The Influence of Recreational Activity on Upland Ecosystems in the UK

A Review of Evidence

January 2023

Natural England Evidence Review NEER025

NATURAL ENGLAND

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Foreword

The uplands are an important destination for people wishing to experience the outdoors. These areas are also of great importance for biodiversity, landscape and understanding the effects of recreational activity in upland areas is important to ensuring that their use is environmentally sustainable.

This work was commissioned so that the findings could be used by all those with an interest in or responsibility for, upland areas and to help make informed decisions about a range of activities and how they relate to the upland environment.

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The Influence of Recreational Activity on Upland Ecosystems in the UK:

A Review of Evidence

Project Report

January 2023

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Executive Summary

Context

On a global scale, visits to upland landscapes account for over 20% of all tourism (UNEP, 2007). Although in the UK this proportion is likely to be lower (although recent UK wide data is not available), in 2007 the UK uplands attracted over 100 million day visits a year (RSPB, 2007). Many visits are focused on designated landscapes in the UK, with visitor data demonstrating that over 45.2 million people visited upland National Parks in England in 2017 (Glaves, *et al*., 2020). Importantly, data from Natural England's Monitoring Engagement with the Natural Environment (MENE) survey estimated that visits to 'mountain, hill or moorland' increased from 61 million in 2009/10 to 147 million in 2018/19 (Natural England, 2019). Similarly, many upland National Parks across the UK are reporting overall increases in visitor numbers and changes to the demographics of those visiting (e.g., see CNPA, 2022). Evidence from across these different sources highlights that recreation in the UK uplands is growing in popularity.

England's uplands are comprised of a diverse range of habitats many of which are designated for their biodiversity value, e.g., Natura 2000 European designations, National Nature Reserves and Sites of Special Scientific Interest (SSSI). These site and landscape-scale designations recognise both the important features of biodiversity value that inhabit upland areas (e.g., ground nesting birds) and the fragility of many of the habitats, some of which have experienced decades or centuries of negative anthropogenic impacts (e.g., blanket bog degradation caused by air pollution). Additionally, much of England's uplands are also designated as either National Parks or Areas of Outstanding Natural Beauty. These designations both recognise the aesthetic importance or 'natural beauty' of upland ecosystems, although National Parks also have dual purposes to conserve wildlife, cultural heritage and promote opportunities for recreational enjoyment.

The combination of intensifying recreational activity and fragile upland ecosystems creates challenges for managing recreation and ecology in these internationally important landscapes. In contrast, however, with other locations where biodiversity and recreation coincide, such as the coast, there is an absence of recent and contemporary evidence relating to the influence of recreational activity on upland sites. This project was therefore commissioned to establish the level of existing knowledge around how recreational activity interacts with upland ecosystems, to guide strategic planning, recreation management and biodiversity conservation in the future.

Purpose of Evidence Review

The purpose of this review was to assess the available evidence on the types of recreation occurring in the English uplands, the receptors and stressors affecting the levels of impact, and identify potential mitigation and adaptation options. The review sought to address the following Research Questions:

1. What types of recreational activity take place in the UK uplands?
2. What factors influence the level of recreational activity in UK uplands?
3. What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?
4. What relationships exist between types of recreational activity and severity of impact in the UK uplands?
5. What are 'appropriate levels of use' of recreation in the UK uplands?
6. What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

Scope

In the absence of a formal classification of upland areas, Less Favoured Areas (LFAs) are a commonly used proxy, denoting areas of natural and socio-economic disadvantage, covering approximately 18% of the England landmass (see Mansfield, 2018; Bonn *et al.,* 2009). Within the UK, the responsibility of the statutory authorities concerned with biodiversity conservation are devolved, so that Natural England has responsibility for conserving and enhancing biodiversity in England only. For the purposes of this review however, the availability of evidence was broadened to cover the entirety of the UK because the uplands of Wales, Scotland and Northern Ireland have similar habitats, species, socio-economic and policy features, although access rights have a more varied history. Evidence about upland areas in any part of the UK was therefore included.

The temporal scope of the review was any evidence published from the year 2000. This date was chosen so that the evidence assessed was deemed relatively recent (i.e., assessing a body of evidence that spanned just over 20 years). Additionally, this date coincided with the establishment of the Countryside and Rights of Way Act (CRoW), which substantially changed access rights to upland areas across England (phased in as a regional roll out over five years) and Wales (in a single-stage implementation) which concluded in October 2005. The same time period also covered changes to access rights in Scotland, as although CRoW excluded Scotland, the Land Reform Act 2003 introduced a general public right of access over most land and inland water in Scotland which became statutory in 2005. By selecting evidence since 2000, this review therefore captured any studies that assessed whether changes to upland access in England, Wales and Scotland influenced recreational pressure in upland ecosystems. This was a particularly important period of time as additional research was commissioned specifically looking into the impacts of recreation on upland wildlife (Bathe, 2007). It should be noted that there were no corresponding changes to access rights in Northern Ireland, which retained a more restricted access policy, with public access limited to public rights of ways (PROW) and land where landowners give permission for public access.

Methods

This review of evidence captured two main bodies of material:

- Academic literature: Published journal articles obtained through systematic searches of literature (including a Boolean search and then more specific searches to address specific gaps missed by the initial Boolean search). This produced **98 pieces of evidence** (hereafter 'studies') that explored recreational impacts in upland ecosystems, or on species or habitat types associated with upland ecosystems.
- Practitioner literature: Alternative forms of valid and objective evidence obtained through a practitioner 'call for evidence' largely comprised of project or consultancy reports. This produced **16 pieces of evidence** (also referred to as 'studies') that explored recreational impacts in upland ecosystems, or on species or habitat types associated with upland ecosystems.

All evidence was assessed and coded according to objectiveness and appropriate validity in line with Natural England guidance on Evidence Reviews (Stone, 2013). This involved treating all evidence (i.e., from both sources) included in the review equally and reviewing it against the same criteria, although the original source of the evidence (i.e., academic or practitioner) is shown in the Evidence Table in Appendix I. Each piece of evidence was assigned a score based on the type of study (numbered 1-5) and a classification of the study's validity ('-', '+' or '++').

In addition to the formal evidence review, practitioner perspectives were also obtained. This was primarily achieved through an online survey disseminated to individuals and organisations

working in the uplands, and also from submissions to the call for evidence that were considered too subjective to be included as formal evidence (as per the validity assessment).

It is important to note that the practitioner perspectives have not been included in the formal evidence review and are not considered as evidence within this report. However, these perceptions provided a valuable insight where evidence is lacking or inconsistent. It also demonstrated where there was consensus or divergence between perceptions and the available evidence. These perspectives are collated in Appendix VII and are also summarised in a separate section at the end of each evidence chapter (Chapters 3-5).

Summary of Conclusions

1. **What form does recreational activity take in the UK uplands?**

The first Research Question examined the different recreational activities that occur in the UK uplands and is addressed in Chapter 3. There were no studies found in this review that fully addressed Research Question 1 by comprehensively assessing the types of recreation that occurred in the UK uplands. Instead, the evidence captured in the review highlighted that only 16 different types of recreation were studied across all 114 pieces of evidence (along with 'general recreation'). However, consultation between members of the Evidence Review Group and using the practitioner perspectives obtained from the online survey demonstrated that there were potentially 40 types of recreational activity occurring within the UK uplands. The evidence review also revealed that there was an imbalance in the proportion of evidence, with 57 studies focused on the management associated with driven grouse shooting, 17 studies on hiking and walking, but importantly, many types of recreation were poorly covered or absent entirely from evidence. Additionally, 29 studies covered 'general recreation' impacts but often these did not detail specific types of recreation occurring in the uplands. Owing to the absence of evidence, no evidence statements were developed that addressed Research Question 1. This absence of evidence led to the development of four recommendations for further research to help address evidence gaps in relation to Research Question 1.

2. **What factors influence the level of recreational activity in UK uplands?**

The second Research Question examined the factors that influence recreational activity in UK uplands and is also addressed in Chapter 3. This led to the identification of two strong and seven moderate evidence statements. There was strong evidence that highlighted the proximity of upland areas to large residential areas was likely to be a strong influencing factor that increased the level of recreational activity, as was the presence and accessibility of footpaths. Moderate evidence highlighted other factors likely to increase recreational activity included the presence of particular landscape features (e.g., specific habitat types or scenery), organised events, the provision of car parks and accessibility of sites to the road network. There was also moderate evidence that recreational activity has increased in upland ecosystems over time, although the drivers of this increase were not clearly defined. This evidence led to the development of 12 recommendations for further research to help address evidence gaps in relation to Research Question 2.

3. **What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?**

The third Research Question examined the influence of different recreational activities on upland species, habitats and ecosystem processes and is addressed in Chapter 4. This led to the identification of 11 strong and 16 moderate evidence statements. Overall, a significant proportion of the evidence focused on the influence on upland bird species, with other taxonomic groups the focus of far fewer studies. Strong evidence demonstrated a negative effect of recreation on the breeding success and populations of birds associated with 'general'

recreation and walking and a negative correlation between recreational activity and habitat quality. There was more strong evidence relating to grouse moor management, including the positive effects of predator control on bird populations and/or breeding success, including red grouse and other upland bird species. There was also strong evidence that disease was a significant issue for red grouse on managed moors. Strong evidence also demonstrated that illegal raptor persecution was having a significant impact on populations of several bird of prey species in the UK uplands. This evidence led to the development of 24 recommendations for further research to help address evidence gaps in relation to Research Question 3.

4. **What relationships exist between types of recreational activity and severity of impact in the UK uplands?**

The fourth Research Question examined the relationship between types of recreational activity and severity of impacts and is also addressed in Chapter 4. There was almost no evidence found that could address this research question. As such, only one moderate evidence statement was developed. This recognised that the severity of impacts did vary with the type of recreation, but too few studies were found to draw generalisations. Additionally, evidence from across the review highlighted that it was likely that responses to different types of recreation were species-specific, although again, this was not possible to detect with so few studies. Based on findings that addressed other Research Questions, a series of characteristics were presented to describe recreational types that may be more likely to have negative impacts on upland ecosystems. This evidence led to the development of four recommendations for further research to help address evidence gaps in relation to Research Question 4.

5. **What are 'appropriate levels of use' of recreation in the UK uplands?**

The fifth Research Question examined the appropriate levels of recreational use and is addressed in Chapter 5. As with Research Question 4, there was very little evidence found that directly addressed this question. The evidence found led to the development of two moderate and one inconsistent evidence statements. These identified that specific visitor level thresholds have been identified for hiking, which if surpassed would cause significant impacts to upland bird species, but that the spatial distribution of visitors may be more important than visitor numbers in terms of their impacts on bird species. There was also inconsistent evidence surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for some species through to opposing evidence that suggested this type of recreation was incompatible with nature conservation. This evidence led to the development of five recommendations for further research to help address evidence gaps in relation to Research Question 5.

6. **What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?**

The sixth Research Question examined the evidence of adaptation and mitigation measures responding to recreational impacts and is also addressed in Chapter 5. The majority of material found relating to this research question did not empirically test the efficacy of measures, meaning only four moderate evidence statements were produced. Moderate evidence concerned the benefits provided by footpath restoration reducing the impact of walking on breeding birds, and that mitigation measures such as signage and education had reduced the impacts of climbing on breeding birds. There was also moderate evidence that diversionary feeding of hen harriers reduced predation of red grouse chicks on grouse moors but that solutions to mitigate the impacts between grouse moor management and conservation are multi-faceted, complex and difficult to implement successfully. Additionally, this chapter also presented six strong and five moderate 'support' statements, where proposals for

adaptation or mitigation measures were made, but were not the subject of empirical analysis. This evidence led to the development of 15 recommendations for further research to help address evidence gaps in relation to Research Question 6.

The evidence review concludes with a chapter that summarises the evidence statements, gaps in evidence and relevant recommendations across all six Research Questions.

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1. Introduction

This report provides the findings of a review of evidence on recreational activity in the UK uplands, which was a six-month project commissioned by Natural England (Cheshire to Lancashire Area Team) in September 2021. This chapter sets out the background, scope and aims of the project.

1.1 Project context and need for the review

The uplands of the UK comprise a diverse range of habitats protected by Natura 2000 European designations, National Nature Reserves and Sites of Special Scientific Interest (SSSI). These site and landscape-scale designations recognise both the important features of biodiversity value that inhabit upland areas (e.g., ground nesting birds) and the fragility of many of the habitats, some of which have experienced decades or centuries of negative anthropogenic impacts (e.g., blanket bog degradation caused by air pollution). Under the Wildlife and Countryside Act 1981, there is the requirement to conserve and enhance the notified features of sites designated for their biodiversity conservation such as Sites of Special Scientific Interest (SSSIs) and those designated under Natura 2000.

In addition to their high biodiversity value, upland areas of the UK also have important socio-economic values, both historic and contemporary. Some of these such as the Peak District and other areas of the South and West Pennines are located in close proximity to large conurbations with dense centres of human population and are therefore readily accessible for day visits. Other upland areas, although further from large conurbations, are recognised internationally for their scenic beauty and valuable cultural landscapes (e.g., Lake District as a World Heritage Site) and are therefore extremely popular destinations for recreation and tourism both nationally and internationally. The relative ease of access (at least in terms of travel distances), longstanding cultural associations and the types of landscape protection mean that upland areas in England are hotspots for recreation, including daytrips and longer residential stays from local residents, UK citizens and overseas visitors (see Section 3.2 for visitor numbers).

Facilitating opportunities for people to enjoy the UK uplands whilst trying to maintain their intrinsic qualities has led to a complexity of landscape designations such as National Parks and Areas of Outstanding Beauty, which aim to both conserve and enhance biodiversity whilst providing opportunities for recreation and/or protecting the aesthetic qualities of these cultural landscapes. As such, UK landscape designations are quite different to upland areas in other countries, e.g., UK National Parks have an IUCN Category V 'Protected Area' classification, which recognises that their management needs to balance the needs of both culture and nature (Dudley, 2008).

The rights surrounding public access to the uplands in different parts of the UK have a complex history. Before the year 2000, access was restricted across a large majority of upland areas, except on Public Rights of Way (PRoW). Some upland landscapes including Dartmoor, parts of the Yorkshire Dales and parts of Cumbria did permit wider public access, but these were notable exceptions to legislation that largely placed access permissions in the hands of private landowners (Shoard, 1999). This restriction to public access to the uplands was fiercely contested from the late 19th Century onwards, involving notable public protests such as the Kinder Trespass in 1932. It took many decades of campaigning before public access rights to the uplands of England and Wales were changed through the passing of the Countryside and Rights of Way (CRoW) Act in 2000, and the Land Reform Act (2003) in Scotland. No changes to access legislation were made in Northern Ireland.

The CRoW Act gave a public right of pedestrian access to land mapped as 'open country' (mountain, moor, heath and down) across England and Wales. In England, the Act was phased in region by region, and the full right of access came into effect on 31 October 2005. In Wales, the CRoW Act was implemented as a single stage in 2005. The total area of 'Access Land' that was defined across England and Wales measured an area of 9,356km^2, covering approximately 8% of the land area of England and Wales; of this 3,694km^2 is Registered Common Land, with the remaining 5,663km^2 recorded as 'open country' (Bathe, 2007). It should be noted that the Access Land classification included 'open habitats' in lowland areas, notably lowland heathland and downs, but the proportion of 'open habitats' in upland ecosystems meant that the majority of land covered by the CRoW Act was in the uplands. Changes to access rights in Scotland occurred at a similar time but was initiated by different legislation (the Land Reform Act, 2003), which provided a right of access to most land (therefore covering a wider range of habitats than in England and Wales) and included all forms of non-motorised access including walking, climbing, cycling, horse-riding, canoeing, wild camping etc. In principle, the CRoW Act in England and Wales and the Land Reform Act in Scotland meant that the total land area of the uplands available for outdoor recreation increased significantly, providing a 'right to roam' across much (albeit not all) of the uplands in England, Wales and Scotland (see Bathe, 2007). There have been no corresponding changes to access rights in Northern Ireland, which has retained a more restricted access policy, with public access limited to PRoW and land where landowners give permission for public access.

During the development of the CRoW Act, it became apparent that there was a significant knowledge gap regarding the relationship between access and biodiversity impacts in the UK (Bathe, 2007). This led to the establishment of a specialist group (the 'Wildlife and Access Advisory Group'), and the commissioning of a programme of research to explore potential impacts of recreation on species, with most outputs of the research programme published in a special issue of *Ibis* (2007, Volume 149, Issue S1). However, of the 12 empirical studies included in this special issue, 10 were conducted in the lowlands, and only two had a specific 'uplands' focus. Following the culmination of this research programme, there have been no further dedicated programmes researching the influence of recreation in upland areas. As such, in contrast with other locations where biodiversity and recreation coincide such as the coast (e.g., see Natural England, 2017 NECR242), there remains a significant knowledge gap surrounding recreational influences in upland ecosystems of the UK.

To address this knowledge gap, Natural England commissioned this evidence review to identify the extent of knowledge surrounding recreational influences in upland ecosystems. This report summarises the project context, methodological approach and findings of the commissioned evidence review.

1.2 Review aim and research questions

The aim of this review was to undertake a systematic review of evidence across academic literature and literature produced by 'practitioner' organisations, to establish the breadth and depth of existing knowledge on the types of recreation occurring in the English uplands, the receptors and stressors affecting the levels of impact, and identify potential mitigation and adaptation options.

This overarching aim was addressed by meeting the following Research Questions:

1. What types of recreational activity take place in the UK uplands?
2. What factors influence the level of recreational activity in UK uplands?

3. What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?
4. What relationships exist between types of recreational activity and severity of impact in the UK uplands?
5. What are 'appropriate levels of use' of recreation in the UK uplands?
6. What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

The final phrasing of the Research Questions is slightly different from the original phrasing drafted by Natural England (see Appendix II). Minor alterations were made to ensure clarity of meaning.

1.3 The nature of the evidence

Two broad types of evidence have been captured and analysed for this review project:

1. Academic literature, obtained through systematic searches of peer-reviewed literature databases,
2. Practitioner evidence (i.e., information, data or other material captured by upland practitioner organisations covering statutory and non-statutory organisations, principally working in the areas of biodiversity conservation or recreation), obtained from an email request for relevant submissions.

In addition to formal evidence, this research also ascertained the perspectives of practitioners working in the areas of recreation and/or biodiversity conservation in the uplands, which was obtained through an online survey, distributed to relevant biodiversity conservation and recreation organisations. This information was not treated as formal evidence within the review but has been used as a means of reflecting on the consistency of evidence, and as a means of identifying potential gaps in research, included as a short section towards the end of each evidence chapter (Chapter 3-5).

This project adopted a methodology in line with a 'Full Systematic Evidence Review' rather than a 'Rapid Evidence Review' (Collins *et al.,* 2015). This facilitated an understanding of the strength of evidence supporting each research question, as opposed to only summarising the key empirical evidence. Given that a very diverse range of stakeholders and associated opinions form the scope of this project (as set out by the proposed Research Questions defined by Natural England), there was a requirement to be both transparent and rigorous in searching, screening and assessing the evidence.

1.4 The Evidence Review Group

This evidence review was undertaken through a collaboration between four academic researchers from the University of Manchester (hereon in 'the Research Group') and two Natural England employees with a particular remit in the uplands (hereon in 'Natural England Representatives'). Combined, these formed the 'Evidence Review Group' who were responsible for designing and shaping the evidence review, although in some instances external advice and verification was also sought, either from within Natural England and in some instances from other upland experts outside Natural England or the University of Manchester.

2. Methods

This chapter summarises the methodological approach used to collect and analyse the existing evidence of recreational activity in the English uplands. To complete this work, the review drew from two discrete bodies of evidence:

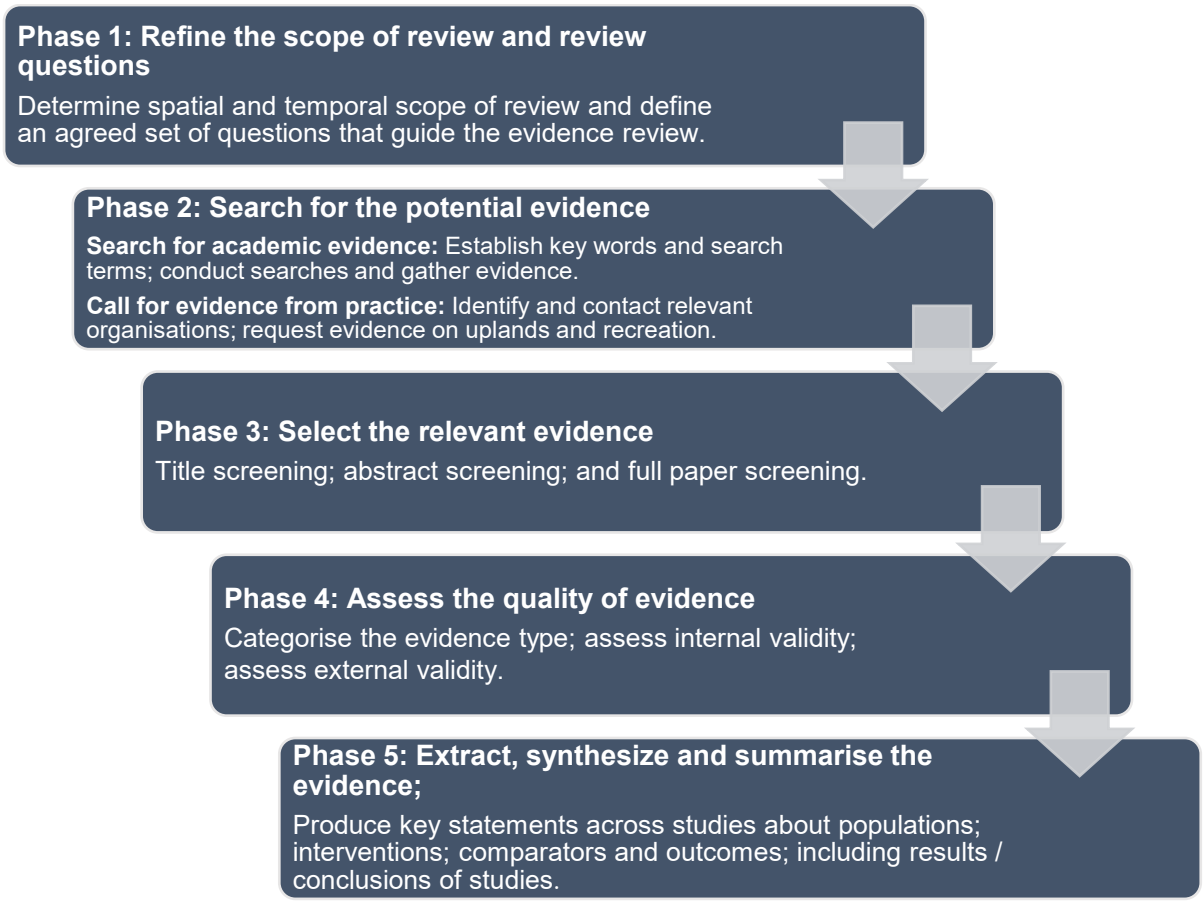
- Peer-reviewed '*academic literature*' identified through a systematic search, screen and analysis process.
- '*Practitioner literature*' produced or commissioned by statutory and non-statutory bodies involved in managing upland areas in the UK, identified through a call for evidence.

2.1 Overarching Approach

The protocol for undertaking the review of evidence was informed by the *Natural England Evidence Reviews: guidance on the development process and methods NEER01* (Stone, 2013). Some adaptations to the approach were needed to meet the specific requirements of this project, which were agreed with Natural England representatives at the start of the project.

For the identification and review of peer-reviewed and practitioner evidence (i.e., not including broader perspectives captured through the online survey), the methodology has adopted the phases proposed in Stone (2013) that guide the systematic capture, assessment and synthesis of evidence (Figure 2.1); these phases provide the structure for this chapter.

Figure 2.1 Proposed phases for systematic evidence review (adapted from Stone, 2013)



2.2 Review Scope and Refining Review Research Questions (Phase 1)

2.2.1 Review Scope

The principal geographical scope of Natural England's upland remit is defined by Less Favoured Area (LFA) classifications (Condliffe, 2009; DEFRA, 2011). In the absence of a formal classification of upland areas, LFAs are a commonly used proxy, denoting areas of natural and socio-economic disadvantage, covering approximately 18% of the England landmass (*ibid*). Using ArcGIS, the location of LFAs in England was used to identify some of the key variables in this study, such as relevant habitats (e.g., Priority Habitats and landcover types).

Importantly, for the academic literature search, the scope for this evidence search was broadened from solely England to include the upland areas of Wales, Scotland and Northern Ireland (i.e., the entirety of the UK). This broader scope was adopted to ensure that the maximum amount of relevant academic literature was included as the rest of the UK has similar ecological, environmental and socio-economic conditions, and many similarities in key policy areas (e.g., conservation policies, designations, etc.) albeit different policies surrounding public access. Excluding evidence from countries outside of the UK did reduce the amount of evidence included (Section 2.4, Table 2.2). Nonetheless, the explicit focus on UK-based studies was determined by the Evidence Review Group to be important because upland recreation in many other countries is very different, often focusing on 'high montane environments' with very different forms of access, recreation pursuits, land use and ownership structure, landscape designations and other policy contexts, as well as different habitat types and species to those of the UK (see Mansfield, 2018; Bonn *et al*., 2009).

The call for practitioner evidence principally involved contacting organisations in England (see Appendix III for details on how these organisations were identified), but any evidence that was submitted including / concerning other areas of the UK was included in the review.

The temporal scope of the review was any evidence published from the year 2000. As summarised in Section 1.1, this date was chosen so that the evidence assessed was deemed relatively recent (i.e., assessing a body of evidence that spanned just over 20 years). Additionally, this date coincided with the establishment of the CRoW Act, which substantially changed access rights to upland areas across England (in a regional roll out) and Wales (in a single-stage implementation) which concluded in October 2005. Additionally, a similar increase in access policy occurred in Scotland under the Land Reform Act (2003). Selecting the date of 2000 allowed any studies that assessed changes brought about by changes to upland access in England to be included in this review. This was a particularly important period of time as additional research was commissioned specifically looking into the impacts of recreation on upland wildlife (Bathe, 2007). It should be noted that CRoW did not affect Scotland and Northern Ireland.

Refining Review Questions

The overarching review adopted the Population, Intervention, Comparison, Outcome (PICO) framework to structure the review process:

- **Population:** the habitat, species or environmental receptor of interest, in this review this included all upland habitats, a 'guild' of upland species and different ecosystem functions.
- **Intervention:** The intervention or approach being studied, in this review, different types of recreation.

- **Comparison:** The main alternative to the intervention, in this review was usually defined as an absence of the recreation type, or lower levels of recreational use.
- **Outcome:** The results or effects being considered, in this review, an assessment of whether recreation influences population features, and if this influence is positive, negative or neutral. It should be noted that specific outcomes such as 'disturbance' or 'erosion' were not defined as it was found this limited the types of recreation identified within the evidence, and also predisposed the search to identify more negative influences.

The individual review questions were adapted slightly to ensure they met the PICO framework (see Appendix II).

2.3 Evidence Search (Phase 2)

2.3.1 Search Strategy

Academic Literature

Two commonly used databases were used to search for academic literature; Scopus and Web of Science (Lefebvre *et al.,* 2021). These two databases were used because they adhere to rigorous standards in terms of both article selection and database upkeep and maintenance (e.g., see Pasko *et al*., 2021; Gusenbauer, 2019; Rousseau *et al*., 2018). The database that each reference was accessed from was recorded for transparency. A series of Boolean searches were used to identify evidence from within these databases (see *Search Terms* in this section). In addition to these Boolean searches, a series of specific 'hand searches' were undertaken (Gusenbauer, 2019). This involved targeting specific topic areas that were deemed to be underrepresented in the Boolean searches. Some additional academic literature was also identified through contact with lead organisations and national experts.

Practitioner Literature

Practitioner literature was searched for through an open call for evidence that requested evidence from organisations involved in the management and conservation of English uplands and recreation organisations (Appendix III). Additionally, a search for practitioner publications was conducted in the Library Hub Discover, Collaboration for Environmental Evidence (CEE) and an additional specific search for visitor and recreation surveys in protected landscapes, notably England's upland National Parks.

The open call for evidence was sent out via an email to 101 representatives closely involved in upland management including statutory agencies and government departments, business associations, land management representative organisations, organisations representing recreational interests, nature conservation and landscape-based organisations and other voluntary organisations with an interest in upland management. A full list of stakeholders was drawn up by the Research Group with input from Evidence Review Group following the stakeholder categories developed by Mansfield (2018, pp.393). Beyond this list, the call for evidence was also circulated to all Natural England Area Team staff and the internal Upland Network as well as various Upland Management Working Groups.

The open call for evidence attracted responses from 18 organisations and 1 private individual. Respondents submitted different forms of evidence, including relevant academic journal articles, (which were added to the academic literature database), reports, ecological survey results, visitor surveys, position statements and photographs.

Three members of the Research Group assessed each practitioner submission, and a decision was made whether to:

- Screen out because of irrelevance;
- Include in Appendix VII on practitioner perspectives because the content was relevant but subjective; or
- Include as accepted evidence for inclusion in the coding evaluation – i.e., code as per academic literature. Only studies that provided a methodology were included within this category. They were then coded for validity using the same approach as the academic literature (see Section 2.5)

Studies that were deemed suitable for inclusion as evidence were then treated in the same way as academic studies, but their provenance has been recorded in the Evidence Table (Appendix I) as 'practitioner evidence' (PE).

Search Terms

Search terms for each of the main PICO categories were proposed and then reviewed by upland specialists and ecologists working within and external to Natural England. These search terms were developed by iteratively testing different combinations to ensure a range of diverse sources were captured (Aromataris and Pearson, 2014).

The search was then conducted using a Boolean-format search (Box 2.1) that identified any literature with different permutations of the search terms to be identified (as per Glaves *et al.,* 2020, p. 7). The script is composed from three main clauses that link directly to the PICO categories ('comparison' not featuring as this was largely determined as where no recreation had occurred within studies, or lower levels of recreation were used for comparison). It should be noted that geographical terms were not used (e.g., 'UK', 'England') because if used as a clause on their own, too many relevant studies would have been missed.

Box 2.1: Final Boolean string (Search 1)

"upland" OR "moorland" OR "hill" OR "mountain" OR "heath" OR "less favoured area" OR "LFA") AND ("recreat*" OR "touris*" OR "visitor*" OR "access*" OR "outdoor pursuit*" OR "shoot*" OR "4x4" OR "hik*" OR "walk*" OR "boulder*" OR "climb*" OR "dog walk*" OR "road driv*" OR "camp*" OR "swim*" OR "paraglid*" OR "sport*" OR "rave" OR "mountain bik*" OR "horse rid*" OR "bik*" OR "birdwatch*" OR "off-road driv*" OR "fishing" OR "ski*" OR "snowsport" OR "country sport" OR "barbecue" OR "BBQ" OR "running" OR "drone" OR "e-bik*" OR "scrambler" OR "orienteer*" OR "triathlon" OR "kayak*" OR "sail*" OR "boat*" OR "canoe*" OR "organi?ed event*" OR "aeroplane" OR "airplane" OR "firework") AND ("natural process*" OR "habitat" OR "ecosystem" OR "wildlife" OR "biodiversity" OR "woodland" OR "mire" OR "scree" OR "cliff" OR "peatland" OR "peat" OR "bog" OR "grassland" OR "flush*" OR "rush*" OR "meadow" OR "marsh*" OR "limestone pavement" OR "orchard" OR "calaminari* grassland" OR "reedbed" OR "stream" OR " reservoir" OR "river" OR "lake" OR "tarn" OR "bird" OR "reptile" OR "mammal" OR "fish*" OR "amphibian" OR "invertebrate" OR "arthropod"

Retrieved n=10,350 from Scopus and n=5167 from Web of Science (17/12/2021)

"*" is used where alternative suffixes occur other than just "s", "?" is used to replace letters where alternative spellings occur (e.g., North American usage).

The Boolean scripts were the same for both databases searched. The only modification was that Scopus searches were prefixed with TITLE-ABS-KEY whereas the Web of Science used TS=. This is because Scopus and Web of Science have different settings for undertaking searches. TS refers to the 'Topic' category in Web of Science which searches the title,

abstract, author, keywords, and Keywords Plus. TITLE-ABS-KEY refers to the Title, Abstract and Keyword search on Scopus. These two settings were used to capture a broad range of relevant sources. In addition to Search 1, a second Boolean script was developed which focused on using a specific set of upland species (Box 2.2). This species list was produced and verified by upland specialists and ecologists working within and external to Natural England. These new references were added to the database for screening. The evidence obtained from the Boolean searches was recorded in the Evidence Table (Appendix I) as 'Academic Evidence – Boolean' (AE-B).

Box 2.2: Additional search using upland species

"upland" OR "moorland" OR "hill" OR "mountain" OR "heath" OR "less favoured area" OR "LFA") AND ("recreat*" OR "touris*" OR "visitor*" OR "access*" OR "outdoor pursuit*" OR "shoot*" OR "4x4" OR "hik*" OR "walk*" OR "boulder*" OR "climb*" OR "dog walk*" OR "road driv*" OR "camp*" OR "swim*" OR "paraglid*" OR "sport*" OR "rave" OR "mountain bik*" OR "horse rid*" OR "bik*" OR "birdwatch*" OR "off-road driv*" OR "fishing" OR "ski*" OR "snowsport" OR "country sport" OR "barbecue" OR "BBQ" OR "running" OR "drone" OR "e-bik*" OR "scrambler" OR "orienteer*" OR "triathlon" OR "kayak*" OR "sail*" OR "boat*" OR "canoe*" OR "organi?ed event*" OR "aeroplane" OR "airplane" OR "firework") AND ("Sky Lark" OR "Tree Pipit " OR "Nightjar" OR "Twite" OR "Cuckoo" OR "Red Grouse" OR "Crossbill" OR "Curlew" OR "Wood Warbler" OR "Capercaillie" OR "Black Grouse" OR "Snipe" OR "Song Thrush" OR "Ring Ouzel" OR "Lapwing" OR "Numenius arquata" OR "Dunlin" OR "Golden plover" OR "Ptarmigan" OR "Meadow pipit" OR "whinchat" OR "wheatear" OR "Short-eared owl" OR "Hen harrier" OR "Merlin" OR "Peregrine falcon" OR "Golden eagle" OR "Whimbrel" OR "Teal" OR "Dipper" OR "Raven" OR "Marsh Harrier" OR "Stonechat" OR "Long-eared Owl" OR "Osprey" OR "snow bunting" OR "wood cock" OR "Red deer" OR "Roe Deer" OR "Mountain Hare" Or "Red Squirrel" OR "Pine Marten" OR "Otter" Or "Adder" OR "palmate newt" OR "Wildcat" OR "Water Vole" Or "Large heath fritillary" OR "Small heath fritillary" OR "Marsh fritillary" OR "Mountain ringlet" Or "Bilberry bumblebee" OR "Golden-ringed dragonfly" OR "Northern emerald dragonfly" OR "Northern damselfly" OR "Emperor" OR "Netted Mountain Moth" OR "Black Mountain Moth" OR "Northern Dart" OR "Northern Arches" OR "Small Dark Yellow Underwing" OR "Beautiful Yellow Underwing" OR "Antler Moth" OR "Argent & Sable" OR "Chevron" OR "Common Heath" OR "Latticed Heath" OR "Clouded Buff" OR "Fox Moth" OR "Grass Wave" OR "Four-dotted Footman"

Retrieved n=363 from Scopus and n=276 from Web of Science (17/12/2021)

The final sample from the Boolean Searches included several literature reviews, many of which were deemed irrelevant because of geography or only indirectly associated with the topic. Only the major review documents that were focused entirely on the UK or that separated evidence by country, were considered directly relevant to the overarching PICO framing or individual research questions were formally assessed (n=2). Other recent literature reviews that covered broad geographical areas were also identified through the Boolean searches (e.g., Huddart and Stott, 2019; Gallo and Pejchar, 2016; Marzano and Dandy, 2012; Steven *et al*., 2011; Park *et al*., 2008). These literature reviews were not reviewed in their own right, but were instead used for 'snowball' sampling. This involved extracting any studies included in these reviews that met the criteria of this evidence review and adding them into the database. In most instances, however, there were very few articles that met these criteria that had not already been obtained through the initial Boolean searches (the principal exception being references from Huddart and Stott, 2019). These literature reviews also provided useful information for the 'Context' sections within the results chapters. The evidence obtained from

these snowball searches was recorded in the Evidence Table (Appendix I) as 'Academic Evidence – Snowball Searches' (AE-SS).

Following the collation of all searches, some additional searches were then conducted applying alternative search terms that addressed key topics to ensure that key literature had not been missed (as per Howe, 2020, pp. 234-236). These searches were largely informed by the information gathered during the practitioner evidence call for submissions. Only studies published after 2000 (for rationale, see Section 2.2) were included in the searches listed above. There were no repeat searches, and studies published after the dates listed above were not captured in the database. The evidence obtained from these additional searches was recorded in the Evidence Table (Appendix I) as 'Academic Evidence – Additional Searches' (AE-AS).

2.4 Selecting the relevant evidence (Phase 3): Eligibility and exclusion screening

A multi-level screening approach was developed to arrive at the final sample. This involved removing all duplicates from the combination of Boolean searches (Boxes 1 and 2) and other subsequent searches. Studies were then screened at title, abstract and full study level for both geography (i.e., if the studies were conducted inside the UK) and relevance (i.e., if the studies addressed any of the research questions). Eligibility and exclusion decisions were applied at each level. Sources were passed onto the next level unless it was clear the exclusion criteria applied (i.e., if there was any uncertainty around eligibility they were passed through to the next level for further scrutiny). The number of references included in each stage of the screening process is shown in Table 2.1. All reference details and their relevant metadata were downloaded from Web of Science and Scopus or inputted manually (practitioner literature) and imported into Microsoft Excel (2018), with duplicates removed before screening commenced.

Table 2.1: Number and sources of evidence included in this report

Stage	Number of references
Boolean search	
References captured using Boolean searches 1 and 2 (including duplicates)	16,165
References captured using Boolean searches 1 and 2 (excluding duplicates)	12,347
References remaining after title screening	2,608
References remaining after abstract screening	202
References remaining after full text screening	62
References added through snowball sampling (from literature reviews captured in Boolean)	10
Sub total	**72**
Practitioner literature (submitted)	
Total submissions of evidence	19
Practitioner literature remaining after screening based on methodology	16
Sub total	**16**
Additional literature searches	
A series of additional literature searches were undertaken based on gaps in evidence identified during the call for evidence.	26
Sub total	**26**
Cumulative total	
Total number of sources of evidence included in the review	**114**

Owing to the large number of studies included in the initial search (Table 2.1), screening was undertaken individually by two reviewers. To ensure consistency, this stage began with a calibration task whereby the two reviewers screened a random sample, approximately 7.2% (n=1164), of the initial overall collection of studies. The results from this process confirmed that the screening approach was undertaken by the two reviewers in a congruous manner. During the final screening process, where there was any uncertainty, references were flagged and discussed by the two reviewers. If still not resolved, these were then escalated to a third member of the Research Group (following Connelly *et al.,* 2020).

2.5 Assessing the type of study and quality of evidence (Phase 4)

Type of Study

Each reference included in the final sample was fully assessed for study type and quality by two reviewers and assigned the appropriate code 1-5 (Table 2.2). On completion of all assessments, any differences were resolved by discussion between the reviewers and where necessary involved a third reviewer. A summary of the proportions of study types is shown in Appendix IV.

Table 2.2: Categorisation of study type example (Stone, 2013)

Rating	Definition
1	Meta-analyses, systematic reviews of, or individual Randomised Control Trials (RCT)
2	Systematic reviews of, or individual, non-randomised control trials, case-control trials, cohort studies, controlled before-and-after (CBA) studies, interrupted time series (ITS) studies, correlation studies, modelling, site comparisons and national or regional (and some local) data sets, statistics and surveys.
3	Non-analytical studies, for example, case reports and case series studies, and traditional, non-systematic literature reviews.
4	Expert opinion and formal consensus.
5	Modelling, where data was used to develop projections of change over time and space rather than evidence changes that have occurred.

Quality of Evidence

The quality of the study was assessed based on six criteria set out by Stone (2013) regarding;

- a clearly defined environmental context,
- the representativeness of the case studies and individual receptors selected for study,
- inclusion of a control sample,
- the objectivity applied to measuring impacts,
- the transferability of findings to the wider UK uplands, and
- identification of significant methodological limitations.

Each reference was fully coded by two reviewers. For every study, both reviewers assigned an applicable code [++], [+] or [-] to each of the six criteria (Table 2.3). These scores were based on the extent to which potential sources of bias had been minimised, which for ease and consistency between reviewers were assessed using text descriptions devised to evaluate bias levels for each criterion.

Table 2.3: Categorisation of study quality example (Stone, 2013)

Rating	Definition
++	All or most of the methodological criteria were fulfilled. Where they had not been fulfilled, the conclusions are thought very unlikely to alter (low risk of bias)
+	Some of the criteria were fulfilled. Those criteria that had not been fulfilled or not adequately described are thought unlikely to alter the conclusions (risk of bias)
-	Few or no criteria were fulfilled. The conclusions of the study are thought likely or very likely to alter (high risk of bias).

Assigning a final, appropriate and agreed validity score for each study is a critical part of the review process. To achieve this, individual scores were assigned for each of the six validity questions ('-' = 0, '+' = 1, '++' = 2), and an average score was then calculated across all six questions (with the total ranging between 0-3). Based on a normal distribution, thresholds were developed for the summed validity score (Table 2.4). Any significant (i.e., threshold) differences in the validity score assigned by each reviewer were resolved by discussion between the reviewers and where necessary involved a third reviewer.

Table 2.4: Definition of Strength of Evidence Terminology

Validity Score	Summed score across six validity variables
[-]	<2.20
[+]	≥2.20 – 2.79
[++]	>2.80

The difference between the initial validity scores assigned by each reviewer is shown for every study in the Evidence Table (denoted as δ=) with the agreed score code ('- ', '+' or '++') also shown in the final column (Appendix I). Regular meetings were undertaken during the course of the coding process to resolve any anomalies or difficulties encountered in coding specific references or evidence. A summary of the proportion of validity scores is shown in Appendix IV.

2.6 Extraction and Synthesis (Phase 5)

Coding framework

Evidence was extracted from references using a coding framework. The framework was produced in Microsoft Excel and tested using a pilot sample (n=10) of literature assessed by three reviewers to test consistency. Extracted results were consistent amongst all three reviewers, but some minor modifications and additions were made to enhance coding reliability. This resulted in a final coding framework that prescribed a total of 56 questions (both open and closed) based on the 6 Research Questions (Section 1.2). The questions were developed around 7 sub-categories (a full list of the coding questions is available in Appendix V):

- Citation information (6 questions)
- Location and context of study (7 questions)
- Internal and external validity (6 questions)
- Recreation type (5 questions)

- Recreation influence on species (12 questions)
- Recreation influence on habitats (10 questions)
- Recreation influence on environmental processes (9 questions)

Synthesis: Strength, Validity and Applicability of Evidence

The synthesis of evidence provides a narrative overview for each research question. Within this structure, studies that met the inclusion criteria were summarised in the Evidence Table (Appendix I), including an assessment of validity / study quality and a brief overview of key findings.

By assessing across evidence, the strength of the evidence on any relevant theme (within the broad theme of each research question) was classified as strong, moderate, weak, or inconsistent (where findings, e.g., direction or trends, differed between studies).

This adopted a systematic, quantitative weighting using the criteria shown in Table 2.5 which combined the weightings advised in both Natural England guidance (Stone 2013) and another Natural England Evidence Review (Glaves *et al*., 2020).

Using the weighting criteria shown in Table 2.5 meant that almost universally, the strength of evidence was easily assessed. Where there was some degree of subjectivity about the assigned strength, there was collaboration between the Research Group about the appropriate classification of evidence.

The resulting evidence was then synthesised into evidence statements presented in Chapters 3-6 around each of the research questions.

Table 2.5: Definition of Strength of Evidence Terminology

Rating	Definition
No evidence	No evidence has been found that can lead to the development of an evidence statement.
Weak evidence	One study (of any validity) or a low number of generally lower quality studies, including some or most with validity classed as minus [-]
Moderate evidence	A smaller number of studies (at least two) of which at least one was classed as a minimum of [2+]
Strong evidence	A number of studies (at least four) showing consistent findings or trends or one or two high quality or national, representative studies or datasets (generally including Office for National Statistics recognised data) [1++, 1+ or 2++]
Inconsistent evidence	References with a similar number of studies or validity scores provide conflicting evidence.

In some cases, evidence was only partly applicable to the context of the evidence review (Stone, 2013). In this evidence review, 22 studies (20% of total) were included that conducted research wholly or partly within the UK lowlands (shown as hashed cells in the Evidence Table, Appendix I). On consultation with Natural England Representatives, evidence relating to recreation habitat types similar to those found in the uplands but that specifically studied species that also inhabit and/or breed in the UK uplands were included in this review. In particular, studies were sometimes included that were undertaken on lowland dry heath, where the open character and species composition of vegetation is often very similar to upland dry or wet heathland (indeed often both are grouped as 'heath or moor'). These studies were only

included, however, if they concerned species known to also inhabit and/or breed in the UK uplands. Where evidence from these studies have been included, a statement has been provided which highlights that the applicability of the evidence may be affected.

2.7 Consideration of Practitioner Perspectives

Whilst evidence reviews are normally conducted based on the weight of published evidence alone, the Research Group involved in this review were concerned about the relative paucity of contemporary literature on the influence of recreational activity in the uplands, which seemed to contradict reporting by upland practitioners (particularly Natural England employees) that recreational pressures in the uplands were increasing. Additionally, many practitioners contacted the Research Group concerned that they did not have the appropriate forms of evidence required for the review but did have substantial experience of the influence of recreational activity in the uplands.

To capture this potential disparity between the quantity and where present, often relatively old, published evidence, and the experience of upland practitioners, an online survey was produced and disseminated along with the Practitioner Call for Evidence. Questions were structured around the six evidence review Research Questions. The survey was designed to capture the perceptions of practitioners working in upland conservation, recreation or land management about recreational influences in the uplands. The questions were reviewed and refined in conjunction with the Natural England representatives.

Questions were themed around:

- Survey respondent information (e.g., type & name of organisation, location, designation type);
- Influence of recreation on wildlife and biodiversity (e.g., general, specific to different forms of recreation, what recreation forms were not mentioned in the survey, the three most damaging forms);
- Habitat and species sensitivity to recreation;
- Key factors influencing the intensity of recreational impacts identified from literature which included facilities, management, policies, specific events or occurrences (e.g., CRoW Act, COVID-19 pandemic and lockdowns); and
- Adaptation and mitigation measures that had been trialled (e.g., specific interventions that have been effective, policy opportunities and barriers).

A summary of the questions that were included in the practitioner survey is included in Appendix VI.

The survey was distributed to over 100 practitioners working across a broad range of organisations including private, public and third sector agencies in December 2021. These practitioners were identified via extensive engagement with the Evidence Review Group aiming to capture a broad range of interest groups actively engaged in upland management. The survey was also distributed amongst a number of working groups. Potential participants were sent an email with a link to the survey and sent a reminder email several weeks later. We received 125 completed responses, of which approximately 25% were conservation or recreation practitioners and over 50% were upland landowners or land managers. The remaining 25% selected ‘other’ and did not stipulate their profession/relevance to the uplands. It should be noted that the grouse shooting and farming community were particularly well represented within this sample. This was due to certain organisations heavily promoting the survey amongst their membership. This over-representation was considered when analysing the results of this survey.

Importantly, this survey should not be seen as an attempt to quantify the different perspectives across different stakeholder types or to demonstrate which perspectives are more dominant among upland practitioners. However, the diverse range of participants and the viewpoints they shared does shed light on the broad range of different perspectives that should be acknowledged in relation to upland management and recreational activity.

The advantage of capturing the perceptions of practitioners on the influence of recreational activity on biodiversity in the uplands, means that issues can be highlighted that have emerged recently (e.g., an increase in recreational pressure because of the COVID-19 pandemic) or that have been historically under-researched. Nonetheless, perceptions based on experience may be subjective and lack the rigour of research studies. **Critically, the survey findings in the evidence review does not mean practitioner perspectives have or should be used as an alternative form of evidence.** Instead, they are presented in detail, in a separate appendix (Appendix VII). A brief summary paragraph for each Research Question is included towards the end of each evidence chapter (3-5) to highlight where practitioner perceptions were supported or contested by the evidence review. This helped to indicate where further research, or stakeholder engagement, might be required to address the conflicts between practitioner perceptions and evidence.

2.8 Presentation of Results

The results are presented in three chapters addressing two research questions in each: **Chapter 3** presents the evidence and practitioner perspectives for Research Questions 1 and 2, **Chapter 4** presents the evidence and practitioner perspectives for Research Questions 3 and 4, and **Chapter 5** presents the evidence and practitioner perspectives for Research Questions 5 and 6.

For each of the evidence chapters, all the evidence that has been screened and validated has been treated as relevant evidence for this review. There are important distinctions in the different sources of evidence (Table 2.6). These are not referred to in the text, but are recorded for every study included in this review in the Evidence Table in Appendix I.

Table 2.6: Evidence Types and Terminology

Type of evidence	Method of data collection	Code used in Appendix VI
High quality objective evidence from empirical academic research	Systematic review of academic literature through Boolean search	Academic Evidence – Boolean Search (AE-B)
High quality objective evidence from empirical academic research	Snowball sampling from literature reviews identified in the Boolean search screened out because not entirely relevant (geographical or topic)	Academic Evidence – Additional Search (AE-SS)
High quality objective evidence from empirical academic research	Specific search of academic literature where call for evidence highlighted evidence missing from Boolean search	Academic Evidence – Additional Search (AE-AS)
High quality objective evidence from practitioners	Emailed material generated from practitioner call for evidence	Practitioner Evidence (PE)

In addition to formal evidence, the review also sought the perspectives of practitioners working in upland ecosystems, on their perception of recreational impacts in upland ecosystems. Practitioner perspectives were obtained through the direct call for evidence and through the invitation to participate in an online survey. This material has not been included as evidence in the main chapters, except as a short summary paragraph. Instead, the detail of these 'practitioner perceptions' is detailed in Appendix VII.

For each evidence chapter (Chapters 3-5), the same structure has been adopted, summarised below:

- Summary of main findings, key evidence and recommendations
- Context including relevant prior evidence published by Natural England and setting out of the research questions
- Evidence statements
- Summary of practitioner perspectives
- Recommendations and further research

Appendix I presents the Evidence Table for each study addressing the six research questions. The Evidence Tables summarises by lead author and year of the study; the type of study, the country/countries included in the study, the type(s) of recreation, a brief summary of the key evidence, the aggregate validity scores, the level of agreement in validity scores between reviewers and the overall validity score.

3. Recreational Activity in the Uplands: Types and Influencing Factors

3.1 Introduction

This chapter seeks to address the following research objectives:

1. What types of recreational activity take place in the UK uplands?
2. What factors influence the level of recreational activity in UK uplands?

The chapter begins with a section that provides some context to these research objectives using literature from beyond the evidence review. The following sections provide a synthesis of the findings from the evidence reviewed related to the types of recreational activity in UK uplands and the factors influencing the level of activity. The final section provides a summary of the key themes from the practitioner perspectives against these research objectives. These have been separated out to differentiate between the formal evidence and the more subjective perspectives of practitioners. Further supporting data and analysis of the practitioner survey is compiled in Appendix VII.

3.2 Context

On a global scale, visits to upland landscapes account for over 20% of all tourism (UNEP, 2007). In the UK this proportion is likely to be lower, but in 2007 the UK uplands attracted over 100 million day visits a year (RSPB, 2007). Many visits are focused on designated landscapes in the UK, with visitor data demonstrating that over 45.2 million people visited upland National Parks in England in 2017 (Glaves, *et al*., 2020). Importantly, data from Natural England's Monitoring Engagement with the Natural Environment (MENE) survey estimated that visits to 'mountain, hill or moorland' increased from 61 million in 2009/10 (Natural England, 2010) to 147 million in 2018/19 (Natural England, 2019). Similarly, many upland National Parks across the UK are reporting overall increases in visitor numbers and changes to the demographics of those visiting (e.g., see CNPA, 2022). Evidence from across these different sources highlights that recreation in the UK uplands is growing in popularity.

Previous Natural England reviews have been undertaken examining the influence of some types of recreational activities across all habitats in England, although these focused primarily on only a few dominant types of recreation such as walking, dog walking, horse riding and mountain biking (Natural England, 2009*a*). There are a number of Natural England Evidence Reviews that deal specifically with aspects of recreation on upland peat and blanket bog including burning for driven grouse shooting (Glaves *et al*., 2013) and tracks (Grace *et al*., 2013). Other national reviews have also been undertaken by other organisations such as the Forestry Commission focusing on specific habitats (Marzano and Dandy, 2012).

Globally, recreational activities are diversifying rapidly to include novel uses such as geocaching, electronic biking, free-flight activities (i.e., hang-gliders, paragliders) and drone activities (see for instance Huddart and Scott, 2019; Tobajas *et al*., 2021). These new forms of recreation create new opportunities and challenges for the protection of habitats, species and ecosystem functions.

In addition, studies have shown that the COVID-19 pandemic has further influenced recreational trends in many locations in the UK (and across Europe, see for instance McGinlay *et al*., 2020). This has highlighted that the demand for recreational activities has increased in key locations emphasising the need for managing both increasing visitor numbers and new profiles of visitors (*ibid*).

One of the most significant factors that has the potential to influence outdoor recreational activity is access rights. The rights surrounding public access to the uplands across the UK have a varied and complex history, as outlined in Section 1.1. The CRoW Act (in England and Wales) and the Land Reform Act (in Scotland) resulted in significant changes to the area of land that could be freely accessed by the general public, without the requirement to remain restricted to footpaths. Nonetheless, under CRoW, there were still some management measures put in place that could be used by landowners to lessen recreational impacts on biodiversity, e.g., preventing access (excluding from public rights of way) for set time periods or imposing dog control restrictions. Following the introduction of CRoW in England and Wales, the extent of access restrictions to humans has been reported as low, with a general perception that the influence of the legislation on wildlife (particularly ground-nesting birds) was not particularly negative (Bathe, 2007). Nonetheless, these initial assessments immediately following the introduction of increased access rights had a significant focus on lowland species, and irrespective, are increasingly becoming outdated. With the potential for growing visitor demand and also changes in the types of popular recreational pursuits, including novel forms, the evidence base of recreational influence in upland landscapes needs to be revisited.

In this context, this chapter explores the evidence (from academic literature and practitioner submissions) published or produced in the English language since 2000 on the types of recreational activity occurring in upland ecosystems in the UK, and what factors influence the level of recreational activity in the UK.

3.3 Evidence on the Types of Recreation

3.3.1 Recreation types within academic literature

In total 114 pieces of evidence (hereon in 'studies') were included within this review. All studies reviewed related to data collected in the UK and varied considerably in terms of their validity (see Appendix I for Evidence Table).

Of these studies:

- 64 were undertaken / partially undertaken in England;
- 55 were undertaken / partially undertaken in Scotland;
- 12 were undertaken / partially undertaken in Wales;
- 5 studies were undertaken / partially undertaken in Northern Ireland; and
- 2 studies were either using data that was not specific to a location or were unclear about the location of the study.

Note that some studies covered multiple countries so total > 114.

No studies were identified that attempted to classify the extent or distribution of different recreation types within the UK uplands or general trends in upland recreation.

Table 3.1 provides a summary of the studies across different recreation types and shows that the majority of studies included within this review focused on either general recreation, i.e., they did not specify the type of recreation under review (*n* = 29), or they researched driven grouse shooting / the associated management of grouse moors (*n* = 57) or they focused on walking/hiking (*n* = 17).

In total, across 114 pieces of evidence, only 16 different types of recreation occurring in the UK uplands were the subject of empirical studies (along with 'general recreation').

Table 3.1: Occurrence of recreation types within evidence

Recreation type	Number of studies
Driven grouse shooting	57
General recreation*	29
Walking/hiking	17
Climbing and bouldering	7
Walked-up grouse shooting / hunting	7
Dog walking	5
Mountain biking / cycling	5
Skiing and snow sports	4
Motorised vehicles (off-road / 4x4 driving, scrambler / trail biking)	3
Barbecuing	2
Camping / wild camping	2
Fishing	2
Bird watching	1
Caving	1
Hill / mountain running	1
Organised events (broad)	1
Orienteering	1

*General recreation was a category developed for studies that did not clearly specify the specific type of recreational activity they were studying. These are coded as 'Recreation (general)' within the Evidence Table (Appendix I).

Note that some studies covered multiple recreation types so total > 114.

As displayed in Table 3.1 a significant proportion of studies did not focus on specific types of recreation (25 studies). The majority of studies focused on one specific type of recreation (75 studies). Only three studies attempted to classify all major forms of recreation occurring within individual study sites. Importantly, these three studies were all conducted in the lowlands (but studied species and habitats applicable to upland contexts). Nonetheless, this highlights that there is a complete absence of literature comparing multiple recreation types in upland areas. These studies selected a small range of recreation types (maximum four) that were representative of a range of different impacts, e.g., walking/hiking (sometimes defining the difference between with and without dogs), mountain-biking and motorised vehicles. All three studies that explored multiple forms of recreation occurring within one or more sites identified walking/hiking or dog-walking as the most prevalent recreational pursuit in terms of numbers of visitors. It should be noted that there was concern that evidence on 'driving' to undertake recreation may be confused with motorised forms of recreation, but in actuality very few articles identified any forms of recreation or accessing recreation linked to driving.

3.3.2 Potential types of upland recreation

A comprehensive list of 28 potential types of upland recreation (non-bolded text in Table 3.2) were developed by the Evidence Review Group, informed by academic literature and expert knowledge of the uplands from Natural England colleagues. In addition, the practitioner survey helped identify twelve further types of recreation occurring (in bold text, Table 3.2) in upland areas across the UK.

Table 3.2: Major recreation types informed by literature and practitioner survey

Recreation type	Recreation type
• Hiking/walking • Dog walking • Climbing / Bouldering • Hill / mountain running • Orienteering • Triathlon • Mountain biking / cycling • E-biking / Electronic biking • Scrambler / trail biking • Off-road / 4x4 driving • Road / scenic driving • Birdwatching • Fishing • Driven shooting • Walked-up shooting / hunting • Skiing / snow sports • Paragliding • Drone flying • Model airplane flying • Canoeing / kayaking • Sailing / boating	• Swimming • Horse riding • Camping • Barbecuing • Picnicking • Fireworks • Raves • **Citizen Science led amateur excavation and recording** • **Sailing model / toy boats** • **Organised events (general)** • **Organised fell races** • **Organised walks or charity walks / runs** • **Organised river walking / ghyll scrambling** • **Rescue dog training** • **Photography** • **Hound trails** • **Pony trekking / alpaca walks** • **Rowing** • **Foraging**

Bold relates to recreation types that were identified specifically by the practitioner survey.

There was **no evidence** detected that provided an overview of all the different types of recreational activity in the uplands and their distribution. Although some evidence exists on the types of recreation occurring within specific localities this is only based on individual project reports (e.g., Faber Maunsell, 2009, **3-**). The exception is one national study (White *et al*., 2013, **2+**) which provided an assessment of 4255 voluntary visits to different types of natural environments within England. This study found that 'walking without a dog' was the most frequently cited reason for outdoor recreation amongst this sample of participants (*n*=1117, 26%) followed by 'walking with a dog' (*n*=1030, 24%), playing with children (*n*=280, 7%) and exercising (*n*=287, 7%). Very few participants within this sample selected 'hunting' or 'off-road driving' as their recreational interest. It is important to note however that this study did not target UK uplands specifically.

There was **no evidence** found in this review that specifically measured the level or intensity of recreational use for any types of recreation specific to upland environments. One study (Sport England, 2021, **3-**) provided approximate figures for two specific types of recreation, which based on the 'Sport England Active Lives Adult Survey' conducted in 2020/21 reported that 3,219,800 people were actively hill and mountain walking, and 135,400 people were actively climbing and bouldering outdoors. It is not clear from this survey, the extent to which these pursuits were specifically undertaken in the uplands, but given the nature of the categories it is likely that the majority were.

3.4 Evidence statements on the Factors Influencing Recreational Activity

The studies included within this section of the literature review highlighted that the way in which 'level of recreational use' can be defined is complex and can vary between studies. The scope of the evidence obtained in this review covered three broad areas, including the distribution of activities, the type of activities and the levels of use. An additional interpretation of 'level of use' not covered in this review, related to the behaviour of visitors from a sociological or applied human behaviour perspective (e.g., how attitudes towards the environment may influence recreation in the uplands). The absence of evidence on this interpretation of 'level of use' is probably in part because of the focus of the specific search terms (see Section 2.3.1). In particular, sociological studies on visitor behaviour rarely focus on specific ecosystems so the focus of this review on upland ecosystems may have prevented their inclusion. Similarly, we retrieved very little evidence that examined specific social or economic factors relating to different types of visitors (e.g., demographic characteristics such as income, education, gender, etc.) although see for example, Suckall *et al*., 2009, **2+** and Zografos and Allcroft, 2007, **2+**. Whilst these factors are important in understanding issues relating to broader influences on recreational level, the Evidence Review Group agreed to maintain the original scope of the evidence review, and to focus on factors that could be directly controlled by upland management.

Overall, 27 studies were identified that examined the factors influencing recreational activity, although only 19 of these empirically tested these factors, with the remaining studies only describing the effects. Only a very small number of studies focused specifically on examining these factors as their primary focus, whereas other studies cited data on these factors as a secondary element of the study. Importantly, the way in which 'level of use' was defined or measured were often conflated within studies and the three broad categories (distribution, type and levels) have therefore not been used to structure the findings.

Instead, evidence about the influence of different factors on levels of recreation activity have been grouped into four broad categories: 1) the overall accessibility of upland areas, 2) 'natural' landscape or site-based factors, 3) site-based management factors including accessibility, management and provision of facilities, and 4) other environmental influences. As above, this search only obtained very limited literature on how socio-economic characteristics or human behaviour may influence levels of recreational activity.

3.4.1 Evidence of the overall accessibility of upland areas influencing levels of recreational use

Influence of proximity to large residential population

There was **strong evidence** across four studies of different validities (**1+**, **1-**, **2+**, **4-**) that outlined that the proximity of sites to large residential areas influenced visitor numbers. One study (Hornigold *et al*., 2016, **1+**) that examined the relationship between outdoor recreation and biodiversity value at a national scale in England, described that the larger the resident population near a site, the more likely it is to be visited, with source population effects diminishing with distance due to increasing travel cost (and time). Another study (White *et al*., 2013, **2+**) that examined 4255 voluntary visits to different types of natural environments within England, reported that approximately 70% of all visits were within 5 miles and are thus relatively local. Drawing on broader literature, this study stated that greenspaces were used progressively less frequently the further away from home they are, with substantial drop-offs

in use occurring beyond around 500–800 meters from home. One study (Underhill-Day and Liley, 2007, **1-**) examined visitor surveys from lowland heath sites across the south of England. This study found that the majority of visitors to urban and suburban lowland heaths visit sites regularly and live nearby (within 5 km). These pressures were also likely to be important in the context of accessible upland areas. Another study (Cavan *et al*., 2006, **4-**), examined stakeholder perceptions of wildfires in the Peak District in relation to visitor pressure. This study outlined that the close proximity of the Peak District to several major urban areas, was a critical factor in influencing visitor numbers. The evidence from the first three of these studies was only partially applicable to this review on upland ecosystems, as they included lowland ecosystems, and the third study (Underhill-Day and Liley, 2007, **1-**) focused solely on lowland ecosystems, although this included bird species associated with UK upland ecosystems.

Whilst not directly contributing to this evidence statement, the Monitor of Engagement with the Natural Environment (MENE) national survey on people and the natural environment (Natural England, 2019, **1+**) noted that since 2009, visits to green spaces within a mile have increased, while visits beyond a mile have remained relatively constant. This report also showed that in 2018/19, approximately two thirds of visits were taken on foot, with almost a third by car. Furthermore, the average distance travelled on journeys taken by car has decreased somewhat over time from around 15 miles to just over 10. However, this study did not examine the impacts of these results within specific localities and is only partially applicable as it is England-wide and not focussed on upland ecosystems.

Influence of proximity to road network on levels of recreational use

There was **weak evidence** across two academic studies (**1+**, **5+**) that suggested that the likelihood of visitor pressure was influenced by accessibility factors such as distance from a road network. One England-wide study (Hornigold *et al*., 2016 **1+**) demonstrated that probability of visits to sites across England was strongly reduced for sites far from major road networks. Another study (Hanley *et al*., 2002, **5+**) that modelled factors affecting levels of mountaineering in Scotland, highlighted the importance of understanding accessibility across a number of different sites. This study predicted that decreasing accessibility (via road networks) could reduce the number of visits to mountaineering sites by 44% (based on a 2 hour increase in travel time), compared with a 33% reduction if car parking fees were raised by £5. Interestingly, the study also highlighted that by reducing the appeal of one site, sequential implications could result for other sites in the vicinity, which would see an increase in popularity (*ibid*).

Influence of socio-economic characteristics influencing levels of recreational use

There was **weak evidence** from one academic study (**2+**) that highlighted that socio-economic characteristics, specifically social ‘class’ and ethnicity had an effect on the likelihood of recreational use occurring in upland environments. This study (Suckall *et al*., 2009, **2+**) explored the differences in perceptions of an upland environment (the Peak District National Park) from residents of nearby Sheffield and demonstrated that belonging to a particular group (either class or ethnicity based) influenced the decision to access upland environments. ‘Working class’ children were significantly less likely to want to visit than ‘middle-class’ children ($p < 0.05$). Importantly, ease of access was not a determining factor in this instance. Additionally, ethnic groups unfamiliar with the National Park did not want to visit, whereas ethnic groups previously involved with environmental volunteering in this environment were significantly more likely to visit ($p < 0.05$). Importantly this demonstrated that groups who previously had no historic connection with UK upland ecosystems, such as new immigrants to the UK, could change their opinions, if they were given the opportunity to do so.

Influence of organised events on levels of recreational use

There was **moderate evidence** from three studies (**2+**, **3-**) that organised events encouraged greater visitor usage of upland areas. One study (Suckall *et* al., 2009, **2+**) demonstrated that between two ethnic groups living in Sheffield, those involved in an organised outreach and volunteering group undertaking environmental volunteering in the Peak District National Park, were significantly more likely to want to visit upland environments than a control group that had not been part of an organised activity. Another study (Parker, 2009, **3-**) demonstrated how an orienteering event that took place over the former upland mining area of Titterstone Clee in the West Midlands of the United Kingdom, had the potential to impact breeding wheatear (*Oenanthe oenanthe*) by attracting over 1000 visitors in a weekend. Another study (Tate, 2021, **3-**) described through analysis of survey data that visitors to the Cumbria and Lake District region were attracted by organised events such as the Keswick Convention, Lake District Summer Music, as well as marathons and trail events. However, the extent and impact of these events were not explored or quantified in any studies identified within this review.

3.4.2 Evidence of natural landscape or 'site-based' factors that influence levels of recreational use

Influence of landscape features on levels of recreational use

There was **moderate evidence** from three studies (**1+**, **2+**, **3-**) that landscape features were likely to play an important role in influencing visitor use of sites. One study (Hornigold *et al*., 2016, **1+**) that modelled outdoor recreation at a national scale, examined habitat preferences of visitors to statutory designated sites (Sites of Special Scientific Interest (SSSI)). This study demonstrated that recreational users across the UK preferred areas of coast, freshwater, broadleaved woodland habitats and avoided arable, coniferous woodland and lowland heath. Another study (Gosal *et al*., 2021, **2+**) used on-site surveys and participatory mapping at Ilkley Moor and identified that a range of factors including landscape features such as open moorland all influenced visitor use of the site. A final study (Tate, 2021, **3-**) demonstrated from visitor survey data that 63% of people chose to visit the Lake District and Cumbria because of the physical scenery and landscape.

Additionally, another study (White *et al*., 2013, **2+**) that used MENE data (Natural England, 2019, **1+**) suggested that visits to mountain and hills, woodland, farmland and beaches, tended to result in the highest levels of enjoyment, relaxation and feeling close to nature. However, this data is only partially applicable as it does not attempt to link the influence of these landscape features in terms of levels of recreational use of upland areas, so has not been included in the previous evidence statement.

There was **weak evidence** from one study (**2+**) that users of sites were likely to be influenced differently by different landscape features. This study (Gosal *et al.,* 2021, **2+**) showed how factors varied between users with 'high' and 'low' environmental awareness demonstrating that knowledge of breeding birds and their vulnerability during nesting season had a significant impact on the spatial behaviour of visitors to the area (*ibid*).

There was **no evidence** found in the sample collected for this review that examined preferences towards any specific upland habitat features or the implications in terms of levels of recreation.

Influence of habitat and species condition on site use

There was **moderate evidence** from three studies (**2+**, **5-**) that demonstrated how some specific recreation types were influenced by the abundance of specific species. These related

to recreation based on species that are quarry such as angling (Johnstone and Markandya, 2006, **5-**) and grouse shooting (Ludwig *et al*., 2017 **2+**; Ludwig *et al*., 2020 **2+**).

However, there was **no evidence** found in this review that tested the effects of species or habitat condition on the number or type of visitors to upland areas or their behaviour.

Influence of nature conservation designations on site use

There was **weak evidence** from one study (**1+**) that suggested 'high nature value' sites do not provide additional recreate onal value for members of the general public. Using data from a national study of recreational users across England, one study (Hornigold *et al.,* 2016, **1+**) showed that high conservation appeal of habitats did not affect the likelihood of recreational access (broadleaved woodland was similar irrespective of whether it was designated as an SSSI, $z = 0.7$, $p = 0.47$, as was semi-natural grassland although the p value was not provided). Visits to the coast, freshwater, heathland, coniferous woodland were all likely to be significantly lower if sites were designated SSSIs ($p < 0.001$). These findings suggest that recreational benefits may not be gained from high nature value sites and recreation could be better targeted at lower value sites. However, this evidence is only partially applicable to this review because it did not focus exclusively on the uplands, and the findings have not been explored in relation to a diverse range of different upland habitats.

3.4.3 Evidence of 'site-based' management factors that influence levels of recreational use

Influence of access rights on levels of recreational use

There was **weak evidence** from two studies (both **3-**) that demonstrated access permission was a key influencing factor impacting levels of recreational use for specific activities. One study (Gunn *et al*., 2000, **3-**) that examined recreational impacts on aquatic invertebrates in two caves in the Peak District, described that open access caves received high levels of recreational use. Another study (Leyland, 2021,**3-**) that surveyed the potential impact of climbing sites on breeding ring ouzel (*Turdus torquatus*) in the Peak District National Park, suggested that climbing levels were reduced by establishing access restrictions during specific breeding periods (discussed further in section 5.4.5).

In terms of the impact of 'Open Access' legislation in upland ecosystems, there was **weak evidence** from two studies (**2-**, **3-**) that the Countryside and Rights of Way Act (CRoW) had negligible impacts on visitor levels and behaviour in specific localities. One study (Warren *et al*., 2009, **2-**) examined the impacts of the Countryside and Rights of Way Act (CRoW) on black grouse (*Tetrao tetrix*) via field surveys in 2004 and 2005. They concluded that although CRoW created 'Open Moorland' in 2005, there was little evidence of change in recreational pressure or the public's behaviour. They highlighted that visitors in the area mostly stayed on existing linear marked footpaths rather than straying from them and there was no obvious increase in the number of people using such areas after access rights changed. This was also the findings of one study (Faber Maunsell, 2009, **3-**) that examined the impact of the CRoW Act on visitor use of three individual upland sites. This study undertook visitor counts and face to face surveys across three years on weekends and bank holidays to compare use of open access land (under CRoW) and areas where access was restricted in the years after CRoW was introduced. Across all three sites (in different areas of Northern England), negligible impacts on the levels of recreational use were identified.

There was, however, **no evidence** from comprehensive large-scale studies on the impact of the CRoW Act on the level of recreational activity or use of sites over longer time frames and in different locations.

Influence of footpath provision on site use

There was **strong evidence** from five academic studies of varying validity (**1+**, **2+**, **4-**, **5+**, **5-**) that suggested that visitors to upland areas use the upland footpath network and that this provision can influence visitor behaviour. One study (Hornigold *et al*., 2009, **1+**) demonstrated that the density of footpaths was an influencing factor in SSSI use at a national scale, and another localised study (Gosal *et al*., 2021 **2+**) showed that the proximity of footpaths to recreation sites was a key feature in influencing visitor behaviour. Another study (Cavan *et al*., 2006, **4-**) exploring the impact of climate change on the visitor economy noted that 87% of visitors to the Lake District National Park used the upland footpath network. One study (Gordon *et al.,* 2002, **5-**) described how access improvements via footpath provision have led to higher recreational use in key areas of the Cairngorms. The final study (Hanley *et al*., 2002, **5+**) highlighted that an important consideration related to footpath provision is that by increasing physical footpaths in one location, other locations can be influenced by making them more accessible.

It should be noted that none of these studies specified the difference between Public Rights of Way and other forms of footpaths such as permissive paths or desire lines and there was **no evidence** found in this review that analysed the difference in recreational use associated with different types of footpath.

Influence of car park provision on levels of recreational use

There was **moderate evidence** from three studies (**1-**, **2+**, **5+**) that car park provision influenced recreational activity. One study (Hanley *et al*., 2002, **5+**) that modelled the influences on the popularity of mountaineering sites in Scotland identified both distance from car parks and the application of car parking charges as important factors. Another study (Mallord *et al*., 2007, **2+**) that examined the impact of recreation on woodlark (*Lullula arborea*) also identified 'distance from nearest car park' as an influencing factor determining visitor numbers and behaviour. A further study (Underhill-Day and Liley, 2007, **1-**) that examined lowland heathland visitor surveys described how the size and accessibility of car parks often limited the numbers of visitors on a site. The evidence from the last two studies is only partially applicable however, as they were conducted in lowland areas where the relationship between car park provision and level of recreational use may be different from upland sites.

3.4.4 Evidence of other environmental factors that influence levels of recreational use

Influence of climate change interacting with recreational activities

There was **moderate evidence** from across three studies (**2+**, **4-**) that indicated climate change has already, and will continue to influence recreational activities in upland areas. One study (Harrison, *et al*. 2001, **2+**) indicated that changes in winter snow cover have already influenced recreation in Scotland including causing a reduction in skiing and snow sports but have caused increases in mountaineering and ice-climbing (the latter, because melt periods followed by cold weather have improved ice-climbing conditions). Two additional studies that drew from the same research project (Cavan *et al*., 2006, **4-**; McEvoy *et al*., 2008, **4-**) also predicted that climate change would lead to increases in visitor numbers in upland ecosystems, particularly in the summer.

Influence of timing on levels of recreational levels

There was **moderate evidence** from two studies (**2++**, **2+**) that demonstrated that visitor numbers increased significantly in popular upland areas during weekends and summer

months and that this increased visitor pressure is associated with more frequent disturbance events. One study (Finney *et al*., 2005, **2+**) that explored disturbance to golden plover (*Pluvialis apricaria*) on the Pennine Way, used surveys of footpath use to demonstrate that two thirds more users were present at weekends than on weekdays. A related, follow-up study (Pearce-Higgins *et al*., 2007, **2++**) that examined disturbance effects to golden plover and dunlin (*Calidris alpina*) on Saddleworth Moor, reported a doubling of visitors to the area during weekends with potential implications on disturbance if sufficient infrastructure was not provided (see Section 4.3.2).

3.4.5 Evidence of changing recreational use in upland areas

Influence of increasing recreational visits to upland areas

There was **no evidence** that provided quantitative empirical data on how levels and types of recreational activity may have changed over time with a specific focus on UK uplands.

There was, however, **moderate evidence** from three studies (**1+**, **2+**, **3-**) that suggested there had been a recent increase in visitor use in upland areas although these did not provide evidence of specific drivers of change. For instance, whilst data from Natural England (Natural England, 2019, **1+**) suggested the frequency of visits to the countryside may have decreased recently (with more frequent visits being taken in parks in towns and cities) analysis of this data specifically reported that visits to 'mountain, hill or moorland' had increased during the same period. This was also supported by other evidence in specific upland locations. One study (Tate, 2021, **3-**) that used STEAM[1] Tourism Economic Impacts data retrieved in 2019 stated that visitor numbers to Cumbria have increased by 15.2% since 2014. Another study (Whitfield *et al*., 2007, **2+**) outlined trend data across Scotland, which described a general rise in visitors from the 1960s and a sharp rise in the 1980s before levelling off in the 1990s. Importantly however, these trends were not validated with quantitative data.

There was **weak evidence** from two studies (**1-**, **3-**) that demonstrated that the COVID-19 pandemic affected the number of people visiting upland ecosystems. One study (Natural England, 2021, **1-**) reported that the pandemic had reduced the number of people visiting upland areas, but when the lockdowns lifted, the number of visits saw a resurgence. This study summarised the findings of the 'People and Nature Survey' (the successor to MENE) and reported that of the people sampled, only 7% visited 'hill, mountain or moor' in April 2020, but that this rose to 13% by September 2020 suggesting that national lockdowns imposed because of the pandemic changed recreational patterns in the uplands during lockdown but once restrictions lifted, the proportion of people visiting nearly doubled. Another study (Friends of the Lake District, 2021, **3-**) reported a similar phenomenon specifically for the Lake District. When the COVID-19 lockdown was lifted in mid-May 2020, and domestic travel could resume, there was a significant increase in visitors to the Lake District National Park, including types of visitors unfamiliar with how to behave responsibly in the countryside. This latter study did not provide specific figures or evidence to underpin this assertion, however.

Influence of changing social attitudes towards biodiversity conservation in upland areas

There was **weak evidence** from one study (Zografos and Allcroft, 2007, **2+**) that explored social attitudes towards ecotourism across 20 Scottish sites, which highlighted that there is growing demand for ecotourism. The study demonstrated high levels of visitor interest for a Scottish ecotourism experience with an emphasis on biodiversity conservation and that requested facilities for wildlife watching, hill walking and relaxing. Importantly however, this

[1] STEAM (Scarborough Tourism Economic Activity Monitor) is an evaluation model used by many Destinations Management Organisations

study demonstrated that the appeal of ecotourism was not limited only to people holding 'green' values, as over 20% of the potential ecotourism market held anthropocentric values of nature (e.g., more instrumental perceptions of the environment and confident in human skills and development). More anthropocentric market users did affect the type of ecotourism activity that they may participate in however, being more likely to engage in hill-walking than 'ecocentric' wildlife-watchers.

3.5 Practitioner survey synopsis: Types of recreation and influencing factors

As detailed in Section 2.7 of the methodology, an online survey was undertaken as part of the call for evidence for this review, to ascertain perspectives of practitioners working in the uplands and to highlight any synergy and disconnect with the review of written evidence. A more detailed analysis of this data is presented in Appendix VII, but the key messages are summarised below.

Broadly, the themes identified in the practitioner survey responses reflected the themes identified in the evidence reviewed in Sections 3.3. and 3.4 of this chapter, although the survey did raise some additional aspects. For instance, some practitioners identified additional recreation types occurring in the uplands that were not identified in the academic literature, including citizen science-led amateur excavation and recording, organised fell race, boating, organised river walking, rescue dog training and hound trails. Practitioners also highlighted the critical difference between legal and illegal activities, especially concerning mountain biking and off-road driving, which was not a significant theme in the written academic evidence.

Overall, there was a perception that recreational activity in the uplands has steadily increased since 2000. Whilst the survey did not necessarily confirm that practitioners perceived the implementation of the CRoW Act as a significant cause of increases, there was a general agreement that recreation had increased since this time period. By contrast, many of the free-text comments highlighted that the COVID-19 pandemic (transitioning between lockdowns and interim periods) was considered a notable point (or points) in time that significantly altered recreational use in upland areas. Practitioners highlighted increased pressure on sites during the opening up of national lockdowns creating new challenges for upland landscapes, partly because many of the 'pandemic' visitors were often less accustomed to upland areas and were less aware of the sensitivity of these ecosystems.

Regarding factors that influence recreational activity, there was a high degree of consensus amongst practitioners and within the evidence, that the ease of access to certain key upland areas was a significant factor impacting levels of recreational activities, followed by the proximity to tourist facilities and site infrastructure aiding accessibility and use. Additionally, some participants also highlighted that recreational activity was influenced by socio-cultural factors. For instance, there was a perception held by some participants that certain demographic groups and communities had a long history of accessing upland landscapes and that this was part of their culture. Whereas other sectors of society did not have the same 'cultural' connection to these landscapes.

Another key theme within the survey was that organised events held in upland areas cause significant negative impacts on upland landscapes. Participants stated that while upland events have been taking place for a long time, the number and type of events have increased in recent years. There was also a concern, primarily held by some farming community members, that specific non-governmental organisations and public bodies were encouraging

greater use of upland areas, increasing the pressure placed on these ecosystems. Respondents also highlighted both the positive and negative importance of social media, commercial advertisements, and published materials in relation to recreational use and the behaviour of users, which were notable differences from the published evidence reviewed. High levels of dog ownership and the ease with which dog walking can occur in the uplands were also mentioned as significant concerns, which again contrasted with the written evidence reviewed.

3.6 Summary of evidence, gaps and recommendations: types of recreation and influencing factors

The following section summarises the strong and moderate evidence statements produced in this chapter, outlines the gaps in evidence and from these suggests a series of recommendations.

3.6.1 Summary of evidence: types of recreation and influencing factors

Research Question 1: What types of recreational activity take place in the UK uplands?

The following evidence was found in relation to Research Question 1: *What types of recreational activity take in the UK uplands?*

- In total, across 114 pieces of evidence, only 16 different types of recreation occurring in the UK uplands were the subject of empirical studies (along with 'general recreation').
- In total, 40 types of potential recreational activity occurring in the UK uplands were identified from evidence and practitioner perspectives (captured from the call for evidence and practitioner survey).

There were **no strong** or **moderate evidence** statements developed in relation to the types of recreational activity that take place in the UK uplands (see gaps in evidence).

Research Question 2: What factors influence the level of recreational activity in UK uplands?

The following nine **strong** or **moderate evidence** statements were developed in relation to Research Question 2, which examined the factors that influence the level of recreational activity in the UK uplands:

- There was **strong evidence** across four studies of different validities (**1+**, **1-**, **2+**, **4-**) that outlined that the proximity of sites to large residential areas influenced visitor numbers.
- There was **moderate evidence** from three studies (**2+**, **3-**) that organised events encouraged greater visitor usage of upland areas.
- There was **moderate evidence** from three studies (**1+**, **2+**, **3-**) that landscape features were likely to play an important role in influencing visitor use of sites, but these studies were not specific to upland ecosystems.
- There was **moderate evidence** from three studies (**2+**, **5-**) that demonstrated how some specific recreation types were influenced by the abundance of specific species (all quarry species).

- There was **strong evidence** from five studies of varying validity (**1+**, **2+**, **4-**, **5+**, **5-**) that suggested that visitors to upland areas use the upland footpath network and that this provision can influence visitor behaviour.
- There was **moderate evidence** from three studies (**1-**, **2+**, **5+**) that car park provision influenced recreational activity, although only one of these studies related specifically to the uplands.
- There was **moderate evidence** from across three studies (**2+**, **4-**) that indicated climate change has already, and will continue to influence recreational activities in upland areas.
- There was **moderate evidence** from two studies (**2++**, **2+**) that demonstrated that visitor numbers increased significantly in popular upland areas during weekends, bank holidays and the summer.
- There was **moderate evidence** from three studies (**1+**, **2+**, **3-**) that suggested there had been a recent increase in visitor use in upland areas, but this did not link changes to specific drivers of change or provide quantitative empirical data on how types of recreational activity may have changed over time with a specific focus on UK uplands.

3.6.2 Gaps in evidence: types of recreation and influencing factors

Research Question 1: What types of recreational activity take place in the UK uplands?

The following two gaps in evidence were found in relation to Research Question 1: *What types of recreational activity take in the UK uplands?*

- There was **no evidence** detected that provided an overview of all the different types of recreational activity in the UK uplands and / or their distribution.
- There was **no evidence** found in this review that specifically measured the level or intensity of recreational use for any types of recreation specific to upland environments.

Research Question 2: What factors influence the level of recreational activity in UK uplands?

The following five gaps in evidence were found in relation to Research Question 2: *What factors influence the level of recreational activity in UK uplands?*

- There was **no evidence** found in this review that tested the effects of species or habitat condition on the number or type of visitors to upland areas or their behaviour or the potential for ecotourism or its influence on upland ecosystems and only **weak evidence** found that explored the relationship between biodiversity value and recreational use (with a study that was not specific to upland areas).
- There was **no evidence** from comprehensive large-scale studies on the impact of the CRoW Act on the level of recreational activity or use of sites over broad time frames and in different locations.
- There was **no evidence** found in this review that analysed the difference in recreational use associated with different types of footpath (e.g., between Public Rights of Way and other forms of footpaths such as permissive paths or desire lines), although there was **strong evidence** that footpaths could influence levels of recreational use.
- There was **no evidence** found in this review that assessed whether accessibility by public transport affected levels of recreational use in upland areas, or whether more sustainable forms of transport could be effectively promoted to focus recreational pressure on less sensitive sites.

- There was **no evidence** that provided quantitative empirical data on how levels and types of recreational activity may have changed over time with a specific focus on UK uplands.

3.6.3 Recommendations: types of recreation and influencing factors

Research Question 1: What types of recreational activity take in the UK uplands?

The following four recommendations were developed in relation to Research Question 1: *What types of recreational activity take in the UK uplands?*

Recommendations from Evidence:

There was **no evidence** found in this review that sought to identify the types of recreation occurring in the UK uplands, other than non-analytical case-studies of specific sites. All the recommendations developed around Research Question 1 are therefore based on the absence of evidence.

Recommendations from Absence of Evidence:

- The evidence captured from both the search of academic literature and the practitioner call for evidence demonstrated that as many as 40 different recreational activities (and potentially more) may be occurring in the uplands, but only 17 types were analysed in the studies captured in this review. Further research is needed that classifies the type, extent and spatial distribution of different recreation types within the UK uplands, including identifying novel or emerging types of recreation.
- The proportion of evidence collected in this review was heavily weighted towards certain types of recreation occurring in the uplands, notably focussing on driven grouse shooting and to a lesser degree walking/hiking. Although not calculated in the evidence collected in this review, this is highly unlikely to be reflective of the proportion of participants that are occupied in upland recreational pursuits in the uplands (either participating or employed in supporting). Although this balance of evidence may be more proportionate to the relative influence of recreation types on upland ecosystems, there were notable types that were entirely absent or the focus of very few studies in the research, e.g., dog walking, mountain biking or use of motorised vehicles for recreation. Further research is needed that assesses the relative proportions of participants taking part in or supporting different types of upland recreational pursuits so that research and the active management of upland ecosystems can better reflect the level of recreational engagement.
- Further research is needed about how recreation has changed over time, including the type, extent and intensity of impact.
- The management of upland ecosystems needs to reflect and/or respond to the diversity in recreational use occurring in upland ecosystems.

Research Question 2: What factors influence the level of recreational activity in UK uplands?

The following 12 recommendations were developed in relation to Research Question 2: *What factors influence the level of recreational activity in UK uplands?*

Recommendations from Evidence:

- There was **strong evidence** that the proximity of landscapes to large residential areas was likely to influence the level of recreational activity, but none of this research was specifically focused on upland ecosystems. Further research is needed to better understand the relative pressures being placed on upland landscapes close to large residential areas, and the degree to which this is directed towards landscapes designated towards supporting recreation (e.g., National Parks and AONBs) and those with less resources to manage recreational pressure (i.e., upland areas outside of these designations)
- There was **moderate evidence** that organised events are likely to increase participation in recreational activity, but there was no research that attempted to identify the range or extent of these events in upland ecosystems. Further research is needed to better understand the types of organised events that occur in the UK uplands and the extent to which the desire to promote greater recreational engagement is balanced against the potential risks of recreational pressure and associated damage or disturbance to upland species, habitats and ecosystems.
- There was **moderate evidence** that landscape features were likely to influence the level and type of recreation, including two studies that suggested that recreational users preferred woodlands to open habitats. This research was not however, focused solely on upland ecosystems where the ability to view and experience dramatic scenery was also identified as an important influence on recreational use. In the light of contestations about the role of the uplands in providing more woodland cover and wilding, further research is needed on landscape preferences in the uplands and how this may influence levels of recreational use. Additionally, much of the evidence comes from upland areas designated for their landscape quality (e.g., National Parks and AONBs), with further research needed to understand perceptions of recreational users in areas outside landscapes that area protected for their scenic value.
- There was **strong evidence** that demonstrated the importance of footpaths for providing access and determining the level of use at sites, but these studies did not distinguish between Public Rights of Way and other forms of footpaths such as permissive paths or desire lines. Further research is needed that analyses recreational use associated with different types of footpath and whether this influences the level of use and the potential impacts.
- There was **moderate evidence** that demonstrated that car parks and other car-related infrastructure (e.g., accessibility of the road network) influenced the level of use at individual sites, but despite proposals in some studies that the strategic provision of car parks could be exploited to reduce the level of recreational use at sensitive sites (by diverting users to more resilient areas), there were no studies that attempted to assess whether this was effective. Further research is needed on how car infrastructure can be used to ease recreational pressure in upland ecosystems, and its role in managing or directing access to try to reduce impacts on the most sensitive sites.
- There was **moderate evidence** that climate change is already altering recreational use in the uplands, but there were no empirical studies that measured the degree to which this has, or may in the future, affect levels of use or associated impacts, other than evidence related to a reduction in snow sports. Further research is needed that explores how levels of use and the relative impacts of recreation may be affected by the combined influence of recreation and different climate change impacts. This research should reflect regional differences in likely climatic patterns (e.g., milder, drier winters versus milder, wetter winters) and secondary impacts such as wildfire risk and footpath erosion.

- There was **moderate evidence** that the level of recreational use in the uplands increases during weekends, bank holidays and the summer holidays, but there were no studies that measured this pattern of use over longer time frames (e.g., whether recreational pressure has increased during these peak periods). Further research is needed on how levels of recreational use change both in short-term and longer-term measures, and whether changes to employment patterns (e.g., home-working and a shorter working week) may also have affected (or affect in the future) recreational pressure in upland ecosystems.
- There was **moderate evidence** from three studies that suggested there had been a recent increase in visitor use in upland areas, but there was **no evidence** about how national/international social or policy drivers (other than CRoW) may influence recreational use in the uplands (e.g., the COVID-19 pandemic and the 'cost of living' crisis), although studies may yet be forthcoming. There was also no quantitative empirical data on how levels and types of recreational activity may have changed over time with a specific focus on UK uplands. Further research is needed that explores the drivers of change in recreational use in upland ecosystems and how this may influence the types and levels of use.

Recommendations from Absence of Evidence:

- There was **no evidence** found in this review that tested the effects of species or habitat condition on the number or type of visitors to upland areas or their behaviour. Additionally, there was **no evidence** about the potential for ecotourism or its influence on upland ecosystems and only **weak evidence** (from one study) that explored the relationship between high-biodiversity sites and recreational use. Further research is needed that explores the current and potential use of sites related to their biodiversity value in upland ecosystems, the potential scope and impacts of ecotourism in the UK and public perspectives around their use of upland sites linked to potential changes in policy drivers in the uplands (e.g., ELMS and changes to agricultural subsidies, etc.)
- There was **no evidence** from comprehensive large-scale studies on the impact of the CRoW Act on the level of recreational activity in upland ecosystems. Further research is needed to better understand how changes in access affect levels of use, particularly in the light of increased calls to extend access rights to other habitats beyond 'hill, heath and moor', including woodlands and reservoirs.
- There was **no evidence** found in this review that assessed whether levels of recreational use were influenced by the accessibility of sites by public transport or the role of more sustainable forms of transport in accessing upland ecosystems. Further research is needed that explores how access to upland sites influence recreational use and empirical studies that explore whether public transport can be exploited to focus recreational pressure in less sensitive areas.
- Research assessing the factors influencing recreation tended to be localised and site -specific (although see Clutterbuck *et al*., 2020 and Hornigold *et al*., 2009 for national studies). Further research is needed on the overall trends in recreational activity in the uplands, including spatial analysis demonstrating where pressure has increased and drivers of this change.

4. The influence of recreational activity on upland species, habitats and ecosystem processes

4.1 Introduction

This chapter seeks to address the following research questions:

- Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*
- Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

The chapter starts by providing the context to the evidence surrounding these research questions (Section 4.2). The evidence is then presented from a search of the academic and practitioner literature published or produced in the English language that explored the influence of recreational activity on UK upland species, habitats and ecosystems, and the relationship between types of recreation and their severity of impact, published since 2000. The evidence is structured sequentially by research question, with Research Question 3 addressed in Sections 4.3 and 4.4, and Research Question 4 addressed in Section 4.5.

4.2 Context

It has long been recognised that different recreation types can influence ecosystems and the species that inhabit them (IUCN, 1967). The degree to which recreational activities and their management exert a positive or negative influence on ecosystems is often debated, however. This debate has usually centred on whether the influence results directly from the recreational activity itself or its associated management. For example, there is generally widespread recognition of the negative influence of recreation types that cause a direct disturbance to wildlife, increase litter and pollution, exacerbate erosion, or increase the risk of major disturbance events like wildfire (Boyle and Samson, 1985). In upland ecosystems, the impact of recreation is a well-established research area, but globally, much of this literature pertains to recreational pursuits that only occur in montane regions such as the impact of snow sports. In the UK, robust evidence of the causes, extent and management of these negative influences in upland ecosystems is surprisingly sparse. Previous evidence reviews either examine only a few specific types of recreation (e.g., Anderson *et al*., 2005) or focus on one recreation type (e.g., Glaves *et al*., 2013).

Whilst recreation types that have a direct impact on ecosystems have long been recognised as potentially harmful to UK upland habitats and species, up until recently, the wider management of heathland and blanket bog for driven grouse shoots, was broadly supported by most conservation organisations as important for supporting priority species (e.g., see Natural England, 2009*b*). More recently, however, the management practices associated with maintaining extensive areas of heather in the uplands have been scrutinised because of their potential impact on biodiversity and wider ecosystem services, including being the focus of several Natural England evidence reviews, specifically on the impacts of burning on blanket bog (e.g., Glaves *et al.,* 2013; Glaves *et al.,* 2020).

The evidence collected in this review identified literature on 16 specific different types of recreation occurring in the uplands (as detailed in Section 3.3.1), as well as ‘general recreation’ (where no specific type of recreation was identified). Using the differences outlined

above, these 16 types have been divided into two distinct categories, based on how they influence upland ecosystems:

1. The first relates to recreation types where there is a direct influence or impact on upland ecosystems caused by people undertaking the recreational activity. This includes 'general recreation' and 14 of the 16 specific recreation types shown in Tables 3.1 and 3.2.
2. The second relates to recreation types where the dominant influence on upland ecosystems is through the year-round, landscape-scale management of the uplands, which is distinct from the recreational pursuit itself. This relates specifically to driven grouse shooting, and to a lesser degree (because of lower intensity management), walked-up shooting. Whilst all forms of recreational activity in the uplands are usually associated with some form of management, the extent, intensity and continuous nature of grouse moor management is notably divergent from most recreation management, and it receives a high degree of attention within academic literature.

This distinction between the 'direct influence' of different recreation types and the influence of grouse moor management have been separated for the remainder of this evidence review, and are dealt with in separate sections in Chapters 4 and 5.

4.3 Evidence Statements on the Direct Influences of Different Recreation Types on Upland Ecosystems

4.3.1 Evidence of the Influence of General Recreation on Upland Ecosystems

29 studies examined 'general recreation' in upland ecosystems, meaning that either all or part of the study made no distinction about the specific type of recreation that was being researched. Of these, 13 solely studied the influence on species, one solely examined the influence on habitat types, three studied how ecosystem processes may be affected, six studied across these groups (e.g., impacts on habitats and ecosystem processes) and six did not explicitly study impacts, but still included relevant information to this evidence review. It should also be noted that some of these studies were undertaken in lowland rather than upland habitats (see Section 3.2.1 and Evidence Table, Appendix I). The partial applicability of these lowland studies to this evidence review has been highlighted in each instance.

Effect of 'general recreation' on bird breeding success

There was **inconsistent evidence** of the influence of 'general recreation' on the breeding success of bird species.

There was **moderate evidence** across three studies (all **2+**) that suggested a negative effect of 'general recreation' on the breeding success of bird species. One study (Murison, 2002, **2+**) that examined the effects of disturbance from general recreation on European nightjar (*Caprimulgus europaeus*) populations found a negative correlation between the success of nightjar breeding on heavily visited sites compared with sites that had little or no public access. Additionally, path effects on disturbed sites correlated strongly with nest failure up to 225m from the path edge, with those closer to the path being more likely to be predated ($p = 0.012$). A similar study (Lowe *et al*., 2014, **2+**) found that the number of breeding pairs of European nightjar was significantly lower in areas with high levels of recreation ($n = 45$) than in areas of much lower disturbance from recreation ($n = 147$). Another study (Murison *et al*., 2007, **2+**) provided mixed evidence of disturbance to the breeding success of the Dartford warbler (*Sylvia undata*), with disturbance effects only identified as negatively impacting breeding

success in open heathland habitats compared with those with gorse (*Ulex*) species that provided more cover. Negative correlation between the timing of first broods and disturbance rates on heather-dominated territories was significant ($p < 0.001$), with delays of up to six weeks. Additionally, this study also demonstrated that disturbance and overall breeding productivity (number of successful broods) was negatively correlated for all habitat types, but only significantly so in heather-dominated territories ($p = 0.012$). The evidence from all of these studies (Murison *et al*., 2007, **2+**; Lowe *et al*., 2014, **2+**; Murison, 2002, **2+**) are only partially applicable to this evidence review as the research was conducted in the lowlands, although the species studied do breed in upland ecosystems in the UK.

There was **moderate evidence** from three studies (**2++**, **2+**) that showed an insignificant correlation between disturbance from general recreation and the breeding success of two different ground nesting bird species. One study (Baines and Richardson, 2007, **2++**) reported that three different fecundity measures of black grouse were unchanged by the proportion of flushing incidents (clutch size, breeding success and survival rates were all non-significant). Another study (Fletcher *et al*., 2005, **2+**) undertook an experimental study to assess whether disturbance from simulated recreation influenced the breeding success of northern lapwing (*Vanellus vanellus*). Using 15 sites in Upper Teesdale this study demonstrated that increased levels of experimental disturbance during incubation did not reduce lapwing clutch survival. However, the study emphasised that further research was needed to test greater levels of disturbance (high disturbance thresholds were still only once every four days) and cover a longer period of the breeding season (e.g., territory establishment). One other study (Mallord *et al*., 2007, **2+**) also found no correlation between levels of disturbance and nest failure in woodlark across 16 different sites. It should also be noted that there was **weak evidence** from the same woodlark study, which recorded a positive correlation between increased reproductive output and the number of people recorded on a site ($p = 0{\cdot}02$). This unintuitive finding was explained by the effects of breeding density potentially being higher, due to disturbance displacement in other areas. The evidence from this final study is only partially applicable to this review, however, as the research was conducted in the lowlands, although concerned a species known to nest in the UK uplands.

The inconsistency in the evidence surrounding the way in which general recreation affected the breeding success of different bird species suggests that responses to recreational disturbance is likely to be species specific, but it could also be affected by site specific variables such as the amount and type of vegetation cover as indicated by the Dartford warbler study (Murison *et al*., 2007, **2+**).

Influence of 'general recreation' disturbance on bird behaviour and population effects

There was **strong evidence** from four studies (**2++**, **2+**, **2-**) that bird behaviour and population effects (e.g., abundance, population density or overall survival) were negatively correlated with disturbance caused by 'general recreation', but this association was sometimes weak or context dependent. One study (Baines and Richardson, 2007, **2++**) reported that flushing distances of black grouse increased with disturbance frequency, with birds flushing at 60% greater distances when exposed to high disturbance rates, (55m under high disturbance, 34m under moderate disturbance, $p = 0.05$). Flushing was linked to population level effects (e.g., higher mortality) but this was not empirically examined. A similar study (Warren *et al.*, 2009, **2-**) about human disturbance of black grouse, described a hypothetical risk of negative impacts on survival rates of black grouse with regular or increased disturbance at winter feeding areas based on a mean density of 11±2 standard error (SE) birds/km^2 but this effect was not empirically tested. Another study (Summers *et al*., 2007, **2++**) examined the correlation between forest tracks and capercaillie (*Tetrao urogallus*) behaviour (avoidance) in four stands in Glenmore Forest and Abernethy Forest, Scotland. The study demonstrated a curvilinear

relationship with distance from tracks ($F_{2,92}$ = 33.91, p = 0.0136) including both linear and quadratic measures, which demonstrated an increase in tree use away from the tracks. Whilst the study showed that there were significantly different impacts between forests ($F_{1,92}$ = 6.84, p = 0.0104) and with different levels of human usage ($F_{1,92}$ = 27.75, p < 0.0001) the study did not disaggregate between different types of recreation and the impacts on habitat usage. Another study (Mallord *et al*., 2007, **2+**) on the effect of recreation on woodlark demonstrated that across 16 different sites, woodlark density was significantly negatively correlated with disturbance (p = 0.02). Through population modelling of different disturbance scenarios however, this study suggested that the potential increase in recreational disturbance associated with the introduction of the CRoW Act would have little discernible effects on woodlark. This was because although the area for potential disturbance increased under the CRoW Act, overall increases in disturbance was likely to remain low, and modelling of woodlark populations suggested that negative effects resulting from the change in access permission was only likely with large increases in overall disturbance.

An additional study (Caravaggi *et al*., 2019, **2-**) was assessed for the presence of a range of anthropogenic pressures in hen harrier (*Circus cyaneus*) breeding territories across Northern Ireland (and the Republic of Ireland). Results suggested that general recreation was detected close to many hen harrier nest sites, and the study concluded that this had the potential to directly disturb breeding activity, but the level of disturbance was not directly measured, and this has therefore not been included in the strength of evidence relating to disturbance.

Influence of 'general recreation' on habitat quality

There was **strong evidence** from four studies (**2-**, **2+**, **3-**, **4-**) that 'general recreation' had a negative impact on habitat quality. Two studies reported a negative correlation between recreation and freshwater habitat quality, although these studies occurred at very different scales. One study (Holland *et al*., 2011, **2-**) reported variable national-scale impacts of recreation on aquatic ecosystems, with one indicator of freshwater ecosystem services, habitat quality assessment, being unaffected by recreation, but the study found a negative correlation between rural recreation and aquatic taxon richness (p = 0.12). Important regional-scale impacts were identified with a negative correlation between taxon richness and recreation in regions where river basins contained upland areas of high amenity value close to high population centres (e.g., the Peak District and North York Moors), but this relationship was weaker where population centres were generally further from upland areas (e.g., North West and North East England). Another study (Forrester and Stott, 2016, **2+**) examined more localised impacts of recreation on freshwater habitat quality. This study indicated the presence of faecal *Coliform* levels described in mountain streams near winter recreation zones in the Cairngorms National Park, although the significance of these findings were not tested statistically. Another study (McEvoy *et al*., 2008, **4-**) that explored the combined impacts of climate change and broad recreation on upland landscapes identified the potential increased risks of wildfire as creating a significant risk to the quality of upland habitats including upland heath and blanket bog. A survey of visitors to the Lake District National Park (Friends of the Lake District, 2021, **3-**) also reported that small numbers of visitors (6-7% of those surveyed) admitted to damaging upland habitats through littering, leaving camping equipment that was damaged or damaging upland vegetation.

Influence of 'general recreation' on ecosystem processes

There was **moderate evidence** from two studies (**2+**, **2-**) of a negative correlation between 'general recreation' and water quality, a critical ecosystem process occurring in the uplands. These studies (Holland *et al.*, 2011, **2-**; Forrester and Stott, 2016, **2+**) related to water quality and were summarised in the previous section on habitats.

There was also **moderate support** (but not empirical evidence) from three studies (**3-**, **4-**) that the combination of climate change and recreation use in the uplands would negatively affect ecosystem processes although these were not tested with empirical evidence. Two related studies (Cavan *et al*., 2006; **4-**; McEvoy *et al*., 2008 **4-**) reported on the combined effects of climate change and associated increases in visitor numbers causing an increased risk and severity of wildfires. Both studies demonstrated through a case study of the Peak District National Park that climate projections suggested the risk and severity of wildfires in upland areas will be increased. This covered accidental fires (e.g., created by barbecues or cigarettes), malicious fires and managed burns that get out of control. Peak periods for fires set by the general public were identified, e.g., the bank holidays in May. Another report (PLB Consulting, 2008, **3-**) on the future of recreation and access in the North York Moors National Park predicted that climate change and recreation combined would increase wildfire risk, reduce natural flood management capabilities and increase erosion, but also predicted it may have a positive effect on carbon budgets if more UK residents chose to holiday in the UK rather than travel abroad.

4.3.2 Evidence of the Influence of Walking and Dog-Walking on Upland Ecosystems

17 studies reviewed walking and hiking in UK uplands, three of which also included dog-walking, and a further two studies examined dog-walking as a separate recreational activity. The following sections review this literature and show that the vulnerability of plant and animal communities to walking and dog-walking pressure were related to factors such as spatial patterns of visitor use, the intensity of use, the wetness and slope of the ground, and the sensitivity of the species (*sensu* Anderson *et al*., 2005). Notably, studies on walking tended to be confined to specific case-study locations rather than broader empirical studies across different locations. In some studies, there was no attempt to disaggregate walking from other types of recreational use (see 'General Recreation' – Section 4.3.1) as 'proximity to footpaths' was often used as an indicator to assess the impacts of walking (e.g., Murison, 2002, **2+**). As above, only two studies examined the effect of dog-walking as a recreation type on its own, but where the impact of dogs was mentioned, they have been included in this section.

Influence of walking on birds in upland ecosystems

There was **strong evidence** from four studies (**2++**, **2+**) that walking caused negative impacts on birds in upland ecosystems.

One study (Finney *et al*., 2005, **2+**), which explored the impact of path resurfacing on bird breeding behaviour, highlighted that walkers on the Pennine Way caused disturbance to breeding golden plover when path braiding was a significant problem. A related study (Pearce-Higgins *et al*., 2007, **2++**) also demonstrated that on the same site (Snake Summit) and an additional site (Bleaklow), walking impacted habitat use by two upland bird species, golden plover and dunlin in some contexts, but there were also neutral effects related to number of walkers and quality of footpath provision (see Section 5.2). Both studies also examined how footpath restoration reduced disturbance effects (see Section 5.5). Another study (Rees *et al*., 2005, **2+**) that explored the impacts of four different recreation types on the alarm response of whooper swan (*Cygnus cygnus*) demonstrated a correlation between walking and disturbance, with distance between birds and the walkers a significant variable. One study (Murison, 2002, **2+**) examined the breeding success of European nightjar on several sites across Dorset with varying levels of public access. Results demonstrated that nightjar breeding success differed between heavily visited sites and those with limited access, with predated nests found significantly closer to paths than non-predated nests (p = 0.0121). In

addition, nests surrounded by greater total path length were associated with higher nest predation. The evidence from the last two studies (Rees *et al*., 2005, **2+**; Murison, 2002, **2+**) were only partially applicable to this evidence review however, as both studies were conducted in the lowlands, although they focused on habitats and species that occur in the UK uplands. It should be noted that there was also weak evidence from one study (Whitfield *et al*., 2007, **2+**), that found no correlation between high areas of walking activity (the presence of Munros) and golden eagle (*Aquilia chrysaetos*) distribution. However, given that this modelling exercise used a relatively weak proxy to assess the presence of recreation it was considered that it did not sufficiently counter the evidence detailed in the four studies above to suggest this evidence was inconsistent.

Influence of dog walking on birds in upland ecosystems

There was **moderate evidence** from two studies (both **2+**) that dog walking had a negative impact on ground-nesting birds relating to increased disturbance effects and reduced breeding success.

One study (Langston *et al*., 2007, **2+**) that investigated the effect of walking and dogs on the breeding success of European nightjar, showed that failed nests were significantly closer to paths, and these were closer to the main points of access to heaths in areas with high footpath density, and sparse vegetation. The study also indicated that birds flushed more readily from nests in short vegetation, leaving eggs/chicks highly visible. However, although the study did attempt to measure the direct impact of dogs (using nest cameras), the data on disturbance by dogs was less clear, partly masked by more successful breeding in the second year of study. Another study (Murison *et al*., 2007, **2+**) that assessed the impacts of all recreation types on the breeding success of Dartford warbler identified that the majority of site users were dog walkers. However, despite detecting a significant impact on breeding behaviour in more disturbed areas, the relationship between dog walking and other types of recreation were not directly measured. Nonetheless, the authors observed in this study that it was *"likely that dogs off-lead had the greatest impact on Dartford Warbler breeding productivity*" (Murison *et al*., 2007, **2+**: 24). The findings from both these studies on dog impacts are only partially applicable as they were conducted in the lowlands, although both studies concerned species that breed in the UK uplands.

It should be noted that although only explained by one study (Langston *et al*., 2007, **2+**), the potential that short vegetation height may increase disturbance to breeding behaviour from dogs and other forms of recreation, may be a particularly important variable to study in the UK uplands, given the range of anthropogenic activities that maintain short vegetation (e.g., heather burning or grazing).

There was **no evidence** from studies examined in this review that measured the effect of dog walking on birds in any upland habitats.

Influence of walking on mammals in upland ecosystems

There was **moderate evidence** from two Scottish studies (both **2+**) that demonstrated a negative correlation between walking and red deer (*Cervus elaphus*). These were, however, the only studies found in this review that assessed the impacts of walking on upland mammals. One study (Sibbald *et al*., 2011, **2+**) utilised GPS collars on eight stags to demonstrate that deer moved away from walkers when footpaths were busy, and this behaviour effect lasted for over 24 hours. Another study (Jayakody *et al*., 2011, **2+**) that examined the effect of walking on red deer in the Eastern Cairngorms, demonstrated that disturbance from hikers affected the foraging behaviour of red deer by reducing the number of beneficial grasses in their diet.

There was **no evidence** from studies examined in this review that measured the effect of dog walking on taxa other than birds.

Influence of walking on vegetation and soil in upland ecosystems

There was **moderate evidence** from three studies (**2+**) of a negative correlation between walking and disturbance to soil in the UK uplands. One study (Grieve, 2001, **2+**) demonstrated that soil quality and soil formation were negatively correlated with soil disturbance caused by trampling on the Cairngorms plateau, with organic matter content of the disturbed profiles between 40% and 65% of that in the vegetated profiles. Another study (McHugh, 2007, **2+**) assessed the scale and causes of change in erosion in upland areas of England and Wales through repeat monitoring of upland sites. Results reported that human influences accounted for the exposure of 233 m^2 of bare soil on 19 sites, or 12.3 m^2 per site (compared with a mean of 6.1 m^2 of erosion attributed to impacts from grazing). Of such erosion, walkers and rabbits ranked lowest (behind sheep grazing, vehicles, cattle and drains). One study (Kincey and Challis, 2010, **2+**) although focusing on the methodological approach using lidar data to analyse the extent of footpath erosion in the Brecon Beacons, recorded 559 discrete erosion features distributed across the entire study area, representing a total length of features in excess of 46.8km in a 3.8km^2 site. Results demonstrated that erosion was clearly concentrated in proximity to established routes through the landscape, e.g., small linear erosion features parallel to the main routes, often on bends in the track. The varying nature of the severity of the erosion across the study area was largely explained by the concentration of visitor pressure in particular areas, i.e., track intersections (although it was also linked to the highly erosive nature of certain land-use practices such as the illegal use of motorised vehicles). Damage to particular species such as golden plover and rare plants such as the scarce bog sedge were identified.

There was also **weak support** (but not empirical evidence) from four additional studies with low validity scores (**4+**, **4-**, **5-**) that discussed a relationship between the impacts of walking on upland vegetation and soil, although all four only described rather than empirically tested this relationship. One study (Gordon *et al*., 2002, **5-**) described the impacts of walking pressure on montane (alpine) vegetation. Through a case study of the Cairngorm Mountains, the study described the impacts of trampling on summit moss heaths, blanket bog, moss-dominated snow beds, wind-clipped dwarf shrub heath and springs and flushes, which were then used to model the effects in GIS. This study highlighted that all these habitats were highly sensitive to trampling. The authors concluded that biodiversity and ecosystem function were closely linked to the geological history, geomorphological processes and soils and that these factors must be accounted for in nature conservation. Another study (MacKay and Prager, 2021, **4+**) also conducted in the Cairngorms that explored the willingness of landowners to maintain and restore footpaths, described the impact of 'millions of feet' and bike tyres on sensitive vegetation. In two other studies (Cavan *et al*., 2006; **4-**; McEvoy *et al*., 2008, **4-**) already described, the combined effects of climate change and recreation was also described to impact upland habitats in terms of increased footpath erosion from extreme weather events (intense rainfall and droughts).

4.3.3 Evidence of the Influence of Mountain-Biking on Upland Ecosystems

In total, this search of literature identified five studies that examined the influences of mountain biking, including some studies that looked at mountain-biking in comparison with other forms of recreation (e.g., walking/hiking). The amount of evidence analysing the influence of mountain biking on upland ecosystems is notably small, given the popularity of this type of recreation and the potential for negative impacts on upland ecosystems (Huddart and Stott, 2019).

Influence of mountain-biking on birds and mammals in upland ecosystems

There was **moderate evidence** from two studies (**2++**, **2+**) that on-track mountain biking was negatively correlated with disturbance to upland species (one bird, one mammal). One study (Summers *et al*., 2007, **2++**) demonstrated that disturbance from tracks in the Cairngorms used for mountain-biking (and other forms of recreation) impacted on capercaillie nest / roost sites, with birds avoiding trees close to tracks and particularly where recreational use was higher. Another study (Lowney, 2011, **2+**) that explored the impacts of designated mountain bike tracks on red squirrels (*Scirius vulgaris*) on a site in the Lake District) suggested a weak (non-significant) relationship between squirrel occurrence in undisturbed as opposed to disturbed areas, but results were confounded by other variables (e.g., the influence of preferred versus less preferred habitat). Additionally, one lowland study (Rees *et al*., 2005, **2+**) demonstrated that whooper swans were disturbed by cycling, with an alarm response recorded on average at 116 ± 17.1 metres, although this was a greater distance than those recorded for most types of pedestrians included in the research. The applicability of these findings needs to be viewed with extra caution however, as the research was undertaken in the lowlands, and whooper swans do not breed in the UK uplands, although they have been extensively recorded overwintering in upland sites in Scotland (Newth *et al*., 2013).

There was **no evidence** found within this review that explored the effect of off-track mountain biking on species. This may be because off-track mountain-biking is likely to be more spatially sporadic than on-track areas, meaning research to measure the impacts would be much harder to conduct.

Influence of mountain-biking on habitats in upland ecosystems

There was **weak evidence** from one study (Hardiman *et al*., 2017, **2+**) that mountain-biking did not affect habitats, although this study focused solely on the potential for mountain-bikes to spread seeds of invasive plant species on tyres. The research found a neutral effect with tyres having very little capacity to transport the seed except in very wet conditions over longer distances. Even in these instances, the amount of seed transported on bike tyres was very low (0.00-0.31%).

Influence of mountain-biking on ecosystem processes in upland ecosystems

There was **weak evidence** from one study (Stavi and Yizhaq, 2020, **5-**) that ecosystem processes were affected by mountain-biking. The study modelled the potential for mountain bikes to cause damage to wider ecosystem processes particularly through erosion. The study demonstrated that the potential for soil erosion increases with precipitation and track incline. The applicability of this evidence is challenging to properly define because the study was undertaken in Israel but modelled a wide range of hydrological and geomorphological conditions, which have at least partial relevance to the UK uplands.

4.3.4 Evidence of the Influence of Motorised Vehicles on Upland Ecosystems

In total, the search of literature identified three studies that examined motorised vehicles in upland ecosystems in the UK. In all three of these studies, the types of motorised vehicles were not specifically defined, and therefore could have referred to off-road, 4x4 driving or motorised bikes such as trail or scrambler biking.

Influence of motorised vehicles on habitats in upland ecosystems

There was **moderate evidence** from two studies (both **2+**) that demonstrated the potential for motorised vehicles to negatively influence upland habitats. One study (McHugh, 2007, **2+**)

assessed the scale and causes of change in erosion in upland areas of England and Wales through repeat monitoring of upland sites. Results reported that human influences accounted for the exposure of 233 m^2 of bare soil on 19 sites, or 12.3 m^2 per site (compared with a mean of 6.1 m^2 of erosion attributed to impacts from grazing). Of such erosion, that due to vehicles and walkers was most evident, with the mean eroded area due to vehicles more than five times greater than the average of 3m^2 per site attributed to walkers. Another study (Kincey and Challis, 2010, **2+**) that used lidar data to analyse the extent of footpath erosion in the Brecon Beacons, identified one of the causes to be the highly erosive nature of certain land-use practices such as the illegal use of motorised vehicles. Damage to particular species such as golden plover and rare plants such as the scarce bog sedge were identified.

Another study (Clutterbuck *et al*, 2020, **2++**) did not provide empirical evidence of motorised vehicle impacts or influences on upland ecosystems but measured the extent of tracks occurring in the UK uplands, which were six times greater in length than the mapped footpath network (2104 vs 355km). Issues surrounding upland tracks are explored further in another Natural England evidence review (see Grace, 2013, NEER002).

4.3.5 Evidence of the Influence of All Other Types of Recreation on Upland Ecosystems

This review identified 20 studies that examined the impacts of six other individual recreation types that are not described in the previous sections; climbing/bouldering, skiing/snow sports, the direct impacts of shooting/hunting, camping/wild camping, barbecuing and caving. Overall, however, there was **limited evidence** of the impacts of these recreation types in upland ecosystems. Notably, many of these recreation types resulted in the same pressures as noted in walking / hiking and 'general recreation' types, but some created recreation-specific effects.

Influence of climbing and bouldering on upland ecosystems

Seven studies were identified in this review that mentioned climbing or bouldering. There was **weak support** (but not empirical evidence) from three studies (**3-**, **5-**) that climbing and/or bouldering negatively impacted species and habitats in upland ecosystems. All of these studies described potential or actual impacts rather than empirically testing their significance, which is why the evidence has only been classified as weak. One study (Gordon *et al.,* 2002, **5-**) modelled the negative impacts of recreation in the Cairngorms based on estimates of damage to different habitat types. These estimates included a description of damage that accessing climbing routes has had on flush habitats, particularly trampling damage to vegetation. Another two studies (Leyland, 2016, **3-**; Leyland, 2021, **3-**) described the impacts of upland climbing causing nest disturbance to ring ouzel in the Peak District National Park. These reports also described mitigation and adaptation measures to mitigate negative impacts of climbing (see Section 5.5). Four further studies (Sport England, 2021, **3-**; Hanley *et al*., 2002, **2+**; Harrison *et al*., 2001, **2+**; BMC, N.D. **3-**) mentioned climbing in an upland context but did not include any measurement or description of the influence of climbing and bouldering on upland ecosystems.

Influence of skiing and snow sports on upland ecosystems

Four studies were found in this evidence review that reported on skiing and snow sports in upland ecosystems in the UK, all focused on Scotland.

There was **moderate evidence** from three studies (**2+**; **5-**) that demonstrated the negative impacts of skiing and snow sports, or the infrastructure associated with them, on upland ecosystems. One study (Watson and Moss*,* 2004, **2+**) that studied the impact of the Aviemore

ski development over a 30-year period showed negative impacts on ptarmigan (*Lagopus mutus*). The study demonstrated that an influx of carrion crows (*Corvus corone),* as generalist predators, had followed the development, which significantly impacted the breeding success of ptarmigan. Ptarmigan mortality also occurred because of the skiing infrastructure, e.g., the ski-lift wires. This before-and-after study showed that breeding success of ptarmigan in the area close to the ski development was the most significantly affected area. In contrast, two other undisturbed areas much further from the resort were unaffected. Another study (Forrester and Stott, 2016, **2+**) explored the water quality of streams near ski resorts in the Cairngorms National Park. Their results demonstrated the presence of faecal *Coliform* levels (including *Escherichia coli*) at sites immediately downstream of a ski resort, but which were absent at higher elevations. Samples only covered winter months (December-May) and were therefore assumed, although not proven, to be associated with winter sports activities. Another study (Gordon *et al*., 2002, **5-**) described the negative impacts of skiing and snow sports in the Cairngorms in Scotland, in particular, linking recent increases in recreational pressure to improved access. The study used this and expert opinion to predict the montane habitats most vulnerable to human impacts from snow sports and other montane recreation, which were identified as plateaus, snow hollows, summit ridges and springs and flushes, but the impacts were modelled rather than measured empirically.

Finally, one study (Harrison *et al*., 2001, **2+**) explored skiing in the Cairngorms in the context of climate change but did not assess its impacts.

Influence of shooting and hunting in upland areas

Four studies were found in this evidence review that reported on the direct influences of shooting and hunting on upland ecosystems or the species that inhabit them, including impacts on quarry species and non-target species.

There was **weak evidence** from one study (Warren *et al*., 2011, **2+**) that the direct recreational pursuit of driven grouse shooting had a negative effect on species other than the quarry species, red grouse (*Lagopus scotica*). This study examined the extent to which black grouse (a UK priority species) were shot during driven shoots (of red grouse). Results demonstrated that driven grouse shooting did lead to accidental black grouse deaths via direct shooting, but this was a small percentage of grouse bags and a small percentage of deaths of radio tagged birds (<1.6%). The study did not directly state how this rate compared with natural deaths or whether this was within a normal 'tolerance range' of mortality.

There was **weak evidence** from one study (**2+**) that driven grouse shooting caused levels of elevated lead toxicity in red grouse. This study (Thomas *et al*., 2009, **2+**) tested the bone lead levels and lead isotope ratios in red grouse from Scottish and Yorkshire moors and found highly elevated levels (> 20 µg/g) in some birds. Although the number of birds on Scottish moors was relatively low, a high incidence (65.8%) of bone lead > 20 µg/g was found in the grouse from one (anonymous) Yorkshire grouse moor. Although historic lead mining was thought to be a contributory factor, the isotope signature of the lead demonstrated that lead shot was likely to be the most significant cause of this high toxicity in Yorkshire birds and the smaller number of grouse with highly elevated levels found in Scotland.

There was also **weak evidence** from one study (**2+**) that disturbance to bird species other than the quarry species may result from those participating in shooting and hunting. This study (Rees *et al*., 2005, **2+**) demonstrated that anglers and wildfowlers more readily displaced whooper swans than other recreation users, with a disturbance distance for anglers of 364m ± 78.1 and 350m ± 12.9 for wildfowlers. This compared with shorter disturbance distances for hikers and cyclists at 249m ± 14.0 and 116m ± 17.1 respectively. The applicability of these findings needs to be viewed with extra caution as the research was undertaken in the

lowlands, and whooper swans do not breed in the UK uplands, although they have been extensively recorded overwintering in upland sites in Scotland (Newth *et al*., 2013).

There was also **weak support** (but not empirical evidence) from one study (**2+**) that the direct recreational pursuit of driven grouse shooting (not the associated management, which there was much more evidence on, see Section 4.4) had negative impacts on red grouse (other than through direct mortality). This study (Baines *et al*., 2020, **2+**) discussed, but did not test for, the potential impacts of repeated disturbance by lines of beaters and noise associated with flushing and shooting at birds. It was reflected that this stress may cause a heightened risk of disease in red grouse.

Influence of camping or wild camping on upland ecosystems

There was **moderate evidence** from two studies (**2+**, **3-**) undertaken in Scotland that wild camping had negative impacts on upland ecosystems. Both studies demonstrated a detrimental effect on upland water quality associated with the impact of human waste (urine and faeces). One study (McDonald *et al*., 2008, **2+**) used 480 spot samples across 59 sites in the Cairngorms National Park between March 2001 and October 2002. This research found that over 75% of samples tested positive for *E. coli* and 85% for total coliforms. The distribution of the samples that tested positive displayed both temporal and spatial patterns showing that the most significant values occurred during the summer months and at weekends near sites that were frequently visited, either for 'wild' camping or day visits. The study concluded that the variations in bacterial concentrations suggest a relationship between visitor numbers and wild camping. Another study (Bryan, 2002, **3-**) highlighted a range of different sources to describe the negative impacts of wild camping and bothy use on water quality but did not present any detailed empirical data.

Influence of barbecues in upland areas

There was **weak evidence** from two studies (**3-**, **4-**) that described the significant negative impacts of barbecues on upland ecosystems. One study (Cavan *et al.*, 2006, **4-**) that explored the combined effects of recreation and climate change through stakeholder workshops, emphasised the increased risk of wildfires associated with barbecues. Another study (Martin, 2019, **3-**) measured the negative impacts on breeding birds on Winter Hill resulting from a large wildfire in 2018 and the associated impact on upland habitats. The cause of this fire was attributed to at least one barbecue. For a more detailed analysis of the evidence on the causes and prevention of wildfires on upland ecosystems see Glaves *et al.,* (2020).

Influence of caving on upland ecosystems

There was **weak support** (but not empirical evidence) from one study (Gunn *et al*., 2000 **3-**) that recreational caving caused a range of negative impacts on upland cave ecosystems. The study discussed the potential impacts of caving on invertebrate communities in two caves in the Peak District National Park (Peak Cavern and Speedwell). Potential impacts include increased CO_2 from human respiration, light pollution and increased temperatures from lighting, artificial ventilation changing chemical and physical conditions in caves. However, there was **no evidence** found in this review of studies that empirically tested the impacts of caving on upland ecosystems.

4.4 Evidence Statement on the Influence of Grouse Moor Management on Upland Ecosystems

4.4.1 Context and Evidence Background

As identified in Chapter 3, there are two broad ways in which recreational activity can influence upland ecosystems and associated biodiversity and ecosystem services; direct influence from the recreational pursuit and the broader landscape-scale effects resulting from management to enhance recreation.

Whilst it has long been recognised that negative impacts can result directly from different recreation types, e.g., disturbance, erosion, etc., there has been less clarity about the impacts associated with upland recreational management. Until recently, the broader management of upland ecosystems in the UK for recreational pursuits, in particular the active management of blanket bog, dry and wet heathland for grouse shooting was more readily supported by most conservation organisations as important for promoting priority species (e.g., see Natural England, 2009*b*). In the last decade however, there has been much greater scrutiny over the types of management practices associated with driven grouse shooting, particularly heather burning, because of their potential impact on biodiversity and wider ecosystem services. Despite this, the annual number of burns across England and Scotland has been increasing dramatically (Douglas *et al*., 2015).

These management practices have been the focus of several Natural England evidence reviews, specifically on the impacts of managed burning on upland peatland biodiversity, carbon and water (Glaves *et al.,* 2013). It is not the intention of this evidence review to revisit these specific questions around burning as, in addition to Natural England evidence reviews, there have been a number of other reviews and reports on the impacts of burning on UK peatlands in recent years (e.g., Tucker 2003; Worrall *et al*., 2010; Lindsay, 2010, Harper *et al.,* 2018). We refer the reader to those reviews and studies for further analysis of wider ecosystem and ecosystem service impacts. The intention of this section is to provide a review of the evidence that surrounds the impact on upland wildlife and the associated habitats that result from all forms of management activities associated with managing upland ecosystems for recreational grouse shooting.

This section draws on academic evidence and practitioner submissions published or produced in the English language on the different types of impact of grouse moor management on upland ecosystems published since 2000. Whilst it is acknowledged that evidence prior to this date exists on issues such as burning, grouse numbers, open habitats, and wader numbers, and indeed may still be relevant, it was decided to only refer to evidence since 2000 to ensure consistency with the rest of the review. For instance, positive impacts have been observed in many studies of prescribed burning and grouse production and have been observed for many years (Picozzi, 1968). This may not be surprising as prescribed burning seeks to optimize habitats for grouse populations so increase in numbers or survival are likely to be observed. However, it must be noted that many of the studies that show positive outcomes of grouse moor management (e.g., Hesford *et al.*, 2020, **2+**; Pearce-Higgins and Yalden, 2003, **2+**) often do not study individual management activities, such as prescribed burning in isolation. The purpose of this review was to compile contemporary evidence on these issues to show the strength of evidence that is emerging within this more recent body of work.

4.4.2 Evidence Overview

57 studies included within the review explored grouse shooting in the context of UK upland landscapes. 51 of these studies specifically focused on driven grouse shooting, where shooters wait in fixed positions ('butts') while the red grouse are flushed over them by people ('beater') and dogs. This form of grouse shooting requires very high densities of red grouse and therefore results in more intense forms of management. The remaining six studies compared driven grouse shooting with walked-up shooting, where hunters move through the landscape and shoot their quarry 'on sight'.

Of this significant body of literature on the influence of grouse shooting on upland ecosystems, only four studies concerned the direct influence of the actual shooting (see Section 4.3.5). The majority, 40 in total, explored the influence of the three legal approaches to upland management associated with the grouse moor industry; creating varied heather structure through burning or cutting, legal predator control and the management of disease (Thompson *et al*, 2016). The principal focus of these empirical studies was to measure the positive and/or negative implications of management on red grouse and other upland species, i.e., other ground nesting birds (particularly waders), other bird species and one mammal species. In some of these studies, there was no distinction between the different forms of management and grouse moor management was considered generically. The remaining 14 studies explored the conflict between grouse moor management and the impact of, and on, raptor populations, including the impact of raptors on grouse populations, the illegal persecution of raptors by those involved in grouse moor management, and studies exploring opportunities for conflict resolution.

Based on this context, the evidence on the influence of grouse moor management has been broken down into five discrete sections:

- Studies relating specifically to heather management, predominantly studies on burning (rather than cutting), also referred to as 'muirburn' in Scotland (Section 4.4.3),Studies relating to predator control (Section 4.4.4),
- Studies relating to the management of disease (Section 4.4.5),
- Studies that did not distinguish between the different types of management practices that occur on grouse moors (Section 4.4.6), and
- Studies exploring the conflict between grouse moor management and raptor populations (Section 4.4.7).

4.4.3 Evidence of the Influence of Burning on Species in Upland Ecosystems

Influence of burning on red grouse abundance

As mentioned at the start of Section 4.4, a significant proportion of the evidence on the influence of burning on species in upland ecosystems was published before 2000 and has therefore not been included in this review. From the literature captured in this evidence review, there was **inconsistent evidence** from across four studies that burning had a beneficial effect on the abundance and breeding success of red grouse.

There was **moderate evidence** from two studies (both **2+**) that demonstrated a positive correlation between rotational burning and red grouse abundance. This included a UK wide study (Buchanan *et al*., 2017 **2+**) on the influence of habitat management on moorland bird abundance, which correlated higher red grouse abundance with areas that have implemented

rotational heather management (mostly burning) to ensure young shoots. This is supported by evidence from a multi-site, before and after study (Robertson *et al.,* 2017*a*, **2+**), which focused specifically on measuring whether heather burning increased red grouse abundance. This study showed that post-breeding density increased after prescribed burning. Modelling within the study indicated that increasing burning by 10% could result in a higher post-breeding density of 10 red grouse per km^2 ($p < 0.04$). However, it should be noted that this study, whilst recognising the relevance of predator control, did not attempt to measure or control for it as a potential variable influencing grouse numbers on grouse moors.

By contrast, there was **moderate evidence** from two studies (both **2+**) of a null effect of heather burning on red grouse abundance. One study (Littlewood *et al*., 2019, **2+**) that explored the influence of different aspects of grouse moorland management on a range of bird species, demonstrated that across both burning and predator control, the latter was a much stronger explanatory variable and that there was no significant correlation between red grouse and burning. Another study (Smith *et al.* 2001, **2+**) that explored the effect of vegetation and habitat characteristics on grouse moors on meadow pipit (*Anthus pratensis*) numbers, showed that there was no relationship between the abundance of grouse and muirburn ($p = 0.56$). It should be noted that in this study no significant relationships between habitat characteristics and grouse abundance were found, with the only explanatory variables for higher red grouse abundance found to be country (higher on English than Scottish moors) and higher altitude. In a related study (Ludwig *et al*., 2017, **2+**), which conducted a before and after trial, researchers found that despite significant investment in management activities, including burning, red grouse numbers were not increased sufficiently to ensure the recreation was economically viable. Although this study did not demonstrate a direct causal link, it highlighted that burning does not always increase grouse populations to a sufficiently high level to support grouse shooting as a commercially viable venture.

Given that burning is such an extensive practise on grouse moors, more contemporary research is needed that explores the relative benefits of this practice on red grouse numbers, particularly in the light of novel influences on population such as climate change and disease.

Influence of burning on the ecology of other bird species

There was **moderate evidence** from two studies (both **2+**) that burning had a largely neutral effect on the abundance of ground nesting waders. Both studies (Littlewood *et al*., 2019, **2+**; Buchanan *et al*., 2017 **2+**) analysed the impacts of different aspects of grouse moor management on upland bird assemblages. Both reported neutral effects on common snipe (*Gallinago gallinago*) and Eurasian curlew (*Numenius arquata*), and one of the studies (Buchanan *et al*., 2017 **2+**) also reported neutral effects for golden plover and northern lapwing. There was, however, weak evidence from one study (Littlewood *et al*., 2019, **2+**) that burning had a positive effect for golden plover although the relationship between burning and abundance was reported as statistically weak.

There was **inconsistent evidence** from across four studies (**2++**, **2+**) of the effects of burning on upland passerines. This included **weak evidence** from one study (Buchanan *et al*., 2017, **2+**) that studied the influence of management and environmental variables on moorland bird abundance, which demonstrated positive effects of heather management on Eurasian skylark (*Alauda arvensis*), stonechat (*Saxicola rubicola*) and whinchat (*S. rubetra*) populations. A similar study (Tharme *et al*., 2001, **2++**) found that burning had a negative effect on meadow pipit and wheatear, although similarly also recorded that burning was favourable for whinchat. There was **weak evidence** from two studies (both **2+**) that found negative effects for passerines. There was weak evidence of a negative correlation between burning and the abundance of meadow pipits (Smith *et al*., 2001, **2+**). This study highlighted that frequent muirburn had a negative impact on meadow pipit numbers (r = -0.33) regardless of the amount

of heather and that this may also have negatively affected hen harrier numbers (which predate on meadow pipits). An additional study (Littlewood *et al*., 2019, **2+**) also demonstrated a weak negative effect of burning recorded for Eurasian wren (*Troglodytes troglodytes*).

This variability in evidence about the influence of burning on bird species other than red grouse suggests that responses are likely to be species-specific, but in general may be more beneficial for ground-nesting waders than for passerines.

It should also be noted that although one study (Tharme *et al*., 2001, **2++**) reported a positive effect of burning on whinchat, the same study also found that the density of whinchat, and an additional two passerine species (meadow pipit and skylark) had populations that were significantly lower on grouse moors when management and habitat variations were accounted for – see Section 4.4.6. This variability in findings highlighted that extreme care should be taken about generating assumptions about the influence of burning on upland ecosystems, if burning is assessed in isolation from other management approaches on grouse moors (e.g., legal predator control).

Influence of burning on the ecology of species from other taxonomic groups

There was comparatively **limited recent evidence** (drawing from only three studies) of the impact of burning on taxonomic groups other than birds; one study related to mammals and two related to invertebrates. All of these studies identified the impacts as negative.

There was **weak evidence** from one long-term study (Watson and Wilson, 2018, **2++**) of a correlative but not causative relationship between burning and mountain hare *(Lepus timidus scoticus*) declines, as the hare population was compared with burnt areas, which were used as a proxy for grouse moors. The study demonstrated that between 1954 and 1999, hare density declined most strongly on sites not subject to burning, whereas after 1999 when the rate of hare decline was much more severe, decline rates were highest on sites with burning. By contrast, on alpine sites (not managed for grouse) between 1954 and 2007, hare density increased per annum by 1.5% ($p < 0.001$) without burning and by 3.5% ($p < 0.001$) on sites with burning. It should be noted however, that burning was not viewed as the cause of decline, but demonstrative of grouse moor management practices more generally. The conclusion of this study was that up until around the year 2000, grouse moor management supported hare populations, but since this date, management practices on grouse moors had altered, with a notable upturn in hare culling, and this was causing the negative correlation between burning and hare numbers, but the study proposed that this was unrelated to the practise of burning itself.

There was **moderate evidence** from two studies (both **2++**) of a negative impact of burning on aquatic invertebrates. One study (Brown *et al*., 2013, **2++**) demonstrated a negative impact on aquatic invertebrates calculated as the mean number of *Ephemeroptera* in rivers where burning occurred. Evidence suggests abundance was negatively affected with *Ephemeroptera* populations 20% lower in streams where burning occurred. Another study (Ramchunder *et al*., 2013, **2++**) examined the effects of rotational vegetation burning on upland streams, specifically the physio-chemistry conditions and benthic macroinvertebrates in sites where burning occurred versus sites with no recent history of burning. In terms of aquatic biodiversity, there were significant reductions in benthic macroinvertebrate richness, diversity and dominance in streams draining burnt catchments, with lower abundance of some mayflies, stoneflies and caddisflies and elevated abundance of some *Diptera* (*Chironomidae* and *Simuliidae*) larvae.

The lack of recent literature on burning impacts on invertebrates is notable, given that the effects of varied heather structure is often described as affecting terrestrial insects and arachnids differently (Swengel, 2001).

Influence of burning on upland habitats

As mentioned at the start of Section 4.4, there has been considerable analysis and review of the evidence about the wider environmental impacts of burning associated with grouse moor, including on habitat quality and it is not the purpose of this review to repeat this work. Two studies did provide useful context, however, in the light of other sections on the conservation merits of grouse moors.

There was **moderate evidence** from two studies (both **2+**) that demonstrated that burning occurs on protected habitats, but this may be an important element of conservation of these ecosystems. One study (Douglas *et al*., 2015, **2+**) used remote sensing data to look at the extent of burning in upland areas of the UK. Results highlighted that burning was significantly greater inside protected areas, i.e., Special Protection Areas (SPAs) and Special Areas of Conservation (SACs), than in matched areas that were not protected, and burning was widespread across protected areas. This highlighted the potential extent of burning, usually (although not explicitly) linked to grouse moors that cover some of the UKs highest level of conservation. Another study (Whitehead and Baines, 2018, **2+**) that investigated the rate of vegetation growth following rotational burning through a long-term experiment at Moor House National Nature Reserve, North Pennines, found that more frequent burning increased the cover of peat-building species such as Sphagnum mosses and cotton grass (*Eriophorum vaginatum*).

There was **weak evidence** from one study (**2++**) that burning can have a negative impact on the water quality of upland streams. This study (Ramchunder *et al*., 2013, **2++**) examined the effects of rotational vegetation burning on the physio-chemistry conditions of upland streams in sites where burning occurred versus sites with no recent history of burning. Results showed significant impacts on water chemistry, with burned catchments characterised by higher fine particulate organic matter (FPOM), suspended sediment concentration (SSC), aluminium, iron and dissolved organic carbon than unburnt catchments. This change in water quality was linked to noticeable changes in the diversity and abundance of aquatic invertebrates.

4.4.4 Evidence of the Influence of Legal Predator Control on Species in Upland Ecosystems

To reduce the predation of red grouse adults and chicks, gamekeepers are employed on grouse estates to legally cull (usually through trapping or shooting) a wide range of predators including red fox (*Vulpes vulpes*), stoat (*Mustela ermine*), weasel (*Mustela nivalis*) and some corvid (*Corvus*) species including carrion crows, hooded crows (*Corvus cornix*) and rooks (*Corvus frugilegus*) (Thompson *et al*., 2016).

Influence of legal predator control on red grouse abundance

There was **strong evidence** across 4 studies (**2++**, **2+**) that demonstrated a positive relationship between legal predator control and the abundance of red grouse. One study (Littlewood *et al*., 2019, **2+**) explored the influence of different aspects of grouse moorland management on non-target bird species, which demonstrated that red grouse abundance was positively correlated with predator control, and of all ten ground-nesting bird species assessed this was the species that demonstrated the strongest relationship (R^2 = 0.51). An additional study (Ludwig *et al*., 2017, **2+**) reported grouse densities were higher during predator control on the Langholm estate in Southern Scotland. When the moor was ‘unmanaged’ and the abundance of crows and the fox index were both higher, grouse densities in spring (March-May) and July were 60% and 76% lower, respectively. One study (Tharme *et al*., 2001, **2++**) reported that the positive effect of grouse moors on grouse numbers was most likely due to

predator control than other grouse management activities. The extent of this relationship was not clear however, as predators were only measured based on the proportion of crows seen (with other predator data therefore missing) but this data demonstrated crows were 3.1 times less abundant on managed grouse moors than other moors. Finally, one study (Buchanan *et al*., 2017, **2+**) that explored the influence of different grouse moor management techniques on various bird species, generated a predator index that was positively correlated with red grouse abundance.

Influence of legal predator control on the ecology of other bird species

There was **strong** evidence from five studies (**2++**, **2+**) that legal predator control can have a positive influence on the abundance of specific species of bird other than red grouse, particularly ground-nesting waders. This included evidence from four studies (Littlewood *et al*., 2019, **2++**; Buchanan *et al*., 2017, **2+;** Douglas *et al*., 2014, **2++**; Fletcher *et al*., 2010, **2+**) that demonstrated a positive effect of predator control on the abundance of Eurasian curlew (e.g., R^2 = 0.40, Littlewood *et al*., 2019, **2+**). Similarly, evidence from four studies (Littlewood *et al*., 2019 **2++**; Buchanan *et al*., 2017, **2+**; Fletcher *et al*., 2010, **2+**; Tharme *et al*., 2001, **2++**) reported a positive influence of predator control on the abundance and/or breeding success of golden plover (e.g., R^2 = 0.60, Littlewood *et al*., 2019 **2++**). Two studies reported a positive influence on northern lapwing (Fletcher *et al*., 2010, **2+**; Tharme *et al*., 2001, **2++**) and a single study (Littlewood *et al*., 2019, **2+**) reported positive benefits for snipe abundance.

There was **inconsistent evidence** on the benefits of predator control on passerines from two studies (both **2+**) that looked at the impact of predator control on multiple upland bird species. There was **weak evidence** from one study (Tharme *et al*., 2001, **2+**) that suggested neutral impacts of predator control on passerines (meadow pipit and skylark), whereas there was weak evidence from one study (Fletcher *et al*., 2010, **2+**) that reported positive effects on the breeding success and abundance of meadow pipit. There was **weak evidence** from one study on the influence of legal predator control on bird of prey species. This study (Baines and Richardson, 2013, **2+**) conducted a before and after study on the Langholm Estate in Scotland to analyse the effect of predator control on the breeding success of hen harriers. Results showed that hen harrier clutch survival and productivity were higher when the moor was managed as grouse moor (i.e., generalist predators were culled). Predation by foxes was the main cause of hen harrier breeding failure. The study concluded that control of generalist predators as part of grouse moor management can benefit hen harrier productivity. However, the same assemblage study (Tharme *et al*., 2001, **2+**) mentioned above, that analysed multiple grouse moors across northern England, reported negative effects on hen harrier, with significantly fewer seen on grouse moors than on other moors, although the study could not demonstrate this was directly related to predator control despite testing for this variable. This suggests that where raptor persecution is absent or very low (as on the Langholm estate) predator control may benefit breeding hen harrier, but on other moors, other factors such as raptor persecution, may have a larger influence on bird of prey populations.

An interesting finding from one of these studies (Littlewood *et al*., 2019, **2+**), was that the benefits provided to some bird species by predator control had a low saturation point, so that increasing the intensity of gamekeeping resulted in diminishing returns. This study suggested that fairly minimal predator control could provide significant benefits, whereas complete cessation would have significant impacts on the wader species studied, as well as on red grouse.

There was **weak evidence** from one study (**2+**) that suggested that the only negative effect of legal predator control on bird species was on the predator species themselves, in this instance, carrion crows. The study (Ludwig *et al*., 2017, **2+**), which explored the impacts of changing management regimes on the breeding success of red grouse and hen harriers on the

Langholm estate in southern Scotland, reported that gamekeepers removed on average 308 ± 18 carrion crows per annum between 1992 and 1999, and 260 ± 22 carrion crows per annum between 2008 and 2015, i.e., 2.2 ± 0.2 crows km^2 (2008–2015). Crow abundance was three times higher during the unmanaged period than in managed periods, although crows showed a high level of annual fluctuation throughout the study period.

Influence of legal predator control on the ecology of other taxonomic groups

There was **no empirical evidence** found in this review that examined the effects of legal predator control on other mammals except the quarry species, or for any other taxonomic groups. Although some studies explored the influence of grouse moor management on mountain hare populations (see Sections 4.4.5 and 4.4.6), these did not empirically test the impact of predator control, although discussion of these studies suggested predator control was an important factor.

There was **weak evidence** from one study (Ludwig *et al*., 2017, **2+**) reported in the section above, that highlighted the impact of predator control on mammalian predators. This study reported that gamekeepers killed on average 187 ± 20 foxes per annum between 1992 and 1999, and 189 ± 22 foxes per annum between 2008 and 2015, i.e., 1.6 ± 0.2 foxes km^2 (2008–2015). The fox index was three times higher during the unmanaged period than in managed periods.

4.4.5 Evidence of the Influence of Red Grouse Disease and Disease Management in Upland Ecosystems

Red grouse are susceptible to several diseases, three of which have the potential to affect the body condition, brood size and mortality rate of the species:

- Louping-ill virus (LIV), transmitted by the sheep tick (*Ixodes ricinus*), has been considered a cause of increased grouse mortality, particularly grouse chicks, for decades (Reid *et al*., 1978).
- Strongylosis, caused by a gastrointestinal worm (*Trichostrongylus tenuis*), has been linked to reduced condition, brood size and increased mortality rates in red grouse (Redpath *et al*., 2006).
- Respiratory cryptosporidiosis, caused by a protozoan parasite (*Cryptosporidium baileyi*), was found relatively recently in English red grouse in 2010 and Scottish red grouse in 2013 (Baines *et al*., 2014). This condition has been found to negatively impact brood size and mortality rates by as much as 50% in UK red grouse populations (Baines *et al*., 2020).

The following sections summarise the evidence on how the management of grouse moors may influence the health of red grouse and other upland species in relation to the above. Each section provides a brief introduction to set the context. Here literature is cited that pre-dates the timeframe of the review to provide background information before introducing the contemporary literature that was retrieved in the academic search.

Influence of louping-ill virus and the associated management on red grouse and other upland species

Research in the 1970s highlighted the potential implications of louping ill virus (LIV) on red grouse populations. These studies (Reid *et al*., 1978; Reid, 1975) one conducted in laboratory conditions and the other in wild grouse, found that LIV was more common in areas where the incidence of sheep ticks was high, and that ticks used red grouse as hosts, thereby transmitting LIV to red grouse. Where grouse chicks were infected with LIV, mortality was

78%, and breeding success in wild populations where chicks were infected with LIV was significantly lower. Since these studies were published, LIV has been considered a significant issue for the health of red grouse in upland ecosystems and has implications for other wild upland bird species such as black grouse and species from other taxonomic groups including red deer and mountain hare.

This review has evaluated the evidence of the direct effect of LIV on red grouse and other upland species. In addition, it has also summarised the evidence collected on the potential for other wild species to act as vectors for LIV, because this has affected management approaches on grouse moors. Most notably, the potential risk of mountain hares spreading disease amongst red grouse stock has meant that the managers of many grouse estates have sought to control the population of mountain hares, particularly in Scotland (Thompson *et al*., 2016).

There was **limited and inconsistent recent evidence** of the effect of louping ill virus (LIV) on red grouse. There was **weak evidence** from one study (Laurenson *et al*., 2003, **2+**) that examined the role of hares as reservoirs of LIV (see below) and measured the change in grouse abundance as the number of hares and the prevalence of LIV reduced. This reported that when LIV reduced substantially, the number of chicks produced per adult female grouse at the treatment site increased relative to the control site ($t = -2.41$ $p < 0.05$), but that there was no significant change in the relative grouse density ($t = 0.32$, NS). By contrast, there was **weak evidence** from another study (Irvine *et al*., 2014, **2+**) that tested the effect of ticks and LIV on red grouse productivity and chick growth in relation to other causes of poor recruitment at two sites in the Scottish uplands. This study demonstrated that neither ticks nor LIV were the main cause of chick mortality. This limited and conflicting evidence highlights the need for further research on the impacts of LIV on different aspects of red grouse ecology (e.g., breeding success, population density) over multiple sites.

There was **weak and inconsistent evidence** of the likelihood of mountain hares causing an increase in LIV in red grouse species. There was **weak evidence** from one study (**2+**) that reported mountain hare as being significantly important in acting as LIV reservoirs and causing high infestations of LIV in red grouse. This study (Laurenson *et al*., 2003, **2+**) that examined the importance of mountain hare as LIV reservoirs, demonstrated that when hare densities were reduced to almost zero on a grouse moor in Morayshire, the tick burden and prevalence of LIV in grouse chicks declined significantly ($p < 0{\cdot}001$). Critically, the findings of this study were one of the principal reasons that Scottish grouse estates embarked upon large scale culling of mountain hare from the 2000s onwards (Gilbert, 2016). It should be noted, however, that the transferability of these findings to other grouse moors has been questioned because of the absence of red deer on this estate (see below).

There was **weak evidence** from one study (**5+**) that reported that mountain hare were likely to only play a partial role in the incidence of LIV in red grouse on managed moors. This study (Gilbert *et al*., 2001, **5+**), which used modelling of LIV persistence in communities with different combinations and densities of red deer, mountain hare and red grouse hosts, demonstrated that in a three-host community, LIV was almost always likely to persist. Although LIV could persist with only mountain hare present (provided hare density was above 5km^2), removing hares entirely would only be effective at eradicating LIV if no other hosts existed that allowed ticks to complete the life cycle (i.e., red deer). It should also be noted that this study did not model for other potential tick hosts such as sheep.

The findings from this study (Gilbert *et al*., 2001, **5+**) have been used by two review articles (Gilbert, 2016; Harrison *et al*., 2010) to highlight that the results of the grouse / hare study (Laurenson *et al.* 2003, **2+**) were not applicable to most of upland Scotland because the grouse moor where the cull was investigated had a complete absence of red deer (as

alternative ticks hosts) and a very high incidence of LIV in the grouse population, both of which were unusual compared to most grouse moors in Scotland. These reviews highlighted that culling to reduce mountain hare density in areas where red deer was present (i.e., most Scottish grouse moors) would not have reduced the abundance of ticks or incidence of LIV because ticks were maintained by the deer population and LIV was maintained by the grouse population. However, there was **no empirical evidence** that examined whether culling has been effective at reducing LIV prevalence in red grouse on estates that have deer species present (as the presence of alternative tick hosts may influence LIV persistence).

The evidence of any potential impact of hare culling (as a management technique applied on grouse moors) on mountain hare distribution and abundance, is presented in Section 4.4.6.

There was **no evidence** collected in this review of the influence of LIV on other wild upland species or the impacts on other wild species caused by the LIV management techniques employed on grouse moors. Although it was anecdotally reported that red deer were culled on grouse moors to reduce tick prevalence (e.g., Thompson *et al*., 2016) and thereby LIV risk for red grouse, no studies were obtained in this review that measured any potential impact on deer or grouse populations.

Influence of strongylosis and the associated management on red grouse and other upland species

It has long been recognised that red grouse are affected by the parasitic worm *T. tenuis*, which like most parasites, can impact the body condition of the host. Research in the latter part of the 20th Century linked the disease to declines in grouse breeding productivity and raised parasite-induced mortality, and this research was further developed to suggest the parasite may be the cause of grouse population cycles (Hudson, 1986; Potts, *et al*., 1984). Since this research was published, red grouse have been routinely provided with anthelmintics, anti-parasitic drugs that expel parasitic worms, which for grouse have been administered through medicated grit on English and Scottish moors to reduce *T. tenuis* burdens (Hudson, 1986). There have been two potential negative implications proposed for this form of pre-emptive disease management. The first is increased anthelmintic resistance in parasites, which is a widespread issue in upland livestock administered with anthelmintics in the UK (Mitchell *et al*., 2010). The second is the potential for wider environmental impacts resulting from routine, pre-emptive administering of veterinary pharmaceuticals (Thompson *et al*., 2016). In addition to the direct effects of *T. tenuis* on red grouse health and breeding productivity, evidence of the potential impacts of disease management were also included in this review, which are presented below.

There was **strong evidence** from three studies (**2+** and **2++**) that suggest that the parasitic worm *T. tenuis* has a negative effect on the breeding productivity of red grouse and that anti-parasite treatment can reduce these impacts. One study (Redpath *et al*., 2006, **2++**) that examined the influence of parasites on the breeding success, abundance and population cycles of red grouse on two moors in England and two moors in Scotland administered anti-parasitic treatment to 1km^2 test areas (and compared with non-treated grouse in control areas). This study demonstrated that treatment was effective at reducing *T. tenuis* intensities, improved grouse brood size (1.7 ± 0.7 chicks per hen on control areas, compared with 3.6 ± 0.7 chicks per hen on treated areas) and led to higher grouse densities in both autumn and spring. Despite these effects however, treatment was unable to prevent the cyclic population declines on all four areas studied, suggesting that the parasite is not the sole cause of populations cycles. Another study (Newborn and Foster., 2002, **2+**) that explored the ability of anthelmintics using a drug called flubendazole to reduce parasite burdens and thereby improve the health, breeding success and density of red grouse, demonstrated that treatment to reduce *T. tenuis* through the provision of medicated grit positively influenced the breeding

success with more than twice as many chicks reared per hen exposed to medicated grit (p = 0.02). However, it was not clear from the study how the medicated grit caused this positive association of more chicks being raised by treated birds because neither clutch size nor hatching rate was influenced. A more recent study (Baines *et al*., 2019, **2+**) that examined whether anthelmintics should be administered routinely on grouse moors, found that across four moors, breeding success was 16% lower when medicated grit was removed.

There was **weak evidence** from two studies (**2+**, **2-**) that suggested that *T. tenuis* in red grouse had not developed resistance to anthelmintics. One study (Webster *et al*., 2008, **2-**) found that in 81 red grouse across 14 sites, genotype analyses of the *T. tenuis* in the red grouse hosts demonstrated there was no anthelmintic resistant mutations found. The study recognised that there was the possibility that the resistance went undetected or that alternative resistance mechanisms existed. Alternatively, the inconsistency in the anthelmintic treatment regime (as wild species take in varied amounts of grit), may mean refugia for susceptible genotypes were maintained, which therefore restricted the development of anthelmintic resistance in *T. tenuis*. Another study (Cox *et al*., 2010, **2+**) explored the potential for *T. tenuis* resistance to anthelmintics in red grouse treated with anthelmintics versus those untreated through examination of red grouse faeces collected from 12 moors in Northern England. This study demonstrated that the provision of anthelmintics to red grouse had no effect on the potential for anthelmintic resistance. However, for two of the 12 samples, there were *T. tenuis* survivors, which suggested that increased resistance might be possible in *T. tenuis*. Owing to the lack of certainty in both these studies, the strength of evidence has only been assessed as weak.

There was **no evidence** found in this review of UK studies that explored the potential for wider environmental impacts of extensive pre-emptive administering of anti-parasitic drugs in upland ecosystems. Several studies have however, highlighted the potential for negative environmental impacts of unmonitored application of anthelmintics in semi-natural ecosystems (Thompson *et al.,* 2016). These concerns were based on studies undertaken outside of the UK, which demonstrated acute and chronic impacts of flubendazole on aquatic invertebrates (Oh *et al*., 2006) but owing to their geographic focus were not included in this review.

Influence of respiratory cryptosporidiosis and the associated management on red grouse and other upland species

Although *C. baileyi* has been found in over 30 avian species worldwide, the respiratory disease associated with the infection was almost entirely restricted to captive-bred birds such as poultry. In the last decade however, the disease has been found in red grouse on UK estates managed for driven grouse shooting. The following section summarises the evidence obtained in this review, about respiratory cryptosporidiosis occurrence and impacts on grouse moors in England and Scotland.

There was **moderate evidence** from two studies (**2+**, **2-**) of the rapid spread of cryptosporidiosis infection in wild red grouse from managed moors in the UK. The first formal verification of cryptosporidiosis infection in wild red grouse was reported in a study (Coldwell *et al*., 2012, **2+**) of veterinary examination and testing of birds that had been caught because they were in visibly poor condition and unable to fly properly. The study confirmed severe cryptosporidiosis infection in wild red grouse caught on an estate in Northumberland in 2010, with later cases reported on an estate in County Durham in 2011 and on a different estate in Northumberland in 2012. This study did not assess wider implications for the health of the grouse other than that it was assumed morbidity associated with infection was low. A later study (Baines *et al*., 2014, **2-**) surveyed the managers of 102 moors in northern England (across five different regions) in 2012 and 2013 to identify potential cases of cryptosporidiosis infection in red grouse. Respondents from 49 moors (48% of the sample) reported that grouse had demonstrated symptoms of cryptosporidiosis infection, although only 14 grouse moor

managers had actually undertaken laboratory testing to verify positive cases (of which 10 were positive). In the North Pennine Dales, the number of grouse moor estates reporting potential cases rose from two in 2009 to 38 in 2013. In only four years therefore, there was a rise from 4% to 80% of moors with positive cases in this region. Biometric data from 670 shot individuals from five Pennine moors demonstrated no significant difference in wing length between infected and healthy individuals, but infected individuals were between 5-7% lighter when infected with cryptosporidiosis.

There was **no evidence** of studies that attempted to identify specific vector pathways for *C. baileyi* between red grouse or from red grouse to other species. Several studies did propose likely causes of disease spread in birds on managed grouse moors however, including close-contact transmission between birds in gritting areas and any adjacent water courses (Coldwell *et al*., 2012, **2+**). Additionally, another study (Baines *et al*., 2014, **2-**) proposed long range transmission was likely to occur because of the characteristics of managed moors, notably density-dependent natal dispersal causing out-migration by juveniles along with the practice of driving birds for several kilometres during shooting. However, neither of these studies actually tested for vector pathways.

There was **weak evidence** from one study (Baines *et al*., 2018, **2-**) of a negative correlation between cryptosporidiosis infection and grouse health. Six-month survival rates were around 50% lower in diseased birds of both sexes ($p < 0.001$) and chick survival 40% higher among healthy pairs than among pairs containing a diseased individual ($p = 0.008$). The study calculated the disease caused an overall 6.2% decline in grouse populations (95% CL 0–31%).

There was **inconclusive evidence** from one study (Parsons *et al*., 2017, **2+**) on whether cryptosporidiosis infection affected other grouse species, specifically black grouse. This study examined the potential for black grouse to be infected with *C. baileyi* by assessing the health of individuals through three approaches: a post-mortem of five individuals, sampling of live individuals (n = 69) between 2011 and 2015 and an observational study of individuals at lek sites (n = 210) in 2016. The latter two methods revealed no evident signs of cryptosporidiosis infection but one individual in the post-mortem had a positive PCR result for *Cryptosporidia* spp., although parasite infestation was not observed in the tissues. The study proposed that there was not conclusive evidence that cryptosporidiosis infection was causing sinusitis in black grouse, but that the post-mortem results raised the possibility that they were infected with the parasite.

Influence of grouse moor management on density-dependent diseases in red grouse and other upland species

Although disease is a naturally occurring phenomenon in natural and semi-natural ecosystems, there are factors associated with the management of grouse moors that may mean disease is a particularly prevalent problem, and that may have implications beyond the target species of red grouse.

There was **strong support** (but not empirical evidence) that grouse moor management increased the risk of disease and disease vectors.

There was **strong support** from four studies (**2+**, **2-**) that highlighted that key aspects of grouse moor management may be significantly increasing the risk of disease in both red grouse and other upland species. Three studies (Baines *et al*., 2020, **2+**; Baines *et al*., 2018, **2-**; Baines *et al*., 2014, **2-**) all explored the impacts of *C. baileyi* infection in red grouse, and highlighted that the density of red grouse, which one of the studies (Baines *et al*., 2020, **2+**) observed had increased significantly over the last decade, was a potential driver of greater disease prevalence and disease spread in red grouse. Another study (Newey *et al*., 2005, **2-**)

that explored the incidence of parasites in mountain hare suggested that disease prevalence in mountain hare communities in Scotland (specifically, infestations of the gastro-intestinal worm *Trichostrongylus retortaeformis*) may be caused by artificially high densities of mountain hare caused by grouse moor management, particularly predator control. This study demonstrated that *T. retortaeformis* infection was widespread in mountain hare populations, had a negative impact on body condition and showed a level of aggregation similar to that found in the T. tenuis–red grouse system, potentially causing population cycles.

By contrast, there was one study (Denny and Latham Green, 2020, **2-**) that explored the socio-economic benefits of grouse moor management that described (but did not empirically test) the relationship between grouse moors and tick densities. This study asserted that grouse moor management reduced tick burdens in the uplands by actively removing bracken and using sheep as 'tick-mops'. Given the lack of empirical data, this study was not deemed to counter the strength of support from the four preceding studies.

4.4.6 Evidence of Influence of Generic Grouse Moor Management on Species

Six studies from the grouse moor evidence did not differentiate between the different types of management associated with grouse moors. In these cases, the influence of burning and predator control and/or other management practices were not distinguished and were seen as representative of grouse moor management as a whole. In some instances, the 'intensity' of grouse moor management was generalised to 'driven grouse shooting', 'walked up shooting' estates and estates not managed for grouse, although the intensity of other management practices (e.g., gamekeeper activity) were not assessed. A further three studies that did differentiate between management practices and have already featured in previous sections (specifically, Buchanan *et al*., 2017, **2+**; Smith *et al*., 2001, **2+**; Tharme et al., 2001, **2++**), drew conclusions about grouse management in general and have therefore also been included in the following section. The following section summarises the evidence from across these nine studies.

Influence of generic grouse moor management on red grouse abundance

There was **strong evidence** from four studies (**2+**, **2++**) that demonstrated a positive association between overall management of grouse moors and red grouse abundance. One study (Buchanan *et al*., 2017, **2+**) on the multi-scale effects of management on moorland birds reported that red grouse (along with two wader species) showed strong positive associations with gamekeeper density, a good overall proxy for generic grouse moor management. Another study (Tharme *et al*., 2001, **2++**) in addition to exploring the influence of individual management variables on bird abundance (see Sections 4.4.3 and 4.4.4), also reported landscape level effects with red grouse significantly more widely distributed in 10km squares with grouse moors than in other upland squares in all the regions studied. It should be noted however, that when 'within region' studies were conducted to test for the influence of factors outside grouse moor management, the population of red grouse between grouse moors and other moors was no longer statistically significant, suggesting regional effects may be very important in determining red grouse populations. Finally, in one study (Smith *et al*., 2001, **2+**) that explored the relationship between grouse moors and meadow pipits on moors in England and Scotland, but which also measured grouse abundance, the mean population density of grouse was found to be almost 50% higher on grouse moors in England than those in Scotland. It should be noted that all these studies conducted further analysis to identify what components of grouse moor management affected red grouse abundance, the evidence from which, has been detailed in previous sections of this review. One long-term study (Robertson *et al*., 2017*b*, **2+**) that compared numbers of red grouse shot across nine British regions over

four time periods (1890– 1920, 1920–1950, 1950–1980, 1980–2010) demonstrated significant regional fluctuations in red grouse density which they attributed primarily to changes in land use (i.e., the loss of grouse moors to, for example, afforestation). Grouse bags were consistently higher in regions of northern England than in Scotland and Wales and declined in all nine regions except the southern Pennines from 1920 to 1950. Bags in northern England increased significantly from 1950, coinciding with increases in keeper density. In north-east Scotland and Wales, numbers of grouse shot declined over the same period, coinciding with declines in keeper density and increased afforestation of moors.

Influence of generic grouse moor management on the ecology of other bird species (excluding raptors)

There was **moderate evidence** from two studies (**2++**, **2+**) that the overall effect of grouse moor management was positive for golden plover. One study (Pearce-Higgins and Yalden, 2003, **2+**) quantified golden plover breeding success on a moor managed for grouse shooting. Breeding success was estimated at a mean of 0.57 fledglings per pair, per year. Modelling results demonstrated that predation rates of golden plover nests and chicks was usually low on grouse moors, which was described as being linked to predator control. However, in the absence of predation, other factors still reduced chick survival and limited breeding success (e.g., exposure). The study concluded that grouse moor management, particularly predator control, could enhance golden plover breeding success, which they argued, may explain the association between golden plovers and grouse moors. Another study (Tharme *et al*., 2001, **2++**), measured the population of 11 bird species on grouse moors compared with 'other moors' (heather moors, with lower or no management). This found that grouse moors were very beneficial for golden plover, with populations five times higher than on unmanaged moors ($p < 0.001$). The study then modelled different aspects of grouse management to establish the likely cause of enhanced populations on grouse moors, which suggested that both predator control and burning benefited golden plover. The same study also showed that both northern lapwing and Eurasian curlew populations were significantly higher on grouse moors than other moors, measured as five times and two times higher respectively. When these figures were adjusted for the influence of regional effects however, only the golden plover population on grouse moors remained statistically significant.

There was **weak and inconsistent evidence** from two studies (**2++**, **2+**) on the overall effects of grouse moor management on black grouse. The same multiple assemblage study (Tharme *et al*., 2001, **2++**) mentioned above, reported neutral influences on the abundance of black grouse. By contrast another study (Warren *et al*., 2019, **2+**) that assessed changes in habitat suitability for black grouse in two regions of southern Scotland over three time periods, demonstrated higher occupation at leks on driven grouse estates. This was confounded by an insignificant relationship between lek occupation and gamekeeper activity, but the study suggested that predator control was likely to be influencing the positive occupation of grouse estate lek sites. It should also be noted that this study reported severe declines of black grouse with extinction of 72 of 103 leks over the 30-year period (although 18 new ones were established). The study concluded that the species needed immediate conservation action, specifically to maintain open habitats, such as those maintained by grouse estates, in upland areas.

There was **moderate evidence** from three studies (**2++**, **2+**) that upland bird species exhibited different responses to overall grouse moor management, and that the increased likelihood of presence or absence of different species may be linked to the intensity of management. This was evidenced by the same multiple assemblage study (Tharme *et al*., 2001, **2++**), which demonstrated neutral influences of grouse moor management on the abundance of wheatear compared with other moors, and negative influences of overall grouse moor management on

meadow pipit, skylark, whinchat and carrion crow. Similarly, another study (Ludwig *et al*., 2020, **2+**) that explored the influence of grouse moor management on predatory bird species reported a neutral effect on raven (*Corvus corax*), with little change in abundance over different phases of management and non-management on Langholm moor in southern Scotland. Another important study (Newey *et al*., 2016, **2+**) explored how bird species composition varied in relation to four principal land management types (grouse shooting, deer stalking, sheep grazing or conservation) on private estates in the Scottish Highlands. The results indicated that, while grouse shooting as a dominant management objective had a strong influence on the occurrence and absolute abundance of only a few species, these estates were still associated with a distinctive avian assemblage including curlew, golden plover, and common sandpiper (*Actitis hypoleucos*), black-headed gull (*Chroicocephalus ridibundus*), buzzard (*Buteo buteo*), short-eared owl (*Asio flammeus*), red grouse, and meadow pipit. However, these estates were also negatively associated with corvids, merlin (*Falco columbarius*), and some passerine species. Importantly however, this study demonstrated that whilst the composition of bird species varied in relation to the four principal management types, measures of diversity and species richness did not. Management of estates for red grouse shooting, characterised by intensive management (rotational burning and predator control) were viewed to be beneficial for certain species, such as some wading birds, but less so for other species including many passerines. Grouse moors therefore had greater influence on the occurrence, absolute and relative abundance of bird species, whereas estates managed for conservation and deer stalking only differed significantly in relative abundance rather than in the presence or absence of species or their absolute abundance.

Influence of generic grouse moor management on the ecology of other taxonomic groups

There was **inconsistent evidence** of the influence of grouse moor management on mountain hare populations (both distribution and abundance). It should be noted that this was the only mammal species to be studied in relation to grouse moors from the evidence found in this review.

There was **inconsistent evidence** on the influence of grouse moor management on the distribution of mountain hare in Scotland. There was **moderate evidence** from two studies (**2-**, **2+**) that grouse management supported the distribution of mountain hare populations in Scotland. It should be noted that both these studies relied on gamekeeper effort and self-reporting of hare presence. Results from 'unmanaged' moors were therefore potentially less reliable due to the lower incidence of gamekeepers, particularly given that alpine areas were not included at all in the study. One study (Patton *et al*., 2010, **2-**) surveyed gamekeepers and landowners to measure the correlation between mountain hare presence on moorlands managed for driven grouse, walked up grouse shooting and unmanaged moors. This study reported that mountain hare distribution on driven grouse moors was on average 55% greater than that of walked-up grouse moors and 64% greater than that of non-grouse moors. A similar study (Hesford *et al*., 2020, **2+**) used surveys of gamekeepers and landowners in 2016/17 to measure changes in distribution over 20 years (combining data with previously undertaken surveys in 1995/96 and 2006/07). This study showed no significant overall change in the proportion of area where mountain hare presence was detected, with driven grouse shooting estates accounting for 68% of the total area where mountain hares were reported as present. It should be noted however, there was significant regional variation with hare range decreasing in the south-west of Scotland by 52% on driven ($p = 0.04$) and 68% on walked-up ($p < 0.001$) grouse moors, but no change occurring on estates with no grouse shooting interest ($p = 0.17$) in the same region. By contrast, over the same 20-year period in the north-west, hare range increased by 61% on driven grouse moors ($p < 0.001$), decreased by 57% on walked-up grouse moors ($p < 0.001$), but showed no change on estates not managed for grouse shooting ($p = 0.65$). The 2016/17 survey also reported a significant increase in the number of hares

being killed on grouse estates (with an increase of 71% compared to the 1995/1996 and 48% compared to the 2006/2007), although it was concluded that this had not affected overall hare distribution.

By contrast, there was **moderate support** (but no empirical evidence) from two studies (**2++**, **2-**) that questioned the reliability of distribution (or 'presence') data as a determinant of the status of mountain hare populations on Scottish grouse moors. This evidence was based on the risk of evaluating the impact of habitat management on a species using distribution/geographic range as a sole variable, because declining or threatened species usually exhibit reductions in abundance before their extinction, but do not display contractions in geographic range size (Casey *et al.,* 2021). One seven-decade study (Watson and Wilson, 2018, **2++**), although focusing specifically on mountain hare abundance (see next paragraph), emphasised that positive correlation between mountain hare distribution and grouse moors may not reflect recent changes in management. This study highlighted that although historically, habitat management and predator control on grouse moors was likely to be very beneficial for mountain hare, since around 2000, significant changes in management have occurred with extensive culling of mountain hare on grouse moors to reduce the spread of louping ill virus (LIV). It was reported that this was likely to have caused significant declines in mountain hare abundance. The importance of understanding the influence of culling on mountain hare populations on grouse moors was also emphasised by a study (Knipe *et al*., 2013, **2-**) that explored the effects of population density on the breeding performance of mountain hare. This study highlighted that close monitoring of hare culling was needed because if the number of individuals harvested exceeded the upper limits of compensatory population growth, overexploitation and population decline could occur, regardless of distribution.

There was **inconsistent evidence** on the relationship between grouse moors and mountain hare abundance.

There was **weak evidence** from one study (Hesford *et al*., 2019, **2+**) that investigated the spatial and temporal variation in mountain hare abundance in relation to grouse moor management. This study reported a positive correlation between hare abundance and grouse moors across different Scottish regions. In Highland, hare indices on driven moors were 35 times higher than on moors that were not shot ($\chi 2\ 1 = 28.9$, $p < 0.001$). Results also varied by type of grouse moor, e.g., in Grampian, mountain hare abundance indices were 3.3 times higher on driven grouse moors than on walked-up moors ($\chi 2\ 1 = 10.5$, $p = 0.001$), and in Highland, they were 2.3 times higher ($\chi 2\ 1 = 6.7$, $p = 0.009$).

By contrast, there was **weak evidence** from one long-term study (Watson and Wilson, 2018, **2++**) that calculated changes in mountain hare abundance in Scotland over grouse moor and non-grouse moor areas over seven decades. This study found marked declines in hare abundance in moors managed for grouse. In particular, on grouse moors, the density index of hares fluctuated through the 1950s–1980s, but declined overall to less than 20% of initial values by the early 1990s. It then fell precipitously after 1999 to less than 1% of initial values by 2009. Critically, this marked decline was not replicated on 'alpine' sites (i.e., sites not managed for grouse). The authors linked this significant decline to marked increases in mountain hare culling on grouse estates (see section on disease).

There was **no evidence** found in this review that attempted to assess the direct effects of mountain hare culling on their population, either abundance or distribution.

4.4.7 Evidence of the Influence of Conflicts Between Grouse Moor Management and Raptor Species

In addition to the approaches to grouse moor management already covered, this evidence review also identified literature that explored the conflicts surrounding raptor populations and their predation of red grouse. This included literature that demonstrated the impact of raptor species on grouse numbers, and the impact of illegal raptor persecution occurring on grouse moors.

Influence of raptor species on generic grouse moor management

The search conducted for this evidence review identified a number of studies that examined the impact of raptors on the productivity of grouse moor estates. Whilst these studies fell outside the core scope of this review on the influence of recreation on upland species, habitats and ecosystems, they provided important information on why conflict between grouse moor management and raptors has become such a pervasive issue. The evidence associated with these studies has therefore been presented, ahead of the section on how grouse moor management influences raptor species.

There was **strong evidence** from four studies (**2+**, **2-**) that raptor predation of red grouse can have significant impacts on grouse numbers. One study (Francksen *et al*., 2019, **2-**) estimated buzzard diet on a Scottish grouse moor using buzzard abundance in bioenergetics and consumption models. This was then compared with estimates of grouse abundance to assess the potential impact of buzzards under a range of scenarios. Results suggested that during breeding seasons, buzzards consumed 5–11% of adult grouse present in April (22–67% of estimated adult mortality) and 2–5% of chicks that hatched (3–9% of estimated chick mortality). During non-breeding seasons, buzzards consumed 7–11% of grouse present at the start of August (14–33% of estimated grouse mortality). The study concluded that buzzard consumption of grouse had the potential to lead to non-trivial economic losses to grouse managers, but only if buzzards predated the grouse they ate, and if grouse mortality was additive to other causes. Another study (Amar *et al*., 2004, **2+**) that focused on measuring whether habitat type affected grouse predation rates by hen harriers on Langholm Moor in Scotland, demonstrated that each nest received an average of 82.8 grouse chicks per season with significant variation between nests (ranging from 0 to 162 grouse). The number of nests varied between 4 and 7 across the six years of study. Although the study did not assess the implications of these findings for grouse shooting viability, it demonstrated a non-trivial number of grouse chicks were predated. One study (Nota *et al*., 2019, **2+**) explored the diet of hen harriers across driven moors, walked up moors and unmanaged moors. Although it did not have direct empirical evidence of the effect of grouse moor management, results showed that hen harrier diets were significantly less diverse on driven grouse moors than on walked up or unmanaged moors. The study concluded that if the high proportion of red grouse in hen harrier diets on driven grouse moors was due to an over-abundance of red grouse, reducing the grouse density may alleviate predation pressure on grouse. Conversely, the study also suggested that the results could indicate that the number of prey species available to hen harriers on driven grouse moors was limited to red grouse and a few other species because of intense management (causing lower alternative prey species abundance and diversity). In this situation the study highlighted that the conservation conflict surrounding driven grouse moors was likely to worsen in the future if management was further intensified. One study (Thirgood *et al*., 2000, **2+**) investigated the influence of habitat change and raptor predation on the number of grouse harvested on the Eskdale half of Langholm Moor in southern Scotland as well as the whole moor. Results demonstrated that long-term declines in grouse bags were related to significant reductions in heather-dominated vegetation, which declined by 48% between 1948 and 1988 (linked to intensive sheep grazing), not least because hen

harriers and peregrine falcons (*Falco peregrinus*) were either absent or bred at low densities throughout the period. However, in 1990, raptors were protected on the estate, and this saw increases in the numbers of breeding raptors over an eight-year period (hen harriers increasing from 1 to 20 breeding pairs, peregrines from 2 to 6). Continued declines in bag numbers in the 1990s (running against the trend of nearby moors which saw cyclical upturns) were therefore linked to raptor predation, although the data supporting evidence that harriers and peregrines reduced autumn grouse densities by 50% were not presented in this study.

Influence of generic grouse moor management on raptor species

There was **strong evidence** from six studies (**2++**, **2+**) identified in this review, that illegal raptor persecution had a significant negative effect on a wide range of raptor species across England and Scotland, and that this persecution was strongly correlated with grouse moors. This evidence is briefly summarised collectively and then broken down by species.

Six studies (Murgatroyd *et al*., 2019, **2++**; Amar *et al*., 2012, **2++**; Sim *et al*., 2007, **2+**; Whitfield *et al*., 2007, **2+**; Whitfield *et al*, 2004, **2++**; Whitfield *et al*., 2003, **2++**) used a combination of raptor population data and persecution data to demonstrate illegal persecution was occurring, and all of these studies demonstrated a significant spatial correlation with the incidence of grouse moors in either England or Scotland, or both. A further study (Tharme *et al*., 2001, **2++**) reported a negative association between the distribution of some raptor species and grouse moors in northern England but did not measure for persecution.

There was also **moderate evidence** from three studies (**2++**, **2+**) that grouse moor management could be beneficial for multiple raptor populations on estates where persecution did not occur. Two of these studies (Ludwig *et al*., 2020, **2+**; Ludwig *et al*., 2017, **2+**) used evidence from Langholm Moor, a demonstrator project in southern Scotland where monitoring and partnership agreements meant persecution was highly unlikely to have occurred, but which was seen as atypical to the practice occurring on most grouse moor estates (Whitfield *et al*., 2003, **2++**). The other study (Tharme *et al*., 2001, **2++**) included some raptor species unlikely to be persecuted because they pose a low risk to red grouse, e.g., common kestrel (*Falco tinnunculus*).

Finally, there was **no evidence** found in this review of the potential impact on raptor species of lead toxicity in shot red grouse or the wider environment, although the potential for toxicity in red grouse was assessed at different sites in England and Scotland (Thomas *et al*., 2009, **2+**).

The following sections present the evidence on the influence of grouse moors on raptors, disaggregated by species.

Hen harrier

There was **strong evidence** from six studies (**2++**, **2+**) that illegal persecution affected hen harrier populations on grouse moors in Scotland (4 studies) and England (2 studies). In a ten-year study (Murgatroyd *et al*., 2019, **2++**) that tracked the fate of 58 tagged hen harriers in England and Scotland, 72% (n = 42) were either confirmed to have been illegally killed or disappeared suddenly with no evidence of a tag malfunction. The probability of these 42 birds dying or disappearing increased significantly with the proportion of foxes on grouse moors (p = 0.003). The study confirmed that squares where hen harriers had a higher-than-average likelihood of dying or disappearing were associated with the highest percentage of grouse moor coverage. Another study (Sim *et al*., 2007, **2+**) reported that although between the late 1990s and mid 2000s the abundance of hen harrier in Scotland increased overall, regional differences suggested grouse moors still had a very negative impact on hen harriers. Hen harrier populations in Orkney and the West Coast Islands, where there were virtually no moors

managed for grouse saw significant increases in population (enough to demonstrate a positive trend for Scotland overall). However, between 1998-2004 in the East Highlands and Southern Uplands, the two regions where grouse moor management was most dominant, hen harrier populations dropped by 38% and 25% respectively. A further study (Whitfield *et al*., 2003, **2++**) that explored the spatial correlation between illegal poisoning of raptors and grouse moors demonstrated that 72% of 121 hen harrier poisoning incidents in Scotland occurred on areas of muirburn (which was used as a proxy for grouse moors), significantly higher than expected, and higher than on other moors ($p < 0.03$). An additional study (Tharme *et al*., 2001, **2++**), already described, found significantly fewer hen harriers on grouse moors than other moors. In England, one study (Sim *et al*., 2007, **2+**) demonstrated that the proportion of English hen harrier populations associated with grouse moors fell from 54% in 1998 to 20% in 2004 ($p < 0.001$). Another study (Tharme *et al*., 2001, **2++**) demonstrated a similar pattern with significantly fewer hen harriers seen on grouse moors than on other moors.

There was **moderate evidence** from three studies (**2+**) that grouse moor management can benefit hen harrier populations where persecution incidents are low. Findings from the same long-term study on Langholm Moor in southern Scotland published in two separate articles (Ludwig *et al*., 2017, **2+**; Ludwig *et al*., 2020 **2+**) both compared the population status of hen harriers on the Langholm Estate in southern Scotland during periods of active management as a grouse moor, and during an interim 'unmanaged' period. One of these studies (Ludwig *et al*., 2017, **2+**) reported that the breeding success of hen harriers was two to three-fold higher during the active management periods ($t = 1.96$, $p = 0.064$). When managed, 80% and 78% of hen harrier breeding attempts fledged chicks, compared to only 39% when unmanaged, although it was not possible to disentangle the relative contribution of individual management practices to the patterns described. The second study (Ludwig *et al*., 2020 **2+**), which focused on a broader suite of raptor species, reported the same data for hen harrier breeding success. Another study (Baines and Richardson, 2013, **2+**), also from Langholm Moor demonstrated that hen harrier abundance increased by 16% per annum during keepering (and saw a 15% decrease per annum after cessation of keepering). This was linked to the importance of legal predator control (see Section 4.4.4) whilst exerting strict monitoring to prevent illegal raptor persecution. During unkeepered periods, hen harrier nest predation by foxes was the main cause of hen harrier breeding failure.

Buzzard, Merlin and Peregrine Falcon

There was **inconsistent evidence** from three studies (**2++**, **2+**) on the influence of grouse moors on buzzard, merlin and peregrine falcon.

One study (Tharme *et al*., 2001, **2++**) reported that buzzards were positively correlated with grouse moors (at a 95% confidence limit) whereas the other study (Ludwig *et al*., 2020, **2+**) reported that the changes between active and lapsed management on the Langholm Estate had no effect on buzzard populations.

Conversely, one study (Tharme *et al*., 2001, **2++**) reported that merlin were observed significantly less frequently on grouse moors (at a 95% confidence limit) whereas the other study (Ludwig *et al*., 2020, **2+**) reported that the abundance of merlin increased during active management phases. This latter study relates the increased population of merlin to raised levels of predator control, which they considered most beneficial to ground-nesting raptors such as merlin.

Finally for peregrine falcon, one large-scale, long-term study (Amar *et al*., 2012, **2++**) used a combination of datasets including peregrine breeding surveys, RSPB persecution data, and satellite imagery to explore the impact of grouse moor management on over 1000 peregrine falcons (1 km resolution) over a 26-year period. This study found that breeding success and

productivity on grouse moors was 50% lower than on non-grouse moor habitat, even though clutch and brood size were similar between habitat types, suggesting there was little difference in prey availability. Population modelling indicated that grouse moor populations were unsustainable and were reliant on immigration. Wildlife crime data revealed that persecution occurred more frequently on grouse moors.

This was countered by **weak evidence** from one other large-scale study (Tharme *et al*., 2001, **2++**) which found that peregrine falcon populations did not differ significantly between grouse moors and other unmanaged moors. Another study (Ludwig *et al*., 2020, **2+**), found that on Langholm Moor, although the overall breeding success of peregrine falcon was unchanged across management periods (managed, then unmanaged, then managed again), the proportion of successful attempts tripled during the second managed period (78%) in comparison to the preceding managed and unmanaged periods (25% and 22%), while there was no difference in brood size. Evidently the Langholm Moor project was not assessing for the impact of raptor persecution, which was strongly monitored and prohibited during the trial period, which is in contrast to evidence from many other grouse moors (see Whitfield *et al*., 2003, **2++**).

Golden Eagle and Kestrel

There was **moderate evidence** from two studies (**2++**, **2+**) that golden eagle were significantly negatively affected by illegal persecution on grouse moors in Scotland. One study (Whitfield *et al*, 2004, **2++**) employed GIS analysis, utilising two national censuses (1982 & 1992) of the golden eagle in Scotland and contemporary data on the distribution of poisoning incidents to examine the age of breeding pairs and the likelihood of persecution affecting population dynamics over a large area. The results demonstrated that persecution, which was strongly associated with grouse moors in the eastern zones of the country, was associated with a reduction in the age of first breeding, increased territory vacancies, and the use of territories by non-breeding immature eagles. This latter phenomenon meant that persecution probably created ecological traps where mobile immature eagles were attracted to persecution areas, increasing sub-adult mortality in birds that originated from persecution-free areas (i.e., the west coast). Although this latter trend was inferred from eagle age rather than empirically tested (i.e., through radio-tagging birds), it highlighted that persecution was significantly impacting the golden eagle population of Scotland, as juvenile eagles from persecution free areas were attracted into vacant territories with abundant prey where they were then persecuted. A second study (Whitfield *et al*., 2007, **2+**) also demonstrated that golden eagle distribution in Scotland was strongly affected by illegal persecution. The study showed that between three golden eagle censuses (1982, 1992 and 2003), occupied eagle territories declined in regions where persecution incidents were still notably high and tended to increase where persecution incidents had declined.

There was **weak evidence** from one study (Tharme et al., 2001, **2++**) that kestrel populations did not differ markedly between grouse moors and other moors not managed for driven grouse shooting.

Other upland bird of prey species

There was **no evidence** of the effect of grouse moor management on the distribution, abundance or breeding success of other upland bird of prey species in the UK, e.g., short-eared owl, long-eared owl (*Asio otus*), goshawk (*Accipiter gentilis*) and white-tailed eagle (*Haliaeetus albicilla*).

Influence of grouse moor management on upland habitats

There was **weak evidence** from one study (**2+**) of the association between generic grouse moor management and the persistence of heather (*Calluna vulgaris*) in upland ecosystems. This study (Robertson *et al*., 2001, **2+**) compared land cover changes on sites managed for grouse (between the period of 1945-1990) and on sites where grouse moor management was occurring in the 1940s but had stopped by the 1980s. The results suggested that the retention of heather coverage in Scotland could be associated with grouse moor management. In the 1940s there were no significant differences in land cover type between areas that were managed for grouse, and areas that were not. However, differences emerged during the 1970s and 1980s; areas where grouse management had ceased by the 1980s showed an expansion in woodland cover from 6% in the 1940s to 30% in the 1980s, and a reduction in heather cover from 53% to 29%. In areas where active grouse management had been maintained, woodland increased from 3% to 10% and heather decreased from 51% to 41% during the same period. Whilst the relationship between grouse moors and heather coverage was evident, the study acknowledged it was not conclusively causal, i.e., it is difficult to assess the extent to which continued grouse shooting has been the cause or the consequence of heather retention during this period.

There was **no evidence** found in this review of literature that examined the influence of complete cessation of grouse moor management, e.g., how this may influence vegetation succession from heather dominated habitats, changes to habitat coverage or any associated species or taxonomic groups.

Although much of the evidence referred to different types of grouse management around 'driven grouse shooting', 'walked up shooting' or 'no shooting', there was **no evidence** found in this review of literature that measured the variability of management intensity within or between these broad classifications beyond fairly basic indicators such as number of game keepers employed.

4.5 Evidence statements on the Relationship Between Types of Recreation and Severity of Impact

Section 4.3 and Section 4.4 have demonstrated the significant influence that some forms of recreation can have on upland ecosystems. Research Question 4 explores an associated theme, on the relationships that exist between types of recreational activity and the severity of their impact on upland ecosystems. However, only a very small number of studies identified in this review examined the influence of multiple forms of recreation in upland ecosystems. This made any assessment of the comparative severity of different recreation types very challenging.

Relationship between recreation type and severity of impact

There was **moderate evidence** from two studies (both **2+**) that the severity of impacts does vary with the type of recreation, but there was no consistency across types because of the focus of the studies. Additionally, it is likely that responses to different types of recreation are species-specific, although this was not possible to detect with so few studies. One study (Murison *et al*, 2007, **2+**) that explored the disturbance effects from recreation in different types of habitat demonstrated that Dartford warbler breeding success was negatively affected in habitats that were open (heathland) compared with those with more cover (e.g., gorse habitats). Importantly for Research Question 4, in this study there was also a recognition that different types of recreation occurred on the path network and that this probably played an important role on the intensity of impact, but this was not empirically tested. The frequency of

disturbance by recreation type was recorded however, with dog walking, birdwatchers/naturalists and walkers/joggers being the three most common forms of recreation that disturbed breeding Dartford warbler. The findings from this study were only partially applicable however, as the research was conducted on lowland sites, although the Dartford warbler has been recorded breeding in upland areas of the UK. Another study (Rees *et al.*, 2005, **2+**) explored the influence of six different disturbance types, three of which were recreation types hiking, cycling and hunting (which grouped together angling and wildfowling). This study demonstrated that anglers and wildfowlers more readily displaced swans, with a disturbance distance for anglers of 364 ± 78.1m, for wildfowlers the disturbance distance was 350 ± 12.9m. By contrast, the disturbance distance associated with hiking was 249 ± 14.0m and for cycling was 116 ± 17.1m. This research highlighted that in whooper swans at least, the type of recreation did appear to have an impact on the severity of disturbance impact (although some other factors like length of disturbance did not seem to be controlled for). The applicability of these findings needs to be viewed with extra caution as the research was undertaken in the lowlands, and whooper swans do not breed in the UK uplands, although they have been extensively recorded overwintering in upland sites in Scotland (Newth *et al.*, 2013).

It should be noted that there was **no evidence** found in this review that assessed the relationship between types of recreation and severity of impacts specifically within upland environments, which is a particular gap in knowledge. One study, which was screened out because the study site and species concerned were in the English lowlands, provided a good example of the type of research needed in the UK uplands. This study (Taylor *et al.*, 2000) analysed the alarm response of stone curlew (*Burhinus oedicnemus*) to three main types of recreation, dog-walking, walking and motorised vehicles. The methodology observed disturbance behaviours at the same site for all three 'disturbance agents'. Although not transferable to upland species, in stone curlew, the greatest severity of disturbance impact was people with dogs, where an alarm response was observed at >500m. People without dogs generated a lesser response and vehicles the smallest, particularly when they were on well-used routes. Repeating this type of study in the uplands targeted at upland bird assemblages would help address the absence of evidence on the relationship between recreation type and severity of impact.

4.6 Practitioner survey synopsis: the influence of recreational activity on upland species, habitats, and ecosystem processes

The online practitioner survey was used to try to ascertain perspectives of those working in the uplands, to provide some context to the review of written evidence. A more detailed analysis of this data is presented in Appendix VII, but the key messages relating to research Questions 3 and 4 are summarised below.

Overall, respondents generally agreed that many forms of recreational uses have negative impacts on upland ecosystems, but this varied considerably based on the participant (e.g., their stakeholder type and interests) and the type of recreational activity in question. Based on the results of the practitioner survey, a divide can be seen between practitioners who viewed upland recreation more positively and those who believed it had primarily negative impacts on upland ecosystems. Generally, these results were consistent with trends in academic literature regarding the polarisation between pro and anti-grouse shooting perspectives.

Practitioners described dog walking, off-road biking (mountain biking, scrambler or trail biking), and barbecuing as the top three damaging activities in the uplands. The practitioner survey

also demonstrated perspectives that off-road/4x4 driving, fireworks, raves, camping, picnicking, and e-biking were all perceived as damaging to upland ecosystems. This highlights the contrast between practitioner perspectives and the availability of evidence from academic studies as very little research was found that focused on these recreational types. It is worth noting that some of these recreational activities are conducted illegally in the upland areas and concerns relating to this were raised within survey responses.

Some recreational activities were regarded as having minimal or no impact on upland ecosystems including birdwatching, road/scenic driving, and horse riding. Many respondents involved in grouse moor management (to varying degrees) ranked driven grouse shooting and walked up shooting positively. Here it is notable that the complexities and negative implications of grouse moor management as presented within academic literature did not feature in many of their responses.

4.7 Summary of evidence, gaps and recommendations: Influence of recreation on upland species, habitats and ecosystem processes

The following section summarises the strong and moderate evidence statements produced in this chapter, outlines the gaps in evidence and from these, suggests a series of recommendations.

4.7.1 Summary of evidence: influences on species, habitats and ecosystem processes, and appropriate levels of use

Research Question 3: What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?

The following 11 strong and 17 moderate evidence statements were developed in relation to Research Question 3*: What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?* Additionally, there were four evidence statements where the evidence was inconsistent, and one where there was moderate support but not empirical evidence.

Given the extent of evidence that was obtained for Research Question 3, the summarised statements have been broken down into the principal sub-categories.

Direct forms of recreational activity

Influence of 'general recreation':

- There was **inconsistent evidence** of the influence of 'general recreation' on the breeding success of bird species, because whilst there was **moderate evidence** across three studies (**2+**, **2-**) that suggested a negative effect of 'general recreation' on the breeding success of some bird species, there was also **moderate evidence** from three studies (**2++**, **2+**) that showed an insignificant correlation between disturbance from general recreation and the breeding success of two different ground nesting bird species. The inconsistency in the evidence surrounding the way in which general recreation affected the breeding success of different bird species suggests that responses to recreational disturbance is likely to be species specific, but it could also be affected by site-specific variables.
- There was **strong evidence** from four studies (**2++**, **2+**, **2-**) that bird behaviour and population effects (e.g., abundance, population density or overall survival) were negatively correlated with disturbance caused by 'general recreation', but this association was sometimes weak or context dependent.

- There was **strong evidence** from four studies (**2-**, **2+**, **3-**, **4-**) that 'general recreation' had a negative impact on habitat quality, two studies related to water quality and two studies related to broader, terrestrial habitat types in the uplands.
- There was **moderate evidence** from two studies (**2+**, **2-**) of a negative correlation between 'general recreation' and water quality, an important ecosystem service in the uplands.
- There was also **moderate support** from three studies (**3-**, **4-**) that the combination of climate change and recreational use in the uplands would negatively affect ecosystem processes although these were not tested with empirical evidence.

Influence of walking / dog walking:

- There was **strong evidence** from four studies (**2++**, **2+**) that walking caused negative impacts on birds in upland ecosystems.
- There was **moderate evidence** from two Scottish studies (both **2+**) that demonstrated a negative correlation between walking and red deer (*Cervus elaphus*). These were, however, the only studies found in this review that assessed the impacts of walking on upland mammals.
- There was **moderate evidence** from two studies (**2+**, **2-**) of a negative correlation between walking and disturbance to soil in the UK uplands.

Influence of 'mountain biking:

- There was **moderate evidence** from two studies (**2++**, **2+**) that on-track mountain biking was negatively correlated with disturbance to upland species (one bird, one mammal).

Influence of motorised vehicles on habitats in upland ecosystems:

- There was **moderate evidence** from two studies (both **2+**) that demonstrated the potential for motorised vehicles to negatively influence upland habitats.

Influence of 'all other types' of recreation:

- There was **moderate evidence** from three studies (**2+**; **2-**) that demonstrated the negative impacts of ski developments on upland ecosystems.
- There was **moderate evidence** from two studies (**2+**, **3-**) undertaken in Scotland that wild camping had negative impacts on upland ecosystems.

Grouse moor management

Influence of grouse moor management: rotational burning

- There was **inconsistent evidence** from across four studies that burning had a beneficial effect on the abundance and breeding success of red grouse because whilst there was **moderate evidence** from two studies (both **2+**) that demonstrated a positive correlation between rotational burning and red grouse abundance, there was **moderate evidence** from two studies (both **2+**) of a null effect of heather burning on red grouse abundance.
- There was **moderate evidence** from two studies (both **2+**) that burning had a largely neutral effect on the abundance of ground nesting waders.
- There was **inconsistent evidence** of the effects of burning on upland passerines with the response of most species being measured as neutral, but some individual species demonstrated either a positive or negative response. These variable responses between species suggested that responses of passerines to burning were likely to be species-specific.

- There was **moderate evidence** from two studies (both **2++**) of a negative impact on aquatic invertebrates due to rotational burning.
- There was **moderate evidence** from two studies that demonstrated that burning occurred on protected habitats (both **2+**), but that this may be an important element of managing these habitats as per existing designations.

Influence of grouse moor management: predator control

- There was **strong evidence** across 4 studies (**2++**, **2+**) that demonstrated a positive relationship between legal predator control and the abundance of red grouse.
- There was **strong evidence** from five studies (**2++**, **2+**) that legal predator control had a positive influence on the abundance of birds other than red grouse, particularly ground-nesting waders.

Influence of grouse moor management: disease and disease management

- There was **strong evidence** from three studies (**2+**, **2++**) that suggested that the parasitic worm *T. tenuis* has a negative effect on the breeding productivity of red grouse and that anti-parasite treatment can reduce these impacts.
- There was **moderate evidence** from two studies (**2+**, **2-**) of the rapid spread of cryptosporidiosis infection in wild red grouse from managed moors in the UK.
- There was **strong support** (but not empirical evidence) that driven grouse moor management increased the risk of disease and disease vectors.

Influence of 'generic' grouse moor management

- There was **strong evidence** from four studies (**2+**, **2++**) that demonstrated a positive association between overall management of grouse moors and red grouse abundance.
- There was **moderate evidence** from two studies (**2++**, **2+**) that the overall effect of grouse moor management was positive for golden plover.
- There was **moderate evidence** from three studies (**2++**, **2+**) that upland bird species exhibited different responses to overall grouse moor management, which for some species may also be related to the intensity of management (e.g., extent and pattern of heather burning).
- There was **inconsistent evidence** on the influence of grouse moor management on the distribution of mountain hare in Scotland because although there was **moderate evidence** from two studies (**2-**, **2+**) that grouse management supported the distribution of mountain hare populations in Scotland, there was also **moderate support** (but not empirical evidence) from two studies (**2++**, **2-**) that questioned the reliability of distribution (or 'presence') data as a determinant of the status of mountain hare populations on Scottish grouse moors.
- There was **strong evidence** from four studies (**2+**, **2-**) that raptor predation of red grouse can have significant impacts on red grouse numbers.
- There was **strong evidence** from six studies (**2++**, **2+**) identified in this review, that illegal raptor persecution had a significant negative effect on a wide range of raptor species across England and Scotland, and that this persecution was strongly correlated with grouse moors.
- There was also **moderate evidence** from three studies (**2++**, **2+**) that grouse moor management could be beneficial for multiple raptor populations on estates where persecution did not occur.
- There was **strong evidence** from six studies (**2++**, **2+**) that illegal persecution affected hen harrier populations on grouse moors in Scotland (4 studies) and England (2 studies).

- There was **moderate evidence** from three studies (**2+**) that grouse moor management can benefit hen harrier populations where persecution incidents are low.
- There was **moderate evidence** from two studies (**2++**, **2+**) that golden eagles were significantly negatively affected by illegal persecution on grouse moors in Scotland.

Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

The following moderate evidence statement was developed in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

- There was **moderate evidence** from two studies (**2+**) that the severity of impacts does vary with the type of recreation, but there was no consistency across types because of the focus of the studies. Additionally, it is likely that responses to different types of recreation are species-specific, although this was not possible to detect with so few studies.

4.7.2 Gaps in evidence: influences on species, habitats and ecosystem processes, and appropriate levels of use

Research Question 3: What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?

The following gaps in evidence were found in relation to Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*

Direct forms of recreational activity:

- There was **no evidence** from studies examined in this review that measured the effect of dog walking on birds specifically in upland habitats (most studies were confined to lowland heathland in Southern England) or that measured the effect of dog walking on taxa other than birds in any habitat.
- There was **limited evidence** on the influence of mountain-biking, with only four studies that solely examined the influences of mountain biking through empirical analysis, and only two that were specific to the UK uplands. The amount of evidence analysing the influence of mountain biking on upland ecosystems seems low, given the popularity of this type of recreation and the potential for negative impacts on upland ecosystems (Huddart and Stott, 2019).
- There was **no evidence** found within this review that explored the effect of off-track mountain biking on species (and only weak evidence from one study that explored the impact on habitats).
- There was **no evidence** of the influence of motorised vehicles in the UK uplands, although one strong study (**2++**) did demonstrate the potential extent of motorised access within the UK uplands.

Grouse moor management:

- There was **limited recent evidence** of the impact of burning on taxonomic groups other than birds; one study related to mammals and two related to invertebrates.
- There was **weak and inconsistent evidence** on the benefits of predator control on passerines because whilst one study suggested neutral impacts of predator control on

passerines (meadow pipit and skylark), another study reported positive effects on the breeding success and abundance of meadow pipit.

- There was **no evidence** found in this review that examined the effects of legal predator control on other mammals except the quarry species, or for any other taxonomic groups. Although some studies explored the influence of grouse moor management on mountain hare populations, they did not empirically test the impact of predator control.
- There was **limited and inconsistent recent evidence** of the effect of louping ill virus (LIV) on red grouse.
- There was **weak and inconsistent evidence** of the likelihood of mountain hares causing an increase in LIV in red grouse species and there was **no evidence** found in this review that attempted to assess the effectiveness of hare culling on estates that have deer species present (as the presence of alternative tick hosts may influence LIV persistence).
- There was **no evidence** collected in this review of the influence of LIV on other wild upland species or the impacts on other wild species caused by the LIV management techniques employed on grouse moors.
- There was **no evidence** found in this review of literature of UK studies that explored the potential for wider environmental impacts of extensive pre-emptive administering of anti-parasitic drugs in upland ecosystems.
- There was **no evidence** of studies that attempted to identify specific vector pathways for *C. baileyi* between red grouse or from red grouse to other species.
- There was **inconclusive evidence** on whether cryptosporidiosis infection affected other grouse species, specifically black grouse.
- There was **weak and inconsistent evidence** on the overall effects of grouse moor management on black grouse.
- There was **weak and inconsistent evidence** on the relationship between grouse moors and mountain hare abundance.
- There was **no evidence** found in this review of the potential impact on raptor species of lead toxicity in shot red grouse or the wider environment, although there was one study (**2+**) that demonstrated lead toxicity in red grouse on grouse estates in England and Scotland.
- There was **weak and inconsistent evidence** on the influence of grouse moors on buzzard, merlin and peregrine falcon. For each species, there were two studies demonstrating opposing population or breeding trends in relation to the influence of grouse moors.
- There was **no evidence** of the effect of grouse moor management on the distribution, abundance or breeding success of other upland bird of prey species in the UK, e.g., short-eared owl, long-eared owl (*Asio otus*), goshawk (*Accipiter gentilis*) and white-tailed eagle (*Haliaeetus albicilla*).
- There was **no evidence** found in this review of literature that examined the influence of complete cessation of grouse moor management, e.g., how this may influence vegetation succession from heather dominated habitats, changes to habitat coverage or any associated species or taxonomic groups.
- There was **no evidence** found in this review of literature that measured the variability of management intensity within or between the broad classifications of different types of grouse management; ‘driven grouse shooting’, ‘walked up shooting’ or ‘no shooting’.

Research Question 4: What relationships exist between types of recreational activity and severity of impact in the UK uplands?

The following gaps in evidence were found in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

- There was **no evidence** found in this review that assessed the relationship between types of recreation and severity of impacts specifically within upland environments, which is a particular gap in knowledge.
- There was **limited evidence** that suggested that recreation pursuits that adopt non-typical routes or included sporadic or unpredictable behaviour were likely to have greater impacts on species than when the activity occurred in a more predictable manner.

4.7.3 Recommendations: influences on species, habitats and ecosystem processes, and appropriate levels of use

Research Question 3: What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?

The following recommendations were developed in relation to Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*

Recommendations from Evidence:

Direct forms of recreational activity

- There was **inconsistent evidence** on whether 'general' recreation (i.e., where there was no distinction about the specific type of recreation being studied) negatively influenced the breeding success of some bird species. Studies that did identify impacts, particularly on ground nesting birds, were mostly conducted on lowland sites (although focusing on species that also breed in the uplands). Much more empirical data is required on the influence of general recreation types in upland ecosystems to corroborate the effects found in lowland studies, and to determine the extent to which issues are species specific.
- There was **strong evidence** that bird behaviour and population effects (e.g., abundance, population density or overall survival) were negatively correlated with disturbance caused by 'general recreation', but these only analysed three species in total (three studies on grouse species and one passerine, the latter in a lowland setting). Further research is needed that investigates disturbance effects on a much broader suite of upland bird species, to determine the extent to which responses are species-specific and whether the impacts differ in different upland habitats. Additionally, similar research is also needed that goes beyond avian fauna to investigate influences on other taxa.
- There was **strong evidence** that 'general recreation' had a negative impact on habitat quality and associated ecosystem processes, but these studies were mostly limited to water quality. Further research is needed that explores the impact of recreation on a much broader suite of upland habitats.
- There was **strong evidence** that highlighted the negative effects of walking and hiking on bird behaviour (including breeding success and disturbance effects) in the uplands and **moderate evidence** that demonstrated a negative correlation between walking and red deer. Importantly however, two studies showed that good footpath provision,

which reduced the deviation of walkers from footpaths significantly lessened these negative effects. Better promotion is needed of the positive effects of footpath restoration and maintenance, to create greater awareness that this management measure can reduce the impacts of walking and hiking on upland species (because diversions into habitats are reduced) as well as the more obvious benefit of reducing habitat damage. Additionally, however, further research is required that explores whether these benefits are transferable to a wide range of upland habitats as both these studies were undertaken on very similar same sites. Further research is also needed to assess whether these benefits extend to other taxonomic groups.

Grouse moor management

- There was **inconsistent evidence** on whether rotational heather burning has a positive effect on red grouse numbers (although it should be noted evidence published before 2000 suggests a positive relationship between burning and red grouse numbers). Further contemporary research is needed that investigates whether the primary purpose of burning, to increase red grouse densities, is effective in different locations across the UK uplands, particularly in the light of novel influences on red grouse populations, e.g., climate change, cryptosporidiosis infection, etc.
- There was **inconsistent evidence** on how rotational burning influenced bird species other than red grouse in the UK uplands with effects being notably species-specific. For the majority of species, burning had a neutral or negative effect, although there were specific anomalies (e.g., moderate evidence of benefits for whinchat). This is an important finding as existing upland management is often cited as sustaining threatened upland bird communities, but the specifics of this management (e.g., burning versus predator control) are often aggregated. This amalgamation of potential management influences associated with grouse moor management was a notable issue with some of the evidence included in this review. Further research is needed that examines the impacts of different grouse moor management activities on birds, mammals, invertebrates and other taxonomic groups, with a particular focus on burning as a discrete measure, compared with other aspects of grouse moor management.
- There was **moderate evidence** that burning occurred on protected habitats, but no evidence found in this review that explored the extent to which this form of management was required to sustain or improve the condition of habitats. Further research is needed that explores a variety of management futures for upland habitats to identify opportunities for socio-economic and ecological diversity in upland management regimes, with less dependence on individual land-uses or management techniques.
- There was **strong evidence** of the benefits of predator control on grouse moors for both red grouse and other upland bird populations. The weight of evidence found in this review suggests this is the most important management technique for maintaining high densities of red grouse, and potentially for supporting other bird species. Research is needed on the economic, social and environmental sustainability of predator control as a tool for conserving specific species in upland ecosystems, and the effects on a broader suite of taxonomic groups (e.g., mammals). Additionally, research is also needed that explores alternatives to generalist predator control.
- There was **strong evidence** that medicating grouse can help to reduce the prevalence of individual diseases but there was an absence of evidence of the wider environmental implications of routine administering of medicines in upland ecosystems. Further research is needed that explores the impacts of applying anti-parasitic drugs on grouse

moors for other taxonomic groups e.g., bird species and invertebrates, and the wider implications for ecosystems including soil and water quality.

- There was **moderate evidence** that some bird species, particularly ground-nesting waders, are positively affected by the overall approach of grouse moor management, but also that responses are species-specific, with some negative responses. There was however a dominant focus within studies to examine the influence of grouse moor management on species currently present on grouse moors. Further research is needed that examines the influence of this management on past assemblages of species, or on species with the potential to extend their ranges into areas managed as grouse moors, e.g., Dartford warbler or woodlark, to explore the influences on a broader suite of species.
- There was **inconsistent evidence** on the influence of grouse moor management on mountain hare populations in Scotland, with a potential conflict between the influence of habitat management (i.e., burning and predator control) set against significant increases in culling as a form of disease management. Given the recent increase in culling rates reported by some studies and the change in law requiring Scottish land managers to be licensed before culling can occur, further research is needed that explores the impact of hare culling and the associated legislation.
- There was **strong evidence** that raptor persecution has had a significant negative effect on most raptor populations on grouse moors in England and Scotland, and that for some species, notably golden eagle and hen harrier, this may have had a much more widespread impact on their population status across the UK. This was linked to **moderate evidence** that raptor populations can benefit from grouse moor management where persecution does not occur (i.e., the Langholm Estate) but also a recognition that the evidence that has emerged from this individual demonstrator project has not significantly influenced the management practices occurring on other Scottish or English estates. Further research is needed that explores other options for preventing widespread raptor persecution occurring on grouse moors.

Recommendations from Absence of Evidence:

Direct forms of recreational activity

- This review has demonstrated that there is, in general, a notable **lack of evidence** about the impacts of specific forms of recreation on upland species, habitats and ecosystems with only moderate evidence (across six studies in total) assessing the influence of three specific types of recreation (on-track mountain biking, ski developments and wild camping). This is despite the popularity of many recreation types in upland areas. Further extensive and wide-ranging research is needed that explores habitat and species level impacts of specific types of recreation – particularly those with either high levels of use and/or where the impact on upland ecosystems is likely to be significant. This includes, but is not limited to, the influence of dog walking, motorised vehicles, off-road biking (e.g., mountain-biking and scrambler/trail biking) and barbecues, all of which were highlighted in the practitioner survey as having significant impacts on upland ecosystems, but which are absent or under-represented in empirical studies. Some specific recommendations for these individual recreation types include:
    - Addressing the absence of evidence surrounding the influence of dog walking in upland ecosystems with further research that explores the differences between on-lead and off-lead impacts and studies that include a broad range of species including (but not limited to) upland birds. Studies on the impacts of

dogs might also determine the effect of different breeds and the impacts of the height and density of different vegetation types.
    - Addressing the absence of evidence on mountain-biking with further research that examines the influence of on-track and off-track pursuits on species and habitats in upland ecosystems, including examining where mountain-biking occurs illegally.
    - Addressing the absence of evidence of how motorised vehicles affect species and habitats with further research that explores the influence on species and habitats, including specifically designated motorsport areas, areas popular for off-road motorsports, and the extent and impact of illegal motorised vehicles across the UK uplands. A lowland study not included in this evidence review (Taylor *et al*., 2007) but conducted on a lowland bird species (stone curlew), suggested that ground-nesting birds can be disturbed by motorised vehicles, but that this disturbance is lower than it is for walkers and dog-walkers. Bird responses occurred more rapidly and at lesser distances if vehicles were using a non-typical route with relatively small responses recorded when motorised vehicles traversed regularly used routes. This type of study needs to be replicated in upland areas, particularly given that practitioner perspectives highlighted the increase in popularity of off-road driving as a recreational activity in upland ecosystems.
- There was much less evidence available regarding the influence of recreation on habitats (as opposed to species), although several studies reported negative impacts of general recreation on freshwater quality. Further research is needed that explores the influence of a range of different recreation types on diverse upland habitats and their relative sensitivity to negative impacts.
- Related to this recommendation on the influence of recreation on habitats, is the relationship between disturbance and vegetation types and heights. There was weak evidence from one study that reported that short vegetation height may increase disturbance to breeding birds from dog-walking and other forms of recreation. Further research is needed that explores the influence of vegetation height on disturbance effects, particularly given the range of anthropogenic activities that maintain short vegetation in upland ecosystems (e.g., heather burning and grazing).
- The majority of species-level studies were focused on the impacts of recreation on breeding birds. Further research is required that explores impacts on other taxonomic groups, both terrestrial and aquatic.
- Although there was extensive evidence on the influence of grouse moor management on upland species, there was **no evidence** relating to the impact of actual shooting days on upland species other than red grouse. Further research is needed that explores the influence of the red grouse shooting period on other upland species.

Grouse moor management

- There was a **lack of evidence** across all aspects of grouse moor management (i.e., burning, predator control, disease management, and 'generic' management), of the influence on taxonomic groups other than birds, and even this was mostly limited to ground-nesting waders and a few passerine species. Whilst these species represent a significant proportion of the protected species occurring on upland habitats (e.g., blanket bog and heathland habitats), they only represent a narrow assemblage of all the biodiversity that could inhabit UK upland ecosystems. Further research is needed that examines the influence of grouse moor management on a much broader suite of species associated with the UK uplands.

- There was **limited and inconsistent recent evidence** of the effect of LIV on red grouse. Given that the management of other upland species (e.g., mountain hare and red deer) on grouse estates is based on the assumption that LIV has significant negative effects on red grouse, there needs to be further research on the impacts of LIV on different aspects of red grouse ecology (e.g., breeding success, population density) over multiple sites.
- There was **weak and inconsistent evidence** of the likelihood of mountain hares causing an increase in LIV in red grouse species and there was **no evidence** found in this review that attempted to assess the effectiveness of hare culling on estates that have deer species present (as the presence of alternative tick hosts may influence LIV persistence). There was also **no evidence** found in this review that attempted to assess the direct effects of hare culling on hare populations, either abundance or distribution. There needs to be further research on the influence of culling on hare populations and whether it achieves its aim of reducing LIV in red grouse.
- Although there was **strong support** from four studies that the density of grouse had increased over the last 20 years (promoted by more intensive management) and that this greater density had increased the risk and prevalence of disease in red grouse and potentially other species (e.g., black grouse and mountain hare), there was **no empirical evidence** of the changes in management intensity or the impact it may be having on other species associated with upland ecosystems. There was also **no evidence** that attempted to identify vector pathways for disease, particularly transfer to other avian species. Further research is needed that explores the recent changes in grouse moor management and whether there is any relationship with diseases in red grouse, coupled with research on the influence of more intensive management on a broad suite of upland species and habitats.
- There was **no evidence** found in this review, of the potential for lead toxicity in red grouse to influence the trophic food chain or the wider environment. Further research is needed, in the absence of restrictions on using lead shot, which explores the wider ecological and environmental impacts of lead toxicity in red grouse and other upland species (e.g., raptors and grit-eating species such as ducks).
- There was **weak and inconsistent evidence** of the influence of grouse moor management on buzzard, merlin and peregrine falcon and **no evidence** on other bird of prey species associated with upland habitats (e.g., short-eared owl, long-eared owl, goshawk, and white-tailed eagle). Given the strength of evidence of persecution of raptors, many of which are killed through indiscriminate methods such as poisoning, further research is needed that explores the impact of grouse moor management on all birds of prey associated with the uplands. This research should consider the full range of management approaches, including habitat management as well as persecution.
- There was **no evidence** found in this review of literature that examined the influence of complete cessation of grouse moor management, e.g., how this may influence vegetation succession from heather dominated habitats, changes to habitat coverage or any associated species or taxonomic groups. The only study of grouse moor cessation found in this review was limited to Langholm Moor, which only demonstrated removal of some management measures for a relatively short amount of time and did not attempt any habitat restoration in the interim period. Further research is needed that explores how obsolete grouse moors might be successfully restored to enhance their value for biodiversity and the associated role of vegetation management versus allowing vegetation succession.

Research Question 4: What relationships exist between types of recreational activity and severity of impact in the UK uplands?

The following recommendations were developed in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

Recommendations from Evidence:

- There was **moderate evidence** that the severity of impacts does vary with recreation type, but there were too few studies to generate any conclusions about more or less impactful types of recreation. There needs to be a strong focus of further research that explores the relationship between types of recreational activity and the severity of impact in upland ecosystems.

Recommendations from Absence of Evidence:

- As above, there was **limited evidence** on the relative impacts of different types of recreation, and the studies that were included were undertaken in the lowlands. One of the major evidence gaps identified in this review highlighted that much more research is needed that identifies the most damaging types of recreation in the uplands for both species and habitats. The practitioner survey highlighted some recreational pursuits that may be more impactful (e.g., dog walking, motorised vehicles, mountain biking and barbecues), but research is needed that explores the impacts of a wide range of recreational activities.
- Although restricted in its nature, there was **limited evidence** that suggested that recreational pursuits that adopted non-typical routes or included sporadic or unpredictable behaviour were likely to have greater impacts on species than when the activity occurred in a more predictable manner. Further research is needed that examines these findings in upland ecosystems and that measures which elements of the activity have the greatest impact (e.g., the noise, light or speed associated with an activity or pollution effects on soil, water or air).
- There was **no evidence** found in this review that related recreational activity and the severity of impact to the difference between legal and illegal activities. More research is needed that explores the relative impact of illegal recreational activity and the role of regulation and enforcement in different site and landscape designations.

5. Appropriate Levels of Recreational Use and Mitigation and Adaptation Strategies to Respond to Recreational Impacts

5.1 Context

The concept of carrying capacity in the context of recreational ecology relates to levels of sustainable recreational use in a given site (Huddart and Scott, 2019). The ecological carrying capacity of an ecosystem can be defined as the number of visitors or visits an area can sustain without degrading natural resources (*ibid*). Understanding an ecosystem's carrying capacity can therefore help direct appropriate conservation management.

Beyond the concept of carrying capacity, there are a range of different tools that can be utilised to reduce the negative impacts of recreational activity (i.e., mitigation) or respond to the potential impacts that have occurred (i.e., adaptation) (Alexander, 2007). Applying these measures effectively requires careful consideration of both the ecosystems in question and the interests of different site users.

This chapter therefore explores the academic evidence and practitioner submissions published or produced in the English language on the appropriate levels of recreational use in upland ecosystems in the UK and adaptation and mitigation measures for protecting upland ecosystems. It also presents the practitioner perspectives collected through the Call for Evidence and the practitioner survey. These different types of data are presented sequentially by research question to address Research Questions 5 and 6:

Research Question 5: What are 'appropriate levels of use' of recreation in the UK uplands?

Research Question 6: What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

5.2 Evidence Statement on the Appropriate Levels of Recreational Use in Upland Ecosystems

The ecological carrying capacity in the context of recreational use can be defined as the number of visitors or visits an area can sustain without degrading natural resources (*ibid*). It is notable that, within the body of literature reviewed, no studies explicitly defined a carrying capacity or appropriate levels of use for any recreation type, although thresholds were identified where disturbance was more likely.

There was **moderate evidence** from three studies (**2++**, **2+**) that defined specific thresholds for hiking, which if surpassed would cause significant impacts to upland bird species. One study (Pearce-Higgins *et al*., 2007, **2++**) that measured the impact of hiking on the breeding success of breeding upland waders, suggested that the response of golden plovers to the location of footpaths was heavily dependent on visitor usage of individual footpaths (e.g., with a potential usage threshold for this species not exceeding 30 visitors a day), although the same sensitivity was not observed for dunlin. Another study (Mallord *et al*., 2007, **2+**) measured the number of disturbance events per hour affecting woodlark populations at 16 heathland sites over a two-year period. This study demonstrated that woodlark density per site was significantly negatively correlated with levels of disturbance (the number of people per survey per hectare, Rs = −0.57, n = 16, p = 0.02). Using this data, modelling of different

scenarios of future recreational disturbance, predicted a threshold level of 8.27 disturbance events per hour beyond which population level effects would occur, with a range between 5.81 and 10.9 disturbance events per hour (5% CL). Importantly however, the results of the model suggested that the distribution of people were more important than numbers; indeed, under some increased disturbance scenarios woodlark density was modelled to increase. Another study (Murison *et al*., 2007, **2+**) that explored the impact of recreation on Dartford warbler populations and breeding success, found that an average of between 13 and 16 people passing on a footpath through a breeding territory dominated by heather (as opposed to habitats with more cover provided by gorse) caused breeding to be delayed by up to six weeks, which in many instances prevented multiple broods. Given that Dartford warbler can have up to three broods in a season, this level of recreational use was enough to significantly decrease both the number of successful broods raised and the average number of chicks fledged per pair. The findings from the latter two studies (Mallord *et al*., 2007, **2+**; Murison *et al*., 2007, **2+**) were only partially applicable however, as both were conducted in lowland habitats, although focused on species known to breed in the UK uplands.

It is difficult to generate any overarching principles about appropriate use thresholds from these studies because the evidence presented throughout this review has highlighted that responses are species-specific and vary depending on the type of recreation.

There was **moderate evidence** from two studies (both **2+**) that the spatial distribution of visitors was more important than visitor numbers in terms of their impacts on bird species. Both studies suggested that the severity of impact increased more as a result of the unfamiliarity of the disturbance, e.g., new locations being disturbed rather than the ongoing deterioration of places that have been disturbed for a long time. One study (Mallord *et al*., 2007, **2+**) concluded that the predicted population size of woodlark was more strongly affected by changes in the spatial distribution of visitor pressure across the sites as opposed to increased use. Another study (Rees *et al*., 2005, **2+**) that explored the impact of different types of disturbance (including four recreation types) on whooper swan demonstrated that the distance at which disturbance occurred decreased with the number of previous disturbance incidents in the day, indicating that swans became less sensitive to disturbance events if daily disturbance frequency was high, although there was no evidence that habituation to disturbance persisted over longer periods. The findings from both these studies were only partially applicable however, as both were conducted in lowland habitats, although focused on species known to occur in the UK uplands (e.g., see Newth *et al*., 2013).

There was **strong evidence** from five studies (**2++**, **2+**) that appropriate levels of use can be affected by the distance between wildlife and the source of disturbance. These studies (Langston *et al*., 2007, **2+**; Murison *et al*., 2007, **2+**; Summers *et al*., 2007, **2++**; Rees *et al*., 2005, **2+**; Murison, 2002, **2+**), which have already been described in Sections 4.3.1 and 4.3.2, reported distance from a recreational activity as a critical factor in determining the appropriate level of use in habitats important for breeding birds. Some of these studies also demonstrated that this distance is altered by recreation type, e.g., whooper swans had disturbance distances ranging between 116-364m depending on recreation type (Rees *et al*., 2005, **2+**), although it should be noted that this study was undertaken in the lowlands and concerns a species that occurs but does not breed in the UK uplands. Another study (Sibbald *et al*., 2011, **2+**) reported the same distance effects for mammals. This study demonstrated that red deer had distance thresholds to footpath users but did not measure the effect of recreation type or the overall distance threshold. This evidence suggests that appropriate levels of use need to consider the distance thresholds of target species but will need to recognise that these are species-specific and may vary depending on the type of recreation being undertaken.

As discussed in Section 4.4, there was **inconsistent evidence** surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for a range of bird and mammal species, to opposing evidence that suggested this type of recreation was incompatible with nature conservation objectives. Importantly, there was a tendency to report all driven grouse shooting as being implemented at the same intensity (which was then compared, for example, with walked up shooting or 'unmanaged moors').

Three studies (Baines *et al*., 2020, **2+**; Baines *et al*., 2018, **2-**; Baines *et al*., 2014, **2-**), discussed that the intensity of management varied between driven grouse shooting estates and that this had implications for appropriate levels of use (see Section 4.4.5), particularly in terms of the implications for disease in red grouse, with lower densities linked to (but not tested for) the likelihood of reducing disease risk.

By contrast, one study (Sotherton *et al*., 2009, **2-**) explored whether conflicts with hen harriers should initiate a transition from driven grouse shooting to lower intensity walked-up shooting, by exploring the economic implications of this change. The study made no direct assessment on the impact on species, but the socio-economic implications highlighted that this approach may result in the demise of grouse moor management altogether because of the unprofitability of walked-up shooting. The study highlighted that owing to the lossmaking of walked up shooting, protected habitats and priority bird species currently found on grouse moors would be negatively affected, although this impact was not tested empirically. However, another study (Mustin *et al*., 2017, **4+**) classified three different types of hunting occurring in Scotland; 'commercial shooting estates', non-commercial shooting estates' and 'diversified estates' (DE) but found little variation between the three models in terms of spending and employment directly related to shooting activities.

There was **no evidence** found in this review that examined the implications of repeated visitor disturbance on vegetation or soil in an attempt to quantify the carrying capacity of upland habitats.

5.3 Evidence of Adaptation and Mitigation Measured in Upland Ecosystems

5.3.1 Evidence of Adaptation and Mitigation Measures for 'All Recreation' in Upland Ecosystems

There were 11 studies found in this review that focused on 'all recreation' (recreation as a single generic category), which proposed, implemented or tested different types of mitigation and/or adaptation options to reduce recreational impacts on species, habitats or ecosystem processes. In the vast majority of cases, these measures were proposed and only very few (mostly relating to grouse moors and footpath restoration) were actually empirically tested for their efficacy. As such, where proposals were made but not measured, the statements highlight the level of 'support' rather than 'evidence'.

Influence of access restrictions as mitigation and adaptation measures for 'all recreation'

There was **strong support** (but not empirical evidence) from five studies (**2++**, **2+**, **2-**, **3-**, **5-**) that recommended the use of access restrictions to reduce recreational impacts on specific species (mostly ground-nesting birds, e.g., black grouse and nightjar), as permitted through the CRoW Act.

All but one of these studies only proposed, but did not actually implement, an application of the precautionary principle through imposition of the legal access restrictions facilitated by the CRoW Act on the grounds of preventing disturbance to priority species. One study (Warren *et al*., 2009, **2-**) that explored the impact of recreation on black grouse, reported that in the North Pennines AONB, Natural England had already imposed a 'precautionary principle' approach in the winter, with human access excluded from black grouse winter feeding areas between 1st October and 31st March. They also commented that if recreational use increased in the future, these restrictions may need to be extended although no further information was provided. It should be noted that this study commented that not only were the winter access restrictions well observed, but also that when spring access resumed, use of the area was very low and recreational users behaved responsibly by remaining on designated footpaths.

The remaining four studies made proposals for access restrictions, usually as part of the conclusion to the work, but there was no demonstration that these were implemented, and the effectiveness was not measured. One study (Baines and Richardson, 2007, **2++**) also focused on the impact of recreation on black grouse, recommended that if the use of a site increased markedly in the future, access restrictions may be needed based on their findings that black grouse behaviour could be influenced by disturbance of hikers near leks during the winter and spring. These proposals included restricting access to black grouse wintering grounds, extending existing restrictions about dogs on leads to a longer period, extending restricted areas to include breeding grounds and providing viewing facilities at lek sites to prevent close contact. One study (Lowe *et al*., 2014, **2+**) on the recreational impacts on breeding European nightjar also proposed (although did not report implementation) that access restrictions during the breeding season should be imposed on a quieter and less disturbed area of the site with no public amenities, whilst permitting access to a busier area where nightjar numbers had already declined. In essence, this study proposed 'sacrificing' the suitability of breeding habitat in one area at the expense of improving it in another. Further research on the ecological and recreational outcomes of this approach would be very informative. This study recognised that although "*manipulating access patterns by the public to heathland areas during critical nesting periods [can] reduce the effects of disturbance, this obviously requires education and enforcement*" (*ibid*: 7). One study (Martin, 2019, **3-**) that reported the findings of breeding bird survey on Winter Hill in the West Pennine Moors concluded the report with a recommendation that 'sensitive areas' should be established for breeding birds across Winter Hill to ensure that priority bird species were retained against a backdrop of high visitor pressure. Another study (Day *et al*., 2018, **5-**) that explored recreation futures in Dartmoor National Park proposed a number of mitigation options related to species-specific impacts. In relation to several breeding bird species (e.g., Dartford warbler, nightjar and ground-nesting passerines), as well as species from other taxonomic groups (e.g., adder (*Vipera berus*) and butterflies), the report proposed restricting access to sensitive areas, although it was not clear if these proposals had been implemented.

Influence of diversionary techniques as mitigation and adaptation measures for 'all recreation'

There was **strong support** (but not empirical evidence) from five studies (**1+**, **2+**, **3-**, **5-**) that suggested reducing impacts of 'all recreation' by encouraging target species away from the most impacted areas. For example, one study (Gosal *et al*., 2021, **2+**) that explored the impact of recreation on 16 different species of breeding bird on Ilkley Moor proposed habitat management that created opportunities for alternative nest sites in areas that were less disturbed. Similarly, one study (Lowe *et al*., 2014, **2+**) on nightjar, mentioned in the previous section, emphasised maximising habitat and nesting opportunities in areas where recreational impacts were lower, with specific proposals to clear patches of heather away from the base of young birch trees in areas where disturbance was lower. In an obverse but related proposal, one study (Hornigold, *et al*., 2016, **1+**) that explored the relationship between high biodiversity

and recreational value, recommended increasing the desirability of habitats that have less biodiversity value or more ability to cope with high recreational impacts (e.g., coniferous woodland should be made more appealing to people with broadleaved planting at peripheries), thereby protecting sites of biodiversity priority. Similarly, another report (PLB Consulting, 2008, **3-**) on recreation and access opportunities within the North York Moors National Park also highlighted opportunities for encouraging recreational use in concentrated areas around honeypot sites and thus retaining the 'quiet' of the central moorland area. One study (Day *et al*., 2018, **5-**), referred to in the previous section, which explored recreation futures in Dartmoor National Park, proposed a re-design of some rights of way to avoid disturbance to breeding wood warbler.

There was **weak support** (although not empirical evidence) from one study (Murison *et al*., 2007, **2+**) on the impacts of recreation on Dartford warbler that proposed reducing the likelihood of disturbance by altering habitat structure, e.g., introducing more gorse into heathland habitats was proposed as a response to reduce disturbance effects. Although this suggestion was not empirically tested, it was based directly on findings from the study that disturbance was much lower in habitats with high proportions of gorse rather than open heathland. The study recognised, however, that such habitat manipulation may contradict current conservation prescriptions.

Influence of education as mitigation and adaptation measures for 'all recreation'

There was **strong support** (but not empirical evidence) from four studies (**2+**, **2-**, **5-**) that promoted the use of education, both of the public and wider stakeholders to minimise recreational disturbance posed to species. One of these studies (Lowe *et al*., 2014, **2+**) made no further recommendations about what form the education should take. One study (Caravaggi *et al*., 2019, **2-**) that explored impacts on hen harrier populations in Ireland, proposed that reducing impacts on breeding hen harriers could be achieved through a programme of community engagement, awareness-raising and upland signage. Additionally, one study (Gosal *et al*., 2021, **2+**) highlighted that education should go beyond typical signage to being more interactive, e.g., organised activities and events that engaged and educated site users. In a similar way, another study (Day *et al*., 2018, **5-**) proposed that education should be in the form of outreach on disturbance reduction such as information provided about when birds are disturbed (e.g., teaching alarm calls) and how to reduce disturbance, rather than merely highlighting the presence of birds.

There was **moderate support** (but not empirical evidence) from two studies (**2+**, **2-**) that suggested that wider landscape or strategic land-use planning could be used to mitigate or adapt to recreational pressures on species. One study (Lowe *et al*., 2014, **2+**) proposed mapping buffers to identify protection zones around nesting sites for nightjar. Another study (Caravaggi *et al*., 2019, **2-**) proposed considering the hostility or suitability of the wider landscape for hen harriers, so that appropriate land uses could be spatially targeted in low-impact areas.

Influence of habitat mitigation and adaptation measures for 'all recreation'

There was **weak support** (but not empirical evidence) from two studies (**2+**, **4-**) for mitigation activities relating to habitats. One study (McEvoy *et al*., 2008, **4-**) recommended a range of different measures to respond to increased threats from wildfires. These proposals were made by experts and practitioners during workshops. Proposals included using the Meteorological Office's Fire Severity Index to create greater awareness and faster responses, providing new water storage measures (e.g., ponds) on moors, generating new funds for firefighting resources, promoting re-wetting regimes, and establishing firebreaks through rotational burning. Additionally, similar to some of the species management mitigation measures, this

study also proposed restricting access to some dry heath areas when wildfire risk is high, implementing zonal planning to manage higher-impact activity and managing car park access. Another study (Forrester and Stott, 2016, **2+**) that investigated the issue of upland water contamination near the Aviemore ski resort proposed mitigation by providing outdoor toilets.

5.3.2 Evidence of Adaptation and Mitigation Measures for Walking in Upland Ecosystems

Influence of access restrictions as mitigation and adaptation measures for 'walking'

As with the mitigation and adaptation options detailed for 'all recreation', there **was strong support** (although not empirical evidence) from six studies (**1-**, **2++**, **2+**) that access should be restricted, either on a seasonal basis or on a permanent basis, to reduce disturbance from hiking/walking. These all concerned proposals rather than reporting actions and were usually proposed for parts of a site that were deemed most susceptible to disturbance by walkers. In particular, five of these studies (Langston *et al*., 2007, **2+**; Summers *et al*., 2007, **2++**; Underhill Day and Liley., 2007, **1-**; Rees *et al*., 2005, **2+**; Murison, 2002, **2+**) proposed the closure or re-routing of paths to reduce the impacts of walking on ground-nesting birds. One study (Jayakody *et al*., 2007, **2+**) made a similar proposal in relation to mammals (red deer). Some studies noted the sensitivity and potential conflict associated with restricting access and recommended that managers should consult with site users "*to ensure that any changes strike the right balance between the conservation and amenity objectives*" (Summers *et al*., 2007, **2++**: 26).

Influence of diversionary techniques as mitigation and adaptation measures for 'walking'

Unlike mitigation and adaptation options for many of the other forms of recreation, which are merely supported (i.e., not actually measured for their efficacy and usually merely proposed rather than implemented), there was **moderate evidence** from two empirical studies (**2+**, **2++**) of the benefits associated with implementing footpath restoration to reduce the negative impacts of walking and hiking on breeding waders in upland ecosystems (see Section 4.3.2).

In one before and after study (Finney *et al*., 2005, **2+**), data across 13 years was used to test the extent of disturbance on the distribution and reproductive performance of golden plover nesting on sites adjacent to Snake Summit on the Pennine Way. During the study period, the footpath was resurfaced, allowing the study to test the impacts of resurfacing. Prior to the footpath restoration, golden plovers avoided areas within 200m of the Pennine Way during chick-rearing periods. Post-resurfacing, the proportion of hillwalkers that remained on the footpath increased from 30% to 96%. This resulted in the distance threshold of nest sites from the footpath reducing by 150m to only 50m. In a follow-up study (Pearce-Higgins *et al*., 2007, **2++**) that examined whether this phenomenon occurred for other upland waders across two sites (Snake Summit and Bleaklow), dunlin occupancy of habitat in disturbed areas showed a non-significant increase of approximately 50% following the provision of a surfaced footpath, mirroring the golden plover response This habitat occupancy occurred despite very high levels of disturbance (with over 120 visitors per weekend day).

There was also **moderate support** from two studies (**3-**, **4+**) that provided insight into the practical challenges of implementing footpath restoration. One study (MacKay and Prager, 2021, **4+**) conducted in the Cairngorms on landowners' willingness to maintain and restore footpaths, although not empirically testing the effects of footpath restoration, demonstrated that private landowners did not consider it their responsibility to maintain or restore footpaths, with cost being the biggest barrier. Another study (Pathways Consultancy, 2012, **3-**) that reported on 'Fix the Fells', a footpath restoration project in the Lake District National Park,

emphasised the importance of pre-emptive restoration of footpaths, rather than waiting until damage has occurred, but recognised this can be challenging to secure. These studies highlighted that although footpath restoration may be an important mitigation measure, barriers to implementation may occur.

Rather than restricting access through closure, there was **strong support** (but not empirical evidence) from four studies (**1-**, **2+**, **5-**) that proposed alternative approaches that would encourage walking in less-sensitive areas (both on and off site). One study on the disturbance posed to Dartford warbler from walkers that proposed path redistribution (Murison *et al*., 2007, **2+**), suggested that visitor access to sensitive areas could be manipulated by the appropriate location of gates, car parks and footpaths. Three other studies proposed using car parking as a means of controlling access by walkers. One study (Underhill-Day and Liley, 2007, **1-**) that measured the impact of walking on priority bird species proposed restricting car-parking facilities. Another study (Langston *et al*., 2007, **2+**) on the impact of walkers on nightjar populations proposed positioning car parks and access points away from areas used by the target species. The same study also made proposals for off-site mitigation, with the provision of alternative greenspaces. One study (Day *et al*., 2018, **5-**) on the impacts of recreation on species in Dartmoor National Park, proposed that impacts from walkers on invertebrates, specifically the southern damselfly (*Coenagrion mercurial*) could be reduced indirectly, by not providing additional car parking facilities and thereby discouraging visitor increases. The findings of two of these studies (Langston *et al*., 2007, **2+**; Murison *et al*., 2007, **2+**) are only partially applicable however, as they were conducted on lowland sites, although concerned species known to inhabit the UK uplands.

Influence of education as mitigation and adaptation measures for 'walking'

There was **moderate support** (although not empirical evidence) from two studies (**1-**, **2+**) that greater engagement with site users and associated education could help inform walkers of their rights and behaviours. One study (Underhill-Day and Liley, 2007, **1-**) that explored the disturbance posed to priority bird species from walkers, proposed that site managers should identify visitors 'likes and dislikes' so that appealing alternatives can be developed that reduce impacts on breeding birds. Another study (Langston *et al*., 2007, **2+**) on the impact of walkers on nightjar populations on Dorset heaths highlighted that there was a need to identify the best communication methods that delivered desired outcomes for responsible access, public ownership and support for wildlife conservation.

Influence of mitigation and adaptation measures targeted at the impacts of dogs and 'dog walking'

There was **strong support** (but not empirical evidence) from six studies (Day *et al*., 2018, **5-**; Martin, 2018, **3-**; Leyland, 2016, **3-**; Baines *et al*., 2007, **2++**; Langston *et al*., 2007, **2+**; Murison *et al*., 2007, **2+**) that all focused on the impacts of recreation on breeding birds, which proposed that the impacts of dogs could be lessened by ensuring that dogs were kept on a short leash (<2 metres). Only one study (Lowe *et al*., 2007, **2+**) proposed that reducing impacts from dogs may need to resort to preventing access for dog-walkers entirely.

Despite the evident impact of wildlife disturbance by dogs in upland ecosystems (see Section 4.2.) and the issue of enforcing measures such as keeping dogs on a short leash, there were remarkably few novel proposals for reducing disturbance by dogs other than the two listed above. There was however **weak support** (but not empirical evidence) from two studies (Langston *et al*., 2007, **2+**; Underhill and Liley, 2007, **1-**) that proposed the possibility of creating alternative spaces or sites for dog walkers away from habitats and species sensitive to disturbance. Additionally, one of these studies (Langston *et al*., 2007, **2+**) on the impact of recreation on breeding nightjar, proposed the potential for areas on-site, that could be provided

for off-lead exercising and play areas for dogs, which were well away from areas important for breeding birds. The proposals from both these studies may only be partially applicable however as they were both undertaken in the lowlands.

It should also be noted, that although not formally proposed as a mitigation or adaptation option for managing impacts by dogs, one study (Murison *et al*., 2007, **2+**) on the impact of recreation on Dartford warbler, observed the potential role of vegetation type in controlling dogs: "*Unlike heather, it is not easy for people and dogs to penetrate U. gallii. Dogs were recorded as moving as far as 45m into heather, but were never seen to move off the path in vegetation dominated by U. gallii*" (*ibid*: 24).

5.3.3 Evidence of Adaptation and Mitigation Measures for Mountain Biking in Upland Ecosystems

There was **moderate support** (but not empirical evidence) from two studies (**2+**, **5-**) that proposed measures for mitigating or adapting to the impacts of mountain bikes in upland ecosystems. One study (Stavi and Yizhaq, 2020, **5-**) that undertook modelling to explore optimal design for mountain bike tracks, proposed that specifics on track design could be used to reduce issues of erosion. Mitigation and adaptation options included management associated with increasing compaction (through moistening and manual ramming), closing paths, ensuring tracks were not too steep (damage was minimal in track sections with longitudinal incline of 5%, moderate for those of 5–10%, and maximal for these greater than 10%), establishing runoff outlets at certain intervals along the track's longitudinal axis and including frequent meanders to slow cyclists. It should be noted however, that these types of modifications would only be applicable in recognised, on-track mountain biking locations. It would not be possible to implement these types of measures where illegal, off-track mountain-biking occurs. Another study (Lowney, 2011, **2+**) specifically focused on the impact of on-track mountain bike trails on red squirrel, proposed that in bike trail developments in coniferous woodland where red squirrel were present, stands of European larch (*Larix decidua*) and douglas fir (*Pseudotsuga menziesii*) should be avoided as these were preferred habitat for the red squirrel and therefore more likely to be subject to species-recreation conflicts.

5.3.4 Evidence of Adaptation and Mitigation Measures for Motorised Vehicles in Upland Ecosystems

There was **no evidence or support** found in this evidence review of practical mitigation or adaptation options to manage motorised vehicle impacts in upland ecosystems. One study (Clutterbuck *et al*., 2020, **2++**) made a policy recommendation however, that legislation surrounding the development of vehicle tracks in upland environments should be reviewed, particularly for surfaced tracks. Additionally, the same study proposed that the *ad hoc* use of vehicles on blanket peat may also need inclusion in upland track legislation because vehicle damage to blanket bog has also resulted in several enforcement actions requiring habitat restoration.

5.3.5 Evidence of Adaptation and Mitigation Measures for All Other Types of Recreation in Upland Ecosystems

Influence of access restrictions as mitigation and adaptation measures for 'all other recreation types'

There were six studies found in this review that explored management responses to mitigate or adapt to negative impacts caused by birdwatching, caving, fishing, orienteering, skiing / snowboarding, orienteering, and one study that explored three different forms of recreation. These studies are summarised in the following section.

As with studies associated with recreation types that have more evidence on mitigation or adaptation (e.g., walking and/or general recreation types), there was **moderate support** from three studies (**2+**, **2-**, **3-**) that proposed restricting access to areas within specified distances or zones around the species of concern, including one study (Rees *et al*., 2005, **2+**) that proposed restricting access to protect whooper swans from three different types of recreation; fishing, cycling and hunting. Another study (Parker, 2009, **3-**) recognised that wheatear were very tolerant to nearby disturbance from an orienteering event, but in some instances, ignorance of nest locations by event organisers meant orienteering infrastructure was placed on the nests causing them to be lost. Another study (Ruddock and Whitfield, 2007, **2-**) reported that the flushing or disturbance distance of a variety of upland bird species with access restrictions needed to be known, if disturbance from all forms of recreation was to be avoided. It was notable from this study that flushing ranges were highly variable between species, with some (e.g., nightjar) not flushing until disturbance was within 50-100m (probably because they rely on camouflage) whereas disturbance of golden eagles has been recorded as far away as 750-1000m from nest sites. Interestingly, seemingly similar species can demonstrate very different tolerances; contrasting with golden eagle the distance reported for white-tailed eagles was 50-500m, with an average of 200-300m. It should be noted however, that one study that was discounted from this review because of its focus on coastal birds (Beale and Monaghan, 2004) emphasised that the appropriate area for exclusion is usually generated from an isolated piece of species-specific research measuring behavioural responses to individuals, whereas in practice, both numbers and distance of people involved in recreation matter in determining the disturbance effects from recreation. They proposed that set-back distances must be periodically reassessed in the light of changing visitor numbers, or that visitor numbers should be strictly capped if effects on priority species were to be minimised (Beale and Monaghan, 2004).

In a related discussion about the area that required mitigation / adaptation responses, one study (Gunn *et al*., 2000, **3-**) on caving highlighted that, although the Peak-Speedwell cave system is protected as a SSSI, to reduce impacts on the aquatic macroinvertebrates in the caves, there also needed to be changes to management in the surrounding catchment that extended well beyond the SSSI designated area. It is likely that the lack of spatial correlation between the area subject to potentially harmful impacts and the specific location of the receptors (e.g., species) may pose challenges to appropriate mitigation and adaptation measures for diverse forms of recreation, not just those relating to water quality, but these have not been detected in the literature collected in this review.

There was **moderate evidence** from three studies that mitigation measures had successfully been introduced to reduce the impacts of climbing on breeding birds. Two studies (Leyland, 2021, **3+**; Leyland, 2016, **3+**) that surveyed ring ouzel (*Turdus torquatus*) in relation to disturbance from climbing routes, reported that signs were erected close to nest sites to prevent disturbance. Restrictions were reported to have been well observed and ring ouzels fledged successfully within these areas, although it should be noted that this study did not attempt to quantify the success of this adaptation method statistically. This work highlighted

the importance of partnership working across different users and interest groups to implement such measures.

The same studies also highlighted that where birds nested on or adjacent to popular climbing routes, there was a clear case, and well-established precedent, for restricting access to the route (and its neighbours) in order to reduce direct disturbance. For nests in less popular areas however, where signs might actually attract attention (and therefore increase disturbance), these studies highlighted that the case for signage was less clear-cut, and a balance must be struck. In relation to climbing, there was evidence of recreation-based policy (BMC, N.D., **3-**), that provided best practice guidance that was being used to educate and encourage responsible practices.

Influence of education as mitigation and adaptation measures for 'all other recreation types'

There was **no evidence or support** found in this review on the use of education as a way of ensuring negative impacts on upland ecosystems could be mitigated or adapted to, other than those already mentioned for 'all recreation' and for 'walking'.

Influence of habitat 'mitigation and adaptation measures for 'all other recreation types'

There was **no evidence or support** found in this review on adaptation or mitigation responses to habitat-level impacts by individual forms of recreation except those already mentioned in Sections 5.3.1 and 5.3.2.

Influence of mitigation and adaptation measures for influence of 'all other recreation types' on ecosystem processes

Similarly, **no evidence** or support was found on adaptation or mitigation responses to impacts on ecosystem processes by individual forms of recreation except those already mentioned in Section 5.3.1.

5.3.6 Evidence of Adaptation and Mitigation Measures for Grouse Moor Management in Upland Ecosystems

In comparison to most of the other forms of recreation covered in this chapter, where mitigation or adaptation options are discussed or proposed without rigorous analysis to support their efficacy, there was more empirical evidence about different ways in which the negative impacts of intensive grouse moor management can be lessened. These included two broad areas; measures to reduce the potential impacts of disease management and lead toxicity in upland ecosystems, and ways of reducing the illegal persecution of raptors.

Influence of mitigation and adaptation measures to reduce the impacts of disease management on grouse moors

Currently, the main management methods of managing louping ill virus (LIV) on grouse moors is to control the spread of disease from other vectors, including treating sheep with acaricide treatment and repeat vaccination against LIV (mostly in Northern England) and culling mountain hare (mostly in Scotland).

There was **no evidence** found to mitigate or adapt to the impacts associated with managing LIV, particularly the potential negative impact of culling mountain hares reported by some studies. In 2020, the Scottish Government passed legislation that required the culling of mountain hares in Scotland to be subject to licence. The potential implications of this legislation, including the likelihood of adherence by grouse moor managers, and the impacts on red grouse and hare populations will need to be monitored.

As reported in Section 4.4.5., there were two potential impacts of managing the parasitic worm *T. tenuis* through the provision of grit treated with anthelmintics that may require mitigation or adaptation. The first was increased anthelmintic resistance in parasites, which is a recognised issue in livestock kept in the UK uplands (Mitchell *et al*., 2010). The second was the potential for wider environmental impacts resulting from routine, pre-emptive administering of veterinary pharmaceuticals (Thompson, 2016).

There was **weak evidence** from one study (Baines *et al*., 2019, **2+**) that highlighted that anti-worming drugs were being administered to red grouse regardless of parasitic burdens. This study demonstrated that removal of medicated grit led to significant increases in parasitic burdens on three of the eight moors studied, and treatment was subsequently resumed (as well on an additional fourth moor where the parasitic burden in grouse was still very low). On the remaining four moors studied however, *T. tenuis* occurrence did not increase significantly, which highlighted that routine applications on most grouse moors may often be unnecessary.

There was **no evidence** found in this review that examined how the potential wider environmental impacts of providing anthelmintics in upland ecosystems may need to be mitigated or adapted to.

As outlined in Section 4.4.5, the main proposal for managing respiratory cryptosporidiosis infection in red grouse was to reduce the population density, which one study (Baines *et al*., 2020, **2+**) observed had increased significantly over the last decade. Despite support from three studies that reduced density my reduce respiratory cryptosporidiosis, there was **no evidence** found in this review that attempted to test whether reducing the density of red grouse lessened the prevalence or severity of impacts of the disease on red grouse.

Influence of mitigation and adaptation measures to reduce lead toxicity in red grouse on grouse moors

There was **weak support** (but not empirical evidence) from one study (Thomas *et al*., 2009, **2+**) that issues associated with lead toxicity in grouse could be reduced through one mitigation and two adaptation options that would curtail the addition of new lead while simultaneously reducing the intake and dietary absorption of lead already present in the environment. This study proposed that mitigating lead toxicity could be achieved by all grouse shooters using acceptable forms of nontoxic, lead-free shot, whether from fixed butts or walked-up situations. Additionally, adaptation through heather management could be used to restrict access of grouse to areas with high lead shot densities (approximately 150 m from either side of shooting butts). Finally, piles of crushed grit high in calcium (such as crushed oyster shells) could be deployed throughout moors and in feeding sites with acid soils (therefore likely to be required on most grouse moors) which would reduce the lead toxicity in the target species.

Influence of mitigation and adaptation measures to reduce negative impacts of grouse moor management on raptors

There was **moderate empirical evidence** from three studies (**2+**, **5++**) that diversionary feeding of hen harriers reduced the predation of red grouse chicks. One study (Redpath *et al*., 2001, **2+**) assessed the effectiveness of feeding for population effects and breeding success. Over both years combined, hen harriers provided with diversionary feeding delivered one grouse chick to their nest every 200 hours, whereas hen harriers without supplementary food delivered one grouse chick every 27 hours, suggesting that diversionary feeding was an effective adaptation response reducing the number of grouse chicks being taken by hen harriers. Another study (Ludwig *et al*., 2018, **2+**) calculated that diversionary feeding reduced the total number of grouse chicks provisioned to hen harrier broods in 2008–15 on average by 81% (measured in pellets), 82% (measured by nest cameras), and by 100% (measured by hide watches). Under supplementary feeding, hen harriers provisioned only approximately

1.7% of annual grouse chick production whereas without diversionary feeding provision was between 15-29%. One study (Amar *et al*., 2004, **2+**) explored whether the proportion of heather around harrier nests could be used to predict grouse predation rates so that diversionary feeding could be targeted at the most impactful nests. Results demonstrated that grouse predation was positively associated with the proportion of heather cover within 2km of harrier nests, and the subsequent model that was developed correctly predicted the top 50% of harrier nests in five of six years. Diversionary feeding was then targeted at these nests, which demonstrated that when harriers were given diversionary food, the relationship between grouse predation rates and habitat was removed, with grouse predation reduced to negligible levels in most cases. This suggested that diversionary feeding could be targeted at nest sites with highest heather cover to reduce economic costs of management and maximise conservation benefits. There was, however, no perceived influence on overall grouse numbers. However, another study (Elston *et al*., 2014, **5++**) reported that concerns from grouse moor managers about the long-term impact of diversionary feeding on harrier numbers have prevented the technique from being widely taken up.

There was **moderate evidence** from two studies (**2+**, **5++**) that solutions to mitigate the impacts between grouse moor management and conservation are multi-faceted, complex and difficult to implement successfully. One study (Ludwig *et al.*, 2017, **2+**) highlighted that the expense of predator control, habitat restoration and diversionary feeding had not led to sufficiently high grouse numbers that facilitated the recommencement of driven shooting on the Langholm Estate. The conclusion from this article was that these intensive forms of management were not economically viable. Another study (Elston *et al*., 2014, **5++**) highlighted seven areas of uncertainty that prevented grouse moor managers reaching solutions over hen harrier conflicts and concluded that an adequate solution to resolving the ongoing conflict between conservation and grouse moor management still needed to be found.

Influence of mitigation and adaptation measures relating to policy and guidance on grouse moor management policy

There was **weak support** from two studies (**1-**, **2+**) that proposed broader changes to policy or management approaches on grouse moors. Based on at least four previous studies by the same authors, one study (Ludwig *et al*., 2020, **2+**) recommended that tighter regulation of illegal raptor control was needed to reduce impacts of grouse moors on birds of prey. There was also weak evidence from one study (Hanley *et al*., 2010, **1-**) of public support for mitigation options that reduced the impacts of grouse moor management on two raptor species (golden eagle and hen harrier): increasing or enforcing legal protection, diversionary feeding or moving to new sites. Results showed that survey respondents (drawn from a random selection of people living in Scotland) were indifferent to which management option was taken up but agreed that changes in management were needed. Additionally, respondents were willing to pay (through taxation) both for avoiding reductions in hen harrier populations and for increases, but that these values were much higher for golden eagle.

Finally, there was **weak support** from one UK-wide study (Sim *et al*., 2007, **2+**) that the status of the hen harrier in the UK and Isle of Man needed to be regularly monitored. Greater monitoring of grouse moor estates as a whole, particularly the prevalence and impact of illegal persecution was highlighted as a particular priority.

It should also be noted that one study (Warren *et al*., 2011, **2+**) stated that the success of voluntary agreements to refrain from targeting black grouse on driven shoot days was more appropriate than top-down pressure to remove black grouse from the quarry list. This highlighted the tension that could emerge between policy and associated enforcement of rules imposed by statutory bodies and bottom-up voluntary agreements with the grouse moor community.

5.4 Practitioner survey synopsis: appropriate levels of use and mitigation and adaptation strategies

The online practitioner survey was used to try to ascertain perspectives of those working in the uplands, to provide some context to the review of written evidence. A more detailed analysis of this data is presented in Appendix VII, but the key messages relating to research Questions 5 and 6 are summarised below.

The results from the practitioner survey demonstrated a perception that the impacts of recreational activity in upland areas varied depending on the type and intensity of recreational activity. Whilst participants were not asked to quantify appropriate levels of recreational activity, some practitioners in certain isolated locations saw recreation as low in intensity and thus less of an issue in relation to the sites they manage. Other participants commented on the challenges of quantifying appropriate levels of recreational use, and that the intensity and impact of recreational activities were complex and often strongly context dependent.

Participants were also asked to provide their perspectives on appropriate measures to reduce or prevent the impacts of recreational activities. A significant proportion of respondents indicated that restricting recreational activities through 'visitor exclusion zones' can (or could) be the most effective method of reducing the impacts of recreation in some contexts. This could involve temporary restrictions during high periods of risk or permanent restrictions in particularly sensitive areas. In contrast, a significant proportion of participants suggested that this measure had been ineffective on the sites they manage. Other respondents acknowledged the benefits of allowing public access to upland areas, making it inappropriate to completely restrict public access in many of these areas.

Improving site-based infrastructure through hard barriers or access restrictions (to restrict vehicle access), and better signposting to divert pressure from sensitive sites were also suggested by participants as effective tools for mitigating the impacts of recreation. Respondents also believed the presence of patrolling staff (such as rangers or gamekeepers) was an important tool for ensuring that visitor behaviour and use of sites were appropriate (especially relating to barbeques/fires and wildfire risks). Online outreach and engagement to encourage appropriate visitor behaviour were deemed partially effective in mitigating recreational pressure. On-site visitor interpretation boards or signage aimed at reducing the likelihood of damage and seasonal restricted visitor access were generally seen to be less effective as direct measures. Participants highlighted the importance of utilising multiple approaches in combination and that partnership working was a key component to overcoming the challenges and opportunities of upland recreational activity. There was also a view that more research may be needed to understand effective means of addressing certain types of recreational use.

5.5 Summary of evidence, gaps and recommendations: appropriate levels of use and mitigation and adaptation strategies

The following section summarises the strong and moderate evidence statements produced in this chapter, outlines the gaps in evidence and from these, suggests a series of recommendations.

5.5.1 Summary of evidence: appropriate levels of use and adaptation and mitigation measures

The following section summarises the strong and moderate evidence statements produced in this chapter, outlines the gaps in evidence and from these, suggests a series of recommendations.

Research Question 5: What are 'appropriate levels of use' of recreation in the UK uplands?

The following strong or moderate evidence statements were developed in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

Direct forms of recreational activity

- There was **moderate evidence** from three studies (**2++**, **2+**) that defined specific thresholds for hiking, which if surpassed would cause significant impacts to upland bird species.
- There was **moderate evidence** from two studies (both **2+**) that the spatial distribution of visitors was more important than visitor numbers in terms of their impacts on bird species.
- There was **strong evidence** from five studies (**2++**, **2+**) that appropriate levels of use can be affected by the distance between wildlife and the source of disturbance.

Grouse moor management

- There was **inconsistent evidence** surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for a range of bird and mammal species, to opposing evidence that suggested this type of recreation was incompatible with nature conservation objectives.

Research Question 6: What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

The following strong or moderate evidence statements were developed in relation to Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

The studies included in this section often proposed adaptation or mitigation measures rather than empirically testing them. In these cases, the statements highlight the level of 'support' rather than 'evidence'.

Direct forms of recreational activity

- There was **moderate evidence** from two empirical studies (both **2+**) of the benefits associated with implementing footpath restoration to reduce the negative impacts of walking and hiking on breeding waders in upland ecosystems.
- There was **moderate evidence** from three studies (**3+, 3-**) that mitigation measures had successfully been introduced to reduce the impacts of climbing on breeding birds.
- There was **strong support** (but not empirical evidence) from five studies (**2++**, **2+**, **2-**, **3-**, **5-**) that recommended the use of access restrictions to reduce recreational impacts on specific species (mostly ground-nesting birds, e.g., black grouse and nightjar), as permitted through the CRoW Act.
- There was **strong support** (but not empirical evidence) from five studies (**1+**, **2+**, **3-**, **5-**) that suggested reducing impacts of 'all recreation' by encouraging target species away from the most impacted areas.

- There was **strong support** (but not empirical evidence) from four studies (**2+**, **2-**, **5-**) that promoted the use of education, both of the public and wider stakeholders to minimise recreational disturbance posed to species.
- There was **moderate support** (but not empirical evidence) from two studies (**2+**, **2-**) that suggested that wider landscape or strategic land-use planning could be used to mitigate or adapt to recreational pressures on species.
- There was **strong support** (although not empirical evidence) from six studies (**1-**, **2++**, **2+**, **2-**) that access should be restricted either on a seasonal basis or on a permanent basis, to reduce disturbance from hiking/walking.
- There was also however, **moderate support** from two studies (**3-**, **4+**) that provided insight into the practical challenges of implementing footpath restoration.
- There was **strong support** (but not empirical evidence) from four studies (**1-**, **2+**, **5-**) that proposed alternative approaches that would encourage walking in less-sensitive areas (both on and off site).
- There was **moderate support** (although not empirical evidence) from two studies (**1-**, **2+**) that greater engagement with site users and associated education could help inform walkers of their rights and behaviours.
- There was **strong support** (but not empirical evidence) from six studies (**2++**, **2+**, **3-**, **5-**) that all focused on the impacts of recreation on breeding birds, which proposed that the impacts of dogs could be lessened by ensuring that dogs were kept on a short leash.
- There was **moderate support** (but not empirical evidence) from two studies (**2+**, **5-**) that proposed measures for mitigating or adapting to the impacts of mountain bikes in upland ecosystems.
- There was **moderate support** from three studies (**2+**, **2-**, **3-**) that proposed restricting access to areas within specified distances or zones around the species of concern, for a variety of recreation types including fishing, cycling, angling, wildfowling and orienteering.

Grouse moor management:

- There was **moderate evidence** from three studies (both **2+**) that diversionary feeding of hen harriers reduced the predation of red grouse chicks, but concerns from grouse moor managers about the long-term impact of diversionary feeding on harrier numbers may prevent take-up of the technique.
- There was **moderate evidence** from two studies (**2+**, **5++**) that solutions to mitigate the impacts between grouse moor management and conservation are multi-faceted, complex and difficult to implement successfully.

5.5.2 Gaps in evidence: appropriate levels of use and adaptation and mitigation measures

Research Question 5: What are 'appropriate levels of use' of recreation in the UK uplands?

The following gaps in evidence were found in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

Direct forms of recreational activity

- The evidence presented in this review highlighted that 'appropriate levels of use' was an area that was under-researched, with an absence of evidence on the appropriate levels of use for almost all forms of recreation.
- It was difficult to generate any overarching principles about appropriate use thresholds. Whilst there was support for certain measures, they were not backed by empirically tested evidence. Furthermore, it was likely that many measures were species-specific and varied depending on the type of recreation, highlighting a considerable gap in knowledge surrounding appropriate use thresholds.
- There was **no evidence** found in this review that examined the implications of repeated visitor disturbance on vegetation or soil in an attempt to quantify the carrying capacity of upland habitats.

Research Question 6: What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

The following gaps in evidence were found in relation to Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

Direct forms of recreational activity

- Apart from a few exceptions studying footpath restoration and grouse moor management, there was very little empirical evidence found in this review about the efficacy of any mitigation or adaptation measures.
- There was **no evidence or support** found in this review on adaptation or mitigation responses to habitat-level impacts by individual forms of recreation except those already mentioned for walking. This means that there was **no evidence or support** found in this evidence review of practical mitigation or adaptation options to manage a range of potentially damaging recreation types as identified in the practitioner survey, including motorised vehicles, mountain biking and barbecues beyond those mentioned under 'general recreation'.
- There was **no evidence or support** found in this review on the use of education as a way of ensuring negative impacts on upland ecosystems could be mitigated or adapted to, other than those already mentioned for 'all recreation' and for 'walking'.

Grouse moor management

- There was **no evidence** found to mitigate or adapt to the impacts associated with managing LIV, particularly the potential negative impact of culling mountain hares reported by some studies.
- There was **no evidence** found in this review that examined how the potential wider environmental impacts of providing anthelmintics in upland ecosystems may need to be mitigated or adapted to.
- There was **no evidence** found in this review that attempted to test whether reducing the density of red grouse lessened the prevalence or severity of impacts of the disease on red grouse.

5.5.3 Recommendations: appropriate levels of use and adaptation and mitigation measures

Research Question 5: What are 'appropriate levels of use' of recreation in the UK uplands?

The following recommendations were developed in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

Recommendations from Evidence:

Direct forms of recreational activity

- There was **moderate evidence** that defined specific thresholds for hiking, which if surpassed would cause significant impacts to upland bird species. This included individual studies that highlighted that the appropriate level of recreational use might be affected by the overall group number or frequency (number per hour) but there was **no evidence** that sought to explore the relative influence of these different factors. Further research is needed that considers different ways in which 'appropriate use' may be determined, including party size and density, relative disturbance factors such as the spatial extent of disturbance, seasonality, noise, visual intrusion, etc.
- There was **moderate evidence** that the spatial distribution of visitors was more important than visitor numbers in terms of their impacts on bird species, but both these studies occurred in the lowlands. Further research is required that explores whether this trend also applies in upland ecosystems, and whether it is relatively universal or species-specific. In addition to distance thresholds, research might include exploring the impact of random or unfamiliar disturbance as opposed to more predictable patterns of use, whether disturbance behaviour becomes reduced over short and long time periods of exposure and examine the effects on species from a range of taxonomic groups.

Grouse moor management

- There was **inconsistent evidence** surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for a range of bird and mammal species, to opposing evidence that suggested this type of recreation was incompatible with nature conservation objectives. Whilst this debate is both political and emotive and therefore unlikely to be completely resolved solely through further academic research, there is the need for research to better understand the relative impacts of different levels of management intensity occurring on driven grouse shooting estates. Grouse moors were often treated as a uniform land use in the evidence, but there was an absence of research that assessed the relative intensity of grouse-moor management with studies often making simplistic assessments between driven grouse moors, walked-up grouse moors and 'un-shot' moors. In practice, however, management intensity is likely to vary significantly, e.g., the extent of rotational burning, predator control and disease management will all very depending on whether the moor is managed as a commercial enterprise and the number of brace expected from the moor. More research is needed that assesses the appropriate levels of use of grouse moors for upland species other than red grouse. This variation in management intensity on grouse moors was also raised in the practitioner survey, which could have markedly different impacts on the species, habitats and processes in upland ecosystems. 'Un-shot' moors in particular require greater exploration and classification as this could vary considerably from land left with minimal management to land with high levels of active management directed primarily towards other land uses, including agriculture or nature conservation (e.g., see Black *et al.,* 2010).

Recommendations from Absence of Evidence:

Direct forms of recreational activity

- The evidence presented in this review highlighted that appropriate levels of use were an area that was under-researched, with an absence of evidence on the appropriate levels of use for almost all forms of recreation. This was a key gap in knowledge highlighted by this evidence review and one that needs to be the focus of future research with breadth that covers different recreation types and different taxa and species in upland ecosystems.
- Although there were very few studies explicitly examining the appropriate levels of use for any specific recreation type, there was limited evidence that suggested that distance thresholds from a recreational activity were species-specific although these were not tested across different species within the same study. Similarly, some studies suggested but did not empirically test, that the sensitivity of different species may vary by type of recreation. A significant evidence gap identified in this evidence review is the need to better understand species-specific responses and what constitutes appropriate levels of use for species with different levels of sensitivity to recreational disturbance in upland ecosystems.

Grouse moor management

- A significant proportion of all the research found in this evidence review was about the influence of grouse moors on upland ecosystems. This may reflect the extent of area covered in comparison to other recreation types but there is a need to broaden the research focus to encourage much more extensive assessment of the impact and management of other recreation types. Related to this is the need for empirical research that explores alternative forms of moorland management to grouse moors. There was an assumption in the literature that in areas where there was an absence of grouse moors, there is a complete absence of management, but alternative upland land uses that require some management are also plausible and may go beyond the familiar alternatives of agriculture and forestry (e.g., see Crowle *et al*., 2022). These alternative upland futures and their implications for the biodiversity of upland ecosystems need to be the focus of future research, including modelling that explores future scenarios and empirical testing of the influence of more novel land uses in upland ecosystems.

Research Question 6: What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

The following recommendations were developed in relation to Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

In almost all instances, where studies made proposals for mitigation or adaptation options these were usually untested and therefore very few recommendations can be made from evidence on adaptation or mitigation measures. Owing to the lack of empirical experiments, recommendations developed on areas where there was strong support (without empirical evidence) are included in recommendations from the absence of evidence.

Recommendations from Evidence:

Direct forms of recreational activity

- Although only the focus of two studies (across two sites in total), there was **moderate evidence** of the significant beneficial impacts that footpath resurfacing had on reducing the spatial extent of disturbance caused by walking / hiking by reducing deviation from footpaths. However, there was also moderate support that highlighted that upland footpath restoration has practical challenges and is resource intensive and further research is needed that explores the relative benefits of this technique across a wide range of upland settings (e.g., different habitat types), visitor densities and that measures the benefits for a much broader range of upland species, habitats and ecosystem functions.

Grouse moor management

- There was **moderate evidence** that diversionary feeding of hen harriers reduced the predation of red grouse chicks. However, there was no evidence of the take-up of diversionary feeding by grouse moor estates other than observations from one study that it was not readily employed because of concerns that it would increase hen harrier numbers. Further research is needed that explores attitudes and approaches of grouse moor managers to different techniques that might reduce the likelihood of illegal raptor persecution.

Recommendations from Absence of Evidence:

Direct forms of recreational activity

- As above, in almost all instance where mitigation or adaptation options were mentioned, these were presented as proposals rather than the focus of studies. Even in the very few studies that did undertake empirical examination of mitigation or adaptation measures, these tested the efficacy of one type of management measure, but there was **no evidence** included in this review that sought to compare the efficacy of more than one type of management measure to reduce impacts on species, habitats or ecosystem processes. Similarly, several studies suggested a diverse range of mitigation measures were likely to be more effective when applied in combination, (e.g., route closures, education, stakeholder-engagement and signage), but there was no evidence that measured this. Further research is needed that seeks to empirically examine the relative effectiveness of different types of management responses at reducing impacts on species or habitats, e.g., comparing the benefits of excluding access, diversionary techniques or habitat management and the potential advantages and disadvantages of using a combination of strategies.
- There was **strong support** (but not empirical evidence) that recommended the use of access restrictions to reduce recreational impacts on specific species (mostly ground-nesting birds, e.g., black grouse and nightjar), particularly in relation to hiking/walking, as permitted through the CRoW Act. There were also proposals that highlighted the difference between direct access restriction or more nuanced access management (e.g., encouraging use in less sensitive areas), but none of the studies included in this review sought to compare the difference between the two and whether their relative success varies by recreation type. Further research is needed that assesses the relative benefits of different types of access restriction/access management and whether the type of recreation determines or affects the most effective type of mitigation or adaptation techniques to minimise harm to upland ecosystems. Additionally, further research is needed that tests the effectiveness of these access

restrictions in different upland settings, with consideration of differences in the ability to enforce restrictions, the perceptions and responses of recreational users and the suitability of the technique for different taxa/species.

- By contrast, there was **strong support** (but not empirical evidence) that suggested an alternative approach of reducing recreational impacts by encouraging target species away from the most impacted areas. Further research is needed that tests whether this is both feasible and effective, and whether efficacy varies by species, recreational type and visitor density.
- There was **strong support** (but not empirical evidence) that promoted the use of education, both of the public and/or training of wider stakeholders to minimise recreational disturbance posed to species. Although in general, active rather than passive techniques of education were encouraged, there was no evidence that empirically tested the benefits of different types of education/training, or whether it was possible to use education where illegal activities were occurring. More research is needed that explores the most effective means of educating different types of recreational users including those involved in illegal activity.
- There was **strong support** (but not empirical evidence) that proposed that the impacts of dogs could be lessened by ensuring that dogs were kept on a short lead. However, there was no empirical studies that explored these proposals in detail, e.g., the impacts of different lengths of lead or the number of dogs. Perhaps most importantly, ensuring compliance with lead restrictions is a particular challenge highlighted in the practitioner survey, and further research is needed that explores different ways in which the impacts of dogs can be lessened in upland sites where enforcement is usually very low.
- There was **moderate support** (but not empirical evidence) that proposed measures for mitigating or adapting to the impacts of mountain bikes in upland ecosystems, but these were only really relevant to on-track sites that are specifically designed for mountain biking. Further research is needed that explores mitigation and adaptation options for off-track mountain-biking, including consideration of management responses where this recreation type occurs illegally.
- There was **no evidence** found in this review that made proposals or tested the efficacy of mitigation or adaptation options for lessening the impacts of motorised vehicles. Further research is needed that explores mitigation and adaptation options for motorised vehicles, including consideration of management responses where this recreation type occurs illegally.
- There was **no evidence** found in this review that empirically tested how wildfire risks from barbecues and wild camping can be lessened. Whilst this may be covered in evidence reviews that are more explicitly focused on this area (e.g., see Glaves *et al*., 2020), further research is needed that examines a wide range of mitigation and adaptation options for reducing the recreational influence on wildfires, as well as the management measures that focus on reducing wildfire risk through habitat management.
- Some studies alluded to the potential for new and innovative forms of technology to help mitigate or adapt to recreational activity. However, this was not the focus of any studies included in this review, and further research is needed to explore the relative benefits of different technological solutions. This may include using drone technology to provide aerial assessments of disturbance responses, citizen science to record species-level responses to recreational users, using social media to conduct education or training and disseminating user zones through mobile mapping applications to encourage and discourage use of specific areas.

- There was **no evidence** found in this review that sought to measure the behavioural responses of recreational users to different management measures (i.e., controls that sought to mitigate for or adapt to recreational impacts on upland ecosystems). More research is needed that assesses compliance of recreational users to different types of management and that assesses their effectiveness under different levels of enforcement. This is particularly important in upland locations where enforcement can be particularly challenging.
- There was **no evidence** found in this review that assessed the role of partnership working and collaboration between different organisations to secure large-scale benefits through mitigation or adaptation, although some practitioner perspectives highlighted this was important. Further research is needed that tests the potential benefits of measures that can cover larger geographical areas and involve more than one organisation to see whether this achieves greater benefits in managing recreational pressure in the uplands.

Grouse moor management

- There was **no evidence** found in this review that attempted to mitigate or adapt to the impacts associated with disease management, e.g., the potentially negative impact of culling mountain hares reported by some studies or the potential wider environmental impacts of providing anthelmintics in upland ecosystem. Further research is needed that explores the potential for mitigation and adaptation options that may reduce the environmental and ecological implications of disease management on grouse moor estates.
- There was **no evidence** found in this review that attempted to test whether reducing the density of red grouse lessened the prevalence or severity of impacts of the disease on red grouse, despite moderate support that this may be an important strategy. Further research is needed that tests whether altered densities of red grouse influences the prevalence or severity of disease on grouse moor estates.

6. Conclusions and Recommendations

The evidence compiled within this review was based on academic studies undertaken within the UK, published since 2000, alongside a practitioner call for evidence. As has been noted elsewhere within this review, it is recognised that there is a significant amount of academic and practitioner evidence that pre-dates this time period. Previous literature and evidence reviews have been undertaken on specific forms of upland recreation that capture this past knowledge. However, it is possible that some of these studies may now be outdated and hence the purpose of this review was to provide a more up to date analysis of contemporary evidence on issues relating to the influence of upland recreation on ecosystems. In so doing the evidence review identified 13 **strong** and 30 **moderate** evidence statements.

This section provides a synthesis of the **strong** and **moderate evidence** statements that have been identified within the evidence review, summarises the evidence gaps and presents key recommendations for each Research Question.

6.1 Research Question 1: What form does recreational activity take in the UK uplands?

The full review of evidence for Research Question 1: '*What types of recreational activity take place in the UK uplands?*' was presented in Chapter 3. This section presents a summary of the evidence statements, summarises the evidence gaps and presents key recommendations for Research Question 1.

6.1.1 Summary of evidence

The following evidence was identified in relation to Research Question 1: '*What types of recreational activity take place in the UK uplands?*'

- In total, across 114 pieces of evidence, only 16 different types of recreation occurring in the UK uplands were the subject of empirical studies (along with 'general recreation').
- In total, 40 types of potential recreational activity occurring in the UK uplands were identified from evidence and practitioner perspectives (captured from the call for evidence and practitioner survey).

There were no **strong** or **moderate** evidence statements developed in relation to the types of recreational activity that take place in the UK uplands (see gaps in evidence).

6.1.2 Gaps in evidence

The following two gaps in evidence were found in relation to Research Question 1: '*What types of recreational activity take place in the UK uplands?*'

- There was **no evidence** detected that provided an overview of all the different types of recreational activity in the UK uplands and / or their distribution.
- There was **no evidence** found in this review that specifically measured the level or intensity of recreational use for any types of recreation specific to upland environments.

6.1.3 Recommendations

The following four recommendations were developed in relation to Research Question 1: '*What types of recreational activity take place in the UK uplands?*'

Recommendations from Evidence:

There was **no evidence** found in this review that sought to identify the types of recreation occurring in the UK uplands, other than non-analytical case-studies of specific sites such as National Parks or Nature Reserves. The four recommendations developed around Research Question 1 were therefore based on the absence of evidence.

Recommendations from Absence of Evidence:

- The evidence captured from both the search of academic literature and the practitioner call for evidence demonstrated that as many as 40 different recreational activities (and potentially more) may be occurring in the uplands, but only 17 types were analysed or discussed in the studies captured in this review. Further research is needed that classifies the type, extent and spatial distribution of different recreation types within the UK uplands, including identifying novel or emerging types of recreation.
- The proportion of evidence collected in this review was heavily weighted towards certain types of recreation occurring in the uplands, notably focussing on driven grouse shooting and to a lesser degree walking. Although not calculated in the evidence collected in this review, this is highly unlikely to be reflective of the proportion of participants that are occupied in upland recreational pursuits in the uplands (either participating or employed in supporting). Although this balance of evidence may be more proportionate to the relative influence of recreation types on upland ecosystems, there were notable types that were entirely absent or the focus of very few studies in the research, e.g., dog walking, mountain biking or use of motorised vehicles for recreation. Further research is needed that assesses the relative proportions of participants taking part in or supporting different types of upland recreational pursuits so that research and the active management of upland ecosystems can better reflect the level of recreational engagement.
- Further research is needed about how recreation has changed over time, including the type, extent and intensity of impact.
- The management of upland ecosystems needs to reflect and/or respond to the diversity in recreational use occurring in upland ecosystems. Whilst this data might be available at a local/site-based level, knowledge of national trends in this area would be beneficial to help steer effective policy and strategy recommendations

6.2 Research Question 2: What factors influence the level of recreational activity in UK uplands?

The full review of evidence for Research Question 2: '*What factors influence the level of recreational activity in UK uplands*?' was presented in Chapter 3. This section presents a summary of the two strong and seven moderate evidence statements, summarises the evidence gaps and presents key recommendations for Research Question 2.

6.2.1 Summary of evidence

The following two strong and seven moderate evidence statements were developed in relation to Research Question 2: '*What factors influence the level of recreational activity in UK uplands*?'

- There was **strong evidence** across four studies of different validities (**1+**, **1-**, **2+**, **4-**) that outlined that the proximity of sites to large residential areas influenced visitor numbers.

- There was **moderate evidence** from three studies (**2+**, **3-**) that organised events encouraged greater visitor usage of upland areas.
- There was **moderate evidence** from three studies (**1+**, **2+**, **3-**) that landscape features were likely to play an important role in influencing visitor use of sites.
- There was **moderate evidence** from three studies (**2+**, **5-**) that demonstrated how some specific recreation types were influenced by the abundance of specific species (all quarry species).
- There was **strong evidence** from five academic studies of varying validity (**1+**, **2+**, **4-**, **5+**, **5-**) that suggested that visitors to upland areas use the upland footpath network and that this provision can influence visitor behaviour, although none of the studies specified whether this referred to Public Rights of Way or included other forms of footpaths such as permissive paths or desire lines.
- There was **moderate evidence** from three studies (**1-**, **2+**, **5+**) that car park provision influenced recreational activity, although only one of these studies related specifically to the uplands.
- There was **moderate evidence** from across three studies (**2+**, **4-**) that indicated climate change has already, and will continue to influence recreational activities in upland areas.
- There was **moderate evidence** from two studies (**2++**, **2+**) that demonstrated that visitor numbers increased significantly in popular upland areas during weekends and summer months and that this increased visitor pressure is associated with more frequent disturbance events.
- There was, **moderate evidence** from three studies (**1+**, **2+**, **3-**) that suggested there had been a recent increase in visitor use in upland areas, although this evidence did not provide evidence of specific drivers of change.

6.2.2 Gaps in evidence

The following five gaps in evidence were found in relation to Research Question 2: '*What factors influence the level of recreational activity in UK uplands*?'

- There was **no evidence** found in this review that examined preferences towards any specific upland habitat features or the implications in terms of levels of recreation.
- There was **no evidence** found in this review that tested the effects of species or habitat condition on the number or type of visitors to upland areas or their behaviour.
- There was **no evidence** from comprehensive large-scale studies on the impact of the CRoW Act on the level of recreational activity or use of sites over broad time frames and in different locations.
- There was **no evidence** found in this review that analysed the difference in recreational use associated with different types of footpaths (e.g., between Public Rights of Way and other forms of footpaths such as permissive paths or desire lines).
- There was **no evidence** that provided quantitative empirical data on how levels and types of recreational activity may have changed over time with a specific focus on UK uplands.

6.2.3 Recommendations

The following 12 recommendations were developed in relation to Research Question 2: '*What factors influence the level of recreational activity in UK uplands*?'

Recommendations from Evidence:

- There was **strong evidence** that the proximity of landscapes to large residential areas was likely to influence the level of recreational activity, but none of this research was

specifically focused on upland ecosystems. Further research is needed to better understand the relative pressures being placed on upland landscapes close to large residential areas, and the degree to which this is directed towards landscapes designated towards supporting recreation (e.g., National Parks and AONBs) and those with less resources to manage recreational pressure (i.e., upland areas outside of these designations)

- There was **moderate evidence** that organised events are likely to increase participation in recreational activity, but there was no research that attempted to identify the range or extent of these events in upland ecosystems. Further research is needed to better understand the types of organised events that occur in the UK uplands and the extent to which the desire to promote greater recreational engagement is balanced against the potential risks of recreational pressure and associated damage or disturbance to upland species, habitats, and ecosystems.
- There was **moderate evidence** that landscape features were likely to influence the level and type of recreation, including two studies that suggested that recreational users preferred woodland to open habitats. This research was not however, focused solely on upland ecosystems where the ability to view and experience dramatic scenery was also identified as an important influence on recreational use. In the light of contestations about the role of the uplands in providing more woodland cover and wilding, further research is needed on landscape preferences in the uplands and how this may influence levels of recreational use. Additionally, much of the evidence comes from upland areas designated for their landscape quality (e.g., National Parks and AONBs), with further research needed to understand perceptions of recreational users in areas outside landscapes that area protected for their scenic value.
- There was **strong evidence** that demonstrated the importance of footpaths for providing access and determining the level of use at sites to varying degrees, but these studies did not distinguish between Public Rights of Way and other forms of footpaths such as permissive paths or desire lines. Further research is needed that analyses recreational use associated with different types of footpath and whether this influences the level of use and the potential impacts.
- There was **moderate evidence** that demonstrated that car parks and other car-related infrastructure (e.g., accessibility of the road network) influenced the level of use at individual sites, but despite proposals in some studies that the strategic provision of car parks could be exploited to reduce the level of recreational use at sensitive sites (by diverting users to more resilient areas), there were no studies that attempted to assess whether this was effective. Further research is needed on how car infrastructure can be used to ease recreational pressure in upland ecosystems, and to reduce impacts on the most sensitive sites.
- There was **moderate evidence** that climate change is already altering recreational use in the uplands, but there were no empirical studies that measured the degree to which this has, or may in the future, affect levels of use or associated impacts, other than evidence related to a reduction in snow sports. Further research is needed that explores how levels of use and the relative impacts of recreation may be affected by the combined influence of recreation and different climate change impacts. This research should reflect regional differences in likely climatic patterns (e.g., milder, drier winters versus milder, wetter winters) and secondary impacts such as wildfire risk and footpath erosion.
- There was **moderate evidence** that the level of recreational use in the uplands increases during weekends, bank holidays and the summer holidays, but there were no studies that measured this pattern of use over longer time frames (e.g., whether recreational pressure has increased during these peak periods). Further research is

needed on how levels of recreational use change both in short-term and longer-term measures, and whether changes to employment patterns (e.g., home-working and a shorter working week) may also have affected (or affect in the future) recreational pressure in upland ecosystems.

- There was **moderate evidence** that suggested there had been a recent increase in visitor use in upland areas, but there was **no evidence** about how national/international social or policy drivers (other than CRoW) may influence recreational use in the uplands (e.g., the COVID-19 pandemic and the 'cost of living' crisis), although studies may yet be forthcoming. There was also no quantitative empirical data on how levels and types of recreational activity may have changed over time with a specific focus on UK uplands. Further research is needed that explores the drivers of change in recreational use in upland ecosystems and how this may influence the types and levels of use.

Recommendations from Absence of Evidence:

- There was **no evidence** found in this review that tested the effects of species or habitat condition on the number or type of visitors to upland areas or their behaviour. Additionally, there was **no evidence** about the potential for ecotourism or its influence on upland ecosystems and only **weak evidence** (from one study) that explored the relationship between high-biodiversity sites and recreational use. Further research is needed that explores the current and potential use of sites related to their biodiversity value in upland ecosystems, the potential scope and impacts of ecotourism in the UK and public perspectives around their use of upland sites linked to potential changes in policy drivers in the uplands (e.g., ELMS and changes to agricultural subsidies, etc.)
- There was **no evidence** from comprehensive large-scale studies on the impact of the CRoW Act on the level of recreational activity in upland ecosystems. Further research is needed to better understand how changes in access affect levels of use, particularly in the light of increased calls to extend access rights to other habitats beyond 'hill, heath and moor', including woodlands and reservoirs.
- There was **no evidence** found in this review that assessed whether levels of recreational use were influenced by the accessibility of sites by public transport or the role of more sustainable forms of transport in accessing upland ecosystems. Further research is needed that explores how access to upland sites influence recreational use and empirical studies that explore whether public transport can be exploited to focus recreational pressure in less sensitive areas.
- Research assessing the factors influencing recreation tended to be localised and site -specific (although see Clutterbuck *et al*., 2020 and Hornigold *et al*., 2009 for national studies). Further research is needed on the overall trends in recreational activity in the uplands, including spatial analysis demonstrating where pressure has increased and drivers of this change.

6.3 Research Question 3: What influence does recreational activity have on upland species, habitats, or ecosystem processes in the UK?

The full review of evidence for Research Question 3: '*What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*' was presented in Chapter 4. This section presents a summary of the strong and moderate evidence statements, summarises the evidence gaps and presents key recommendations for Research Question 3.

6.3.1 Summary of evidence

The following 11 strong and 17 moderate evidence statements were developed in relation to Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?* Additionally, there were four evidence statements where the evidence was inconsistent, and one where there was moderate support but not empirical evidence.

Direct forms of recreational activity

Influence of 'general recreation':

- There was **inconsistent evidence** of the influence of 'general recreation' on the breeding success of bird species, because whilst there was **moderate evidence** across three studies (**2+**, **2-**) that suggested a negative effect of 'general recreation' on the breeding success of some bird species, there was also **moderate evidence** from three studies (**2++**, **2+**) that showed an insignificant correlation between disturbance from general recreation and the breeding success of two different ground nesting bird species. The inconsistency in the evidence surrounding the way in which general recreation affected the breeding success of different bird species suggests that responses to recreational disturbance is likely to be species specific, but it could also be affected by site-specific variables.
- There was **strong evidence** from four studies (**2++**, **2+**, **2-**) that bird behaviour and population effects (e.g., abundance, population density or overall survival) were negatively correlated with disturbance caused by 'general recreation', but this association was sometimes weak or context dependent.
- There was **strong evidence** from four studies (**2-**, **2+**, **3-**, **4-**) that 'general recreation' had a negative impact on habitat quality, two studies related to water quality and two studies related to broader, terrestrial habitat types in the uplands.
- There was **moderate evidence** from two studies (**2+**, **2-**) of a negative correlation between 'general recreation' and water quality, an important ecosystem service in the uplands.
- There was also **moderate support** from three studies (**3-**, **4-**) that the combination of climate change and recreational use in the uplands would negatively affect ecosystem processes although these were not tested with empirical evidence.

Influence of 'walking':

- There was **strong evidence** from four studies (**2++**, **2+**) that walking caused negative impacts on birds in upland ecosystems.
- There was **moderate evidence** from two Scottish studies (both **2+**) that demonstrated a negative correlation between walking and red deer (*Cervus elaphus*). These were, however, the only studies found in this review that assessed the impacts of walking on upland mammals.
- There was **moderate evidence** from two studies (**2+**, **2-**) of a negative correlation between walking and disturbance to soil in the UK uplands.

Influence of 'mountain biking':

- There was **moderate evidence** from two studies (**2++**, **2+**) that on-track mountain biking was negatively correlated with disturbance to upland species (one bird, one mammal).

Influence of motorised vehicles on habitats in upland ecosystems:

- There was **moderate evidence** from two studies (both **2+**) that demonstrated the potential for motorised vehicles to negatively influence upland habitats.

Influence of 'all other types' of recreation:

- There was **moderate evidence** from three studies (**2+**; **2-**) that demonstrated the negative impacts of ski developments on upland ecosystems.
- There was **moderate evidence** from two studies (**2+**, **3-**) undertaken in Scotland that wild camping had negative impacts on upland ecosystems.

Grouse moor management

Influence of grouse moor management: rotational burning

- There was **inconsistent evidence** from across four studies that burning had a beneficial effect on the abundance and breeding success of red grouse because whilst there was **moderate evidence** from two studies (both **2+**) that demonstrated a positive correlation between rotational burning and red grouse abundance, there was **moderate evidence** from two studies (both **2+**) of a null effect of heather burning on red grouse abundance.
- There was **moderate evidence** from two studies (both **2+**) that burning had a largely neutral effect on the abundance of ground nesting waders.
- There was **inconsistent evidence** of the effects of burning on upland passerines with the response of most species being measured as neutral, but some individual species demonstrated either a positive or negative response. These variable responses between species suggested that responses of passerines to burning were likely to be species-specific.
- There was **moderate evidence** from two studies (both **2++**) of a negative impact on aquatic invertebrates due to rotational burning.
- There was **moderate evidence** from two studies that demonstrated that burning occurred on protected habitats (both **2+**), but that this may be an important element of managing these habitats as per existing designations.

Influence of grouse moor management: predator control

- There was **strong evidence** across 4 studies (**2++**, **2+**) that demonstrated a positive relationship between legal predator control and the abundance of red grouse.
- There was **strong evidence** from five studies (**2++**, **2+**) that legal predator control had a positive influence on the abundance of birds other than red grouse, particularly ground-nesting waders.

Influence of grouse moor management: disease and disease management

- There was **strong evidence** from three studies (**2+**, **2++**) that suggested that the parasitic worm *T. tenuis* has a negative effect on the breeding productivity of red grouse and that anti-parasite treatment can reduce these impacts.
- There was **moderate evidence** from two studies (**2+**, **2-**) of the rapid spread of cryptosporidiosis infection in wild red grouse from managed moors in the UK.
- There was **strong support** (but not empirical evidence) that grouse moor management increased or decreased the risk of disease and disease vectors.

Influence of generic grouse moor management

- There was **strong evidence** from four studies (**2+**, **2++**) that demonstrated a positive association between overall management of grouse moors and red grouse abundance.
- There was **moderate evidence** from two studies (**2++**, **2+**) that the overall effects of grouse moor management were positive for golden plover.
- There was **moderate evidence** from three studies (**2++**, **2+**) that upland bird species exhibited different responses to overall grouse moor management, which for some species may also be related to the intensity of management (e.g., extent and pattern of heather burning).
- There was **inconsistent evidence** on the influence of grouse moor management on the distribution of mountain hare in Scotland because although there was **moderate evidence** from two studies (**2-**, **2+**) that grouse management supported the distribution of mountain hare populations in Scotland, there was also **moderate support** (but not empirical evidence) from two studies (**2++**, **2-**) that questioned the reliability of distribution (or 'presence') data as a determinant of the status of mountain hare populations on Scottish grouse moors.
- There was **strong evidence** from four studies (**2+**, **2-**) that raptor predation of red grouse can have significant impacts on red grouse numbers.
- There was **strong evidence** from six studies (**2++**, **2+**) identified in this review, that illegal raptor persecution had a significant negative effect on a wide range of raptor species across England and Scotland, and that this persecution was strongly correlated with grouse moors.
- There was also **moderate evidence** from three studies (**2++**, **2+**) that grouse moor management could be beneficial for multiple raptor populations on estates where persecution did not occur.
- There was **strong evidence** from six studies (**2++**, **2+**) that illegal persecution affected hen harrier populations on grouse moors in Scotland (4 studies) and England (2 studies).
- There was **moderate evidence** from three studies (all **2+**) that grouse moor management can benefit hen harrier populations where persecution incidents are low.
- There was **moderate evidence** from two studies (**2++**, **2+**) that golden eagle were significantly negatively affected by illegal persecution on grouse moors in Scotland.

6.3.2 Gaps in evidence

The following 21 gaps in evidence were found in relation to Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*

Direct forms of recreational activity

- There was **no evidence** from studies examined in this review that measured the effect of dog walking on birds in any upland habitats.
- There was **no evidence** from studies examined in this review that measured the effect of dog walking on taxa other than birds.
- In total, the search of literature identified only four studies that solely examined influences of mountain biking, and only two specific to the UK uplands. The amount of evidence analysing the influence of mountain biking on upland ecosystems is surprisingly small, given the popularity of this type of recreation and the potential for negative impacts on upland ecosystems (Huddart and Stott, 2019).

- There was **no evidence** found within this review that explored the effect of off-track mountain biking on species (and only weak evidence from one study that explored the impact on habitats).
- There was **no evidence** of the influence of motorised vehicles in the UK uplands, although one strong study (**2++**) did demonstrate the potential extent of motorised access within the UK uplands.

Grouse moor management

- There was **limited recent evidence** of the impact of burning on taxonomic groups other than birds; one study related to mammals and two related to invertebrates.
- There was **moderate evidence** from two studies (both **2++**) of a negative impact on aquatic invertebrates.
- There was **no evidence** found in this review that examined the effects of legal predator control on other mammals except the quarry species, or for any other taxonomic groups. Although some studies explored the influence of grouse moor management on mountain hare populations, they did not empirically test the impact of predator control.
- There was **limited recent and inconsistent evidence** of the effect of louping ill virus (LIV) on red grouse.
- There was **weak and inconsistent evidence** of the likelihood of mountain hares causing an increase in LIV in red grouse species.
- There was **no evidence** collected in this review of the influence of LIV on other wild upland species or the impacts on other wild species caused by the LIV management techniques employed on grouse moors.
- There was **no evidence** found in this review of literature of UK studies that explored the potential for wider environmental impacts of extensive pre-emptive administering of anti-parasitic drugs in upland ecosystems.
- There was **no evidence** of studies that attempted to identify specific vector pathways for *C. baileyi* between red grouse or from red grouse to other species.
- There was **inconclusive evidence** on whether cryptosporidiosis infection affected other grouse species, specifically black grouse.
- There was **weak and inconsistent evidence** on the overall effects of grouse moor management on black grouse.
- There was **weak and inconsistent evidence** on the relationship between grouse moors and mountain hare abundance.
- There was **no evidence** found in this review of the potential impact on raptor species of lead toxicity in shot red grouse or the wider environment, although there was one study that demonstrated lead toxicity in red grouse on grouse estates in England and Scotland.
- There was **weak and inconsistent evidence** from three studies on the influence of grouse moors on buzzard, merlin and peregrine falcon. For each species, there were two studies demonstrating opposing population or breeding trends in relation to the influence of grouse moors.
- There was **no evidence** of the effect of grouse moor management on the distribution, abundance or breeding success of other upland bird of prey species in the UK, e.g., short-eared owl, long-eared owl (*Asio otus*), goshawk (*Accipiter gentilis*) and white-tailed eagle (*Haliaeetus albicilla*).
- There was **no evidence** found in this review of literature that examined the influence of complete cessation of grouse moor management, e.g., how this may influence vegetation succession from heather dominated habitats, changes to habitat coverage or any associated species or taxonomic groups.

- There was **no evidence** found in this review of literature that measured the variability of management intensity within or between the broad classifications of different types of grouse management; 'driven grouse shooting', 'walked up shooting' or 'no shooting'.

6.3.3 Recommendations

The following 24 recommendations were developed in relation to Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*'.

Recommendations from Evidence:

Direct forms of recreation

- There was **inconsistent evidence** on whether 'general' recreation (i.e., where there was no distinction about the specific type of recreation being studied) negatively influenced the breeding success of some bird species. Studies that did identify impacts, particularly on ground nesting birds, were mostly conducted on lowland sites (although focusing on species that also breed in the uplands). Much more empirical data is required on the influence of general recreation types in upland ecosystems to corroborate the effects found in lowland studies, and to determine the extent to which issues are species specific.
- There was **strong evidence** that bird behaviour and population effects (e.g., abundance, population density or overall survival) were negatively correlated with disturbance caused by 'general recreation', but these only analysed three species in total (three studies on grouse species and one passerine, the latter in a lowland setting). Further research is needed that investigates disturbance effects on a much broader suite of upland bird species, to determine the extent to which responses are species-specific and whether the impacts differ in different upland habitats. Additionally, similar research is also needed that goes beyond avian fauna to investigate influences on other taxa.
- There was **strong evidence** that 'general recreation' had a negative impact on habitat quality and associated ecosystem processes, but these studies were mostly limited to water quality. Further research is needed that explores the impact of recreation on a much broader suite of upland habitats.
- There was **strong evidence** that highlighted the negative effects of walking and hiking on bird behaviour (including breeding success and disturbance effects) in the uplands and **moderate evidence** that demonstrated a negative correlation between walking and red deer. Importantly however, two studies showed that good footpath provision, which reduced the deviation of walkers from footpaths significantly lessened these negative effects. Better promotion is needed of the positive effects of footpath restoration and maintenance, to create greater awareness that this management measure can reduce the impacts of walking and hiking on upland species as well as the more obvious benefit of reducing habitat damage. Further research is also needed to assess whether these benefits extend to other taxonomic groups.

Grouse moor management

- There was **inconsistent evidence** on whether rotational heather burning has a positive effect on red grouse numbers (although it should be noted evidence published before 2000 suggests a positive relationship between burning and red grouse numbers). Further contemporary research is needed that investigates whether the primary purpose of burning, to increase red grouse densities, is effective in different

locations across the UK uplands, particularly in the light of novel influences on red grouse populations, e.g., climate change, cryptosporidiosis infection, etc.

- There was **inconsistent evidence** on how rotational burning influenced bird species other than red grouse in the UK uplands with effects being notably species-specific. For the majority of species, burning had a neutral or negative effect, although there were specific anomalies (e.g., moderate evidence of benefits for whinchat). This is an important finding as existing upland management is often cited as sustaining threatened upland bird communities, but the specifics of this management (e.g., burning versus predator control) are often aggregated. This amalgamation of potential management influences associated with grouse moor management was a notable issue with some of the evidence included in this review. Further research is needed that examines the impacts of different grouse moor management activities on birds, mammals, invertebrates and other taxonomic groups, with a particular focus on burning as a discrete measure, compared with other aspects of grouse moor management.
- There was **moderate evidence** that burning occurred on protected habitats, but no evidence found in this review that explored the extent to which this form of management was required to sustain or improve the condition of habitats. Further research is needed that explores a variety of management futures for upland habitats to identify opportunities for socio-economic and ecological diversity in upland management regimes, with less dependence on individual land-uses or management techniques.
- There was **strong evidence** of the benefits of legal predator control on grouse moors for both red grouse and other upland bird populations. The weight of evidence found in this review suggests this is the most important management technique for maintaining high densities of red grouse, and potentially for supporting other bird species. Research is needed on the economic, social and environmental sustainability of predator control as a tool for conserving specific species in upland ecosystems, and the effects on a broader suite of taxonomic groups (e.g., mammals). Additionally, research is also needed that explores alternatives to generalist predator control.
- There was **strong evidence** that medicating grouse can help to reduce the prevalence of individual diseases but there was an absence of evidence of the wider environmental implications of routine administering of medicines in upland ecosystems. Further research is needed that explores the impacts of applying anti-parasitic drugs on grouse moors for other taxonomic groups e.g., bird species and invertebrates, and the wider implications for ecosystems including soil and water quality.
- There was **moderate evidence** that some bird species, particularly ground-nesting waders are positively affected by the overall approach of grouse moor management, but also that responses are species-specific, with some negative responses. There was however a dominant focus within studies to examine the influence of grouse moor management on species currently present on grouse moors. Further research is needed that examines the influence of this management on past assemblages of species, or on species with the potential to extend their ranges into areas managed as grouse moors, e.g., Dartford warbler or woodlark, to explore the influences on a broader suite of species.
- There was **inconsistent evidence** on the influence of grouse moor management on mountain hare populations in Scotland, with a potential conflict between the influence of habitat management (i.e., burning and predator control) set against significant increases in culling as a form of disease management. Given the recent increase in culling rates reported by some studies and the change in law requiring Scottish land

managers to be licensed before culling can occur, further research is needed that explores the impact of hare culling and the associated legislation.

- There was **strong evidence** that raptor persecution has had a significant negative effect on most raptor populations on grouse moors in England and Scotland, and that for some species, notably golden eagle, and hen harrier, this may have had a much more widespread impact on their population status across the UK. This was linked to **moderate evidence** that raptor populations can benefit from grouse moor management where persecution does not occur (i.e., the Langholm Estate) but also a recognition that the evidence that has emerged from this individual demonstrator project has not significantly influenced the management practices occurring on other Scottish or English estates. Further research is needed that explores other options for preventing widespread raptor persecution occurring on grouse moors.

Recommendations from Absence of Evidence:

Direct forms of recreation

- This review has demonstrated that there is, in general, a notable **lack of evidence** about the impacts of specific forms of recreation on upland species, habitats and ecosystems with only moderate evidence (across six studies in total) assessing the influence of three specific types of recreation (on-track mountain biking, ski developments and wild camping). This is despite the popularity of many recreation types in upland areas. Further extensive and wide-ranging research is needed that explores habitat and species level impacts of specific types of recreation – particularly those with either high levels of use and/or where the impact on upland ecosystems is likely to be significant. This includes, but is not limited to, the influence of dog walking, motorised vehicles, mountain-biking and barbecues, all of which were highlighted in the practitioner survey as having significant impacts on upland ecosystems, but which are absent or under-represented in empirical studies. Some specific recommendations for these individual recreation types include:
    - Addressing the absence of evidence surrounding the influence of dog walking in upland ecosystems with further research that explores the differences between on-lead and off-lead impacts and studies that include a broad range of species including (but not limited to) upland birds. Studies on the impacts of dogs might also determine the effect of different breeds and the impacts of the height and density of different vegetation types.
    - Addressing the absence of evidence on mountain-biking with further research that examines the influence of on-track and off-track pursuits on species and habitats in upland ecosystems, including examining where mountain-biking occurs illegally.
    - Addressing the absence of evidence of how motorised vehicles affect species and habitats with further research that explores the influence on species and habitats, including specifically designated motorsport areas, areas popular for off-road motorsports, and the extent and impact of illegal motorised vehicles across the UK uplands. A lowland study not included in this evidence review (Taylor *et al*., 2007) but conducted on a lowland bird species (stone curlew), suggested that ground-nesting birds can be disturbed by motorised vehicles, but that this disturbance is lower than it is for walkers and dog-walkers. Bird responses occurred more rapidly and at lesser distances if vehicles were using a non-typical route with relatively small responses recorded when motorised vehicles traversed regularly used routes. This type of study needs to be replicated in upland areas, particularly given that practitioner perspectives

highlighted the increase in popularity of off-road driving as a recreational activity in upland ecosystems.

- There was much less evidence available regarding the influence of recreation on habitats (as opposed to species), although several studies reported negative impacts of general recreation on freshwater quality. Further research is needed that explores the influence of a range of different recreation types on diverse upland habitats and their relative sensitivity to negative impacts.
- Related to this recommendation on the influence of recreation on habitats, is the relationship between disturbance and vegetation types and heights. There was weak evidence from one study that reported that short vegetation height may increase disturbance to breeding birds from dog-walking and other forms of recreation. Further research is needed that explores the influence of vegetation height on disturbance effects, particularly given the range of anthropogenic activities that maintain short vegetation in upland ecosystems (e.g., heather burning and grazing).
- The majority of species-level studies were focused on the impacts of recreation on breeding birds. Further research is required that explores impacts on other taxonomic groups, both terrestrial and aquatic.
- Although there was extensive evidence on the influence of grouse moor management on upland species, there was **no evidence** relating to the impact of actual shooting days on upland species other than red grouse. Further research is needed that explores the influence of the red grouse shooting period on other upland species.

Influence of grouse moor management:

- There was a **lack of evidence** across all aspects of grouse moor management (i.e., burning, predator control, disease management, and 'generic' management), of the influence on taxonomic groups other than birds, and even this was mostly limited to ground-nesting waders and a few passerine species. Whilst these species represent a significant proportion of the protected species occurring on upland habitats (e.g., blanket bog and heathland habitats), they only represent a narrow assemblage of all the biodiversity that could inhabit UK upland ecosystems. Further research is needed that examines the influence of grouse moor management on a much broader suite of species associated with the UK uplands.
- There was **limited and inconsistent recent evidence** of the effect of LIV on red grouse. Given that the management of other upland species (e.g., mountain hare and red deer) on grouse estates is based on the assumption that LIV has significant negative effects on red grouse, there needs to be further research on the impacts of LIV on different aspects of red grouse ecology (e.g., breeding success, population density) over multiple sites.
- There was **weak and inconsistent evidence** of the likelihood of mountain hares causing an increase in LIV in red grouse species and there was **no evidence** found in this review that attempted to assess the effectiveness of hare culling on estates that have deer species present (as the presence of alternative tick hosts may influence LIV persistence). There was also **no evidence** found in this review that attempted to assess the direct effects of hare culling on hare populations, either abundance or distribution. There needs to be further research on the influence of culling on hare populations and whether it achieves its aim of reducing LIV in red grouse.
- Although there was **strong support** from that the density of grouse had increased over the last 20 years (promoted by more intensive management) and that this greater density had increased the risk and prevalence of disease in red grouse and potentially other species (e.g., black grouse and mountain hare), there was **no empirical evidence** of the changes in management intensity or the impact it may be having on

other species associated with upland ecosystems. There was also **no evidence** that attempted to identify vector pathways for disease, particularly transfer to other avian species. Further research is needed that explores the recent changes in grouse moor management and whether there is any relationship with diseases in red grouse, coupled with research on the influence of more intensive management on a broad suite of upland species and habitats.

- There was **no evidence** found in this review, of the potential for lead toxicity in red grouse to influence the trophic food chain or the wider environment. Further research is needed, in the absence of restrictions on using lead shot, that explores the wider ecological and environmental impacts of lead toxicity in red grouse.
- There was **weak and inconsistent evidence** of the influence of grouse moor management on buzzard, merlin and peregrine falcon and **no evidence** on other bird of prey species associated with upland habitats (e.g., short-eared owl, long-eared owl, goshawk, and white-tailed eagle). Given the strength of evidence of persecution of raptors, many of which are killed through indiscriminate methods such as poisoning, further research is needed that explores the impact of grouse moor management on all birds of prey associated with the uplands. This research should consider the full range of management approaches, including habitat management as well as persecution.
- There was **no evidence** found in this review of literature that examined the influence of complete cessation of grouse moor management, e.g., how this may influence vegetation succession from heather dominated habitats, changes to habitat coverage or any associated species or taxonomic groups. The only study of grouse moor cessation found in this review was limited to Langholm Moor, which only demonstrated removal of some management measures for a relatively short amount of time and did not attempt any habitat restoration in the interim period. Further research is needed that explores how obsolete grouse moors might be successfully restored to enhance their value for biodiversity and the associated role of vegetation management versus allowing vegetation succession.

6.4 Research Question 4: What relationships exist between types of recreational activity and severity of impact in the UK uplands?

There was very little evidence found that addressed Research Question 4: '*What relationships exist between types of recreational activity and severity of impact in the UK uplands?'* was presented in Chapter 4. This section presents a summary of only one moderate evidence statement, summarises the evidence gaps and presents key recommendations for Research Question 4.

6.4.1 Summary of evidence

The following single moderate evidence statement was developed in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

- There was **moderate evidence** from two studies (**2+**) that the severity of impacts does vary with the type of recreation, but there was no consistency across types because of the focus of the studies. Additionally, it is likely that responses to different types of recreation are species-specific, although this was not possible to detect with so few studies.

Given the limited evidence of studies that compared the type of recreational activity and severity of impact, the Research Group have identified a series of characteristics from the evidence compiled throughout this review that may help to define recreation types that may have the most significant negative impacts on upland species, habitats, and ecosystems. These include recreation types that:

- Involve large groups of people
- Where the recreational disturbance coincides with a seasonally critical element of a species lifecycle or its habitat (such as breeding season).
- Occurs on or near habitats or species that are particularly vulnerable to disturbance.
- Involves repeated disturbance for prolonged periods of time.
- Results in new areas being disturbed rather than those recreation types that concentrate disturbance in specific locations (such as footpaths or tracks).

6.4.2 Gaps in evidence

There was a paucity of evidence found in this evidence review in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?* As such, there is one main and principal gap in evidence:

- There was **no evidence** found in this review that assessed the relationship between types of recreation and severity of impacts specifically within upland environments, which is a particular gap in knowledge.
- There was **limited evidence** that suggested that recreation pursuits that adopt non-typical routes or included sporadic or unpredictable behaviour were likely to have greater impacts on species than when the activity occurred in a more predictable manner.

6.4.3 Recommendations

The following four recommendations were developed in relation to Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

Recommendations from Evidence:

- There was **moderate evidence** that the severity of impacts does vary with recreation type, but there were too few studies to generate any conclusions about more or less impactful types of recreation. There needs to be a strong focus of further research that explores the relationship between types of recreational activity and the severity of impact in upland ecosystems.

Recommendations from Absence of Evidence:

- As above, there was **limited evidence** on the relative impacts of different types of recreation, and the studies that were included were undertaken in the lowlands. One of the major evidence gaps identified in this review highlighted that much more research is needed that identifies the most damaging types of recreation in the uplands for both species and habitats. The practitioner survey highlighted some recreational pursuits that may be more impactful (e.g., dog walking, motorised vehicles, mountain biking and barbecues), but research is needed that explores the impacts of a wide range of recreational activities.
- Although limited in its nature, there was **limited evidence** that suggested that recreational pursuits that adopted non-typical routes or included sporadic or unpredictable behaviour were likely to have greater impacts on species than when the activity occurred in a more predictable manner. Further research is needed that

examines these findings in upland ecosystems and that measures whether other factors may influence the severity of impact (e.g., the noise, light or speed associated with an activity or pollution effects on soil, water or air).

- There was **no evidence** found in this review that related recreational activity and the severity of impact to the difference between legal and illegal activities. More research is needed that explores the relative impact of illegal recreational activity and the role of regulation and enforcement in different site and landscape designations.

6.5 Research Question 5: What are 'appropriate levels of use' of recreation in the UK uplands?

The full review of evidence for Research Question 5: '*What are 'appropriate levels of use' of recreation in the UK uplands?*' was presented in Chapter 5. This section presents a summary of the strong and moderate evidence statements, summarises the evidence gaps and presents key recommendations for Research Question 5.

6.5.1 Summary of evidence

The following two moderate and one inconsistent evidence statements were developed in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

- There was **moderate evidence** from three studies (**2++**, **2+**) that defined specific thresholds for hiking, which if surpassed would cause significant impacts to upland bird species.
- There was **moderate evidence** from two studies (both **2+)** that the spatial distribution of visitors was more important than visitor numbers in terms of their impacts on bird species.
- There was **strong evidence** from five studies (**2++**, **2+**) that appropriate levels of use can be affected by the distance between wildlife and the source of disturbance.
- There was **inconsistent evidence** surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for a range of bird and mammal species, to opposing evidence that suggested this type of recreation was incompatible with nature conservation objectives.

6.5.2 Gaps in evidence

The following gaps in evidence were found in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

- The evidence presented in this review highlighted that 'appropriate levels of use' was an area that was under-researched, with an absence of evidence on the appropriate levels of use for almost all forms of recreation.
- It was difficult to generate any overarching principles about appropriate use thresholds. Whilst there was support for certain measures, they were not backed by empirically tested evidence. Furthermore, it was likely that many measures were species-specific and varied depending on the type of recreation, highlighting a considerable gap in knowledge surrounding appropriate use thresholds.
- There was **no evidence** found in this review that examined the implications of repeated visitor disturbance on vegetation or soil in an attempt to quantify the carrying capacity of upland habitats.

6.5.3 Recommendations

The following six recommendations were developed in relation to Research Question 5: *What are 'appropriate levels of use' of recreation in the UK uplands?*

Recommendations from Evidence:

Direct forms of recreation

- There was **moderate evidence** that defined specific thresholds for hiking, which if surpassed would cause significant impacts to upland bird species. This included individual studies that highlighted that the appropriate level of recreational use might be affected by the overall group number or frequency (number per hour) but there was **no evidence** that sought to explore the relative influence of these different factors. Further research is needed that considers different ways in which 'appropriate use' may be determined, including party size and density, relative disturbance factors such as the spatial extent of disturbance, seasonality, noise, visual intrusion, etc.
- There was **moderate evidence** that the spatial distribution of visitors was more important than visitor numbers in terms of their impacts on bird species, but both these studies occurred in the lowlands. Further research is required that explores whether this trend also applies in upland ecosystems, and whether it is relatively universal or species-specific. In addition to distance thresholds, research might include exploring the impact of random or unfamiliar disturbance as opposed to more predictable patterns of use, whether disturbance behaviour becomes reduced over short and long time periods of exposure and examine the effects on species from a range of taxonomic groups.

Grouse moor management

- There was **inconsistent evidence** surrounding the appropriate levels of use for driven grouse shooting, ranging from evidence that demonstrated it was beneficial for a range of bird and mammal species, to opposing evidence that suggested this type of recreation was incompatible with nature conservation objectives. Whilst this debate is both political and emotive and therefore unlikely to be resolved solely through further research, there is the need for research to better understand the relative impacts of different levels of management intensity occurring on driven grouse shooting estates. Grouse moors were often treated as a uniform land use in the evidence, but there was an absence of research that assessed the relative intensity of grouse-moor management with studies often making simplistic assessments between driven grouse moors, walked-up grouse moors and 'un-shot' moors. In practice, however, management intensity is likely to vary significantly, e.g., the extent of rotational burning, predator control and disease management. More research is needed that assesses the appropriate levels of use of grouse moors for upland species other than red grouse. This variation in management intensity on grouse moors was also raised in the practitioner survey, which could have markedly different impacts on the species, habitats and processes in upland ecosystems.

Recommendations from Absence of Evidence:

Direct forms of recreation

- The evidence presented in this review highlighted that appropriate levels of use were an area that was under-researched, with an absence of evidence on the appropriate levels of use for almost all forms of recreation. This was a key gap in knowledge

highlighted by this evidence review and one that needs to be the focus of future research with breadth that covers different recreation types and different taxa and species in upland ecosystems. However, as per the practitioner survey the concept of defining 'carrying capacity' for different habitats and species is challenging and requires greater exploration alongside practitioners working in upland areas.

- Although there were very few studies explicitly examining the appropriate levels of use for any specific recreation type, there was limited evidence that suggested that distance thresholds from a recreational activity were species-specific although these were not tested across different species within the same study. Similarly, some studies suggested but did not empirically test, that the sensitivity of different species may vary by type of recreation. A significant evidence gap identified in this evidence review is the need to better understand species-specific responses and what constitutes appropriate levels of use for species with different levels of sensitivity to recreational disturbance in upland ecosystems.

Grouse moor management

- A significant proportion of all the research found in this evidence review was about the influence of grouse moors on upland ecosystems. This may reflect the extent of area covered in comparison to other recreation types but there is a need to broaden the research focus to encourage much more extensive assessment of the impact and management of other recreation types. Related to this is the need for empirical research that explores alternative forms of moorland management to grouse moors. There was an assumption in the literature that in areas where there was an absence of grouse moors, there is a complete absence of management, but alternative upland land uses that require some management are also plausible and may go beyond the familiar alternatives of agriculture and forestry (e.g., see Crowle *et al*., 2022). Whilst reviewing such scenario literature was beyond the scope of this evidence review, there is an overlap between recreational use and alternative land uses that require more in-depth exploration. These alternative upland futures and their implications for the biodiversity of upland ecosystems need to be the focus of future research, including modelling that explores future scenarios and empirical testing of the influence of more novel land uses in upland ecosystems.

6.6 Research Question 6: What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?

The full review of evidence for Research Question 6: '*What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands*?' was presented in Chapter 5. This section presents a summary of the moderate evidence statements and strong and moderate support statements, summarises the evidence gaps and presents key recommendations for Research Question 6.

6.6.1 Summary of evidence

There was a lack of empirical studies that addressed Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?* The following section summarises the information from both empirical studies as four moderate evidence statements, but also presents where there were proposals for adaptation and mitigation measures, shown as six strong support and five moderate support statements.

Direct forms of recreation

- There was **strong support** (but not empirical evidence) from five studies (**2++**, **2+**, **2-**, **3-**, **5-**) that recommended the use of access restrictions to reduce recreational impacts on specific species (mostly ground-nesting birds, e.g., black grouse and nightjar), as permitted through the CRoW Act.
- There was **strong support** (but not empirical evidence) from five studies (**1+**, **2+**, **3-**, **5-**) that suggested reducing impacts of 'all recreation' by encouraging target species away from the most impacted areas.
- There was **strong support** (but not empirical evidence) from four studies (**2+**, **2-**, **5-**) that promoted the use of education, both of the public and wider stakeholders to minimise recreational disturbance posed to species.
- There was **moderate support** (but not empirical evidence) from two studies (**2+**, **2-**) that suggested that wider landscape or strategic land-use planning could be used to mitigate or adapt to recreational pressures on species.
- There **was strong support** (although not empirical evidence) from six studies (**1-**, **2++**, **2+**, **2-**) that access should be restricted either on a seasonal basis or on a permanent basis, to reduce disturbance from hiking/walking.
- There was **moderate evidence** from two empirical studies (both **2+**) of the benefits associated with implementing footpath restoration to reduce the negative impacts of walking and hiking on breeding waders in upland ecosystems.
- There was also however, **moderate support** from two studies (**3-**, **4+**) that provided insight into the practical challenges of implementing footpath restoration.
- There was **strong support** (but not empirical evidence) from four studies (**1-**, **2+**, **5-**) that proposed alternative approaches that would encourage walking in less-sensitive areas (both on and off site).
- There was **moderate support** (but not empirical evidence) from two studies (**1-**, **2+**) that greater engagement with site users and associated education could help inform walkers of their rights and behaviours.
- There was **strong support** (but not empirical evidence) from six studies (**2++**, **2+**, **3-**, **5-**) that all focused on the impacts of recreation on breeding birds, which proposed that the impacts of dogs could be lessened by ensuring that dogs were kept on a short leash.
- There was **moderate support** (but not empirical evidence) from two studies (**2+**, **5-**) that proposed measures for mitigating or adapting to the impacts of mountain bikes in upland ecosystems.
- There was **moderate support** from three studies (**2+**, **2-**, **3-**) that proposed restricting access to areas within specified distances or zones around the species of concern, for a variety of recreation types including fishing, cycling, angling, wildfowling and orienteering.
- There was **moderate evidence** from three studies that mitigation measures had successfully been introduced to reduce the impacts of climbing on breeding birds.

Grouse moor management

- There was **moderate evidence** from three studies (both **2+**) that diversionary feeding of hen harriers reduced the predation of red grouse chicks, but concerns from grouse moor managers about the long-term impact of diversionary feeding on harrier numbers may prevent take-up of the technique.
- There was **moderate evidence** from two studies (**2+**, **5++**) that solutions to mitigate the impacts between grouse moor management and conservation are multi-faceted, complex and difficult to implement successfully.

6.6.2 Gaps in evidence

The following seven gaps in evidence were found in relation to Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

- Apart from a few exceptions studying footpath restoration and grouse moor management, there was very little empirical evidence found in this review about the efficacy of any mitigation or adaptation measures.
- There was **no evidence or support** found in this evidence review of practical mitigation or adaptation options to manage motorised vehicle impacts in upland ecosystems.
- There was **no evidence or support** found in this review on the use of education as a way of ensuring negative impacts on upland ecosystems could be mitigated or adapted to, other than those already mentioned for 'all recreation' and for 'walking'.
- There was **no evidence or support** found in this review on adaptation or mitigation responses to habitat-level impacts by individual forms of recreation except those already mentioned for walking.
- There was **no evidence** found to mitigate or adapt to the impacts associated with managing LIV, particularly the potential negative impact of culling mountain hares reported by some studies.
- There was **no evidence** found in this review that examined how the potential wider environmental impacts of providing anthelmintics in upland ecosystems may need to be mitigated or adapted to.
- There was **no evidence** found in this review that attempted to test whether reducing the density of red grouse lessened the prevalence or severity of impacts of the disease on red grouse.

6.6.3 Recommendations

The following 15 recommendations were developed in relation to Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

In almost all instances, where studies made proposals for mitigation or adaptation options these were usually untested and therefore very few recommendations can be made from evidence on adaptation or mitigation measures. Owing to the lack of empirical experiments, recommendations developed on areas where there was strong support (without empirical evidence) are included in recommendations from the absence of evidence.

Recommendations from Evidence:

Direct forms of recreation

- Although only the focus of two studies (across two sites in total), there was **moderate evidence** of the significant beneficial impacts that footpath resurfacing had on reducing the spatial extent of disturbance caused by walking / hiking by reducing deviation from footpaths. However, there was also moderate support that highlighted that upland footpath restoration has practical challenges and is resource intensive and further research is needed that explores the relative benefits of this technique across a wide range of upland settings (e.g., different habitat types), visitor densities and that measures the benefits for a much broader range of upland species, habitats and ecosystem functions.

Grouse moor management

- There was **moderate evidence** that diversionary feeding of hen harriers reduced the predation of red grouse chicks. However, there was no evidence of the take-up of diversionary feeding by grouse moor estates other than an observation from one study that it was not readily employed because of concerns that it would increase hen harrier numbers. Further research is needed that explores attitudes and approaches of grouse moor managers to different techniques that might reduce the likelihood of illegal raptor persecution.

Recommendations from Absence of Evidence:

Direct forms of recreation

- As above, in almost all instance where mitigation or adaptation options were mentioned, these were presented as proposals rather than the focus of studies. Even in the very few studies that did undertake empirical examination of mitigation or adaptation measures, these tested the efficacy of one type of management measure, but there was **no evidence** included in this review that sought to compare the efficacy of more than one type of management measure to reduce impacts on species, habitats or ecosystem processes. Similarly, several studies suggested a diverse range of mitigation measures were likely to be more effective when applied in combination, (e.g., route closures, education, stakeholder-engagement and signage), but there was no evidence that measured this. Further research is needed that seeks to empirically examine the relative effectiveness of different types of management responses at reducing impacts on species or habitats, e.g., comparing the benefits of excluding access, diversionary techniques or habitat management and the potential advantages and disadvantages of using a combination of strategies.
- There was **strong support** (but not empirical evidence) that recommended the use of access restrictions to reduce recreational impacts on specific species (mostly ground-nesting birds, e.g., black grouse and nightjar), particularly in relation to hiking/walking, as permitted through the CRoW Act. There were also proposals that highlighted the difference between direct access restriction or more nuanced access management (e.g., encouraging use in less sensitive areas), but none of the studies included in this review sought to compare the difference between the two and whether their relative success varies by recreation type. Further research is needed that assesses the relative benefits of different types of access restriction/access management and whether the type of recreation determines or affects the most effective type of mitigation or adaptation techniques to minimise harm to upland ecosystems. Additionally, further research is needed that tests the effectiveness of these access restrictions is different upland settings, with consideration of differences in the ability to enforce restrictions, the perceptions and responses of recreational users and the suitability of the technique for different taxa/species.
- By contrast, there was **strong support** (but not empirical evidence) that suggested an alternative approach of reducing recreational impacts by encouraging target species away from the most impacted areas. Further research is needed that tests whether this is both feasible and effective, and whether efficacy varies by species, recreational type and visitor density.
- There was **strong support** (but not empirical evidence) that promoted the use of education, both of the public and/or training of wider stakeholders to minimise recreational disturbance posed to species. Although in general, active rather than passive techniques of education were encouraged, there was no evidence that empirically tested the benefits of different types of education/training, or whether it was

possible to use education where illegal activities were occurring. More research is needed that explores the most effective means of educating different types of recreational users including those involved in illegal activity.

- There was **strong support** (but not empirical evidence) that proposed that the impacts of dogs could be lessened by ensuring that dogs were kept on a short lead. However, there was no empirical studies that explored these proposals in detail, e.g., the impacts of different lengths of lead or the number of dogs. Perhaps most importantly, ensuring compliance with lead restrictions is a particular challenge highlighted in the practitioner survey, and further research is needed that explores different ways in which the impacts of dogs can be lessened in upland sites where enforcement is usually very low.
- There was **moderate support** (but not empirical evidence) that proposed measures for mitigating or adapting to the impacts of mountain bikes in upland ecosystems, but these were only really relevant to on-track sites that are specifically designed for mountain biking. Further research is needed that explores mitigation and adaptation options for off-track mountain-biking, including consideration of management responses where this recreation type occurs illegally.
- There was **no evidence** found in this review that made proposals or tested the efficacy of mitigation or adaptation options for lessening the impacts of motorised vehicles. Further research is needed that explores mitigation and adaptation options for motorised vehicles, including consideration of management responses where this recreation type occurs illegally.
- There was **no evidence** found in this review that empirically tested how wildfire risks from barbecues and wild camping can be lessened. Whilst this may be covered in evidence reviews that are more explicitly focused on this area (e.g., see Glaves *et al*., 2020), further research is needed that examines a wide range of mitigation and adaptation options for reducing the recreational influence on wildfires, as well as the management measures that focus on reducing wildfire risk through habitat management.
- Some studies alluded to the potential for new and innovative forms of technology to help mitigate or adapt to recreational activity. However, this was not the focus of any studies included in this review, and further research is needed to explore the relative benefits of different technological solutions. This may include using drone technology to provide aerial assessments of disturbance responses, citizen science to record species-level responses to recreational users, using social media to conduct education or training and disseminating user zones through mobile mapping applications to encourage and discourage use of specific areas.
- There was **no evidence** found in this review that sought to measure the behavioural responses of recreational users to different management measures (i.e., controls that sought to mitigate for or adapt to recreational impacts on upland ecosystems). More research is needed that assesses compliance of recreational users to different types of management and that assesses their effectiveness under different levels of enforcement. This is particularly important in upland locations where enforcement can be particularly challenging.
- There was **no evidence** found in this review that assessed the role of partnership working and collaboration between different organisations to secure large-scale benefits through mitigation or adaptation, although some practitioner perspectives highlighted this was important. Further research is needed that tests the potential benefits of measures that can cover larger geographical areas and involve more than one organisation to see whether this achieves greater benefits in managing recreational pressure in the uplands.

Grouse moor management

- There was **no evidence** found in this review that attempted to mitigate or adapt to the impacts associated with disease management, e.g., the potentially negative impact of culling mountain hares reported by some studies or the potential wider environmental impacts of providing anthelmintics in upland ecosystem. Further research is needed that explores the potential for mitigation and adaptation options that may reduce the environmental and ecological implications of disease management on grouse moor estates.
- There was **no evidence** found in this review that attempted to test whether reducing the density of red grouse lessened the prevalence or severity of impacts of the disease on red grouse, despite moderate support that this may be an important strategy. Further research is needed that tests whether altered densities of red grouse influences the prevalence or severity of disease on grouse moor estates.

6.7 Implications of Evidence Review for Further Research

This evidence review of recent literature (since 2000) has highlighted that there are substantial gaps in the existing evidence base on the influence of recreation in upland ecosystems in the UK. This review has highlighted many areas for further research that are needed to guide appropriate responses to recreational pressure, and without this investment in upland research, there is significant potential that species, habitats and ecosystems will be subject to disturbance and/or damage. Whilst it is not within the scope of this evidence review to make explicit conclusions and recommendations that should guide policy or management approaches, it is important that future policies should be developed based on appropriate knowledge and information.

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Appendix I: Evidence Table

Type of evidence indicator (see Section 2.3.1 for a full explanation of the methodological approach for each search type):

AE-B (academic evidence – Boolean searches): includes all the academic literature obtained from Boolean searches.
AE-SS (academic evidence – snowball searches): includes all academic literature obtained from snowball sampling of other, non-empirical evidence reviews.
AE-AS (academic evidence – additional searches): includes all academic literature obtained from additional searches.
PE (practitioner evidence): includes all the evidence submitted as part of the call for evidence that was subsequently screened in.

Type of study indicator:

1. Meta-analyses, systematic reviews of Randomised Control Trials (RCTs), or RCTs including cluster RCTs.
2. Systematic reviews of, or individual, non-randomised controlled trials, case-control trials, cohort studies, controlled before-and-after (CBA) studies, interrupted time series (ITS) studies, correlation studies.
3. Non-analytical studies, for example; case reports, case series studies.
4. Expert opinion, formal consensus.
5. Modelling, where data was used to develop projections of change over time and space rather than evidence changes that have occurred.

 Hashed cells denote studies wholly or partly conducted in the UK lowlands

Table A1.1 Summary of Studies Included in the Evidence Review

Reference	Source of evidence	Country	Type of recreation	Summary of evidence	Type of study	Validity score (++, +, -)
Amar *et al.* (2004)	AE-AS	Scotland	Driven shooting	This study explored whether the proportion of heather around harrier nests could be used to predict red grouse predation rates. The study then assessed whether diversionary feeding of hen harriers could be used to reduce predation rates in a targeted manner. Results demonstrated that the rate at which red grouse were delivered to harrier	2	(+)

				nests was positively associated with the proportion of heather cover within 2 km of harrier nests. Based on these findings, a model was developed that predicted predation rates based on the proportion of heather cover, which correctly predicted the top 50% of harrier nests in five of six years. Finally, the study assessed whether diversionary feeding could be targeted at high heather nests. This demonstrated that when harriers were given diversionary food, the relationship between grouse predation rates and habitat was removed, with grouse predation reduced to negligible levels in most cases. This suggests that diversionary feeding could be targeted at nest sites with the highest heather cover to reduce the economic costs of management and maximise conservation benefits.		
Amar *et al.* (2012)	AE-AS	England	Driven shooting	This study used a combination of data sets including peregrine breeding surveys, RSPB Persecution data, and Google Earth to explore the impact of grouse moor management on peregrine falcon populations (1 km resolution). The study found that productivity on grouse moors was 50% lower than on non-grouse moors. Clutch and brood size was similar between habitat types, suggesting little difference in prey availability. Population modelling indicated that grouse moor populations were unsustainable and were reliant on immigration. Wildlife crime data revealed that persecution occurred more frequently on grouse moors.	2	(++)
Baines and Richardson (2007)	AE-B	England	Recreation (general)	This study measured the impact of simulated hiking on black grouse individuals in Northern England. Three simulated levels of disturbance were used, but no effect on breeding success or population level effects were identified across these. However, disturbance effects were noted, with birds flushed at 60% greater distances when exposed to high disturbance rates, at an average distance of 55 m,	2	(++)

				compared with 34 m at moderate disturbance rates (F1,100 =3.66, P=0.05).		
Baines and Richardson (2013)	AE-AS	Scotland	Driven shooting	This before-and-after study analysed the effect of predator control on the breeding success of hen harriers at the Langholm Estate in Scotland. The results showed that hen harrier clutch survival and productivity were higher when the moors were managed as grouse moors (i.e., predators were culled). Predation by foxes was the main cause of hen harrier breeding failure. The study concluded that control of generalist predators as part of grouse moor management can benefit hen harrier productivity.	2	(+)
Baines *et al.* (2014)	AE-AS	England	Driven shooting	This study surveyed the managers of 102 moors in northern England (across five different regions) in 2012. Respondents from 49 moors (48% of the sample) reported that grouse had demonstrated symptoms of cryptosporidiosis infection, although only 14 grouse moor managers had undertaken laboratory testing to verify positive cases (of which 10 were positive). In the North Pennine Dales (NPD), the number of moors reporting potential cases rose from two in 2009 to 38 in 2013 meaning in only four years there was an increase from 4% to 80% of NPD moors with positive cases. Biometric data from 670 shot individuals from 5 Pennine moors demonstrated no significant different in wing length between infected and healthy individuals, but infected individuals were between 5-7% lighter when infected with cryptosporidiosis.	2	(-)
Baines *et al.* (2018)	AE-B	England	Driven shooting	This study measured the potential impacts of cryptosporidiosis in red grouse and identified negative impacts of disease on six-month survival rates and concluded by recognising that as the disease was associated with captive-bred birds kept at high densities, reducing the density of grouse may need to be considered.	2	(-)

Baines *et al.* (2019)	AE-AS	UK wide	Driven shooting	This study examined whether anthelmintics should be administered routinely on grouse moors. It highlighted that anti-worming drugs were being administered to red grouse regardless of parasitic burdens. It demonstrated that the removal of medicated grit led to significant increases in parasitic burdens on three of the eight moors studied, and treatment was subsequently resumed (as well on an additional fourth moor where the parasitic burden in grouse was still very low). On the remaining four moors studied, however, T. tenuis occurrence did not increase significantly, which highlighted that routine applications on most grouse moors may often be unnecessary. However, across four moors, breeding success was 16% lower when medicated grit was removed suggesting potential repercussions of removing medication, which would need to be offset against the potential risks of over-medicating.	2	(+)
Baines *et al.* (2020)	AE-AS	England	Driven shooting	This study used data from 45,914 red grouse shot on 10 moors in northern England between 2013 and 2018 which were visually screened for signs of respiratory cryptosporidiosis. Signs of infection were reported from grouse on half of all grouse moors in northern England. Respiratory cryptosporidiosis varied with age, being twice as common in juveniles (4.5%) as in adult birds (2.4%). Birds shot later in the season were also more likely to have the disease than those killed earlier. Incidence was highest in naïve juveniles that have previously not been exposed to infection, with prevalence dropping as birds develop immunity. The study found no evidence of increased prevalence over time. Despite fears, the study did not identify escalation of the disease, which could cause increased mortality and lowered productivity and impact on the economic viability of shoots.	2	(+)

British Mountaineering Council (N.D.)	PE	UK wide	Climbing / bouldering	This policy brief identified 11 principles developed by the British Mountaineering Council to mitigate the impacts of climbing on wildlife and habitats.	3	(-)
Brown *et al.* (2013)	AE-B	England	Driven shooting	The study examined ten rivers across the north of England between March 2010 and October 2011, five from drained burned catchments and five from unburned catchments. There were significant effects of burning, season and their interaction on river macroinvertebrate communities.	2	(++)
Bryan (2002)	AE-SS	Scotland	Camping / wild camping	This study examined the impact of human sanitation on water quality in montane environments with particular reference to recent developments likely to increase this type of pollution in part of the Cairngorms National Nature Reserve now owned by the National Trust for Scotland.	3	(-)
Buchanan *et al.* (2017)	AE-B	UK wide	Driven shooting	This study used hierarchical partitioning to assess the absolute and relative importance of climate, topography, soil, landscape management (wider scale habitat configuration of forestry and agriculture) and site-based management (indices of predator control, and vegetation characteristics) in determining the abundance of a suite of upland birds in four regions of the UK. An index of predator control was positively correlated with the abundance of Red Grouse and two waders. Vegetation characteristics (composition and structure) were, together, strong correlates of the abundance of passerine species. Vegetation characteristics were as important as indices of predator control for waders and grouse. The importance of regional effects, physical characteristics and variables relating to management suggests targeting site-based management (such as predator control or vegetation management) to the areas where physical characteristics are most favourable.	2	(+)
Caravaggi *et al.* (2019)	AE-B	Northern Ireland	Recreation (general)	This study investigated landscape-scale associations between habitat composition and Hen Harrier territory site	2	(-)

				selection. It focused on the influence of habitat and climate on breeding success, based on spatial analysis and data from national breeding surveys in 2010 and 2015. The results suggest that Hen Harrier breeding success is compromised by the effects of climate, landscape composition and management. The study concluded that the effective conservation of Hen Harriers in Ireland is dependent on landscape-scale initiatives.		
Cavan *et al.* (2006)	AE-B	England	Recreation (general), barbecuing	This study used two case studies (Peak District National Park and Lake District National Park) to examine the impacts of climate change and visitor pressure on protected areas in upland landscapes. The study used both expert opinion (through risk workshops) and climate change projections. This research highlighted the need for good quality data and improved monitoring of people and the environment for effective resource management, especially in response to climate change.	4	(-)
Clutterbuck (2020)	AE-B	UK wide	Motorised vehicles (off-road / 4x4 driving, scrambler / trail biking)	In this study, surfaced and unsurfaced vehicular tracks, footpaths and land cover in approximately 5% sample of mainland British uplands (1910 km^2) were mapped using aerial imagery from between 2007 and 2016. An information theory approach was used to identify models that best predicted the presence and extent of surfaced tracks.	2	(++)
Coldwell *et al.* (2012)	AE-AS	England	Driven shooting	This study reports the findings of veterinary analysis of wild red grouse caught and tested for cryptosporidiosis because they were exhibiting visible signs of infection. The first positive cases of severe cryptosporidiosis infection in wild red grouse were confirmed in 2010 for grouse from an estate in Northumberland, and then later detected on an estate in County Durham in 2011 and on a different estate in Northumberland in 2012. This study did not assess wider implications for the health of the grouse other than it was assumed morbidity associated with infection was low.	3	(+)

Cox *et al*. (2010)	AE-AS	England	Driven shooting	This study explored whether anthelmintic application affected the likelihood of resistance in *Trichostrongylus tenuis* populations (a parasitic nematode affecting red grouse) found in grouse faeces on 12 moors in Northern England. The study demonstrated that the provision of anthelmintics to red grouse had no effect on the potential for anthelmintic resistance. However, for two of the 12 samples, there were *T. tenuis* survivors, which suggested that increased resistance might be possible in *T. tenuis*.	2	(+)
Day *et al.* (2018)	PE	England	Recreation (general), dog-walking	This report, compiled by academics from the South West Partnership for Environmental and Economic Prosperity (SWEEP) project, identified both how the expanding population of Dartmoor will benefit from the National Park as a recreational resource and how the pressure of the additional visits coming from those new residents will impact the National Park's environment.	5	(-)
Denny and Latham-Green (2020)	PE	England	Driven shooting, walked-up shooting / hunting	This report was the output of a research project that identified the economic and social circumstances of communities in moorland areas where grouse shooting takes place and compared them with UK national data sets and other upland areas where grouse shooting is not practised. Data were collected between April and June 2020 from 644 people, 61 interviewees and 583 survey respondents. This study suggested that the financial value of the social impacts associated with driven grouse shooting are potentially significant, due to the cost-savings to the taxpayer in avoiding poor mental health and maintaining physical health.	2	(-)
Douglas *et al.* (2014)	AE-B	England and Scotland	Driven shooting	Using resurveys of the rapidly declining Eurasian curlew, this study investigated whether upland land use predicts low nesting success and population decline. The study found that upland land use is associated with curlew declines. The removal of isolated woodland plantations from otherwise unforested landscapes may help reduce predation pressure	2	(++)

				across a range of systems including moorland. However, direct predator control may also be important to conserve ground-nesting birds in these landscapes, for example, where moorland management and forestry coexist as major land uses. The study suggested that predator control may also mitigate climate change effects by enhancing wader productivity, particularly where climate effects coincide with changing land use.		
Douglas *et al.* (2015)	AE-AS	UK wide	Driven shooting	Using remotely sensed data, this study mapped burning for gamebird management across c.45000 km^2 of the UK. Burning occurred across 8,551 1km squares; a third of the burned squares in Scotland and England were on peat ≥0.5 m in depth, and the proportion of moorland burned within squares peaked at peat depths of 1–2 m.	2	(++)
Elston *et al.* (2014)	AE-B	England	Driven shooting	This study worked with conservation and moorland management interests to model the potential use of a quota system to address the long-standing conflict arising from hen harrier predation on red grouse. The model results quantified the extent to which high densities of harriers pose challenges for grouse management. At harrier densities of or below 0.025 km^2, harrier impacts were predicted to reduce autumn grouse densities by <10%, suggesting that a quota scheme could theoretically support coexistence between grouse shooting and harrier conservation.	5	(++)
Faber Maunsell (2009)	PE	England	Recreation (general)	This research report was produced by a consultancy to monitor a research programme and obtain market information on the public use of open-access land mapped under the CRoW Act 2000.	3	(-)
Finney et al (2005)	AE-B	England	Hiking/ walking	This study empirically tested the potential for hikers to disturb breeding golden plovers. The area around the Pennine Way in the Peak District that was avoided by breeding golden plovers fell from 200 m before the footpath was resurfaced to just 50 m following the resurfacing work.	2	(+)

				Golden plovers were 24% less likely to occupy areas within 50 m of the footpath at weekends but did not appear to avoid areas close to the footpath on weekdays. These changes occurred despite a twofold increase in the number of people visiting the Snake Summit study site over the same period.		
Fletcher *et al.* (2005)	AE-AS	England	Recreation (general)	Through a case study of 15 sites in Upper Teesdale, this study demonstrated that increased levels of experimental disturbance during incubation did not reduce Lapwing clutch survival whereas nesting in pastures with black-head gull abundance did. However, the authors noted that further studies were needed to test higher levels of disturbance (the high disturbance threshold tested in the study was relatively low) and only hatching success was investigated.	2	(+)
Fletcher *et al.* (2010)	AE-AS	England	Driven shooting	This study examined the influence of predator control on the abundance and breeding success of seven ground-nesting birds on a driven grouse moor in northern England. Results demonstrated that reductions in foxes and crows led to an average threefold increase in breeding success of lapwing, golden plover, curlew, red grouse and meadow pipit. These results had population effects and subsequent increases in breeding numbers (≥14% per annum) of lapwing, curlew, golden plover and red grouse, all of which declined in the absence of predator control (≥17% per annum). The study concluded that resources could be better directed towards predator control in upland areas.	2	(+)
Forrester and Stott (2016)	AE-SS	Scotland	Recreation (general), skiing / snow sports	This study established the spatial distribution of stream water faecal coliform concentrations in specific winter recreation areas in the Northern Corries of the Cairngorm Mountains, Scotland. A total of 207 water samples were collected from 10 sites during two winter seasons (2007–2009). Results provided data on the level of faecal bacteria in selected Scottish mountain streams, whilst also providing	2	(+)

				comparative benchmark data for similar studies proposed in other UK upland recreational hotspots.		
Francksen *et al.* (2019)	AE-AS	Scotland	Driven shooting	This study estimated the common buzzard diet on a Scottish grouse moor using buzzard abundance in bioenergetics and consumption models. This was then compared with estimates of grouse abundance to assess the potential impact of buzzards under a range of scenarios. Results suggested that during breeding seasons, buzzards consumed 5–11% of adult grouse present in April (22–67% of estimated adult mortality) and 2–5% of chicks that hatched (3–9% of estimated chick mortality). During non-breeding seasons, buzzards consumed 7–11% of grouse present at the start of August (14–33% of estimated grouse mortality). The study concluded that buzzard consumption of grouse had the potential to lead to non-trivial economic losses to grouse managers, but only if buzzards predated the grouse they ate, and if grouse mortality was additive to other causes. Caution does need to be noted when considering the generalisability of results, however, as the study observed that raptor diet can vary both temporally and spatially in relation to habitat, prey availability and local conditions.	2	(-)
Friends of the Lake District (2021)	PE	England	Recreation (general)	This research report explored littering and related anti-social behaviours in the Lake District National Park.	3	(-)
Gilbert *et al.* (2001)	AE-AS	Scotland	Driven shooting	This study modelled (using empirical data to test the model) the persistence of the Louping ill virus (LIV) in a three-host community: red deer, mountain hare and red grouse. The results showed that LIV was less likely to persist in two host communities - without mountain hare. Furthermore, LIV was not supported when deer levels were very high, or very low but moderate levels meant LIV persisted. Where red deer were absent, LIV was not supported when hare levels dropped very low, but even without grouse (i.e., one host	5	(+)

				community), LIV persisted with a hare density of 6 km^2 and above. In a three-way host community, LIV almost always persisted unless the hare or deer were entirely removed. When deer density was 5 km^2 or higher, LIV persisted. These results highlight that removing one vector (e.g., hare) will not eradicate LIV unless all the potential hosts are accounted for.		
Gordon *et al.* (2002)	AE-B	Scotland	Hiking / walking, climbing / bouldering, skiing / snow sports	This study recognises the characteristics of specific vegetation types (associated with geological features) that are highly sensitive to trampling; summit moss heaths, blanket bog, moss-dominated snow beds, wind-clipped dwarf shrub heath, springs and flushes, whereas wet heaths and snow-bed grasslands are moderate and low sensitivity respective.	5	(-)
Gosal *et al.* (2021)	AE-B	England	Recreation (general)	This study demonstrated a method to map on-site visitation by latent groups of visitors based on their environmental awareness of on-site issues. On-site surveys and participatory mapping were used to collect data on environmental awareness of birds nesting and spatial visitation patterns in an upland moor in northern England. Visitors were segmented into 'aware' and 'ambiguous' groups and their potential spatial visitation patterns were mapped. The results demonstrated the ability to uncover groups of users by environmental awareness and map their potential visitation across a site using a variety of on-site predictors.	2	(+)
Grieve (2001)	AE-SS	Scotland	Recreation (general)	This study explored human impacts on soil properties and concluded that human trampling, while highly localised, affects sensitive mountain soils in popular areas, leading to the loss of surface organic horizons and therefore, carbon storage. The future impacts of human activities on the soil may be exacerbated by changing climate, and the need to monitor and predict these will not diminish.	2	(-)

Gunn *et al.* (2000)	AE-B	England	Caving	The study discussed the potential impacts of caving on invertebrate communities in caves but did not empirically test these. Potential impacts included increased CO_2 from human respiration, light pollution and increased temperatures from lighting, artificial ventilation changing chemical and physical conditions in caves.	3	(-)
Hanley *et al.* (2002)	AE-SS	Scotland	Climbing / bouldering	This study considered alternative means of rationing access to outdoor recreation areas, focussing on rock-climbing sites in Scotland. They used a repeated nested multinomial logit model to predict the impacts on welfare and trips of two alternative rationing mechanisms currently being considered by resource managers and found that a 2 h increase in walk-in time in the Cairngorms reduces predicted visits by 44%, with knock-on effects being felt at other, substitute sites.	5	(+)
Hanley *et al.* (2010)	AE-B	Scotland	Driven shooting	This study explored public attitudes and willingness to pay (WTP) for different conservation measures in upland settings in Scotland. Overall, people are willing to pay for a change in the current management situation but are rather indifferent as to which policy option is implemented or how increases in the populations of the birds are achieved. Hunters are willing to pay substantially less for the proposed population increases of hen harriers and golden eagles than non-hunters. In the case of hen harriers, the hunters' WTPs are approx. £11 and £16, while for non-hunters the implicit prices are £44 and £53 respectively. Conservation efforts for the golden eagle were more favoured than for the hen harrier.	1	(-)
Hardiman *et al.* (2017)	AE-B	No region	Hiking / walking, mountain biking / cycling	This study investigated the effect of seed attachment propensity and transport rate on boot soles and bike tires by experimenting with beads in a controlled condition. The study found that the % attachment rate on boot soles was much lower overall than previously reported, but that boot	2	(+)

				soles had a higher propensity for seed attachment than bike tires in almost all conditions.		
Harrison *et al.* (2001)	AE-B	Scotland	Skiing / snow sports, climbing / bouldering	This study looked at the changes in the duration of snow cover in Scotland during the latter part of the 20th century. There was evidence that there had been a significant reduction in the duration of snow cover since the late 1970s and that this had a detectable effect on a range of socio-economic activities including skiing and other snow sports.	2	(+)
Hesford et al (2019)	AE-B	Scotland	Driven shooting, walked-up shooting / hunting	This study used mountain hare data collected during red grouse counts in Scotland, to consider spatial and temporal variation in annual mountain hare indices of spring abundance. The study explored the impacts in relation to different grouse management intensities, classified as either 'Driven' (driven grouse shooting), 'Walked-up' (walked-up shooting) or 'Not-shot' (where there was no grouse shooting interest). Trends in mountain hare abundance indices varied with region and grouse management intensity. Hare indices were higher and relatively stable on moors where driven grouse shooting was practised relative to lower indices and declines on moors where grouse were either walked-up or not shot.	2	(+)
Hesford et al (2020)	AE-B	Scotland	Driven shooting, walked-up shooting / hunting	This study investigated the distribution of mountain hares in Scotland by conducting questionnaire surveys in 1995/1996 and 2006/2007 to assess the 2016/2017 distribution and hunting records of mountain hares in Scotland. Results demonstrated range contractions in the south, compared with a static distribution in north-east Scotland and an expanding distribution in the north-west. Although the study found that the number of hares being killed had increased markedly, it concluded that recent range contraction could be attributed to factors other than culling, such as changes in habitat and management.	2	(+)

Holland *et al.* (2011)	AE-B	UK wide	Recreation (general)	This study provided an examination of relationships between indicators of riverine water and associated habitat quality, freshwater biodiversity, three terrestrial ecosystem services, and terrestrial biodiversity across England and Wales. The results indicate strong associations between the indicators of freshwater services. However, a comparison of these indicators of freshwater services with other ecosystem services (carbon storage, agricultural production, recreation) and biodiversity of species of conservation concern in the surrounding terrestrial landscape shows no clear relationships.	2	(-)
Hornigold *et al.* (2016)	AE-B	England	Recreation (general)	This study assessed the likelihood of recreation in different habitat types based on high nature conservation value (using SSSI as a proxy). Models were based on a three-year national household survey providing spatially-referenced recreational visits to the natural environment. Site characteristics including land cover were compared between these observed visit sites (n = 31,502) and randomly chosen control sites (n = 63,000). Recreationists preferred 'areas of coast', 'freshwater', 'broadleaved woodland' and 'higher densities of footpaths' and avoided areas such as 'arable', 'coniferous woodland' and 'lowland heath'.	1	(+)
Irvine *et al.* (2014)	AE-B	Scotland	Driven shooting	This study reported on an experiment assessing the effect of ticks on red grouse productivity and chick growth in relation to other causes of poor recruitment at two sites in the Scottish uplands during 2005. The results indicated that in the case study sites, predation may have a more important impact on grouse population dynamics than ticks and tick-borne disease.	2	(+)
Jayakody *et al.* (2011)	AE-B	Scotland	Hiking / walking	This study analysed faecal samples of red deer from three habitat types (grassland, heather moorland and woodland) collected at sites close to a busy track (disturbed) and at a distance from it (less disturbed) in a case study in Scotland.	2	(+)

				The findings demonstrated that disturbance effects from hikers may affect the foraging behaviour of red deer by reducing the number of beneficial grasses in their diet.		
Johnstone and Markandya (2006)	AE-B	England	Fishing	This study presented new welfare measures for marginal changes in river quality in selected English rivers by using surveys distributed to anglers to build models. The model results showed that higher flow rates, biological quality and nutrient pollution levels affect site choice and influence the likelihood of a fishing trip. Consumer surplus values per trip for a 10% change in river attributes range from £0.04 to £3.93 (2001) depending on the attribute.	5	(-)
Kincey and Challis (2010)	AE-AS	Wales	Hiking / walking, motorised vehicles (off-road / 4x4 driving, scrambler / trail biking)	This study is methodological in approach, exploring the potential to use lidar data to analyse the extent of footpath erosion in the Brecon Beacons. Analysis recorded 559 discrete erosion features distributed across the entire study area, representing a total length of features in excess of 46.8 km in a 3.8 km^2 site. Results demonstrated that erosion was clearly concentrated in proximity to established routes through the landscape, e.g., small linear erosion features parallel to the main routes, often on bends in the track. The varying nature of the severity of the erosion across the study area was largely explained by the concentration of visitor pressure in particular areas (i.e., track intersections) or the highly erosive nature of certain land-use practices such as the illegal use of motorised vehicles. Damage to species such as golden plover and rare plants such as the scarce bog sedge were identified.	2	(+)
Knipe *et al.* (2013)	AE-B	Scotland	Driven shooting	This study tested whether reproduction and juvenile recruitment of mountain hare changed in response to altered population densities when harvesting occurs on red grouse estates. The results demonstrated a significant negative correlation between population density and the proportion of juveniles recruited into the breeding population, particularly female hares. The study suggested	2	(-)

				that harvested populations have the potential for compensatory juvenile recruitment, however a conclusion of the study was that if the number of individuals harvested exceeded the upper limits of compensatory population growth, overexploitation and population decline could occur, and close monitoring of harvesting rates was needed. To avoid this, the study recommended that harvesting rates needed to be accurately estimated to avoid the risk of overharvesting.		
Langston *et al.* (2007)	AE-B	England	Hiking/ walking, dog walking	This study investigated the mechanisms and effects of recreational disturbance on breeding nightjars on lowland heaths in Dorset. The results showed that nightjar nests closer to footpaths were more prone to failure across all sites. The median distance from the nearest path for unsuccessful nests as 45 m and for successful nests was 150 m (p = 0.002). The effect of disturbance by dogs was less clear, partly masked by a more successful breeding year. The biggest cause of nest failure is flushing, which left eggs open to predation, usually by corvids. Dogs were found to be flushing agents, but not enough data was captured to allow significance to be tested.	2	(+)
Laurenson *et al.* (2003)	AE-AS	Scotland	Driven shooting	This study examined the role of hares as reservoirs of the louping ill virus (LIV) by reducing hare density on one site to <1 per 1 km^2 and measuring the change in tick burdens, LIV and grouse abundance as hare numbers reduced. Results demonstrated that the reduction in hare populations caused a significant reduction in the incidence of LIV and that when LIV reduced, the number of chicks produced per adult female grouse at the treatment site increased relative to the control site (p < 0·05). Despite these findings, the results also demonstrated that there was no significant change in the relative grouse density.	2	(+)
Leyland (2016)	PE	England	Climbing / bouldering	This report was commissioned by the British Mountaineering Council (BMC) to look at the use of access	3	(-)

				restrictions during the ring ouzel breeding season in the Peak District (specifically the Eastern Edges). Although the quantitative results involved too small numbers to be tested for significance, they suggested that using signage to indicate to mountain/rock climbers that nests were present to try to reduce disturbance had a positive effect on breeding success, but that it did not entirely prevent disturbance or nest failure. The report also highlighted additional issues associated with signage, including the potential risk that signage can cause crowding close to a nest, which may cause disturbance. Recommendations about appropriate signage practice were included.		
Leyland (2021)	PE	England	Climbing / bouldering	This report presented the findings of a survey of breeding ring ouzel in parts of the Peak District in 2021 that are popular for climbing and bouldering, compared with findings from a 2016 survey. The report highlighted that number of breeding pairs had reduced since 2016, although of the pairs that did breed, productivity was generally high. The survey also highlighted that nests on popular climbing buttresses on Stanage successfully fledged, which the report suggests may have been related to signage erected to reduce disturbance. The report highlighted that nest failures were all judged to be caused by predation, and that most failures had occurred in areas where predator control was implemented, compared with more successful nests on land where predators were not culled.	3	(-)
Littlewood *et al.* (2019)	AE-B	UK wide	Driven shooting	This study measured the potential influence of two aspects of grouse moor management, muirburn and predator control on the population of red grouse, three ground-nesting waders, three passerines and 'birds of prey' (measuring several raptors as one category). Results demonstrated that no significant relationship was found between burning and the abundance of any of the species. Predator control was found to be beneficial for all the ground-nesting birds,	2	(+)

				although, for the three waders, this was saturated (i.e., benefits did not increase with intensity beyond a certain threshold). No significant effects on the abundance of the other bird species (including raptors) were found that directly relating to grouse moor management but other variables (e.g., woodland cover) did have some effect. Concluding remarks suggested cessation of driven grouse moors could impact ground-nesting birds if predator control was not continued, but only low-level may be required.		
Lowe *et al.* (2014)	AE-B	England	Recreation (general)	This study compared the potential for recreational disturbance on the habitat use and reproductive success of European nightjar populations over 10 years on a lowland site in Nottinghamshire. The results showed that the distribution of adult nightjars changed significantly over the 10-year period. By 2010, nightjar density and the number of breeding pairs were significantly lower in the north (disturbed) than in the south (less disturbed) section. However, the study found no significant difference in individual reproductive success between the two sections, but of the few nightjars that remained in the north section, breeding was as successful as the nests in the south.	2	(+)
Lowney (2011)	AE-B	England	Mountain biking / cycling	This study tested the effects of two mountain bike trails within Whinlatter Forest, Cumbria on the abundance of red squirrel. The study found that habitat type was the principal determinant of red squirrel abundance, with a significant correlation identified between squirrel density and larch plantations. Although the density of red squirrel was found to be much higher in less disturbed areas than the areas with mountain-bike trails, this was linked to habitat preferences rather than recreational disturbance effects. The selection of mountain-bike trails that avoided the red squirrel's preferred habitat was proposed as a key reason for minimal recreational disturbance in this study.	2	(+)

Ludwig *et al.* (2017)	AE-B	Scotland	Driven shooting	This study compared changes in the population of red grouse and hen harrier over periods of grouse moor management (1992-1999 and 2008-2015) versus an unmanaged period (2000-2007). During periods of management, the abundance of red grouse and hen harrier increased, whereas, during the period of no/lower intensity management, the numbers of both species decreased, whilst the abundance of their perceived key predators; red fox and carrion crow increased. The study concluded that both grouse and hen harriers can benefit from grouse moor management, provided that hen harriers are not illegally persecuted.	2	(+)
Ludwig *et al.* (2018)	AE-B	Scotland	Driven shooting	This study explored whether supplementary feeding of hen harriers could reduce predation of red grouse chicks. The results demonstrated that under supplementary feeding, hen harriers provisioned only approximately 1.7% of annual grouse chick production whereas, without diversionary feeding, the provision of grouse chicks was predicted to have been between 15-29% of red grouse production based on previous studies. The study concluded that diversionary feeding may help to reduce conflict between hen harrier conservation and grouse moor management, but only if overall grouse productivity was thereby maintained or increased.	2	(+)
Ludwig *et al.* (2020)	AE-B	Scotland	Driven shooting	This study explored the potential for management on Langholm moor, a driven grouse estate, to benefit the abundance and breeding success of raven and four different raptor species in a before-and-after study, covering on/off periods of grouse moor management. Results showed that ground-nesting raptors (hen harrier and merlin) increased during periods of grouse moor management and had a higher proportion of successful nesting attempts. No effects were detected for buzzard, peregrine falcon or raven. The study concluded that where illegal persecution is absent,	2	(+)

				grouse moors can be beneficial for ground-nesting raptors, but this trend is absent from most grouse moors due to illegal persecution.		
MacKay and Prager (2021)	AE-B	Scotland	Hiking / walking	The study explored landowners' attitudes to path maintenance and upkeep through semi-structured interviews in Cairngorms National Park. Private land managers almost unanimously shared a view that footpath maintenance was not their responsibility although most were prepared to engage in path maintenance to some degree, with funding being the biggest barrier. The study identified six behaviour types related to landowner perceptions towards path management on an active to passive spectrum.	4	(+)
Mallord *et al.* (2007)	AE-B	England	Recreation (general)	This study explored the population effects of different levels of recreation on a ground-nesting passerine, woodlark on 16 lowland Dorset heaths. Results indicated that across heaths, woodlark density (per hectare of suitable habitat) was lower on sites with higher levels of disturbance. Within heaths with recreational access, the probability of suitable habitat being colonized was lower in those areas with greater disturbance and was reduced to below 50% at around eight disturbance events per hour. There was no relationship between disturbance and daily nest survival rates.	2	(+)
Martin (2018)	PE	England	Recreation (general)	This study reports the findings of a breeding bird survey on Darwen and Turton Moors (Lancashire), which was commissioned by new landowners. Results demonstrated the presence of breeding territories for several important upland breeding bird species, including curlew, snipe and long and short-eared owls as well as a displaying pair of hen harrier. However, the report also described the absence of formerly breeding species including grey partridge, merlin, redshank, ring ouzel, twite, whinchat and declines in	3	(-)

				the breeding territories and/or abundance of lapwing, linnet, stonechat and wheatear.		
Martin (2019)	PE	England	Recreation (general)	This study reports the findings of a breeding bird survey on Winter Hill (Lancashire), which was commissioned following a major fire in 2018, started by a recreational barbecue. Results demonstrated the presence of breeding territories for several important upland breeding bird species. This included ground nesting waders; curlew, dunlin, golden plover, lapwing, snipe, passerines; linnet, meadow pipit, reed bunting, skylark and other rarities, e.g., calling cuckoos. However, the report also described the absence of formerly breeding species including ring ouzel, stonechat, twite, whinchat, and birds of prey including kestrel, merlin and long-eared owl.	3	(-)
McDonald *et al.* (2008)	AE-SS	Scotland	Camping / wild camping	This study analysed the impact of human waste on water quality caused by recreational visits to a Scottish National Park. Results from over 480 spot samples, from 59 sites in Cairngorms National Park demonstrated that over 75% of samples tested positive for *Escherichia coli* (E. coli) and 85% for total coliforms. Concentrations displayed both temporal and spatial patterns, with the largest values occurring over the summer months and particularly high during weekends at sites frequented by visitors, either for 'wild' camping or day visits, or where water was drawn from the river for drinking. Overall, the spatial and temporal variations in bacterial concentrations suggested a relationship between visitor numbers and certain types of recreation, in particular wild camping.	2	(+)
McEvoy *et al.* (2008)	AE-B	England	Recreation (general)	This study presents localised predictions of climate change for the uplands of North West England (the Lake District and Peak District). It then draws from a series of 'risk' workshops held with practitioners to describe some of the	4	(-)

				ways climate change and recreation may combine to impact habitats and ecosystem processes in the future.		
McHugh (2007)	AE-AS	England and Wales	Recreation (general)	This study assessed the scale and causes of change in erosion in upland areas of England and Wales through repeat monitoring of upland sites. Results reported that human influences accounted for the exposure of 233 m^2 of bare soil on 19 sites, or 12.3 m^2 per site (compared with a mean of 6.1 m^2 of erosion attributed to grazers). Erosion caused by vehicles and walkers was most evident, with the mean eroded area due to vehicles more than five times greater than the average of 3 m^2 per site attributed to walkers. Overall, walkers and rabbits ranked lowest (behind sheep grazing, vehicles, cattle and drains). The study reflected by concluding that climate change may exacerbate erosion risk from walkers by increasing recreation popularity and extreme weather.	2	(+)
Murgatroyd *et al.* (2019)	AE-AS	UK wide	Driven shooting	This study tested whether deaths or disappearances of hen harrier were associated with areas managed for red grouse shooting. Results drawn from 58 satellite-tracked hen harriers showed high rates of unexpected tag failure and low first year survival compared to other harrier populations outside of grouse moors. Furthermore, the likelihood of harriers dying or disappearing increased as their use of grouse moors increased. Similarly, at the landscape scale, satellite fixes from the last week of life were distributed disproportionately on grouse moors in comparison to the overall use of such areas. The study concluded hen harriers in Britain suffer elevated levels of mortality on grouse moors, which is most likely the result of illegal killing.	2	(++)
Murison (2002)	AE-SS	England	Recreation (general), hiking / walking, dog walking	This study presents the findings of research undertaken by English Nature, which compared the breeding success of nightjars on several sites in Dorset with varying levels of public access. Sites with no public access showed significantly higher breeding success than sites with open	2	(+)

				access. On sites with public access, territory centres and nest sites occurred at a distance from urban development. In addition, nests that did succeed were located at a distance from paths. The probability of nest survival was 12%, with the key cause of nest loss being predation. Results suggested a link between predation and recreational disturbance.		
Murison *et al.* (2007)	AE-B	England	Recreation (general)	This study tested the effects of recreational disturbance in different open habitat types on the breeding success of Dartford warbler. Breeding productivity was significantly affected by the timing of breeding in all habitats, but disturbance only appeared to have a significant impact on the productivity of birds in heather territories. Disturbance events in heather territories delayed breeding pairs for up to 6 weeks. This significantly decreased both the number of successful broods raised and the average number of chicks fledged per pair. Nests situated close to territory boundaries in heather territories, with high numbers of disturbance events, were more likely to fail outright.	2	(+)
Mustin *et al.* (2017)	AE-B	Scotland	Driven shooting, walked-up shooting / hunting	This study sought to explore the different approaches to the shooting industry in Scotland and their implications for economic benefits. The study used semi-structured interviews to construct a typology of management models based on three categories - commercial, non-commercial and diversified. Although there was no assessment of the influence on upland ecosystems directly, it highlighted the different factors influencing estate management and types of recreational hunting. The study concluded that there was little variation between the three models in terms of spending and employment directly related to shooting activities, despite them potentially having very different environmental and ecological impacts.	4	(+)
Natural England, 2019	PE	England	Recreation (general)	This report provided the final year summary for the national survey 'Monitor Engagement with the Natural Environment'	1	(+)

				(MENE), a national survey that ran for 10 years from 2009 to 2019. The survey was conducted across the whole of England and the majority of the results are therefore not relevant to this study as they did not distinguish between different ecosystems. A section of the survey did investigate where people visited nature in England including the category of 'hill, mountain or moor'. These results, which specifically related to upland environments were included as relevant to this evidence review.		
Natural England, 2021	PE	England	Recreation (general)	This report provided the summary of the 'People and Nature Survey', a national survey that sampled up to 25,000 adults in England on a continuous basis over 2020/2021. The survey was launched in April 2020 and built on the Monitor of Engagement with the Natural Environment (MENE) survey that ran from 2009 to 2019. As with MENE, the survey was conducted across the whole of England and the majority of the results were therefore not relevant to this study as they did not distinguish between different ecosystems. A section of the survey did investigate where people visit nature in England including the category of 'hill, mountain or moor'. These results, which specifically related to upland environments were included as relevant to this evidence review. The 'People and Nature' survey also demonstrated how the COVID-19 pandemic changed people's access to nature in England, which was considered relevant to this evidence review.	1	(-)
Newborn and Foster (2002)	AE-B	England	Driven shooting	This study measured the influence of indirect applications of anthelmintics through medicated grit to control parasitic worms in red grouse. The study compared the effects on grouse health (worm burdens), productivity (eggs laid) and breeding success (chick survival) between grouse fed the medicated and plain grit and between years. Results demonstrated significantly lower worm burdens in adult grouse in treated areas. Although productivity was	2	(+)

				unaffected, chick survival was significantly greater in the medicated grit areas, with hens that had access to anthelmintic drugs rearing more than twice as many chicks as control hens. The study advocated the economic benefits of using anthelmintics as a low-cost treatment increasing grouse productivity but did not consider any environmental implications on upland ecosystems.		
Newey *et al.* (2005)	AE-B	Scotland	Driven shooting	This study explored the potential for parasites to be causing cyclical population crashes in mountain hare, a protected species. The study examined the parasitic loads and overall health of hares shot on grouse estates and discussed the implications for the species' conservation. Although the empirical findings of this study were not directly relevant to this evidence review, the discussion of this study suggested that parasitic overload in hare populations, which may explain the cyclical nature of populations, might be explained by grouse moor management. Grouse moor management, particularly predator control, was considered a likely factor in creating artificially high mountain hare populations, which may then result in episodic periods of parasite-related mortality. The discussion suggested that parasites, as a density-dependent regulator of hare populations, may mean ill health in wild species was resulting from intensively managed grouse moors.	2	(-)
Newey *et al.* (2016)	AE-AS	Scotland	Driven shooting, walked-up shooting / hunting	This study explored how different land management approaches in Scotland affected the composition, diversity and species richness of bird species in Scotland, looking at land managed for grouse shooting, deer stalking, sheep grazing and conservation. The results indicated that, in relation to the dominant management type, the composition of bird species varied but measures of diversity and species richness did not. Intensive management for grouse shooting affected the occurrence, absolute and relative abundance of bird species, while other less intensive forms of land	2	(+)

				management appeared to only affect the relative abundance of species. The study concludes that multiple land management approaches may create optimal conditions for biodiversity conservation.		
Nota *et al.* (2019)	AE-AS	UK wide	Driven shooting	This study explored the diet of hen harriers across driven moors, walked-up moors and unmanaged moors. Although the study did not have direct empirical evidence of the effect of grouse moor management, results showed that hen harrier diets were significantly less diverse on driven grouse moors than on walked-up or unmanaged moors. The study proposed that if the high proportion of red grouse in hen harrier diets on driven grouse moors was due to an over-abundance of red grouse, reducing the density may alleviate predation pressure on grouse. Conversely, the study also suggested that the results could indicate that the number of prey species available to hen harriers on driven grouse moors was limited because of intensive management, forcing predation of red grouse. In this situation, the study highlighted that the conservation conflict surrounding driven grouse moors was likely to worsen in the future if management is further intensified.	2	(+)
Parker (2009)	AE-SS	England	Orienteering	This study researched the effect of an organised orienteering event on breeding wheatear at Titterstone Clee, Shropshire. Results demonstrated that the event had no observable effect on the breeding success of the nests within the competition area. However, four nests were abandoned in the derelict quarry used for car parking, even though this area had been selected to minimise visual intrusion and ecological disturbance. The study concluded that breeding wheatear were very tolerant of transient disturbance, but also highlighted that those involved in organising large events in rural environments should not discount the potential wildlife value (e.g., nest sites) of anthropogenic habitats.	3	(-)

Parsons *et al.* (2017)	AE-AS	England	Driven shooting	This study examined the potential for black grouse to be infected with respiratory cryptosporidiosis because of the prevalence of the disease in red grouse on driven grouse moors in similar habitats in Northern England. The study assessed the health of individuals using three sources (post-mortem, sampling of live individuals and an observational study of individuals at lek sites). The latter two methods revealed no evident signs of cryptosporidiosis but one individual in the post-mortem had a positive PCR result for *C. baileyi* although parasite infestation was not observed in the tissues. The study concluded that whilst there was no conclusive evidence that cryptosporidiosis was causing sinusitis in black grouse, the post-mortem results raised the possibility that they may be infected with the parasite. The study concluded that the risk of black grouse infection remained because of the prevalence in red grouse and that ongoing monitoring was needed.	3	(+)
Pathways Consultancy (2012)	PE	England	Hiking / walking	This study reported on the implementation of a pathway reconstruction project in the Lake District 'Fix the Fells' which was implemented between 2007-2011. The study reported significant improvements to landscape and vegetation caused by footpath restoration and the reduction in ecosystems impacts that had resulted. Although reporting was not quantified, before and after demonstration through photographs highlighted the significant reduction in ecological (and wider environmental) impacts that can result from footpath restoration in upland ecosystems, particularly those with very high visitor numbers.	3	(-)
Patton *et al.* (2010)	AE-B	Scotland	Driven shooting, walked-up shooting / hunting	This study assessed the distribution of mountain hare, identified overall changes in distribution and reported on the intensity of culling undertaken in Scotland. The study used survey data from landowners, land managers and gamekeepers, reporting 90% coverage of Scotland. Results suggested no overall change in the extent of mountain hare	2	(-)

				distribution and reported that distribution was strongly associated with grouse moors. The extent of culling (usually for tick control or sport) was reported as only 7% of total population numbers, although this was based on potentially outdated population assessments. The study did not assess hare abundance, which it recognised was necessary to monitor the impact of management and culling on this protected species.		
Pearce-Higgins *et al.* (2003)	AE-AS	England	Driven shooting	This study quantified the breeding success of golden plover on a moor managed for driven grouse shooting to develop a model that would predict factors affecting chick and adult survival. Results demonstrated that breeding success was estimated at a mean of 0.57 fledglings per pair, which was still considered quite low, particularly in the context of a grouse moor where predator control reduced predation levels. However, in the absence of predation, other factors still reduced chick survival and limited breeding success such as starvation and exposure. The study concluded that the low level of nest and chick predation at Snake Summit, Peak District, supported the hypothesis that grouse moor management can enhance golden plover breeding success, and could explain the association between the species and grouse moors but also that the importance of other (non-predator) mortality in limiting chick survival highlighted the need for practical conservation to ensure habitat and food supply.	2	(+)
Pearce-Higgins *et al.* (2007)	AE-B	England	Hiking / walking	This study compared the disturbance effect of the footpath on Snake Summit, Peak District, on the breeding success of two ground-nesting waders, golden plover and dunlin, and was also able to consider the influence of footpath resurfacing on dunlin breeding success (already undertaken for golden plover, see Finney *et al*., 2005). Results suggested that high levels of disturbance can impact habitat usage by upland waders, but only in limited circumstances	2	(++)

				where visitor pressure is very high (greater than at least 30 visitors per weekend day). However, access to such areas even for large numbers of visitors avoided negatively impacting wader reproductive performance through the provision of a well-surfaced route, as visitors were much less likely to leave the footpath and therefore disturbance was reduced.		
PLB Consulting (2008)	PE	England	Recreation (general)	This report presented the first Recreation and Access Strategy for the North York Moors National Park and addressed both topic areas – conservation and public enjoyment - in an integrated way. The purpose of this strategy was to help the Park Authority identify how it could best deliver its recreation and access objectives. The report identified key areas of influence, set out a vision and strategic objectives that attempted to balance the overarching aims of conservation and public enjoyment and used zoning to identify how different objectives could be met.	3	(-)
Ramchunder *et al.* (2013)	AE-AS	England	Driven shooting	This study examined the effects of rotational vegetation burning to assess the impacts on upland streams, specifically the physio-chemistry conditions and benthic macroinvertebrates in sites where burning occurs versus sites with no recent history of burning. In terms of water chemistry, burned catchments were characterized by higher fine particulate organic matter, suspended sediment concentration, aluminium, iron and dissolved organic carbon than unburnt catchments. In terms of aquatic biodiversity, burned catchments experienced significant reductions in benthic macroinvertebrate richness, diversity and dominance, with a lower abundance of some mayflies, stoneflies and caddisflies and an elevated abundance of some Diptera larvae.	2	(++)
Redpath *et al.* (2001)	AE-B	Scotland	Driven shooting	This study explored whether supplementary feeding of hen harriers could reduce predation of red grouse, using	2	(+)

				Langholm Moor as a case study site. Results demonstrated that across two years, hen harriers that had supplementary feeding delivered on average 0.5 grouse chicks to their nests per 100 hours, compared with 3.7 grouse chicks delivered to nests without supplementary food, although feeding some of the breeding harriers did not lead to an increase in grouse density at Langholm. The study concluded that supplementary feeding could provide a useful tool in reducing the number of grouse chicks taken by harriers, but further research was needed to identify whether reduced predation could increase grouse density.		
Redpath *et al.* (2006)	AE-AS	Scotland	Driven shooting	This study examined the influence of parasites on the breeding success, abundance and population cycles of red grouse on two moors in England and two moors in Scotland by manipulating parasite intensities in four, paired 1 km^2 study areas during cyclic population declines over 4 years. Although treatment was effective at reducing parasite intensities, improving grouse brood size and leading to higher grouse densities in both autumn and spring, the treatment did not prevent the cyclic population declines. The study concluded that another process was operating to drive the populations down and that a single trophic interaction between a parasite and its host did not explain cyclic dynamics, although it did contribute to the start of a cyclic decline.	2	(++)
Rees *et al.* (2005)	AE-B	Scotland	Hiking / walking, mountain biking / cycling, fishing, walked-up shooting / hunting	This study analysed the variation in the behaviour of wintering whooper swans, to determine whether their susceptibility to human activity changes with time, location and the type of disturbance involved. Disturbance frequency resulting from human activity was lower with increasing flock size and with increased distance to the nearest road or track. Distances that humans could approach before alerting the birds varied with the type of disturbance involved and also field characteristics. In terms of recreation types, swans	2	(+)

				were generally more tolerant of vehicles, including bicycles, than of pedestrians (particularly wildfowlers and anglers), being alerted by vehicles at much shorter distances.		
Robertson *et al.* (2001)	AE-AS	Scotland	Driven shooting	This study assessed the implications that 20th Century reductions in grouse management have had on the retention of heather moorland in the Scottish uplands. The study compared land cover changes on sites managed for grouse (between the period of 1945-1990) and on sites where grouse moor management was occurring in the 1940s but had stopped by the 1980s. Results showed that between the 1940s-1980s, the number of sites actively managed for grouse declined by 59%, whereas the total area of heather decreased by 34%. The study concluded that the retention of heather coverage in Scotland might be associated with grouse moor management but that identifying grouse moors as the cause or merely the consequence of heather retention was challenging.	2	(+)
Robertson *et al.* (2017*a*)	AE-AS	England, Scotland and Wales	Driven shooting	This study explored whether trends in the number of grouse shot on moors was explained by changes in keeper density, heather moor extent or replacement of moorland by afforestation, comparing 'bag counts' across nine British regions over four time periods (1890-1920, 1920-1950, 1950-1980 and 1980-2010). Grouse bags were consistently higher in regions of northern England than in Scotland and Wales, and declined in all nine regions except the southern Pennines from 1920 to 1950. Bags in northern England increased significantly from 1950, coinciding with increases in keeper density. In north-east Scotland and Wales, the number of grouse shot declined over the same period, coinciding with declines in keeper density and increased afforestation of moors. The study concluded that regional variation in red grouse bag counts over time may be explained by changes in land use and management	2	(+)

				intensity affecting the extent of suitable habitat and predator prevalence.		
Robertson *et al.* (2017*b*)	AE-B	England	Driven shooting	This study conducted before-and-after measures of the effects of prescribed burning on the heterogeneity of heather habitats and the effects on red grouse breeding success. Results demonstrated that pre-breeding grouse density was not related to the burning extent, but breeding success and post-breeding density were positively associated with the extent of burning on moors. Relationships between grouse and burning were similar on heath and blanket bog. Higher grouse breeding success and post-breeding density were likely to be associated with a more varied vegetation structure following burning although the effects of other aspects of grouse management were not controlled for. The study concluded that the potential benefits of burning for increasing grouse density needed to be considered carefully against any likely impacts on ecosystem services, particularly in areas of blanket peat.	2	(+)
Ruddock and Whitfield (2007)	PE	Scotland	Recreation (general)	This report explored the disturbance effects of humans on 26 'priority' bird species that breed in Scotland. Using an expert opinion survey, data was collected to produce a range of 'static' and 'active' disturbance distances for the bird species, when approached by a single pedestrian when incubating eggs and when with chicks. The results showed a diversity of opinions and diversity between species. The study highlighted that expert opinion should typically be used as a stopgap between empirical evidence and policy and that this research needed to be reinforced by empirical evidence using field studies of disturbance distances.	4	(-)
Sibbald *et al.* (2011)	AE-B	Scotland	Hiking / walking	This study used GPS collars to monitor the movements of red deer stags in a herd whose feeding grounds were close to a popular walking track in the Highlands of Scotland, comparing quieter and busier periods. Results demonstrated that the stags were consistently further away	2	(+)

				from the track and moved greater distances between grazing at busier periods (i.e., on Sundays compared with Wednesdays). The study concluded that wild animals that appear to be habituated to regular disturbance within their home territory may, nevertheless, alter their behaviour and potentially their diet composition, as a result of recreational disturbance.		
Sim *et al.* (2007)	AE-B	UK wide	Driven shooting	This study aimed to estimate the size of the UK and Isle of Man Hen Harrier breeding population in 2004 using field survey data across the species known range and to compare this with previous estimates made in 1988/89 and 1998 to demonstrate population trends. Results showed that although the overall number of hen harriers increased in the 5-year period, the number in the Southern Uplands and East Highlands of Scotland, England and Wales all reduced. The study attributed population increases in Scotland to increasing use of non-moorland habitats, such as mature conifer plantations and scrub/brash. The study concluded that declines in England and areas of Scotland show a strong association with grouse moors and proposed that continued illegal persecution arising from perceived conflicts between breeding hen harriers and driven grouse shooting may be a major cause of these regional declines.	2	(+)
Smith *et al.* (2001)	AE-B	UK wide	Driven shooting	This study examined the habitat characteristics of managed grouse moors, to determine whether changes in vegetation altered the ratio of meadow pipits, and thus hen harriers, to red grouse. Results demonstrated that red grouse and meadow pipit abundance were not correlated and preferred habitat conditions for grouse (i.e., heather) were less preferred by pipits. Additionally, the study reported a correlation between higher bird diversity and muirburn, but the study did not control for other aspects of grouse moor management, notably predator control. The study concluded that long-term increases in heather cover through muirburn	2	(+)

				on grouse moors may reduce pipit numbers and thus reduce the ratio of hen harriers to grouse.		
Sotherton *et al.* (2009)	AE-AS	UK wide	Driven shooting	This study explored the economic impacts of transitioning from driven grouse shooting to lower-intensity walked-up shooting. There was no direct assessment of the impact on species, but the socio-economic implications were highlighted, which the study suggested may result in the demise of grouse moor management altogether. The study highlighted that owing to the economic unprofitability of walked-up shooting, protected habitats and priority bird species currently found on grouse moors would be negatively affected, although this impact was not tested empirically.	3	(-)
Sport England (2021)	PE	England	Hiking / walking, climbing / bouldering	This report presented data from the Active Lives Adult Survey, undertaken between November 2020-November 2021 (and therefore included significant periods of COVID-19 restrictions). Most of the data were collected generically across all of England and therefore were not relevant to this evidence review on the uplands. However, the survey did identify that there were 3,219,800 people actively hill and mountain walking, and 135,400 people actively climbing and bouldering outdoors in England.	3	(-)
Stavi and Yizhaq (2020)	AE-B	No region	Mountain biking / cycling	This study reviewed and conceptually analysed the forces applied on single tracks used for mountain biking, and implemented mathematical modelling of these forces, for a range of climatic conditions and geographic settings. Results showed that climate, topography, surface roughness, hydrological connectivity, and paedology all helped to determine the processes of water runoff and soil erosion on mountain bike trails. Additionally, the models demonstrated how riders' behaviour determined the rate of shearing, wearing, compaction, deformation, and rutting of the track. The study concluded that the impacts of mountain	5	(-)

				biking could be reduced by applying geomorphological principles in the design of mountain bike tracks.		
Suckall *et al.* (2009)	AE-AS	England	Recreation (general)	This study explored the differences in perceptions of an upland environment (the Peak District National Park) held by people belonging to different social classes and ethnicities. Results demonstrated that belonging to a particular group (either class or ethnicity-based) influenced the decision to access 'natural' places, with 'working class' children less likely to want to visit, and ethnic groups unfamiliar with the National Park unlikely to visit. The results also suggested that barriers were not associated with a lack of means (e.g., accessibility). The results showed that groups who previously had no historic connection with a specific type of landscape, such as new immigrants to the UK, can change their opinions if they are given the opportunity to visit upland environments.	2	(+)
Summers *et al.* (2007)	AE-SS	Scotland	Recreation (general), hiking / walking, mountain biking / cycling	This study measured the distances over which capercaillies avoided woodland that was close to forest tracks in Glenmore Forest and Abernethy Forest, Scotland, which were used by recreational walkers and cyclists during autumn and winter. Results demonstrated that at all sites, the use of trees by capercaillies was lower when close to tracks. The amount of woodland effectively avoided by capercaillies ranged from 1 ha per 46 m of track to 1 ha per 82 m of track at the different sites. Given the high density of tracks at Glenmore and Abernethy Forests, the percentage of woodland avoided by capercaillies ranged from 21-41%. The study concluded that a likely explanation for the capercaillie behaviour was that human activity was causing a direct disturbance, which may be reducing their carrying capacity.	2	(++)
Tate (2021)	PE	England	Recreation (general); organised	This report provided an overview of the visitor economy in Cumbria, including the Lake District National Park and other Local Authority areas within Cumbria. The report presented	3	(-)

			events (broad)	survey data on reasons for visiting, spending, visitor perceptions of attractions and facilities as well as general attitudes towards Cumbria and the Lake District. Results demonstrated that despite the COVID-19 pandemic, there was a significant number of visitors that still spent time in Cumbria. There was a wide range of motivations for visiting, but the most prominent was because of the landscape and scenery.		
Tharme et al (2001)	AE-B	UK wide	Driven shooting	This study compared the effects of grouse moor management on the abundance of 11 upland bird species between managed grouse moors and other types of moors with similar vegetation. Results demonstrated significant differences between species; with grouse moors correlated with positive trends for densities of red grouse, golden plover, lapwing and curlew than on other moors, while meadow pipit, skylark, whinchat and carrion/hooded crow were less abundant, on grouse moors. The study concluded that it was unclear what aspects of grouse moor management caused the variation and proposed experimental manipulations of predator numbers and heather burning to test these variables.	2	(++)
Thirgood *et al.* (2000)	AE-AS	Scotland	Driven shooting	This study investigated the influence of habitat change and raptor predation on the number of grouse harvested on the Eskdale half of Langholm Moor in southern Scotland as well as the whole moor. Results showed that the grouse bags declined significantly throughout the 20th century linked to a 48% decline in heather habitats. However, continued grouse bag declines in the 1990s were then linked to increases in raptor numbers, which the study argued, suppressed cyclical upturns predicted for grouse numbers.	5	(+)
Thomas *et al.* (2009)	AE-B	England and Scotland	Driven shooting	This study investigated lead levels in the bones of red grouse shot in managed estates in Scotland and Yorkshire, England. By measuring the isotope ratios in the leg and foot bones of adult and juvenile red grouse, the study attempted	2	(+)

				to demonstrate levels and potential sources of lead. Results demonstrated that relatively few birds from Scottish moors showed high concentrations of lead. By contrast, grouse from the Yorkshire estates demonstrated a high incidence (65.8%) of bone lead > 20 µg/g. The lead ratios in the bones of these highly exposed birds were consistent with combined exposure to ingested lead gunshot and lead from galena mining in the region. The study concluded that management was needed to reduce lead contamination occurring from shot.		
Underhill-Day and Liley (2007)	AE-B	England	Hiking / walking, dog-walking	This study used visitor survey data to explore different recreational uses of lowland heaths in England and the attitudes of visitors, to reflect on the potential impacts on protected bird species and implications for heathland management. Results demonstrated different types and attitudes of users between smaller urban and suburban sites versus larger, better-known heathlands (such as Cannock Chase or the New Forest). The majority of visitors to urban and suburban lowland heaths visited sites regularly and lived nearby, with a large proportion driving to sites for dog walking. Although these visitors usually stayed on footpaths, most dogs were allowed off leads and owners considered this important. On large, regionally or nationally known rural sites, more visitors were day trippers and tourists, fewer were dog walkers, stays were for longer and their reasons for visiting differed from those of local residents.	1	(-)
Warren *et al.* (2009)	AE-B	England	Recreation (general)	This study aimed to identify the extent of black grouse winter feeding habitat in the North Pennines AONB on land recently designated as 'Open Access Land' as part of the CROW Act. A total of 52 heather moorland areas were identified, with 30 enclosed and 22 unenclosed moorlands. A total of 143 males and 249 females were recorded in the enclosed areas, at a mean density of 55±14 SE birds per	2	(-)

				km^2 whereas a total of 61 males and 114 females were recorded in the unenclosed areas, at a mean density of 11±2 SE birds per km^2. The study concluded that despite low disturbance levels, Natural England adopted a precautionary approach by excluding human access from recognised winter habitats from 1st October to 31st March inclusive.		
Warren *et al.* (2011)	AE-AS	England	Driven shooting	This study examined the extent to which threatened black grouse were accidentally shot during driven shoots (of red grouse). The study used three different data sources, although two of these relied on self-reporting. Results demonstrated that red grouse shooting does lead to black grouse deaths via direct shooting, but this is a small percentage of grouse bags and a small percentage of deaths of radio-tagged birds (<1.6%). The study did not directly state how this rate compared with natural deaths or whether this was within a normal tolerance range of mortality. The study concluded that the voluntary restraint from shooting black grouse in northern England appeared to be effective, with reported incidents of shooting infrequent.	2	(+)
Warren *et al.* (2019)	AE-AS	Scotland	Driven shooting	This 30-year study aimed to assess changes in habitat suitability for black grouse over three time periods, linked to land management regimes. The study also aimed to identify preferred habitat surrounding lek sites and predict suitable lek sites based on patch size estimates. Results demonstrated severe declines with the extinction of 72 of 103 leks over the 30-year period (although 18 new ones were established). Declines in abundance were unaffected by gamekeeper activity, the proportion of broadleaved woodland, or heath and bog but were positively correlated with acid/rough grassland. Preferred habitat at leks for the final period were acid/rough grassland in the (more occupied) SE region and heath/bog in the SW region. Higher occupation at leks on DGS estates for this time	2	(++)

				period was not clearly explained given null results for gamekeeper activity but the study suggested that predator control likely to be influencing results. The study concluded that immediate conservation is needed, specifically to maintain open habitats in upland areas.		
Watson and Moss (2004)	AE-B	Scotland	Skiing / snow sports	This 30-year study explored the impact of a ski resort in the Cairngorms on the abundance and breeding success of ptarmigan. The study was conducted as a before and after study across areas affected by the ski development and used a control site, with areas unaffected by the development. Results showed significant negative impacts on the areas close to the ski resort, with an influx of carrion crows. On the most developed area near the main car park, ptarmigan occurred at high density but then lost nests to crows, reared abnormally few broods, died flying into ski-lift wires and declined until none bred for many summers. By contrast, in another area further away from the resort where there were few or no crows, ptarmigan bred as well as in the massif's centre and showed cycles of the same amplitude as there.	2	(+)
Watson and Wilson (2018)	AE-B	Scotland	Driven shooting	This study aimed to analyse the influence of grouse moor management, particularly hare culling, on the abundance of mountain hare in Scotland. Hare population data from 1943 to 2017 was compared between land managed for grouse shooting and contiguous alpine land. Results from the long-term field counts suggested that intensification of game bird management resulted in severe, recent declines in mountain hare numbers, exacerbating longer-term declines associated with land-use change. In particular, mountain hare declines on grouse moors were notably faster after 1999, at a time when hare culling by grouse moor managers became more frequent. The study concluded that hare culling required regulation.	2	(++)

Webster *et al*. (2008)	AE-AS	England and Scotland	Driven shooting	This study explored the potential for the parasitic nematode *Trichostrongylus tenuis* to be developing resistance to the anthelmintics administered to red grouse, by sampling individuals from across 14 sites in England and Scotland and analysing the parasites for three typical types of genetic mutation associated with anthelmintic resistance. The study suggested that *T. tenuis* had not developed resistance using the three recognised mutations at the studied locations. The study recognised that there was the possibility that the resistance went undetected or that alternative resistance mechanisms exist. Alternatively, the inconsistency in the treatment regime (as wild species take in very varied amounts of grit), means that maintaining refugia for susceptible genotypes may be retarding the development of anthelmintic resistance in *T. tenuis*.	2	(-)
Whitehead and Baines (2018)	AE-AS	England	Driven shooting	This study explored the rate of peat-building species such as *Sphagnum* mosses and cotton grass following rotational burning through a long-term experiment at Moor House National Nature Reserve, North Pennines, northern England. Results demonstrated that the highest levels of peat-building species occurred in areas where fires had last burned within 3–10 years. The study concluded that by reducing the dominance of tall heather, burning increased the cover and species richness of *Sphagnum* mosses for a post-burn period of up to 10 years.	2	(+)
White *et al.* (2013)	AE-B	England	Recreation (general)	This study investigated the feelings of restoration (measured as calm, relaxed, revitalized and refreshed) recalled by individuals after recent visits to different natural environments. The study used data from 4,255 respondents drawn from Natural England's Monitoring Engagement with the Natural Environment survey (2009-2011). Although the study looked at a range of lowland habitat types that were not considered relevant to this evidence review, the results demonstrated that of rural environments, one of the most	2	(+)

				beneficial habitat types to visit was hills/ moorland/ mountains. The study concluded that the average level of restoration provided from nature visits was particularly high in upland areas, along with coastal and woodland environments.		
Whitfield *et al.* (2003)	AE-B	Scotland	Driven shooting	This study explored whether there was an association between the location of illegal poisoning of birds of prey and land used for grouse shooting in Scotland between 1981 to 2000. Results showed that poisoning events were disproportionately associated with grouse moors (i.e., areas where strip muirburn was occurring). The association between poisoning incidents in the uplands and grouse moors was stronger in the later years of the study period. This was linked, at least partly, to a decline in the illegal use of poisons away from grouse moors. There was no evidence of any temporal decline in poisoning incidents on grouse moors over the study period. The study concluded that illegal methods of predator control (including poisoning protected birds of prey) were associated with traditional field sports and highlighted the need for management action.	2	(++)
Whitfield *et al.* (2004)	AE-AS	Scotland	Driven shooting	This study sought to investigate the effect of persecution on the population dynamics of Scottish golden eagles. The study employed GIS analysis from two national censuses (1982 and 1992) and contemporary data on the distribution of poisoning incidents to examine the age of breeding pairs and the likelihood of persecution affecting population dynamics. Results demonstrated that persecution, which was strongly associated with grouse moors in the eastern areas of the country, was associated with a reduction in the age of first breeding, increased territory vacancies, and the use of territories by non-breeding immature eagles. The study also inferred that ecological 'traps' were being created, as mobile immature eagles were attracted to empty territories in persecution areas, increasing subadult mortality	2	(++)

				in birds from persecution-free zones. The study concluded that persecution was significantly impacting the entire Scottish golden eagle population.		
Whitfield *et al.* (2007)	AE-B	Scotland	Hiking/ walking, driven shooting	This study assessed the potential causes of regional and national population trends in Scottish golden eagle populations. The GIS study utilised temporal changes in the distribution and occupation of Golden Eagle territories in Scotland between the 1992 and 2003 national censuses to assess potential causes of regional and national population trends, by examining spatial associations with several potential constraints including changes in land use, prey availability, persecution and recreation. The study concluded that there was little evidence to suggest that recreational disturbance was influential on the occupation of Golden Eagle territories, instead identifying persecution as the most important factor.	2	(+)
Zografos and Allcroft (2007)	AE-B	Scotland	Recreation (general), hiking / walking, birdwatching	This study considered the potential of ecotourism development in Scotland through a market segmentation study. The study explored different environmental values of potential ecotourists (from ecocentric to anthropocentric), collecting data from 20 sites around Scotland about opinions of a hypothetical ecotourism experience. Results demonstrated that demand for ecotourism was not confined to ecocentric segments and that biodiversity protection was prioritised by all segments as the most salient ecotourism attribute and found that demand for ecotourism is not confined to ecocentric segments.	2	(+)

Appendix II: Revised Research Questions

Table A2.1 shows the minor amendments made to the Research Questions from those originally proposed by Natural England. Changes were made to provide clarity and to meet the PICO framework and are shown in **bold** in the second column.

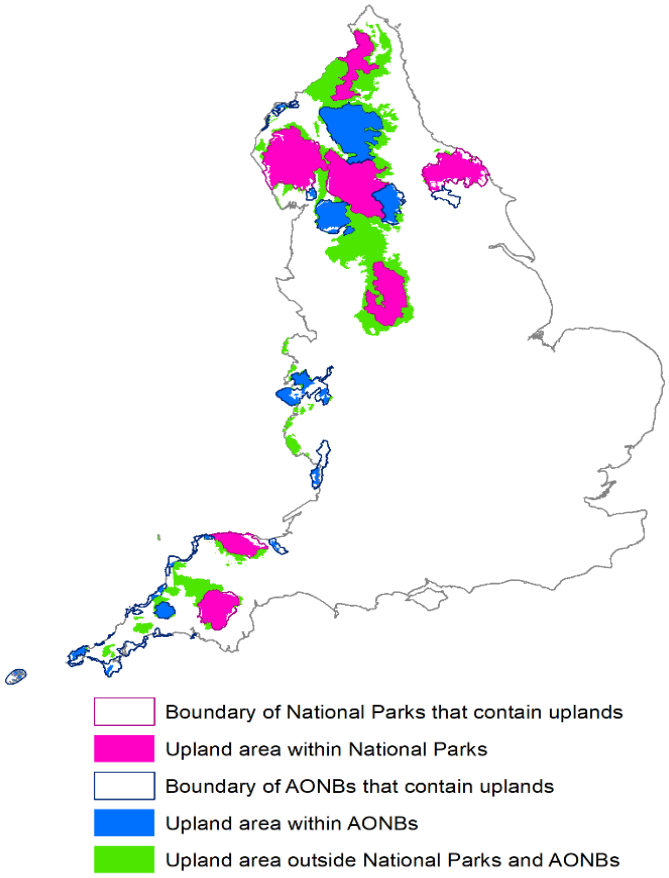
Table A2.1: Research Question Refinement

Original question	Revised question to meet PICO framework and to provide clarity
What form does recreational activity take in the uplands?	What **types** of recreational activity take place in the **UK** uplands?
What factors influence the level of recreational activity?	What factors influence the level of recreational activity **in the UK uplands**?
What impact does recreational activity have on upland habitats and species?	What **influence** does recreational activity have on upland habitats and species **in the UK**?
What relationships, if any, exist between types of recreational activity and severity of impact?	What relationships exist between types of recreational activity and severity of impact **in the UK uplands**?
What are 'appropriate levels of use' of recreation?	What are 'appropriate levels of use' of recreation **in the UK uplands**?
What evidence exists of adaptation or mitigation measures in response to recreational impacts?	What evidence exists of adaptation or mitigation measures in response to recreational impacts **in the UK uplands**?

Appendix III: Rationale for Inclusion and List of organisations contacted in Practitioner Call for Evidence

The Call for Evidence included all National Park Authorities (NPAs), and organisations involved in managing Areas of Outstanding Beauty (AONBs) that fall within the English Uplands (Figure A3.1). A notable proportion (approximately 38%) of upland areas (as defined by Less Favoured Areas) do not fall within National Park or AONB designations. This includes the West Pennine Moors, which like many of the other upland areas shown in green in Figure A3.1, have a Site of Special Scientific Interest (SSSI) designation, but no specific remit for the managing body (one or more Local Authorities), to provide or manage recreational use. All statutory Local Authorities that had upland areas within their boundary to be included in the Call for Evidence were therefore contacted.

Figure A3.1: Upland areas occurring within National Park and AONB designations



Upland areas are defined using the Less Favoured Area classification

Additionally, a range of different non-statutory organisations involved in managing or supporting biodiversity conservation or recreation in the English uplands were also contacted. Table A3.1 provides a summary of the type of organisations that were contacted as part of this evidence review.

Table A3.1: Practitioner Call for Evidence Organisation Type

Type of organisation	Number of organisations
Local authorities	30
National Park Authorities	7
Areas of Outstanding Natural Beauty (AONB) and Landscape-scale partnerships	16
Contacts in business associations including the CLA, NFU and Tenant Farmers Association, National Sheep Farming Association	10
Membership organisations including Wildlife Trusts, National Trust, Moorland Association, Game & Wildlife Conservation Trust, Ramblers Associations, British Mountaineering Council (BMC), CPRE, Friends of groups	35
Other statutory agencies	3

Appendix IV: Overview of Studies Included in Evidence Review

Study Categorisation and Validity

Tables A4.1 and A4.2 show the proportion of studies (*n* = 114) based on study type and validity score.

Table A4.1: Categorisation of Study Type

Rating	Definition	Number of Studies	Percentage of Total
1	Meta-analyses, systematic reviews of, or individual Randomised Control Trials (RCT)	5	4.4%
2	Systematic reviews of, or individual, non-randomised control trials, case-control trials, cohort studies, controlled before-and-after (CBA) studies, interrupted time series (ITS) studies, correlation studies, modelling, site comparisons and national or regional (and some local) data sets, statistics and surveys.	79	69.3%
3	Non-analytical studies, for example, case reports and case series studies, and traditional, non-systematic literature reviews.	17	14.9%
4	Expert opinion and formal consensus	5	4.4%
5	Modelling	8	7.0%

Table A4.2: Categorisation of Study Quality

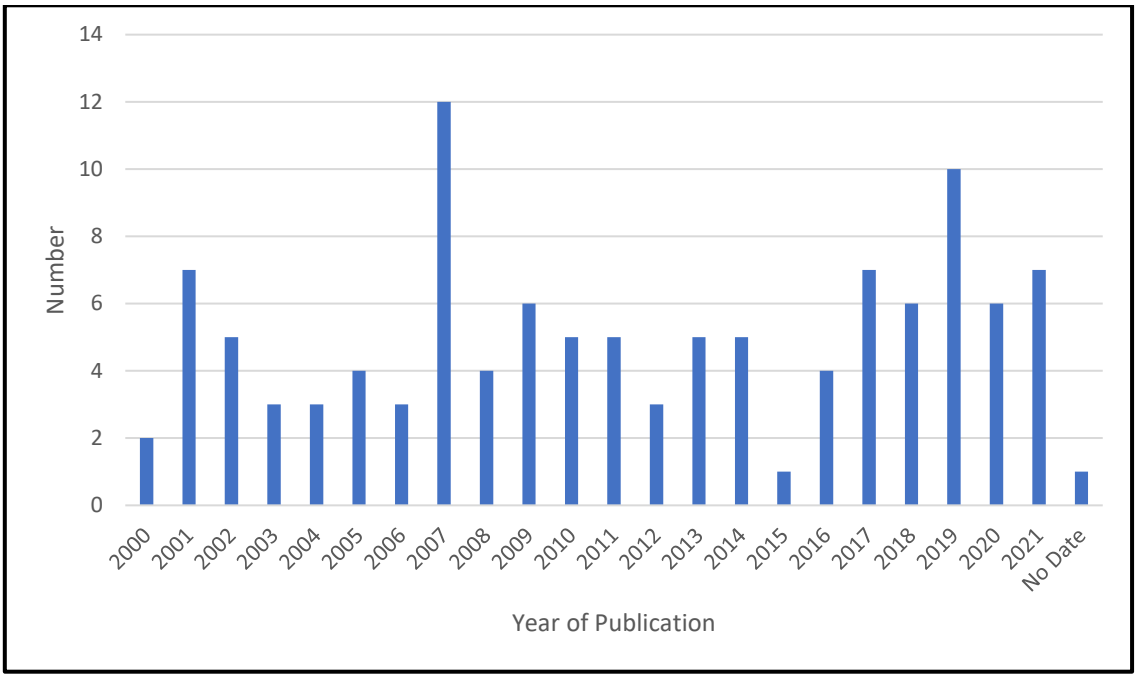
Rating	Definition	Number of Studies	Percentage of Total
++	All or most of the methodological criteria were fulfilled. Where they had not been fulfilled, the conclusions are thought very unlikely to alter (low risk of bias)	17	15.0%
+	Some of the criteria were fulfilled. Those criteria that had not been fulfilled or not adequately described are thought unlikely to alter the conclusions (risk of bias)	60	52.2%
-	Few or no criteria were fulfilled. The conclusions of the study are thought likely or very likely to alter (high risk of bias).	37	32.8%

The main reasons for studies being assessed as [-] quality were lack of information on methods, insufficient explanation / justification for case-study selection, evidence of subjective or bias in assessments, and/or poor accountability for the influence of other variables or confounding factors.

Year of Publication

The number of publications included in the review shows a gradually increasing trend of more publications throughout the review period, although the peak year was 2007 with 12 publications.

Figure A4.1: Number of studies by year of publication



Country of Study

- 63 were undertaken / partially undertaken in England;
- 54 were undertaken / partially undertaken in Scotland;
- 12 were undertaken / partially undertaken in Wales;
- 5 studies were undertaken / partially undertaken in Northern Ireland; and
- 2 studies were either using data that was not specific to a location or were unclear about the location of the study.
- Note that some studies covered multiple countries so the total is > 114.

Appendix V: Coding Framework

Table A5.1 shows the coding framework used to evaluate each study. This consisted of a total of 56 questions across seven categories, including the citing information, location and context of the study, internal and external validity, the recreation type, and the influences on species, habitats or ecosystem processes.

Table A5.1: Questions and Responses for Coding Framework Applied to Studies by Two Reviewers

Sub-Categories	Questions	Closed Responses
Citation information	1. Study ID	
	2. Authors	
	3. Article title	
	4. Document type	
	5. Publication year	
	6. Permanent link (e.g., DOI)	
Location and context of study	7. Country (CLOSED)	UK wide; England; Wales; Scotland; N. Ireland
	8. Region (CLOSED)	East Midlands (England); North East (England); North West (England); South West (England); West Midlands (England); Yorkshire and the Humber (England)
	9. Site location including site name and any spatial reference given (e.g., grid reference, Lat and Long, or Postcode) (OPEN)	
	10. Study type (CLOSED)	1. Meta-analyses, systematic reviews of Randomised Control Trials (RCTs), or RCTs including cluster RCTs. 2. Systematic reviews of, or individual, non-randomised controlled trials, case-control trials, cohort studies, controlled before-and-after (CBA) studies, interrupted time series (ITS) studies, correlation studies. 3. Non-analytical studies, for example; case reports, case series studies. 4. Expert opinion, formal consensus. 5. Modelling.
	11. Start date (YYYY)	
	12. End date (YYYY)	
	13. Methods used	

Internal and external validity	14. Is the environmental context of the study (i.e., ecosystem, ecosystem function, habitat or species) clearly defined? (CLOSED)	Ecological records (secondary data source); Ecological survey; Bibliographic/archival research; Ecological modelling; Expert opinion/opinions of stakeholders; Bibliographic/archival research; Participant observation; Semi-structured interviews; Structured surveys performed face to face with participants; Structured surveys online or via post; Visual methods; Content analysis.
	15. Is the representativeness of the case study(ies) (in sites of data collection) clearly defined in relation to the broader environmental context described in 14? (CLOSED)	++ Details the methods including the broad context and specific variables in a repeatable way. + Methods describe either broad context and/or specific receptors (social/eco) but lack detail on how the research can be repeated. - Only very vague information was provided, either on broad context or specific variables/receptors.
	16. Is the representativeness of the individual receptors selected for the study clearly defined in relation to the case-study(ies) selected in 15? (CLOSED)	++ Study provides clear criteria for selecting case studies that are representative of the environmental context (which allows the research to be repeated). + Study provides some discussion of how the individuals were selected but not their representativeness. - Individuals are not clearly linked to the case studies/ unclear how the individuals are represented in the broader case study sites. N/A No specific location or sites of data collection
	17. Is there a control sample or comparison to areas without recreation? (CLOSED)	++ A control occurs at the same time at a different location. + Before and after control measurement - No control provided NA - No data is collected
	18. Are impacts measured objectively? (CLOSED)	Impacts consider: 1. reliability of evidence (and relevance of proxies); 2. consistency / completeness of assessment; 3. designed to assess + and - outcomes (++ = all 3; + = 2/3; - = 1 or 0; NR, NA)
	19. Are findings transferable to wider UK uplands? (CLOSED)	++ Research is totally conducted in UK uplands + Research is partially conducted in the UK uplands (including NI) - Research is not conducted in the UK uplands
	20. General limitations of study (OPEN)	
Recreation type	21. What recreation type is being assessed? (CLOSED)	Recreation (general); Hiking/walking; Dog walking; Climbing/bouldering; Hill/mountain running; Orienteering; Swimming; Triathlon; Mountain biking; E-biking; Scrambler/trail biking; Off-road/4x4 driving; Road/scenic driving; Bird-

		watching; Fishing; Driven shooting; Walked-up shooting; Skiing/snow sports; Paragliding; Drone flying; Model airplane flying; Canoeing/kayaking; Sailing/boating; Swimming; Horse riding; Camping; Barbecuing; Picnicking; Fireworks; Raves; Organised events (broad).
	22. Does the study assess the extent to which this recreation type is occurring in the uplands? (CLOSED)	1. No; 2. Yes, it empirically tests the extent of this recreation type; 3. Yes, it describes the extent of this recreation type
	23. If yes to 20 provide details (OPEN code)	
	24. Does the study assess factors which influence this type of recreation use? (CLOSED)	1. No; 2. Yes, it empirically assesses the factors that influence this recreation type; 3. Yes, it describes the factors that influence this recreation type.
	25.. If yes to 23 provide details (OPEN)	
Recreation influence on species	26. Does the study look at the impact on species? (CLOSED)	Yes, it empirically tests the impact on species; Yes, it describes impacts on species; No; N/A;
	27. What taxon are studied (CLOSED)	None; Plants; Trees; Bryophytes; Fungi; Fish; Invertebrates; Reptiles; Amphibians; Mammals; Birds
	28. Include common name and scientific name (OPEN)	
	29. What impact is being studied? (CLOSED)	Disturbance effects; Alterations to habitat; Population effects; Species composition; Species distribution; Breeding success; Fragmentation; Add additional code; N/A.
	30. Additional notes on impacts being studied (OPEN)	
	31. What is the influence of impact? (CLOSED)	Negative, Neutral, Positive, Unclear
	32. Does the study assess the extent or intensity of impact? (CLOSED)	Yes, it empirically assesses the extent or intensity of impact; Yes, it describes the extent or intensity of impact; No; N/A.
	33. If yes briefly define the extent or intensity of impact (OPEN)	
	34. Does the study suggest appropriate levels of impact (CLOSED)	Yes, it empirically tests the appropriate levels of impact; Yes, it describes the appropriate levels of impact; No; N/A.

	35. If yes to 33 provide details (OPEN)	
	36. Does the study outline any adaptation or mitigation measures? (CLOSED)	Yes, it empirically tests adaptation and mitigation measures; Yes, it describes adaptation and mitigation measures; No; N/A.
	37. If yes to 35 provide details (OPEN)	
Recreation influence on habitats (10 questions)	38. Does the study look at the impact on habitat types? (CLOSED)	Yes, it empirically tests the impact on habitats; Yes, it describes the impact on habitats; No; N/A.
	39. What type of habitats are being studied? (CLOSED)	Broadleaved woodland; Coniferous woodland; Scrub; Heather moorland/heathland; Blanket bog (active); Blanket bog (restoring); Blanket bog (degraded); Mire; Flush/rushes; Molinia (purple moor grass) grassland Acid grassland (unimproved); Neutral grassland; Calcareous grassland (unimproved); Calimanarian grassland; Semi-improved grassland; Limestone pavement; Bare rock (horizontal); Cliff /rock face; Scree; Reedbed; River; Stream; Tarn; Lake; Reservoir; Canal; General upland habitat; N/A.
	40. What impact is being studied? (CLOSED)	Percentage cover; Growth rates; Species composition; Age structure; Loss of organic matter; Compaction; Habitat fragmentation; Habitat loss; N/A.
	41. What is the extent of impact? (CLOSED)	Negative, Neutral, Positive, Unclear
	42. Does the study assess the extent or intensity of impact? (CLOSED)	Yes, it empirically assesses the extent or intensity of impact; Yes, it describes the extent or intensity of impact; No; N/A.
	43. If yes to 41 briefly describe the extent or intensity of impact (OPEN)	
	44. Does the study suggest appropriate levels of recreation? (CLOSED)	Yes, it empirically tests the appropriate levels of impact; Yes, it describes the appropriate levels of impact; No; N/A.
	45. If yes to 43 provide details (OPEN)	
	46. Does the study outline any adaptation or mitigation measures? (CLOSED)	N/A; Yes, it empirically tests adaptation and mitigation measures; Yes, it describes adaptation and mitigation measures; No; N/A.
	47. If yes to 45 provide details (OPEN)	
Recreation influence on	48. Does the study look at the impact on natural processes? (CLOSED)	Yes, it empirically tests the impacts on natural processes; Yes, it describes impacts on natural processes; No; N/A.

environmental processes	49. What impact is being studied? (Closed)	Water quality; Water quantity; Carbon sequestration; Carbon storage; Soil formation; Soil integrity; Wildfire risk; Erosion control; Succession; Trophic complexity; Natural flood management
	50. What is the extent of impact? (CLOSED)	Negative, Neutral, Positive, Unclear
	51. Does the study assess the extent or intensity of impact? (CLOSED)	Yes, it empirically assesses the extent or intensity of impact; Yes, it describes the extent or intensity of impact; No; N/A.
	52. If yes to 50 provide details (OPEN)	
	53. Does the study suggest appropriate levels of recreation? (CLOSED)	Yes, it empirically tests the appropriate levels of impact; Yes, it describes the appropriate levels of impact; No; N/A.
	54. If yes to 52 provide details (OPEN)	
	55. Does the study outline any adaptation or mitigation measures? (CLOSED)	Yes, it empirically tests adaptation and mitigation measures; Yes, it describes adaptation and mitigation measures; No; N/A.
	56. If yes to the previous provide details (OPEN)	

Appendix VI: Practitioner Survey Questions

This appendix provides a list of the questions that were asked in the practitioner survey (see Section 2.7 for further details on rationale and methodology).

Q1) What type of organisation do you work for?

Q2) Please provide the name of your organisation.

Q3) Which region(s) are the uplands in that your work relates to?

Q4) Please provide the name of the upland(s) that you work in.

Q5) Are there any landscape or conservation designations that cover your upland area?

Q6) In general, how would you classify the influence of recreation on wildlife and biodiversity in the upland area(s) you work in?

Q7) For each recreation type, how would you classify the influence on wildlife and biodiversity in the upland area(s) you work in?

Q8) Are there any significant recreation types missing, if so, how impactful are they on wildlife and biodiversity?

Q9) Specifically regarding impacts on wildlife and biodiversity, what do you think are the three most damaging types of recreation occurring in your upland area (this might be because of proximity to sensitive wildlife, intensity / frequency of recreational activity, etc.)?

Q10) For each habitat type present in your upland area, how would you classify its general sensitivity to recreational activity?

Q11) If you answered 'highly sensitive' to any of the habitats in Q10, please provide more details about why it is particularly sensitive / what forms of recreation affect it.

Q12) Are there any species that you are aware of (e.g., plants, trees, bryophytes, fungi, fish, invertebrates, reptiles, amphibians, mammals or birds) that are particularly vulnerable or sensitive to recreation in the uplands?

Q13) Please rank the factors that most influence the level of recreational activity, where 1 is the most impactful through to 6, the least impactful.

Q14) Please comment on how you think the intensity of recreational activity has changed over the following time periods.

Q15) Please identify which of the following measures you have put in place to reduce negative recreational impacts on upland habitats or species and reflect on how effective they have been.

Q16) Please provide any additional measures that have been successful in reducing negative recreational impacts that have caused damage to upland habitats or species.

Q17) Are there any existing policies (international, national or local) that you think significantly influence recreational activity in the uplands?

Q18) Are there any specific gaps that you think policy should address in relation to recreational activity in the uplands?

Q19) If you have any other comments about recreational activity in the uplands, please feel free to provide them in the box below.

Appendix VII: Summary of Findings from Practitioner Survey

This Appendix reports the results of an online survey which engaged practitioners working in upland areas across the UK. The purpose of this survey was to supplement the academic evidence by drawing on the knowledge and perceptions of practitioners. A list of the questions presented in the survey can be found in Appendix VI.

The survey was distributed to over 100 practitioners working across a broad range of organisations including private, public and third-sector agencies. These practitioners were identified by the authors via extensive engagement with the Evidence Review Group. Potential participants were sent an email with a link to the survey on the 30th of November 2021 and a reminder email several weeks later requesting completion by December 31st, 2021. The practitioners that were emailed were invited to send the survey to other colleagues that worked in upland areas but were asked to not share it on social media or send it out on distribution lists to avoid attracting the general public or unduly unbalancing the proportion of stakeholder types.

We received a total of 125 completed responses (hereon in 'respondents'), of which approximately 25% were conservation or recreation practitioners and over 50% of which were upland landowners or land managers. The remaining 25% selected 'other' and did not stipulate their profession / relevance to the uplands. It should be noted that the grouse shooting and farming community were particularly well represented within this sample. This was due to certain organisations promoting the survey amongst their members.

It should also be noted that the UK was not equally represented. The majority worked in England, with 51 respondents indicating that their work was based in the North-west of England, followed by Yorkshire and the Humber (33 responses). Respondents also took part from other regions across England, Scotland, Wales, and Northern Ireland (in total 23 responses). 18 participants did not state where they were based.

Importantly, this survey should not be seen as an attempt to quantify the different perspectives across different stakeholder types or to demonstrate which perspectives are more dominant across upland practitioners. However, the diverse range of participants and the viewpoints presented in this Appendix does shed light on a broad range of different perspectives that it is important to acknowledge in relation to upland management and recreational activity.

The first section of this Appendix looks at responses addressing Research Questions 1 and 2:

- Research Question 1: *What form does recreational activity take in the UK uplands?*
- Research Question 2: *What factors influence the level of recreational activity in UK uplands?*

Perspectives on Types of Recreation

Pertaining to Research Question 1: *"What form does recreational activity take in the UK uplands?*" the survey added several recreational activities not initially identified by the Evidence Review Group. These recreation types were included in the list reported in section 3 of the main report.

1. **Citizen Science led amateur excavation and recording**
2. **Organised river walking / ghyll scrambling**
3. **Organised walks / charity walks / runs**

4. **Pony trekking / alpaca walks**
5. **Organised fell races**
6. **Rescue dog training**
7. **Photography**
8. **Hound trails**
9. **Foraging**
10. **Rowing**
11. **Boating**

Respondents to the survey suggested that there were many types of recreational activities occurring within the UK uplands. Many of these types of recreation are not currently examined within the academic literature captured within this report.

Perspectives on the Factors Influencing Recreational Activity in the Uplands

To address Research Question 2: *"What factors influence the level of recreational activity in UK uplands?"* several questions were asked in the survey to gauge practitioners' insights on the emerging trends of recreational activity and factors influencing the level of pursuit.

Emerging trends of the intensity of recreational activity between 2000-2021

Survey respondents suggested that for different time periods, the intensity of recreational activity has changed over time. In particular, the survey confirmed that respondents perceived the implementation of the CRoW Act and the COVID-19 pandemic (lockdowns and interim periods) to have altered recreational use in upland areas significantly. The majority of respondents indicated that recreational activity in the uplands has generally increased across all three time periods compared to the previous period. This equated to 71 of the overall rankings (82%). Even though the majority of respondents indicated that the use increased between 2010 and 2020 (88% vote), a small number indicated that the level of use remained the same (10%). This could be due to spatial differences in visitor trends between the different areas that respondents were operating in.

92% of respondents believed that the level of recreational use in the uplands further increased during the COVID-19 lockdowns throughout 2020-2021. The responses suggested that this was motivated by the inability of the public to socialise indoors (out of their 'social bubbles') along with other social distancing measures. There was also a perception that the level of public use in the uplands increased due to an enhanced need for personal wellbeing during lockdowns.

Figure A7.1 summarises the perceptions of trends in recreational activity in the upland areas from the year 2000 to 2021.

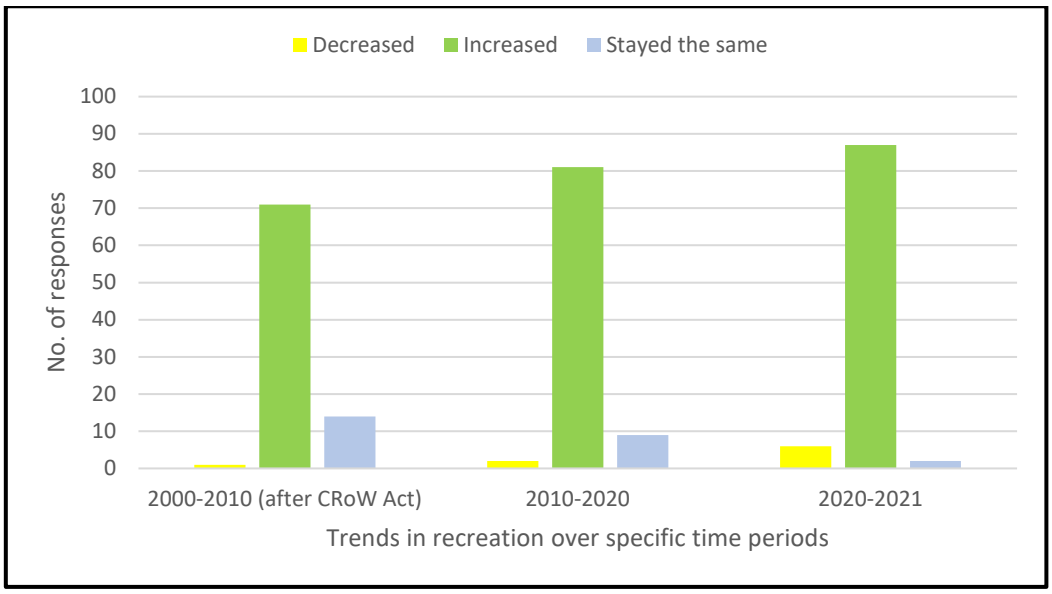


Figure A7.1: Perceptions regarding trends in the intensity of recreational activity throughout the periods of 2000-2021

Ranking of factors that influence the level of recreational activity

Of all the 125 survey respondents who completed the online survey, 96 responses (77%) provided answers to Research Question 2: "*What factors influence the level of recreational activity in UK uplands?*". Respondents were asked to rank six categories of factors influencing the level of recreational activity in the uplands, with (1) being the most impactful factor to (6) being the least impactful. The six most prominent factors were gathered from existing literature (e.g., Bathe 2007; Hanley *et al*., 2002), which focused primarily on environmental management literature (i.e., they did not seek to address the wider sociological or socio-economic issues related to the accessibility of nature or protected areas as this was beyond the scope of the review). However, to provide scope to identify other factors that may influence the level of recreational activity, participants were given the opportunity to suggest other contributing factors that they deemed important in an open question. The results are shown in Figure A7.2 and are briefly summarised below.

1) Ease of access to the site

The survey revealed that ease of access was perceived by respondents as the primary factor that influences the level of recreational activity in the uplands. This includes the proximity of upland areas to large conurbations, public transport and good road access to the site. Approximately 70% of the respondents (68 votes) who answered this question found this factor to be the most impactful in influencing the level of recreational activity.

2) Proximity to tourist facilities

The survey demonstrated that the proximity to tourist facilities such as car parks, toilets, cafés and pubs was perceived as the second most important factor that influences the level of recreational activity in upland ecosystems, with almost 40% of respondents (38 votes) voting for this as the second most important factor.

3) Site infrastructure aiding accessibility and use

The survey indicated that the accessibility of sites via site-based infrastructure was a further key influencing factor, with 43% of respondents (41 votes) ranking it in third place. Specific

features included the availability of footpaths, disabled access, signage at the site and other factors that help site users navigate through the site conveniently.

4) *Popularity or public awareness of the upland landscape*

The level of public awareness of a particular upland area was indicated as the fourth most impactful contributing factor that influences the level of recreational activity. 36% of respondents voted for this factor in 4th place.

5) *Availability of information*

The availability of information about upland areas was considered one of the least influential factors on levels of recreational activity with most votes placing it fifth out of six. This lower score may be affected because assessing to what extent visitors have sought or obtained available information (e.g., hardcopy of maps, walking routes published on the internet and potentially fliers or websites that advertise the upland areas) may be harder to assess than some of the other factors.

6) Availability of equipment for recreation influences the level of recreation

Respondents indicated that the availability of equipment for recreation, for instance, the availability of cheaper mountain bikes and better-quality footwear and waterproofs was the least impactful factor out of the pre-determined categories. This was evidenced by 51% of all responses (49 votes) placing this as the least influential.

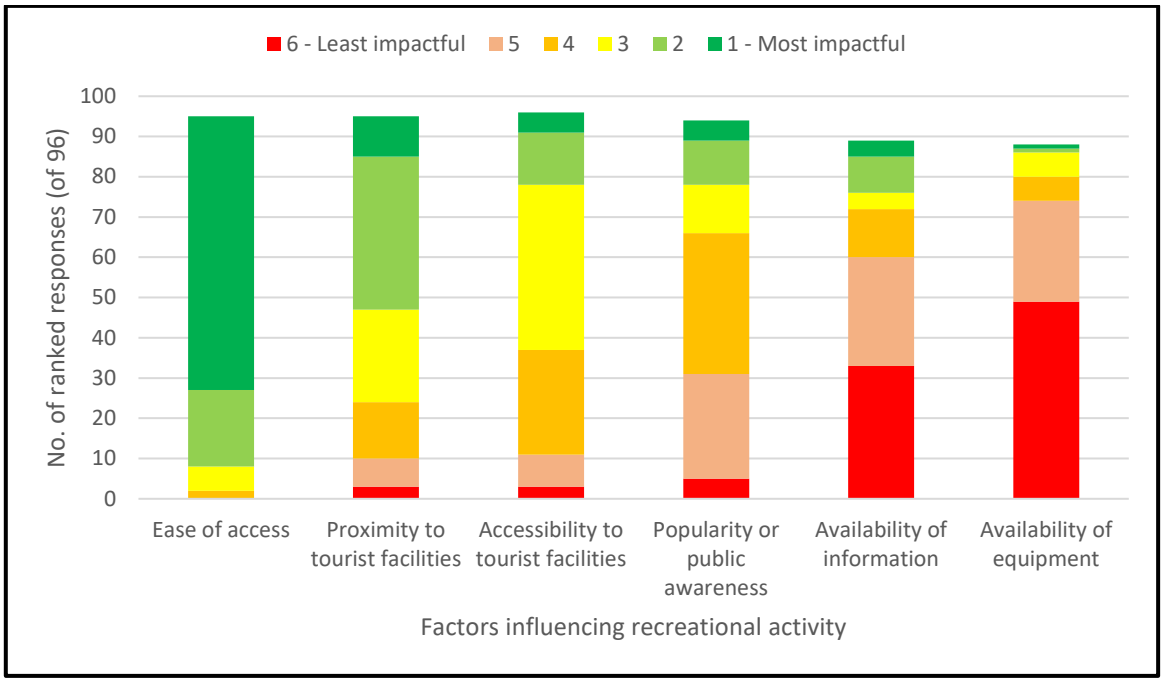


Figure A7.2: Perceptions regarding the factors that cause the most recreational impact on upland species, habitats and ecosystems

Other factors influencing the level of recreational activity

Respondents were also given the opportunity to provide further comments on other factors influencing recreational activity. Here respondents suggested that social media, commercial advertisements and published materials have a strong influence on upland recreational use.

The same number of participants proposed that the lack of awareness of some members of the public about priorities for managing upland areas (for instance if they are privately owned and managed) and the associated restrictions was a significant influencing factor. Respondents reported that COVID-19 lockdowns had increased visitor use of the uplands, and organised events held in the upland areas can cause significant negative impacts in a short period of time.

Respondents also suggested that the combination of easy walking tracks available in the uplands, coupled with poor signage, can increase the amount of off-track use. Additionally, high dog ownership and the ease of dog walking were also seen to contribute to the high use of sites in upland landscapes.

Some respondents also suggested that they felt there was a lack of support from statutory authorities recognising landowners' or managers' views or concerns regarding the damage that recreational activities can cause to upland ecosystems. This was seen as being linked to the lack of public education about the causes of impacts on upland ecosystems and how they can be avoided. Respondents also indicated that the public might be influenced to use such sites as a result of encouragement from non-governmental organisations, in their effort to generate more income from increased visitor numbers.

Respondents indicated that other additional factors affecting the levels of recreational pursuits involve seasonality (month of the year, weekends, bank holidays, school holidays), environmental factors (weather, climate) and culture, acknowledging that some communities have a long history of accessing the hills. One of the practitioner submissions (not included in the full evidence review) also highlighted that external events can also influence the level of recreational activity. For example, during recent football tournaments, it was observed that the Stiperstones National Nature Reserve was noticeably quieter on days when the England football team were playing.

Perspectives on the Influence of Recreation on Upland Ecosystems

Relationship Between Types of Recreation and Severity of Impact

This section focuses on addressing the following research questions:

- Research Question 3: *What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*
- Research Question 4: *What relationships exist between types of recreational activity and severity of impact in the UK uplands?*

From the practitioner survey conducted, it was observed that there was a broad divide between respondents who saw upland recreation as generally positive and those who saw it as negative. This is broadly in line with the patterns observed in academic literature, particularly regarding the positive and negative impacts of driven grouse shooting. However, overall, respondents generally felt that recreational uses have negative impacts on upland ecosystems, but this varied considerably based on stakeholder type and the type of recreational activity under question.

Many respondents involved in grouse moor management (to varying degrees) ranked driven grouse shooting and walked up shooting positively. Here it is notable that some of the complexities and negative implications of grouse moor management as presented within academic literature were not reflected in their responses.

Additionally, many recreation pursuits were regarded as highly damaging, such as scrambler or trail biking, picnicking, barbecuing, fireworks, rock climbing and raves that were underexplored or not present at all in the academic literature review.

The practitioner survey provided interesting insights into perspectives on Research Question 3: "*What influence does recreational activity have on upland species, habitats or ecosystem processes in the UK?*". In general, respondents strongly believed that recreational activities held in the uplands were 'somewhat damaging' to the habitats and species (44% vote out of 118 responses). 26% of respondents, however, believed that recreational activities were very damaging to the uplands (31 responses), while 20% believed that they can be very beneficial (24 responses). The distribution of these responses is illustrated in Figure A7.3.

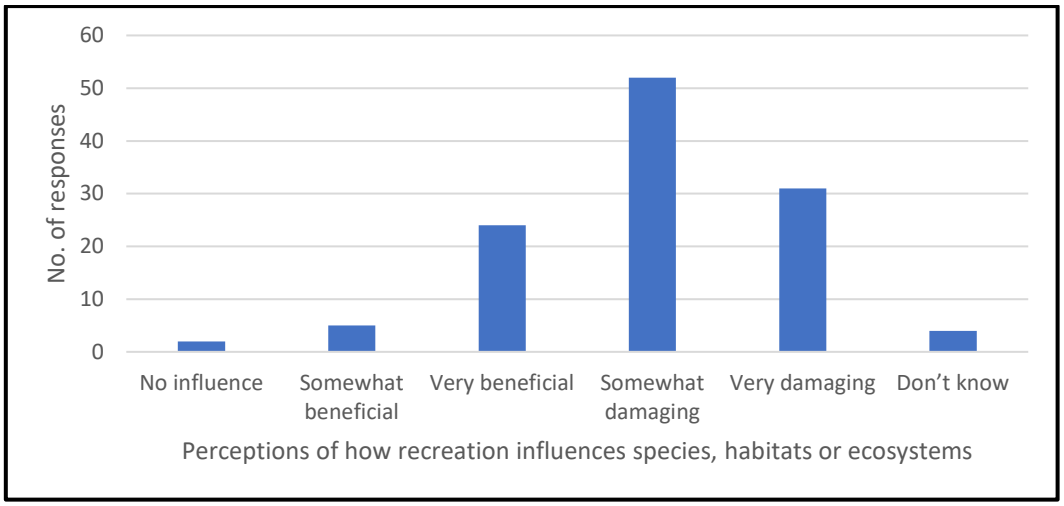


Figure A7.3: Perceptions regarding the influence of recreation on species, habitats or ecosystems in upland areas.

Damaging activities to upland ecosystems

The practitioner survey provided additional insights into the relationship between the type of recreational activity and severity of impact addressing *Research Question 4: "What relationships exist between types of recreational activity and severity of impact in the UK uplands?"* Respondents described dog walking, scrambler or trail biking, and barbecuing as the top three damaging activities in the uplands, with more than 100 votes for each recreational pursuit, accounting for more than 90% of overall votes. These perspectives were interesting given the absence of evidence that compared different forms of recreation in the uplands, in terms of impacts on species, habitats or ecosystems, and the absence of studies on types such as dog walking in the uplands. However, these responses were more closely aligned to the practitioner evidence (see 'PE' entries in Evidence Table, Appendix I) that were provided by various organisations that dog walking had a direct impact on the breeding success of ground-nesting birds, scrambler/trail biking causing erosion and soil compaction, and barbecuing posing a risk of wildfire, besides the high risk of littering (Friends of the Lake District, 2020).

The practitioner survey also included perspectives that off-road/4x4 driving, mountain biking, fireworks, raves, camping, picnicking, and e-biking were all perceived as damaging to upland ecosystems. This highlights the contrast between practitioner perspectives and the availability of evidence from academic studies, as none of these recreational types appeared in the academic literature found on the UK uplands except mountain biking (and this only retrieved two relevant studies). It is worth noting that some of these recreational activities are conducted illegally in the upland areas and concerns relating to this were raised within survey responses.

The complete distribution of all recreational activities and their relative severity of impact as perceived by the participants is presented in Figure A7.4.

Respondents were also asked about other organised events that can impact upland ecosystems. Activities that were suggested included citizen science-led amateur excavations, fell running events, charity walks, boating, rescue dog training, hound trails and river walks.

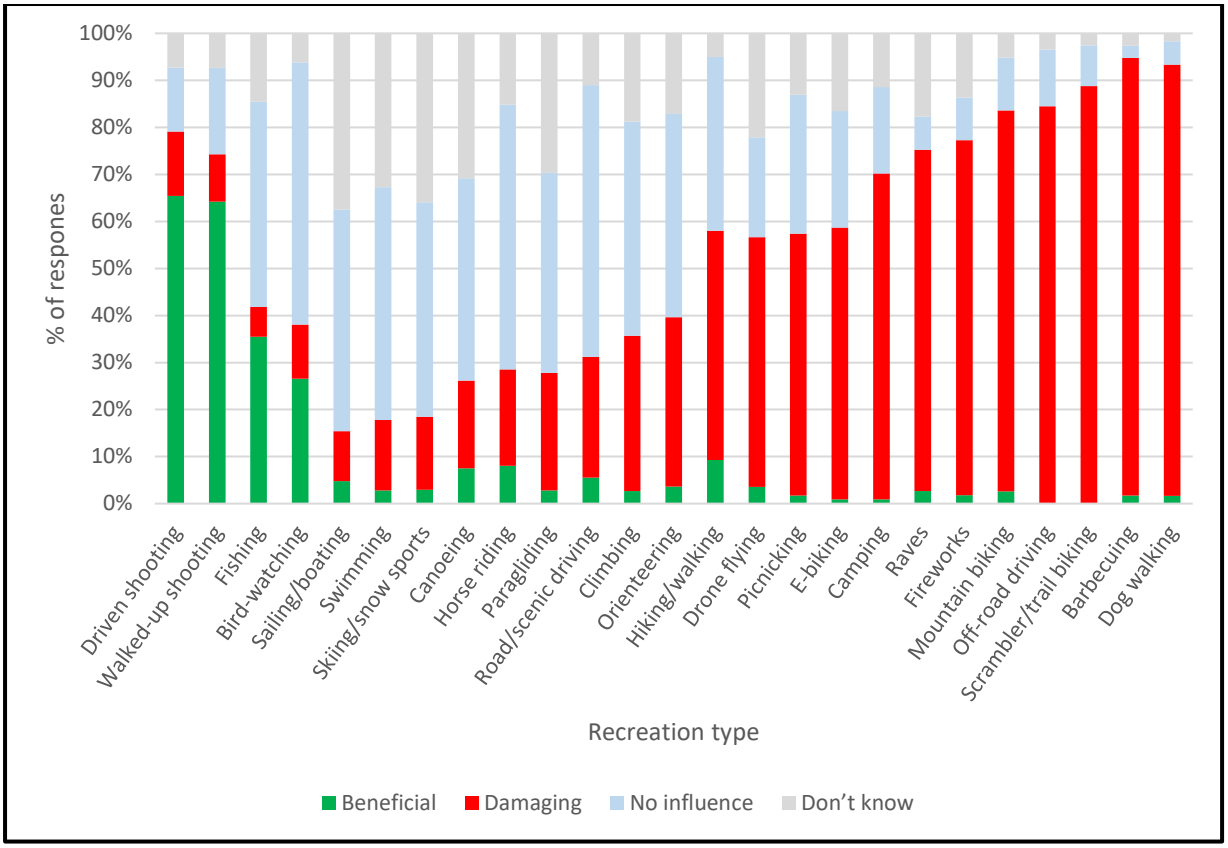


Figure A7.4: Perceptions regarding the type of influence of different recreational activities on upland ecosystems.

Beneficial activities for upland ecosystems

The practitioner survey demonstrated that a significant proportion of respondents only identified two forms of recreation as beneficial for upland ecosystems, driven grouse shooting and walked-up shooting (72 and 70 votes respectively). These activities were the only two that received more than 50% of votes identifying them as beneficial activities, most other activities received less than 10% of votes for being beneficial. This high proportion of very positive perspectives from respondents is to be expected given that a high proportion of survey participants were associated with grouse shooting / grouse moor management.

Activities with no damaging influence on upland ecosystems

Birdwatching, road/scenic driving and horse riding were the top three recreational pursuits that respondents perceived had no damaging influence on upland ecosystems. Each activity received 63 votes, equating to around 56% of overall votes. These were followed by swimming, sailing/boating, climbing, sailing/boating, skiing/snow sports, fishing, orienteering, paragliding, canoeing/kayaking, bouldering and model aeroplane flying.

Although the survey revealed that most respondents believed climbing had limited impact on upland ecosystems, it should be highlighted that one respondent highlighted that rock climbing was a major recreational activity, with potential disturbance to crag breeding birds such as

raven, peregrine falcon and ring ouzel, especially in the spring or early summer. Climbing can also impact sensitive alpine plant communities through the 'gardening' of climbing routes. These sensitivities were matched by other practitioner evidence from the British Mountaineering Council (see Appendix I).

Top three most damaging forms of recreation

Apart from voting for the pre-set options for the influence of recreational activities, respondents were also asked for the top three most damaging types of recreation through a free text question. Their responses were categorised by the stakeholder groups they belong to, illustrated in Figure A7.5.

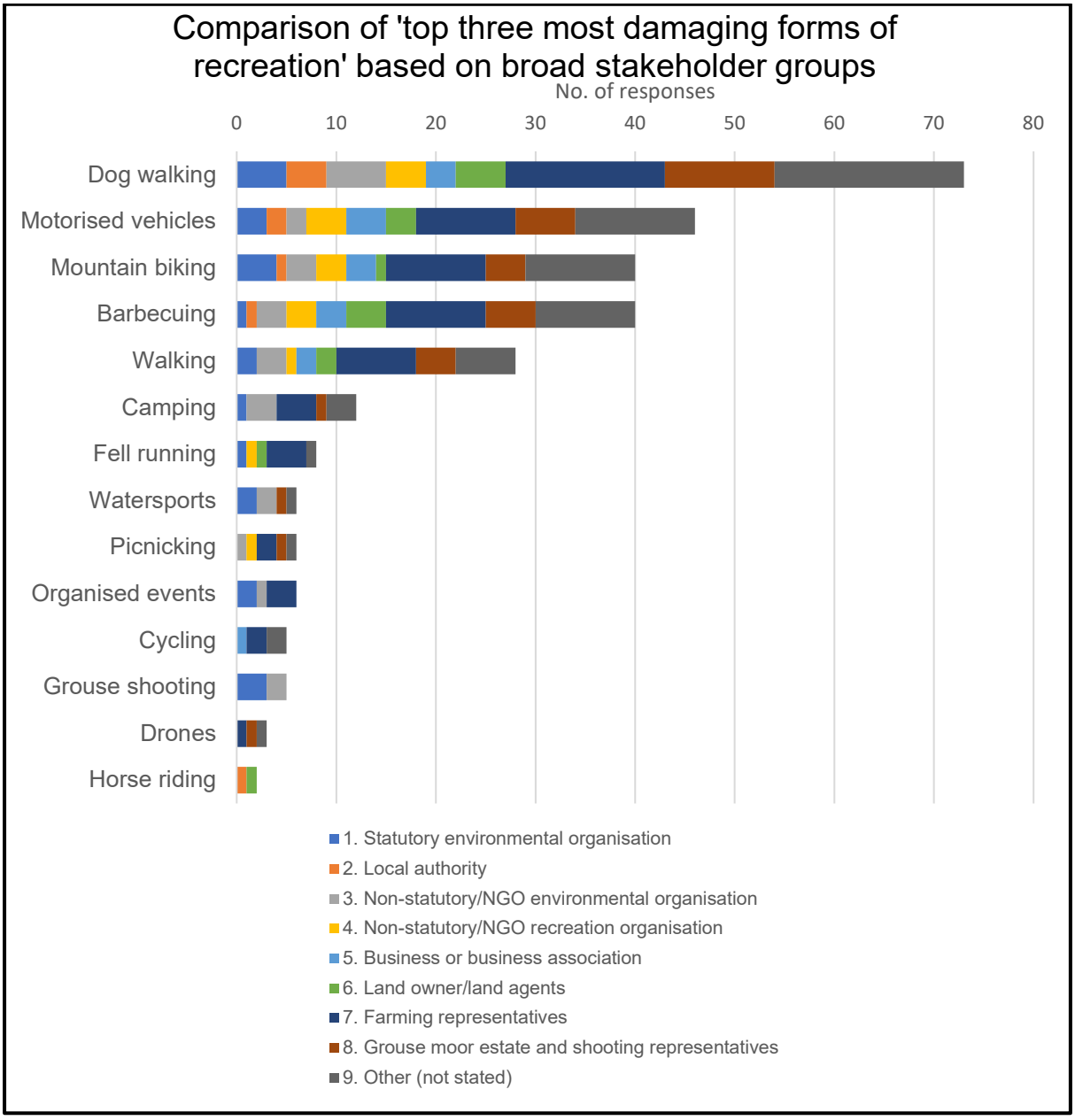


Figure A7.5: Top three most damaging forms of recreation based on stakeholder groups.

The majority of respondents associated with land ownership and stock management (including farming representatives, grouse moor estate and shooting representatives and 'other stakeholders') consistently agreed that dog walking was the most damaging activity impacting the upland ecosystems. However, it was notable that across all stakeholder types, dog walking

was one of the most frequently cited damaging forms of recreation. They also emphasised that dog walking can impact ground-nesting birds, especially when off leads, dogs that got out of control and professional dog walking. A total of 73 responses were received with the mention of dog walking. This is particularly notable when compared with the academic evidence, where very few studies focused specifically on the impacts of dog walking, and none were retrieved that looked at this type of recreation in upland habitats.

The second most damaging form of recreation was deemed to be motorised vehicles with a total of 46 responses received, indicating the damaging effect of motorised vehicles on upland ecosystems. These include 4x4 driving, 4x4 (off-road), e-bikes, heavy machinery, motorised bikes and general motorised vehicle usage. Again, owing to the large proportion of farming, grouse moor and shooting representatives and 'other stakeholder' types that responded to the survey, they occupy a significant proportion of those identifying motorised vehicles as the issue, but it was notable that at least two respondents from each stakeholder category listed motorised vehicles in their top three most damaging forms of recreation.

Barbecuing and mountain biking were both deemed to be the third most damaging activity, with each receiving 40 mentions as one of the top three most damaging recreation types. Additionally, an almost equal number of votes were received from farming, grouse moor and shooting representatives and other stakeholders for both activities, which contributed to the majority of responses.

Perspectives on Appropriate Levels of Recreational Use and Mitigation and Adaptation Strategies to Respond to Recreational Impacts

The practitioner survey did not generate information that addressed Research Question 5: "*What are 'appropriate levels of use' of recreation in the UK uplands?".* This was because it was felt that assessing appropriate levels of use for all 40 recreation types would make the survey unwieldy and may prevent respondents from completing the survey. However, some of the practitioner submissions in the Call for Evidence provided insights on this Research Question, which have been included in Section 5.2 of the main report.

This section, therefore, focuses on addressing Research Question 6: *What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?*

Mitigation and Adaptation Measures

The practitioner survey generated several important perspectives in relation to Research Question 6: "*What evidence exists of adaptation or mitigation measures in response to recreational impacts in the UK uplands?".*

In the survey, nine broad categories of mitigation or adaptation measures were suggested. Respondents were asked if they considered them effective and were given the opportunity to propose additional measures not listed. Results are shown in Figure A7.6 and summarised below.

Half of the respondents indicated that restricting recreational activities through 'visitor exclusion zones' could be the most effective method of reducing the impacts of recreation in some contexts. In contrast, other respondents acknowledge the benefits of allowing public

access to upland areas, making it inappropriate to completely restrict public access in many of these areas.

Perspectives of effective mitigation and adaptation measures

17 respondents perceived 'visitor exclusion zones' to be the most effective measure to reduce negative recreational impacts on upland habitats and species. However, 13 participants suggested that this measure had been ineffective on their sites.

Perspectives of partially effective mitigation and adaptation measures

Respondents perceived a range of mitigation and adaptation measures that they deemed partially effective in reducing recreational impacts on upland ecosystems such as opportunities to include hard barriers or access restrictions, better signposting to divert pressure from sensitive sites, online outreach and engagement to encourage appropriate visitor behaviour, provision of infrastructure to facilitate better access and modification of the environment to try to reduce sensitivity or vulnerability. These options received a range of between 25 and 39 votes from respondents.

Perspectives of ineffective mitigation and adaptation measures

Respondents perceived some mitigation and adaptation measures to be comparatively less effective. On-site visitor interpretation boards or signage aimed at reducing the likelihood of damage and restricted visitor access (seasonal) were both perceived to be ineffective in reducing negative impacts, with 31 and 17 votes respectively.

Figure A7.66 shows the distribution of survey responses for each of the measures implemented, arranged by the highest number of votes for 'very effective', followed by 'partially effective' and 'ineffective'. Respondents highlighted that illegal bike trails have the potential to escalate quickly, due to trail-sharing apps like Strava.

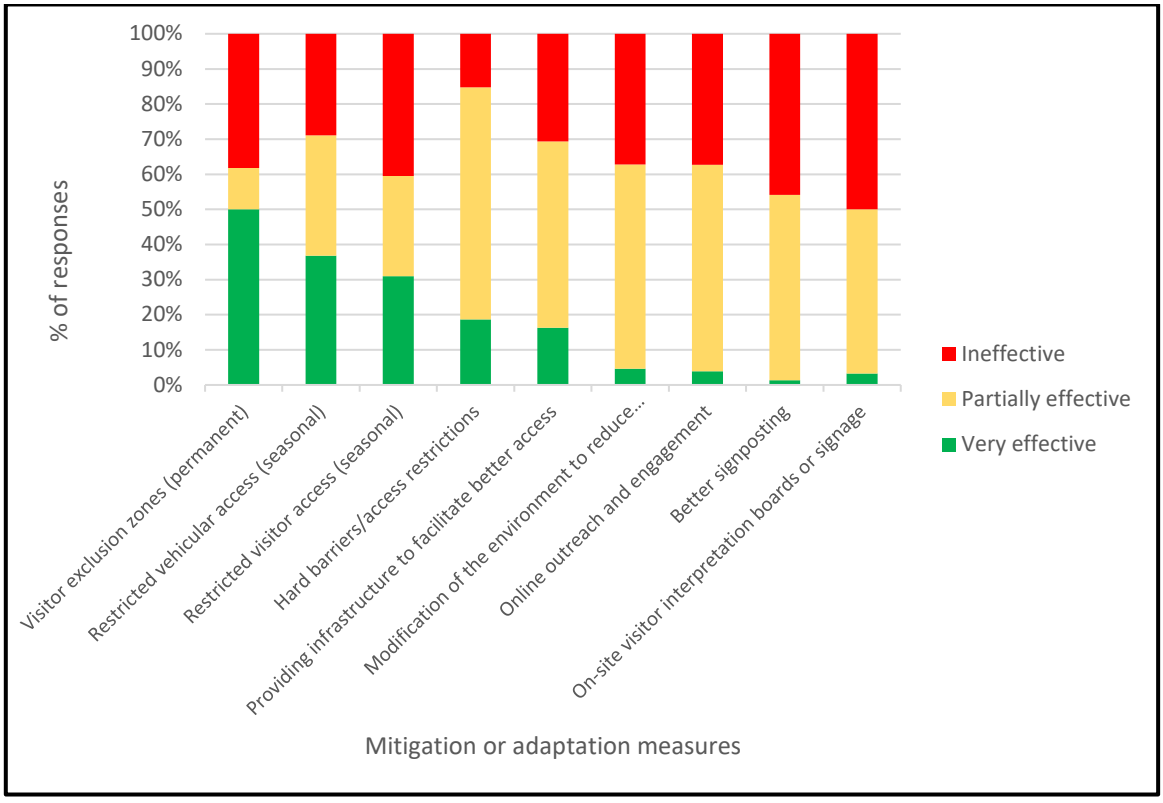


Figure A7.6: Distribution of effectiveness of measures put in place to reduce negative recreational impacts on upland areas as perceived by respondents

With the expansion of social media for recreational pursuits, people are easily encouraged to try new routes that they have not tried before. Therefore, management has to act fast in identifying illegal trails and removing them from trail-sharing websites or apps. On a positive note, participants suggested that social media can and should also be used to educate and engage with the public on ways to conserve nature while allowing legal recreation.

Additional measures implemented to reduce the impact of recreational activity

Respondents also highlighted additional mitigation and adaptation measures that they (or others) have put in place. The largest number of suggestions revolved around the themes of engagement with visitors, education about the importance of conservation and appropriate behaviours in upland ecosystems and the promotion of the Countryside Code.

Respondents also believed the presence/patrolling of staff or gamekeepers would ensure that rules could be better enforced, help to guide people to the correct paths and keep dogs away from sensitive species or habitats.

Excluding people from livestock areas was also a tactic that was mentioned that has been used for the last few decades in agri-environmental schemes where there is evidence of recreational damage. This exclusion tactic was suggested by respondents as something that could be applied to access and recreational activities in special areas in the uplands which were showing damage from recreational activities. Indeed, in some contexts, these measures have already been applied. However, there was limited academic research captured within the literature review that investigated such measures.

The third theme presented by the survey respondents was the importance of partnership-working with different stakeholders operating across sectoral areas. For instance, it was highlighted that working with partners could enable the control of licencing of large recreational events such as fell races, hound trailing and paragliding while restricting activity during bird nesting season and keeping activity away from sensitive locations.

Summary messages from the practitioner survey

- The survey highlighted that many participants felt that upland recreational activity has diversified in recent years. Many new types of recreational activity were identified in the survey that were not present in the academic literature reviewed. This lack of knowledge could create significant challenges for managing upland ecosystems.
- There was a strong perception amongst respondents that recreational activity in upland areas has changed over time linked to certain national drivers including the establishment of the CRoW ACT and the COVID-19 pandemic.
- In many cases, participants felt that recreation in upland areas has increased creating further pressure on upland ecosystems.
- There was significant diversity in viewpoints regarding the impacts of different recreational activities. In many cases, perceptions of impact did not directly align with academic peer-reviewed research. This highlights a significant difference in stakeholders' opinions on the impact of certain types of recreation and the conclusions that can be drawn from the academic evidence currently available.
- There were types of recreational activities such as dog walking, motorised vehicles, mountain biking and camping that were perceived to have significantly negative impacts on upland ecosystems, but these negative consequences were under-explored in academic studies.

- Some types of potentially damaging recreational activities were highlighted by respondents which were completely absent from the academic studies reviewed in this report (such as drone flying).
- There were types of recreational activities that were perceived as being highly beneficial to upland ecosystems which contradicts the academic evidence which is significantly more complex (notably grouse shooting)
- Participants highlighted the importance of partnership-working to overcome the challenges and opportunities of upland recreational activity.

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