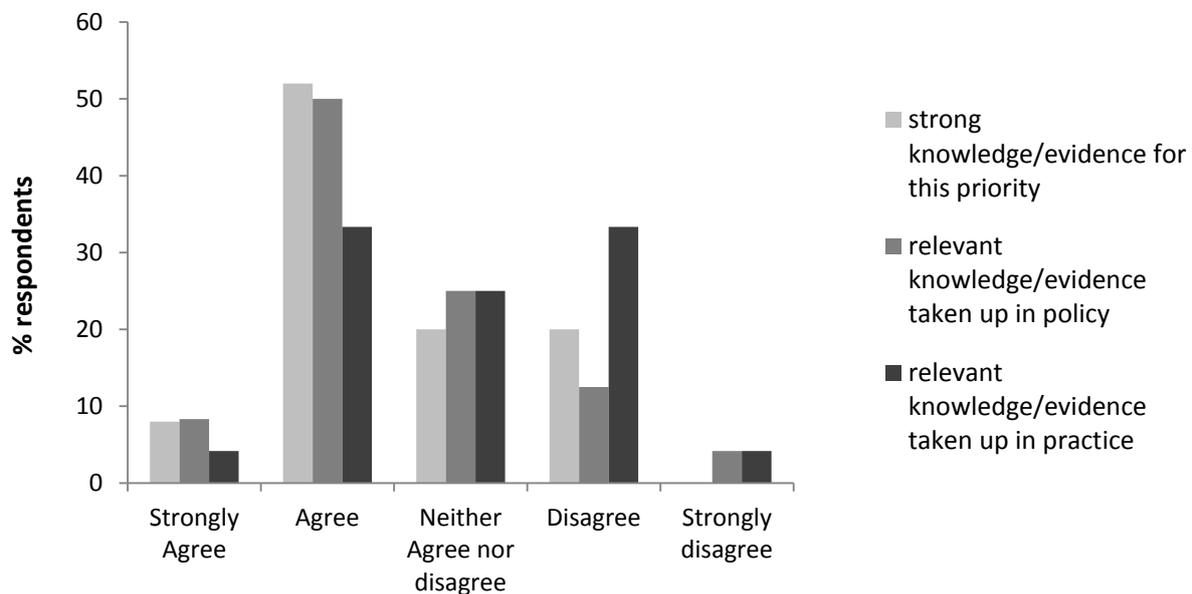


Figure 4.3 - The respondents views on the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice for Priority 1

There were divided views on whether there is a strong knowledge/evidence base to help meet this priority with 60 % of respondents strongly agreeing or agreeing and 20% disagreeing (Figure 4.3). A majority agreed that such knowledge/evidence has been taken up in policy while opinion was more divided on whether it had been taken up in practice (Figure 4.3). Some respondents explained that there has been an increased focus on deer management planning and emphasis on delivering public benefits driven by policy processes such as the 2014 RACCE Review. It was suggested that this has positively influenced the collaborative activities of deer management groups to some extent. It was suggested by one respondent that the control agreements from SNH were a helpful structure for collaboration. Another suggested that the current deer management planning process has had a high level of input from both practitioners and the research community. However, the point was also made that many of the individuals involved in DMGs don't currently possess the knowledge and skills needed for effective negotiation and conflict resolution. The onus is now upon them to do so but this should be supported. There is also a perception that managers in areas without proactive DMGs will not have access to a strong knowledge base and will therefore not take up relevant evidence. Respondents readily gave examples of the ways in which collaboration is hampered in practice e.g. conflicting objectives, lack of resources and lack of trust. Availability of specialist knowledge about public interest delivery was also mentioned as a barrier. The SNH best practice guidance was reported to have been taken up well due to the good communication between the range of organisations and individuals involved in its development. However, the cessation of training opportunities associated with the best practice guidance (e.g. regional training days) was considered regrettable. The Deer Stalking Certificate (DSC) Levels 1 and 2 training courses have also received good uptake due to an increased requirement for qualifications by employers. An evidence gap related to local deer movements was highlighted; a lack of confidence regarding how deer are using a particular area can make it difficult to define what collaborative activities should

take place. Some respondents emphasised that there was a rich body of evidence and many studies that advised appropriate management actions. However, there are doubts as to whether policy provides enough specific guidance on deer population management. Examples of conflict related to culling of deer to meet woodland regeneration targets and apparent detrimental effects on commercial stalking on neighbouring estates were mentioned. It was suggested that an unwillingness to seek compromise between competing interests was a greater barrier to effective management than a lack of information or knowledge. Social science research findings on the topic of collaboration may be viewed as rather abstract or 'woolly' and there is a need for quantitative data which is considered by some to be lacking at the appropriate spatial scale. Collecting such data is thought to be a disincentive for land managers with objectives that are not compatible with other managers or the public.

Priority 1	
Examples of uptake in policy and practice	Reason for uptake
Increased focus by DMGs to update and develop formal Deer Management Plans to improve future deer management and deliver the public interest	<ul style="list-style-type: none"> - Outcomes of the RACCE Review 2014 and strong focus on deer management by the Scottish Government - Engagement of professionals in preparation and update of DMPs
Wild deer Best Practice guidance	Guidance was formulated through excellent collaboration between relevant organisations and practitioners. It is focused, pragmatic and presented in a neutral way, and is appealing to practitioners
Good uptake of biological knowledge of deer populations and dynamics, and their impacts in a way that has informed management practice	
Dung counting for population assessments	Methods have become well-established and trusted, and are now required as part of grant schemes
Habitat impact assessments (HIA) are increasingly viewed as a standard management practice (although as yet far short of universal)	Partly due to policy drivers but also the practical value of HIA for informing management decisions
Implementation of deer management planning	Government pressure and threat of regulation (it remains to be seen whether plans will actually be implemented)
DSC 1 and 2 training courses are now required by many employers and FCS for shooting lets	Leadership by public agencies

Priority 1	
Examples of limited/non-existent uptake	Reason for limited uptake
Lack of high quality deer counts	Resource limitation
Challenge of ecological monitoring as part of managers' remit	Shifts in expectations and negotiated understanding take time
Larder sharing has not been taken up as a part of collaborative deer management on a significant scale by the industry	It is less convenient to implement joint hygiene regimes and market forces
Understanding the potential for immunocontraceptive vaccines	Not enough information is available regarding feasibility
Establishing goals for 1:1 sex ratios in deer herds to reduce overall deer pressure while maintaining stag populations	Traditional views of management remain entrenched
Understanding differential impacts of different herbivores	Lack of joined up thinking between parts of government
Lack of information sharing	Lack of trust impedes sharing of information
Collaborative deer management between land holdings with different land management objectives	Collaboration between neighbours is often difficult due to different competing pressures on time / manpower, differing management objectives, pursuit of private interests, lack of shared responsibility, lack of trust and confidence in the outcome
High deer numbers/densities in some areas from deer counts have not led to increased culls	Varying deer management objectives with some land managers requiring high densities of deer for stalking purposes

Priority 2 - Healthy Ecosystems (19 respondents)

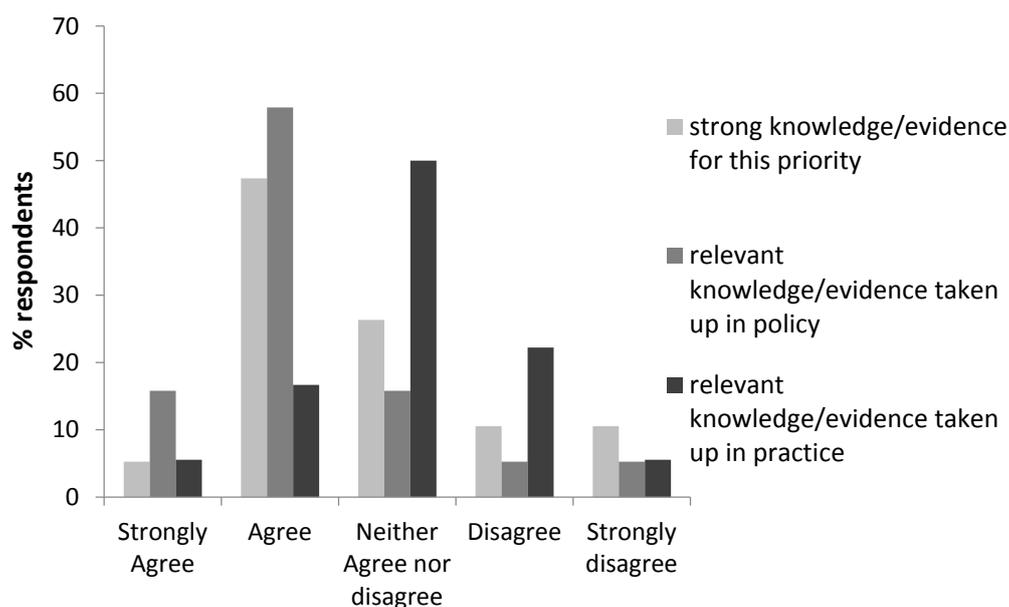


Figure 4.4 - The respondents views on the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice for Priority 2

Fifty-three percent of respondents agreed or strongly agreed that there is a strong knowledge/evidence base to help meet this priority while 21% disagreed or strongly disagreed so views were again quite divided on this question. A further 26% neither agreed nor disagreed. Many more people felt that relevant knowledge and evidence had been taken up in policy than in practice. A wide range of research that has informed policy and guidance was recognised by respondents when they were asked to give examples. A large body of evidence in relation to damaging deer impacts was highlighted. Awareness and uptake of this in policy is thought to have been increased by the long-term lobbying of environmental groups. The growing focus on carbon sequestration and habitat connectivity was considered a driver for better woodland planning in upland areas. Where information uptake was limited, this was partly attributed to low motivation among managers for conducting habitat monitoring, particularly outside designated sites. A focus on 'traditional' approaches and economic priorities was thought to detract from efforts towards habitat improvement. There is an apparent lack of training for some involved in deer management e.g. farmers and crofters, which also hinders effective habitat monitoring. There may be some issues translating policy guidance into habitat improvement. While 'favourable condition' status for designated sites is commonly used in policy guidance, the relevance of this concept is less well recognised in practice. Disagreement about the methods and results associated with habitat assessments was highlighted as a reason for landowners failing to follow subsequent management recommendations. The challenge of translating broad-scale predications into local management actions was also highlighted. The complexities of analysing deer distribution and impacts were raised. The concerns over the lack of integration of agricultural statistics with deer count and habitat data were also considered problems in terms of understanding herbivore interactions.

Priority 2	
Examples of uptake in policy and practice	Reason for uptake
Site condition monitoring	- Legal requirement on designated sites - Existence of well-established monitoring systems
Widespread understanding of acceptable deer densities in different habitats	Extensive research
SNH control agreements to reduce deer densities	Viewed by some practitioners as helpful and structured approach for collaboration
Habitat Impact Assessment option available through AECS	
More integrated and planned approach to woodland planting in uplands	Objectives for carbon sequestration and habitat connectivity
Woodland expansion, leading to biodiversity benefits	Financial incentives and/or carbon offsetting opportunities for business
Deer management plans that address sustainable management	Scottish government policy and lobbying by environmental groups
Increase in woodland for deer shelter	Increased acceptance that shelter is beneficial for red deer

Priority 2	
Examples of limited/non-existent uptake	Reason for limited uptake
'Deer Map' produced by James Hutton Institute to predict deer densities at a landscape scale	The model is unsupported and has not been further developed
Red deer larder data collection project (SNH, FR, JHI, estates)	Data not collected past pilot stage. Project not continued
Holistic view of ecosystem function	Traditional view of management and focus on local objectives
Deer management to restore peat	Insufficient knowledge of herbivore impacts on peat
Sika introgression with red deer	Inertia in SNH about issue/sika shooting can have economic benefits for estates
Achieving deer densities compatible with forestry regeneration	Conflicting objectives
The Environmental Co-operation Action Fund	50% funding whilst the other 7 options were 100%
Farmers and crofters working in partnership	Lack of training to deal with high deer numbers
Habitat monitoring outside designated areas	Lack of motivation/interest; if data is submitted to SNH, there is no feedback
The Rum red deer research showed that having high densities of hinds on the open hill reduced the yield of stags for stalking	Most open hill estates are run on 'traditional' grounds and little regard is taken of research

Priority 3 - Lowland and urban deer (16 respondents)

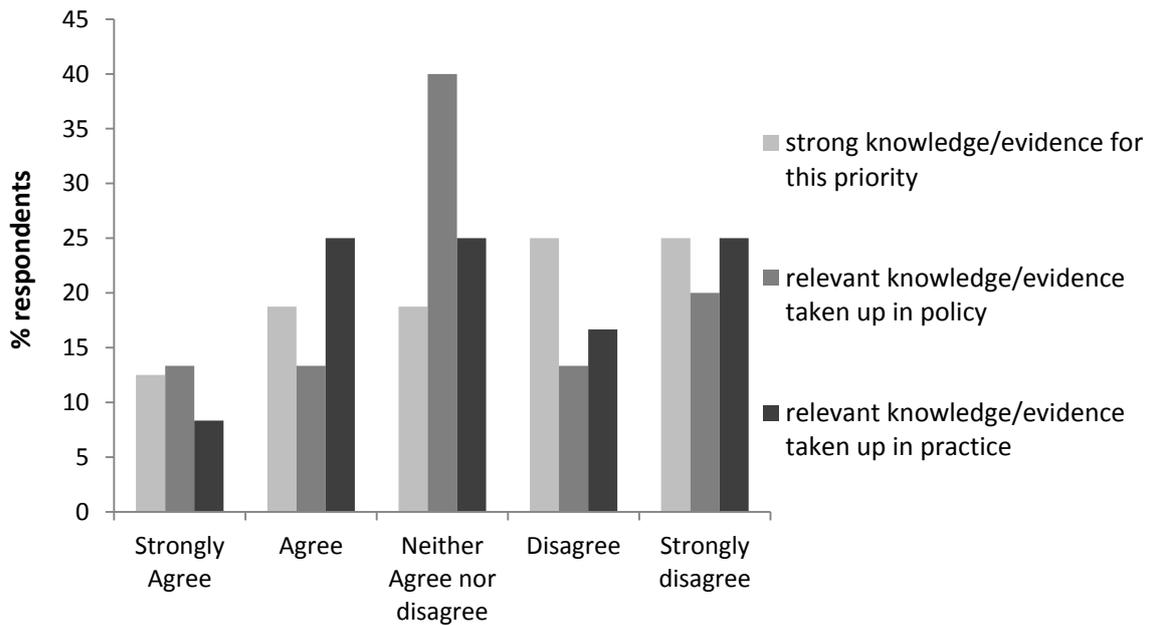


Figure 4.5 - The respondents views on the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice for Priority 3

Fifty percent of respondents either disagreed or strongly disagreed that there is a strong knowledge/evidence base to help us meet the challenges of managing lowland and urban deer while 31% agreed. This suggests that respondents were aware of less information than for priorities 1 and 2. There were also lower numbers of respondents who believe that relevant knowledge/evidence has been taken up in policy or practice than for the other priorities. However, one respondent referred to surveys of deer populations that have been done in areas where problems have been identified, as a result of improved collaboration between SNH, Transport Scotland and the Lowland Deer Network. Other respondents felt that there was in fact a good body of knowledge about the impacts of deer on lowland woodlands and forestry and that, in general, knowledge of lowland deer issues have steadily improved in recent years; partly due to the activities of the Lowland Deer Network. Another respondent suggested that the knowledge is available but is not in the hands of those who are able to take a pro-active approach to deer management in lowland/urban areas. Negative assessments of designated sites have been a driver for improved collaboration in relation to deer management in lowland areas as they have in the uplands. However, achieving effective collaboration remains a barrier according to respondents and approaches lag far behind those of upland DMGs. One respondent highlighted the lack of formal council policies on deer management meaning that deer management tends to be conducted on a case by case basis. It was suggested that local authorities need to invest in improved mitigation of deer-vehicle collisions, beyond the use of warning signs, and are not engaged with relevant ongoing research.

Priority 3	
Examples of uptake in policy and practice	Reason for uptake
Use of thermal imaging to better assess lowland deer populations	Effectiveness of approach
Surveys of deer populations in areas where potential problems identified	Improved collaboration between stakeholders e.g. SNH, Transport Scotland through participation in LDNS
Collaborative deer management in lowland woodland	Response to negative assessments of SSSIs
Use of habitat condition monitoring for targeted deer control (Native woodland Survey of Scotland and Site Condition Monitoring)	Use of monitoring to deliver targeted control encouraged by FCS

Priority 3	
Examples of limited/non-existent uptake	Reason for limited uptake
Development of formal council policy on deer management	Work is required to improve public awareness and understanding of wild deer before formal statements on deer management can be made
Perceived increase in numbers of roe deer (especially in urban areas) is not accepted by private land owners	Insufficient information on numbers; unwillingness of land owners to accept partial responsibility for increasing numbers

Priority 4 - Economic and Community Development (12 respondents)

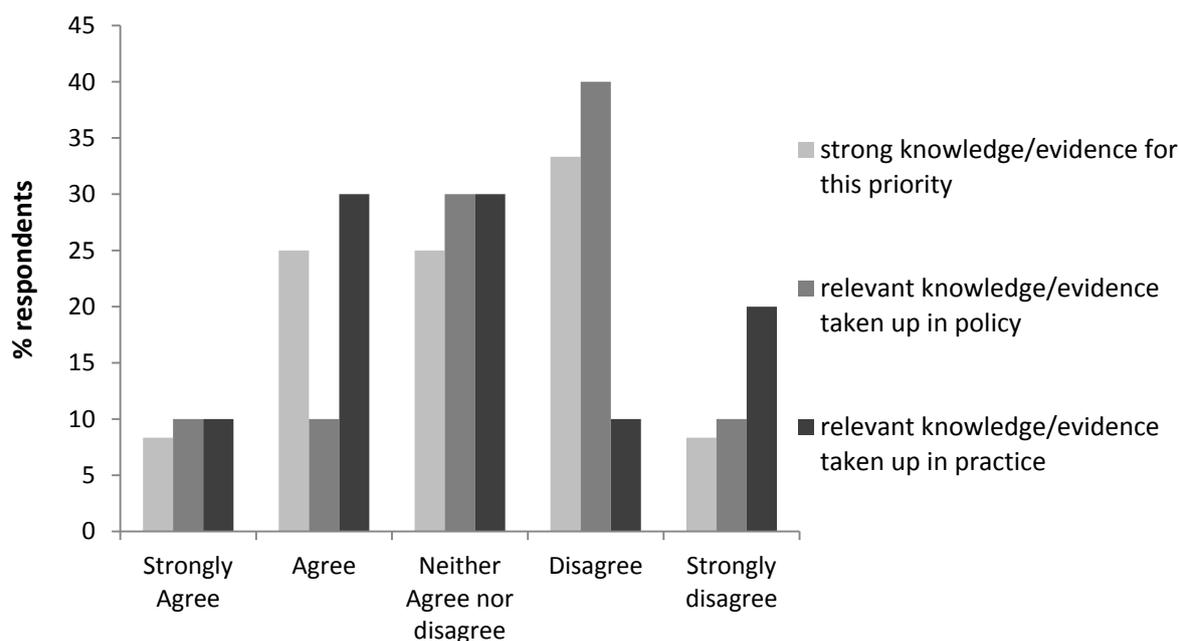


Figure 4.6 - The respondents views on the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice for Priority 4

Forty-two percent of respondents disagreed that there is a strong knowledge/evidence base to help meet this priority compared to 33% who agreed. One respondent commented that while economic and community development appears nominally in policy (as a result of sporting sector economic assessments such as PACEC, 2014), it receives insufficient weight in relation to other priorities. One respondent commented that these themes tend to be talked about in general terms and there is little specific evidence available to inform management decisions. A lack of knowledge about the socio-economics of deer management was highlighted and questions raised about the impact of lower deer densities on employment levels and the value of deer stalking relative to other rural businesses. There is also a lack of analysis of the costs and benefits of the different economic opportunities associated with deer e.g. tourism and venison production, in addition to traditional stalking. The lack of a 'culture' of deer management among farmers and crofters was raised as a barrier to information uptake on economic and community development. Incentivising estate stalkers to increase the hind cull by involving them more directly in the financial benefits from hind stalking, was suggested by another respondent as a means of encouraging more engagement with economic priorities. The same respondent suggested that existing legislation is a barrier to the uptake of new sustainable approaches such as tradeable cull quotas.

Priority 4	
Examples of uptake in policy and practice	Reason for uptake
Economic and community dimensions included in Land Use Strategy and WDNA	Emphasis of importance by deer management organisations and economic assessments they have initiated e.g. PACEC, 2014
Examples of estate diversification from agriculture and sporting practices to include native woodlands, forestry and renewable energy	

Priority 4	
Examples of limited/non-existent uptake	Reason for limited uptake
Recommendations for economic incentives for deer management e.g. research on economic incentives for stalkers to increase hind cull and tradeable cull quotas (MacMillan, 2004; MacMillan and Phillip, 2010)	There is obviously considerable resistance to innovation and change in this sector. Also there are insufficient opportunities of fora for deer management related research to reach stakeholders and policy makers

Priority 5 - Training and Deer Welfare (16 respondents)

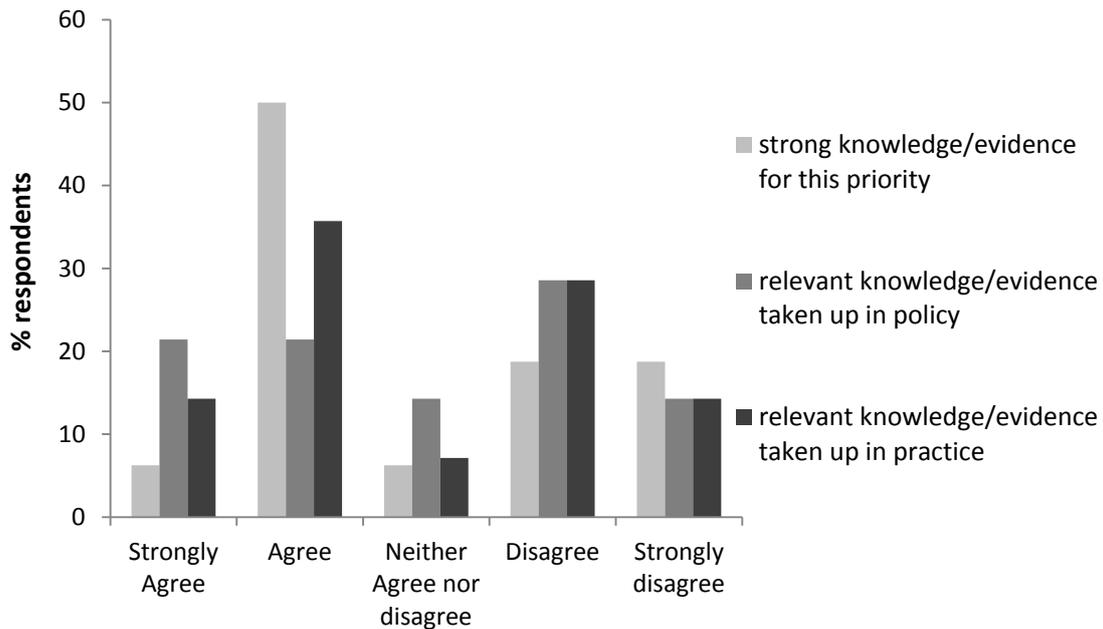


Figure 4.7 - The respondents views on the strength of the knowledge/evidence base and the extent to which such knowledge/evidence has been taken up in policy and practice for Priority 5

Fifty-six percent of respondents agreed that there is a strong knowledge/evidence base to help meet this priority while 38% either disagreed or strongly disagreed so views were quite mixed. There was also a range of views as to the extent to which knowledge/evidence has been taken up in policy and practice with no big differences between the two. Respondents were aware of deer welfare issues and research on definitions and assessments of welfare. The importance of deer welfare in relation to shooting practice among the stalking community was emphasised. One respondent felt that the uptake of Deer Stalking Certificate Levels 1 and 2, which are now widely expected to be held by those involved in deer management, have improved practitioner knowledge of deer welfare. However, there are still many individuals and groups who don't take up DSC training e.g. long-term employees in the deer sector who value traditional approaches and farmers/crofters. Concern was expressed that consideration of deer welfare is restricted to wounding during shooting and orphaning of juveniles; there is little information for the wider assessment of the welfare of individuals or populations. In terms of wider training, there was a suggestion from one respondent that the perceived extra burden for stalkers of delivering more complex or detailed cull targets is a barrier to achieving more sustainable deer populations. While the information is available for managers to achieve more sustainable management, there may be a lack of motivation/incentive to engage with it.

Priority 5	
Examples of uptake in policy and practice	Reason for uptake
Hunters strive not to orphan juveniles - i.e. they shoot calf and hind at the same time	Knowledge that orphans are going to suffer without their mothers
SNH commissioning of research related to definition of welfare at individual and population level	
Uptake of DSC levels 1 and 2	Personal benefits that can come from training are evident and qualifications are often required by employers

Priority 5	
Examples of limited/non-existent uptake	Reason for limited uptake
There are segments of the deer management community who do not undertake training or hold qualifications	Some adhere to traditional management approaches and do not perceive training as necessary or valuable. Those in long-term secure employment on estates or who manage deer less frequently in relation to primary activities (e.g. farmers and crofters) may be less likely to engage with training

4.1.5 Discussion

The survey results illustrate some of the factors perceived to be facilitating and obstructing knowledge uptake across the different WDNA priorities. There is some overlap as many of the challenges within the priorities are inter-linked. The priority areas contain a broad range of topics so the range of views associated with how well they are supported by a strong evidence base and the extent to which information has been taken up in policy and practice varies depending on respondents' interests and experience.

A lack of trust was mentioned repeatedly as a barrier to the uptake of knowledge and evidence in practice. If the information or evidence is not perceived to have come from a process which sufficiently recognises practitioner perspectives, uptake may be limited. This is related to a resistance to change and preference for traditional approaches among part of the practitioner community, where a focus on meeting economic objectives with limited resources is a priority, and pursuing other objectives is not seen as viable or worthwhile. A lack of trust can undermine confidence in both research and policy processes.

Policy drivers have acted as an incentive for collaborative initiatives that draw on knowledge and evidence. A combination of public agency initiatives, stakeholder engagement processes and training opportunities have encouraged collaboration. The availability of established methods and best practice guidance was viewed as an important mode of transferring knowledge and evidence among the stakeholder community. Where there has been disagreement or uncertainty about the relevance and use of some methods e.g. habitat impact assessments, establishing updated and trusted training initiatives which acknowledge and address the concerns of managers, may improve comprehension, acceptance and uptake. A lack of feedback on the results and application of monitoring data back to practitioners was also highlighted as a barrier to the uptake of monitoring processes; hence improved two-way communication between managers and public agencies may improve trust. Members of deer management groups have also responded to recent pressure exerted by the RACCE review process, by collaboratively producing deer management plans; sometimes engaging with external experts and public agencies in doing so. Legislation for protected areas and the existence of control agreements have acted as long term pressures on managers to invest in collaborative planning for sustainable deer management. Including a requirement for certain activities such as population assessment in government grant schemes also encourages compliance. Thus both legislation and positive government initiatives play a role in shaping the use of information and evidence by managers. Long term lobbying by environmental and sporting NGOs is thought to have had a considerable influence on awareness and uptake of research evidence e.g. impacts of deer on conservation interests and the importance of sporting for the rural economy. Such organisations tend to have a strong voice and are effective at raising awareness of specific issues. A barrier relating specifically to the uptake of research evidence was the perceived lack of long-term support for research projects. With finite funding, data collection and the application and testing of research findings and new tools e.g. mapping approaches, tends to be limited despite the interest and time invested by stakeholders. Ensuring ongoing support for promising tools and the development of widely useful long term data sets would help ensure greater value from research initiatives.

The barriers that exist to the uptake of knowledge and research evidence according to the survey respondents reflect some of the broader barriers to sustainable deer management reported by practitioners in the workshop entry questionnaires (see [Section 2](#)). For example a lack of information sharing and lack of trust was considered a considerable barrier to sustainable deer management, including a lack of consistency in available policy and practice guidance. The operational constraints caused by a lack of resources were also a significant factor.

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5. GAP ANALYSIS

5.1 Introduction

This section sets out to identify gaps in the knowledge with regard to the specific research and knowledge transfer needs associated with meeting the priorities and challenges for 2015-2020 as set out in the WDNA. During the life of this project, a series of participatory activities were carried out, on which this analysis is based. The objectives of this gap analysis were to: a) distinguish between gaps in knowledge (i.e. gaps that require further research) and gaps in the way knowledge and information is communicated between stakeholders, therefore representing barriers to achieving the WDNA challenges; b) evaluate the significance of the research and knowledge transfer gaps for stakeholders; c) compare research and knowledge gaps identified from stakeholder participatory processes to gaps identified in the literature review; and d) provide recommendations for further research and activities that will address gaps and contribute to meeting the challenges under the five WDNA priorities.

5.2 Gap Analysis Methodology

The knowledge and evidence gaps identified in the stakeholders' workshops, the research and KE gaps identified in the researchers'/policy makers' workshop ([Section 2.5](#)), and the gaps mentioned in the online survey ([Section 4.1.4](#)), were considered together, to identify a ranked list of common gaps between all the participatory exercises (Figure 5.1).

We considered the following procedure to identify and rank the gap themes in each WDNA, using the workshop results tables ([Section 2.5](#), Tables 2.3 to 2.7). First, any gap theme mentioned in the researchers'/policy makers' workshop was retained. These retained gap themes were then ordered by: a) the number of stakeholders' workshops in which they were mentioned (✓); and b) the number of times they had been mentioned in the policy/research workshop (✓).

This gave us a list of gap themes, by order of importance (highest numbers of (✓) in columns "stakeholders' workshops" and "researchers'/policy makers' workshop"), as shown in the Tables 5.1 to 5.5 below, for each WDNA priority.

If these gap themes were also mentioned in the online survey or were found to be a gap identified in the literature review ([Section 3](#)), they were also ticked.

We then discussed the gaps to emerge under each WDNA theme in the light of the findings from the literature review ([Section 3](#)). We explored to what extent the gaps reported through our participatory approaches aligned with those from the literature ("Research" and "KT gaps" columns in the following tables). It is likely that many of the widely reported research and knowledge transfer gaps do represent either a lack in the transfer or effective application of relevant knowledge, or a real gap in the evidence base. However in some cases, we may find good evidence or examples in scientific articles and reports that would suggest the gap is more one of perception than reality.

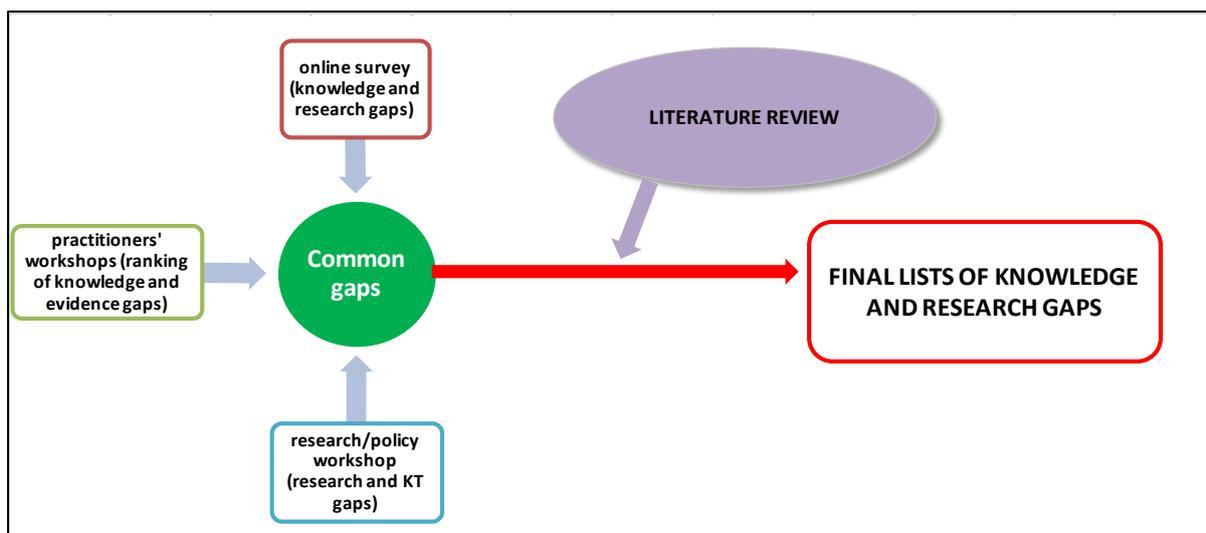


Figure 5.1 – Methodology

5.3 Research and Knowledge Transfer Gaps

The findings of this approach are presented in the following pages, for each WDNA priority. The gaps presented are summarised to represent broad themes, which were expressed across stakeholder activities. The gap analysis results are summarised in a table for each WDNA priority. The results for each table are discussed on the following page.

Table 5.1 - WDNA 1: Collaboration & Effective Deer Management Planning & Implementation

Gap themes	Stakeholders' workshops	Research/policy workshop	Online survey	Literature review gap	Research gaps	KT gaps
Understanding differing objectives and pressures/drivers)	✓✓✓✓	✓✓	✓	✓		- Need to facilitate understanding of different perspectives and sharing of knowledge.
Understanding deer movement and migration at landscape scale	✓✓✓	✓✓	✓		- Need further research on factors affecting deer movements and migration - Better evidence to understand the dynamics of deer movements to predict the impacts of management activities on deer distribution and density - Improved understanding of habitat utilisation patterns.	- Local information on trends and patterns observed in deer populations is not widely available or adequately communicated
Mediation and facilitation for conflict management	✓✓✓	✓✓	✓	✓	- Trust building processes and understanding the drivers of conflicts	- Need to translate and communicate existing theory and research to facilitate development of conflict management tools or frameworks for use in practical conflict management scenarios
Future remit and governance of DMGs	✓✓✓	✓	✓			- Need to tackle DMG resourcing (costs of DMPs/developing long term approach) - Need to consider area specific context and the role and inclusion of wider stakeholders. - Need for developing stronger DMG evidence bases through data gathering and sharing to facilitate adaptive management approaches. - Need for wider understanding of long-term trends in deer populations to inform current management
Insufficient deer counts or overemphasis on counts and misleading data	✓✓✓	✓	✓		- Need for the development of improved deer count techniques, including remote sensing methods	
Understanding of public perceptions of deer management and of public and community engagement	✓✓✓	✓✓		✓		- Need for engagement and transfer of knowledge to the wider public (including communication of knowledge and information between deer managers and land owners/decision makers) - Limited understanding of the stakeholders' values and motivations underlying deer management conflicts - Lack of community interest and engagement in deer management (particular issue in lowland/peri-urban areas)
Improved population models for better understanding of density-dependence and population dynamics.	✓	✓✓		✓		- Need effective translation and uptake of existing research on deer population dynamics and density dependence (e.g. need for clear guidance and the use of straightforward population dynamics models to facilitate cull target setting within Deer Management Plans) - Need to apply existing models (e.g. SWARD) and DSS.

One of the most important themes discussed in relation to collaborative deer management was that of addressing differing management objectives between stakeholders. This was viewed as a **knowledge transfer gap**, in terms of a lack of knowledge and information sharing between different land managers, agencies and other stakeholders which can lead to mistrust and conflict. The literature review ([Section 3.1](#)) highlights the predominance of a **negative discourse** surrounding deer management issues, rather than one that promotes discussion of deer as a positive natural resource that could provide wider benefits under effective collaborative management. Both our participatory work and evidence from the literature suggest that **shared knowledge and objectives will lead to more effective collaboration**. Similarly the literature finds that stakeholders are often not incentivised to take part in collaborative management when costs are considered against potential benefits. Mistrust appears to be one of the drivers behind gaps in practitioners' knowledge about deer numbers. Some studies have shown that DMG group members can be reluctant to openly share such data with one another. This reluctance also applies to the sharing of habitat impact data with agencies. There are concerns over how the data will be used to support management interventions. There is a clear indication from our stakeholder processes and the literature review that the ways in which data is communicated between agencies and practitioners and vice versa should be improved. A **KT gap** highlighted in the research policy workshop was that of the **limited understanding of the values and motivations underlying deer management conflicts**. There has been research on the different 'cultures' involved with deer management and a recommendation that collaborative processes are structured in a way that allows different perspectives to be understood in more depth.

Another gap emphasised the issue of including different stakeholder groups in discussions about deer management including community groups and the general public. The literature does reflect the importance of understanding different perspectives and contains some substantial discussion on this topic. For instance there are a range of examples of community engagement in deer management, in countries, such as the USA and Norway. The **KT gaps** highlighted in the researchers'/policy makers' workshop reflect the **need to improve current collaborative mechanisms by investing more time and resources in knowledge sharing and community engagement**. Some of the community challenges are specific to lowland and peri-urban/urban settings and are discussed further under the table for WDNA 3.

The gap related to **understanding the dynamics of deer movements and habitat utilisation** was considered to be both a **knowledge transfer** issue and a gap in terms of **research** evidence. It was indicated in the researchers'/policy makers' workshop that further evidence is required to allow managers to better predict how management activities at different scales would influence deer movements between areas. This was partly linked to a reported lack of use and communication of valuable local information on trends and patterns in deer patterns, which used in conjunction with existing research evidence (e.g. from long term population studies on the Isle of Rum) might allow these questions to be better addressed at the local/regional level. A need to improve the understanding of habitat utilisation patterns was discussed during the researchers'/policy makers' workshop. The literature review indicated that attempts to combine scientific and local ecological knowledge have been successful and that using existing spatial and decision support tools could be carried out more widely, thus addressing some of the gaps raised by stakeholders.

Table 5.2 - WDNA 2: Healthy Ecosystems

Gap themes	Stakeholders' workshops	Research/policy workshop	Online survey	Literature review gap	Research gaps	KT gaps
Understanding the relative impact of wild deer on different types of habitat, such as peatland, and on ecosystem services	✓✓✓✓	✓✓✓✓	✓	✓	<ul style="list-style-type: none"> - The impact of deer (and other herbivores) on peatland habitats and dynamics - Understanding the influence of deer management on ecosystem services, including carbon sequestration and greenhouse gas emissions - Need for further data on habitat impacts outside of designated sites 	- Increased need for information on ecosystem services to be communicated to land managers and a requirement for effective markets to be developed for trading carbon credits.
Population trends, impacts and data collection over larger spatial and temporal scales	✓✓✓✓	✓✓	✓	✓	<ul style="list-style-type: none"> - High quality dataset should be used for improved predictive modelling of long-term habitat impacts by deer. 	- Need for the use of specific techniques such as remote sensing to identify habitat change over time. This is necessary for providing Deer Management Groups (DMGs) with an evidence base so that they can develop adaptive management plans.
Impacts of other herbivores on ecosystems/habitats and herbivore interactions	✓✓✓✓	✓	✓	✓	<ul style="list-style-type: none"> - Evidence and data on the impacts of other herbivores (sheep, hare, goats etc.) - Improve methodologies to differentiate between the grazing impacts of different herbivores 	
Need for reliable evidence on habitat impacts for different habitats, and adaptable, robust Herbivore Impact Assessment (HIA) methodologies	✓✓✓	✓✓✓	✓			<ul style="list-style-type: none"> - Issues of uptake of HIA methodologies, in terms of skills training and practice. - Need to facilitate understanding and trust in the HIA process and the end use of HIA data. - Need for greater integration of impact assessment data with the Deer Management Plan (DMP) process and cull target setting assessments.
Developing agreed definitions of degraded habitat and good ecological conditions	✓✓	✓✓				<ul style="list-style-type: none"> - Need for developing clear definitions (more effective interpretation of relevant research on ecological condition for different habitat types)
Impacts of climate change on deer management	✓✓	✓	✓	✓	<ul style="list-style-type: none"> - Impacts of flooding and access, habitat condition, changing of the timing of the rut 	
Non-native deer species	✓	✓✓		✓	<ul style="list-style-type: none"> - Potential spread, population dynamics, long-term impacts, interactions with native deer species and other herbivores, potential value 	
Understanding the link between deer densities and deer impacts	✓	✓	✓	✓	<ul style="list-style-type: none"> - Research should focus on specific case study sites to conduct long term monitoring of deer and habitat impacts 	

The main research gaps that emerged from the practitioners' and researchers'/policy makers' workshops centred on a better understanding of the **impacts of deer and other herbivores on different habitats and species**, and how **herbivore interactions** influence these impacts. The literature review indicated that although research exists in this area further work was required to improve our understanding and to help achieve appropriate levels of grazing that reduce the negative impacts of deer and other herbivores across different habitats and ecosystems. Collecting data over **larger spatial and temporal scales** is required if we are to improve the predictive modelling of long-term impacts of deer and other herbivores. More data gathering and research on **population trends** and the **link between deer densities and deer impacts** would help land managers with their deer management decision making. The literature review has shown how important the long-term research into the ecology of red deer on the Isle of Rum has been for supporting deer management. The continued use of this site and the establishment of other specific case study sites across Scotland to conduct long term monitoring of wild deer and their impacts was seen as important.

Differentiating between the grazing and trampling impacts of different herbivores is difficult and there is a need for improved, effective and practical methodologies that enable these differences to be detected and monitored.

There is a lack of information on the impacts of deer and other herbivores on **peatlands** (i.e. impacts on other species, peatland dynamics, hydrology, carbon storage and greenhouse gas emissions). Understanding the influence of deer and deer management on the whole range of **ecosystem services** provided by upland and lowland habitats, including **carbon sequestration** and **greenhouse gas emissions**, is seen as an important research gap. A KT gap which needs addressing that is linked to this is the need for more information to be communicated to land managers on **the role deer play in the provision of ecosystem services** and the requirement for effective markets to be developed for trading carbon credits.

Although habitat impact data is routinely collected for designated sites using the HIA methodology, there is a **lack of data on the impacts of deer** and other herbivores on upland and lowland semi-natural habitats **outside designated sites**. There do however appear to be some continued **issues over the uptake of HIA methodologies** by land managers that need addressing through **skills training**. In addition there is a need to facilitate understanding and trust in the HIA process and the use of HIA data particularly within the deer management planning process and the setting of cull targets.

An important research gap identified was the need for more information on the potential **impacts of climate change on deer**, including impacts on the life history, productivity, population dynamics and health of deer, as well as impacts on their habitats and on deer management (e.g. flooding and access issues).

More research on **non-native deer species** was seen as a major gap, particularly in respect to their ecological impacts, population dynamics, potential spread and interactions with native deer species, as well as their potential economic value.

Table 5.3 - WDNA 3: Lowland and Urban Deer

Gap themes	Stakeholders' workshops	Research/policy workshop	Online survey	Literature review gap	Research gaps	KT gaps
Improved understanding of functioning of existing management models and collaborative deer management mechanisms	✓✓	✓✓✓	✓	✓	- Constraints and opportunities for cooperative actions	- Improved collaborative mechanisms that encourage leadership and training in deer management - Understanding of barriers to local authority involvement and sharing of knowledge between local authorities
Understanding population dynamics and distribution of roe deer and non-native species	✓✓	✓✓✓✓	✓	✓	- Understanding relationship between population dynamics and habitat impacts in lowland and peri-urban areas - Impact on culling on lowland, peri-urban and urban populations	- Population assessments of roe deer in low land, peri-urban and urban areas need to be better communicated - There is a need for improved deer management planning in urban and lowland woodlands
Best practice management models for lowland, roe and urban deer management contexts	✓✓	✓	✓	✓		- There is considerable information and best practice knowledge available on the management of urban and peri-urban populations which could be better utilised; particularly international examples e.g. USA, Norway
Understanding/managing disease transmission between deer and livestock e.g. Lyme disease transmission	✓	✓	✓		- Determining the importance of disease transmission (from deer to livestock).	
Understanding habitat impacts: spatial variability in impacts, carrying capacity of lowland habitats and habitat impact assessments	✓✓	✓✓		✓	- Understanding spatial variability of habitat impacts - Understanding carrying capacity of lowland habitats	Understanding and adoption of habitat impact assessment
Understanding public perceptions and education about deer management in lowland and urban contexts	✓✓	✓✓				- Initiatives needed to raise awareness of deer and deer management
Lack of awareness of local deer management resources	✓	✓✓✓				- Need to develop a database of land managers and skilled deer stalker contacts within local authorities to increase awareness of utilising the deer management resource effectively. - Need to release the potential of the volunteer deer management resource in lowland areas through coordination, facilitating new stalking entrants and potential use of 'citizen science'.

The management of lowland, peri-urban and urban deer populations present particular management challenges due to the difference in configuration of habitat types, the proximity of high numbers of people and the variability of management structures currently in place. The gaps discussed in the stakeholders' workshops were more focussed around knowledge transfer than the identification of gaps in the research evidence base. The main **knowledge transfer gaps** that impede sustainable management are similar to those that exist in the uplands, for example the need for improved collaboration and information sharing. The stakeholders' landscape in lowland and urban areas is more complex than in the uplands and an important challenge appears to be **developing stable and effective collaborative structures with increased engagement** where management issues can be discussed. There is often a lack of trust and a low level of engagement. In particular, a lack of involvement and leadership by local authorities was highlighted. Both the literature and stakeholder processes discussed the lack of incentives for deer management in a lowland/urban context. A consideration of how management activities could be incentivised in the lowland and urban contexts may accelerate the development of effective lowland deer management groups. In terms of wider best practice management knowledge, it was found from both the stakeholder processes and the literature, that there is a considerable amount of best practice guidance information available, particularly from other countries such as the USA and Norway that could be better utilised. There is also still much scope for learning from collaborative management carried out in the uplands.

As in the uplands, an apparent lack of understanding of how the public perceive deer in urban and peri-urban settings was reported. This topic has actually been addressed in some detail by the research study of roe deer in peri-urban Scotland (Dandy, 2009). Deer were found to be a highly valued part of the local environment for many people but the ecological and economic aspects of deer management were less understood. This reported **knowledge gap** may indicate a **need for better local public engagement initiatives** such as the 'deer on your doorstep' events mentioned as examples in the researchers'/policy makers' workshop.

Table 5.3 highlights a research gap on **deer population dynamics in lowland/urban settings and how management activities influence levels of habitat impact**. A further gap was identified in relation to the spatial distribution of habitat impacts. Again, this reflects themes also important in the uplands. Related **knowledge transfer gaps** include a **lack of knowledge of local deer populations** based on **population assessments** that may be used to predict habitat impacts. There are fewer studies about the impacts of deer on lowland habitats. Impacts appear to depend on habitat configuration and can be localised and patchy. Stakeholders discussed questions about densities, behavioural ecology and recruitment of roe deer populations. There is less information available on roe deer populations than for red deer but information is available from other parts of Britain and Europe. As highlighted in the literature review section on collaborative management, **initiatives that bring together scientific information and local knowledge** can be effective for local management planning when underpinned with spatial decision support tools. Developing similar approaches with lowland deer management groups is likely to inform management approaches.

Table 5.4 - WDNA 4: Economic and Community Development:

Gap themes	Stakeholders' workshops	Research/ policy workshop	Online survey	Literature review gaps	Research gaps	KT gaps
Understanding the public perception and awareness, as well as the mechanisms for public engagement and education	✓✓✓✓	✓✓✓✓		✓		- More interventions are required (e.g. citizen science, educational initiatives, targeted projects, public events communicating the role and history of deer and deer management) - Better links between the deer management and local community councils are needed.
Socio-economic impacts and economic value of deer management	✓✓✓	✓✓	✓	✓	- There is a need to understanding the role of deer management in local economies and community development at different spatial scales (including at site level) - The full economic and social benefits, including the downstream effect (multiplier), of deer management need to be investigated	
Economic analysis of venison supply chain development as well as processing and marketing capacity	✓✓✓	✓✓	✓	✓	- The supply and demand for venison (addressing cost and seasonality) and the monetary flows relating to venison (especially in lowland areas) must be analysed - More marketing research, investigating the barriers to opportunities for venison from upland and lowland deer, must be done, to provide incentives to estates owners and make the supply chain for venison more effective	- There is a need for more communication and cooperation to improve local supply chains
Supporting and exploring market diversification	✓✓	✓✓✓	✓	✓	- More research need to be done on market diversification for alternative income related to deer management (such as wildlife and deer watching, hind stalking, alternative hunting)	
Cost benefit analysis of alternative models of management and their true economic cost	✓✓	✓✓	✓	✓	- There is a need for up-to-date cost benefit analyses for alternative deer management models (private sporting, community stalking, conservation management by NGO etc.) - There is a need to assess and valuing the public benefits delivered by private land owners/managers	
Better clarity in policy mechanisms and guidance	✓✓	✓			- This is policy rather than research gap: there is a need for improved clarity of the 'vision' for deer management at the policy and national level in Scotland (including suitability of designation and subsidy systems)	

One of the most important gap themes that were discussed in all participatory activities in relation to economic and community development was the need for **socio-economic** research on the environmental and economic impacts of deer management (alternative business to stalking, tourism, conservation costs, etc.). The literature review ([Section 3.4](#)) highlighted several studies on the relative economic, environmental and social contribution of wild deer. However, whilst most were very detailed and provided numbers and estimation of values, the literature nonetheless points out that the **costs and impacts may be better understood at a site level**. Additionally, although the literature reports on various market incentives that have been explored, it also showed that some of the estate owners' **motivations** are sometimes related to non-pecuniary objectives, which renders such analysis more challenging. This is perhaps why our workshop results show a need to better understand the relationships between deer density and deer-related employment; the socio-economic impacts of alternative models of management (e.g. conservation, stalking groups); the value of deer stalking relative to alternative businesses; and the importance of deer to tourism. This gap was identified as a **research gap** in the researchers'/policy makers' workshop and the literature review also supports this. So, perhaps more recent comprehensive studies on specific sites as case studies are needed to answer this issue.

Another gap emphasised the issue of the **economic analysis of the venison supply chain development and potential for diversification**. This was viewed as a **research gap** on the local and regional impacts of wild deer management, with the need for more research on the monetary flows coming from wild deer management activities (including lowland deer), and more analysis on the consumption versus demand for venison. The literature review also highlighted the issue of fragmentation of the supply chain and lack of marketing (MacMillan and Phillip, 2008), for both upland and lowland deer. Although several cost-benefit analyses and the contribution of wild deer to the economy have been researched in the past, as seen in our literature review, our workshop results highlight a need for more up-to-date comprehensive studies about the economic opportunities and costs associated with wild deer (e.g. added value; processing and marketing capacity; how to link supply and demand; addressing cost and seasonality of venison; how to improve product branding; address hygiene and regulatory challenges; as well as supporting and exploring the market through other diverse activities such as wildlife/deer watching, hind stalking and alternative hunting). Although one study looked at **overcoming barriers to economic opportunities**, this was for deer farming. Studies similar to this one, but focused on wild deer, would perhaps also be useful to answer this research gap. Within that theme, another **research gap** identified was the need to understand the **motivations and values** that influence deer management drivers (capital value and personal enjoyment). However, this gap is only a perceived one, as the literature already exists on that theme (e.g. MacMillan *et al.*, 2010, Hanley and Sumner, 1993). Likewise, evaluating the costs of deer to agriculture and woodlands is a research topic that has been investigated in the past (e.g. Putman, 2012; Scott and Palmer, 2000), but more up-to-date data is required.

Understanding the **public perception and awareness** of deer management was also an important theme that was discussed. The literature review also pointed out the need for more attention on how to involve and educate the public in wild deer management (e.g. Dandy *et al.*, 2011). This was mostly in relation to conflict resolution between public access and deer management, and can be considered mainly as a knowledge transfer or exchange gap.

The **suitability of policy mechanisms**, such as subsidy regimes and land designations was identified more as a **policy gap** rather than a research or KT gap. There is a need for improved clarity of the 'vision' for deer management at the policy/national level in Scotland. Although the literature review did not highlight any specific studies directly relevant to this topic, the present WDNA should be considered to be the current vision at the national level.

Table 5.5 - WDNA 5: Training and Wild Deer Welfare

Gap themes	Stakeholders' workshops	Research/policy workshop	Online survey	Literature review gap	Research gaps	KT gaps
Welfare impacts of night shooting, cruelty, different habitats and disturbance timing	✓✓✓✓	✓✓✓	✓	✓	Research on disturbance impacts over time	Development of specific skills training; night shooting
Defining and assessing deer welfare	✓✓✓✓	✓	✓	✓		<ul style="list-style-type: none"> - Need to develop/communicate clear criteria for defining welfare and improved data gathering on cull and carcass numbers, mortality, breeding success and ageing to facilitate effective monitoring of deer welfare, in relation to the impacts of habitat conditions) -Develop a consistent approach to assessing stalker competence applicable to all those managing deer
Raising of training standards and training uptake for deer managers	✓✓✓✓	✓				<ul style="list-style-type: none"> - Need to foster a Continuing Professional Development (CPD) approach (reassessments) -Enhance relevance of training and best practice (e.g. for Habitat Impact Assessment) and direct applicability to local context and objectives
Expansion of deer qualifications to include habitat management and assess training	✓✓✓	✓	✓	✓		<ul style="list-style-type: none"> - Lack of engagement of managers with HIAs and of understanding of science underpinning HIA - Need to promote the sharing of habitat information (with neighbours/DMGs) - Need to incorporate the underpinning science and role of HIA in cull planning - Coverage of links between HIA and cull planning in training to increase confidence and knowledge of deer managers
Alignment of tertiary education with WDNA	✓✓✓	✓				<ul style="list-style-type: none"> - Lack of links with tertiary education that go beyond DSC1+2; development of relevant higher level courses
Deer Vehicle Collisions reporting mechanisms	✓✓	✓✓	✓	✓	<ul style="list-style-type: none"> - Need for a review of the effectiveness of DVC avoidance mechanisms 	<ul style="list-style-type: none"> - Need to encourage citizen science opportunities for recording deer vehicle collisions (DVCs)
Update best practice guidance.	✓✓	✓				<ul style="list-style-type: none"> - Development of meaningful indicators for stalkers to assess deer welfare and stalker competence
Need to develop training for a wider range of stakeholder groups (e.g. farmers, foresters, stalkers, estate managers, local authority representatives)	✓	✓	✓			<ul style="list-style-type: none"> - Low uptake of training by farmers and crofters - Welfare principles not adequately integrated into training - Lack of qualification(s) in integrated land management for more holistic perspectives - Lack of alignment between training and future strategic visions of land use (e.g. Land Use Strategy and other land use policy)

Across almost all gap themes within WDNA Theme 5 (Table 5.5) **knowledge transfer gaps were identified more frequently, and as being of consistently greater importance, than any identified research gaps. Defining and assessing deer welfare criteria/indicators emerged as an important knowledge transfer gap**, with the need to develop and communicate clear welfare criteria confirmed by the literature review findings ([Section 3.5.2](#)). Literature relating to welfare and key elements of a definition and criteria for welfare exists ([Section 3.5.2](#)) and research on that topic has been very recently commissioned by SNH (Green, 2016). However, **the gap analysis confirms literature review conclusions that incomplete availability and accuracy of cull records at regional/national levels represents an important underlying evidence gap**. This gap is identified here (Table 5.5) as a knowledge transfer gap due to the associated requirement for comprehensive recording and sharing of cull data as opposed to actual research. In practice, **data gaps for cull records further limits the possibilities for assessing/monitoring welfare and for sustainable management of deer populations**. Table 5.5 also identifies gaps relating to specific aspects of deer welfare, including the welfare impacts of night shooting and disturbance. These factors are also noted in the literature review, although some research evidence does exist in relation to disturbance and welfare impacts of different culling approaches, with temporal/seasonal disturbance impacts potentially representing a growing welfare challenge for deer managers worthy of research. Notably, disease transmission as a welfare concern, although an important theme within the literature review, does not emerge in Table 5.5 as a distinct theme due to it being mentioned only infrequently in workshops. **Existing research nevertheless indicates that national-level disease monitoring represents an important aspect of protecting Scottish wild deer populations in the future**. The link between deer management and over-wintering mortality and impacts of supplementary feeding on protecting habitats and crops are two further welfare related themes which may deserve future attention.

A theme which emerged strongly across all of the separate elements of this research (including the literature) is the **requirement for raising training standards for deer managers** and increased professionalisation. The key linked (knowledge transfer) gaps identified here, include **upskilling relating to Information technology, participatory methods and habitat impact assessment (HIA)**. The gaps identified in relation to habitat assessment link to gaps in uptake of both training and practice, with a **consistent requirement identified to increase the relevance and direct applicability (and usefulness) of HIA processes to local deer manager objectives**. Importantly, this includes a requirement for adequately incorporating the underpinning science and the role of HIA in cull planning within training programmes. These factors represent considerable knowledge transfer challenges, reflecting the friction between management practice and science identified in the literature review. Building on these key gaps is the **identified requirement for greater integration of WDNA with tertiary education and specifically the development in the future of relevant higher level qualifications relating to integrated land management**. A linked gap theme further identifies the potential for knowledge transfer through increased training uptake by wider stakeholders, including farmers and enhanced alignment between training and future strategic visions for land use. This finding re-emphasises the importance of consideration of action learning for participatory approaches and land use integration. Table 5.5 also identifies the importance of further research on the effectiveness of Deer Vehicle Collision (DVC) avoidance mechanisms, with a linked opportunity for knowledge transfer (and public engagement) identified through the use of citizen science to record DVCs (see WDNA Theme 4 discussions for further information on DVCs).

6. KEY FINDINGS

Cross Cutting Themes: There were a number of key themes and issues identified that were relevant across all the WDNA priorities:

- There is a need for improved communication, information sharing and conflict management in order to overcome mistrust and to facilitate understanding of the different perspectives of the many stakeholders. Building trust will improve the uptake of research and strengthen collaboration.
- Better knowledge exchange of existing research and best practice is often more important and more relevant than undertaking new research.
- Improved public engagement and education is needed in order to better inform the public's perception of deer management.
- Upland, lowland, peri-urban and urban areas have their own issues and gaps, but there are also common issues across these areas.
- There is a need to carry out research at a range of spatial and temporal scales.

WDNA 1 (Collaboration and Effective Deer Management Planning and Implementation): Identified gaps tended to be linked to a need for improved knowledge transfer rather than new research. A wider understanding of different stakeholder perspectives and cultures is required to underpin conflict management processes and the future management of deer management groups. Sharing of knowledge and data is necessary for improved deer management planning and this depends on overcoming mistrust between stakeholders. Understanding deer movements and habitat utilisation and how this is influenced by management activities emerged as a key research gap. A lack of available data on local trends and patterns was considered a barrier to improving this evidence base.

WDNA 2 (Healthy Ecosystems): The gap analysis identified a range of both research and knowledge transfer gaps associated with the Healthy Ecosystems priority. Although a considerable amount of research has been carried out on the impacts of deer and other herbivores on habitats and species, there remain knowledge gaps in this area of research. Most of the key research gaps relate to a need for a better understanding of herbivore impacts and interactions across a range of temporal and spatial scales, and more knowledge on the influence that deer and deer management have on ecosystem services. One of the main knowledge transfer gaps relates to the need to facilitate understanding of the herbivore impact assessment methodology and the practical use of the HIA data within the deer management planning process, through the provision of skills training.

WDNA 3 (Lowland and Urban Deer): Gaps tended to be more related to issues of knowledge transfer than to new research needs. Research gaps that did emerge as important for the lowland and urban deer context tended to reflect those that are also pertinent in the uplands. There is a need to understand the effectiveness of existing collaborative structures and linked to this are more context specific knowledge transfer challenges related to incentivising and involving stakeholders in lowland and urban areas e.g. local authorities and the public, and ensuring that decision making incorporates multiple perspectives. A further research gap concerns the relationship between deer population dynamics and habitat impacts in lowland and urban areas. There are related knowledge transfer needs for improved gathering and sharing of information about local deer populations.

WDNA 4 (Economic and Community Development): In this particular challenge, the approach used showed that nearly all the gaps identified were research gaps rather than knowledge transfer or exchange gaps, contrary to the other challenges. The key research gaps related to a need for more studies on socio-economic impacts at local and site level,

the venison supply chain and the potential for diversification, as well as cost-benefit analysis on alternative deer management models, both for upland and lowland wild deer. Unlike the other challenges, the gap analysis also identified a particular policy gap, to gain improved clarity as to what the vision for wild deer management should be at the national level. Clearly the WDNA was designed to fulfil this role, which tends to suggest that stakeholders either feel it is not providing the vision that they want or they are not fully engaged with the process.

WDNA 5 (Training and Wild Deer Welfare): In this theme gaps predominantly related to knowledge transfer gaps and/or gaps in uptake of training and/or practice - communicating knowledge and facilitating knowledge uptake as opposed to carrying out new research. The enhancement of data driven management processes is a strong cross-cutting theme within WDNA 5, particularly in relation to improved accuracy and coverage in cull records as a basis for welfare assessments and wider sustainable deer management processes. A second critical cross-cutting theme which has emerged as a key priority knowledge transfer opportunity is the further professionalisation of deer management through enhanced training provision and uptake in key areas; participatory approaches, Information Technology and Habitat Impact Assessment. Increasing the uptake and direct relevance of habitat assessment and management to all deer managers represents a cornerstone of WDNA 5.

7. RESEARCH PRIORITIES

From the different approaches used in this study (i.e. literature review and participatory methods) a series of research priorities can be identified:

7.1 WDNA 1 - Collaboration and Effective Deer Management Planning and Implementation

- **Understanding the dynamics of deer movements and habitat utilisation in response to management:** Studies that combine ecological and local knowledge are useful for understanding deer movements at a local/regional scale. There may be benefit to further using and developing existing spatial decision support tools so they may be applied across a greater range of habitat types. Studies that further consider the impact of different management approaches on deer movements and habitat impacts would be beneficial and these could be informed using both modelling and empirical approaches.
- **Development of improved deer count techniques:** Use of remote sensing and thermal imaging technology for more accurate counts.
- **Understanding the effectiveness of collaborative structures:** Research is needed to better understand the factors that influence collaboration and conflict. For example, how can processes be designed to address power imbalances and overcome mistrust? There needs to be consideration of the future role and scope of deer management groups and other stakeholder forums in relation to information sharing, trust building, and conflict resolution.

7.2 WDNA 2 - Healthy Ecosystems

- **Improved understanding of the impacts of deer and other herbivores on different habitats and species.** Studies that consider the impacts of deer and other herbivores on peatlands would be particularly useful.
- **Improved understanding of the responses of habitats and species to changes in deer grazing pressure (deer densities) across a range of spatial and temporal scales.** The establishment of one or more study sites on mainland Scotland where long term studies of impacts, responses and changes in herbivore densities, could be carried out would help to fill some of the knowledge gaps. The location of these sites would require some careful consideration.
- **Improved understanding of the interactions of different herbivores, including deer and domestic livestock, and how these interactions affect different habitats and species.** Changes in the number, distribution, movement and interaction of different herbivores will result in different impacts across a range of spatial scales. With recent and continuing changes in both livestock and deer numbers more information is needed on how this will impact deer movements and habitat impacts.
- **More studies on the influence of deer and deer management on ecosystem services,** including carbon sequestration and greenhouse gas emissions, would be useful.

7.3 WDNA 3 - Lowland and Urban Deer

- **Understanding how collaboration and decision making in lowland and urban areas can incorporate a range of values and impacts.** For example, studies to identify the constraints and opportunities for collaborative actions in specific lowland and urban contexts would be useful and could be helpfully informed by case studies. These could demonstrate the benefits of collaboration and engagement and contribute to best practice guidance. A fuller understanding is needed of the cultural value that deer hold for people in lowland and urban areas and how this can be accounted for in deer management planning.

- **Understanding population dynamics of deer in lowland and urban areas and relationships with habitat impacts.** These relationships could be better understood by analysing population assessment and habitat monitoring data from lowland and urban areas. Combining ecological information and local data on populations and culling/management approaches in spatial decision support tools (as developed for use in upland areas) would be useful for informing management. Modelling studies that consider future land use change (e.g. woodland expansion) on deer populations and habitat impacts in lowland and peri-urban areas will be important for considering future management requirements.

7.4 WDNA 4 - Economic and Community Development

- Improved understanding of the **socio-economic impact and value of deer** management. This should include local and regional economic impacts, any multiplier effects of investment, rural employment impacts and true costs/benefits of management in relation to public and private benefit streams. Case study approaches taking into account economic and social benefits at different spatial scales (local or even site level) would be beneficial.
- Fuller understanding of the **direct and indirect impacts of alternative models of deer management** (conservation, community stalking groups, private sporting etc.) and the development of a transferable economic outputs model (decision support tool) for application on a case by case basis would be useful.
- More **market research and diversification** for any alternative forms of income (e.g. wildlife and deer watching, hind stalking, alternative hunting) related to deer management would be beneficial. Case studies and modelling approaches could be appropriate.
- Marketing research into the **venison supply chain and incentives** (both for upland and lowland deer) should be carried out. The cost and seasonality, the fragmentation of the supply chain should be addressed, as well as how to provide adequate and effective incentives to estate owners, taking into account their motivations and values. A case by case approach (at local or regional level) would be useful, involving all the potential supply chain agents.
- Although research on Deer Vehicle Collisions has been carried out extensively, better consideration of specific mitigation measures in hotspots would be helpful. GIS based approaches should be used to identify and record such hotspots and the mitigation measures required. The impact of Deer Vehicle Collisions on the rail network is also unknown and would merit more research.

7.5 WDNA 5 - Training and Wild Deer Welfare

- Further research on the **impacts of recreational disturbance on deer welfare**, including impacts on feeding habitat and variation of impacts seasonally and in relation to wider environmental factors (e.g. habitat type).
- Improved understanding through research of **Deer Vehicle Collisions and the identification of suitable collision avoidance mechanisms** in different contexts (peri-urban, lowland and rural) with potential for incorporation of citizen science approaches through DVC reporting.
- Review and investigation of **key future disease risks and risk factors for wild deer populations** in Scotland in relation to climate change and potential disease transmission from European ungulate populations.
- Further investigation of the **link between deer management intensity and rates of over-wintering mortality** in wild deer populations.

APPENDIX 1: WORKSHOP METHODOLOGY

At the start of each regional workshop, participants completed an entry questionnaire ([Appendix 2](#)) to determine: i) their role and affiliation(s); ii) their pre-workshop views on key challenges for sustainable deer management; iii) what sources of information they currently use to address those challenges; iv) their views on key existing knowledge and information gaps relating to deer management; and v) their expectations of the workshop.

Following an overview presentation, regional workshop participants were then split into three or four groups, with each group discussing key knowledge and evidence gaps relating to each of the WDNA themes, with approximately 20-25 minutes of facilitated discussion per theme:

- *Collaboration and effective deer management planning and implementation*
- *Healthy ecosystems*
- *Economic and community development*
- *Training and wild deer welfare*
- *Lowland and urban deer*

The lowland and urban deer theme was not treated as a separate theme in the four regional workshops (which concentrated on the other four themes) due to the Strathclyde workshop having a specific lowland and urban focus. The trainers' workshop looked at all five WDNA themes in turn, with an emphasis throughout on training needs and training related knowledge gaps.

Each sub-group of 5-6 participants addressed two questions in relation to each WDNA theme in turn: i) what are the key regional issues for deer managers and what knowledge is used at different scales to inform management?; and ii) what information, evidence or guidance is missing and how should this be addressed in the future? Participants were provided with maps of the workshop region showing key features and DMG boundaries to stimulate discussion. During a coffee break facilitators (4 per workshop) summarised the thematic discussions for each WDNA theme into a set of numbered bullet points (a maximum of ten points). These numbered lists of knowledge gaps (across all 3-4 sub-groups) were then posted on the wall (one list per WDNA theme). Participants then completed an exit questionnaire ([Appendix 3](#)) which asked them to select six knowledge gaps from any of those on the four lists, as the gaps which they felt were most important within their region. This provided a basis for ranking/placing emphasis on specific discussion themes across the workshops. Participants were also asked: i) whether their views had changed in any way as a result of the workshop; and ii) whether they found the workshop useful. The gaps identified through the questionnaires and discussion from the regional workshops represented *undifferentiated* knowledge gaps. As such, gap themes include points which may reflect research gaps (i.e. real gaps in the evidence base), as well as those which reflect gaps in transfer of knowledge (e.g. between researchers and policymakers or deer managers) and gaps in skillsets related to training provision. In practice, some gaps also represented wider gaps in policy and practice and challenges facing the sector (e.g. limited access to deer larders in the lowlands).

The final researchers'/policy-makers' workshop was designed to address the lack of gap differentiation in the earlier workshops and to help clarify which of the knowledge gaps identified previously constituted actual gaps in the research evidence base; which relate more to gaps in communication/transfer of existing knowledge; and which represented policy/practice gaps or broader challenges. Participants completed a similar entry survey to the regional workshop participants ([Appendix 4](#)) to identify their views on existing challenges and key knowledge gaps. This was followed by an overview presentation of the key undifferentiated challenges and gaps identified within the preceding five workshops.

Workshop participants were then split into three groups, with each group addressing two key questions in relation to each of the WDNA themes (20 minutes per WDNA theme): i) which of the gaps identified in previous workshops represent real gaps in the evidence base and which are gaps in the use and transfer of existing knowledge; and ii) how should the research/evidence gaps or knowledge transfer/use gaps you have identified be addressed? During a coffee break facilitators summarised the thematic discussions for each WDNA theme into two sets of bullet points: i) a list of gaps differentiated as research/evidence gaps or knowledge transfer gaps and ii) a list of solutions/future initiatives to address research/evidence and KT gaps. These numbered lists were posted on the wall (one list per WDNA theme). Participants were then asked to complete an exit questionnaire ([Appendix 5](#)) including identifying: i) their top five future research priorities; ii) their top three priorities for transfer of existing knowledge; and any suggested specific solutions for addressing key gaps. This provided a basis for ranking/placing emphasis on specific research or KT gaps across the workshops.

The response data generated from the entry and exit questionnaires for all workshops has been analysed descriptively in excel including breakdown by workshop and stakeholder type for challenges and gaps identified in the entry survey, and is presented in Sections [2.4](#) and [Appendix 6](#). Findings from the researchers'/policy makers' workshop entry survey are presented as separate charts to highlight alignments and divergences of opinion. Qualitative data from the surveys was coded, with coding trees developed and responses re-coded to facilitate concise presentation and summary of themes.

The workshop discussions were coded and summarised using a thematic analysis across all six workshops and are presented using tables with key points highlighted in the text (Tables 2.3-2.7). The final part of the research results presents a bullet list summarising the main themes related to proposed solutions to the identified knowledge gaps identified in exit questionnaires from the final synthesis workshop.

The over-arching focus of the workshop process was initially to identify a broad range of perceived undifferentiated knowledge gaps. The researchers'/policy makers' workshop and subsequent comparative analysis across workshop findings focused on differentiating perceived research gaps from knowledge transfer gaps and wider policy/practice gaps or management/policy challenges.

APPENDIX 2: REGIONAL WORKSHOP ENTRY QUESTIONNAIRE

Meeting the challenge of wild deer research to support sustainable deer management in Scotland

1. Please state your name:

2. What landholding, Deer management Group and/or organisation do you represent?

3. What is your role in relation to deer management? (Tick more than one box if necessary)

- Private estate factor
- Private estate gamekeeper
- NGO land manager/representative
- Public land manager/representative
- Deer Management Group Chair/Vice chair
- Deer Management Group Secretary
- Independent deer management consultant
- Other (please specify) _____

4. In your opinion, what are the greatest challenges to implementing sustainable deer management in your area/region? (please list up to 5 in order of importance, the most important first)

1.
2.
3.
4.
5.

5. Where do you obtain information to help you address these challenges? (please tick all that apply)

<input type="checkbox"/> Training courses and events (e.g. demonstration days, conferences)
<input type="checkbox"/> Communication with peers/colleagues (e.g. meetings, face to face contact, social media)
<input type="checkbox"/> Personal observation and experience
<input type="checkbox"/> Academic sources (e.g. text book or scientific journal articles)
<input type="checkbox"/> Reports for governmental or non-governmental agencies
<input type="checkbox"/> Popular media (e.g. TV, radio, newspapers)
<input type="checkbox"/> Other (please specify) _____

6. Are there gaps in knowledge/information relating to deer and deer management in your area/region that make addressing these challenges more difficult? Please list up to 3 in order of importance.

1.
2.
3.

7. What do you expect from participating to this workshop?

APPENDIX 3: REGIONAL WORKSHOP EXIT QUESTIONNAIRE

Post Discussion Questionnaire

1. During this workshop have you changed your views in any way on the knowledge/information gaps that prevent the implementation of sustainable deer management in your region?

Yes No

If yes, please state in which area you have changed your views/which knowledge gaps you now think are more or less important?

2. Please indicate in the table below which of the knowledge/information gaps identified during the workshops (in relation to any of the WDNA themes) you think are most important in your region.

[Please select up to six (you can select less) and **rank them in order of importance from 1 (most important) to six (least important)**]

Knowledge gaps (identified in workshop)	WDNA Theme(s) which knowledge gap relates to
1.	
2.	
3.	
4.	
5.	
6.	

3. Did you think this workshop was: Very useful Useful Not at all useful

If you found the workshop useful, what was the most useful aspect for you?

4. Do you have any comments on the planned deer research website presented during the workshop?

5. If you would like to receive a copy of the final report, please provide your email address:

6. Do you have any additional comments on any aspect of the workshop?

Many thanks for your time and thoughts!

**APPENDIX 4: RESEARCHERS'/POLICY MAKERS' WORKSHOP ENTRY
QUESTIONNAIRE**

**Meeting the challenge of wild deer research to support sustainable deer management
in Scotland**

1. Please state your name:

2. What organisation do you represent?

3. In your opinion, what are the greatest challenges to implementing sustainable deer management in Scotland? (please list up to 5 in order of importance, the most important first)

1.
2.
3.
4.
5.

4. Are there gaps in knowledge/evidence relating to addressing these challenges and delivering sustainable deer management in Scotland? Please list up to 3 knowledge/evidence gaps in order of importance.

1.
2.
3.

5. What do you expect from participating to this workshop?

APPENDIX 5: RESEARCHERS'/POLICY MAKERS' WORKSHOP EXIT QUESTIONNAIRE

Post Discussion Questionnaire

1. Please indicate below what you think the top five **future research priorities** are in relation to sustainable deer management in Scotland. These can be derived from summary points on evidence gaps from this workshop or from your own experience.
2. [Please select up to five and **rank them in order of importance from 1 (most important) to five (least important)**]

Future research priorities for Sustainable Deer management in Scotland
1.
2.
3.
4.
5.

3. Please indicate below whether you feel gaps also exist in transfer of existing knowledge/evidence. If yes, please **indicate up to three knowledge transfer gaps below in order of importance** (1 being the most important).

Future priorities for transfer of existing knowledge/evidence relating to Sustainable Deer management
1.
2.
3.

4. What specific **solutions/initiatives** should be developed in your opinion in relation to addressing these research priorities or knowledge transfer gaps in the future? [**Please list up to three points**]

Specific solutions for addressing research priorities and knowledge/evidence transfer gaps
1.
2.
3.

5. What do you consider your role to be in addressing the research priorities or developing the initiatives identified above?

6. Do you have any additional comments on any aspect of the workshop?

Many thanks for your time and thoughts!

APPENDIX 6: PARTICIPANT EXPECTATIONS OF AND FEEDBACK ON WORKSHOPS

In the pre-workshop questionnaire participants were asked what they expected from the workshop. Eighty participants from the regional and trainers' workshops provided a response, with the most frequently listed expectations including: the sharing of knowledge of management challenges between DMGs and stakeholders; receiving an update on relevant policy measures; collaboratively identifying knowledge gaps; improving understanding of other managers and stakeholders perspectives on key deer management challenges; an opportunity to network with local deer managers and stakeholders/agencies and exchange ideas; and identifying useful contacts and sources of information and data.

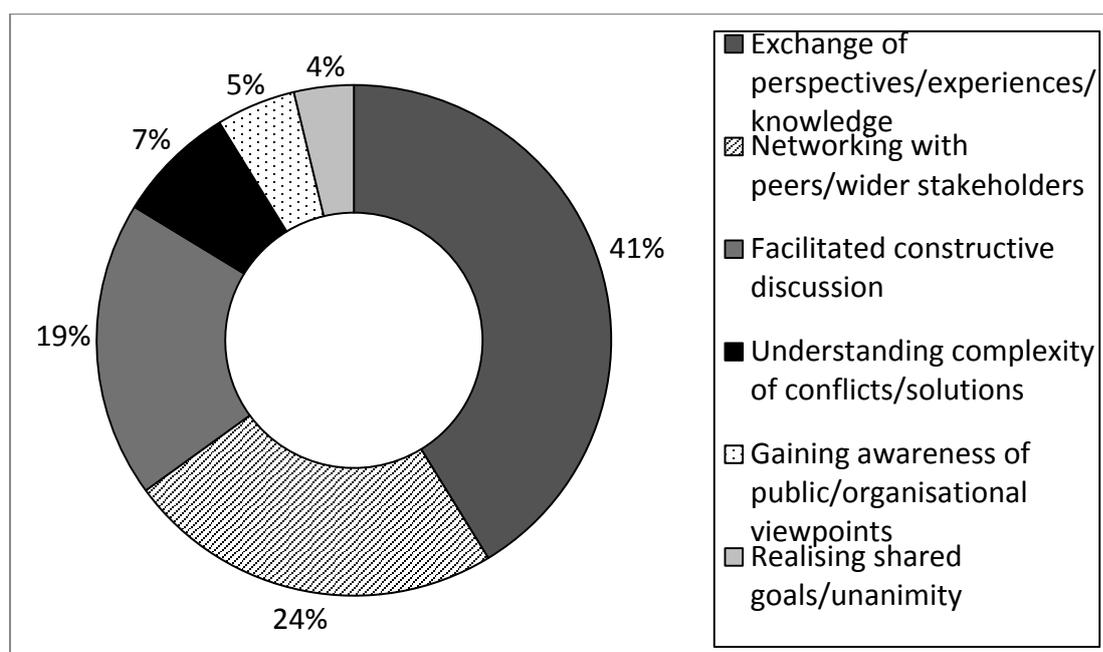


Figure A6.1 - Most useful aspects of workshops as identified by workshop participants (all workshops excluding the final synthesis workshop)

Following completion of the workshop, participants were asked if they had learned anything new/if their views had changed as a result of the workshop, 30 said yes and 53 said no. The most frequently listed responses for why participants views had changed included: learning about new topics and issues including ecosystem services and deer welfare; improving understanding of other managers perspectives, including economic constraints; the opportunity for discussion across sectors (e.g. private estate-conservation NGO); communicating with/increased knowledge of local DMG representatives; increased awareness of the role of public bodies; and discussing different deer count methodologies. Attendees to the final synthesis workshop also commented most frequently on the opportunity to network with wider stakeholders and share perspectives, with improving understanding of current key issues and understanding key current gaps also frequently mentioned as expectations in the final workshop.

Workshop participants (excluding the synthesis workshop) were also asked to indicate if they thought the workshop was useful or not, with 36 indicating they thought the workshop was very useful, 51 indicating that it was useful and 1 indicating that it was not at all useful. Figure A6.1 shows the breakdown of coded responses relating to why respondents thought the workshops were useful. The most frequent comments related to the opportunity to exchange perspectives and experiences and to network with peers and wider stakeholders. A further 19% of respondents also recognised the opportunity the workshops provided for facilitated structured discussion.

APPENDIX 7: ONLINE SURVEY

Meeting the challenges of wild deer research to support the delivery of sustainable deer management in Scotland

Understanding how knowledge and evidence is used in deer management

This survey is part of a research project being conducted by Scotland's Rural College (SRUC) and the Centre for Mountain Studies, Perth College UHI, on behalf of the Scottish Government, Scottish Natural Heritage and Forestry Commission Scotland. The project is entitled 'Meeting the Challenge of Wild Deer Research to Support Delivery of Sustainable Deer Management in Scotland'. The results of the survey will help us understand how policy makers and practitioners have used research on wild deer to underpin sustainable deer management in Scotland. You have been invited to take part in this survey as you have expertise either as a researcher or in a policy role relevant to wild deer management.

The survey is structured around the five high level priorities for sustainable deer management and their associated challenges for 2015-2020 as identified in the policy document *Scotland's Wild Deer: A National Approach (WDNA)*. We would like to understand how evidence from research relevant to these priorities has been taken up and used in policy and practice, and the factors that have influenced this. We would also like to identify any knowledge gaps which need to be addressed to more effectively deliver sustainable deer management in Scotland.

We recognise that your knowledge may not extend to all five priorities in the survey. We will ask you to start by answering questions about the priority with which you are most familiar. You will then have the option to repeat the process for other priorities if you choose. You will need approximately 15 minutes to complete the survey (although this will depend on the number of priorities you select).

If you have any questions about the survey please contact:

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Part 1 - Your Details

Occupation

Employer and/or place of work

Please describe your role in relation to the research to policy/practice system for deer management (e.g. developing policy, carrying out or managing research projects)

Part 2 - Uptake of research to meet deer management priorities

Please tick all the priority areas for deer management with which you are most familiar:

- Priority 1: Collaboration and effective deer management planning and implementation
- Priority 2: Healthy Ecosystems
- Priority 3: Lowland and urban deer
- Priority 4: Economic and Community Development
- Priority 5: Training and Deer Welfare

Priority 1: Collaboration and effective deer management planning and implementation

- Build on work to develop conflict management tools;
- Ensure robust deer management planning;
- Promote and implement the Code of Practice on Deer Management;
- Raise awareness of the need for effective deer management;
- Establish a shared, trusted and high quality knowledge base associated with wild deer.

1. To what extent do you agree there is a strong knowledge/evidence base to help us meet this priority?

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Comments:

2. To what extent do you agree that knowledge/evidence relevant to this priority has been taken up and used in a) policy and b) practice?

a) Policy

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

b) Practice

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Please comment on your answer

3. a) Please give an example of knowledge/evidence relevant to this priority that have been taken up in policy and/or practice (if published research, please give details):

b) Why do you think uptake occurred in these examples?

4. a) Please give an example of knowledge/evidence relevant to this priority which have had limited or no uptake in policy and/or practice (if published research, please give details):

b) Why do you think uptake was limited or non-existent in these examples?

5. Are you aware of any key knowledge gaps in relation to this priority which should be addressed by future research?

Priority 2: Healthy ecosystems

- Contribute to the 2020 Challenge for Scotland's Biodiversity;
- Carry out work to mitigate against, reduce and adapt to the effects of Climate Change;
- Contribute to achieving Favourable Condition status for designated features;
- Differentiate between herbivore impacts.

6. To what extent do you agree there is a strong knowledge/evidence base to help us meet this priority?

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Comments:

7. To what extent do you agree that knowledge/evidence relevant to this priority has been taken up and used in a) policy and b) practice?

a) Policy

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

b) Practice

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Please comment on your answer

8. a) Please give an example of knowledge/evidence relevant to this priority that have been taken up in policy and/or practice (if published research, please give details):

b) Why do you think uptake occurred in these examples?

9. a) Please give an example of knowledge/evidence relevant to this priority which have had limited or no uptake in policy and/or practice (if published research, please give details):

b) Why do you think uptake was limited or non-existent in these examples?

10. Are you aware of any key knowledge gaps in relation to this priority which should be addressed by future research?

Priority 3: Lowland and urban deer

- Improve understanding of deer population dynamics;
- Develop different options for deer management planning;
- Co-ordinate, make available and use current data on lowland and urban deer;
- Understand public perception of urban and lowland deer.

11. To what extent do you agree there is a strong knowledge/evidence base to help us meet this priority?

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Comments:

12. To what extent do you agree that knowledge/evidence relevant to this priority has been taken up and used in a) policy and b) practice?

a) Policy

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

b) Practice

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Please comment on your answer

13. a) Please give an example of knowledge/evidence relevant to this priority that have been taken up in policy and/or practice (if published research, please give details):

b) Why do you think uptake occurred in these examples?

14. a) Please give an example of knowledge/evidence relevant to this priority which have had limited or no uptake in policy and/or practice (if published research, please give details):

b) Why do you think uptake was limited or non-existent in these examples?

15. Are you aware of any key knowledge gaps in relation to this priority which should be addressed by future research?

Priority 4: Economic and community development

- Encourage diverse economic opportunities associated with wild deer;
- Understand the costs and benefits of deer management;
- Develop appreciation and understanding between access and deer management;
- Build on work to address deer vehicle collisions and human disease risks;
- Improve understanding of deer impacts on agriculture and forestry.

16. To what extent do you agree there is a strong knowledge/evidence base to help us meet this priority?

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Comments:

17. To what extent do you agree that knowledge/evidence relevant to this priority has been taken up and used in a) policy and b) practice?

a) Policy

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

b) Practice

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Please comment on your answer

18. a) Please give an example of knowledge/evidence relevant to this priority that have been taken up in policy and/or practice (if published research, please give details):

b) Why do you think uptake occurred in these examples?

19. a) Please give an example of knowledge/evidence relevant to this priority which have had limited or no uptake in policy and/or practice (if published research, please give details):

b) Why do you think uptake was limited or non-existent in these examples?

20. Are you aware of any key knowledge gaps in relation to this priority which should be addressed by future research?

Priority 5: Training and deer welfare

- Ensure a strong skill base in deer management;
- Understand, promote and deliver wild deer welfare.

21. To what extent do you agree there is a strong knowledge/evidence base to help us meet this priority?

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Comments:

22. To what extent do you agree that knowledge/evidence relevant to this priority has been taken up and used in a) policy and b) practice?

a) Policy

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

b) Practice

- Strongly Agree*
- Agree*
- Neither Agree nor disagree*
- Disagree*
- Strongly disagree*

Please comment on your answer

23. a) Please give an example of knowledge/evidence relevant to this priority that have been taken up in policy and/or practice (if published research, please give details):

b) Why do you think uptake occurred in these examples?

24. a) Please give an example of knowledge/evidence relevant to this priority which have had limited or no uptake in policy and/or practice (if published research, please give details):

b) Why do you think uptake was limited or non-existent in these examples?

25. Are you aware of any key knowledge gaps in relation to this priority which should be addressed by future research?

Part 3 - Feedback and next steps

Please use this box to add any further comments you have about any aspect of this survey

We will be holding a final seminar targeted at those involved in deer policy and management, to present and discuss some of the issues and knowledge gaps that will have emerged from the project.

This will take place at Battleby Conference Centre, near Perth (PH1 3EW), on the 23rd November 2016 (time TBC). Please provide your details if you would like to receive an invitation to the seminar.

Name

Email address:

Telephone number:

Thank you very much for your time!

APPENDIX 8: WEB-BASED DEER RESEARCH RESOURCE

The key published deer research reports and articles relevant to delivering the WDNA challenges have been made available via an open-access, web-based resource in the public domain. This resource includes hyper-links to the abstracts and to the full reports where the reports are open-access. The database allows cross referencing and is structured around the 5 WDNA priorities.

The web-based deer resource has been developed by Big Toe Web Design Ltd., a web design and development company. The resource is a dynamic website with a database and content management system. It is responsive (i.e. designed to respond to the size of the user's screen so that it displays perfectly on the full range of devices: smartphones, tablets, laptops, desktops, wide screens).

The 'manager' section of the site (where non-technical staff can update the website after the end of the project) was specifically designed and developed for this project, ensuring that the on-going management of the resource is user-friendly and provides a resource that will last long beyond the end of the project.

The database holds the details of each report or article (as listed in Table A8.1 below). These can be added, edited and deleted through a bespoke 'manager' section of the website. A bespoke 'administration' section allows administrators to manage the 'managers' (i.e. to add new managers, delete old ones, grant permissions etc.).

The website is structured around the 5 WDNA priorities, using a database that allows users to select easily the content that they want to see (e.g. content can be displayed by keyword, theme, etc.).

A content management system is integrated into the site so that 'managers' can edit/update general text.

The web address for the deer research resource is www.deerscotland.info. The domain is being hosted on the Big Toe Web Design Ltd. servers.

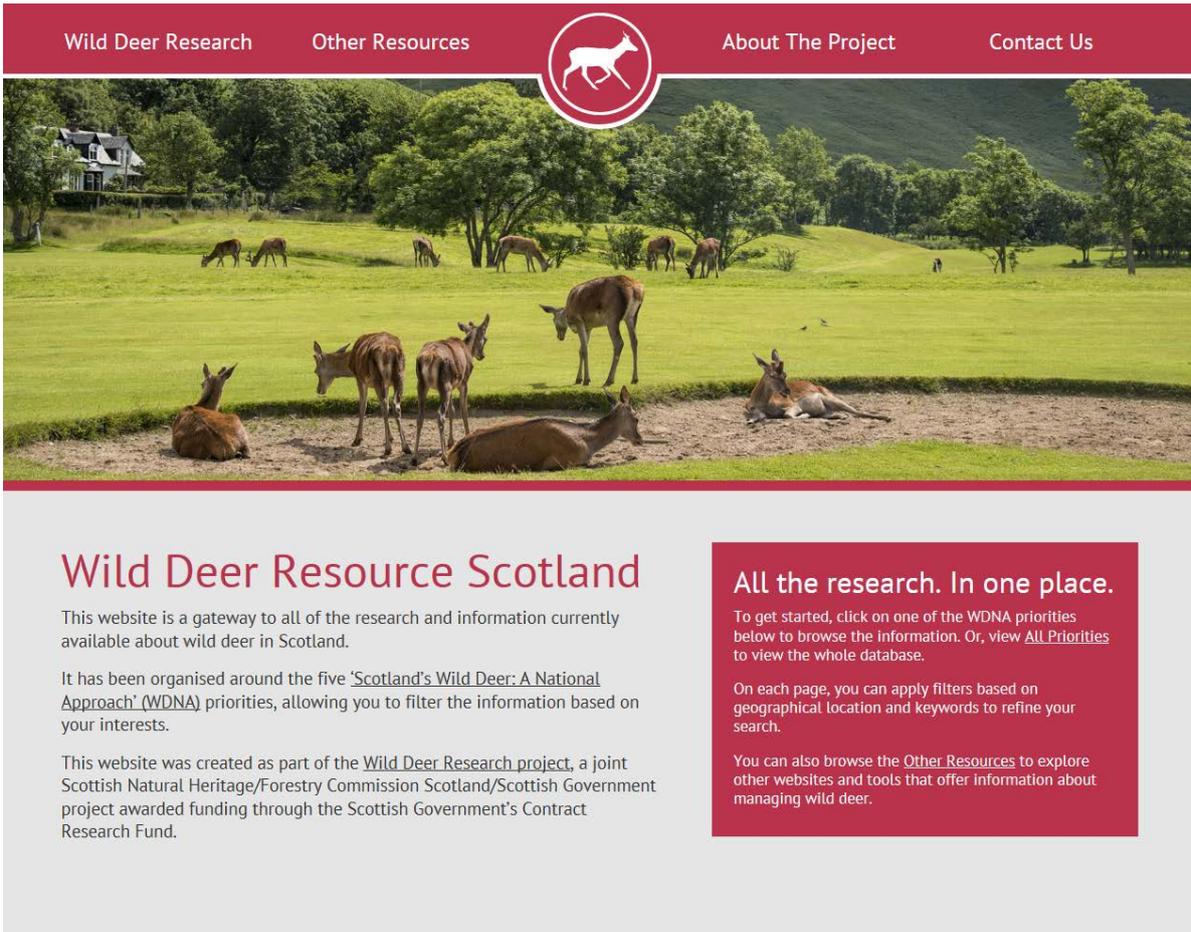


Figure A8.1 - Website front page

Table A8.1 - Database Content

Title:	
WDNA Priority:	<ol style="list-style-type: none"> 1. Collaboration 2. Healthy Ecosystems 3. Lowland and Urban 4. Economic and Community 5. Training and Welfare
Keywords: (drop down list)	~20 key words
Publication Name:	
Journal Volume:	
Journal Start Page Number:	
Journal End Page Number:	
Type of Research:	
Commissioned By:	
Year Completed: (drop down list)	
Year Published: (drop down list)	
Publication Type: (drop down list)	<ol style="list-style-type: none"> 1. Appendix 2. Annex 3. Exec Summary 4. Final Draft 5. Full Report - Published 6. Full Report - Unpublished 7. Journal paper 8. Literature review and scoping 9. Summary 10. Summary of workshop 11. Book Chapter 12. Website 13. Other
Weblink (URL):	Link to abstract or full report where available
Lead Author:	
Lead Institute:	
Geographical Location: (drop down list)	<ol style="list-style-type: none"> 1. North East Scotland 2. Central Highlands and Perthshire 3. North West Scotland 4. Lowland Scotland 5. Scotland (All) 6. UK 7. Europe 8. International
Specific Location:	
Summary:	~100 word summary of the content
Management Recommendation:	Practical implications of the findings for deer managers (maximum 100 words)
Comments on Limitations:	Comments on any barriers or limitations to the implementation of the recommendations (maximum 100 words)

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