Improving decision-making on wild land conservation in Europe through analysis of human perceptions of wild spaces and species

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The PGR confirms that the work submitted is his own, except where work which has formed part of jointly authored publications has been included. The contribution of the PGR and the other authors to this work has been explicitly indicated below. The PGR confirms that appropriate credit has been given within the thesis where reference has been made to the work of others.

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Abstract

The conservation and restoration of wild spaces and species has become popular as a cost-effective, nature-based solution, to address biodiversity loss, landscape fragmentation and flood risk. Effective conservation requires a comprehensive evidence base, and there is a clear need for integrated methods to map remaining wilderness areas in support of decision-making on their protection for future generations.

This PhD focuses spatially on wild spaces and species within upland areas in France and Scotland. It explores participatory, place-based methods, for capturing human perceptions of wild spaces that could be used to improve the quality of the maps that we make of wildness. It analyses public perceptions towards wild spaces and species *in situ* at the local level, and examines how they relate to current wildness mapping. It explores the impact of immersion in wild spaces and exposure to historical landscape conditions on attitudes to possible landscape futures and species reintroductions. As an answer to the challenges of better capturing local ecological knowledge, and the subjective nature of our experience of wild spaces, it tests novel methods for including ecoacoustics in the mapping of wildness, which capture more than just the visual attributes of wild spaces.

Significant correlations were found between existing maps of wildness, human perceptions of wildness, and ecoacoustic indices captured along the same transect. The results of the different methodological approaches showed a high level of agreement and together reveal details of key attributes of wildness excluded under current methods. An important next step is to develop these methods, improve how the results can be integrated, and explore how additional knowledge types and data could be included. Taken together, the results suggest that future wildness mapping could benefit from the potential of the methods tested here to support more effective conservation of wild spaces and wild species within Europe.

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Chapter 1
Introduction

1.1. Background to the conservation and mapping of wild spaces and species

Biodiversity loss is accelerating and we are now considered to be entering 'an age of extinction' (Naeem et al. 2012, Ceballos et al. 2017). The focus of European Commission (EC) conservation efforts within Europe to 2020 is to halt biodiversity loss, to develop a sustainable economy that is resilient to climate change, and to ensure the healthy status of surface and groundwater (EU Commission 2011). These conservation goals and the related funding mechanisms, which largely determine the wider conservation agenda in Europe, were established to protect the natural environment from the significant multi-faceted pressures on biodiversity arising from changes in land use (e.g. agricultural practices) and climate. It is argued that these goals can be achieved if conservation efforts are well designed in space, target the key sites for recovery, and achieve their maximum ecological and cost effectiveness across all scales from local to continental (Holl & Aide 2011). A core element of this in the last decade has been the drive to quantify the value of biodiversity, and measure it in terms of ecosystem services, to facilitate its incorporation into decision-making (Ring et al. 2010; Maes et al. 2012). In parallel, there have been significant conservation efforts to map and quantify the value of wild spaces and wild species in support of their protection (Kuiters et al. 2013; Wilderness Register 2009, Carver et al. 2013). Within the academy, scholars across disciplines have established the importance of wilderness as a key site for endangered species (Soulé 2014), human recreation and well-being (Milner-Gulland et al. 2014), as well as the wider network of ecological processes on which all life depends (Chan et al. 2006).

Yet despite this, the trend of accelerating biodiversity loss continues. Increasing fragmentation of landscapes has significantly reduced the overall amount of wild places globally, as well as the size and connectivity of those remaining un-fragmented wild pockets (Ellis et al. 2010). Fragmentation of habitats impacts negatively on biodiversity and key ecosystem functions, with reductions in biodiversity of up to 75% in fragmented forest habitats (Haddad et al. 2015). The species affected are often those native species which are already listed as vulnerable or threatened (Pfeifer et al. 2017).

European biodiversity targets were established on the basis of an EC commitment to wider international targets under the UN Convention on Biological Diversity. Despite these commitments, it seems very unlikely that they will be met (Tittensor et al. 2014; European Commission 2015; Hill et al. 2015). Of the European Union (EU) national level assessments of Annex I habitats, only 16% are favourable, with most being either unfavourable-inadequate (47%) or unfavourable-bad (30%), with the trend that one-third of the unfavourable assessments are stable, with only 4% improving. In terms of species, under a quarter of EU biogeographical species assessments (23%) are favourable, while more than half are unfavourable (EEA 2015). In spite of these negative trends, a recent vote on the EC biodiversity strategy was overwhelmingly in favour of continuing with the current trajectory (Europa 2016a).

In the 'State of Nature' report, which examined national reporting on habitats and species, 'natural processes' were ranked, based on a summary of national reporting, as one of the key threats and pressures to habitats in Europe (EEA 2015:59). 'Natural processes' here refers to 'vegetation succession, abiotic natural processes and interspecific faunal relations'. Examples of these processes include the natural regeneration of scrub woodland caused by land abandonment and lack of grazing, changes in food webs driven by this regeneration, and predation on livestock by wild species (EINOET 2016).

Creating the necessary conditions to allow natural processes to develop, as opposed to conservation focused on the restoration of specific habitat types, is now one of the core tenets of the re-wilding movement within Europe (Sturm, 1993; Fisher et al., 2010; Jørgensen, 2015). In recognition of the importance of natural processes to integrated environmental management going forward, the German Advisory Council has recently proposed the allocation of 2% of the national land area as wild spaces (German Advisory Council on the Environment 2016). Similarly, the EC's flagship Horizon 2020 research agenda is also investing large amounts of money in a research programme to better understand the multiple benefits of 'nature-based solutions', and how allowing natural processes to take hold can be used to mitigate hydro-meteorological risks (Europa 2016b; IUCN 2016). Wild spaces are attributed the highest levels of protection under the International Union for the Conservation of Nature (IUCN), Protected Area designations. This IUCN system identifies two main attributes of wild spaces: a relatively high degree of ecological naturalness, and the absence of human artefacts and influence (e.g. roads, houses, train lines, etc) (Dudley 2008). The IUCN has recently established a task force on wildness to review the evidence base on the importance of wild spaces and natural processes to landscape conservation. Given this national and international interest, the conservation of wild spaces and species has become popular within the research and conservation communities as a nature-based solution, which has potential as a cost-effective approach capable of delivering multiple benefits at scale and meeting the challenges of accelerating biodiversity loss (Brown et al. 2011; IUCN 2016;). It has been the focus of numerous projects linked to the mapping and management of protected areas and threatened species (Scottish Natural Heritage 2014; Müller et al. 2015; Lorimer et al. 2015).

1.2. Challenges for the conservation of wild spaces and species

Decision-making on the protection of wild spaces and wild species[1] faces, however, a number of problems linked to the wider challenges of conservation. Firstly, it necessarily takes place within complex heterogeneous landscapes which are often fragmented and subject to a wide range of uses, pressures and interests (McShane et al. 2011; Redpath et al. 2015; Pooley et al. 2017). This often brings conservation-focused planning decisions on wildness into conflict with a wide range of other landscape planning, such as for renewable energy (McMorran & Carruthers-Jones 2015; Scottish Natural Heritage 2014). Secondly, historical landscape change means that many of the naturally occurring wild species and habitats are either missing or severely degraded (Jachowski et al. 2015). This process has taken place slowly over multiple generations, and has as a result become accepted as the normal baseline condition of these habitats. A lack of local knowledge about how local landscapes and species compositions have changed over time is a phenomenon often described and explained by the concept of 'shifting baseline syndrome'[2] (Pauly

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[1] See Section 2.2.1 for discussion of complex and contested concepts such as 'wilderness' and 'wild spaces' and definition of the key terms used in this thesis.

[2] See Section 2.2.3 for a discussion of shifting baseline syndrome in conservation.

1995). Conservation initiatives to restore the landscape to its former 'natural' wild condition or reintroduce wild species are more likely to be seen as contentious when this knowledge has been lost (Monbiot 2013). Across Europe, projects focusing on the mapping, protection or restoration of wild spaces and species have as a result proved highly contentious (Lorimer et al. 2015; UK Lynx Trust 2016; T. Lefebvre, personal communication, June 22, 2017).

The mapping of wilderness is undertaken to support effective and spatially targeted decision-making, identifying the remaining wild spaces of importance for humans and the wild species which inhabit them (Lesslie 1996). Yet the mapping of wilderness has proved challenging for a number of reasons.

Firstly, mapping projects are limited by the availability of standardised spatial data with homogenous coverage relevant to the scale of a given map. This means that the mapping is based on a limited set of data sources: primarily, remotely sensed data derived from the processing of reflected light, available from satellites (Potapov et al. 2008). Effective conservation requires a rich, comprehensive evidence base, and there is a paucity of methods to comprehensively and cost-effectively map remaining wilderness areas in order to protect them for future generations (Navarro & Pereira 2015; Carver & Fritz 2016). The predominant tools for mapping wilderness have been expert-led, and have used quantitative techniques to represent wildness as the absence of human infrastructure and human modification of vegetation (Sanderson et al. 2002).

Secondly, the definition of 'wilderness' is itself recognised as subjective, and as a result the landscape attributes which these maps attempt to represent are themselves often contested (Cronon 1995). A diverse range of meanings are attached to the idea of 'the wild', and this is problematic when conservation mapping imposes expert definitions and representations (Jørgensen 2015; Marris 2013).

Thirdly, the final wildness maps produced by these projects are then used by experts to spatially delimit target areas for conservation, and these lines on a map are often in turn also contested, especially when they come into conflict with other landscape uses as described above. This thesis argues that these challenges are exacerbated by the use of top-down remote sensing approaches, which capture neither broad subjective variation in perceptions of the wild, nor local ecological knowledge, nor do they involve local stakeholders.

In order to address these problems, and support improved decision-making on the conservation of wild spaces and wild species, three main solutions are discussed. Firstly, participation in the process of conservation is essential to address the challenges that relate to contested definitions of 'wilderness' and the areas set aside to protect it. Secondly, the use of walking or mobile methods is considered key to both delivering genuine participation in the decision-making process, as well as including human perceptions of wilderness in the mapmaking process. Both these elements address the core challenge facing the conservation of wild spaces and species – its highly contested nature. Furthermore, these immersive methods also allow us to address key issues linked to awareness of how the landscapes we are familiar with have shifted over time. Thirdly, including additional data on wild spaces using novel approaches such as ecoacoustics offers us the chance to improve the way wilderness maps represent both the landscape and our human experience of it. These additional data coming from human perceptions and sound captured *in situ* has a further role in ground-truthing the existing mapping of wild spaces, potentially further helping to resolve their contested nature.

1.3. Research aims and objectives

The overall aim of this PhD is to research methods to address the challenges facing current approaches to the representation and protection of wild spaces and species, thereby developing more integrated and inclusive maps to support improved decision-making on wild land conservation in Europe. The thesis therefore explores the multi-disciplinary challenges inherent in the mapping of wildness (Sections 2.1 and 2.2). It aims to develop a series of disciplinary solutions which could be used to address these challenges (Section 2.3). Taking a transdisciplinary 'integrated' research approach (Tress et al. 2001), it outlines the individual disciplinary methods used, and proposes how they could be linked using a shared 'transect' approach along a gradient of wildness to provide broader insights to improve the mapping of wildness (Sections 3.1 to 3.6). The detailed results from the individual methods are then presented and interpreted individually (Chapters 4, 5 and 6).

Discussing the overall results, the thesis situates the methods conceptually in the place, discussing the use of the 'path' as a transect which integrates the different disciplinary research approaches (Chapter 7). Bringing all of the methods together, it aims to discuss the limitations of the approaches used here, and outlines a collaborative pilot project used to test a possible solution to these limitations

(Sections 7.3 and 7.4). Finally, it explore the results in the wider context of the conservation of wild spaces and species, discussing their relevance and potential applications (Chapter 8).

This PhD project specifically aims to develop integrated participatory mobile methods which involve people in decision-making, and which can capture a broader range of meanings/knowledges from human perceptions *in situ.* The use of participatory methods requires that we understand their advantages and address their limitations, so the thesis also explores the impact of experience and historical knowledge on attitudes to wild spaces and species, specifically the phenomenon of 'shifting baseline syndrome' and how it might be offset (Sections 2.1, 2.3, 5.2 and 8.3).

As part of a ground-truthing component of relevance to the conservation of wild spaces and species, the thesis examines specific methods for integrating the bottom-up project data on human perceptions of wild spaces with existing mainstream remote-sensing approaches to mapping wilderness quality. It also looks at methods that go beyond the visual, applying new methods from soundscape ecology as part of an innovative approach to map human and biophysical aspects of wild spaces and wild species.

The PhD focuses on key representative upland wild areas within Europe as 'living laboratories' within which to explore these methods (Voytenko et al. 2016). These locations are the Scottish Highlands and the French Pyrenees. The aim is that these methods and the linked data could be used both to improve the quality of the maps that we make of wildness, as well as to do this in a participatory way. It presents the findings of this transdisciplinary research within the broader goal of examining the potential of this knowledge for improved decision-making on the conservation of wild spaces and species within Europe.

This project asks the following research questions:

1. How can we capture information to better understand current stakeholder attitudes to wild spaces and wild species? (For methods, see Section 3.4; for results, see Chapter 4).
2. How can human perceptions of wildness be captured *in situ* using mobile methods? (For methods, see Section 3.5; for results, see Chapter 5).
3. What is the relationship between human perceptions of wildness and existing satellite-based data on wildness? (For methods, see Section 3.5; for results, see Chapter 5).

4. What is the impact of immersing people in wild spaces, and of communicating knowledge on historical landscape change, on their attitudes to these wild spaces and wild species? (For methods, see Sections 3.4 & 3.5; for results, see Section 5.2).
5. Can ecoacoustic methods enhance wildness mapping by providing both a productive conceptual framework and a practical method for rapid assessment of both biodiversity and human subjective experience, by including sensory (auditory) information that is not currently mapped? (For methods, see Section 3.6; for results, see Chapter 6).
6. How can these integrated and participatory mapping techniques be developed to support more inclusive and sustainable approaches to the conservation of wild spaces and species? (For discussion, see Chapter 8).

Chapter 2 – Challenges and solutions

2.1 Summary

Wilderness mapping is currently used to support dialogue and spatially explicit decision-making on the conservation of wild spaces and species. In this chapter I expand upon the methodological challenges inherent in the current approaches to mapping wilderness. Spatially explicit mapping of wilderness is discussed as challenging given the history of the term 'wilderness', the range of meanings attributed to the term, and its often contested nature (see Sections 2.2 & 2.3). I discuss how the concept of 'shifting baseline syndrome' is of particular relevance to the conservation of wild spaces and species, and how this might be addressed within the participatory mobile methods (see Sections 2.2.3 & 2.4.3).

I argue that outside of the debates on the meaning of 'wilderness' in the academy, current models, which focus on operationalising the concept in mapping, place too much emphasis on the use of objective, remotely sensed data as a proxy for subjective perceptions of wilderness (see Sections 2.3.2 & 2.3.4). I discuss these models as being over-dependent on data representing the visual attributes of wild spaces and species, to the exclusion of other human sensory modalities. Outside of improvements to the representation of subjective attributes of wilderness, I further suggest that the current mapping models need to better account for more objective ecological landscape attributes, often referred to as 'naturalness' (see Sections 2.2.2 & 2.3.4).

I focus the discussion on literature and methods to measure wilderness that show potential to make maps more representative of our experience of wild spaces, with a particular focus on methods which achieve this in a more inclusive way in order to support more effective decision-making on the conservation of wild spaces and wild species (see Sections 2.4.1 & 2.4.2). Methods from the emerging field of ecoacoustics are discussed, which show potential for capturing information on biodiversity and landscape intactness as well as acoustic dimensions of the human experience of wildness (see Section 2.4.4). I argue, based on this literature, that developing methods to capture a better understanding of human perceptions and attitudes to wild spaces and species would lead to more representative maps of wilderness, and that a co-produced representation of this kind may be less contested, thereby supporting more effective decision-making.

2.2 Challenges in the measuring of wilderness

Walking back down off the hill at the end of the day with a group of research participants in the Scottish Highlands, I asked them to look around and comment on any landscape features which they thought were particularly important in terms of their experience of wildness. In spite of its distance from where we stood, several members of the group remarked on the presence of a large antenna on a far hillside. The most vocal member of the group, who was a mountain guide, was clear in his mind that the visibility of such an object even in the distance made this place feel much less wild for him. Wildness for him was the absence of any visible signs of human impact, a belief calibrated in part by his experiences in remote parts of the Arctic and Alaska. Several members of the group, who hadn't travelled as widely, agreed that for them a wild place, even within the context of Scotland, should really be a place with no visible built structures.

Even when prompted to look for landscape features, the other half of the group hadn't noticed the antenna on the far side of the valley, and were more preoccupied with the perceived natural quality of the ancient Caledonian forest remnants which were close to where we stood. As the discussion progressed one of the group - who lived locally, loved the mountains, and believed quite strongly that a wild place should be a natural place with no signs of human influence - said, "Well, I'm not really bothered about the antenna all the way over there. It doesn't really change my experience of wildness in this place, and anyway, we all love the telly, don't we?"

Even at this one small point in the landscape, a group of six people were experiencing its wildness in significantly different ways. Specific elements of the landscape such as an antenna either did or did not form part of their experience and, even if it did, its meaning for them in terms of wildness could vary. This diversity of experiences highlights some of the potential challenges faced by organisations tasked with protecting and conserving wildness. It is easy to understand why making a definitive map to represent wildness for an entire country, where each square on the map has a fixed value of wildness, could be problematic. It is also easy to understand why using that map to support decisions on the delineation of important wild land areas, or where renewable energy projects which bring money to local economies are located, could be contested.

2.2.1 Wildness as subjective and difficult – the human perspective

This PhD project focuses on developing methods for use in conservation to more effectively map wilderness. In doing so, it is important to take account of the challenges inherent in this task linked to the concept of 'wilderness' itself. The protection of wilderness is a much-debated topic in environmental conservation, with a long history at the national and international level (Muir 1911; Wilderness Act 1964; Lucas 1966; Aitken 1977; Nash 1982). The 'wilderness movement' in North America centred on the strict protection and restoration of wild landscapes and more recently has advocated a cores, corridors and carnivores rewilding approach, orientated around the reintroduction of 'keystone' species at or near the top of the food chain to increase structural and species diversity within ecosystems (Foreman 2004; Soulé & Noss 1998). There has been extensive discussion of the problematic nature of the term 'wilderness' across multiple disciplines within the humanities and social sciences, which have discussed variously the misuse of the 'wilderness' concept in conservation, and the impact on indigenous peoples of pursuing the myth of a pristine nature without human presence (Cronon 1995; Denevan 2011; Marris 2013); the importance of cultural and subjective components in our experience of place (Calicott & Nelson 1998; Lorimer et al. 2015); ethics and politics in the conservation of wilderness (Clapp 2004); the cultural and historical paradox of the term 'wilderness' (Arts et al 2012); the etymology of the term 'wild', and its impact on the rewilding movement (Jørgensen 2015; Prior 2016); and the historical impact of human attitudes to nature and the wild on legal frameworks for wilderness protection (Bastmeijer 2016a).

This PhD project forms part of the 'Wilds' work package within a wider, multi-disciplinary, Marie-Curie funded project, called 'Environmental Humanities for a Concerned Europe', (ENHANCE). Within this work package, the PhD brief was to explore the 'representation and conservation of wild spaces and wild species in Europe.' However, our commonly used terms for themes such as 'wilderness' and 'wildness' evade a simple interpretation or definition (McMorran et al. 2009), and are widely contested, as highlighted above. This thesis focuses on methods for measuring these concepts, rather than on the deeper debates about what they mean. Nevertheless, simple working definitions are a necessary pre-requisite for the task at hand.

A common feature of most definitions of 'wilderness' is that it refers to a place, and a 'wilderness area' necessarily retains the natural state of the environment, is not currently inhabited by humans, and furthermore lacks any visible signs of human influence and impacts (Carver et al. 2002). 'Wildness' as a term speaks to the experience we have in a 'wilderness' area, rather than an actual place. Within the context of mapping, it is often the 'wildness quality' of an area that is measured and then represented in the maps. In the more densely populated European arena, the term 'wildness' is argued to be a less politicised term than 'wilderness', capturing key characteristics such as the presence of 'self-willed' natural processes (Fisher 2019), as well as the smaller size of the remaining intact land areas In Europe as compared with North America (Ward 2019).

Discussions over the definition of terms such as 'wildness', or even the best approach to protecting it, are ongoing and raise questions that go to the heart of the debate about human-nature interactions: For whom are we conserving the landscape? For what purpose? What place is there for local people in a re-wilded landscape? (McMorran et al. 2006; Deary 2016; Hourdequin 2017).

An in-depth discussion of each of these is beyond the scope of this thesis and would be a thesis in itself. However, given the European focus of the PhD and for the purposes of the research that is being presented here, I use three key terms: 'wildness', 'wild spaces', and 'wild species'. 'Wildness' denotes those qualities of the landscape that we experience, the attributes of that landscape that impact on us both via our senses and emotionally; the sense of being far from civilisation that comes from spending time in a natural landscape where there is no evidence of humans, a place where the ruggedness and remoteness of the environment is dominant and even challenging. The term 'wild spaces' is used as a simple description for those areas where wildness is the dominant character of the land and of the experience we have in those places. 'Wild species' are, using the same logic, those animals that live in the 'wild spaces', not just the iconic wild predators such as bears and wolves, but also the smaller creatures such as the mountain hare whose tracks we follow in the early winter snow. Whilst these simple umbrella terms may, as highlighted above, be problematic to some scholars, they are considered appropriate and adequate for the analysis in this thesis.

Given the complex background to the terminology, it is easy to understand why implementing planning decisions focused on the conservation of wildness is considered problematic (Nelson & Callicott 2008; Wynne-Jones et al. 2018). This multiplicity of subjective meanings may result in a given area being valued by one individual for its wildness, while the same area may not be considered wild at all by another (Vistad & Vorkinn 2012). It has been said that 'One man's wilderness is another man's roadside picnic ground' (Nash 1982:1). This difference of opinion can be exacerbated by varying levels of local knowledge on historical landscape change (see Section 2.4).

These arguments often come to a head when trade-offs are necessary, such as when environmental conservation decisions are seen to take priority over economic and social considerations, or vice versa (Steinwall 2015; Jepson 2016). The bulk of wildness areas are to be found in economically less favoured areas, which are often desperate for jobs and investment (Navarro & Pereira 2015). A classic example of this kind of conflict within Scotland is the use of wild land mapping in planning and decision-making on zoning within protected areas, such as assessing the impact of windfarm developments on wild land areas (McMorran & Carruthers-Jones 2015). There is strong evidence, however, that if these challenges can be met, a wide range of social, economic and environmental benefits can accrue from the conservation of wild spaces and species across Europe (Brown et al. 2011; Cerqueira et al. 2015). There is therefore a clear need for research into methods than can improve the ways we measure and represent attributes of the human experience of wildness[3].

2.2.2 Wildness as objective and difficult – factoring in landscape attributes and change

Outside of the debate within the academy on wildness, there has been widespread adoption at the national and international levels of formal criteria, such as the International Union for the Conservation of Nature (IUCN) Protected Area designations, although criticisms have been levelled at them (Shafer 2015; Locke & Dearden 2005). The IUCN Protected Area designations are claimed to offer a standardised system to classify protected areas according to their management objectives, and feature descriptions of the typical distinguishing features for an area of a given category (IUCN 2019). Within this Protected Area framework, Category Ib describes what the IUCN considers to be the two main attributes of wild spaces: a relatively high degree of ecological naturalness, and the absence of human artefacts and influence (e.g. roads, houses, train lines, etc) (Dudley 2008). Whilst these attributes include features of the landscape which speak directly to the human

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[3] For the sake of clarity, and given the European focus of the fieldwork in this project, I refer from now on only to 'wildness'

experience of wildness ('opportunities for solitude; free of modern infrastructure; free of inappropriate or excessive human use or presence'), they are dominated by ecological criteria ('be of sufficient size to protect biodiversity; to maintain ecological processes and ecosystem services; characterized by a high degree of intactness: containing a large percentage of the original extent of the ecosystem, complete or near-complete native faunal and floral assemblages …') (IUCN 2019). This is also reflected in the wider literature, where the idea that natural processes should be restored and protected to sustainably solve conservation problems - a 'self-willed land' (Fisher 2019) - has gained ground (Sturm 1993; Schnitzler et al. 2008; Kuiters et al. 2012; Carver 2016).

Detailed and complete datasets to support the mapping of naturalness at the national scale, which are based on precise information of those plants species which are present, are however missing. Work on the definition of broader ecological attributes which could be measured for wild places, such as the intactness of their natural processes, is a long-term project (Dearden 1989), and operationalising an assessment protocol for use at scale has yet to be achieved (M. Fisher, personal communication, March 5, 2018). There is therefore a clear need for research into methods than can improve the way we measure and represent ecological attributes of wildness.

One further reason why the mapping of wildness is challenging is because historical landscape change means that many of the naturally occurring wild species and habitats are either missing or severely degraded (Scottish Natural Heritage 2002; Fisher et al. 2010). Whilst the idea of restoring the landscape to a specific former 'Garden of Eden' baseline state is both arbitrary and problematic (Breed 2016), the importance of this lies in the fact that these species and habitats are also missing from our human experience of wild spaces (Monbiot 2013; Perino et al. 2019).

One way in which the loss of wild species and habitats has been described is through the concept of 'dark diversity'. Dark diversity attempts to measure the species absent from a habitat area that have historically existed there, or could at least historically have been present, given key factors such as soil type, climate and altitude (Lewis et al. 2016). Work to date on the dark diversity of several geographical areas in Europe has shown that many plant species are missing even though the current habitat could support them (Partel et al. 2013; Ronk et al. 2015; Lewis et al. 2017). The classic example of this in Scotland is the loss of the Caledonian Forest, the extent of which is generally agreed to be perhaps less than 5% of its historical size (Hobbs 2009, Thomas et al. 2015).

Similarly, large carnivores have either been eradicated, or their numbers significantly reduced, from the bulk of their historical range in Europe (Mech 2017). This has led to high herbivore density in countries such as France and Scotland, a situation intensified in Scotland by land estate management practices focused on the creation of sporting estates for hunting (Gordon et al. 2004; Nilsen et al. 2007). Whilst this is now changing (Deary 2016), high grazing pressure has over time negatively impacted the diversity of vegetation as well as tree regeneration, and as a result impacted on bird species densities (Hester 1996: Fuller & Gough 1999; Putnam & Moore 2008).

The importance of large carnivores as keystone species and ecosystem engineers within the animal and plant kingdom is captured by the idea of 'trophic cascades' (Pace et al. 1999; Duffy et al. 2007). 'Trophic cascades' triggered by the reintroduction of an apex predator such as the wolf, have far-reaching trickle-down consequences, impacting positively on plant and insect abundance as well as diversity (Fortin et al. 2005; Ripple & Beschta 2012). The protection and restoration of wild spaces, and the reintroduction of native wild species is of critical importance to stopping biodiversity loss and mitigating climate change (Bakker & Svenning 2018). To facilitate a balanced discussion on wild spaces and species, there is a clear need for research into methods than can offset the impacts of limited knowledge on the missing dark diversity of wild spaces.

2.2.3 Wild spaces and species and 'shifting baseline syndrome'

One key reason for the absence of the full range of naturally present wild plant and animal species, and linked trophic cascades, is because this process has occurred over multiple generations (Thurstan et al. 2015). This gradual process of 'generational amnesia' (Alleway & Connell 2015) results in a widespread belief that the current condition of the landscape is in fact the way that landscape has always been - the normal baseline condition. As a result, the majority of people who live, work and play in wild spaces are unaware of this missing dark diversity, and therefore do not recognise that there is a need to restore the landscape. The impact of this is that people are more resistant to projects which aim to restore and conserve wildness because they do not see the need for them (Bilney 2014). This lack of local knowledge about how local landscapes and species compositions have changed over time is a phenomenon often described and explained by the concept of 'shifting baseline syndrome' (SBS) (Pauly 1995).

SBS is the idea that each generation defines the 'normal' state of the landscape based on their personal experiences, which - considering accelerating biodiversity loss - leads progressively to the acceptance of biologically depauperate landscapes, thereby undermining conservation efforts, especially for wild spaces and species (Kahn 1995; Papworth et al. 2009; Jachowski et al. 2015). The idea of 'shifting baseline syndrome' as a key factor impacting on the success of nature conservation efforts was first developed to explain declines in fish stocks (Pauly 1995). Pauly argues that each generation of scientists bases their restoration targets on fish stock levels and species composition as they were when the scientists started their careers. Given the trend of declining fish stocks and loss of species over time, this results in each generation of scientists basing their evaluations on progressively lower levels of stock and diversity:

"The result obviously is a gradual shift in the baseline, a gradual accommodation of the creeping disappearance of resource species, and inappropriate reference points for evaluating economic losses resulting from overfishing, or for identifying targets for rehabilitation measures."

Pauly 1995:430

It is through this process of generational amnesia that SBS could potentially have a significant effect on local ecological knowledge (Kai et al. 2014). If conservation objectives are based on erroneous reference conditions then there is a strong probability that the limited resources available will be spent 'restoring' the landscape to a degraded condition (Vera 2010; Pitkanen et al. 2016; Guette et al. 2018a). Efforts to tackle shifting baseline syndrome are therefore considered to be urgent and critical for those who aim to use local environmental knowledge as a tool for adaptive management (Fernández-Llamazares et al. 2015). There is a clear research need for the development of participatory method to address the challenges of SBS and support more informed decision-making on wildness conservation (see Section 2.4).

2.3 Challenges in the mapping of wild spaces

In response to rapid landscape change, calls have been made to identify and preserve large extents of the Earth's surface as wild places (Mittermeier et al. 1998).

One key way in which these calls have been answered, across multiple spatial scales, is through the production of so called ‘human footprint assessment’ or ’wild land quality mapping’ (Lesslie 1995; Sanderson et al. 2002; Carver et al. 2012). This approach is predicated on the assumption that by identifying remaining areas of wildness, and those spaces where wild species may still be present, we will be better able to protect and - if necessary - restore them (Wilson 2016). However, the drawing of lines on a map has often led to conflict, and maps of wildness are no exception (Neumann 1998; Spence 1999; Bastmeijer 2016b). Given the complexity of the concept of ‘wildness’ (see Section1.1 above), and the complexity of the social and political context within which its conservation takes place (Redpath et al. 2013), methods to produce spatially explicit representations of wildness are particularly challenging. Maps that represent wildness need to define attributes that meet both the objective and subjective dimensions discussed above, and then spatially categorise the entire landscape according to these attributes, using standardised spatial data with homogenous coverage at the national or even international scale (Orsi et al. 2013).

2.3.1 Wildness mapping as a response to the challenges of conservation of wild spaces and wild species

It has been argued that it is only through the process of making a map that we truly come to understand both the preconceptions involved and the repercussions of its existence (Harley 1989). In order to better understand the practical challenges of representing wildness in support of decision-making on wild spaces and species, I have considered some recent examples of its use in conservation planning.

Wildness maps spatially define wildness quality on a continuum from least wild (e.g. the centre of a large urban conurbation) to most wild (e.g. a remote corner of a mountainous region). An example of this is the Scottish map of wildness quality (Scottish Natural Heritage 2014). The map is made up of a composite of four key layers: perceived naturalness, absence of modern artefacts, rugged or challenging terrain, and remoteness from roads and ferries (Figure 2.1).

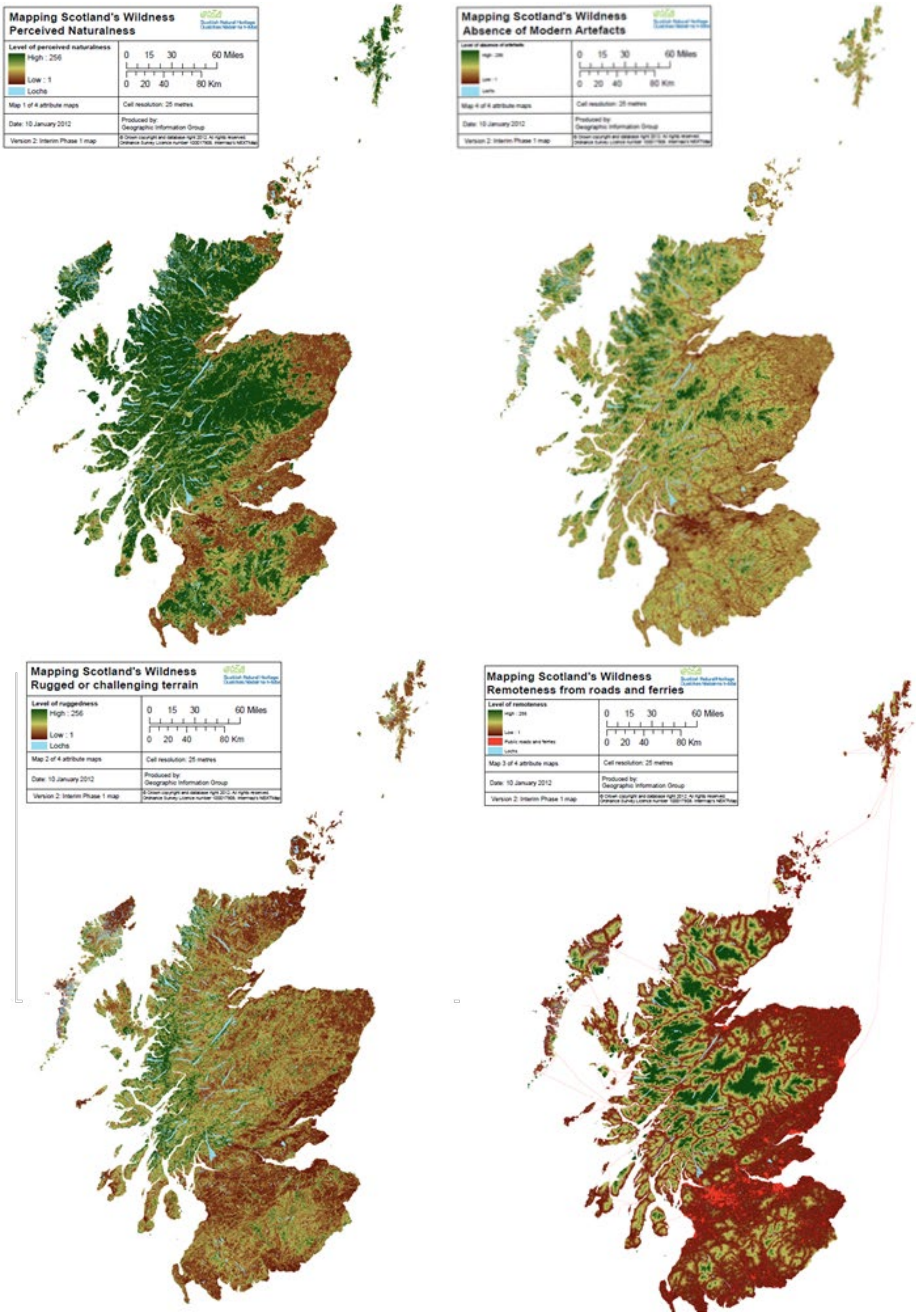

Figure 2.1: Wildness quality component map layers for Scotland. Reproduced with permission from SNH and Steve Carver.

These maps represent wildness using a continuum scale, and respond to the fuzziness of the 'wildness' concept by using a spatially explicit multi-criteria evaluation approach (MCE) which combines a range of datasets on human influence, man-made artefacts and landscape quality into a single thematic map (Comber et al. 2010). Conceptually this process begins with 'raw' data obtained from sensors on Earth-orbiting satellites that capture the light reflected from the Earth's surface. These data are then processed using Geographic Information Systems (GIS) to produce thematic data layers showing buildings or water bodies or habitat types, thereby building up a complete layer-by-layer description of everything that occupies the surface of the Earth (Figure 2.2).

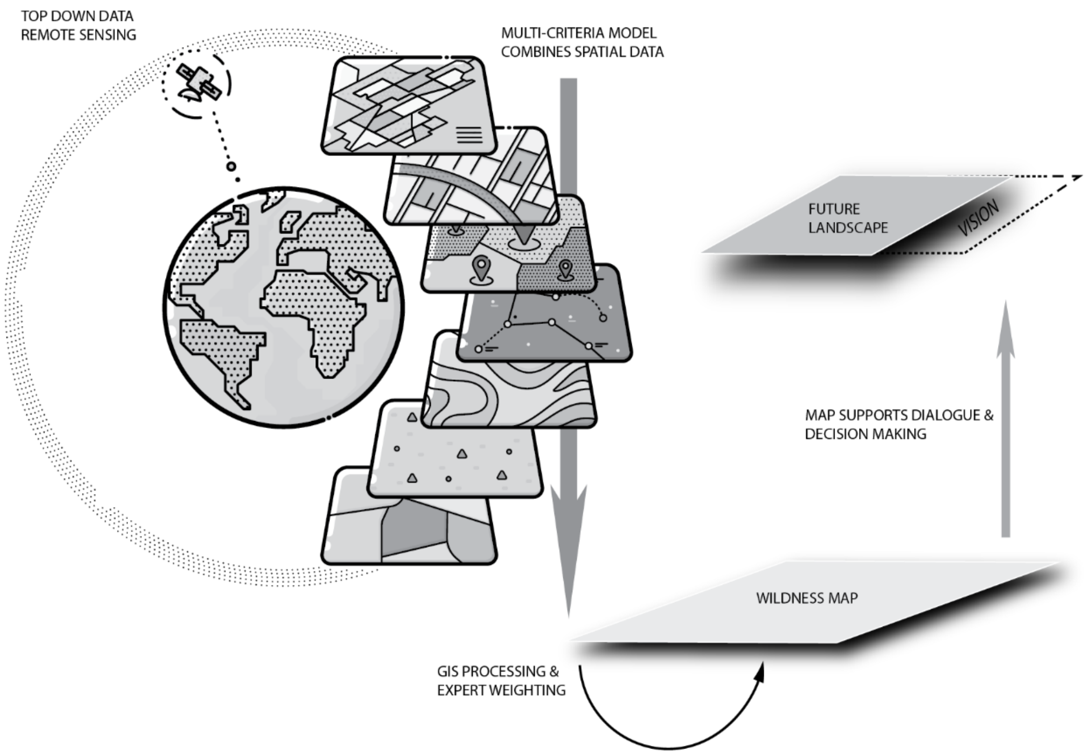

Figure 2.2: Conceptual representation of the process of wildness mapping from remote-sensing data acquisition to desk-based GIS processing using multicriteria-models and expert weighting for use in decision-making on the conservation of wild spaces and species.

This approach has been applied on a wide range of spatial scales across the globe, including the Australian National Wilderness Inventory (Lesslie & Maslen 1995); the Wilderness Quality Index for Europe (Kuiters et al. 2013); the human footprint index at the global scale (Sanderson et al. 2002); the wilder parts of anthropogenic landscapes in Denmark (Muller et al. 2015); the Cairngorm National Park wildness map (Scottish Natural Heritage 2014); and, most recently, a preliminary study on mapping wildness in China (Cau et al. 2019).

At the global level, human influence mapping helps us to understand the importance of our role as the stewards of nature, and to assess the suitability of conservation actions based on the intensity of human influence within the surrounding landscape matrix (Sanderson et al. 2002). Concrete examples of how wildness maps have been used in conservation actions include their role in planning to support decision-making on zoning within national park areas, and assessing the impact of wind-farm developments on wild land areas (McMorran & Carruthers-Jones 2015). In Scotland the maps on wildness quality were used to define a series of wild land areas which are now recognised in national level planning legislation (Figure 2.3).

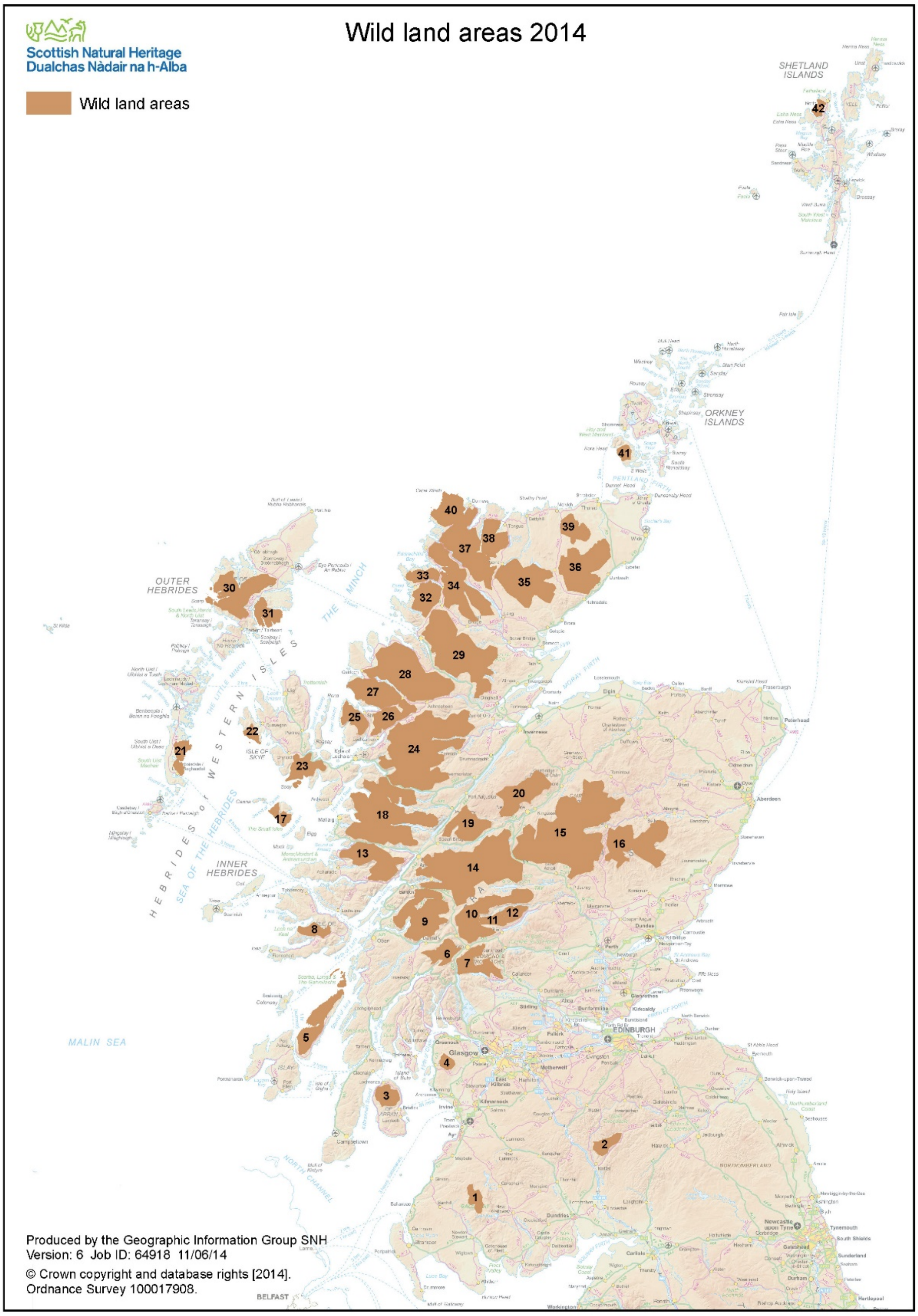

Figure 2.3: Wild land areas in Scotland. Reproduced with permission from SNH and Steve Carver.

The creation of these wild land areas was positively received by conservation organisations such as the John Muir trust but has proved contentious in some sectors where it is argued that they represent a second highland clearance, effectively airbrushing the long history of human occupation of the highlands from the historical record (Warren 2009; McMorran et al. 2014).

In France, a map of the current baseline for landscape naturalness quality is in production (IUCN France 2019). It is also being developed as a fast-track tool to identify those highly natural areas that are not currently protected; and more widely, as a tool to identify where the optimum locations would be to preserve natural process evolution, or to develop re-wilding projects (Guette et al. 2018).

2.3.2 Wildness mapping is difficult because the objective attributes used represent subjective properties of wildness

One reason why the mapping of wild spaces is challenging is that in spite of the significant body of research on the aforementioned wildness mapping methods, questions remain about what attributes these maps show, and whether they accurately represent our experience of wildness (Ólafsdóttir et al. 2016; and see Section 2.2 above). The definition of mapped wildness attributes and linked data categories is usually expert-led, and even when best practice is observed, conservation projects of this kind are open to criticism as the imposition of an establishment point of view (Vuceticha et al. 2018). Even the expert process of defining these objective wildness attributes involves numerous subjective choices about what is considered to be wild or not. Different people - even experts - with varying experiences and cultural backgrounds will perceive the same area differently, as outlined above, even when focused around a specific theme such as forests (Frey et al. 2019; see Section1.1).

The complex nature of 'wildness' as a concept and descriptor means that there is a clear research need to identify methods that go beyond spatially delineating wild spaces using only satellite data and quantitative mapping tools such as GIS. A more diverse approach to mapping wildness is needed to include more of our experience of place and to better reflect the rich, multi-sensorial and subjective reality of how people understand and value wild places as well as their essential ecological attributes (Carver & Fritz 2016).

One way to supplement remote-sensing data is to take advantage of computational advances to include a 'Viewshed Analysis' in the mapping method. This allows cartographers to not only represent a top-down perspective of surface land cover, but also to take account of the more subjective notion of what can be seen from various points at ground level (Carver & Washtell 2012; Sang 2016).

Another proposed solution has tested personalised versions of wildness maps, whereby the importance of a given spatial layer within the mapping model is weighted differently according to the perspectives of an individual (Watson 2008).

Whilst these methods begin to address the way we might incorporate a more human perspective in wildness maps, as well as individual differences in points of view, there is a clear need for novel methodological tools to take this further (see Section 2.4.5).

2.3.3 Wildness mapping is difficult because it is over-reliant on satellite-based data

Another key challenge for the mapping of wildness is that it is based on a limited set of data sources, primarily remotely sensed satellite data derived from the processing of reflected light (see Figure 2.1). Effective conservation requires a rich, comprehensive evidence base, and there is a paucity of methods to comprehensively and cost-effectively map the remaining wild spaces in order to protect them for future generations (Tricker & Landres 2018; Radford et al. 2019; Carruthers-Jones et al. 2019). The use of remote sensing as the primary data source for wildness mapping necessarily excludes attributes of wildness which cannot be measured from space. This top-down data-driven approach increases the importance of the need for ground-truthing and other validation approaches to check the quality of thematic national-scale maps, and to verify that the datasets used at the national scale are a suitable proxy for what they purport to represent on the ground. Ground-truthing data of this kind is recognised as fundamental in many areas of environmental research, ranging from ecology to remote sensing (Nagai et al. 2017; Muller et al. 2015).

One way to address the subjective challenges inherent in mapping wildness, the accusations of expert-led exclusivity, as well as its overreliance on top-down data sources, is the incorporation of participatory methods. The growth of connected societies and the pervasiveness of smartphones has opened up myriad opportunities to incorporate participation, and the potential of social media and online tools has been explored as a scalable method for the classification of landscape character. Examples of this include the crowdsourcing of visitor perceptions of trails in the USA to monitor landscape quality and inform protected area management (Carver et al. 2013), as well as the use of participatory GIS such as Geo-Wiki, which allows individuals to upload their own perceptions of wildness in a given location to a centralised updatable map (See et al. 2015a; See et al. 2015b).

Another approach to supplementing large-scale satellite-based spatial datasets has been the use of public perception surveys, combining landscape photographs and questionnaires, to capture a broader range of perceptions of wild places (Van den Berg & Koole 2006). Land cover categories within a given spatial layer, such as different forest cover types, or the antenna discussed in the Introduction, are given a wildness quality ‘weighting’ in the MCE. This weighting value for a given category is usually derived exclusively from expert opinion, but information from public perception surveys can be used to adjust these weightings (Market Research Partners 2008). For example, if public perception ranks areas covered with native woodland species as more wild than the current expert opinion, then these areas could be given more ‘weight’ in the model, with the result that they are accorded higher wildness quality in the final map.

Whilst such approaches undoubtedly improve the quality of the mapping, these studies are carried out *ex situ* and focus exclusively on visual attributes of the wild landscapes, which limits their value in operational use (S. Brooks, personal communication, August 21, 2019). But MCE model approaches show their potential to facilitate dialogue when used to support decision-making in situations of conservation conflict (Davies et al. 2013).

2.3.4 Wildness mapping needs better data on naturalness, and more than just the visual

In spite of recent advances in the resolution of satellite data, the process of making a map of wildness is still primarily based on the processes described above: using GIS and MCE to reclassify remotely sensed data. This inevitably leads to an overemphasis in the MCE models for wildness on those items which can be accurately mapped from space, such as buildings, roads and topography. Two of the four spatial layers used in the wildness quality map of Scotland relate to human-built structures or distance from them (used as a proxy for ‘remoteness’). A third layer represents topography, on the assumption that the more mountainous a landscape, the more unlikely it is to have been developed or inhabited because of the challenges of weather and terrain. The fourth layer uses broad categories of land cover habitat types as the basis for the spatial layer on the ‘perceived naturalness’ of the landscape. In the final MCE model of wildness, these data layers are often given equal weighting to each other; and because the majority of these layers are constructed using spatial data on human influence, human influence as a result has an overall higher weighting in the final model of wildness than other information such as that on the naturalness of the landscape (see, for example, the IUCN categories in Section 1.1 above). The presence or absence of native wild species, or the naturalness of the landscape (see Section 1.1 above), cannot currently be measured from space (ZSL 2016). Key properties of wild spaces are therefore necessarily absent from these top-down data-driven models.

The use of symbology in mapping has a significant impact on how we understand and use maps (Bertin 1983). Based on this composite MCE model, the final map of wildness quality is usually scaled from a reference point of complete human impact (a major city) towards ever reducing human impacts, increasing wildness and perceived habitat naturalness. Such analysis assumes that as human impacts increase, then *a priori* ‘naturalness’ must decrease, an idea often referred to as ‘hemeroby’ (Grabherr et al. 1992; Walz & Stein 2014) (Figure 2.4).

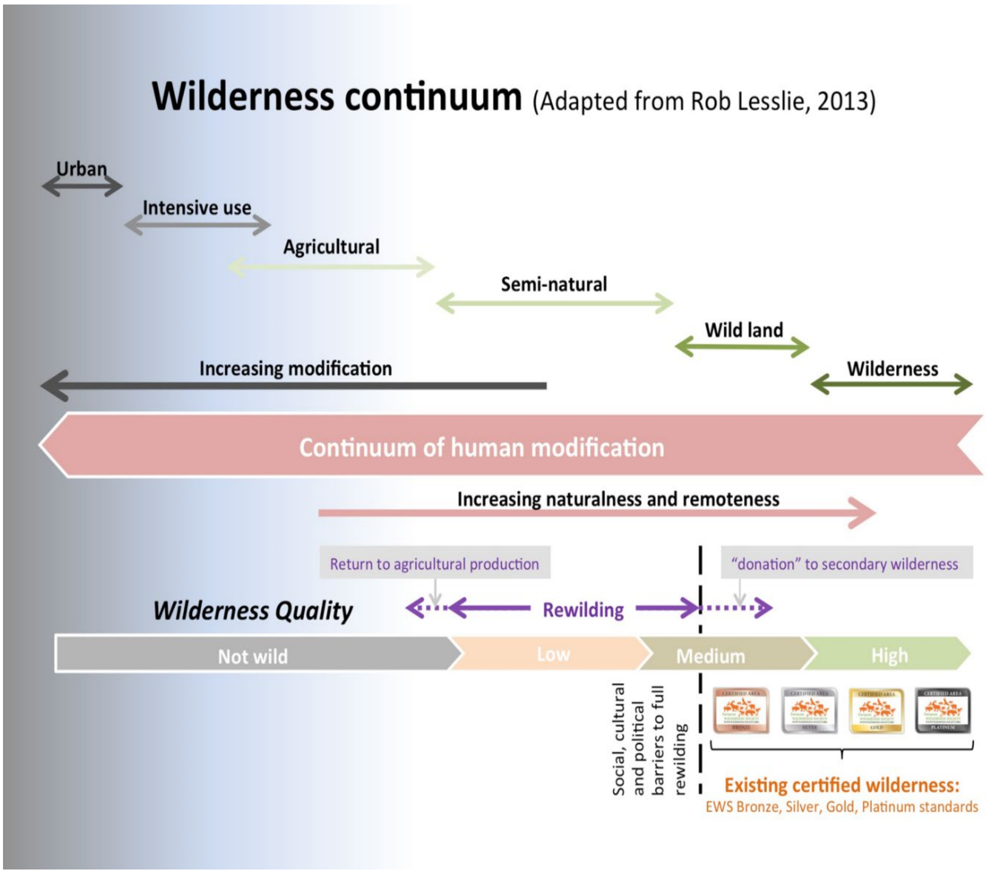

Figure 2.4: The wilderness continuum. Figure courtesy of Steve Carver.

As a result of these data and methodological challenges, wildness maps struggle to differentiate between areas such as undisturbed natural forest and managed forest of the same habitat type or species (Guette et al. 2018a). In order to go beyond methods based on remote-sensing, data are required on how long an area has remained unmanaged, or *in situ* surveys such as how much dead wood is present, as well as surveys of bio-indicators such as particular wood-decaying fungi/beetles, or other indicator species unique to undisturbed areas which are not detectable from space (see, for example, Rossi & Vallauri 2013; Savoie et al. 2015). The time-consuming nature of collecting accurate data of these types means that they are currently available only for limited areas, it is difficult to scale, and the associated costs prohibit creation of larger scale maps, whereas it is precisely at the national level that maps are often conceived and required. Where such initiatives are underway, such as the CARTHAB map of France, they are multi-million euro projects estimated to take decades (G. Largier, personal communication, March 12, 2018). There is a clear research need for scalable bottom-up methods that can measure attributes of wild spaces not currently detectable using remote-sensing approaches based exclusively on light reflected from the earth's surface (see Section 3.6).

2.3.5. Overall summary of challenges to measuring and mapping wildness

In summary, there are many problems in making decisions regarding conflicting and competing land uses in wilder areas. One of the main challenges facing decision-making on wild spaces and wild species is that the very definition of 'wildness' is itself recognised as subjective; and as a result, the landscape attributes which these maps attempt to represent are themselves often contested.

Secondly, conservation takes place in landscapes with a complex matrix of competing and often conflicting land uses, which have changed significantly even in recent generations, let alone over longer timeframes. This situation is aggravated by the fact that wildness mapping methods are currently over-dependent on expert opinion and remotely sensed top-down data on visible signs of human influence, at the exclusion of other people's knowledge and other ways of measuring wildness. I argue that this creates significant theoretical and technical challenges for the production of thematic maps as accurate representations of wildness, which are also meaningful for a wide range of people, hindering their utility as a basis for either community-backed conservation initiatives or national-level legislation and planning.

2.4 Solutions to challenges: mobile methods and beyond the visual

In order to address these problems, and support improved decision-making on the conservation of wild spaces and wild species, three main solutions are discussed: broader participation in the mapmaking process; the use of mobile walking methods to achieve this; and the inclusion of acoustic landscape data to better capture the human experience of wildness, as well as ecological attributes such as naturalness.

2.4.1 Participatory stakeholder processes

One way in which we can address the challenge of subjectivity, both in terms of defining wildness and the attributes we use to spatially represent it, is by exploring methods embracing public participation. It is argued that using participatory methods would result in a broader ownership of the final mapping output, thereby making them less contested (DeLyser & Sui 2013). The participatory generation of scenarios for landscape futures emerged at the turn of the century as a key tool for landscape conservation (Peterson et al. 2003). The integration of local and scientific knowledge can increase the diversity, detail and precision of these future landscape scenarios (Reed et al. 2007; Raymond et al. 2010).

The European Landscape Convention (ELC), for example, recognizes the complex interactions between social, economic and environmental factors in landscape conservation, which must all be reconciled if the benefits from approaches such as re-wilding are to be delivered (Council of Europe, 2000). In response to this, and in recognition of the importance of involving local people if conservation is to succeed, European-funded conservation actions under the LIFE environment programmes require significant participatory involvement of local stakeholders to deliver the aims of the ELC (LIFE 2016). This is based on a significant body of research that has shown that to understand complex environmental factors, monitor environmental change and deliver effective conservation requires integrated approaches, based on local participatory stakeholder processes, including participatory scenario planning (PSP) (see, for example, Fraser et al. 2006; Reed 2008) (Figure 2.5).

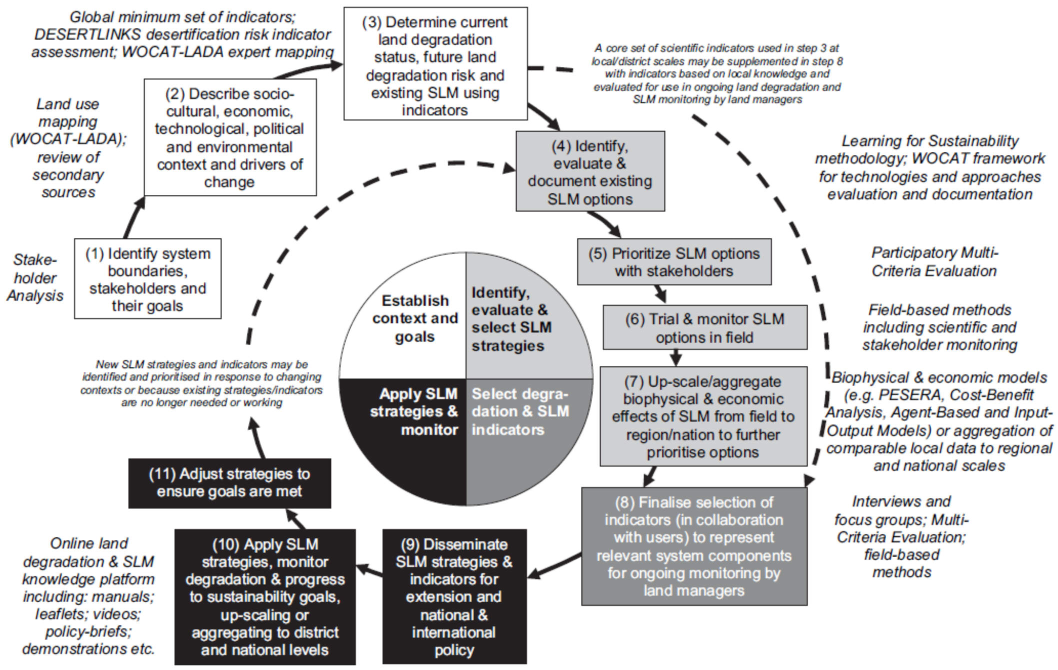

Figure 2.5: Conceptual framework for best practice in PSP land degradation and sustainable land management monitoring and analysis (Reed et al. 2011:266).

Building a common vision through participation is argued to increase the cost-effectiveness of biodiversity conservation (Reyes et al. 2019). This PSP approach has been widely adopted as the recommended method to support the delivery of both international and European biodiversity targets (EU Commission 2011;CBD 2016).

Advice to the German government on achieving the 2% wild spaces target (see Section 1.1) has highlighted the need for a better understanding of the process of identifying suitable areas, and the importance of a participatory dimension to this (German Advisory Council on the Environment 2016). The proposal is to preserve 7,000 km² of the German landscape where natural processes themselves are protected:

> *“The search for suitable wilderness areas should, from the outset, be a participatory process involving all key stakeholders which is open as to its outcome process and its stated intention to develop all of this at the local level with local people”*

(German Advisory Council on the Environment 2016:12-13)

This highlights a clear operational need for robust, repeatable and spatially explicit participatory methods to support conservation decision-making on the protection of wild spaces and species (Watson et al. 2015).

2.4.2 Mobile methods

The use of walking or mobile methods is one possible way to capture data on wild spaces and species beyond remote sensing, on-line participation and desk-based studies. Mobile methods offer a genuine opportunity for participation in the decision-making process, as well as including human perceptions in the mapmaking process (DeLyser & Sui 2014; Alaimo & Picone 2015). Methods of this kind offer a way to share decision-making, and they show potential for dealing with 'wicked' problems such as the conservation of wild spaces and species (Mason et al. 2018).

The use of walking methods or mobile methods to research people's attitudes to place has grown markedly in recent decades as a key research tool for capturing data relating to people's experience, knowledge and attitudes to surrounding landscapes (Macpherson 2016; Vergunst & Ingold 2008). They have been used to capture a range of attributes, including cultural values for wild land areas (Holden 2013). Capturing stakeholder attitudes to landscape may be most accurately performed in the field, in spite of the challenges this brings (Scott et al. 2009). Walking research offers an intuitive and compelling means of studying human relationships with landscape and place (de Certeau 1984; Pink 2007; Edensor 2008). It also offers a more grounded and neutral context in which to communicate our experiences and perceptions which is less encumbered by sociocultural politics and the expert/non-expert dichotomy (Pink et al. 2010; Irving 2007). Mobile methods of this kind are therefore considered as attractive tools to support landscape conservation efforts, especially for protected areas management (Beeco & Brown 2013; Plieninger et al. 2015) (see Section 1.2 above).

When walking methods involve walking interviews, they have been found to generate deeper place-based narratives than sedentary research practices, particularly in terms of narrative 'quantity and spatial specificity to the study area' (Evans & Jones 2011). *In situ* participatory methods of this type could potentially be used to ground-truth the standard multi-criteria analysis approach used by all current wildness mapping initiatives. Spatially explicit bottom-up data from *in situ* landscape assessments could, for example, be added as additional data layers in the MCE to deliver a hybrid model. However, most structured approaches to walking methodologies have focused on urban zones and have been led by architects with a focus on urban planning (Middleton 2018; Pierce & Lawhon 2015).

A key challenge emerging from this walking methods approach remains how this fine-grained local qualitative knowledge can implemented in a structured way so as to allow comparison between individuals and across sites. Combining mixed methods, such as spatial data and perceptions of place, shows great promise to advance understanding of the complex interactions between society, environment and place in modern conservation approaches (Yeager & Steiger 2013; Larkin & Beier 2014; Zia et al. 2015). An outstanding methodological challenge remains: how the resulting rich qualitative data that comes from these mobile methods and public participation could then be combined with the more structured quantitative data available from remote sensing which forms the bedrock of current wildness mapping approaches (Fuller & Kitchin 2004; Flanagan & Anderson 2008).

2.4.3 Addressing methodological challenges to the risk of participation

Participatory methods place emphasis on local ecological knowledge as the basis of resilient and sustainable landscape planning (Turnhout et al. 2012; Gómez-Baggethun et al. 2012). I have argued above that the impact of ‘shifting baseline syndrome’ (SBS) on local ecological knowledge has the potential to limit the effectiveness of conservation actions (Manning et al. 2006; Ban et al. 2014; Fernández-Llamazares et al. 2015) (see Section 2.2.3 above). The importance of factoring in historical knowledge and spatial data is considered crucial if conservation initiatives are to avoid the consequences of SBS and achieve their stated conservation goals (Pindozzi et al. 2016). Generational amnesia is argued to reduce the value of local ecological knowledge, and leads to conservation planning based on incomplete knowledge (Ban et al. 2015). There is therefore a fundamental tension between using participatory methods and overcoming shifting baseline syndrome. This creates a fundamental challenge to the utility of participatory mechanisms, because they can create situations where long-term ecological changes, such as the loss of habitats and species, are not considered in conservation.

To give one concrete example, within the EU Annex I, grassland habitat areas are restored in preference to highly natural marsh areas on the perceived assumption that the grassland areas are natural, when historical analysis shows they are actually the product of anthropogenic influences (Godet & Thomas 2013). These issues are especially problematic given the current ‘breathless celebration of the transformative potential of participation’ (Chilvers & Kearnes 2015:13).

The impact of generational amnesia is likely to be particularly marked with regard to the protection of wild spaces and wild species which are, respectively, often lost or extinct. In an upland conservation context this appears to lead to a predominance of future land use scenarios and conservation objectives closely based on the present state of the landscape (Reed et al. 2013). This poses two significant challenges to the success of conservation of wild spaces and wild species going forward:

1) This loss of knowledge makes it significantly more likely that when the suite of possible scenarios or conservation objectives for landscape conservation is developed in PSP, either the stakeholders will not consider habitats and species for which local memory has been lost, or they will mistakenly focus on preserving ‘natural’ habitats which are in fact highly modified (Godet & Thomas 2013).
2) The PSP will actually serve to reinforce this loss of knowledge by establishing reference baselines for monitoring progress relative to the current ‘normal’ condition of the local environment, which excludes these forgotten native habitats and species.

There is a clear research need for methods to help us better understand the effect of SBS and generational amnesia on attitudes to the conservation of wild spaces and species (RQ4). Methods which provide information on historical landscape conditions and immersion in wild spaces may have potential to address this. Research on wildness experience programmes in the USA has shown both that they increase participants’ preferences for wildness experiences, and that they have positive long-term effects (Gillet 1991; Gass 2003; Lindley 2005).

2.4.4 Including other data types: from integrated mapping to ecoacoustics

I have argued that there is a clear need for bottom-up scalable methods to capture data on landscape condition of relevance to wildness mapping (Pettorelii et al. 2018) (see Section 2.2.2). There is a corresponding need for methods that can capture other attributes of wildness which have meaning for our subjective experience of those places (Pheasant & Watts 2014) (see Section 2.2.1). Furthermore, if wildness maps are to provide ‘an effective means of holistically encapsulating the landscape’

(Sang 2016:84), then they need to expand upon a single sensory channel. Recent developments in ecological science (Pijanowski et al. 2011), ethnography (Pink 2015) and geography (Prior 2017; Paiva 2018) highlight the importance of the acoustic environment as a significant component in both ecological function and experience of landscape. It is proposed that methods which can measure the acoustic dimension of our wildness experience could also provide a valuable means to facilitate rapid ecological assessment of wildness at scale (see Section1.2).

Within the emerging discipline of ecoacoustics (Sueur & Farina 2015), there is increasing interest in acoustic methods for biodiversity appraisal from researchers, managers and policymakers alike. Ecoacoustics understands the acoustic environment, or 'soundscape' (Pijanowksi et al. 2011), as a resource, and therefore as a source of information about ecological status - the soundscape being structured through evolutionary processes, akin to other niche construction processes. Based on the assumption that computational analyses of acoustic recordings therefore provide a biodiversity proxy, an ecological machine listening is emerging, dubbed Rapid Acoustic Survey (Sueur et al. 2008).

Over 60 computational acoustic indices (AIs) have been proposed and evaluated to date (Buxton et al. 2018), and have been variously shown to map spatial heterogeneity (Bormpoudakis et al. 2013), reflect observed changes in habitat status (Kasten et al. 2012) and biocondition (Eyre et al. 2015), and to strongly predict species richness across a wide range of terrestrial (Eldridge et al. 2018; Boelman et al. 2007) and aquatic habitats (Bertucci et al. 2016; Harris et al. 2016). The increasing power and decreasing cost of hardware makes acoustic survey comparable to satellite monitoring in terms of scalability in space and time, but it has the benefit of providing high-resolution data which intimately reflect the real-time dynamics of populations *in situ*. Acoustic survey is a highly attractive solution for large-scale ecological monitoring, especially in remote locations such as wild spaces, because it is non-invasive, obviates the need for expert aural identification of individual recordings, is potentially sensitive to multiple taxa, and scales cost-effectively (Sueur et al. 2008).

As well as providing cost-effective monitoring methods, ecoacoustics offers a valuable conceptual framework to integrate biospheric and anthropogenic perspectives. Following Odum's (1963) classification of broad ecosystem components, elements of the soundscape are described according to their source: 'geophony' denotes the sounds made by abiotic processes (wind, rain, etc.) in the landscape; 'biophony', the sounds of animals; and 'anthrophony', the sounds of humans (Pijanowksi et al. 2011). Increasingly the term ‘technophony’ is replacing ‘anthrophony’ (Gage & Axel 2014) as it is considered to be more useful in order to refer specifically to the noises of man-made, electrically powered machinery, which is distinct in terms of its acoustic signals and resulting impact on soniferous species communication.

The soundscape is therefore a site of rich interaction between processes of the lithosphere, the biosphere, the hydrosphere and the anthroposphere. Machine listening of this kind provides a means to listen to and interpret these interactions. In terms of wildness, soundscape components provide descriptors for auditory correlates of existing wildness mapping attributes (e.g. distance from road), and a unified framework within which to consider facets of biodiversity and human experience which are currently absent in wildness quality mapping and therefore excluded in decision-making.

While public participation surveys to support wildness mapping have, for example, completely neglected the acoustic dimension of wildness (Market Research Partners 2008), there is increasing interest in acoustic methods from researchers, managers and policymakers alike (E. Sourp, personal communication, January 11, 2017; K. Frediani, personal communication, October 15, 2018; Farina 2019). A new direction for wildness mapping is proposed by investigating the potential for ecoacoustics as both a conceptual framework and a monitoring method to integrate human and ecological perspectives with the current geophysical mapping schema. Within the stated research goal of RQ5, I explore the potential of ecoacoustics for wildness mapping using the following questions:

1) How do AIs differ along a gradient of mapped wildness categories?

2) What is the relationship between AIs and a) wildness categories and b) human subjective perceptions of wildness and biodiversity?

3) Do AIs predict a) wildness quality and b) human perceptions of wildness and biodiversity?

2.4.5 Solution summary: spatially explicit mobile methods and ecoacoustics

I have argued that we need improved methods to measure and map wildness in support of decision-making on the conservation of wild spaces and species. These methods need to address the subjectivity of the term ‘wildness’ (see Section 2.2.1), as well as capture information of relevance to geophysical attributes of wildness which are not currently measured (see Section 2.2.2). Ideally, they would also provide insights into the particular challenges of the conservation of wild spaces and wild species linked to shifting baseline syndrome and generational amnesia (see Section 2.2.3).

These methods should allow MCE models of wildness to be more accurately weighted by integrating non-expert perceptions of wildness (see Section 2.3.2), address their overdependence on remotely sensed data (see Section 2.3.3); and be sensitive to non-visual attributes of wildness (see Section 2.3.4).

I propose that these research needs could be addressed using spatially explicit, mobile participatory methods, linked to the existing maps of wildness (see Section 2.4.2). These immersive mobile methods may have the potential to address the challenges of generational amnesia on local knowledge in relation to wild spaces and species (see Section 2.4.3). Integrating these mobile methods with additional bottom-up data, using the methods of ecoacoustics, offers potential to improve the way we both measure and represent ecological and experiential data of relevance to wildness (see Section 2.4.4). Researching methods that can capture these additional data on human perceptions and sound, especially if captured *in situ* and spatially linked to existing maps of wildness, has a potential role in ground-truthing the existing mapping of wild spaces, which may contribute to resolving their contested nature.

Based on this review of problems and potential solutions, five key research questions were developed, as listed in Chapter 1. These are mapped onto research problems and solutions in Table 2.1 below.

Table 2.1: Research challenges, proposed solutions and linked research questions.

CHALLENGES	SOLUTIONS	RESEARCH QUESTIONS	RESEARCH METHODS SECTIONS	RESULTS FROM METHODS
Subjectivity of the term ‘wildness’ (Sect. 2.2.1)	Mixed-methods and participatory methods linked to the existing maps of wildness (Sect.2.4.1 & Sect.2.4.2)	**RQ1** - How can we capture information to better understand current stakeholder attitudes to wild spaces and wild species?	Chapter 3 Section.3.6	Chapter 4 Chapter 7
Subjectivity in mapping of wildness (Sect.2.3.2)	Participatory mapping in situ (Sect.2.4.2)	**RQ2** - How can human perceptions of wildness be captured in situ using participatory mobile methods?	Chapter 3 Section.3.3 Section.3.4 Section.3.7	Chapter 5 Chapter 7
Limited consideration of non-expert perceptions in maps of wildness (Sect. 2.3.2)	Spatially explicit participatory methods, linked to the existing maps of wildness (Sect.2.4.2)	**RQ3** - What is the relationship between human perceptions of wildness and existing satellite-based data on wildness?	Chapter 3 Section.3.3 Section.3.4 Section.3.7	Chapter 5 Chapter 7
Challenges to conservation of wild spaces and species linked to SBS (Sect.2.2.3)	Immersive mobile methods (Sect.2.4.3)	**RQ4** - What is the impact of immersing people in wild spaces, and of communicating knowledge on historical landscape change, on their attitudes to these wild spaces and wild species?	Chapter 3 Section.3.6	Chapter 5 Chapter 7
Limited geophysical attributes of wildness measured (Sect.2.2.2) Overdependence on remotely sensed data (Sect.2.3.3) Absence of non-visual attributes of wildness (Sect.2.3.4)	Ecoacoustics methods to measure ecological and experiential data of relevance to wildness (Sect.2.4.4)	**RQ5** - Can ecoacoustic methods enhance wildness mapping by providing both a productive conceptual framework and a practical method for rapid assessment of both biodiversity and human subjective experience?	Chapter 3 Section.3.8	Chapter 6 Chapter 7
Difficulty of involving people in decision making (Sect. 2.3.1)	Spatially explicit inclusive methods linked to conservation challenges (Sect.2.4.1-3)	**RQ6 -** How can these integrated and participatory mapping techniques be developed to support more inclusive and sustainable approaches to the conservation of wild spaces and species?	Chapter 3 Section.3.6 Section.3.7	Chapter 8

Chapter 3 – Research Methods

".. this nonsense of physiology does not really explain it all…there is more in the lust for a mountaintop than a perfect physiological adjustment. What more there is lies within the mountain. Something moves between me and it. Place and a mind may interpenetrate til the nature of both is altered. I cannot tell what this movement is except by recounting it"

Shepherd 1977:8

3.1 Summary

Based on the review of challenges and potential solutions for mapping wildness (Chapter 2), I propose a mixed-methods approach which could address these challenges. I outline a theoretical framework which can accommodate the multi-disciplinary nature of these methods, link the results of the different methods, and explore how they relate to the existing maps of wildness (see Section 3.2).

Methods are proposed and described which can address five of the key research questions. The research methods contain three key elements 1) novel, spatially explicit approaches for capturing a wider range of knowledges on attitudes to wild spaces and species (RQ1, see Section 3.6.1); 2) participatory mapping of human perceptions of wildness *in-situ* (RQ2, see Section 3.7); 3) analysis of how human perceptions of wildness relate to existing remote-sensed mapping (RQ3, see Section 3.7); 4) methods to test how the experience of immersion in wild spaces impacts on attitudes and preferences to the conservation of wild spaces (RQ4, see Sections 3.6.2 & 3.6.3); 5) a novel implementation of ecoacoustic methods to capture hitherto neglected sensory components of wildness, and explore how the results of this approach compare with current wildness mapping, as well as human perceptions of wildness (RQ5, see Section 3.8).

3.2 Overall methodological approach

This PhD project was part of a wider European Commission Marie Curie-funded project on the environmental humanities: Environmental Humanities for a Concerned Europe (ENHANCE). The wider Marie Curie project placed an emphasis on the need for project members to pursue interdisciplinary research to meet pressing environmental challenges in Europe.

The use of methods from a range of disciplines, deployed in an iterative and participatory manner, is deemed necessary to address the complex ‘wicked’ environmental questions facing modern societies (Balint et al. 2011; Palsson et al. 2013; Palmer et al. 2016). ‘*Wicked problems can be difficult to define, with different stakeholders perceiving varying versions of the same problem based on their differing values and ideologies*' (Laurance et al. 2012:165). The challenges described in Chapter 2 suggest the mapping of wildness in support of the conservation of wild spaces and species is a classic example of a ‘wicked’ problem. The review of the challenges facing the mapping of wildness revealed insights into the problem from across a range of disciplines (see Sections 2.2, 2.3 & 2.4). It was also clear that the types of knowledge and data that could answer these challenges would necessarily be both qualitative and quantitative (Sui & DeLyser 2012).

In order to explore solutions to address the challenges, I did not seek methods to answer the research questions from within a single discipline. Instead I selected methods on the basis that they had the potential to capture knowledge and data to address the challenges and answer the research questions. The mixed research methods described here have their origins in a range of disciplines from human and physical geography, visual anthropology, biology and psychology.

A key challenge for research of this kind is how to integrate knowledge and data coming from multiple disciplines in a way which addresses the problem at hand (Tress et al. 2001). Multi-, inter- and transdisciplinary (MIT) research projects aimed at addressing contemporary social and ecological problems may best be referred to as ‘integrated projects’ (Stock & Burton 2011:1091). This approach combines the rigour and integrity that comes from the use of individual disciplinary methods and knowledge, with the holistic transdisciplinary perspective emerging from a wider framing. In spite of the appeal of this approach, there are significant barriers to implementing it, not least of which is that 'The world has problems, but universities have departments' (Brewer 1999:328), a harsh reality which faces early-career researchers (Haider et al. 2018). If we can reach agreement on the meaning of ‘transdisciplinarity’, it holds great potential to support research on the environment of practical relevance to solving complex challenges in the real world (Frescoln & Arbuckle 2015; Bendito & Barrios 2016; Luthe 2017; Sakao & Brambila-Macias 2018).

I address this potential in the current project in several ways. Methodologically, given the focus on wild spaces, as well as the need to offset the dominance of remote sensing in wildness mapping, I situated the research methods in the place. A place-based research approach is recommended in situations which involve a complex range of human and ecological factors such as we see in the conservation of wild spaces and wild species (Clark & Dickson 2003; Liu et al. 2007; Cutter et al. 2008; van Vliet et al. 2015) (see also Section 2.4.2). This creates a space within which each disciplinary approach can be explored in its own right in line with best practice for that specific discipline.

I argue that when these methods are structured around a shared, spatially explicit landscape element, this also provides a methodological framework within which results coming from each approach can be analysed and integrated. This project uses a path or 'transect' along a gradient of wildness (low to high) as this shared structuring element. A transect-based approach has been found to be a useful analytical method and research tool to explore contested issues in relation to urban and landscape planning (Talen 2002; Moccia & Berruti 2018). It has also been argued that the transect provides a site for the construction of knowledge via the vertical integration and analysis of lateral data coming from different disciplinary approaches used along the same transect (Ingold 2011) (see Chapter 7 for further discussion).

I describe below the methods used to design and implement a transect along a continuum of wildness as a shared methodological approach (see Section 3.5 to Section 3.7), and I discuss in detail the value of this approach to transdisciplinary research on wildness in relation to the combined disciplinary results in Chapter 7. Epistemologically, this mixed-methods approach has its origins in pragmatism (James 1912). Mixed-methods research of this kind is predicated on a recognition that no single disciplinary lens can generate the knowledge required to deal with the complex nature of the question at hand (Biesta 2010). The 'wicked' nature of the problem requires a research approach where the methodological tools and their results can be integrated in an attempt to triangulate in on the knowledge required (Tashakkori & Teddlie 2010). The research is also focused on action, testing methods to measure wildness *in situ,* with specific consideration of how these might be operationalised in conservation (Johnson et al. 2007).

Given the need to explore the potential of these methods to support conservation practice, this theoretical framing and the linked methods were also discussed with, and feedback given by experts in conservation research and practice including: the Wildland Research Institute; Scottish Rural College; the Centre for Mountain Studies; James Hutton Institute; Scottish Natural Heritage; University of Nantes; IUCN France; Nature Occitanie; Ligue pour la Protection des Oiseaux; and Pyrenees National Park. Overall this was considered to be a logical research approach with potential to capture knowledge and data of practical relevance to the challenges at hand.

3.3 Study sites

A further consideration arising from the Marie Curie project was the need to develop research of relevance across Europe. This is of course challenging for a solo researcher, but I felt that this could be most practically addressed by using two field study sites, representative of the key issues affecting wild spaces and wild species in Europe. Given the time available under the Marie Curie ENHANCE project (three years funded), I also sought locations where there were pre-existing reference projects and data available on the representation and mapping of wildness. I finally chose France and Scotland as focal countries for the research because a study of the existing literature, and discussion with specialists from the Wildland Research Institute and IUCN France, suggested that these two areas well capture the diversity of debating challenges facing the protection of wild spaces and wild species in Europe (S.Carver, personal communication, October 13th, 2015; T. Lefebvre, personal communication, December 5th, 2015).

The Scottish Highlands and the French Pyrenees are both mountain regions well known for their wild spaces and wild species, and both areas are currently dealing with the challenges of protecting them. In Scotland, wildness is considered an important landscape attribute, for both tourists and local residents, and Scottish legislation now requires that the planning process includes consideration of the impact of any proposed project on the wild land quality of that location (Scottish Government 2014). In spite of this formalisation of wildness, the debate in Scotland on the protection of wild spaces has been heated, and several planning proposals have been contested, some resulting in legal tribunals (Scotsman 2014). A further debate rages about potential positive and negative aspects of reintroducing extinct wild native species such as the wolf or the lynx (see, for example, Hetherington 2018).

In France, whilst there is no current legislation which directly addresses the protection of wild spaces, there is legislation designed to protect and improve natural areas, as well as the landscape connectivity of key areas for the movement of wild species (French Government 2019). The reintroduction of bears to the Pyrenees by the government has sparked a fierce reaction amongst local farmers and the hunting community (Piédallu et al. 2016; Gastineau et al. 2019). The return of the lynx and the wolf to areas of eastern France has produced similarly heated debates (Trouwborst 2010).

These conflicts have led to a reticence within the conservation community to use the term 'wildness', and a preference for a landscape approach focused on the conservation of 'naturalness' (X. Escute, personal communication, February 25, 2017). The French committee of the International Union for the Conservation of Nature established a working group to explore the potential for protecting highly natural and intact ecological areas, but this process has yet to result in official government legislation. Whilst both countries interpret 'wildness' or 'naturalness' slightly differently, discussions have revealed that many of the same themes are present in both locations, as such, shared concepts and methods could be used in both sites (H.Deary, personal communication, November 6th, 2015; M.Price personal communication, November 5th, 2015). Underlying the debate in both countries is a degree of conflict between those who want to protect wild or natural spaces, and those who see this as a barrier to necessary economic development in impoverished rural areas (Schnitzler et al. 2008; Deary & Warren 2017; Burton et al. 2019).

Therefore, I located the research fieldwork at a series of place-based study sites in France and Scotland. At each of the sites I organised a research day with the specific goal of using a multi-disciplinary approach to capture attitudes to wild spaces and wild species. The first part of this research day consisted of a photo-based task and questionnaire to assess participants' current attitudes to wild spaces and wild species (RQ1). The bulk of the day then involved a five-hour walk along a continuum of wildness from a small urban area into a remote, wild area, during which participants conducted a landscape assessment task (RQ2 & RQ3). After returning from this walk, participants completed a second round of questions with the aim of understanding any possible impact of the research walk on their attitudes (RQ4).

Whilst it was challenging to complete all of the human participant research and walking methods within a single day for each group, I decided that this was the most realistic way to complete the research, given that a) participants were expected to travel to remote areas, and b) one of the research questions was interested in the idea of immersing participants in wild spaces.

As part of addressing the research goals of capturing additional data on wild spaces (RQ5), I also deployed automatic sound recorders along the same walking transects for a period of a week.

Given, in particular, the research questions on mobile methods for participatory mapping (RQ2), the goal of exploring how human perceptions of wildness could be combined with existing data obtained from satellites (RQ3), and the aim to capture additional perceptual data on wildness (RQ5), I deemed it necessary to identify, within each country, specific study locations which offered as broad a continuum of wildness as possible. This would allow human participants to walk along a representative range of landscapes, and for sound recorders to be deployed along the same continuum.

I also considered it to be a constructive methodological approach, given the complexity of the debates on wild spaces and wild species - especially the strong subjective challenge (see Chapter 2) - to use an existing framework of wildness to define that continuum. A practical research constraint for site selection within each country was therefore to identify specific research locations which offered walks from a lower wild urban area to a relatively remote wild area, and back, within a period of five to six hours. In terms of health and safety, as well as research completeness, all sites had to be accessible to a wide and representative range of participants. In order to do this, I conducted a desk-based study of existing maps of wildness for the two countries in order to identify suitable locations. This desk-based analysis was supported by discussion with local experts from Scottish Natural Heritage (SNH), the Centre for Mountain Studies and the Pyrenees National Park. The desk-based study used a Geographical Information System (GIS) to review available maps of wildness for both countries.

In Scotland, there is already available a map of wildness quality at the national scale (see Figure 2.1). There was, however, no equivalent map for France. In order to fill this gap, and as part of an ongoing project with IUCN France, I have been involved in the development of methods to map naturalness at the national scale for France (see Guette et al. 2018b). This project is led by the Wildland Research Institute at the University of Leeds in collaboration with the University of Nantes in France. This mapping methodology, although described as the mapping of naturalness, rather than wildness, in fact uses almost identical remotely-sensed datasets to the map of Scotland. This provided me with access to spatial data on wildness quality of an equivalent type to that available for Scotland.

Both the Scottish map of wildness and the French map of naturalness mapped values on a relative scale of 0 to 256. The map of wildness quality in Scotland was used in a series of workshops by SNH to identify important wild land areas in Scotland (Scottish Natural Heritage 2014). As part of these workshops, SNH prepared a version of the wildness map which used a simplified scale, using a statistical method known as ’Jenks’ classification to reclassify all pixels on the map with a similar value for wildness into eight classes, least to most wild. This simplified Jenks version of the wildness map was made available by SNH for this project. I used an identical statistical process to reclassify the French map of the Hautes Pyrenees into eight Jenks classes - least wild to most wild. I used these existing data on wildness quality to provide a spatially explicit reference condition against which to measure other data types. I then used these simplified Jenks maps of wildness in the GIS to search for a viable continuum of wildness - least wild to most wild - which could be walked in five to six hours.

Even given this privileged access to data, in combination with expert advice, identifying suitable walking transects proved hugely challenging. Nevertheless, following discussion with statisticians (in France, l’Institut National de la Recherche Agronomique, INRA; and in the UK, supervisor Mark Conner), I felt that it would be wise to have two paired sites, which were also representative of the typical landscapes to be found in each country. Once I had identified a small subset of possible locations, I then conducted a field survey to test the feasibility of walking them with a group within the timeframe available.

I identified four of these transects which contained a continuum of wildness - least wild to most wild - which could be walked in five to six hours. I reviewed these proposed sites for suitability in discussion with local experts from Scottish Natural Heritage, the Centre for Mountain studies and the Pyrenees National Park. The four sites were Invereshie & Inshriach National Nature Reserve (I&I) in the Cairngorms National Park, Scotland (57° 6' 45'' N, 3° 50' 39'' W); Beinn Eighe National Nature Reserve (BEN) on the Scottish west coast (57° 36' 8'' N, -5° 19' 0'' W) (Figure 3.1); Lesponne, Hautes-Pyrenees (LES), southern France (42° 58' 51'' N, 0° 8' 44'' E); and Pouey Trenous, in the centre of the Pyrenees National Park (POT), southern France (42° 50' 6'' N, -0° 9' 35'' W) (Figure 3.1).

Figure 3.1: Location map for all participatory mapping walking transects. Site 1 - Beinn Eighe National Nature Reserve (BEN), site 2 - Invereshie & Inshriach National Nature Reserve (I&I), site 3 - Pouey Trenous (POT), and site 4 - Lesponne Valley (LES).

All sites were accessible to a wide and representative range of participants, and included areas within National Nature Reserves in the UK or National Parks in France which are considered noteworthy for the presence of relatively intact natural areas (see Figure 3.2 i-iv). Each transect spanned wildness class 2 (low, a small village), to wildness class 8 (high, mountain area) (see, for example, Figure 3.3). It was not possible to include wildness class 1 (least wild), as these areas were all in large urban areas, making a walk into a wild area impossible within a single day. Maps showing the wildness gradients for the other three study sites are included in Appendix A.

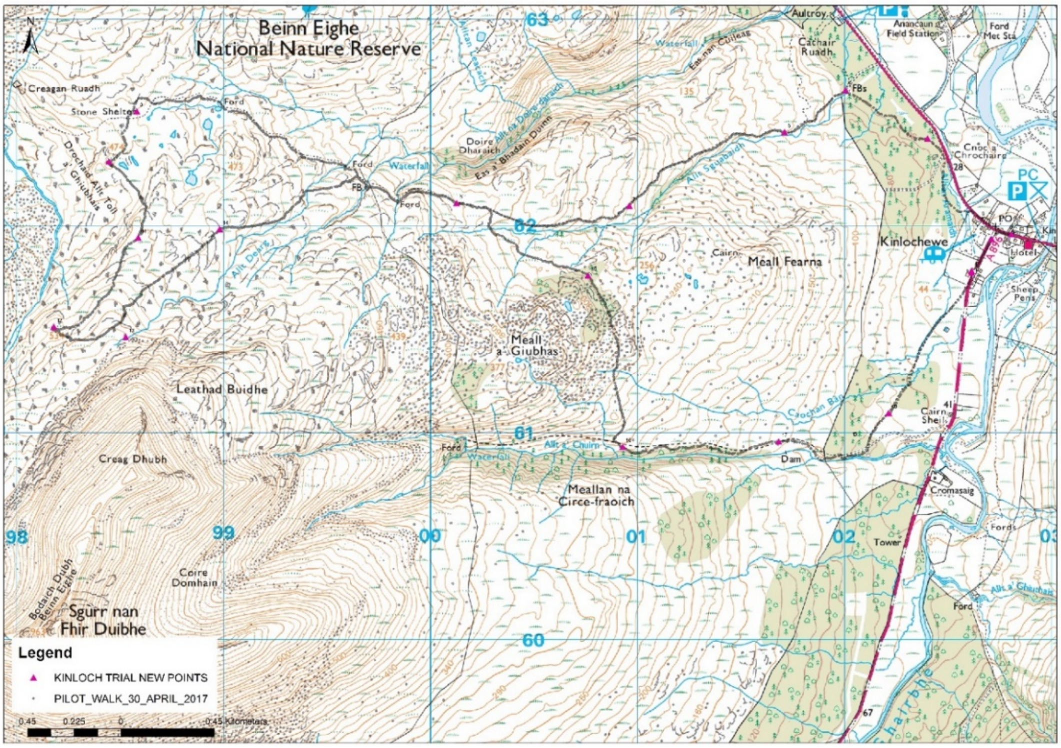

Figure 3.2i: Participatory mapping walking transect for study site Beinn Eighe showing Ordinance Survey map information and provisional mapping stops.

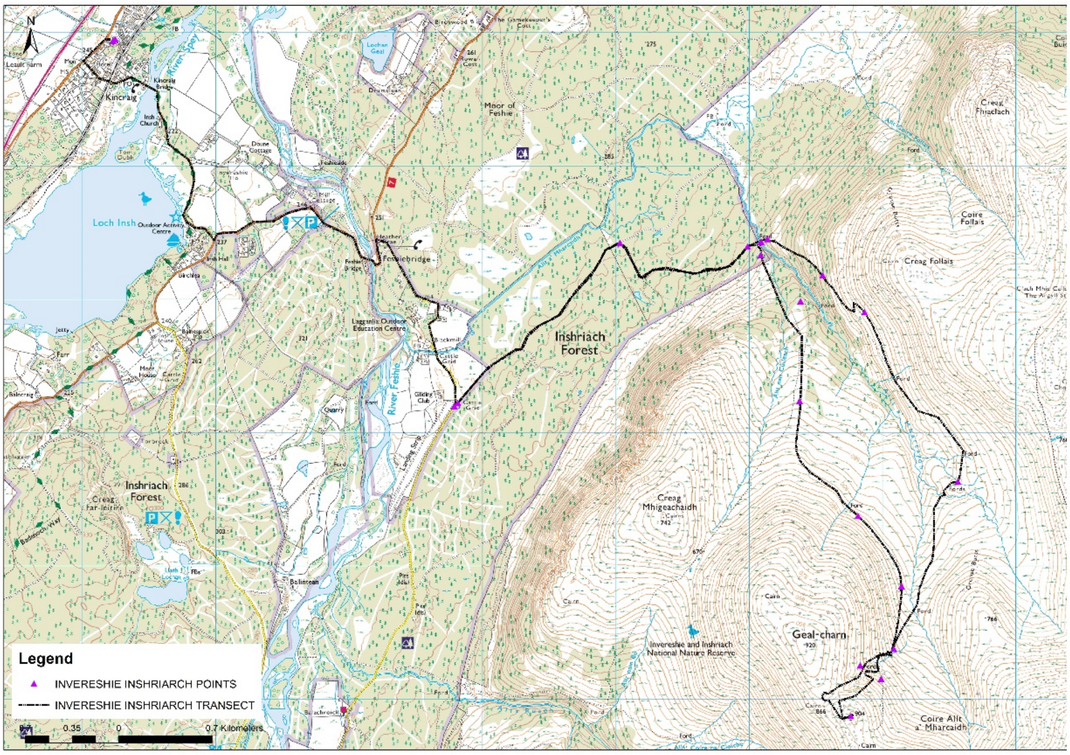

Figure 3.2ii: Participatory mapping walking transect for study site Invereshie & Inshriach National Nature Reserve showing Ordinance Survey map information and provisional mapping stops.

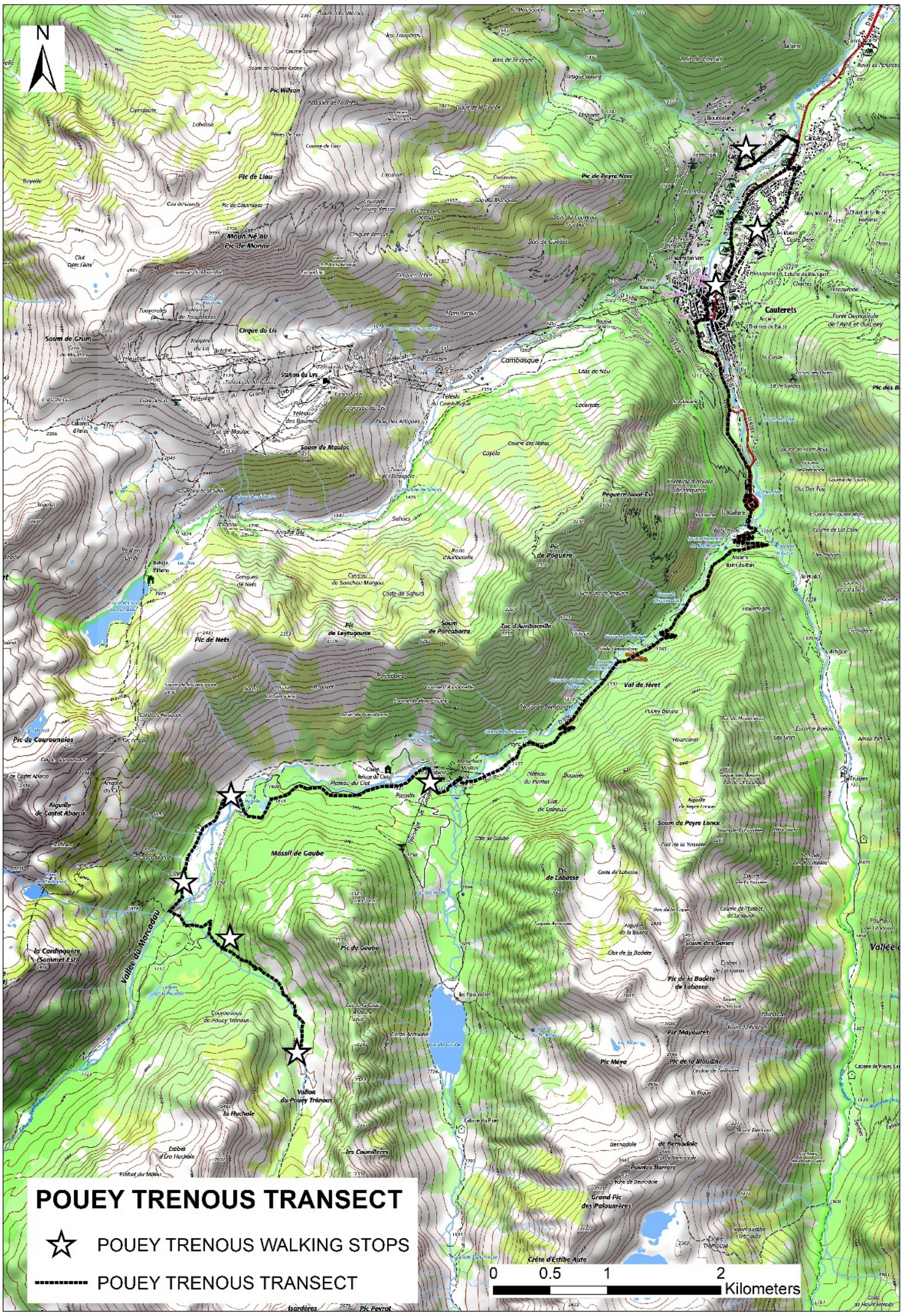

Figure 3.2iii: Participatory mapping walking transect for study site Pouey Trenous showing Ordinance Survey map information and provisional mapping stops.

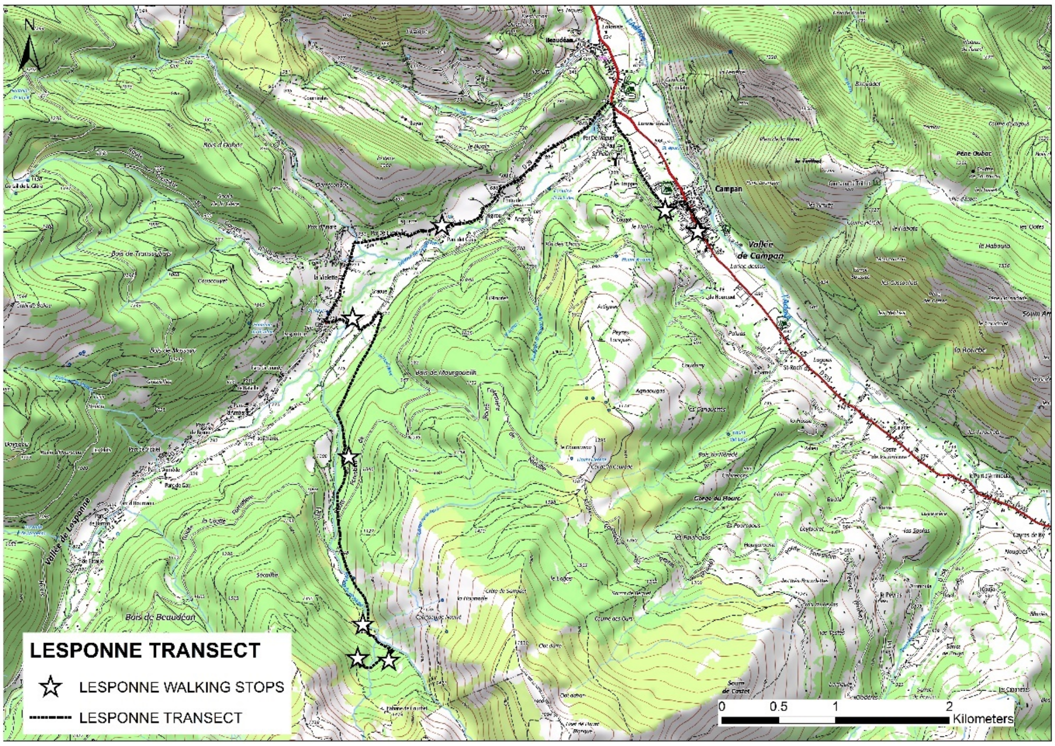

Figure 3.2iv: Participatory mapping walking transect for study site Lesponne Valley showing Ordinance Survey map information and mapping stops.

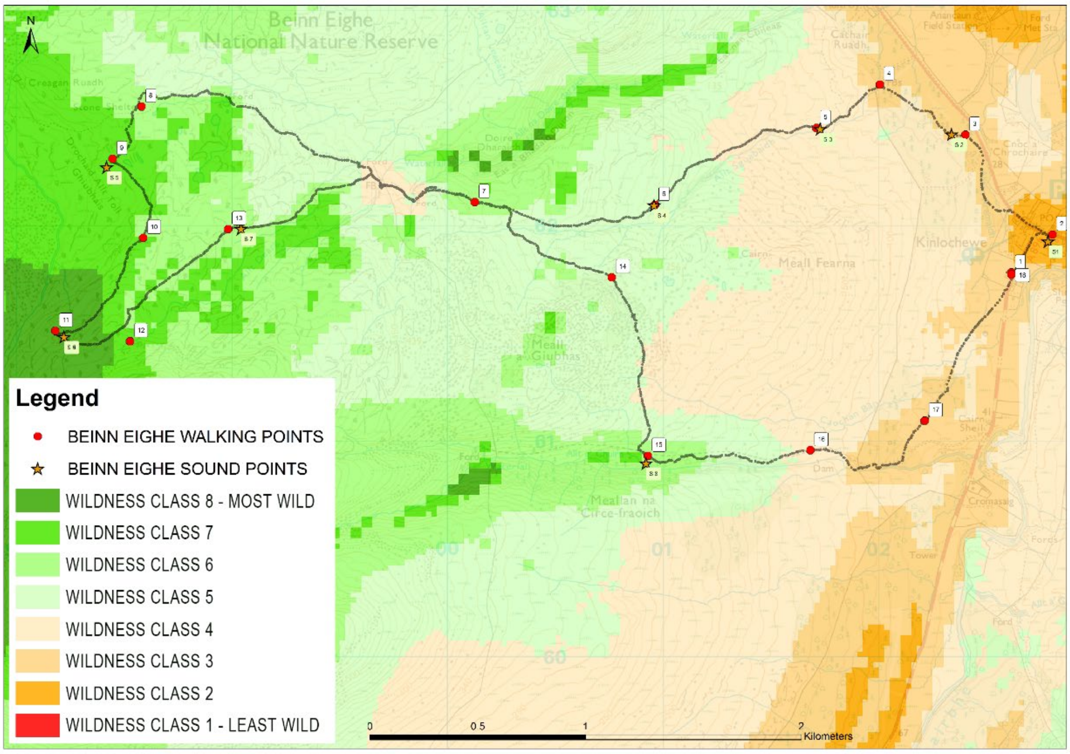

Figure 3.3: Participatory mapping walking transect for study site Beinn Eighe showing underlying Jenks wildness classes, human perception stops, wildness scores from SNH map and acoustic sample points.

3.4 Human participants

Conducting research with human participants requires the identification of a representative group of participants that includes all users of the study sites as well as those groups which have an interest in the study site – essentially described as 'those that have a stake in the issue at hand' (see, for example, Reed et al. 2009; Reed 2010; Colvin et al. 2016). For this methodological pilot study I therefore used a non-random purposive sample designed to address the research question and recruit a diverse mix of policymakers, landowners, conservation actors, general public, and other relevant groups involved in the debate on wild spaces and wild species in each country. I identified target participant groups using an iterative process where the key components of the strategy were a) to avoid imposing a selective stakeholder typology on the study, b) to develop a rounded understanding of who had an interest in the issue, and c) ensure no social groups were excluded.

In an early iterative step I used semi-structured interviews with researchers working in mountainous areas of Scotland (the Scottish Rural College, SRUC; and the Centre for Mountain Studies, CMS); and France (the Pyrenees National Park, PNP; and the Conservatoire Botanique, CBNPMP). I performed these interviews to open the door to possible participants, and during the recruitment process I used an informal and ongoing snow-ball process to explain to participants the goals of the project and who was already involved, and I asked the question, – "Who is missing from this list of participants?"

Expert advice from these initial interviews had outlined four potential groups to represent the broad spectrum of stakeholder opinion on landscape futures: (i) general public, (ii) government (at different levels, including local authorities and government agencies - SNH, Forestry Commission Scotland, Office Nationale des Forets, etc.), (iii) environmental sector (John Muir Trust, Friends of the Earth, National Trust for Scotland, Nature Midi-Pyrenees, FERUS etc.), (iv) land owners/managers sector. I used these groups as a guiding structure only, and I used the snow-ball method to identify other groups. I recruited participants through local press, social media, organisational contacts, and member groups such as mountain clubs and other local associations. Word of mouth was a key feature of this process, which proved especially useful to reach individuals and groups identified during the recruitment process. The recruitment process was ongoing, starting six months before the fieldwork began and continuing throughout the project, right up until the end of the fieldwork.

Ethical review of the proposed research was conducted by the University Of Leeds, ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee. The research design in this thesis was not considered to involve sensitive or controversial data. Informed consent was recognised as the most prominent issue. This was addressed by giving identified potential participants an overview of the research project, how their data would be used, and the costs/benefits involved. Potential participants were then given the choice of whether to participate or not. The data collected are about landscape preferences, the rationale behind these, and whether these change if new information is presented. Whilst there may be disagreement over these issues amongst participants, it was not anticipated that these would require special consideration as sensitive data, beyond the norm for most social research. It was agreed that direct and indirect identifiers that might allow an individual to be identified would be removed from any publications.

3.5 Research structure

At each of the study sites I organised a research day with the specific goal of testing a multi-disciplinary approach to capture participant attitudes and perceptions to wild spaces and wild species. This required a research design that contained components to capture information on current attitudes to wild spaces and species (RQ1), time to complete a five-to-six-hour participatory mapping walk along a continuum of wildness (RQ2 & RQ3), and a way of testing the impact of immersion in wild landscapes and information about their historical condition (RQ4). This design had to be compatible with the ecoacoustic methods (RQ5) (see Table 2.1, for list of methods and research questions). After discussion with local gatekeepers, it was felt that these research aims, and the practical challenges of recruiting individuals to participate in research in remote parts of mountain areas, was best achieved through a single intensive research day that combined all the components together.

The following diagram summarises the structure of the research design which was conducted at each study site and which took a day to complete, starting at 9.00 am and finishing around 6.00 pm (see Figure 3.4).

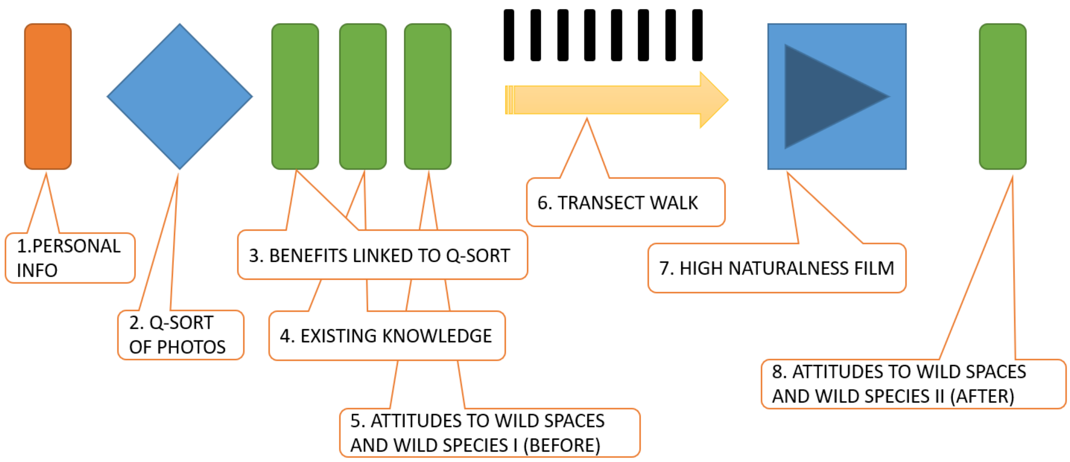

Figure 3.4: Step-by-step breakdown of research method design structure for all study sites.

The first part of this research day consisted of a questionnaire completed indoors to assess participants' current attitudes to wild spaces and wild species (steps 1-5, see Section 3.6). The bulk of the day then involved a five-hour walk along a continuum of wildness, from a small urban area into a remote wild area, during which participants conducted a participatory mapping exercise (step 6, see Section 3.7). After returning from this walk, participants watched a short film (step 7). I made this film with the specific intention of showing intact examples of the kinds of landscape the participants had just walked through, as well as making sure that all participants received similar levels of knowledge on historical landscape change in the study areas (see Appendix B for details). Finally, the participants completed the questionnaire with a second round of questions (paired with step 5), with the aim of highlighting any possible impact of the research walk on their attitudes (step 8, see Section 3.6.3) (see Appendix C for full questionnaire).

The idea of situating the place-based research methods along a continuum of wildness became a defining framework for the research questions and the methods used to address them. This meant that the majority of the activities during the research day - the photo-based Q-Method (see Section 3.6.1), the questions on key criteria for wildness (see Section 3.6.2), the participatory mapping exercise (see Section 3.7), and the ecoacoustic sampling (see Section 3.8) - were structured with clear spatial reference to an existing continuum of wildness. This research design allowed the results from each of these approaches to be compared with that continuum for the purposes of subsequent statistical analysis.

3.6 Attitudes to wild spaces and wild species

A crucial step in developing improved methods for representing and mapping wildness in support of decision-making on the conservation of wild spaces and wild species is to develop an in-depth understanding of current attitudes to these issues and explore methods that could deepen this understanding (RQ1). In addition to the core goal of more accurately capturing current attitudes, a secondary goal was to explore how those attitudes might be affected by immersion in a wild space and exposure to knowledge on natural historical landscape conditions (RQ4).

As described above and illustrated in Figure 3.4, research days were structured around a questionnaire that was completed before and after a participatory mapping exercise (see Section 3.7 for details on participatory mapping). The questionnaire was designed to test novel methods for collecting quantitative and qualitative data on participant’s current knowledge of and attitudes towards wild spaces. Further questions were also asked on attitudes to wild species within these spaces, and the reintroduction of extinct native wild species. The main body of this questionnaire consisted of a photo-based Q-sort exercise and a series of linked questions a) to understand why participants answered the way they did (see Section 3.6.1), b) to gain a deeper understanding of a given individual's attitude to wild spaces and wild species (see Section 3.6.2), and c) to test the impact on attitudes of immersion in a wild space (see Section 3.6.3).

3.6.1 Photo-based Q-Method

Steps 2 and 3 of the research day consisted of a photo-based Q-Method task (step 2) and a series of linked follow-on questions to understand the task (step 3). The objective of these methodological steps was to address RQ1 (see Table 2.1) by using a mixed-method research approach to capture information on participant's qualitative attitudes to the visual attributes of the landscape in a structured way so that those attitudes could be linked to quantitative spatial data on wildness quality.

I have highlighted the need to address the challenge of subjectivity in the mapping of wildness (see Sections 2.2.1 & 2.3.3). Q-Methodology is an empirical tool that uses sets of statements to better understand the 'subjective realities' (McKeown & Thomas 2013) of the subjects taking part. The approach identifies groupings, called 'factors', of similar attitudes among a population, based on the way participants respond to and classify a set of 'statements' on a particular theme or debate (Brown 1993). Q-Methodology is a mixed-method approach that has become popular among researchers as it is claimed to offer the best of both worlds: the richness of qualitative data with the robustness of quantitative methods and statistical analysis (Watts & Stenner 2012). It is considered effective for exploring environmental discourses (Barry & Proops 1999); perceptions of landscape (Fairweather & Swaffield 2001); attitudes to nature (Hutson & Montgomery 2006); conservation conflicts (Rastogi et al. 2013; Zabala et al. 2018); wild species conservation (Hamadou et al. 2016); and views on wild land management (Deary & Warren 2019; Holmes et al. 2019).

As a mixed-method which has been used extensively to research themes of relevance to wild spaces and species, I therefore considered Q-Method to be an appropriate tool for this research project. Q-Method is usually used with text 'statements' which represent the full range of possible views on the theme at hand. Q-Method has also been used with image 'statements' to visually represent the diversity of landscapes in question (Naspetti et al. 2016). Photo-based Q-Method requires participants to sort photographs along a continuum according to the instructions of the research team. A recent example of its use in landscape assessment asked participants to sort photographs from most to least desirable, based on what participants valued most in the landscape (See Figure 3.5).

Figure 3.5: Example photo-based Q-Method study focusing on landscape preferences (after Milcu et al. 2014:414)

Landscape photos were included in a public perception survey as part of the development of the wildness quality map of Scotland (see Section 2.3.3). The photos used were of specific landscape elements such as powerlines or forestry, and in that sense were considered to be representative of particular attributes that were subsequently mapped using large-scale spatial data. To a large degree I followed this method in the current study, in the sense that I took photographs at particular locations around Scotland and France in order to capture specific and representative attributes of the landscapes featured in the maps. The main difference here is that, in addition, I also carefully controlled the spatial locations of the photographs to ensure that I presented participants with a series of photos that were representative of the different Jenks wildness classes (WC) present within the French and Scottish maps. It is this underlying logic that is a key part of the method for linking qualitative attitudes, such as participants' discrete views on what they consider as wild elements within the landscape, to pre-existing quantitative spatial data that classify the landscape in those photos on a continuum of wildness.

For each of the two pairs of national study sites, the set of photos used in the Q-Method task included five images from each of the eight WCs, for each respective country. In collaboration with my supervisors and members of the Wildland Research Institute I selected the final two sets of 40 pictures, from a group of several thousand photos taken during the initial desk-based GIS analysis and the field survey of potential walking sites in Scotland and France.

The Q-Sort exercise (step 2) asked participants to rank this representative series of 40 landscape photos on a scale of least to most wild. This task also served the function of exposing all participants at the start of the research day to the same representative range/spectrum of landscapes in Scotland and France respectively (see Figure 3.6). Written instructions for the Q-Sort are contained in the questionnaires in Appendix C.

Figures 3.6a & 3.6b: Participants completing the photo based Q-sort exercise at the Beinn Eighe study site, Kinlochewe.

I asked participants to provide a series of keywords and comments to explain the logic of their photo choices for each of the columns (A to I) in the Q-sort, and score the perceived benefits of the landscapes shown in a given column for a range of ecosystem services (step 3).

The remote location of the research and the difficulty of recruiting research participants meant that the Q-Method task was completed in small groups. A traditional Q-Sort study would typically, but not always, follow the sort with a one-on-one interview with the participants to elicit greater understanding of how and why they sorted the statements the way they did. Most Q-Sorts ask participants to order their statements according to their agreement with the content of the statement. In the study featured above (Milcu et al. 2014), image statements were rated in terms of their desirability. In this thesis the Q-Sort asked participants to organise the images on the basis of how they aligned to the concept of wildness. In the overall methodological approach, this served to explore how existing maps of wildness correspond to subjective ideas of wildness. As such, whilst a one-on-one interview would have been useful, this approach placed less importance on the need for qualitative data to interpret the Q-Sorts. This consideration, combined with the practical constraints of working with small groups, meant that I decided to design the questionnaire format to elicit this information, as well as participants' attitudes to a wide range of themes linked to wild spaces and wild species in remote mountain landscapes.

I digitised the Q-Sorts from all participants for analysis using the KenQ on-line software tool (Banasick 2018). I analysed Scottish and French study data separately as, whilst they were designed to be methodologically as similar as possible, they were based on different image statements. I used a strategic approach to analysing Q-sort data as part of an exploratory factor analysis, and in line with recommended best practice (Watts & Stenner 2012). The purpose of a factor analysis in Q-methodology is to account for as much of the variance in participant opinions as possible, and identify the factors present in the data, where a factor is a group of people sharing a common viewpoint on the meaning in the statements with which they are presented during the Q-Sort. Choosing a representative number of factors to capture the opinions of the participants is a core challenge in Q-methodology. "Factor analyses have an infinite number of acceptable solutions", and so a strategic exploration of the possible solutions is recommended in light of the researcher's knowledge of the data (Watts & Stenner 2012:Ch5:21).

In order to address in detail Research Question 1 (see Table 2.1), I analysed the results of the Q-Method task for the following sub-questions (see Sections 4.2 & 4.5):

A. How can the Q-Sorts for each country be grouped by factor?
B. What are the distinguishing statements for each factor?
C. Which statements show the highest level of variance across each study site?
D. Do the results for the Q-Sorts correlate with the underlying mapped wildness values for a given photograph?

3.6.2. Questions on current attitudes and future preferences

I used a standard questionnaire format to ask a series of question groups on participant attitudes to key attributes of wild spaces, current opinions on wild species and reintroductions, and future preferences for wild spaces and wild species (steps 4, 5 & 8, see Figure 3.4).

Likert-style questionnaires are a well-established research tool for exploring participant attitudes in disciplines of specific relevance to this study, including environmental psychology (Hinds & Sparks 2008) and human geography (McLafferty 2003; Parfitt 2005). Questionnaires have also been combined with collaborative Geographical Information Systems (GIS) to understand attitudes towards urban green spaces (Balram & Dragićević 2005). I also considered the questionnaire to be useful to support the interpretation of the results from the Q-Methodology, especially as this was done in large groups. This dual approach may also help to address some of the issues linked to the impacts of each given methodology (Eyvindson et al. 2015). This is in line with the wider research goal of designing innovative mixed methods models that allow qualitative and quantitative data to be compared (see also RQ3) (see Appendix C for details of questions).

I analysed question responses from all participants using the package ‘Likert’ in R, which is a tool for analysing Likert response items, with an emphasis on visualizations, especially the stacked bar plot (Likert 2016; R Core Team 2018). As part of exploring a mixed-methods approach to gain further insights into attitudes, I analysed these results by country, local and non-local, as well as by Q-Factor (RQ1). I split the overall research question into the following sub-questions for statistical analysis (see Chapter 4):

A. What were participants' attitudes on key attributes of wildness, split by country and local/non-local?
B. What were participants' attitudes to wild spaces and species, split by country and local/non-local?
C. What were participants' attitudes to attributes of wildness, split by Q-Sort factors?

3.6.3 Before-the-walk and after-the-walk questions

Steps 5 and 8 were designed in the format of before (the walk) and after (the walk and the film) paired questions in order to address the research question on immersion and exposure to historical knowledge (RQ4) (see Section 3.5). Before and after questions used a seven-point Likert scale (1-7) and asked participants to rate their attitude on 1) wild spaces, 2) wild species, and 3) wild predators. Specifically, this asked participants to state, using a Likert scale, whether they felt there were sufficient wild spaces and sufficient wild species such as deer, wildcat or birds of prey. Depending on the study site, questions were also asked about participants' attitudes towards the reintroduction of wild species such as lynx, bear or wolf. All questions are listed in the questionnaire in Appendix C and summarised in Table 3.1 below.

Table 3.1: Details of before-and-after comparison questions used in the questionnaire (steps 5 & 8)

BEFORE	AFTER
SCOTLAND	
There are sufficient wild spaces in mountain areas in Scotland	**In terms of wild spaces, there are currently already enough of these to be found in mountain areas in Scotland**
There are sufficient wild species such as deer, mountain hare and birds in mountain areas in Scotland	**In terms of wild species such as deer, mountain hare and birds there are currently already enough of these to be found in mountain areas in Scotland**
There should be wild species such as lynx, bear and wolf in mountain areas in Scotland	**Wild species such as lynx, bear and wolf should be present in mountain areas in Scotland**
FRANCE	
Il y a assez d'espaces de haute-naturalité actuellement dans les zones de montagne pyrénéennes	**Actuellement, il y a assez d'espaces de haute-naturalité dans les zones de montagne pyrénéennes**
Il y a assez d'espèces sauvages (par ex. cerfs, isards, sangliers, fouines, oiseaux …..) actuellement dans les zones de montagne pyrénéennes	**Actuellement, il y a assez d'espèces sauvages (par ex. cerfs, isards, sangliers, fouines, oiseaux …..) dans les zones de montagne pyrénéennes**
Actuellement, il y a assez d'espèces sauvages (par ex. loups, ours, lynx ….), dans les zones de montagne pyrénéennes	**Actuellement, il y a assez d'espèces sauvages (par ex. loups, ours, lynx ….), dans les zones de montagne pyrénéennes**

I used a Likert scale structure as this is considered a useful tool to assess shifts in viewpoints in before and after experiments (Alexander & Wells 1991; Maehr et al. 2015; Klopčič et al. 2019). Also, I considered simple and clearly structured questions to be preferable because detectable shifts in attitudes linked to the walking exercise (i.e. differences in the before and after questions) were likely to be minimal (M.

Conner, personal communication, November 20, 2015; Takayama et al. 2017). I conducted an analysis of the before-and-after questions in R, using a non-parametric correlation analysis, Wilcoxon signed-rank test, to measure whether there were any significant differences that could potentially be attributed to the walking task (RQ4). I report results relating to the impact of the walk on attitudes (before-and-after question sets) in Chapter 5 (see Section 5.3), along with the linked data analysing the impact of the walk on human perceptions of wildness captured *in situ* (see Section 3.7 for details).

Given the complexity of the debate on wild spaces and wild species in both of the study countries, I included a final section of questions to measure attitudinal ambivalence to the key themes. I designed this set of questions to acknowledge the fact that people have mixed feelings about complex debates, feelings which are often complicated by the social context in which they take place. Attitudinal ambivalence is used to explore why and how attitudes to challenging issues change, and explore how people may act in the future based on their current attitudes (Conner & Armitage 2008). Strength of feeling, for example, may determine whether people do or do not change their mind as a result of immersion. Questions used a similar Likert format, and for clarity the key question statements are presented in Table 3.2 (see also Appendix C).

Table.3.2: Attitudinal ambivalence questions on participant attitudes to 1) wild spaces and 2) the reintroduction of wild species such as the lynx.

A) **The protection of wild spaces**
A.1. I have mixed feelings about supporting the protection of wild spaces
Strongly disagree (1) - Strongly agree (7)
A.2. If I only think about my negative thoughts about supporting the protection of wild spaces, I would say I am...
Not at all negative (1) - Extremely negative (7)
A.3. If I only think about my positive thoughts about supporting the protection of wild spaces, I would say I am...
Not at all positive (1) - Extremely positive (7)
A.4. I intend to support the protection of wild spaces
Strongly disagree (1) - Strongly agree (7)
B) **The reintroduction of wild species such as Lynx**
B.1. I have mixed feelings about supporting the reintroduction of extinct wild species such as Lynx
Strongly disagree (1) - Strongly agree (7)

B.2. If I just think about my negative thoughts about supporting the reintroduction of extinct wild species, I would say I am...
Not at all negative (1) - Extremely negative (7)
B.3. If I just think about my positive thoughts about the reintroduction of extinct wild species, I would say I am...
Not at all positive (1) - Extremely positive (7)
B.4. I intend to support the reintroduction of extinct wild species
Strongly disagree (1) - Strongly agree (7)

Lynx were historically present in the Pyrenees but are currently not resident in this mountain range, so the question format is identical between France and Scotland. I report results on attitudinal ambivalence in Chapter 5 (see Section 5.4).

Upon completion of the questionnaire, a group session brought participants together, and I asked them to highlight the key themes emerging from the research day. This was designed to create a space within what was a very structured research day to allow for free expression of people’s ideas, as well as the emergence of themes which were not identified prior to the beginning of the research process.

The questionnaires used in France and Scotland were almost identical, with minor changes made to recognise the differences in habitats and species present at the two sites. I designed the questionnaire in English, with support from my supervisors in psychology and conservation humanities, as well as social scientists at the Centre for Mountain Studies and the Scottish Rural College with experience of working on these themes in Scotland. I am fluent in French, and so I provided translations into French, with supervision and support from a native speaker with over 30 years’ experience teaching in the French school system.

3.7 Participatory mapping task

Participatory mapping has been used in a wide range of research scenarios to address research questions of direct relevance to the mapping of wildness (see Section 2.4.2).

Rather than just walking a straight line transect through an area of interest, a walking transect can be designed which takes participants through a representative continuum, taking account of the transitions along the continuum (Duany et al. 2002). At each point or stop along the transect, information can be gathered from participants which is spatially explicit (Duany & Talen 2002; Abunnasr & Hamin

2012). Structuring a wildness research participatory mapping walk in this way allows participants to be queried about landscape values at carefully predetermined locations, and the resulting human perception data can then be directly compared with existing mapped values of wildness for the same locations (see RQ2 & RQ3, Table 2.1). This is also of interest in the resolution of conflicts around subjective values for landscape (RQ5) (Talen 2002).

Linear walking paths are spatially representable within a GIS, and stops made along these paths, where landscape scale assessments are conducted, can also be stored with a GIS and data attached to these points using relational data tables (Evans & Jones 2014). The data stored in these tables can be of multiple formats, and numerical data can be stored alongside text-based data, such as subjective opinions collected from participant interviews at these points. In this sense, a walking path can, as stated, be equated to a traditional ‘transect’, and the data from these walking ‘transects’ can be stored in a similar fashion to ecological surveys. A GIS can be built with multiple spatially explicit layers, including numerical landscape perception assessment scores, text-based keywords from linked interviews, and wildness quality values from remote-sensed data. Within this GIS, the data layers can then be overlaid and compared as part of the process of participatory mapping (Carver et al. 2009; Huck et al. 2014). In the overall methodological research framework I made use of existing spatial data on wildness as a potential ‘base’ layer to incorporate into such a model.

The majority of such collaborative or participatory mapping exercises are, however, conducted in urban settings (Evans & Jones 2014), indoors (Balram & Dragićević 2005), or are not linked to a repeatable spatially explicit framework (Holden 2016). A recent study on wild land values in Scotland was conducted *in situ,* and used a prior assessment phase, based on a combination of expert knowledge and spatial analysis of wild land maps, to identify the optimum locations for a walking transect (Scottish Natural Heritage 2014). That project then used these walks as the basis of an analysis of landscape values in wild land areas in Scotland. The *in situ* mapping phase of that project was, however, conducted by a single individual (a landscape architect), leaving the assessment vulnerable to the same accusations of expert-driven bias that were levelled at the original definitions of wild land areas (MacDonald 2018). A similar exercise has not yet been completed with the wider stakeholder community, but was considered of interest to those currently working on wildness mapping in Scotland (C. Harry, personal communication, October 2, 2017). I considered this transect-based approach for capturing human perceptions along a gradient of wildness, linked to underlying spatial data on wildness, to be an appropriate research method to address Research Questions 2 and 3 (see Table 2.1).

For step 6 (see Figure 3.4), participants rated their immediate surrounding landscape on a scale of 1 (least), to 7 (most) in terms of wildness, naturalness, biodiversity, management, emotional response and connectivity. This task was completed at pre-designated stopping points for each study site (n=18 in Scotland and n=14 in France) (see Figures 3.2 & 3.3 and Appendix A for walking transects). Stops were evenly distributed along the walk, and designed to be representative of the study site and to capture all of the wildness classes present at that site. Differences in numbers of stops between the two countries were due to practical considerations and the longer time taken to complete the French walks. I made every effort to ensure that the walks were of a similar type, to standardise the experience of participants. I also used the desk-based GIS phase to identify pairs of walking stops of a similar wildness class (WC) that could be visited on the way out and the way back, in order to gather evidence in relation to the impact of immersion in a wild place on perceptions of wildness (RQ3) (see Section 5.2.3 for details).

I didn't collect any human data at the study site Pouey Trenous (POT) because extreme weather (high levels of snow) made the paths impassable during the planned survey period.

I briefed participants and guided them along the transects in groups of eight or less. Participants were unaware of how the walk they followed had been designed, or the link to the underlying data on Jenks wildness classes. To minimise the impact of weather on participant experience, I conducted all walks on days of non-extreme weather conditions (absence of lying snow cover, high winds or heavy rain). I conducted the walks at the Scottish sites (I&I and BEN) between April and September 2017. I conducted the walks at the French site (LES) between June and September 2018. I list specific mapping questions in Table 3.3 below. I explained these in detail to participants, with examples, at the start of each walk.

Table 3.3: Questions asked during the participatory mapping task.

CATEGORY	THINK ABOUT
1. Biodiversity	How many different habitats and species are here ?
2. Naturalness	How close to its natural state is the surrounding area ? (Post last glaciation)
3. Connectivity	How well connected are the habitats here for wildlife to move ?
4. Wildness	How wild does this area feel to you ?
5. Land management	How heavily/intensely managed by man/woman is this landscape ?
6. Emotion	Do you like it ? Does it make you feel good ? Happy or sad ? A score of intensity not positive or negative.

Following the decision to deploy ecoacoustic recorders, I added an additional question on the importance of sound to a participant's experience of place for the study in France. I gave participants weatherproof notebooks and invited them at each stop to write down a score on a scale of 1 (low) to 7 (high), and to make comments in order to explain their scores (see Figures 3.7, 3.8 & 3.9).

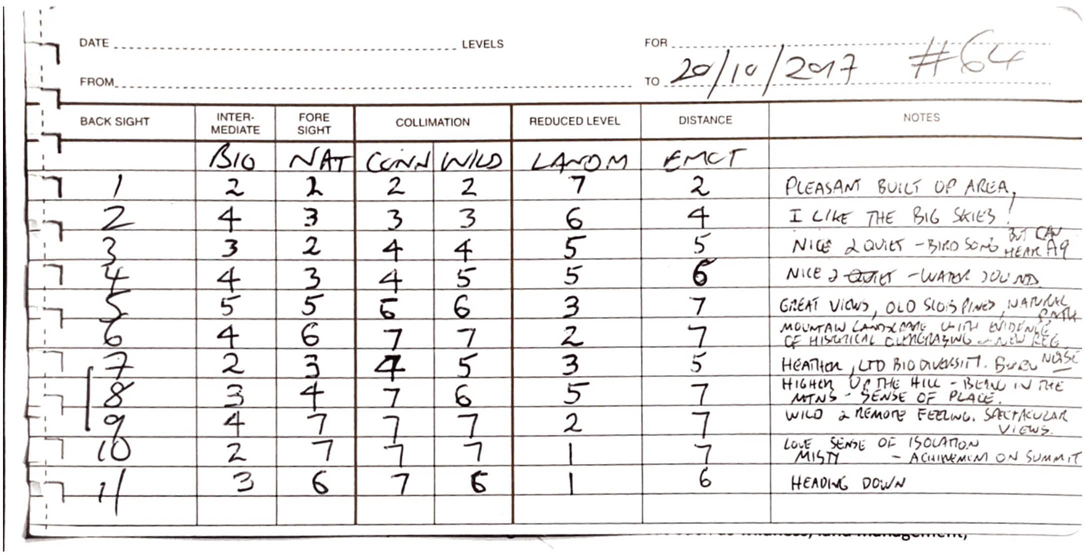

Figure 3.7: Sample of a participatory mapping score with comments from the landscape assessment task.

Figure 3.8: Participatory mapping participants scoring a low wildness urban area in the Beinn Eighe (BEN) study site.

Figure 3.9: Participatory mapping participants scoring a high wildness area in the Beinn Eighe (BEN) study site.

I digitised the human perception scores from each of the stops along the walking transects, along with the pre-existing values for wildness and naturalness at the same locations as specified by the maps of wildness quality for Scotland, and naturalness for France. I completed a non-parametric correlation analysis in R, Spearman's rank correlation, to analyse human perception scores for wildness (RQ2), and compare these with pre-existing mapped values for wildness at a given location (RQ3). I split these research questions (RQ2 and RQ3) into the following sub-questions for statistical analysis (see Chapter 5):

A. Do scores for perceived wildness vary along a gradient of mapped wildness?
B. Do scores for perceived wildness correlate with existing mapped values for wildness?
C. Do scores for the same walking stop change on the return leg?
D. How do the scores for perceived wildness relate to other perceived landscape values?
E. Did immersion in a wild place and historical knowledge of a wild place impact on people's attitudes?
F. How do participant attitudes to wild spaces and wild species vary in terms of attitudinal ambivalence?
G. How do values for walking scores vary amongst participants ? Does this vary by stakeholder group?

3.8 Ecoacoustic methods

I have proposed the emerging field of ecoacoustics as a possible new direction for wildness mapping and management, with potential as both a conceptual framework and a monitoring method to integrate human and ecological perspectives with current geophysical wildness mapping schema (see Sections 2.2.2, 2.3.4 & 2.4.4). In order to explore this potential, I conducted a systematic investigation of the relationship between acoustic indices, wildness quality metrics and *in situ* human subjective perceptions of wildness and biodiversity (RQ5).

3.8.1 Ecoacoustic study sites

Availability of equipment limited the acoustic survey to a sub-set of the human perception sampling stops. However, I conducted acoustic sampling at all four study sites identified (see Section 3.3). I selected at least eight acoustic survey points along the mapping transect at each site, matched across sites to give equivalent representations of wildness class (WC) (see, for example, Figure 3.10).

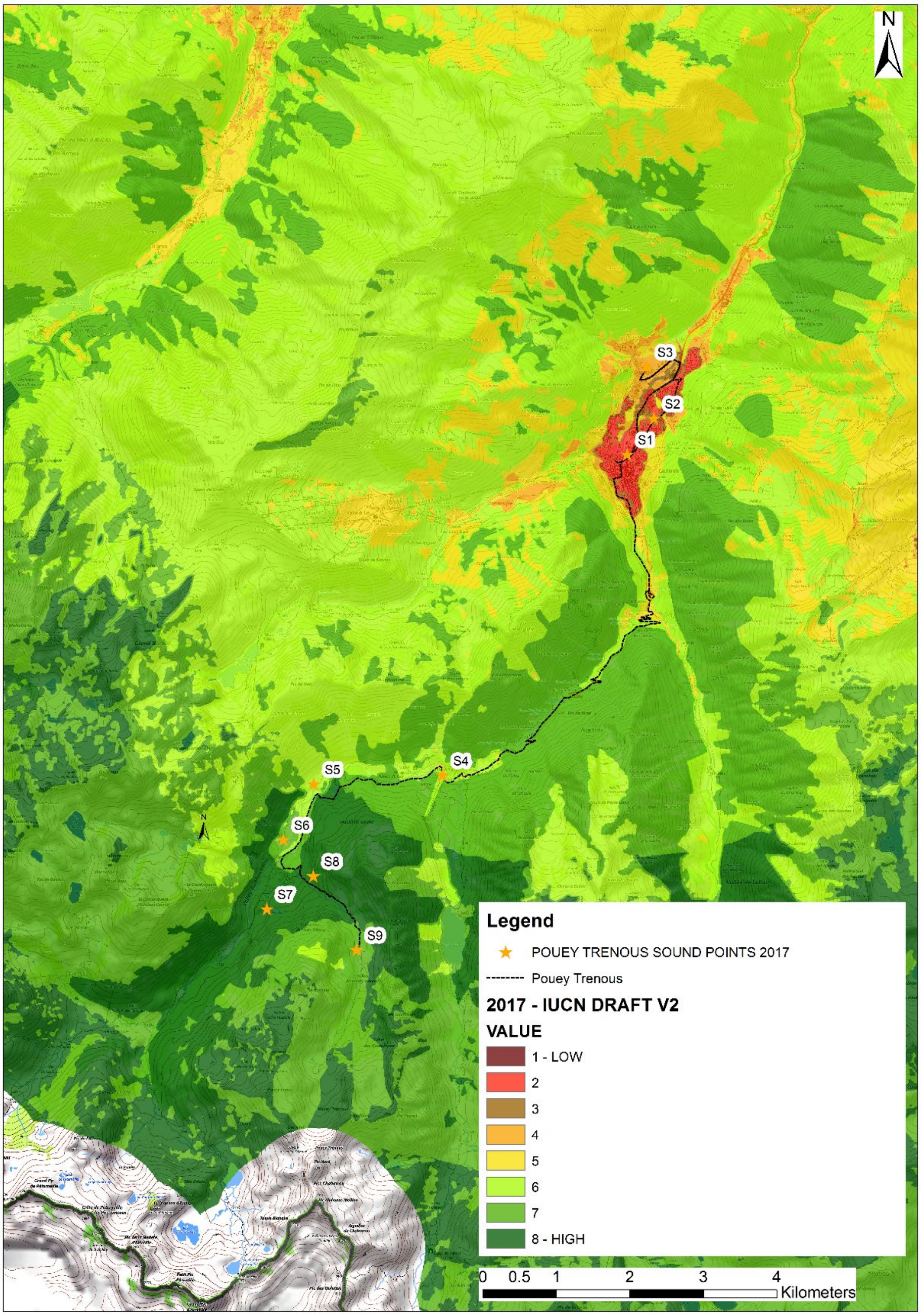

Figure 3.10: Transect along gradient of Jenks wildness classes (low to high) for French site Pouey Trenous (POT) in the Pyrenees National Park, France (57° 36' 8'' N, -5° 19' 0'' W), showing proposed walking transect path (dashed line) and acoustic survey points (stars). See Appendix A for corresponding maps of other sites. Note that due to extreme weather during the human

survey period (high levels of snow), human participants did not complete the participatory mapping task at this site (see in text for details).

3.8.2 Acoustic surveys

I carried out acoustic surveys for a minimum of four days at each of the eight sample points at each site sequentially (I&I and BEN, 20th to 29th July 2017; LES and POT, September 2017). To avoid interference from additional human sound sources, I held participatory walks and acoustic surveys on different days. I carried out acoustic surveys during daylight hours to match the acoustic environment experienced by mapping participants. I made recordings for five minutes out of every fifteen minutes between 07:00 and 21:00 using eight Wildlife Acoustics Song Meter SM2+ offline digital recorders at 16 bit amplitude resolution with a 48 kHz sampling rate and a gain of +36dB, giving a total of 7,168 stereo files. The Song Meter is a battery-powered, offline, programmable weatherproof recorder, with two channels of omni-directional sound and a flat frequency response between 20 Hz and 20 kHz (see Figure 3.11).

Figure 3.11: Song Meter 2+ *in situ* at the Beinn Eighe (BEN) study site.

I fixed the recorders to trees or posts at 1-1.5m above ground level, and orientated them south to standardise for prevailing weather conditions and wind noise (see Appendix D for images of acoustic survey points).

Manual screening of audio data confirmed that the left (opposite to prevailing weather) channel was consistently less distorted by wind, so I dropped the right channel from the analysis. I pre-processed mono recordings using a high pass filter at 1kHz to remove remaining artefacts, whilst preserving low-frequency energy associated with human influence (technophony). Equipment failure and extreme weather rendered 1,275 files (17%) unusable; these sites were dropped from the recordings, leaving a total of 5,893 files (I&I, N=1,351; BEN, N=1,110; POT, N=1,715; LES, N=1,717). In addition to wildness class, I also considered final sampling points in terms of habitat. The combined technical and habitat considerations left five matched sample points (from the original eight) at each of the four study sites, representing five different wildness classes (see Table 3.4).

Table 3.4: Descriptions of habitat at each of the final five wildness classes studied.

Jenks Wild Class	Description of Scottish sites	Description of French sites
2	Least wild, urban site	Least wild, urban site
3	Lowland, plantation native woodland	Lowland, woodland edge
5	Middle mountain, open mountain heath/ moorland	Middle mountain, grazing
6	Upland, natural native woodland site	Upland grazing pasture surrounded by native woods
8	Most wild, mountain, upland scrub	Most wild, mountain, ancient woodland

3.8.3 Acoustic Indices

I selected and designed acoustic indices (AIs) based on extensive literature review and in consultation with the authors of previous validation studies (Eldridge et al. 2018). I selected six acoustic indices from over 50 initially explored to characterise: a) biophonic activity as an indicator of biodiversity, b) technophonic activity as an indicator of human influence, and c) overall sound energy as an indicator of absence of noise.

I chose three ecological indices, which have been demonstrably linked with biodiversity in temperate biomes, as biodiversity proxies: Acoustic Complexity Index (ACI), which has been reported to correlate significantly with the number of avian vocalisations in an Italian national park (Pieretti et al. 2011); Bioacoustics Index (BAI)

(Boelman et al. 2007), which is reported to show significant association with avian species richness (Fuller et al. 2015); and Acoustic Evenness Index (AEI) (Villanueva-Rivera et al. 2011), which has been shown to strongly predict avian species richness (Eldridge et al. 2018).

I introduce a novel variant of the Normalised Difference Soundscape Index (NDSI) (Kasten et al. 2012), the Relative Technophony Index (RTI), developed in collaboration with my co-authors on the published journal article, as a measure of technophony (see Appendix E for details); and two standard acoustic descriptors used in machine listening tasks to track overall sound energy: Root Mean Square (RMS) and Spectral Centroid (SC), a measure of the overall distribution of sound energy across the frequency spectrum (Peeters 2004). I used median values for RMS and SC as they are more robust to outliers. See Appendix E for details of AIs used.

All acoustic analyses were carried out using a bespoke Python library (Guyot 2018) which implements and extends R libraries 'Seewave' (Sueur et al. 2008) and sound ecology (Villanueva-Rivera et al. 2018).

3.8.4 Auditioning

In order to support interpretation of the acoustic indices, I selected a subset of recordings by taking the median value for RMS at each sample point for each site as indicative of the acoustic activity at that site. In collaboration with my main co-authors on the article in which this research appears, Alice Eldridge (AE) and Patrice Guyot (PG), I auditioned this subset of sound recordings. We conducted auditioning noting the dominant sound sources (cars, planes, people, birds, wind, rain). Recordings used for this task are available at http://tiny.cc/mdiq6y.

3.8.5 Statistical Analyses

To explore how each AI differs along a wildness gradient, I performed Wilcoxon signed-rank tests to test for differences in AI values between pairs of WCs across days. To investigate the relationship between AIs and WCs and human perceptions of wildness and biodiversity, I carried out two-tailed Spearman's rank correlation tests between each of the six AIs and respective wildness measures and human perceptual judgements. I performed all analyses for all sites combined, as well as for all sites individually.

Previous ecoacoustic research has demonstrated that compound metrics are more powerful than any single AI in predicting biodiversity metrics such as species richness and/or abundance (Eldridge et al. 2018; Towsey et al. 2014). Therefore, to test whether acoustic analyses predict either WC or human perceptions of wildness, I built multivariate random forest regression models (Breiman 2001) using all six AIs as predictors, and either WC or human perception of wildness or biodiversity as response. Multivariate random forest regression creates a model based on multiple decision trees to describe a response variable based on one or more predictors, then merges those trees to obtain a more accurate prediction. They are tolerant of deviations from parametric assumptions and skews in the data. The total percentage variance explained and mean squared error (MSE) of the model provide an indication of predictive strength and accuracy. I assessed the relative contribution of predictors using Variable Importance (VIMP): the difference between prediction error when a given predictor variable is noised up by randomly permuting its values, compared to prediction error under the observed values.

I tested ecoacoustic methods to explore their potential for capturing biodiversity data of relevance to wildness mapping criteria and information of relevance to human perceptions of wildness (RQ5). I split Research Question 5 into the following sub-questions for statistical analysis (see Chapter 5):

A. How do AIs differ along a gradient of mapped wildness categories?
B. What is the relationship between AIs and a) wildness categories and b) human subjective perceptions of wildness and biodiversity?
C. Do AIs predict a) wildness quality and/or b) human perceptions of wildness and biodiversity?

Based on discussions with my co-authors we predicted that: i) overall sound levels and presence of low-frequency signals will decrease with increasing wildness as we move away from roads and other human influence; ii) if wildness is associated with higher biodiversity, then we would expect an increase in biophonic activity with increasing wildness; iii) if AIs are sensitive to factors which influence human perceptions of WAs other than those captured in wildness quality metrics, then AIs will predict human perceptions more strongly than wildness classes.

Chapter 4 - Results: Attitudes to wild spaces and species

4.1 Summary

In this chapter I present the results and discussion for two main components of the fieldwork: the questionnaire on attitudes to wild spaces and species, and the Q-Method task. The questionnaire measured participant attitudes to key attributes of wildness, wild spaces and wild species, and I present the results below (see Section 4.3). I also present the results of the photo-based Q-Method approach used to capture participants' attitudes to wild spaces (see Sections 4.4.2 & 4.4.3).

In this chapter I also include results for how the Q-Sorts of the image statements related to the underlying wildness quality mapping for each country (see Section 4.4.4), and for how the Q-Sort factor groups relate to the questionnaire results on key attributes of wildness (see Section 4.4.5). I then discuss the individual results from these two methods (see Section 4.5). These results and discussion sections are for detailed investigation of the results, and I reserve the broader discussion, in the context of the literature, for the discussion chapters (see Chapters 7 & 8).

4.2 Introduction

I conducted fieldwork at two study sites in the Scottish Highlands and two study sites in the French Pyrenees (see Section 3.3). For the research with human participants (n=71), I used a photo-based Q-Sort, a linked research questionnaire, and a participatory mapping walk at the two sites in Scotland (n=41), and one of the study sites in France (n=30). Research on ecoacoustic components of wildness took place at all four study sites.

Recruitment for human components of the research was conducted in line with best practice, and every attempt was made to balance human participants for gender and local/non-local using a purposive sampling strategy (see Section 3.4). Participant numbers for gender and local/non-local were well balanced. Participants classified themselves into local/non-local residents, and whether they visit the mountains often/not often (see Appendix C for full questionnaire). A large majority of the participants regularly visit the mountains. Participant numbers for the pre-identified stakeholder groups (Group 1 = general public, Group 2 = government agencies, Group 3 = environmental sector, Group 4 = land owners/managers) is dominated by the general public. The least well represented group are land owners/managers (see Table 4.1).

Table 4.1: Breakdown of human research participants by gender, local/non-local, how often they visit the mountains, and expert-proposed stakeholder groupings. Group 1 = general public, Group 2 = government agencies, Group 3 = environmental sector, Group 4 = land owners/managers.

MALE - FEMALE		**LIVE LOCALLY**		**GO TO THE MOUNTAINS OFTEN**		**STAKEHOLDER GROUPINGS**	
SCOTLAND		**SCOTLAND**		**SCOTLAND**		**SCOTLAND**	
MALE	21	LIVE LOCALLY	25	GO OFTEN	37	GEN PUBLIC	18
FEMALE	20	DON'T LIVE LOCALLY	16	DON'T GO OFTEN	4	ENV. AGENCIES	12
						GOV. SECTOR	7
FRANCE		**FRANCE**		**FRANCE**		LAND	4
MALE	20	LIVE LOCALLY	6	GO OFTEN	21		
FEMALE	10	DON'T LIVE LOCALLY	24	DON'T GO OFTEN	9	**FRANCE**	
						GEN PUBLIC	27
ALL SITES		**ALL SITES**		**ALL SITES**		ENV. AGENCIES	0
MALE	41	LIVE LOCALLY	31	GO OFTEN	58	GOV. SECTOR	3
FEMALE	30	DON'T LIVE LOCALLY	40	DON'T GO OFTEN	13	LAND	0
						ALL SITES	
						GEN PUBLIC	45
						ENV. AGENCIES	12
						GOV. SECTOR	10
						LAND	4
TOTAL	**71**		**71**		**71**		**71**

4.3 Questionnaire results

The questionnaire completed by participants consisted of a series of grouped questions on attitudes to wild spaces and wild species (see Section 3.6.2). I present a basic descriptive analysis of data here for the results of questions on: 1) attributes of wildness, and 2) attitudes to wild spaces and species. I present further statistical analysis of specific components of the questionnaire data in relation to the before-and-after questions in Chapter 5 in the context of the results on mobile methods (see Section 5.3).

4.3.1 Importance of key attributes of wildness

I measured participant attitudes to the key attributes of wildness which were used as part of the wildness quality mapping of Scotland using a standard Likert format. The questionnaire asked participants to evaluate a given statement in terms of how important it was as a criterion of wildness. An example question is “How important do you feel the following criterion for wild spaces is: a high degree of perceived naturalness?”; (not important to very important,1-8). Attributes included were as follows: a sense of sanctuary or solitude, perceived naturalness of the landscape, remoteness from civilization, lack of human artefacts, inspiring quality of the landscape, emotional response to landscape – e.g. it creates a sense of awe, lack of evidence of land use, fulfilment from the physical challenge of accessing the area, geophysical ruggedness of the terrain (see Appendix C:5-6 for full question set). I reprocessed participant scores on attribute importance for both sites (Scottish and French study sites’ data combined, n=71), across the nine wildness attribute statements, into four groups: strongly disagree (1-2), disagree (3-4), agree (5-6) and strongly agree (7-8).

All of the nine attributes listed were considered important attributes of wildness. Strongest agreement is seen on the importance of a feeling of sanctuary (97%), with similarly high scores for perceived naturalness (93%), remoteness (92%) and artefacts (92%). Highest disagreement is seen on the importance of the attributes for how physically challenging (18%) and rugged the terrain is (28%). How inspiring the landscape is, its ability to create an emotional response, and the presence of contemporary land use were also considered important attributes of wildness (see Figure 4.1).

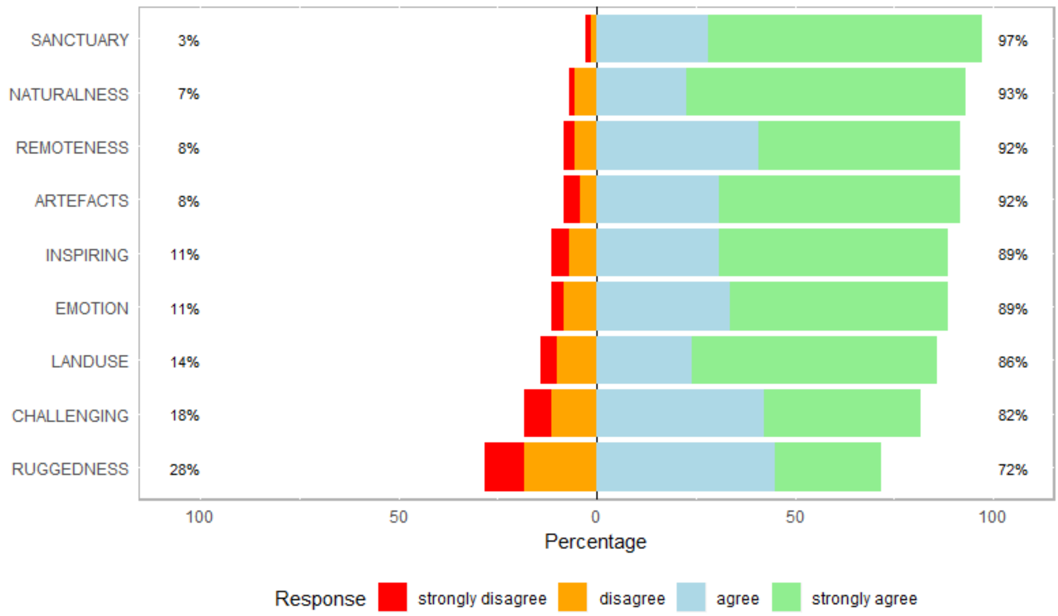

Figure 4.1: Combined participant scores for the questionnaire completed at sites BEN,I&I and LES on the importance of a given attribute of wildness. See main text for details of questions.

I show the results for the same set of questions on key attributes of wildness, split by country, in Figure 4.2. Participant agreement on the importance of sanctuary or solitude as an attribute of wildness is higher in both Scotland (95%) and France (100%) than for all other attributes. Similar patterns are seen in both countries for most attributes, with the strongest divergence in opinions between countries seen for the attributes ‘human artefacts in the landscape’ and ‘ruggedness’.

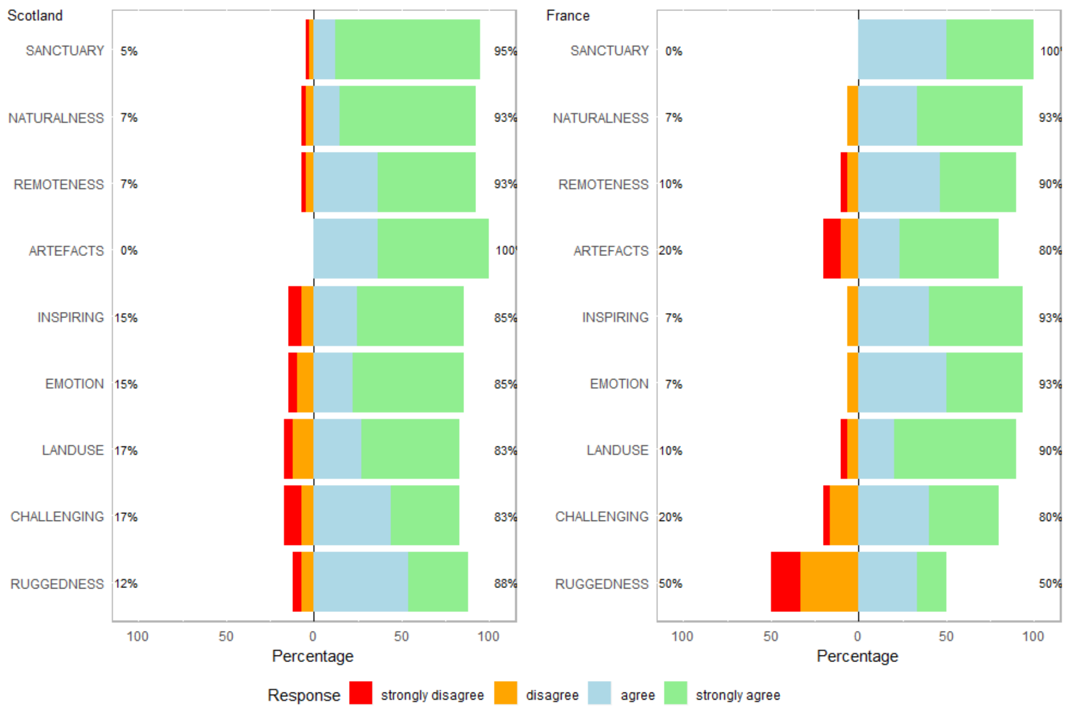

Figure 4.2: Participant scores for the questionnaire completed at sites BEN,I&I and LES on the importance of a given attribute of wildness, split by country – Scotland vs France. See main text for details of questions.

I show the results for the questions on key attributes of wildness, split by local/non-local, in Figure 4.3. Again, agreement is higher for ‘sanctuary’ than for any of the other scores, with identical scores for each country (97%). Least agreement is shown for the attributes ‘human artefacts’, ‘land use’ and ‘ruggedness’.

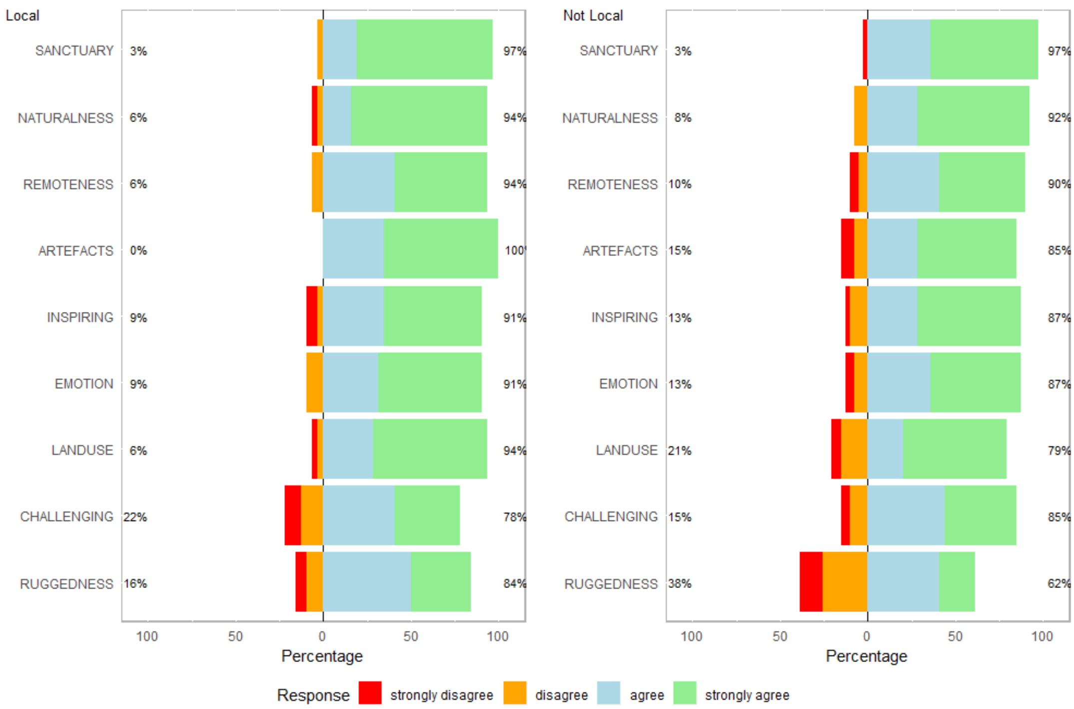

Figure 4.3: Participant scores for the questionnaire completed at sites BEN,I&I and LES on the importance of a given attribute of wildness, split by local vs. non-local. See main text for details of questions.

I show the results for the same set of questions for all sites, split by stakeholder group, in Figure 4.4. Overall, the results for all four groups are very similar, with the majority of respondents agreeing on the importance of all attributes of wildness. For group 1 (the general public), most importance is placed on the attributes ‘sanctuary’ (98%) and ‘naturalness’ (91%), and strongest disagreement on the importance of ‘ruggedness’ (40%) and how challenging the terrain is (24%). For group 2 (government agencies), ‘naturalness’ (100%), ‘remoteness’ (100%), and ‘artefacts’ (100%) are considered the most important; strongest disagreement is shown for the importance of land use (25%). For group 3 (environmental sector) all attributes are considered important. with the attributes ‘sanctuary’, ‘naturalness’, ‘remoteness’, ‘inspiring’, and ‘emotion’ all scoring 100% agreement, and all the remaining attributes scoring 90%. For group 4 (land owners/managers), strongest agreement is on the importance of ‘sanctuary’, ‘artefacts’, ‘challenging’ and ‘ruggedness’: all scoring 100%; and strongest disagreement is on the importance of land use, and ‘naturalness’ (25% strongly disagree).

Figure 4.4: Participant scores for the questionnaire completed at sites BEN, I&I and LES on the importance of a given attribute of wildness, split by stakeholder group. Group 1 = general public, group 2 = government agencies, group 3 = environmental sector, group 4 = land owners/managers. See main text for details of questions.

4.3.2 Attitudes to wild spaces and species

I measured participant attitudes to wild spaces and wild species using a standard Likert format. An example question is: "'The amount of native woodland in Scotland should be increased', strongly disagree (1) – strongly agree (7)". Questions of this format were asked on: the amount of native woodland, the number of butterflies, the number of corvids, the number of foxes, the number of raptors, the number of birds of prey, and the number of capercaillie (see Appendix C:7 for full question set).

There were two additional broad questions on wild spaces and wild species. These were of a different format. The statement format was: "'There are sufficient wild spaces/wild species in Scotland', strongly disagree (1) – strongly agree (7)". Species in Scotland were wild cat, beaver, pine marten and birds of prey; and in France, red deer, wild boar, isards, stoats and birds of prey. Participant scores for all sites (BEN, I&I, & LES; n=71), were reprocessed into five groups; strongly disagree (1), disagree (2-3), neutral (4), agree (5-6) and strongly agree (7).

Across all study sites, strongest agreement is seen for the idea of allowing the amount of native woodland to increase (100%). Levels of agreement for butterflies (99%), capercaillie (94%), and birds of prey (97%) are also very high. Overall, the largest group of participants agree that there are sufficient wild spaces (45%), but disagree that there are sufficient wild species (40%) (see Figure 4.5).

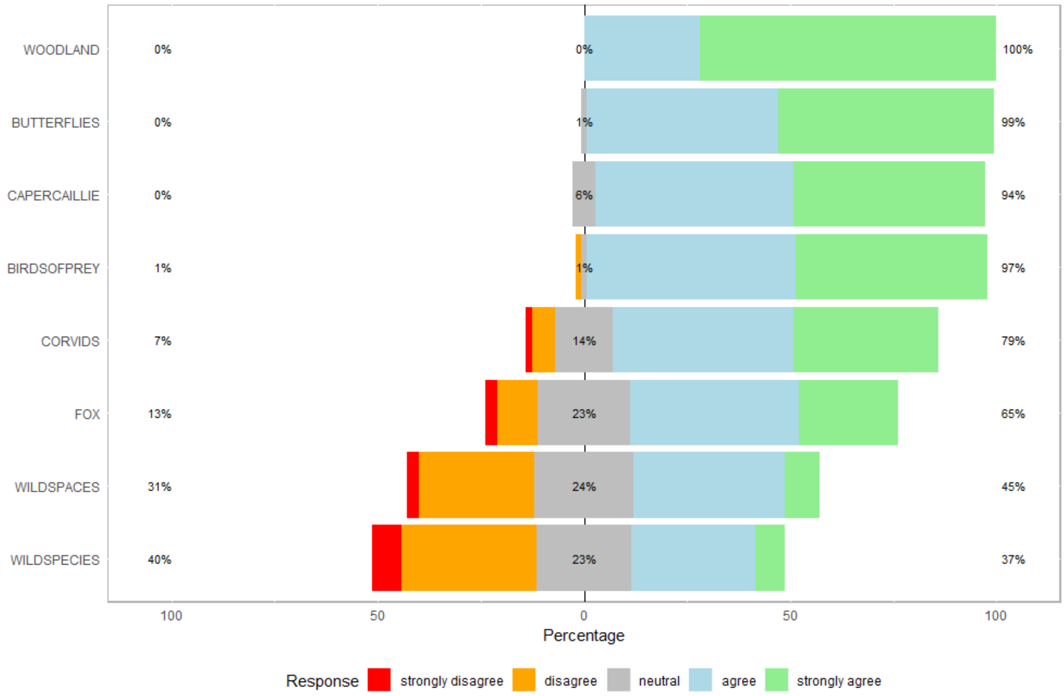

Figure 4.5: Combined participant scores for the questionnaire completed at sites BEN,I&I and LES on attitudes to wild spaces and wild species. See main text for details of questions. See main text for details of questions.

Attitudes to native woodland and individual wild species split by country show similar scores to the overall result. In France, there is almost complete agreement on the idea of increasing the amount of woodland (100%), butterflies (100%), capercaillie numbers (100%) and birds of prey (97%). In Scotland, the result is similar for woodland (100%), butterflies (98%) and birds of prey (98%), although agreement is lower on increasing capercaillie numbers (90%). In France, there was high agreement that corvid (90%) and fox (90%) numbers should increase. However, in Scotland fewer people agreed on an increase in corvid (71%) and fox (46%) numbers, with a high number of responses classified as 'neutral', notably on the question of foxes (37%).

In France, most respondents disagreed that there were sufficient wild spaces (43%) and wild species (57%). In Scotland, the opposite was true, with the majority agreeing there were already sufficient wild spaces (59%) and wild species (45%).

One additional question on wild predators was also asked in Scotland and France, but because these species (e.g. bears) are already present in France, the question format is different and the results were not grouped for all site analysis in the Figure 4.5 results above. The question statement on wild predators for Scotland was “There should be wild species such as lynx, bear and wolf in mountain areas in Scotland”. In Scotland, the majority of respondents (54%) stated that wild predators should be present. In France, the question statement was “There are currently enough wild species such as lynx, bear, wolf in the Pyrenees mountains”. In France, the majority did not feel there are enough wild predators (73%). See Figure 4.6.

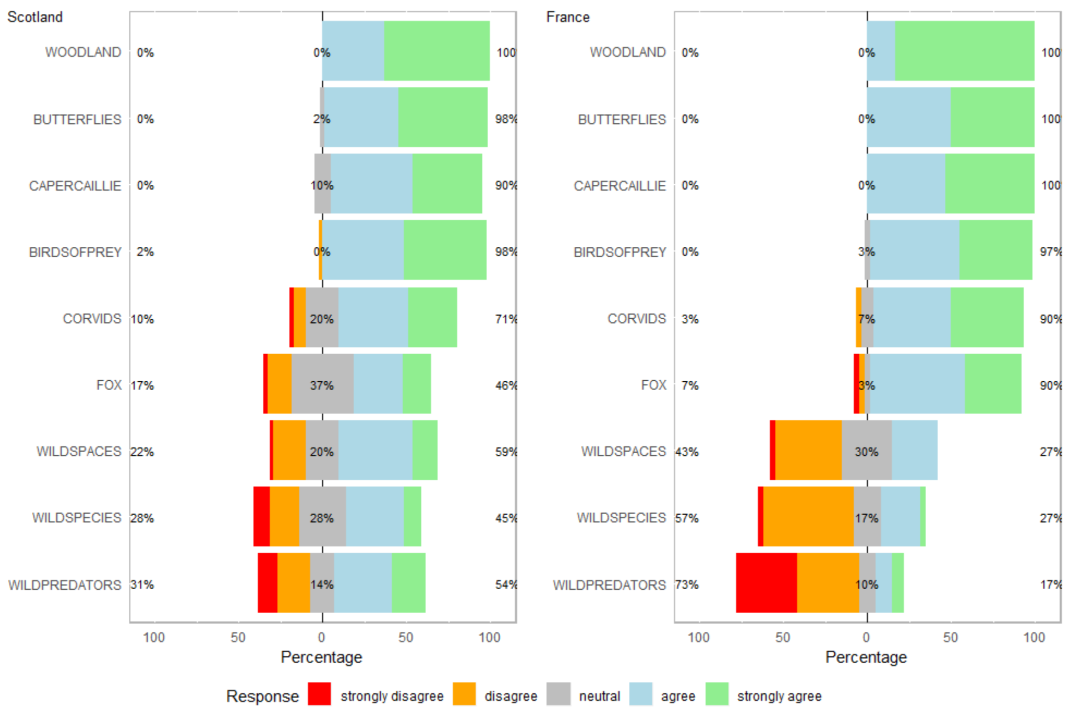

Figure 4.6: Participant scores for the questionnaire completed at sites BEN,I&I and LES on attitudes to wild spaces and wild species, split by country. See main text for details of questions.

Attitudes to native woodland and individual wild species also show similar scores for most questions asked when split by local/non-local groups (see Figure 4.7). For the local group, agreement is high for woodland (100%), butterflies (97%) and birds of prey (97%), although agreement is lower on increasing capercaillie numbers (88%). For the non-local group there is almost complete agreement on the idea of increasing the amount of woodland (100%), butterflies (100%), capercaillie numbers (100%) and birds of prey (97%). For the question on fox numbers, local respondents show a slightly lower level of agreement that they should increase (62%), than non-local respondents (67%). Local respondents more strongly agree that there are sufficient wild spaces (56%) than non-local (36%). Local respondents more strongly agree that there are sufficient wild species (45%) than non-local (31%). Data on attitudes towards wild predators is not presented as this cannot be grouped across responses.

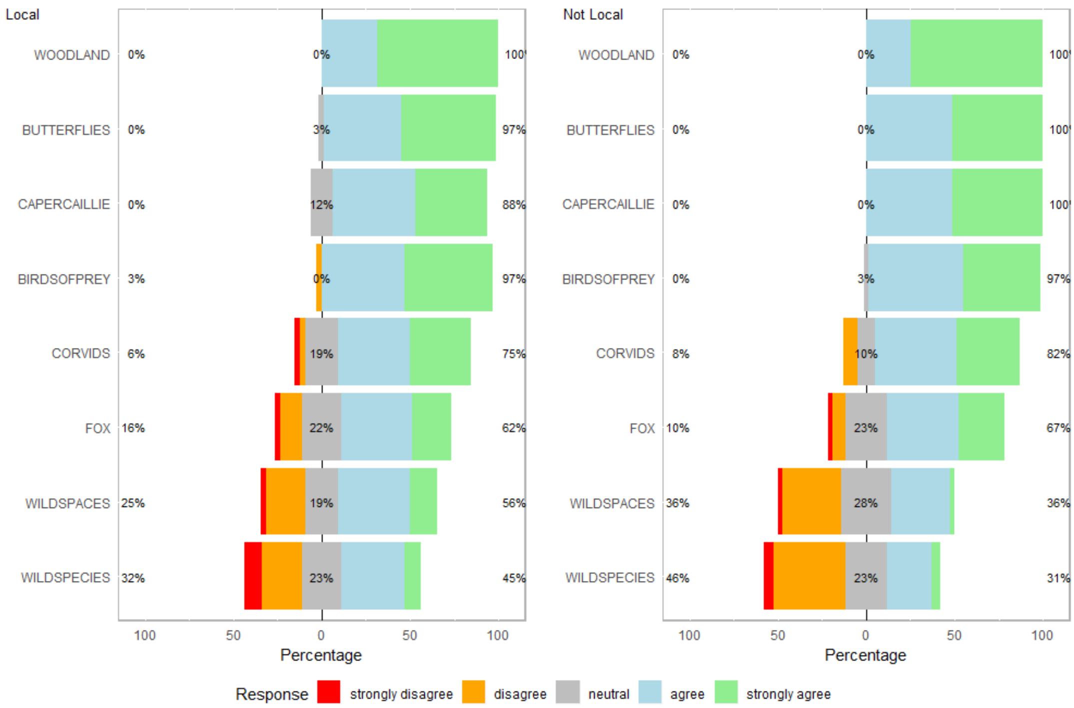

Figure 4.7: Participant scores for the questionnaire completed at sites BEN,I&I and LES on attitudes to wild spaces and wild species, split by local/non-local. See main text for details of questions.

Attitudes to native woodland and individual wild species also show similar scores for most questions asked when split by the pre-defined participant groups (see Table 4.1), with 90% agreement or greater for group 1 (general public), group 2 (government agencies) and group 3 (environmental sector) on the idea of increasing the amount of woodland, butterflies, capercaillie and birds of prey (see Figure 4.8). Of note is that group 4 (land owners/managers) most clearly diverge from the other groups on the question of butterflies and birds of prey, with 25% disagreeing that bird of prey numbers should increase.

For groups 1, 2 and 3 there was 98% agreement or greater that bird of prey numbers should be allowed to increase. Group 4 showed the highest levels of disagreement on corvids (25%) and foxes (25%) with the most pronounced difference in comparison with group 3 (environmental sector), where none of the respondents expressed disagreement on increasing numbers of any of the species.

For the question, “Are there sufficient wild spaces?”, attitudes varied amongst groups, with the highest agreement (67%) amongst group 2 (government agencies). For the question “Are there sufficient wild species?”, the highest agreement came from group 4 (land owners/managers), who either agreed (50%) or were classified as neutral (50%). The highest disagreement score for this question (49%) was expressed by group 1 (general public).

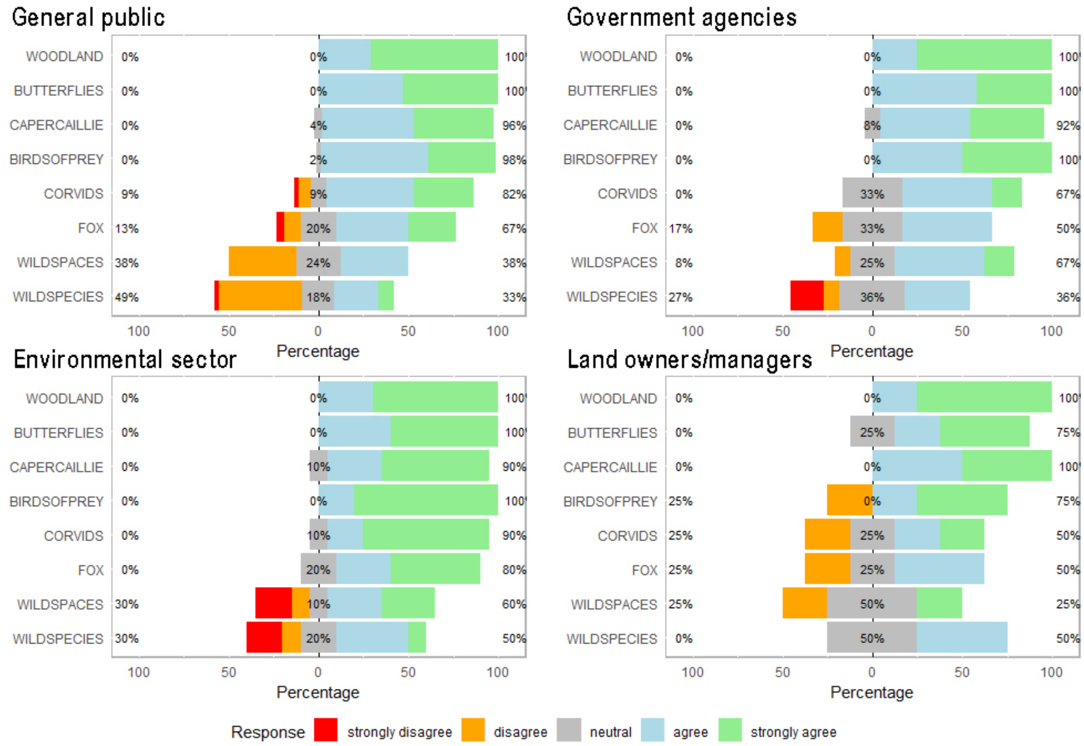

Figure 4.8: Participant scores for the questionnaire completed at sites BEN,I&I and LES on attitudes to wild spaces and wild species, split by stakeholder group. Group 1 = general public, Group 2 = government agencies, Group 3 = environmental sector, Group 4 = land owners/managers. (See Table 4.1. for group details)

4.4 Q-Method results

4.4.1 Exploratory factor analysis

Preliminary analysis is considered a key part of Q-Method to determine how the factor analysis should best be approached (Watts & Stenner 2012) (see Section 3.6.1). An exploratory review of these data revealed that for both study sites there were high levels of commonality in the viewpoints expressed, with a single factor explaining 85% of the variance at the Scottish sites and 88% of the variance at the Pyrenees site (see Tables 4.2a and 4.2b).

Table 4.2a: Percentage variance explained by factor for Scottish study site

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	34.1625	1.1855	0.6348	0.4397	0.3858	0.3449	0.3353	0.2749
% Explained Variance	85	3	2	1	1	1	1	1
Cumulative % Expln Var	85	88	90	91	92	93	94	95

Table 4.2b: Percentage variance explained by factor for Pyrenees study site

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8
Eigenvalues	26.5273	0.5295	0.455	0.334	0.2837	0.2134	0.2059	0.1894
% Explained Variance	88	2	2	1	1	1	1	1
Cumulative % Expln Var	88	90	92	93	94	95	96	97

Looking at these first pass data from Scotland, one initial query was whether there were four distinct factors detectable in the Q-sorts in line with the broad spectrum of stakeholder opinion that emerged from discussions with local experts in Scotland (see Section 3.4). I dismissed this attempt at a confirmatory factor analysis (CFA) because a four-factor solution to the Scottish Q-Sort is confounded by the Eigenvalues for the factors. Eigenvalues are calculated based on how many sorts load onto that factor and measure the strength and potential explanatory power of an extracted factor. It is considered the norm, based on the Kaiser–Guttman criterion, to only keep factors with an Eigenvalue of 1 or above (Kaiser 1970, Watts & Stenner 2012). Based on this single criterion, in Scotland the data support at best a two-factor solution. Looking at the data for France, by the same criterion we only have a single-factor solution. Attempting to force a four-factor solution onto the Scottish data revealed that nearly half of participant sorts did not load significantly onto any single factor ($n=17$, $p< 0.05$). If, however, we force a single-factor solution onto the same data, without rotation, all respondents load significantly onto a single factor ($n=40$, $p<0.01$) suggesting high levels of common variance, with the participants sharing a common viewpoint on the question at hand (Kline 1994).

The field of Q-methodology tends to assume that where a single factor explains the majority of the variance in a sample of sorts, it is unlikely that there will be a robust solution that contains multiple narratives (Brown 2019). Single-factor solutions for Q-Sorts are, however, rare, and are often linked to methodological issues to do with participant selection or statement choice (Fairweather 2002). The current study recruited participants widely, and selected image statements using a robust and representative model (see Section 3.6.1 & Table 4.1).

A single-factor solution does not necessarily mean that there is a methodological flaw in the study design. Cases are reported where a single-factor solution, combined with analysis of the qualitative data (post-sort interviews), reveals that the single-factor solution may in fact represent an interesting result in its own right, such as documenting the presence of the "overwhelming influence of professional socialization" (Brown 2019). Furthermore, the results of the other methods used in this research project (see Chapters 5 & 6.) also suggest that there is significant agreement among participants on perceptions of wildness along a gradient of wildness. In this regard, the emergence of a clear one-factor solution in the Q-Sorts may be a reflection of this same shared viewpoint.

Review of the qualitative post-sort data, and the walking interviews with participants, suggested however that there were differences in their opinions on certain images and specific themes in relation to wild spaces. Whilst the *common variance* – the meaning and variability held in common - is very high, there are nevertheless divergences in particular points of view (linked to specific statements) also present within this overall agreement (Kline 1994). Given that the stated purpose of a factor analysis is to account for as much of the variance as possible, this *specific variance* is also of key interest (Watts & Stenner 2012). It is also of particular interest given my specific research aim of capturing new knowledge of people's perception and attitudes towards wild spaces and wild species (RQ1).

These differences in opinions are also reflected in the exploratory stakeholder analysis of the scores from the walking landscape assessment task. This showed that, despite significant agreement both amongst participants as well as with the existing maps of wildness, there remained a significant difference between two of the stakeholder groups for the study site BEN (see Section 5.5). This is also reflected in the differences in attitudes to key attributes of wildness, as outlined above (see Section 4.1.1). Taking account of these considerations, and following a review of the limited post-sort interviews, I performed a further Q-Method analysis to explore whether a two-factor solution was informative in terms of understanding any differences in the perspectives of the participants (Stephenson 1953; Watts and Stenner 2012).

It is of note that in recent debates on the value of Q-Method as an exploratory method, the importance of the researcher's knowledge and experience of the nuances of the debate at hand has been emphasised (Brown 2016). Nevertheless, there is a growing trend of focusing on the statistical power of Q-Method to give us simple, robust quantitative data from a complex qualitative world (Akhtar-Danesh 2016). In respect of this subsequent analysis, I used a 'standardized approach to data analysis' in Q-Method, implementing computer-based software tools, to conduct: 1) centroid analysis, 2) VARIMAX rotation, and 3) automatic flagging of factor loadings (Nilsson 2018:5). A comparison of the results from a Centroid versus a principal component analysis (PCA) approach revealed minimal differences in the composition of the factors and the distinguishing statements. In terms of the rotation method, a judgmental rotation was tested, but did not produce a clearer separation of factors than the standard VARIMAX option. A VARIMAX rotation technique uses statistical criteria to identify factors with the maximum amount of study variance.

A further reason for using a standard VARIMAX route is because of the dual criticisms of subjectivity in factor choice and scientific reproducibility that have been levelled against this approach, although I note that there is disagreement on this (Watts & Stenner 2012; Akhtar-Danesh 2016; Brown 2016). See Tables 4.3a and 4.3b for the results of this analysis for both study sites.

Table 4.3a: Scottish Q-Sort data, percentage explained variance, cumulative percentage explained variance and Eigenvalues for a two-factor solution.

	Factor 1	Factor 2
Eigenvalues	34.0156	1.0765
% Explained Variance	85	3
Cumulative % Expln Var	85	88

Table 4.3b French Q-Sort data, percentage explained variance, cumulative percentage explained variance and Eigenvalues for a two-factor solution.

	Factor 1	Factor 2
Eigenvalues	26.4123	0.3703
% Explained Variance	88	1
Cumulative % Expln Var	88	89

4.4.2 Factor analysis and results from Q-Method

After initial exploratory factor analysis, I used the two-factor solution with VARIMAX rotation for both sites to analyse the results of the Q-Sort. A two-factor solution for the Scottish data explains 88% of the variance amongst participants (see Table 4.3a). A factor solution that explains over 40% of the variance is considered sound, so I have a high level of confidence that this two-factor solution accurately captures the viewpoints expressed by the participants (Kline 1994; Watts & Stenner 2012).

It is considered the norm – based on the Kaiser–Guttman criterion - to only keep factors with an Eigenvalue of 1 or above, and a two-factor solution appears robust in this respect, whether we use a centroid or a PCA approach (Kaiser 1970; Watts & Stenner 2012). A strong positive correlation between a participant sort, and the reference sort for that factor, is considered in the context of Q-Method to be a score greater than 0.7 (Watts & Stenner 2012). Using this correlation criterion, participants load evenly onto these two factors (n=23 Factor 1, n=17 Factor 2, auto-flagged at $p<0.01$). This strong correlation also means that both factors pass Humphrey's rule which states that a factor is significant if *"the cross-product of its two highest loadings (ignoring the sign) exceeds twice the standard error"* (Brown 1980: 223). I note, however, that several participants loaded evenly onto the two factors and did not correlate strongly with either of the two factors (n=3 in Factor 1, and n=4 in Factor 2, <0.7) (see Table 4.4).

Table 4.4: Factor matrix for Scottish Q-Sort data showing factor loadings, which sorts were flagged onto which factors, and percentage variance explained by each factor.

FACTOR MATRIX WITH DEFINING SORTS FLAGGED					
Sort.No.	**Participant code**	**Factor 1**		**Factor 2**	
1	RB11	0.8832	flagged	0.3858	
2	FC8	0.8741	flagged	0.391	
3	DM29	0.8432	flagged	0.4098	
4	JS9	0.8067	flagged	0.5067	
5	EM22	0.8007	flagged	0.5236	
6	AM30	0.7775	flagged	0.5373	
7	SM6	0.7647	flagged	0.5392	
8	DB37	0.7642	flagged	0.558	
9	NM21	0.7635	flagged	0.5989	
10	CR40	0.7603	flagged	0.4633	

11	CD15	0.7517	flagged	0.5722	
12	LR17	0.7513	flagged	0.5455	
13	TL23	0.7509	flagged	0.5835	
14	FB4	0.7285	flagged	0.578	
15	SP26	0.7202	flagged	0.6034	
16	NH3	0.7107	flagged	0.586	
17	BT16	0.7084	flagged	0.6612	
18	GT38	0.7037	flagged	0.6278	
19	LB12	0.7022	flagged	0.6363	
20	WG10	0.7017	flagged	0.6507	
21	MG20	0.6958	flagged	0.6259	
22	GM41	0.6777	flagged	0.6475	
23	MA39	0.6423	flagged	0.6216	
24	CC31	0.6569		0.7003	flagged
25	NA19	0.6226		0.7155	flagged
26	SB24	0.6199		0.7236	flagged
27	SR13	0.6187		0.7212	flagged
28	NK28	0.6164		0.6819	flagged
29	SN25	0.6036		0.7171	flagged
30	AH33	0.6018		0.6695	flagged
31	MB42	0.6001		0.6976	flagged
32	SK27	0.5793		0.7375	flagged
33	CT35	0.5717		0.7131	flagged
34	DA18	0.5593		0.6896	flagged
35	SM14	0.5513		0.7595	flagged
36	JW36	0.5194		0.7207	flagged
37	RB34	0.5091		0.7684	flagged
38	AR32	0.507		0.7752	flagged
39	AC5	0.4168		0.8526	flagged
40	AS7	0.2846		0.9059	flagged
%Explained Variance		**46**		**42**	

A two-factor solution for the Pyrenees data explains 89% of the variance amongst participants (Table 4.3b). Whilst the Pyrenees data only have one factor with an Eigenvalue above 1, and therefore fails to pass the Kaiser–Guttman criterion, I maintained a two-factor solution, even given the high degree of common variance. This was done in line with the logic outlined above that there were clear differences found between participants in their attitudes to key attributes of wildness (see Section 4.3.1). Participants load less evenly onto these two factors than in the Scottish data (n=22 Factor 1 and n=8 Factor 2 auto-flagged at $p<0.01$). Several participants loaded evenly onto the two factors and did not correlate strongly with either of the two factors (n=7 in Factor 1and n=4 in Factor 2, <0.7) (see Table 4.5).

Table 4.5: Factor matrix for Scottish Q-Sort data showing factor loadings, which sorts were flagged onto which factors, and percentage variance explained by each factor.

FACTOR MATRIX WITH DEFINING SORTS FLAGGED					
Sort.No.	**Participant code**	**Factor 1**		**Factor 2**	
1	NT21	0.8556	flagged	0.4404	
2	SL16	0.812	flagged	0.5007	
3	NL9	0.8097	flagged	0.5387	
4	GS30	0.773	flagged	0.5376	
5	BM12	0.7709	flagged	0.574	
6	JL5	0.7535	flagged	0.5548	
7	PD6	0.7519	flagged	0.6108	
8	CR15	0.7519	flagged	0.6042	
9	MC22	0.7488	flagged	0.6015	
10	JS11	0.7415	flagged	0.5575	
11	PD10	0.7369	flagged	0.5704	
12	NL26	0.7303	flagged	0.6145	
13	PJ19	0.7278	flagged	0.6284	
14	MJ18	0.725	flagged	0.5999	
15	EA14	0.7013	flagged	0.6446	
16	JS23	0.6965	flagged	0.6659	
17	M7	0.6953	flagged	0.6184	
18	CL25	0.6949	flagged	0.6751	
19	MC17	0.6897	flagged	0.6264	
20	JM3	0.6895	flagged	0.6525	
21	GJ13	0.6887	flagged	0.6574	
22	GM20	0.64	flagged	0.5319	
23	ZZ24	0.6653		0.7204	flagged
24	PG4	0.6608		0.6877	flagged
25	CB29	0.6594		0.6805	flagged
26	RL1	0.6481		0.6986	flagged
27	PA8	0.618		0.6466	flagged
28	LL28	0.6146		0.7307	flagged
29	PL2	0.5511		0.7976	flagged
30	CD27	0.3701		0.7745	flagged
%Explained Variance		**50**		**40**	

4.4.3 Analysis of Q-Sorts of image statements

I completed an analysis of the Q-Sorts for both countries to show consensus versus disagreement for the images (n=40), sorted by variance in Z-Scores (see Tables 4.6a & 4.6b).

Table 4.6a: Q-sort values for individual images for both Scottish sites combined (BEN and I&I), sorted by consensus vs. disagreement using variance in Z-Scores. Values in factor columns show position in Q-Sort grid where negative is less wild and positive is more wild. Statements with most consensus between factors are at the top. Significant distinguishing statements (p<0.01) are highlighted in grey and marked with an asterisk. Images are described using descriptive statements for ease of reference.

Factor Q-sort Values for images sorted by Consensus vs. Disagreement				
No.	**Image statement (* notes a distinguishing statement)**	**factor 1**	**factor 2**	**Z-Score variance**
7	Small footpath amongst Heather in Cairngorm National Park	0	0	0
16	Vague footpath on summit ridge with plantation forest Cairngorm	2	2	0
17	Tesco open 24 hours in Inverness	-4	-4	0
18	Old church and car park in Kincraig	-2	-2	0
34	Small metal gate on footpath outside Torridon	-1	-1	0
39	Road junction outside Balmacara	-3	-3	0
1	Forest track junction in Plantation Scots pine in Cairngorm	-1	-1	0.001
6	Bus stop in the middle of Kinlochewe	-3	-3	0.002
20	Small footpath on old pine woods in Cairngorm	0	0	0.002
24	School and school signpost in Kinlochewe	-2	-2	0.002
26	Old silver birch forests woodland and small path Balmacara	0	-1	0.002
40	Natural river Ford on steppingstones of the back of Torridon	1	1	0.002
13	Crofter with flock of sheep near Dundonnell	0	0	0.004
15	Small B Road amongst fields in agricultural setting near Strathpeffer	-2	-2	0.004
12	Roundabout near petrol station outside Tesco in Inverness	-4	-4	0.005
36	Ptarmigan on a snow patch in the mountains in the Cairngorm area	3	3	0.005
9	Main A road to Ullapool	-2	-1	0.007
11	Small dam by reservoir with person walking Pentlands	-1	-1	0.008
3	Railway infrastructure around Edinburgh	-3	-3	0.009
21	Farm gates in Kinlochewe	-2	-2	0.009

19	Mountaintops and moorlands off the back of Torridon	2	3	0.01
10	Mountain ridge with rocks and some snow in Cairngorm area	4	2	0.012
29	Stony path climbing out the back of Torridon	0	1	0.015
23	Wooden gate and deer fence near woodland planting scheme Badachro	0	0	0.016
31	Otter caught on camera trap in Invereshie	0	0	0.017
35	Quartz plateau and mountain scenery snow sun Beinn Eighe area	4	4	0.017
27	Footpath in beech forest in Park area outside Perth	-1	-1	0.018
30	View down river gully towards Loch mountains Fisherfield *	3	4	0.029
32	Sandy beach with footprints and reeds Badachro	2	2	0.034
37	Sheep in rural agricultural setting with pine forest Balmacara *	-1	-2	0.041
38	Small loch in mountain area at dusk on the footpath above Dundonnell *	2	1	0.048
2	Small frog on footpath in Creag Meagaidh area *	1	0	0.068
33	Small steep river gully with natural tree growth in Beinn Eighe *	3	1	0.079
4	Footpath showing plastic tubing and corries Creag Meagaidh area *	1	2	0.11
5	Cairn on top of Creag Meagaidh in foggy and snowy weather *	1	3	0.124
28	Shenaval bothy in the Fisherfield wild land area *	0	1	0.141
8	Wind turbines on a hilltop with snow in the background *	-1	0	0.143
22	Single tent wild camping in Caledonian pine woods in Cairngorm *	2	1	0.15
14	Old silver birch forest woodland with no path near Balmacara *	1	0	0.159
25	Trig point with person in the background in Pentlands *	1	2	0.206

Factor Q-sort Values for images sorted by Consensus vs. Disagreement				
No.	**Image statement (* notes a distinguishing statement)**	**factor 1**	**factor 2**	**Z-Score variance**
7	Grazing field	0	0	0
8	Rural village in mountains	-1	-1	0
15	Old growth wood with fungi	2	3	0
33	Sheep grazing in foothills of mountains	1	0	0
30	Grass cut for making hay in rural mountain valley	0	0	0.001
14	Diverse natural habitat off path in Pont d'Espagne	3	3	0.002
27	Forest track and plantation woodland	1	1	0.002
37	Rough track in mountains	1	2	0.002
4	Remote wild valley	4	4	0.003
6	Old growth forest	3	3	0.003

17	Suburban lotissement (housing estate)	-1	-2	0.003
26	Small street with trees in town	-2	-2	0.003
28	Electric pylons in rural setting	0	0	0.003
35	Gite in mountains	0	0	0.003
25	Back street in small town	-1	-1	0.004
1	Old cement bridge in the semi-wild	1	1	0.005
11	Old ruined cabin in mountains	2	2	0.005
21	Agriculture maize and grass	0	0	0.007
10	Hazel woodland	2	2	0.012
12	Open beech woodland	2	2	0.012
40	Market with stalls and police	-2	-3	0.013
2	Ski uplift at Pont d'Espagne in a wild setting	0	0	0.014
34	Small road and grass in mountains	-1	0	0.014
3	National park sign	1	1	0.015
19	Car park with trees and grass by hotel	-2	-2	0.015
39	Cows sitting down in mountains	1	1	0.016
20	Small road in small town	-3	-2	0.017
31	Road in rural mountain area	-1	-1	0.022
29	Signs in small mountain village	-2	-1	0.023
22	Agriculture grazing and farm buildings	0	-1	0.024
36	Old cabin in mountains	0	1	0.026
18	Traffic and roads in town	-4	-3	0.027
32	Sunny square in town	-3	-4	0.032
38	Horses grazing in rural setting	2	1	0.033
9	Road junction in small town	-2	-1	0.035
23	Main road in small town outside school	-3	-4	0.036
5	Remote wild valley floor *	3	4	0.041
16	Natural wild lake *	4	2	0.076
13	Car park in town *	-4	-2	0.078
24	Sports field *	-1	-3	0.097

Analysis of consensus and disagreement between factors based on a statistical analysis of the Z-scores highlights which statements a given factor has ranked significantly differently when compared to the other study factor. In Q-Methodology, consensus statements are often used to identify shared themes in situations where there are multiple factors (Eden et al. 2005). With only two factors explaining at least 88% of the variance in both sites, I did not consider this approach to be useful, as almost all statements could be considered consensus statements. Instead, analysis of the results focused on distinguishing statements. Identification of these distinguishing statements is considered useful when interpreting the divergence between factors in their overall point of view (Watts & Stenner 2012). There are a greater number of distinguishing statements between factors for the Scottish study (n=12) than for the French study site (n=4). Both 12 and 4 are low numbers of distinguishing statements, which is likely to be a product of the consensus within the cohort. I note both that the number of participants was lower in France and that a single-factor solution explained a higher level of variance for the French Q-Sort than the Scottish Q-Sort (see discussion of distinguishing statements in Section 4.5.2).

4.4.4 How do the results for the Q-Sorts correlate with the underlying mapped wildness values for a given photograph?

Photo statements were selected for the photo-based Q-sorts at both study sites using the same underlying theoretical framework based on existing spatial mapping of wildness (see Section 3.6.1). Analysis of the results from the Q-sort compared the Jenks wildness value (WC) for the landscape shown in the photograph with its position in the Q-Sort grid, from least wild (negative) to most wild (positive), as calculated based on the mean Q-Sort position (Figures 4.9a & 4.9b).

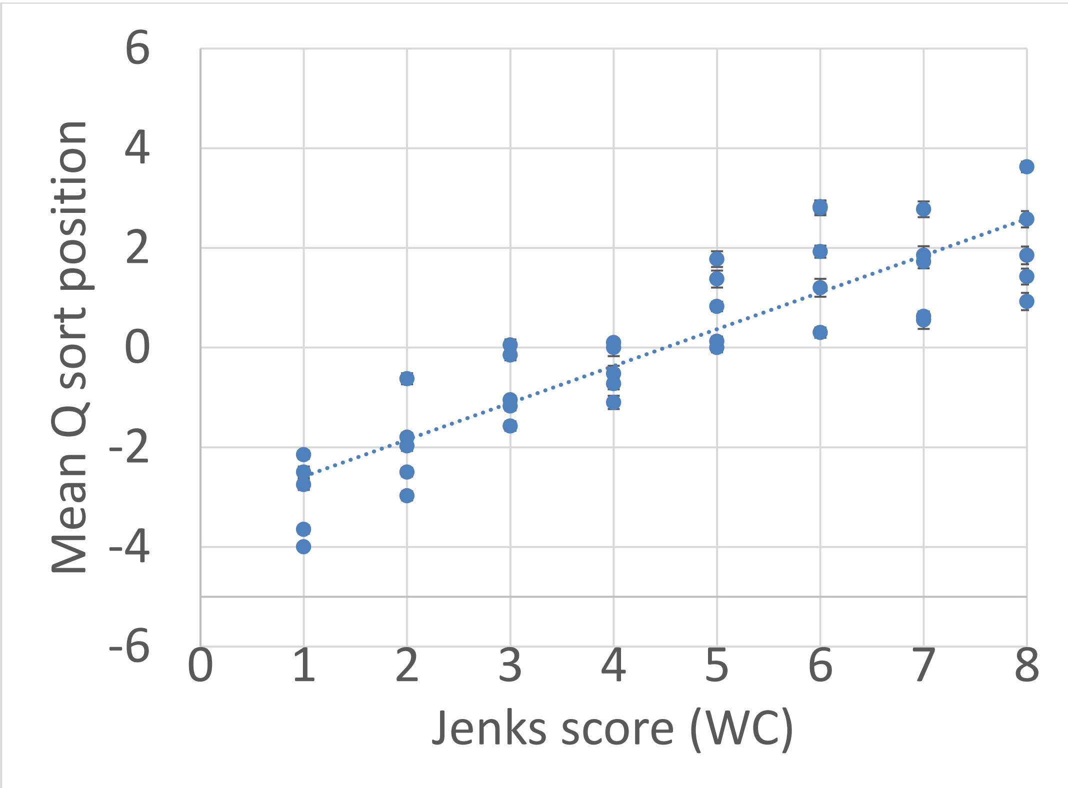

Figure 4.9a: Mean Q-Sort position versus Jenks wildness score for that statement for Scottish study sites (BEN, I&I).

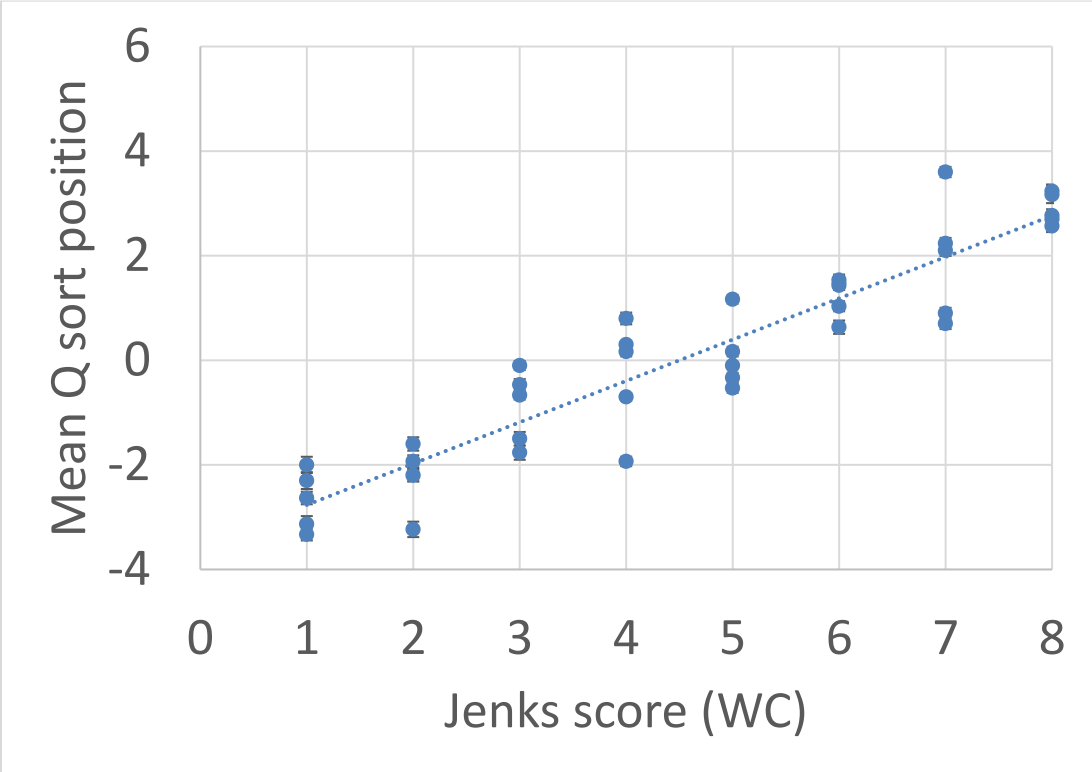

Figure 4.9b: Mean Q-Sort position versus Jenks wildness score for that statement for French study site (LES).

Q-Sort image statement position was calculated using a two-tailed Pearson rank correlation test, and is significantly correlated with wildness class for Scotland ($r=0.889$, $p<0.001$), and France ($r=0.935$, $p<0.01$).

4.4.5 Attitudes to attributes of wildness for Q-Sort factors

I analysed participant attitudes to the key attributes of wildness using the Q-Sort factors identified for each individual country. This followed the same method as described above (see Section 4.4.1).

Overall, respondents from both factors show high levels of agreement on the importance of all attributes. Slight differences are seen for factor 1 in Scotland, which places less importance on the attributes ‘sanctuary’, ‘remoteness’, ‘inspiring’, and ‘challenging’ than those in factor 2. Factor 1 places more importance on the attributes ‘land use’ and ‘ruggedness’ than factor 2. Whilst both factors show high levels of agreement for the attribute ‘naturalness’, 94% of respondents in factor 2 strongly agreed that it was important (see Figure 4.10).

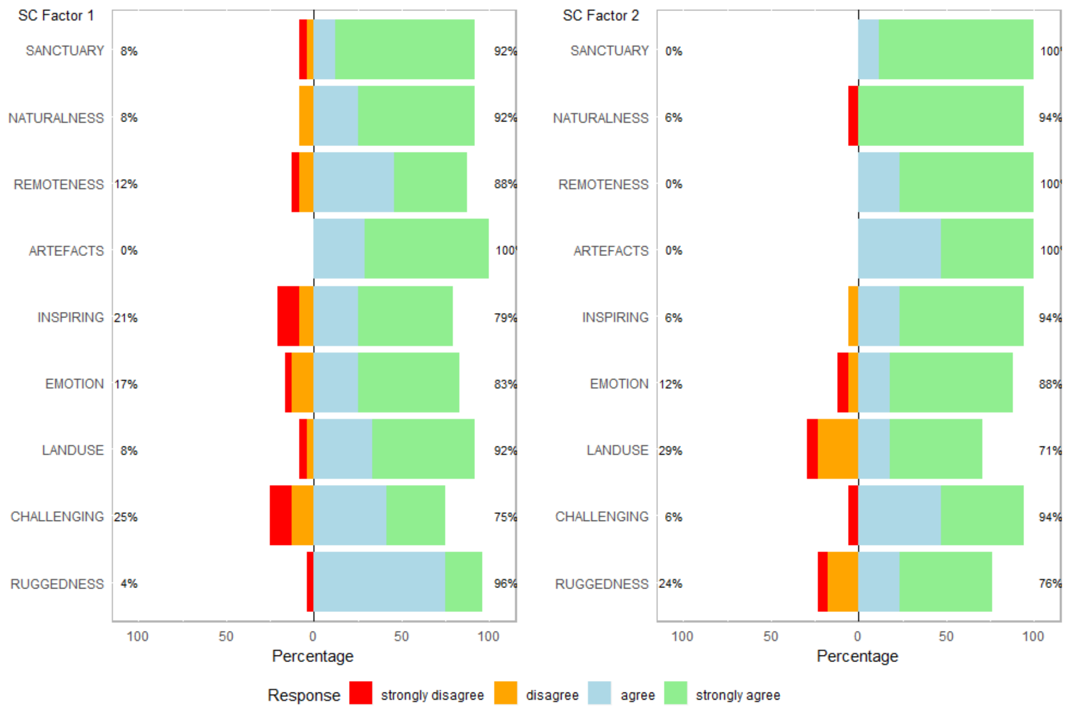

Figure 4.10: Participant scores for the questionnaire completed at Scottish sites BEN and I&I on the importance of a given attribute of wildness, split by Q-Sort factors. SC Factor 1 = Scotland Factor 1, SC Factor 2 = Scotland Factor 2.

In the Pyrenees, respondents from both factors again show high levels of agreement on the importance of all attributes, although the level of agreement is higher for factor 2 than for factor 1. The main divergence between the two factors is for the attribute ‘ruggedness’, with the majority of factor 1 disagreeing that it is important. Participants classified under factor 2 more strongly agree on the importance of ‘naturalness’ and ‘remoteness’ than factor 1. Participants classified under factor 2 more strongly disagree on the importance of human artefacts in the landscape than those in factor 1 (see Figure 4.11).

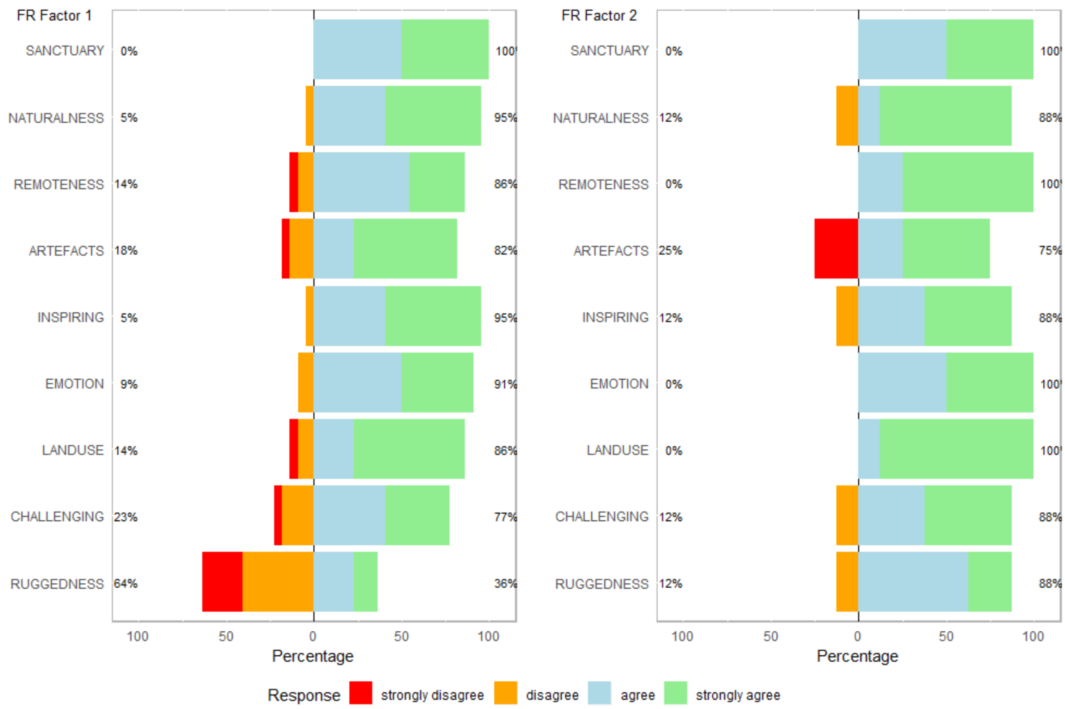

Figure 4.11: Participant scores for the questionnaire completed at French site LES on the importance of a given attribute of wildness, split by Q-Sort factors. FR Factor 1 = France Factor 1, FR Factor 2 = France Factor 2.

4.5 Discussion of results

4.5.1 Attitudes to wild spaces and wild species

I used a traditional questionnaire to measure, in a quantitative way, a broader range of knowledge on participants' attitudes, as well as to provide a reference point for the other methods used in this pilot project. This section discusses the detailed results presented above and, as stated above, I reserve the broader discussion, in the context of the literature, for the discussion chapters (see Chapters 7 & 8).

Across all participants from all study sites there was agreement on the importance of the nine **key attributes of wildness**, with sanctuary or solitude the highest ranked attribute. This simple attribute of wildness ('sanctuary' or 'solitude') is often overlooked in modern debates on wildness, which often focus on the acceptability of economic development in wild spaces, or how we choose to define reference states for how natural the vegetation is (Barry et al. 2001; Ridder 2007; Schnitzler et al. 2008). It is possible that a re-framing of the debate focused on this less contested attribute may provide a way to assess the acceptability of planning decisions that may impact on wild places. The solitude that wild spaces bring is increasingly valued in modern life, and is seen as strongly supporting the argument for the need to increase the accessibility and amount of wild spaces (McMorran & Carruthers-Jones 2015).

Comparing results between countries does raise the question of whether language or translation had an impact on any results found. I made every effort to minimise any possible effects of this type by using a local translator with a lifetime of experience in the mountains, and by piloting the questionnaire in both countries to identify any issues (see Section 3.6.2). Furthermore, I conducted all the fieldwork, I know all the study sites well, and I was always available to answer any questions and explain the instructions further if necessary.

One key difference that did emerge between countries was the importance of human artefacts and ruggedness. French respondents had much lower levels of agreement on the importance of these attributes. One possible explanation is that the presence of significant infrastructure, such as roads, tunnels, and ski resorts in upland areas of both the French and the Spanish sides of the Pyrenees, means that people living in this region are habituated to their presence. As a result, human artefacts are less likely to detract from their experience of wildness, although this can vary depending on how closely people live to developments of this kind (Lasanta et al. 2007; Kliskey 1994).

The other major difference between countries was with respect to the attribute ‘ruggedness’. The fact that the Pyrenees is a mountainous area stretching for almost 420km suggests that this attribute is also a constant in the background of local French people’s experience of wild spaces. Participants may not therefore consider it as an important defining attribute of what makes a wild space in the Pyrenees wild or not, as almost all places in the Pyrenees are rugged, with even quite large towns often dominated by cliffs and mountain tops. ‘Ruggedness’ is also the only attribute that clearly differentiates local and non-local participants. Following the same line of reasoning as above, it could be argued that to a visitor, mountain areas in Scotland and France all appear rugged. In the context of wildness, a ‘purism scale’ is often used as a tool to segment visitors to protected areas into groups for management and monitoring purposes. There have been numerous iterations of this tool, but originally it segregated users along a scale from ‘Strong Wildernists’ to ‘Urbanists’, based on their attitudes and preferences to key features of wildness, such as rugged topography (Hendee 1968). A local is perhaps able to distinguish more clearly between different levels of ruggedness within the mountains than a non-local, as they have deeper knowledge of the place, so for them ‘ruggedness’ still has a value in distinguishing the wilder spaces (Vistad & Vorkinn 2012; Ólafsdóttir et al. 2016).

Looking at the grouped results for all participants on **attitudes to wild spaces and wild species**, highest agreement was for the idea that there should be more native woodland, butterflies, capercaillie and birds of prey. Levels of agreement on increasing the population of corvids and foxes were lower, especially for the fox, but still high. Between stakeholder groups, differences were strongest when comparing the environmental sector with land owners/managers. The environmental sector were almost completely in agreement on increasing numbers for all species, with the majority strongly agreeing, as might be expected from this group. Land owners/managers, however, had much lower levels of agreement for birds of prey, corvids and foxes. This is in line with what we would expect given the current narrative on this latter group’s attitudes to wild species, and the wider debate on the friction between the conservation of biodiversity and human development (Young et al. 2007; Avery 2015; Pooley et al. 2017).

Looking at the more general questions, the results from all respondents combined were fairly balanced on whether there were sufficient wild spaces and species. Looking more closely, respondents in Scotland had higher levels of agreement than those in France that there were already sufficient wild spaces and species. In terms of wild spaces, this is surprising given the size of the Pyreneen mountain range, but may again be a reflection of the degree to which the Pyrenees is also an area developed for tourism and the ski industry. Our attitudes to wild species are based not on scientifically measurable levels of biodiversity, but more often on how visible species are (Buijs et al. 2006). The Pyrenees has a greater abundance and diversity of wild species than Scotland, but given the size of the mountain range and the level of forest cover, those wild species are less visible, which may explain why the French group feels that population numbers should be increased. It is also possible that the French group are more used to co-existing with wild species and therefore see no issues with increasing their numbers. Stakeholder group responses for the question on wild species are not clear in either direction, but it is perhaps of note, in line with earlier comments, that land owners/managers is the only group where no respondents disagreed with the statement that there are already enough wild species in the mountains. I note that the low number of participant (n=5) in this group limits the weight I can give to their results as being representative of attitudes in the wider population.

Finally, looking at the question on wild predators, there were in fact similar attitudes expressed in both countries. The majority of respondents in Scotland felt that bear, wolf and lynx should be re-introduced to mountain areas. In France, an even bigger majority disagreed that there were sufficient numbers of bears, wolves and lynx in mountain areas. This result is surprising given the heated debates around issues related to large carnivores in Europe (Wilson 2004; Hetherington 2018; Penteriani et al. 2018). Attitudes to brown bears have, however, been shown to vary significantly depending on which area of the Pyrenees respondents live in (Piédallu et al. 2016), and this result would require further analysis and larger participant numbers to interpret properly.

Overall, I consider the results from the questionnaire to be useful for developing a deeper understanding of the diversity of views among the participants in the project, as well as exploring whether this sample was heterogenous enough to be of value in interpreting the results of the other methodological approaches such as the Q-Sort.

4.5.2 Q-Sort

The key result emerging from the results of the Q-Sort is the low number of extractable factors found in Scotland and France. The results from the questionnaire clearly suggest that the sample of participants was not homogenous, reinforcing the decision to use a two-factor solution in both countries in an attempt to explore differences in opinions. The choice of a two-factor solution based on analysis of the Q-Sorts still suggests, however, that within each country there is a high level of agreement in the way participants perceive the wildness of the landscape. This is especially true in France, where a single factor explained 88% of the variance (see Table 4.3b), and there were fewer distinguishing image statements (see Table 4.6b). This statistical result is clearly visible in the typical Q-sorts for each factor for a given country, which appeared very similar.

Looking specifically at the Q-Sort results from Scotland, there is more disagreement at the high wildness end of the continuum, with almost all of the significant distinguishing statements (n=12) coming from the wilder end of the continuum (see Table 4.6a) This suggests that there is much more agreement between factors on what is not wild, rather than what is wild. In order to understand the between-factor differences as they relate to the wilder end of the spectrum, I conducted an analysis of the significant distinguishing image statements.

Factor 2 ranks the image of a wind-farm in a remote location to be more wild than factor 1 (see Figure 4.12a). One possible interpretation of this is that they do not consider renewable energy installations, placed in remote locations, to have as negative an impact on the wild character of these places as members of factor 1. We would assume this means therefore that they are more accepting of renewable energy installations and their impacts, at least on wildness quality, in remote locations. Higher levels of acceptance for wind farm installations have been found amongst those that live closest to them, especially after construction, and aesthetic perceptions are the most important explanatory variable for understanding attitudes towards them (Warren et al. 2005). This suggests that members of factor 2 have a perspective on windfarms which is typical of those that live near to them, although further analysis would be required to explore how local and non-local groupings relate to the factors at the national level, and that was not a key research objective of this thesis.

Members of factor 2 also ranked a number of image statements featuring natural vegetation or intact ecological landscapes as less wild than those in factor 1. This included images of native birch woodlands (with or without a path), a steep gulley in Beinn Eighe with intact native woodland, as well as the image of a frog in the Creag Meagaidh National Nature Reserve (NNR) area (see Figure 4.12b to Figure 4.12e). For factor 2, the image of the steep gully (see Figure 4.12c) was positioned two columns left of its position for factor 1. Factor 1 considered this image to be one of the two most wild images. The difference in positioning of multiple images of this type, in a consistent direction, would suggest that factor 2 considered intact natural vegetation to be a less important attribute of wildness than factor 1.

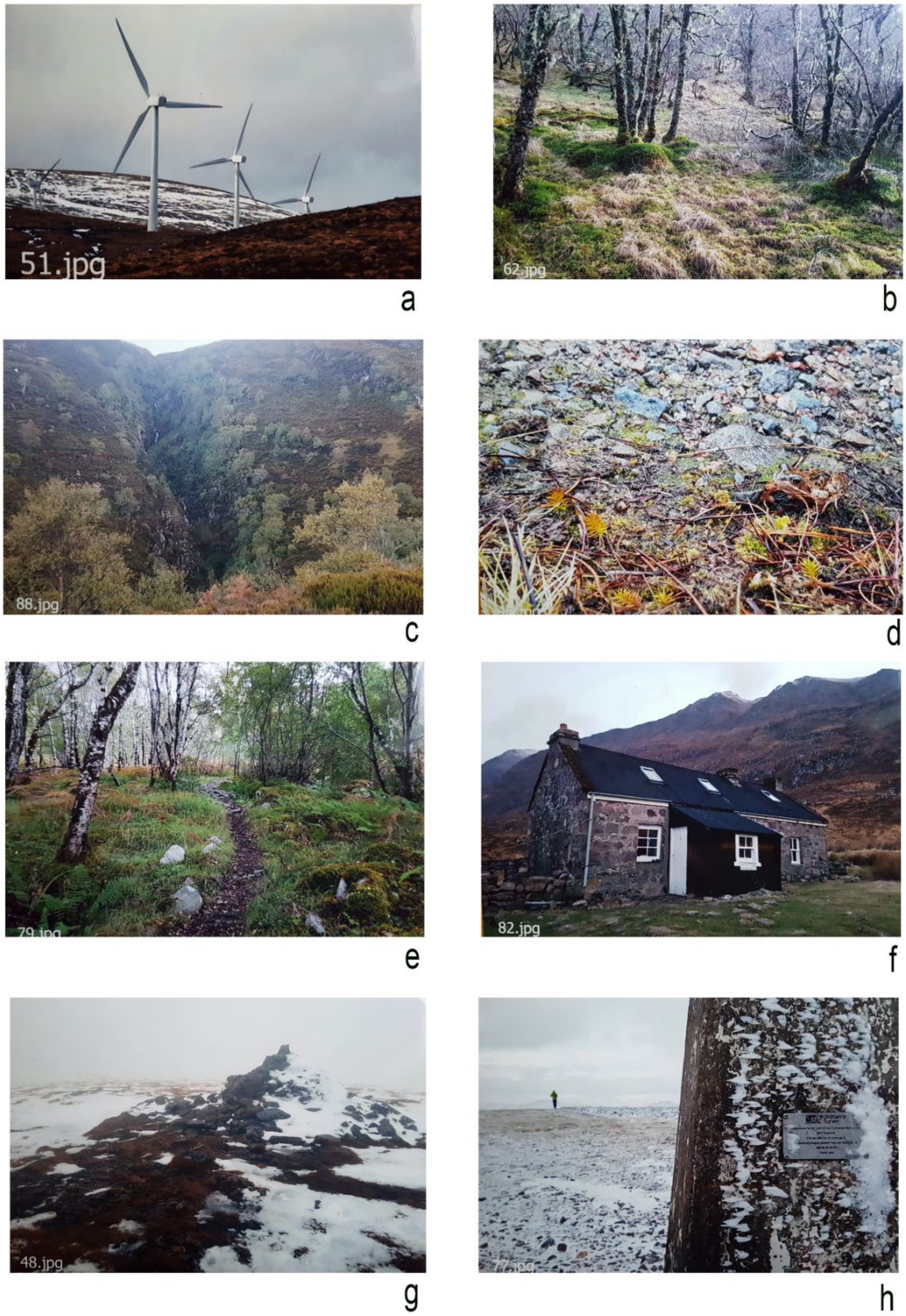

Figure 4.12: Distinguishing image statements between factors for the Q-Sort completed by participants in Scotland.

As stated, theoretical and practical considerations meant that typical Q-Method post-sort interviews were not possible and I asked participants to provide keywords and comments to explain why they had placed image statements into a particular column in the grid (see Section 3.6.1). Unfortunately, not all participants completed this task, which was in part attributable to the challenging and time-consuming nature of Q-Method (Peter et al. 2008). Describing the factors is considered as a 'fundamentally interpretative' process, and the most 'problematic phase' in Q-Method (Eden et al. 2005). An incomplete set of comments explaining the Q-Sort makes it challenging to interpret the results, and is obviously a key limitation of the results from this specific method.

In order to address this issue, I also analysed the results of the questionnaire on attitudes to attributes of wildness in relation to Q-Sort factors (see Section 4.4.5). I considered this to be a pragmatic way to interpret the factors. Q-Method has become popular because it has been claimed to be more suitable for measuring 'subjectivity' than the so-called R-Methods, typified by Likert-style questionnaires, which remove a subject's frame of reference (Stephenson 1953; McKeown & Thomas 2013). A key limitation of Q-Method, however, is that the factors identified cannot be extrapolated to the whole population; nor can they be used to make claims about what percentage of the population shares the views expressed by a given factor (Robbins & Krueger 2000; Milcu et al. 2014:11). The applicability of Likert-style questionnaire results outside of the sample population may in fact mean that the hybrid approach to factor interpretation used in this thesis adds value to the analysis, especially in the context of an integrated research approach.

Interpretation of the distinguishing statements above suggests that there was a divergence between the two factors in Scotland in terms of how they rated the wildness of image statements showing natural landscapes. Between-factor differences in questionnaire results on the importance of naturalness as an attribute of wildness are not evident, with high agreement for both factors. Overall, factor 1 agreement scores place naturalness third in importance out of nine possible attributes of wildness, and factor 2 rank it fourth. Factor 2 more strongly agree on the importance of naturalness than factor 1, but they also have a higher percentage who more strongly disagree (see Figure 4.10).

Distinguishing image statements showing landscapes containing human artefacts were ranked as more wild by factor 2, such as the Shenavall bothy in the remote Fisherfield area, a cairn in the Creag Meagaidh NNR, and a trig point in the Pentlands with a human figure visible (see Figure 4.12f-h). The image statement of the cairn was two columns to the right (more wild) in factor 2. This is consistent with the interpretation of the image of the wind farm (see Figure 4.12a), and suggests that, overall, factor 2 do not consider anthropogenic landscape elements to detract from the wildness of that landscape.

This interpretation is reinforced by the results of the questionnaire. Whilst both factors agree that the absence of human artefacts is the most important attribute of wildness, factor 1 more strongly agree on its importance than factor 2 (see Figure 4.10). Whilst the interpretation of the factor results using the questionnaire is not clear-cut, the results of the Q-Sort suggest that: a) images of intact natural landscapes are considered more wild by factor 1 than factor 2; b) factor 2 consider the presence of human artefacts in the landscape to have a less significant impact on the wildness of that landscape than factor 1.

One distinguishing statement confounds this clear trend: an image showing wild camping in the Cairngorms National Park (see Figure 4.13a) which was ranked as more wild by factor 1 than factor 2. One possible interpretation of this is that factor 2 consider permanent landscape elements (such as cairns, bothies and windfarms) to be more a part of the natural cultural landscape than temporary elements such as tents which are often linked with the presence of tourists and non-locals. The results of the questionnaire show that factor 2 have a higher level of agreement that a sense of sanctuary or solitude is the most important attribute of wildness than factor 1. This may suggest that factor 1 are more accepting of sharing wild spaces with other temporary visitors than factor 2.

The only distinguishing statement from the less wild end of the continuum was an image of an agricultural setting from the National Trust for Scotland (NTS) Balmacara Estate showing sheep grazing in a large fenced pasture, surrounded by plantation and clear-felled woodland. Factor 2 considered this image to be less wild than factor 1 suggesting that the presence of agriculture and silviculture of this type had a bigger negative impact on their perceived wildness of the landscape than it did for factor 2 (see Figure 4.13b).

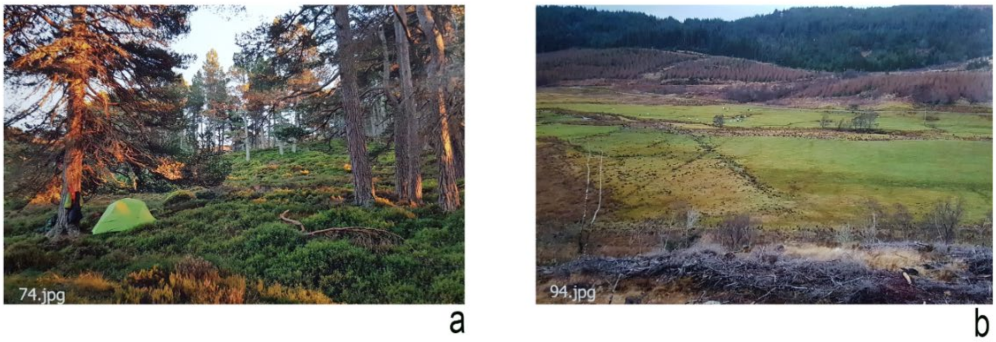

Figure 4.13: Distinguishing image statements between factors for the Q-Sort completed by participants in Scotland

One other explanation for the way images are sorted is seasonality, and I note that images 4.12g and 4.12h both show snowy winter scenes. A member of factor 1 commented in their questionnaire that weather had an influence on their feeling of wildness, but as this aspect was not part of the research questionnaire it is difficult to interpret within the current study.

As regards the Q-Sort image statements and attitudes to wild species, there were very few images of wildlife amongst the image statements, as the task was focused on landscape. However, the image of an otter caught in a camera trap did not shift between factors, remaining in the same central column (0).

At the study site in the Pyrenees, there were a total of four significant distinguishing image statements, separating the two factors (see Table 4.4.b and Figure 4.14). This, and the fact that a single-factor solution explained 90% of the variance between sorts, suggests overall higher levels of agreement on perceptions of wildness between the factors in the Pyrenees than in Scotland. There were, however, lower numbers of participants in France compared with Scotland, and less variation in participants in terms of the expert-proposed stakeholder groups, and this might also account for the smaller number of distinguishing statements (Fairweather 2002).

Figure 4.14: Distinguishing image statements between factors for the Q-Sort completed by participants in France.

Reviewing distinguishing image statements showing a remote wild valley floor (Figure 4.14a) and a natural wild lake (Figure 4.14b) in the Pyrenees National Park (PNP) suggests that one theme which distinguishes factor 1 from factor 2 is attitudes towards the importance of ruggedness, remoteness and naturalness as attributes of wildness. Images of intact natural landscapes also featured amongst the distinguishing statements in France. In factor 2, the image in Figure 4.14b from the Pyrenees National Park is positioned two columns to the left (less wild) from its position as one of the two most-wild images in factor 1. In factor 2, it was replaced by the image in Figure 4.14a, with the other most-wild image in factor 2 also being an image where the remoteness and ruggedness of the landscape are the dominant attributes.

The results from the questionnaire also highlight this difference, with the overall results for factor 1 ranking 'ruggedness' last in terms of importance as an attribute of wildness, whilst 'naturalness' is second most important, along with 'inspiring' (see Figure 4.11). Factor 2 participants also rank 'naturalness' second, but it shares second position with three other attributes (including 'ruggedness'), and four attributes have a higher score, including 'remoteness'. This would suggest agreement between the Q-Sorts and the questionnaire results that: a) factor 1 consider ‘naturalness’ to be a more important attribute of wildness than factor 2; b) factor 2 consider ‘remoteness’ and ‘ruggedness’ to be more important attributes of wildness than factor1.

Distinguishing image statements of the carpark in town (Fig 4.16.d) and the sports field (Figure 4.14c) are from the less wild end of the continuum. They cannot be interpreted clearly using the questionnaire results, as these are focused on attributes of wildness, rather than attributes of non-wildness. The carpark image (Figure 4.14d) was one of the two least-wild images for factor 1, but was placed two columns further right (more wild) by factor 2.

Factor 2 instead placed two images of large built-up areas with people as their least-wild images. One possible interpretation of this is that factor 2 consider people and built-up areas as having a greater impact on wildness than the mere presence of cars and road infrastructure, both of which penetrate deep into the mountains of the Pyrenees, especially because of the presence of ski resorts.

4.5.3 Q-Sort and spatial data on wildness

I selected the two sets of Q-Sort image statements (Scotland and France) as being representative of the continuum of wildness quality in both countries (see Sections 3.3 & 3.6.1). This methodological choice served two purposes: firstly, to present all participants at the start of the day with a reference scale of least to most wild landscapes based on the existing wildness mapping for that area; secondly, to explore the methodological research interest of linking the results of the Q-Sort to these existing spatial data on wildness (RQ1).

The grouped results of the Q-Sorts for both countries correlate strongly with the existing wildness mapping (see Figures 4.9a & 4.9b). Participants were unaware that the images were spatially linked to the existing maps of wildness. This strong correlation suggests that the way the participants arranged the image statements, from least to most wild, was in line with the way those same landscapes are classified in terms of wildness quality (low to high) by the wildness maps. This could be argued to ground-truth the existing mapping, confirming that the current methods used to map wildness result in a meaningful representation of wildness for the participants surveyed in this pilot project.

The wildness classes used in this analysis are derived from a single thematic spatial layer on wildness and cannot easily be distinguished in terms of naturalness or ruggedness to further explore the factor interpretation above. As a result, I decided that a by-factor analysis of the relationship between the Q-Sorts and the wildness classes was not useful for the current methodological design used in this study. However, the maps of wildness are built up from a combination of four spatial layers, two of which represent perceived naturalness and ruggedness. These composite layers could be used to explore the factor interpretation further, and to deepen understanding of what might be driving the correlation between the overall Q-Sorts and the wildness classes. I did not complete this under the current study, but I did trial it as a way of exploring the acoustic indices in more detail (see Section 6.5).

Presenting all participants with a task that gives them the same range of landscape photographs could be argued to have the undesired effect of impacting on, or even structuring, their perspectives of what is wild. The results of the questionnaire, which took place after the Q-Sort, suggest that a significant diversity of opinions was nevertheless retained. Indeed, an advantage of the Q-Sort over a traditional Likert-style question format is exactly that it offers the opportunity to present participants with a full continuum of options, rather than asking them to consider individual questions in isolation (Watts & Stenner 2012). The results of Likert questionnaires are sensitive to the questions asked, as well as how the answers are structured and analysed (Eyvindson et al. 2015).

The use of Q-Method in the current study served two main purposes: firstly, it provided a way to measure subjectivity in participant perceptions of wild spaces; secondly, it tested whether the results of this more unstructured qualitative approach correlated with the existing quantitative spatial data on wildness. I argue that a hybrid approach to interpreting the factors using the Likert responses is advantageous in terms of the potential to generalise from the factors to the wider population.

The use of *in situ* participatory methods also served a dual purpose: firstly, to measure subjectivity in participant perceptions of wildness *in situ*; and secondly, to test whether the results of this method also correlated with the existing quantitative spatial data on wildness. I report and discuss the results of this in the next chapter.

Chapter 5 - Results: Participatory mapping

5.1 Summary

In this chapter I present the results and discussion for the participatory mapping task, and analyse how the human perception scores vary along a gradient of wildness and in comparison to the wildness mapping (RQ2 & RQ3, see methods Section 3.7, and results Section 5.2). I also present the results relating to testing the impact of immersion and knowledge on attitudes (RQ4, see methods Section 3.6.3, and results Section 5.3). I then discuss the individual results from these two methods (see Section 5.4). These results and discussion sections are for detailed investigation of the results and I reserve the broader discussion, in the context of the literature, for the discussion chapters (see Chapters 7 & 8).

5.2 Participatory mapping

Human participants completed a participatory mapping walk along a gradient of wildness at three of the four study sites (BEN, I&I & LES). One of the study sites in the high Pyrenees was too dangerous to be used with human subjects during the fieldwork phase because of high levels of snow.

5.2.1 Do scores for human perceived wildness vary along a gradient of mapped wildness?

For each of the study sites, I plotted scores from the human participant walking transect by stop for perceived wildness (see Figures 5.1 to 5.3). The pattern of perception scores for the walk in Beinn Eighe National Nature Reserve (BEN) show a clear peak at stops 10 to 12 (see Figure 5.1). There is a deviation from the trend for higher scores at stop 2. There is also a deviation from the trend towards lower perceived wildness on the return leg at stop 15. The trend for perceived wildness follows the mapped values for Jenks wildness class (WC), including where there are deviations from the linear trend. This is especially clear for the return stop 15. A notable exception to this is stop 18 (see Figure 5.1).

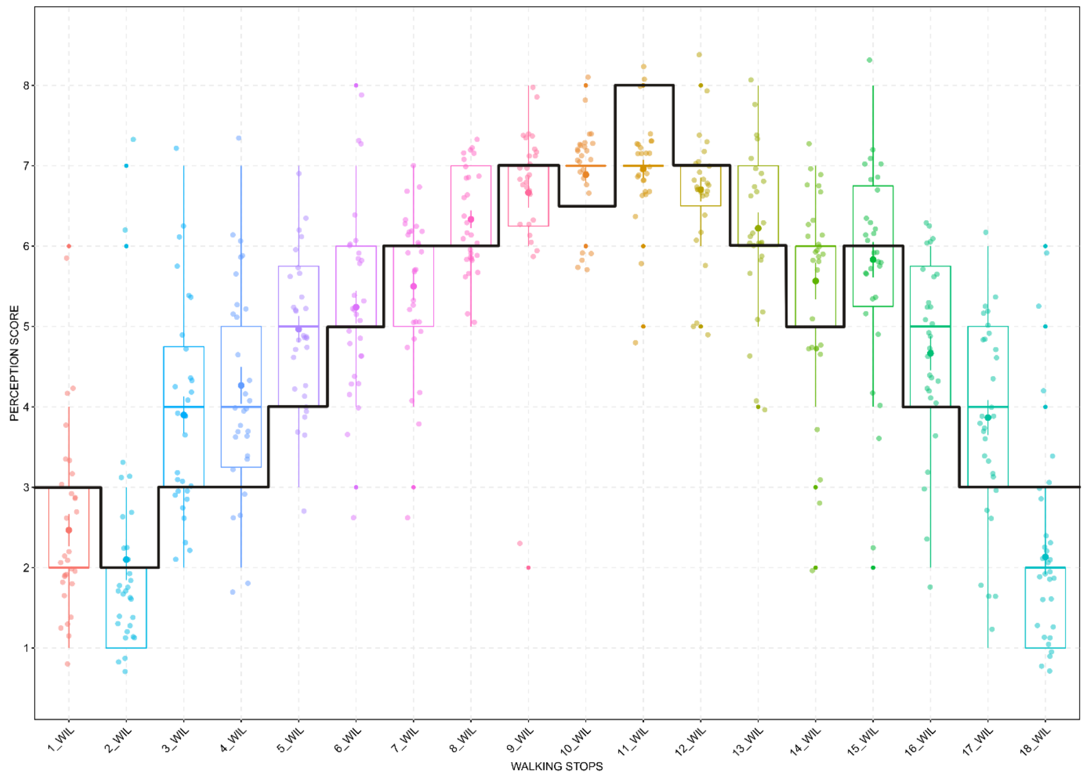

Figure 5.1: Site Beinn Eighe (BEN). Wildness perception scores given by participants during participatory mapping walk (coloured points and box plots) with Jenks-based wildness classification of each walking stop (black line).

For the site at Invereshie National Nature Reserve (I&I), there is a clear trend towards increasing perceived wildness, which peaks at stops 9 and 10 (see Figure 5.2). There is then a decline in values for perceived wildness on the return journey, with a clear deviation from this trend at stop 14. The trend for perceived wildness follows the mapped values for wildness, including where there are deviations from the linear trend. The exception to this is site 10 (see Figure 5.2).

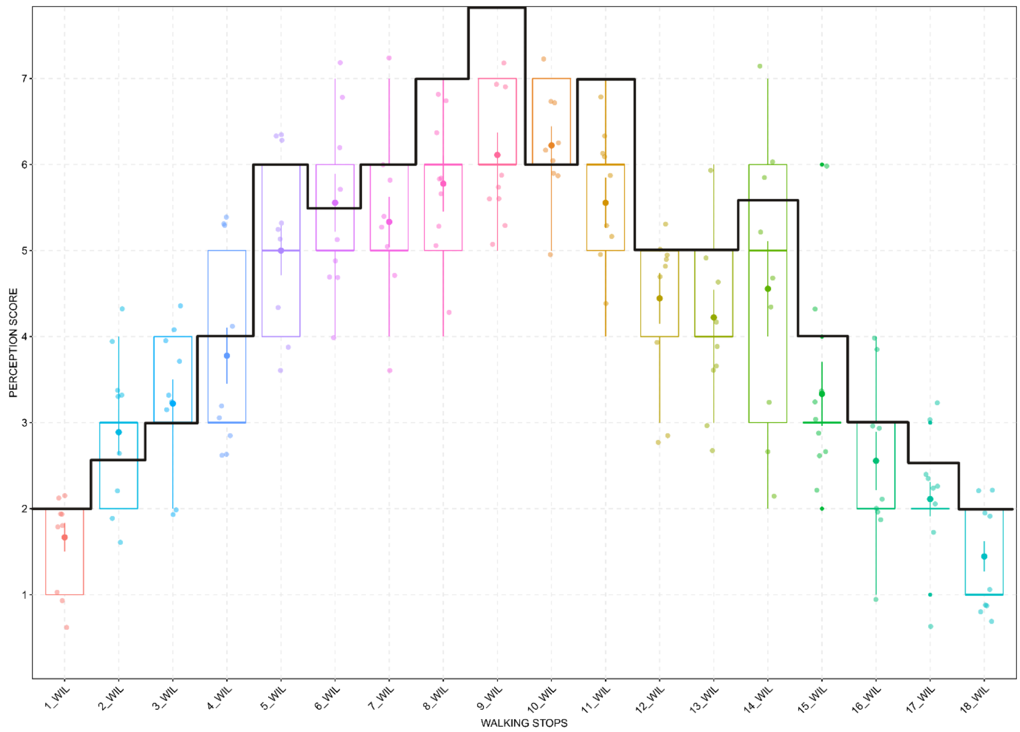

Figure 5.2: Site Invereshie (I&I). Wildness perception scores given by participants during participatory mapping walk (coloured points and box plots) with Jenks-based wildness classification of each walking stop (black line).

In the Pyrenees for the study site Lesponne (LES) the pattern of perception scores suggests a clear in and out pattern, where average scores do not differ significantly from mapped values for wildness (see Figure 5.3).

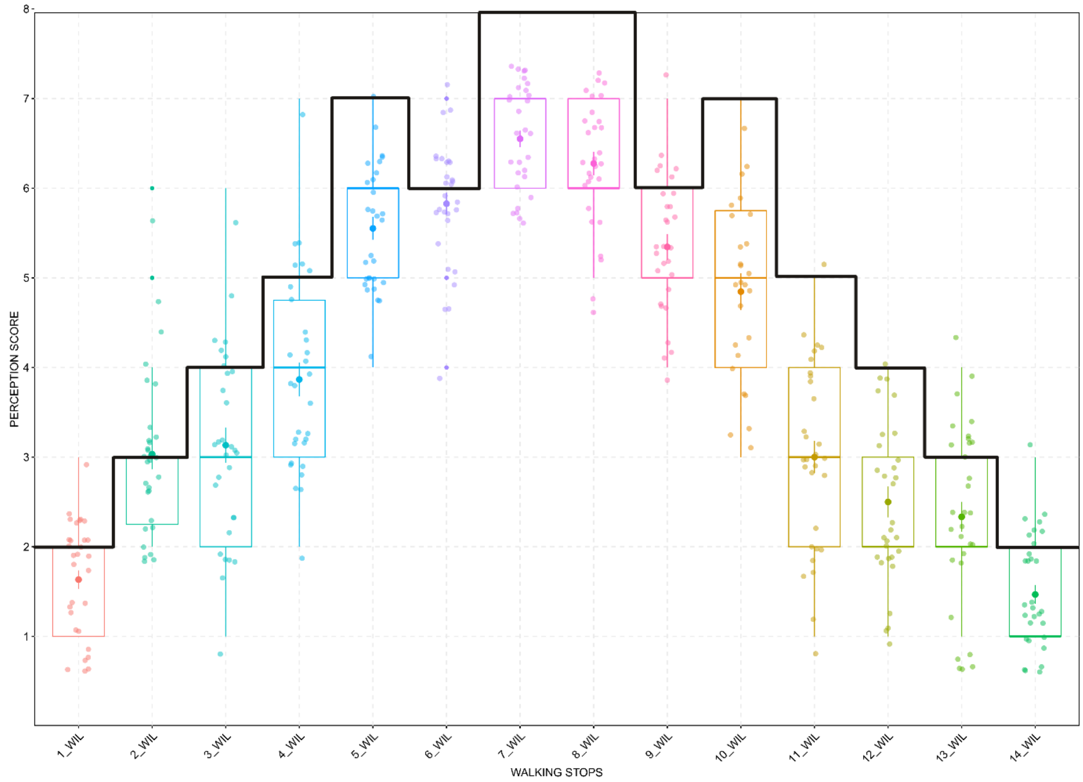

Figure 5.3: Site Lesponne (LES). Wildness perception scores given by participants during participatory mapping walk (coloured points and box plots) with Jenks-based wildness classification of each walking stop (black line).

5.2.2 Do scores for perceived wildness correlate with existing mapped values for wildness ?

For each study site, I grouped together participant scores for perceived wildness during the walking transect by mapped Jenks wildness class (WC). For each study site, I pooled those stops with the same WC. This process gives mean human-perceived wildness scores for a given mapped WC (see Figure 5.4).

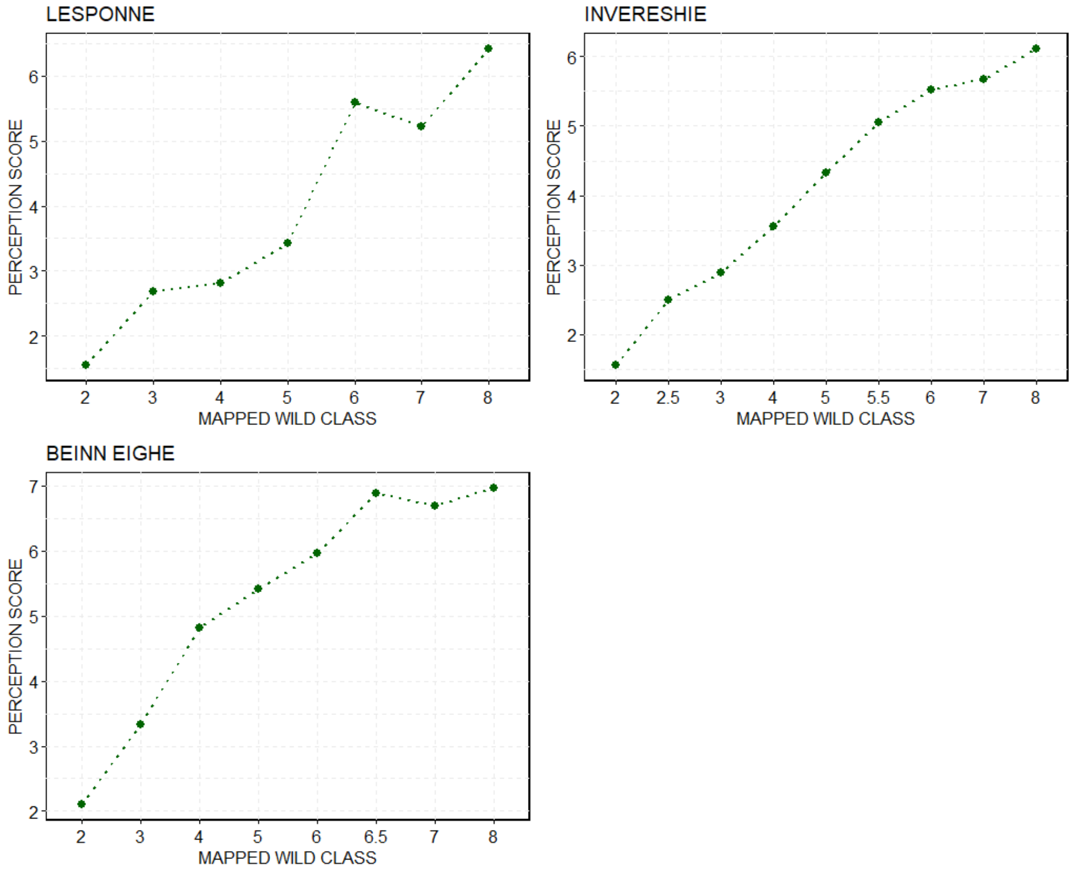

Figure 5.4. All study sites. Wildness perception scores given by participants during participatory mapping walk grouped by mapped wildness class.

I conducted a Spearman's rank correlation test to compare the values for human-perceived wildness with mapped wildness class values for each study site. I found a significant relationship for all three study sites: Lesponne, $r_s = 0.96$, $p < 0.003$; Invereshie, $r_s = 1$, $p < 0.001$; and Beinn Eighe, $r_s = 0.98$, $p < 0.001$.

5.2.3 Do scores for the same walking stop change on the return leg ?

Depending on the study site, we repeated some of the walking stops on the way back. In Scotland, for study site BEN, we visited only one stop twice; for I&I, three stops; and for LES, six stops. Analysis of human perception scores for wildness showed a significant shift for seven out of the ten paired stops. All sites were considered to be less wild on the return leg. Analysis was run using Wilcoxon signed-rank test for paired data. The data are summarised in Table 5.1.

Table 5.1. All study sites. Comparison of paired participatory mapping stops for values of human perceived wildness (WC), showing significance results from Wilcoxon signed-rank test for paired data (**ns** denotes not significant)

BEINN EIGHE			**INVERSHIE & INSHRIARCH**			**LESPONNE**		
OUT	BACK		OUT	BACK		OUT	BACK	
STOP 1	STOP 18	p<0.027	STOP 1	STOP 18	**ns**	STOP 1	STOP 14	**ns**
			STOP 2	STOP 17	p<0.027	STOP 2	STOP 13	p<0.001
			STOP 3	STOP 16	p<0.048	STOP 3	STOP 12	p<0.004
						STOP 4	STOP 11	p<0.001
						STOP 5	STOP 10	p<0.001
						STOP 6	STOP 9	**ns**

5.2.4 How do the scores for perceived wildness relate to other perceived landscape attributes ?

At each of the study sites, for each walking stop, in addition to the key question on perceived wildness, I asked a series of other questions to explore the relationship between wildness and other potentially linked landscape attributes, including perceived biodiversity, degree of management, and level of naturalness (see Section 3.7).

For the site Beinn Eighe, human-perceived naturalness and wildness show a general increase towards peak wildness based on mapping, followed by a decline back to the start of the walk. Perceived management shows the opposite relationship, declining with increasing wildness before increasing again towards the end of the walk. Biodiversity, on the other hand, shows a bimodal relationship through the walk, representing a peak at intermediate wildness on the outbound and inbound legs of the walk (see Figure 5.5).

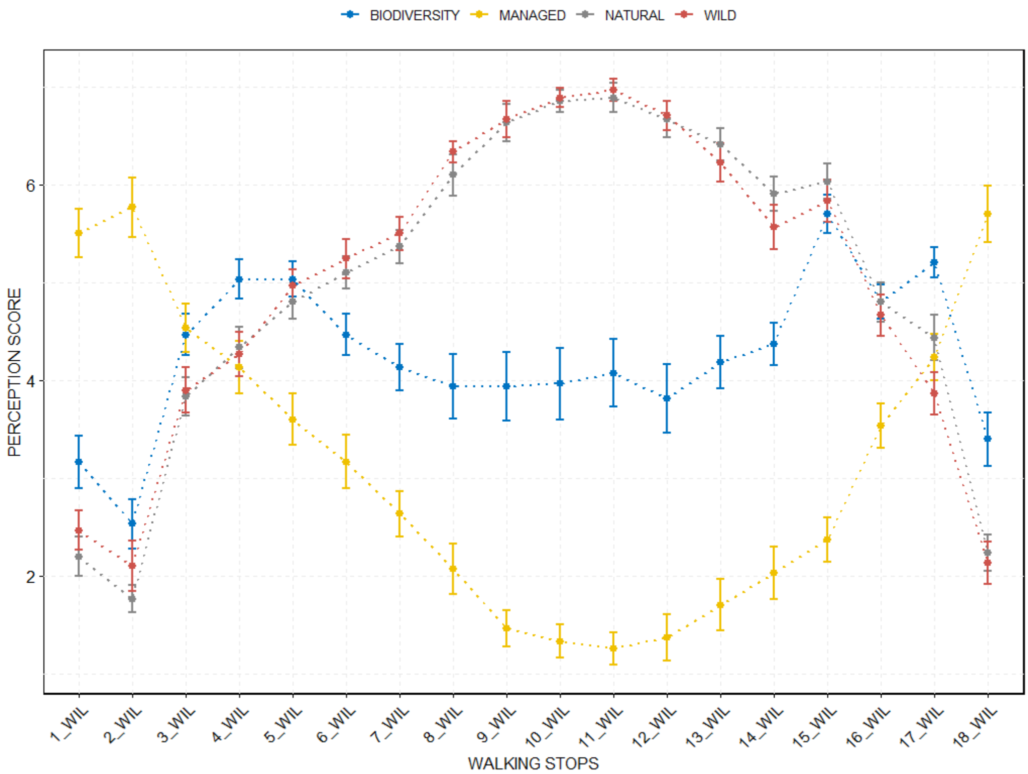

Figure 5.5: Site Beinn Eighe (BEN). Perception scores given by participants during participatory mapping walk for wildness, biodiversity, degree of management and naturalness (coloured points and error bars).

For the site Invereshie, human perceived naturalness and wildness show a general increase towards peak wildness at stop 10, followed by a decline back to the start of the walk. Biodiversity follows the same general pattern, but clearly deviates from scores for wildness and naturalness as peak wildness is reached. Of note is that biodiversity values spike, along with values for naturalness, at stop 14, whilst the value for wildness is lower. Perceived management again shows the opposite relationship, declining with increasing wildness before increasing again towards the end of the walk (see Figure 5.6).

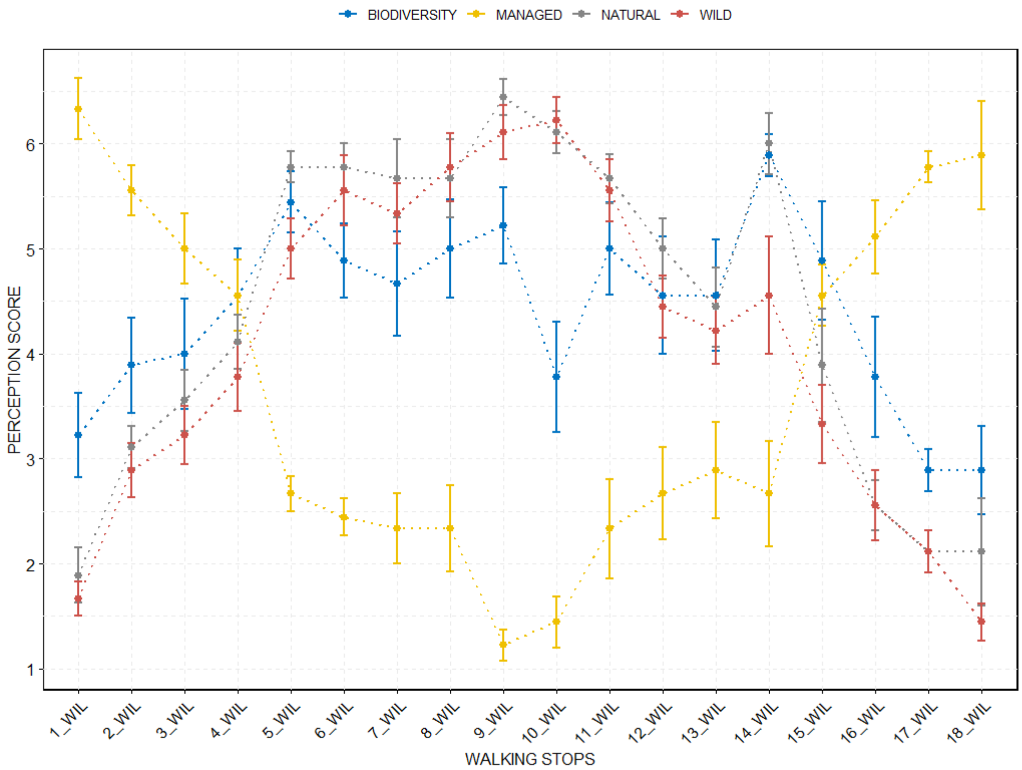

Figure 5.6: Site Invereshie (I&I). Perception scores given by participants during participatory mapping walk for wildness, biodiversity, degree of management and naturalness (coloured points and error bars).

For the site Lesponne, human-perceived naturalness, biodiversity and wildness show a general increase towards peak wildness, followed by a decline back to the start of the walk. Perceived values for wildness are most closely tracked by perceived values for biodiversity. Values for naturalness are consistently lower than for wildness, although they converge with values for naturalness at stops 7 and 8. Perceived management shows the opposite relationship to the other value, declining with increasing wildness before increasing again towards the end of the walk (see Figure 5.7).

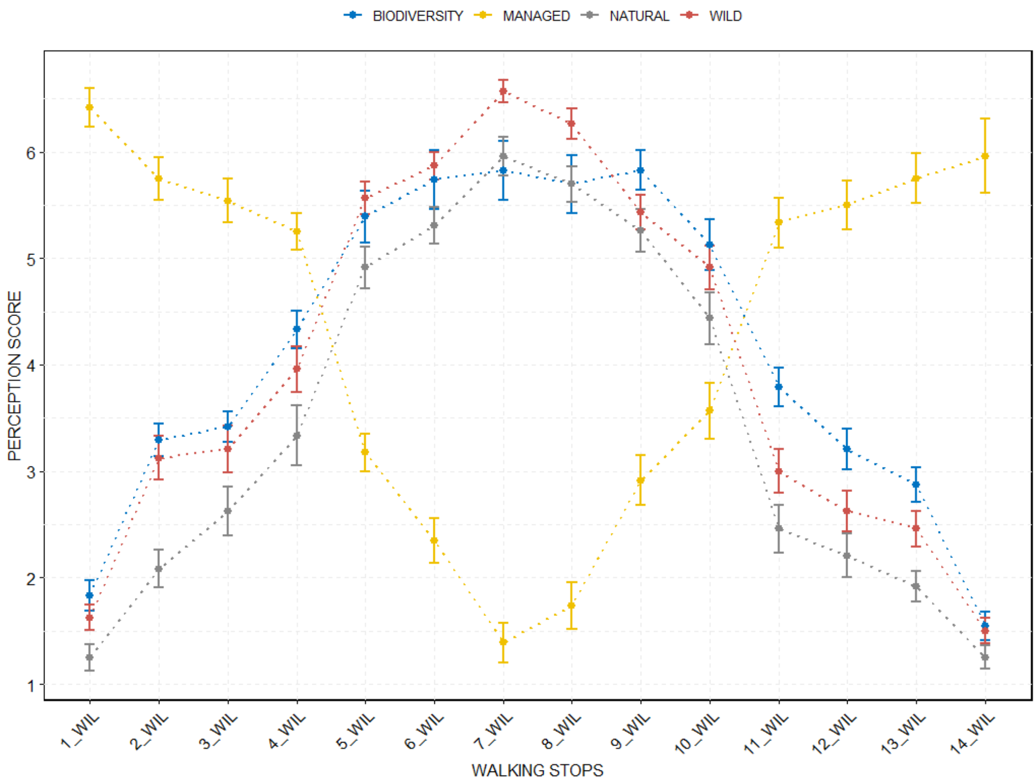

Figure 5.7. Site Lesponne (LES). Perception scores given by participants during participatory mapping walk for wildness, biodiversity, degree of management and naturalness (coloured points and error bars).

I show a statistical analysis of the strength of the relationships between the human-perceived values for wildness, biodiversity and naturalness, acoustic indices and mapped values for Jenks wildness class and distance to road in Figure 6.5, along with the other results on ecoacoustics.

5.3 Did immersion and historical knowledge on wild spaces impact on people's attitudes to them ?

In relation to the walking task, a further linked research question was asked: "What is the impact of immersing people in wild spaces, and of communicating knowledge on historical landscape change, on their attitudes to these wild spaces and wild species?" (RQ4).

Participants answered a series of questions before going on an extensive walk along a gradient from a low wildness area to a high wildness area and back. On returning from the walk, all participants watched a short film describing the natural condition of the landscape they had just moved through, and explaining the process of historical landscape change since the last ice age. After watching the film, participants completed a follow-on set of paired questions to assess whether immersion (the walk) and knowledge (the film) had impacted on their attitudes to wild spaces and wild species.

The challenge of recruiting sufficient participant numbers meant that it was not possible to have control groups as planned (e.g. a group that completed all the same tasks but did not watch the film). The three before-and-after Likert-style questions used for this task each asked participants to give their response to a statement on wild spaces, wild species and wild predators. The results for the individual before questions were reported in Section 4.3.2. In this current section I present a comparison of the results from the before-and-after questions.

The statement format for wild spaces and wild species was: "'There are sufficient wild spaces/wild species in Scotland', strongly disagree (1) – strongly agree (7)". Species in Scotland were wild cat, beaver, pine marten and birds of prey; and in France, red deer, wild boar, isards, stoats and birds of prey (see Appendix C:7 & 11 for full question set).

I reprocessed participant scores for all sites (BEN, I&I, & LES; n=71) into five groups: strongly disagree (1), disagree (2-3), neutral (4), agree (5-6) and strongly agree (7). I analysed the questionnaire responses for the paired before-and-after questions via a comparison of means test, conducted using the non-parametric Wilcoxon signed-rank test. I present means rather than medians here because the change in scores was small in magnitude. Effect size (given by the value 'r') was calculated using the 'rFromWilcox' function (Field et al. 2012:65). For the question 'Are there sufficient wild spaces in mountain areas?' there was a significant difference between attitudes before the walk (Mean = 4.3) and after the walk (Mean = 3.8), (n=71, p = 0.006, r = - 0.23), (see Figure 5.8).

Across all study sites, for the question "Are there sufficient wild species in mountain areas?" there was no significant difference between attitudes before the walk (Mean = 4.0) and after the walk (Mean = 3.8), (n=71, p = 0.157, r = -0.12), (see Figure 5.8).

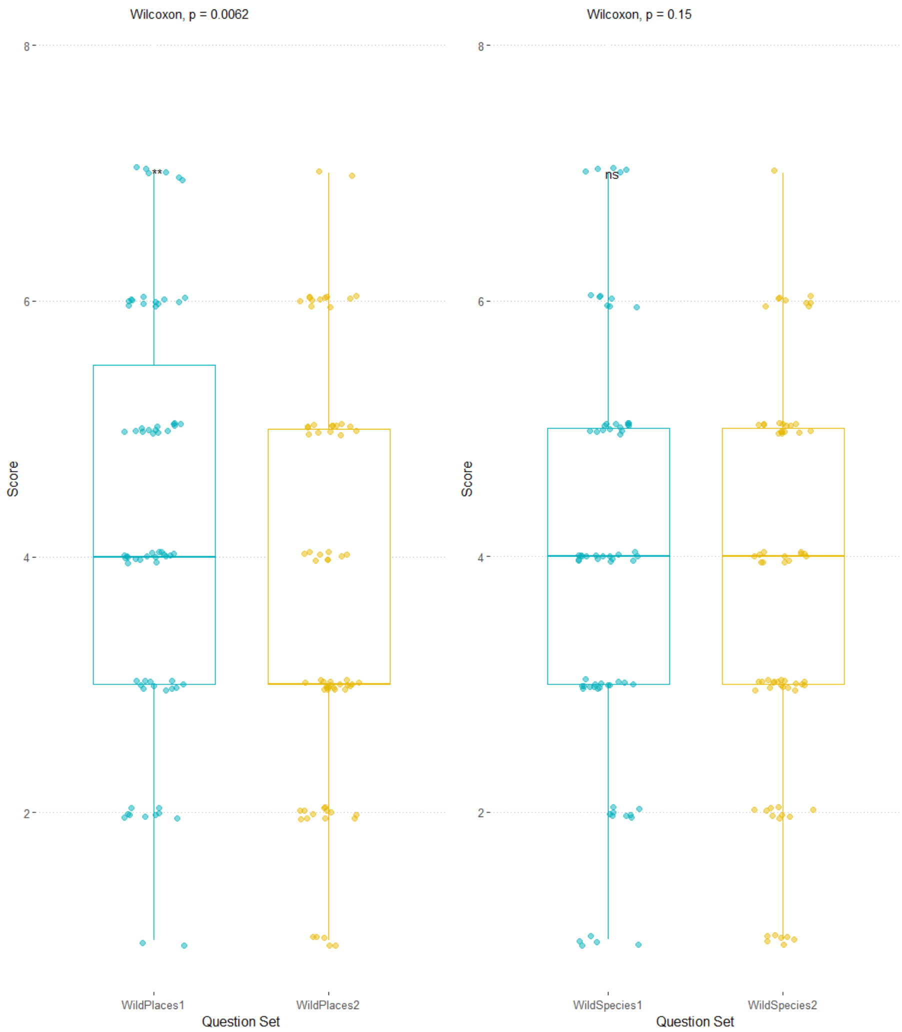

Figure 5.8: All study sites. Pre- and post-walk answers to the questions (A) “are there sufficient wild spaces?” and (B) “are there sufficient wild species?”. See text for details.

Looking at the question on wild spaces by country, for the Scottish study sites combined there was a highly significant difference between attitudes to wild spaces before the walk (Mean = 4.8) and after the walk (Mean = 4.0), (n=41, p = 0.0005, r = -0.38). There was no significant difference in attitudes for the Pyrenees study site before the walk (Mean = 3.6) compared with after the walk (Mean = 3.5), (n = 30, p= 0.8138, r = -0.03), (see Figure 5.9).

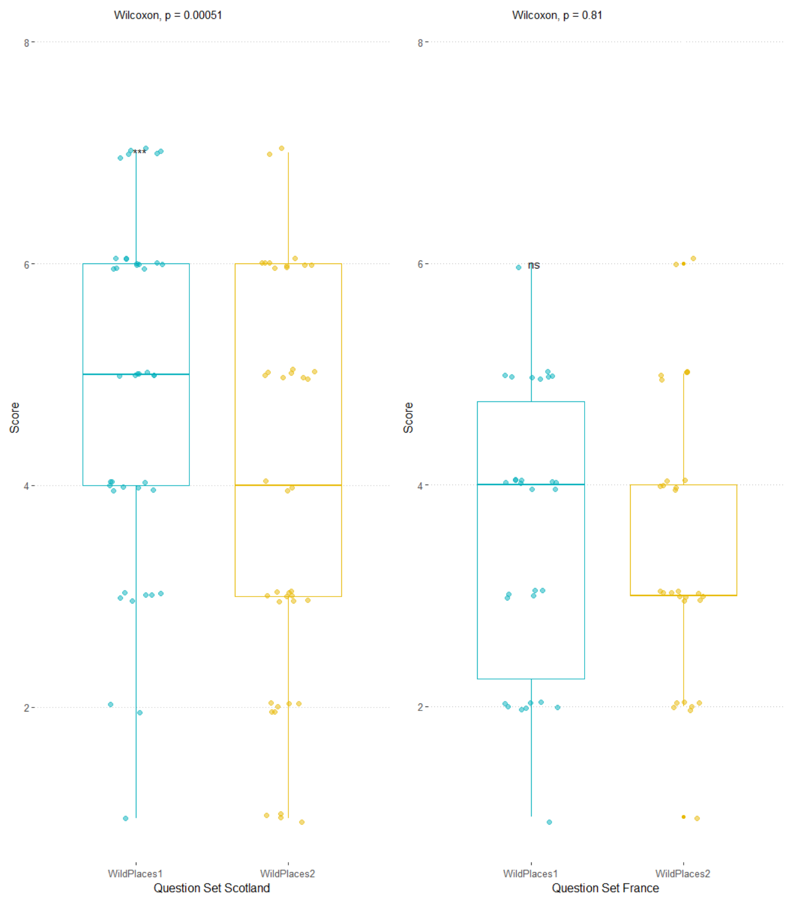

Figure 5.9: Pre- and post-walk answers to the question “are there sufficient wild spaces?” (A) Scotland and (B) France. See text for details.

For the question on wild species, for the Scottish study sites participants there was a significant difference between attitudes to wild species before the walk (Mean = 4.3) and after the walk (Mean = 3.6), (n=41, p = 0.010, r = -0.28). There was no significant difference in attitudes for the Pyrenees study site before the walk (Mean = 3.5), compared with after the walk (Mean = 3.8), (p= 0.297, r = -0.13), (see Figure 5.10).

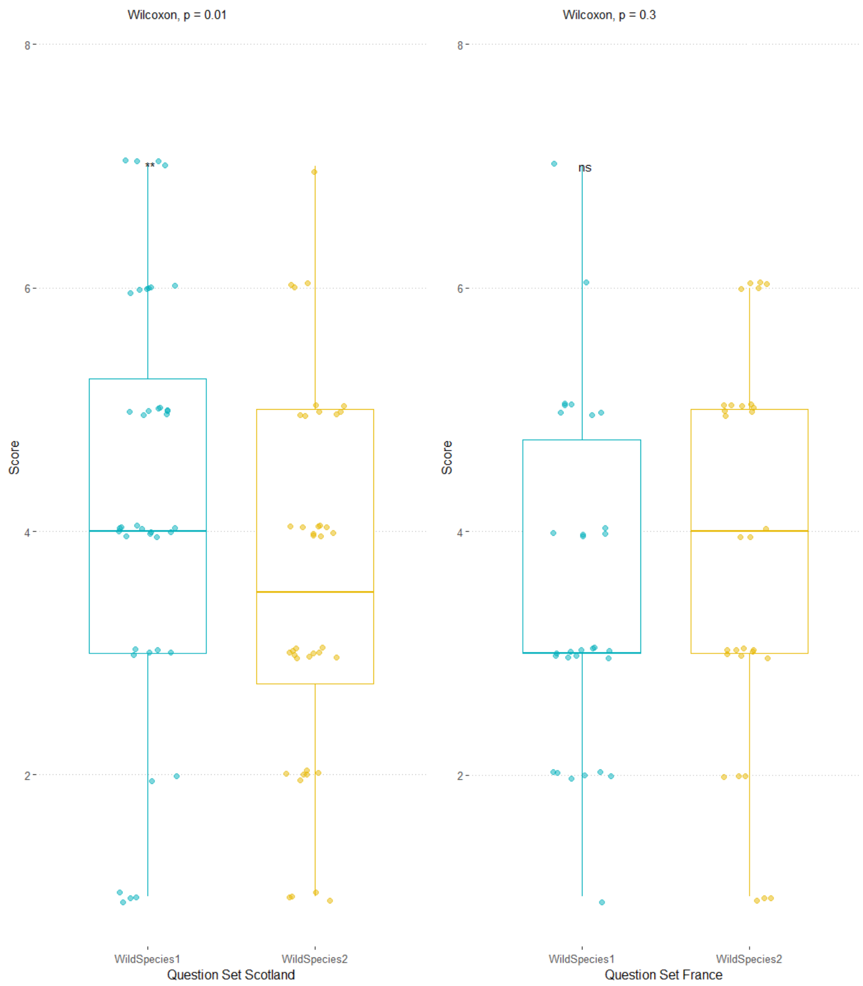

Figure 5.10: Pre- and post-walk answers to the question “are there sufficient wild species?” (A) Scotland and (B) France. See text for details.

For the question format used for attitudes to wild predators (see Section 4.1.2), in Scotland, there was no significant difference between attitudes before the walk (Mean = 4.5) and after the walk (Mean = 4.7), (n=40, p = 0.331, r = -0.10). In the Pyrenees study site, there was no significant difference between attitudes before the walk (Mean = 2.7) and after the walk (Mean = 2.6), (n=30, p = 0.846, r = -0.03), (see Figure 5.11).

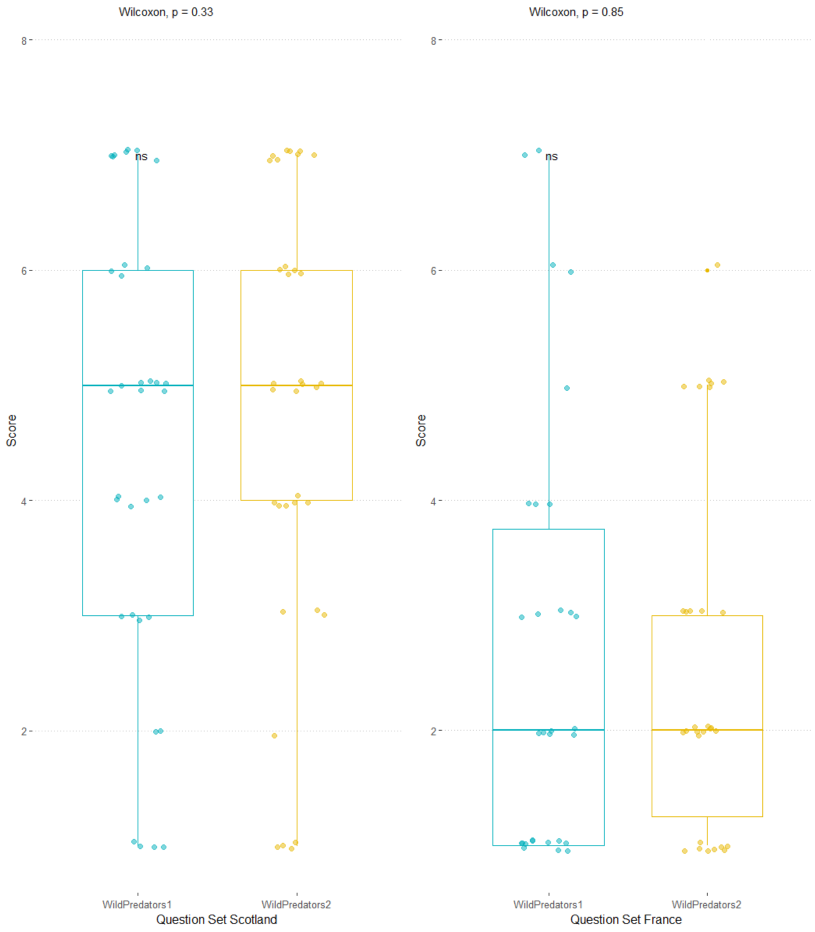

Figure 5.11: Pre- and post-walk answers to the question on wild predators (A) Scotland “there should be wild predators in Scotland” and (B) France “there are already sufficient wild predators in France”. See text for details.

5.4 How do participant attitudes to wild spaces and wild species vary in terms of attitudinal ambivalence ?

I asked a series of questions to assess levels of attitudinal ambivalence towards the protection of wild spaces and wild species (see Section 3.6.3). I report these results here to support interpretation of the results of the before-and-after questions (see Section 5.3). The results for the question on wild spaces are similar for both countries. The majority of participants in both countries express disagreement that they have mixed feelings towards the protection of wild spaces. More people express strong disagreement on this question in Scotland than in France. The majority of participants in both countries state that if they think only of their negative thoughts towards protecting wild spaces, they are not negative. A higher number of people in Scotland (100%), than France (90%) state that if they think only of their positive thoughts towards protecting wild spaces, they are highly positive. The majority of participants in both countries express agreement that they intend to protect wild spaces, although a higher percentage is neutral on this in France (see Figure 5.12).

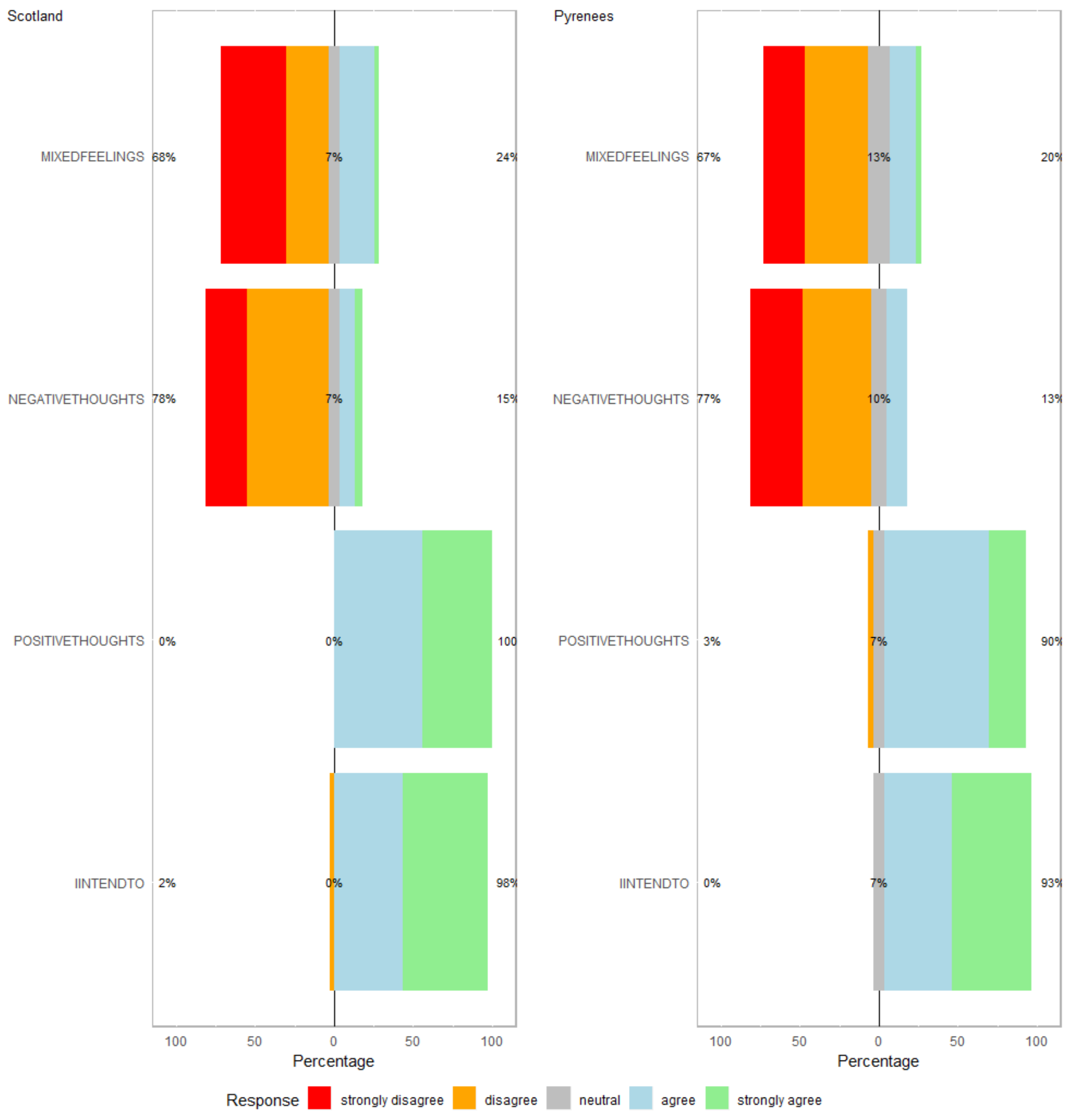

Figure 5.12: Participant scores for the attitudinal ambivalence questions completed at sites BEN, I&I and LES on attitudes to protecting wild spaces, split by country for A) Scotland and B) France.

For the question on reintroducing wild species such as lynx, the overall pattern for the results is also similar in each country. A higher percentage of people in France (60%) than in Scotland (39%) express disagreement that they have mixed feelings towards the reintroduction of wild species.. The majority of participants in both countries state that if they think only of their negative thoughts towards reintroduction of wild species, they are not negative, although the percentage is higher in France (57%) than in Scotland (44%). A higher percentage of participants is also neutral on this question in France (30%) than in Scotland (22%). A higher number of people in France (77%) than Scotland (68%) state that if they think only of their positive thoughts towards reintroduction of wild species, they are highly positive. The majority of participants in both countries express agreement that they intend to support the reintroduction of wild species, although the percentage is slightly higher in France (see Figure 5.13).

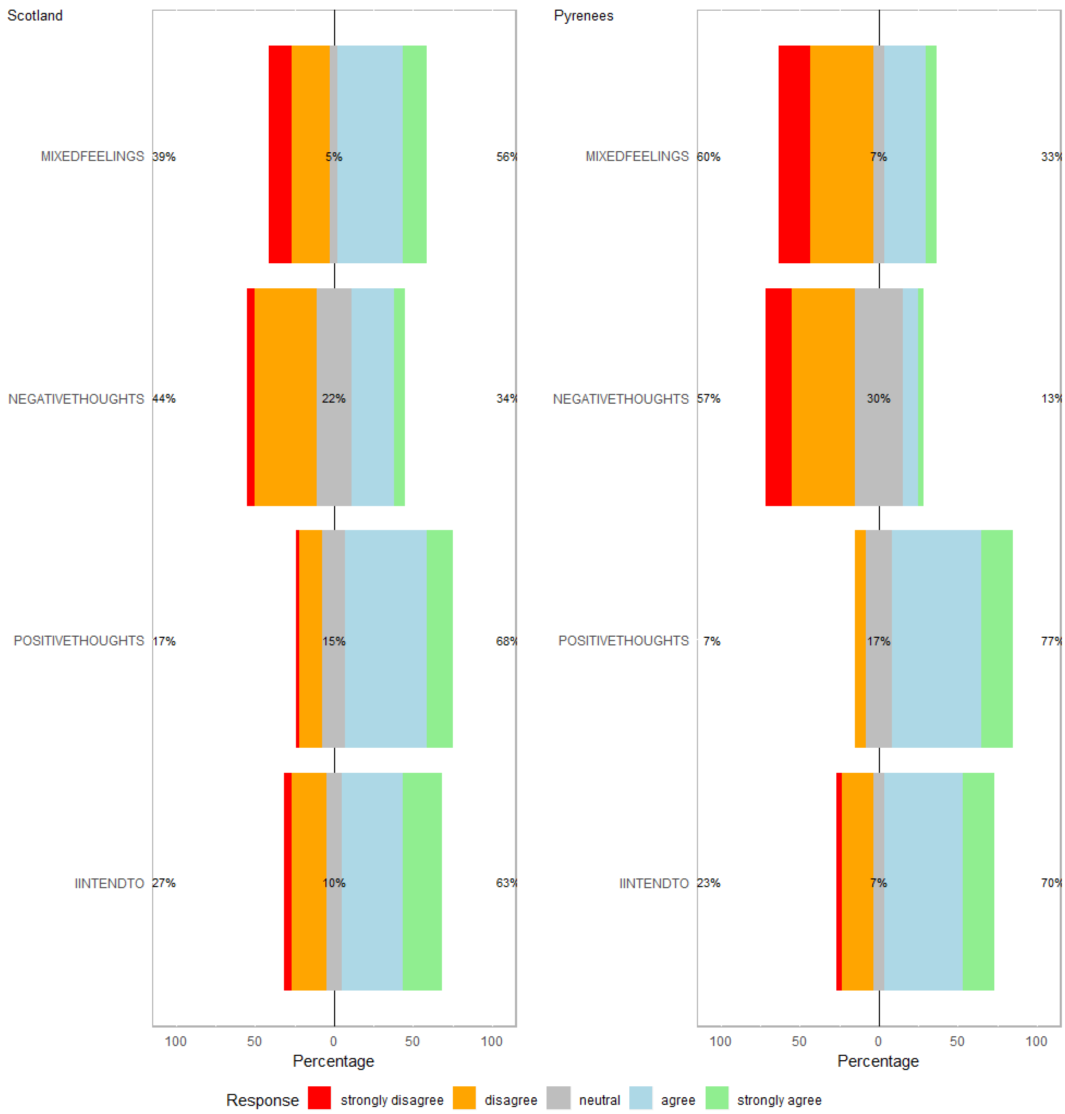

Figure 5.13: Participant scores for the attitudinal ambivalence questions completed at sites BEN, I&I and LES on attitudes to reintroducing wild species, split by country for A) Scotland and B) France.

5.5 How do values for walking scores vary amongst participants ? Does this vary by stakeholder group ?

Whilst the research worked with a purposive sample of participants and was focused on the specific methods used and how they relate to reach other, I consider it relevant to explore how the results of the walking scores might be examined using a traditional stakeholder analysis. I considered the expert-proposed stakeholder groupings (see Section 3.4) to be a useful working model for this examination. Only the study site Beinn Eighe (BEN) had all four stakeholder groups represented. I analysed human perceptions scores for wildness for the participatory mapping tasks by stakeholder groups for each stop on the walk, and compared them with the Jenks mapped wildness class scores (WC) for the same stop (see Figure 5.14).

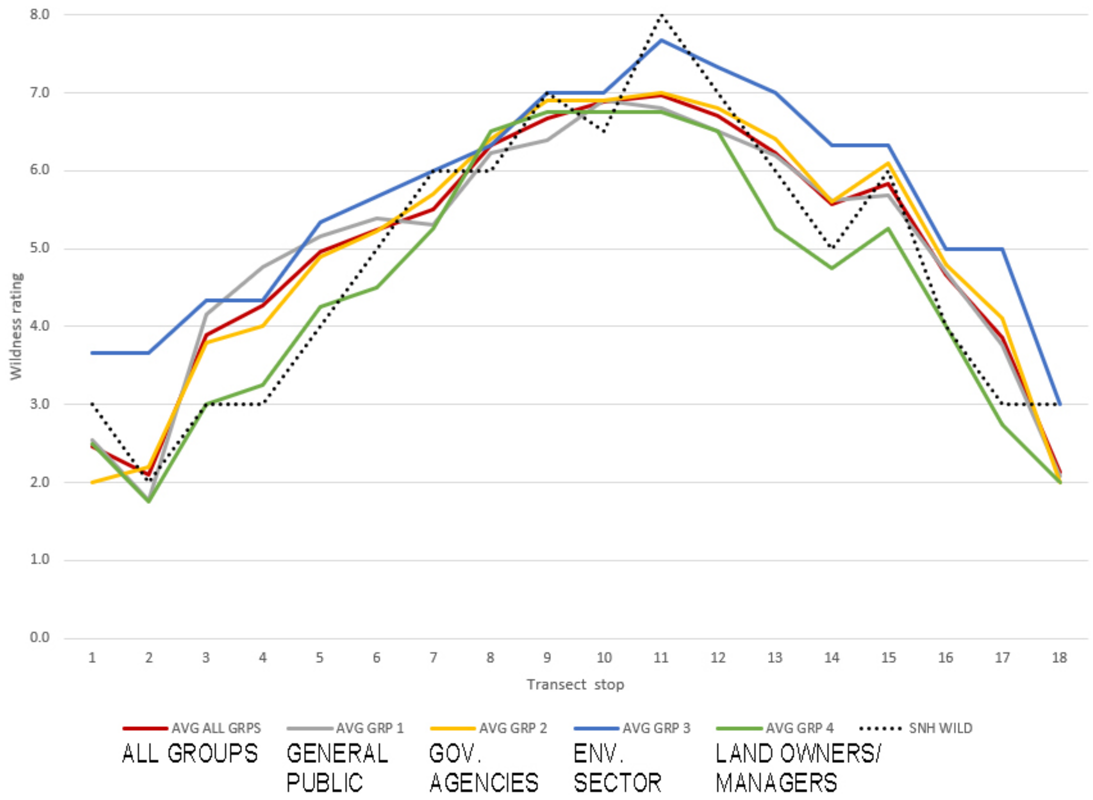

Figure 5.14: Study site Beinn Eighe (BEN). Walking 'wildness' transect scores from human participants – averages for individual groups and across all groups (coloured lines) and existing mapped SNH Jenks wildness class for that stop (SNH wild - dotted line). Group 1 = general public, Group 2 = government agencies, Group 3 = environmental sector, Group 4= land owners/managers.

Linear mixed effects models showed that there was a significant difference in wildness ratings between Jenks wildness classes ($F_{1,16.76}$=83.733, p<0.001) and between stakeholder groups ($F_{3,71.08}$=2.943, p=0.039), but the interaction between wildness class and stakeholder group was not significant ($F_{3,477.61}$=2.078, p=0.103). These results suggest that membership of different stakeholder groups increases or decreases general perceptions of wildness in an additive sense, but that wildness classes are not viewed differently by the different groups.

A post hoc comparison looked at the pairwise differences between factor levels to test where the effect was located among the inter-stakeholder group differences. The between-stakeholder group differences for wildness rating compared with Jenks wildness class were significant (df=25.9, t=2.18, p<0.05) for Groups 3 and 4, environmental sector and land owners/managers (see Figure 5.15).

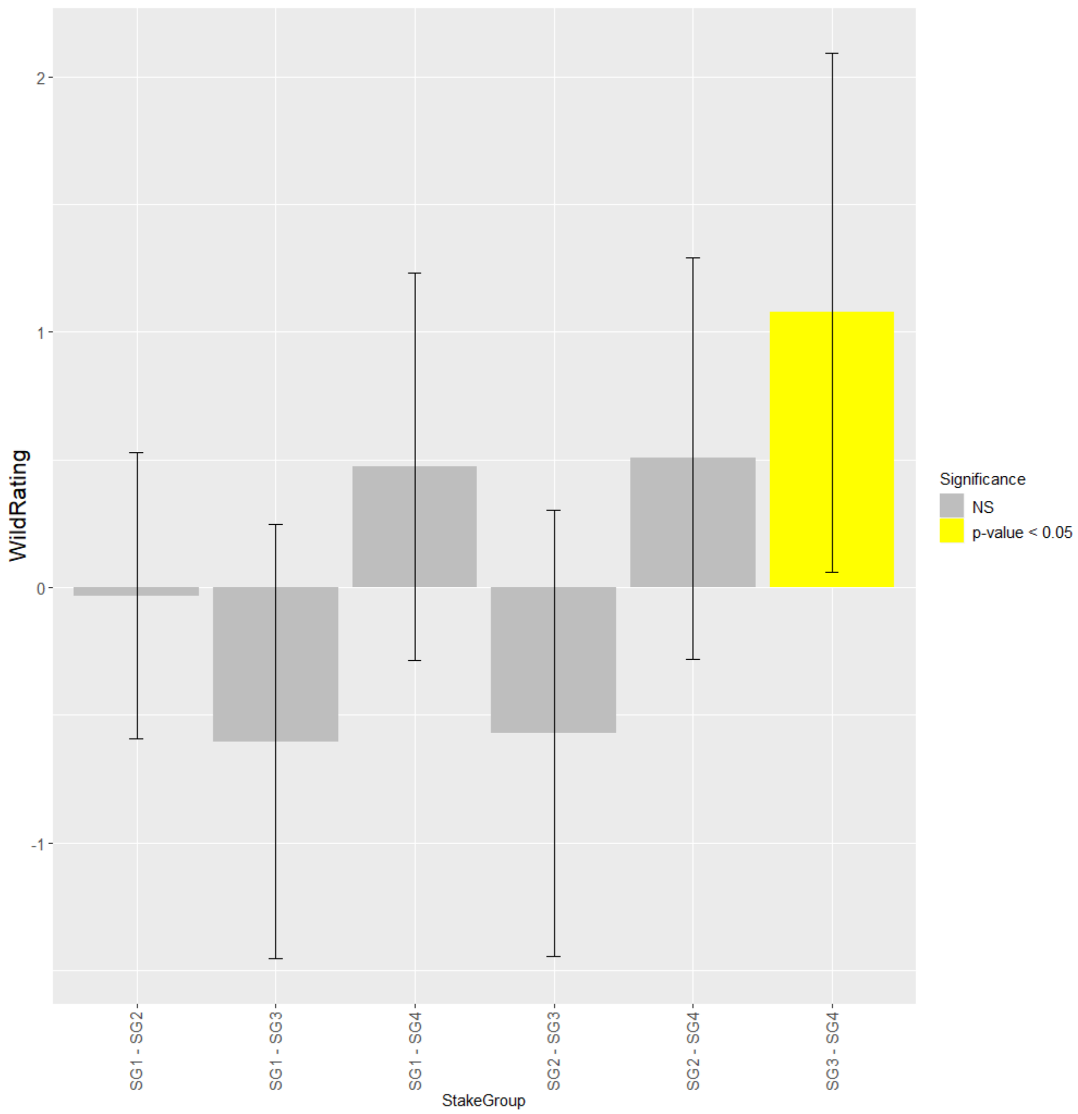

Figure 5.15: Pairwise differences and 95% confidence intervals between pairs of stakeholder groups' ratings of wildness in Beinn Eighe. Where the confidence intervals overlap zero, there is no significant difference between that pair of SGs. The statistics represent the output from a posthoc analysis of SG differences from an ANOVA model (see text for details and Figure 5.12 for a related plot of SG mean ratings across the transect). SG1 = general public, SG2 = government agencies, SG3 = environmental sector, SG4 = land owners/managers.

5.6 Discussion of participatory mapping and immersion results

5.6.1 Human perceptions of wildness along a gradient of wildness *in situ*

Human perceptions of wildness varied along a gradient of wildness at all three sites, suggesting that participants were sensitive to differences in the landscape along the gradient. The walking transects were structured around a gradient of mapped Jenks wildness class (WC), based on existing national-scale wildness mapping, and the results show that the mean wildness perception scores correlate strongly with the existing wildness mapping (see Figure 5.4).

The result suggests that this pilot ground-truthing study, using this participatory mapping approach, validates the current national-scale mapping. This is a significant result, especially considering that this is the first time these maps have been tested in this way. The Scottish Government's National Planning Framework aims to both protect areas of high wildness quality and expand Scotland's renewable energy capacity. Both of these policy aims relate to remote areas, and this leads inevitably to land-planning trade-offs. The existing wildness quality mapping and Wild Land Area designations for Scotland (see Figures 2.1 and 2.3) have been used to resolve these trade-offs, but have also been criticised, especially with regard to the planning and development of wind-farms and small-scale hydro projects in wild spaces. Validation of this existing mapping using an *in situ* participatory method, even as a pilot project, is of relevance to these debates, especially as the map of Scotland continues to be used in national-level planning (S. Brooks, personal communication, August 21, 2019). The wildness map of France used in this study is still in final-phase development, but is also intended for use in supporting planning decisions in the same way as the wildness quality mapping and Wild Land Area designations in Scotland (see Chapter 8 for further discussion).

Whilst the transect walks took participants from a low Jenks wildness class (WC) into a high WC and back in a single day, the WC of the pre-determined stops did not necessarily increase and decrease progressively. The wildness perception scores from the participants were sensitive to this, and walking stops which deviated from the progressive decline in mapped WC on the return leg were detected by participants and ranked as wilder. This is evidenced, for example, by the outlier peaks in perception scores for stops 2 and 15 in Beinn Eighe (BEN), and stop 14 in Invereshie & Inshriarch (I&I) (see Figures 5.1 & 5.2).

Participants also gave varying perceived wildness scores for a given walking stop of a particular WC, suggesting they are sensitive to differences in the landscape which are not captured by the wildness classes. This was true for all stops across all sites studied. Furthermore, participants scored perceived wildness differently for walking stops of the same WC. At study site BEN, walking stops 7, 8 and 15 were all Jenks wildness class 6, yet the walking scores varied, with median value highest for stop 8 and lowest for stop 7, and stop 15 showing the greatest variance (see Figure 5.1). Again this suggests that participants are sensitive to differences in the landscape which are not captured by the Jenks wildness classes. Images for these three stops reveal that visible differences do exist in the immediate surrounding landscape, despite them all being WC6 (see Figure 5.16).

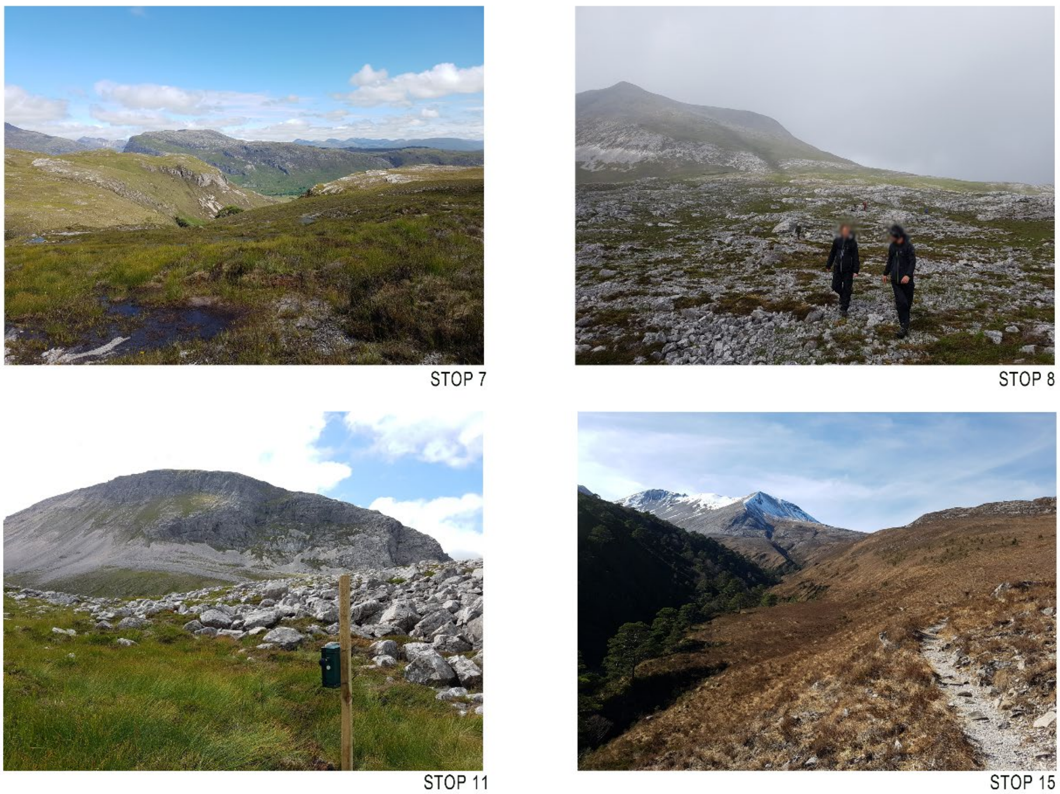

Figure 5.16: Study site Beinn Eighe (BEN). Images for participatory walking stops 7,8 & 15 (all Jenks wildness class 6), and stop 11 (Jenks wildness class 8).

Discussions amongst participants at site BEN, and their comments for stop 15, highlighted the importance to them of the sight of the older Caledonian trees (visible bottom-left in Figure 5.16, stop 15) after traversing a barren hillside, as well as the sight of regeneration of smaller Scots pine trees (visible top-right in Figure 5.16, stop 15). The older Caledonian trees were also visible in the distance at stop 7, but were a less immediate feature of the surrounding landscape. Stop 8 was much more barren in terms of vegetation, as well as being higher in terms of altitude, and many participants commented that by this stop they had 'left civilisation behind'.

This variance in perceived wildness scores for BEN is also matched by a similar result for stop 14 at Invereshie (I&I), where variance in scores is much higher than at stop 6, which has the same WC. Both stop 15 (BEN) and stop 14 (I&I) are distinctive for being pockets of ancient Caledonian woodland, a fact which was commented on by participants, and equates for them with an area having a higher level of wildness, or even being the place 'where the fairies live' (see Figures 5.16 & 5.17).

Figure 5.17: Study site Invereshie (I&I). Images for participatory walking stops 6 and 14 (both wildness class 5.5) and stops 7 and 10 (both wildness class 6).

The association of wildness with undisturbed natural habitats is, as stated, one of two key components, along with an absence of human influence, in the IUCN definition of 'wildness' and in the wider literature (Dudley 2008; Lorimer et al. 2015).

This distinction between those areas that were devoid of visible human influence yet lacking their intact native vegetation was a recurring theme in the informal and unstructured discussions which took place on the walking transects. The lack of native vegetation was often recognised as being caused by human influence (e.g. comments on ‘intensive grazing’ or ‘was cleared years ago for charcoal making’) even though this causality was only visible in the absence of native vegetation, rather than the presence of anthropogenic structures in the landscape. Other differences in perception scores for stops of the same WC, such as stops 7 & 14 in I&I, are driven more obviously by participant comments on feeling the ‘elation’ and ‘relief’ that comes from reaching a spectacular viewpoint (see Figure 5.17).

At the study site LES, there were lower levels of variance in perception scores between stop 7 and stop 8, both of which were WC8 and are also designated as sites of old-growth woodland. However, I note that the median score was higher for stop 7, where participants were completely surrounded by ancient woodland, in a location that was also off the path (see Figures 5.3 & 5.18).

The participatory mapping results for the other landscape attributes captured *in situ* demonstrated that participants do distinguish between the levels of biodiversity, naturalness and wildness for a given stop (see Figures 5.5, 5.6 & 5.7). Overall perceived wildness and perceived naturalness were the most closely related landscape attributes in the results for all sites. Perceived management was also always inversely related to perceived wildness. Echoing the earlier discussion point on intact natural habitats, there is a spike in values for perceived naturalness (and biodiversity) at stop 14 (I&I), whilst perceived wildness does not change, suggesting again that participants are sensitive to this distinction (see Figures 5.6 and 5.17).

Comparing results for Scotland and France, there is a clear difference between countries for the values for perceived biodiversity in areas of high perceived wildness. At site BEN, perceived naturalness and wildness follow a similar linear trend, but as perceived wildness increases, values for perceived biodiversity level out (see Figure 5.5). At site LES, values for perceived naturalness, wildness and biodiversity follow a similar linear trend throughout the participatory mapping task.

For the highest WC stops (stops 7 & 8), perceived biodiversity more closely tracks the values for perceived naturalness than for perceived wildness. One possible interpretation of this is that levels of biodiversity are much higher in areas of high wildness in France than they are in Scotland. Looking at the images for the higher wildness stops for the two countries (see Figure 5.16, stop 11 & Figure 5.18, stop 7), this does appear to be a valid observation. I collected habitat survey data for each of the stops for study site LES using a quadrat sampling method, but there was not sufficient time to do this for the Scottish study sites. Comparing actual measures of biodiversity with perceived biodiversity along the same transects would reveal whether human perceptions were validated by ecological data, and I consider this to be an interesting avenue for future participatory mapping research of this type.

As regards the overall link between the perception scores and the wildness classes, it is important to remember that for the study sites in Scotland and France, the wildness classes were statistically derived from earlier, more detailed spatial data on wildness quality. The differences in human perception scores for stops of the same WC may potentially be more accurately reflected in this underlying wildness quality mapping, which has a higher level of detail, with each landscape 'pixel' scored on a range of 1-256, as opposed to 1-8 as in the WC.

However, the importance of these WCs is evidenced by the fact that they were used as a key spatial decision support tool in the definition of the wild land areas in Scotland (Scottish Natural Heritage 2014; see Figure 2.3). There are 42 of these defined wild land areas in Scotland, and much of the debate on wild land in Scotland has turned around these specific areas, rather than the WC or the original underlying wildness quality mapping. WCs were used in the consultation phase for wild land area designation because it was found that they were easier to work with than the more detailed underlying wildness quality data. It is likely, given the planned use for the wildness quality map of France, that this would be statistically simplified in the same way as part of any stakeholder consultation phase.

This is especially relevant if we consider, for example, the BEN study site (see Figure 3.2i). In BEN, the entire area west of the road is designated as a single wild land area, even though it is clear that this contains a large number of different Jenks wildness classes. Drawing lines on a map to designate a boundary is a well-known source of conflict historically (Bastmeijer 2016b). Whilst there has been opposition from certain sectors to the wild land areas, the results from this study suggest that whilst there is variance in perceived values for wildness, there is overall a high level of agreement between the participants on the detailed differences in perceived wildness within this wild land area. Furthermore, the agreement on perceived wildness correlates strongly with the mapped WC. Given that the majority of the statistical analyses used to test these relationships are based on formulas which rank the order of the mean scores in the data, it is highly likely that this correlation extends to the wildness quality mapping from which these Jenks classes were statistically derived.

5.6.2 Measuring the impact of immersing people in wild spaces, and knowledge about them, on perceptions of wildness

There was a significant shift for the majority of the before-and-after perceived wildness scores, for the paired participatory mapping stops (see Table 5.2). Mean scores were always lower for perceived wildness on the way back. One obvious interpretation of this is that direct experience of being in a wild space for a day had a significant impact on perceived wildness. This is in line with the wider literature on the human experience of wildness (Gillet 1991; Gass 2003; Lindley 2005). Looking at study site LES, for example, there is a very strong effect for stop 5 (stop 10 on the way back). This is perhaps best explained by considering that participants had just left behind a rural but heavily managed village (stop 3) and grazing area (stop 4), and then walked uphill into the a large beech woodland area (stop 5). In comparison, the higher altitude areas they visited afterwards seem quite wild and unkempt (stop 7) (see Figure 5.18). By the time they returned to stop 5 (labelled ‘stop 10’ on the way back), they had spent several hours higher up the mountain. They had also spent an hour or so in an old-growth forest area (typified by stop 7), where standing and lying deadwood is a typical feature, clearly indicative of a lack of management. Visiting stop 5 again (as stop 10) after seeing these old-growth forest areas made participants sensitive to the signs of managed forestry (e.g. ”I can see now that this is all quite ordered”). This often sparked a discussion about what we consider as wild and unmanaged, and that unmanaged sites may often be the result of management on a much longer timescale, as is in fact true of the beech forests at stop 5/10 (see Figure 5.18). This suggests that participants are experiencing wildness in a relative rather than an absolute sense. This is in line with research looking at the impact on perceptions of time spent in wild spaces, although there seems to be a lack of literature that examines this in structured way as I have done here (Harper 1995; Ridder 2007).

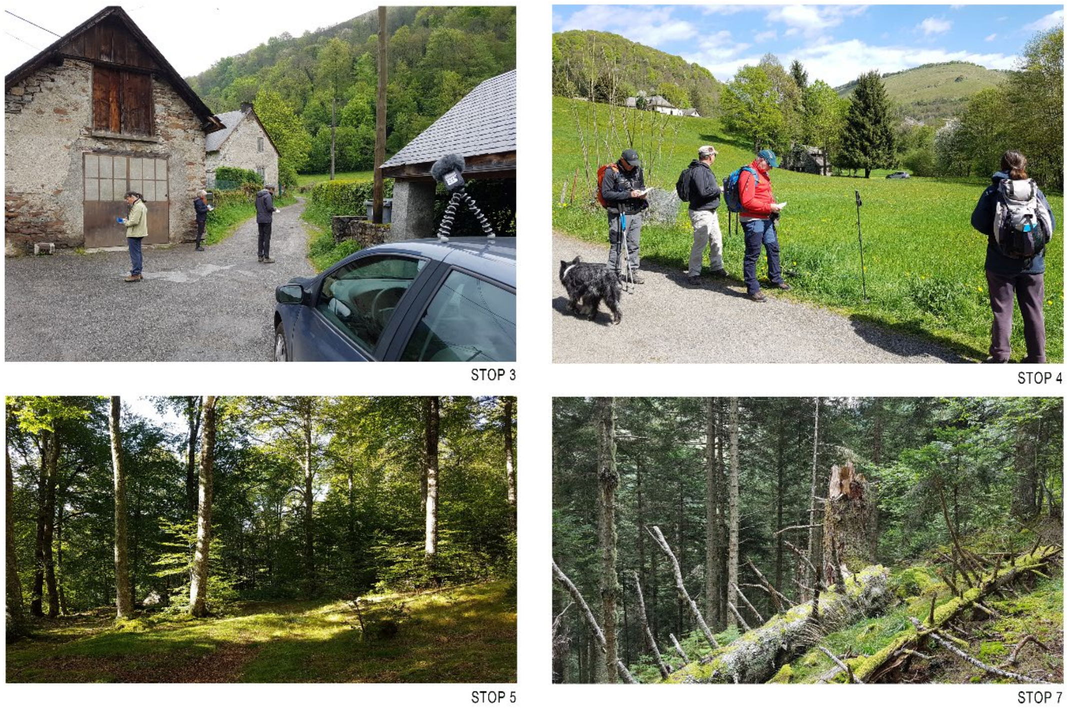

Figure 5.18: Study site Lesponne (LES). Images for participatory walking stop 3 (Jenks wildness class 4), stop 4 (Jenks wildness class 5), stop 5 (Jenks wildness class 6) and stop 7 (Jenks wildness class 8).

After the walk and watching the film on historical landscape change, participants were also queried again on their attitudes to three key questions on wild spaces, species and predators (see Section 5.3). Attitudes to wild spaces shifted significantly after the walk, with people more strongly disagreeing that there are enough wild spaces (see Figure 5.8). Of the three questions, this was the only result that was significant across all study sites, although it is noted that the opinions expressed varied widely, and the effect size was small, limiting the strength of the result (Thalheimer & Cook 2002).

I hypothesise that attitudes to this question changed more easily during the period of the research day than for the other questions on wild species and predators, for two key reasons. Firstly, the research walk was focused on moving through a wild space and, outside of occasional encounters with birds, there were very few encounters with wild species or wild predators. Participants were therefore focused more on wild spaces, and more immersed in thinking about the wildness of wild spaces, and as a result this was more likely to see a change in attitude. Secondly, the theme of wild spaces is a far less contentious theme than that of wild species or wild predators, so opinions about wild spaces are likely to be less deeply entrenched than opinions about wild species or wild predators (Miller & Peterson 2004).

Looking at the individual countries, whilst the shift in attitudes to wild spaces was highly significant in Scotland, there was no significant shift in the Pyrenees (see Figure 5.9). This suggests that the finding of significance for both countries combined was driven by the strength of the result in Scotland. Again, the interquartile range of attitudes expressed varied widely for both countries, and attitudes in Scotland became more diverse after the walk, whilst in the Pyrenees they became less so. One simple interpretation for this result is that participants in Scotland changed their minds about whether there were sufficient wild spaces as a result of spending a day walking through a wild space, reflecting with others on how wild it actually is, and learning about historical landscape change. This led them to realise that spaces they thought of as wild are not perhaps as wild as they thought. As a result, they more strongly disagreed that there are sufficient wild spaces after the walk.

This theme emerged during the walks, and was often focused around the paucity of native woodland as the basis for it feeling less natural, more human influenced and therefore less wild. As noted earlier in regard to Figure 5.16, this often emerged as a theme in Beinn Eighe, which - even though it is one of the wildest parts of the UK - has very few pockets of remnant native woodland. Even before watching the film, groups at this site regularly discussed how much of the surrounding landscape would historically have been covered by native woodland of one species or another.

In France, participant responses to the attitude questions did not change, and a regularly emerging theme in relation to wild spaces was that the mountains are in fact now less populated than they had been 150 years ago, and that the local areas are now more heavily forested than they were then. During the walk at LES, the higher wildness stops of the transect that participants pass through are in a large area of remnant old-growth forest, which covers the hillside, creating a very different experience to the isolated pockets of Scots pine at BEN. The site LES is typical of many areas in the Pyrenees region. Thus whilst the extent of old-growth forest in the Pyrenees is far lower than it was 8,000 years ago, before significant human presence in the region, it is still extensive, and the majority of areas that can support native woodland do so, or at least appear to do so (Jalut et al. 1998).

The short, nationally-adapted film that participants watched after the walk also discussed this theme, and presented the basic historical data on how wild spaces and wild species in Scotland or France have changed over time. For Scotland, this necessarily explained that most areas in Scotland have been dramatically changed by human impacts, with many of the native species of plants and animals which were once present being now either absent or in much lower abundance, although this framing is contested by some (Fenton 2008). Separating out the effect of the walk versus the film was originally a research objective, but the difficulty of recruiting sufficient participants to give over a whole day to a research project in a wild space prohibited the creation of the four necessary test groups: 1) those who walk and watch the film and complete the questionnaire, 2) those who walk and complete the questionnaire, 3) those who watch the film and complete the questionnaire, and 4) those who only complete the questionnaire.

The results for all study sites in both countries combined show attitudes to wild species did not change significantly after the walk ($p = 0.157$), although a test for the hypothesis that people more strongly disagreed that there are sufficient wild species was nearly significant ($p = 0.157$, see Figure 5.8). However, the results for just the Scottish sites combined were highly significant, with a medium effect size, especially for the hypothesis that people more strongly disagreed there are sufficient wild species (see Figure 5.10). Again, one possible interpretation for this shift is that participants in Scotland became more aware during the day of how few native species are present in wild places in modern-day Scotland compared to previous historical periods since the end of the last glacial period. The Pyrenees, by contrast, has a far wider diversity and abundance of wild species than Scotland, which may explain why attitudes to this question did not shift.

Attitudes to wild predators did not change significantly, whether analysed across all sites or within individual countries. However, the interquartile range for attitudes was smaller after the walk for both Scotland and France, perhaps suggesting less divergence in opinions for the majority of the group.

When interpreting these results it is worth remembering that people store multiple and sometimes conflicting attitudes that they might draw upon at any given time (Martinez et al. 2005). As discussed earlier, the concept of attitudinal ambivalence is used to explain this position, where people can have mixed-feelings about a given theme, with strong positive and negative feelings in conflict with each other (Conner & Armitage 2008).

Whilst I have not yet calculated full statistical analysis of values for attitudinal ambivalence for the current study, overall the results suggest that attitudinal ambivalence is low for attitudes to wild spaces. There are high levels of disagreement that participants have mixed feelings on this question. There is a high level of disagreement that any negative thoughts they have are strongly negative. There are high levels of agreement that their positive thoughts are positive. Overall, participants express an intention to support the protection of wild spaces. In Scotland, percentage scores for positive thoughts were even higher than in France. This lack of ambivalence may explain why attitudes in Scotland changed after the walk and the film. Participants support the protection of wild spaces, and spending time there and discovering how the landscape has changed strengthens this attitude.

The results of the question on reintroducing wild species such as the lynx were similar but not as clear as the results for wild spaces, suggesting that participants had higher levels of ambivalence on this question. As proposed above, the traditional interpretation for this is that wild species such as lynx evoke a greater strength of opinion than wild spaces. Discussion amongst participants whilst walking on the reintroduction of lynx suggested that many of them saw both positive and negative consequences, even if they were overall in favour of it. Based on this and the literature, another interpretation of the before-and-after question results on wild species could be that participants have higher levels of mixed feelings, and that this clash of values may reduce the likelihood that their opinions change even after a day thinking about wildness (Maio et al. 2018).

Whilst these preliminary results on attitudinal ambivalence are interesting, methodologically the order of the questions in the questionnaire makes them problematic. The questions on ambivalence were only asked once, and they were asked after the walk and the film, so we do not know how ambivalence may or may not have shifted in response to immersion. As with the overall before-and-after design, a greater number of study groups with a larger number of participants would be required to control for the effects of the individual methodological components.

Overall, this set of results would suggest that immersion in wild spaces and communicating knowledge on historical landscape change appear to change people's attitudes to wild spaces and wild species. It has also been shown that immersion in nature increases environmental awareness and the value that people place on it, which may in turn increase their desire to protect it (Palmberg & Kuru 2000; Rosa et al. 2018). This methodological approach does therefore show potential to offset the effects of generational amnesia and shifting baseline syndrome, and their impacts on the conservation of wild spaces and wild species (see Sections 2.2.3 & 2.4.3).

5.6.3 Discussion of exploratory analysis of between-group difference for the walking scores

I used an exploratory analysis to test the expert-proposed stakeholder group types for between-group differences in the participatory mapping scores for wildness. This was only possible for study site Beinn Eighe (BEN). There was a significant difference for human wildness scores, compared to mapped Jenks wildness class, between group 3 (environmental sector) and group 4 (land owners/managers). This suggests that whilst the overall results of the participatory mapping task show strong correlation between perceived wildness and mapped wildness class, there were significant differences in the results, at least for this study site.

The results of this pilot study demonstrate that the participatory mapping method used shows potential for exploring perceived wildness in the wider population. One of the key challenges of this study was recruiting sufficient numbers of participants, especially given the demands placed on participants' time. Nevertheless, it is felt that the sample was of sufficient size to properly test the methods used and to perform a statistical analysis. Clear variation is seen amongst the population sampled in the participatory mapping scores as well as the linked before-and-after questions reported in this chapter.

The stakeholder groups were proposed by researchers working in Scotland, and were chosen as useful to explore the results, especially given the current debates in Scotland on wild land (Marsden 2018). A larger study within Scotland which aimed for a representative and balanced sample of these groups would certainly be of great interest in the context of these debates. Using study sites in two different countries highlighted one clear difference of relevance to these stakeholder groupings: land ownership. Land ownership in Scotland is concentrated in the hands of a small number of wealthy individuals (Scottish Land Commission 2019). In France, land ownership is very different, with thousands of people owning small parcels of land, and most of the land above 1,500m being owned and managed by local communes.

The different land ownership models in Scotland and France is of course only one of many social, cultural and economic differences between the two countries. I did not, however, have enough time in the current study to complete a full stakeholder analysis for the two countries. Even if it had been possible, as a solo researcher with limited time and resources, I would have found it hugely difficult to recruit enough participants in each country to have a balanced sample for all groups identified.

Chapter 6 – Results: Ecoacoustics

6.1 Summary

In this chapter I present the results and discussion of the ecoacoustics research which I conducted along a gradient of Jenks wildness quality (WC) at four study sites (see methods Sections 3.3 & 3.8). This work was supported by my co-authors for the article published in the journal Science of the Total Environment, as acknowledged and detailed on page ii. I explored three key questions: firstly, how acoustic indices (AI) differ along a gradient of WC (see results Section 6.3). Secondly, I analysed the relationship between AI and: 1) Jenks wildness classes, 2) human subjective perceptions of wildness and biodiversity (see results Section 6.4). Finally, I tested whether AIs predict 1) wildness class, and 2) human perceptions of wildness and biodiversity along the same transect (see results Section 6.5). I then discuss the individual results from this methodological approach (see Section 6.6). Again, I present the wider discussion of these results, and how they integrate with the results from the other methods, in Chapter 7.

6.2 Introduction

As highlighted in the methods section (Chapter 3), high levels of snow cover in the Pyrenees meant that I only used one of the two proposed French study sites, Lesponne (LES), in the participatory mapping task. The four ecoacoustic sites were Invereshie & Inshriach National Nature Reserve (I&I) in the Cairngorms National Park, Scotland; Beinn Eighe National Nature Reserve (BEN) on the Scottish west coast; Lesponne (LES), Hautes-Pyrenees, southern France; and Pouey Trenous (POT), in the centre of the Pyrenees National Park, southern France (see Figure 3.1). The higher altitude stops (>1,500m) at the site at Pouey Trenous (POT) were so altered by snow that this rendered the participatory mapping task not only dangerous but impractical, as differences in land cover were obscured.

For the site LES, where I conducted research with human participants in France, I asked an additional question on sound during the participatory mapping task. I asked participants to rate how important sound was to their experience of wildness at each stop on a scale of 1 (very low) to 7 (very high). Sound was considered an important component of participant experience of wildness regardless of how wild that stop was perceived to be (see Figure 6.1).

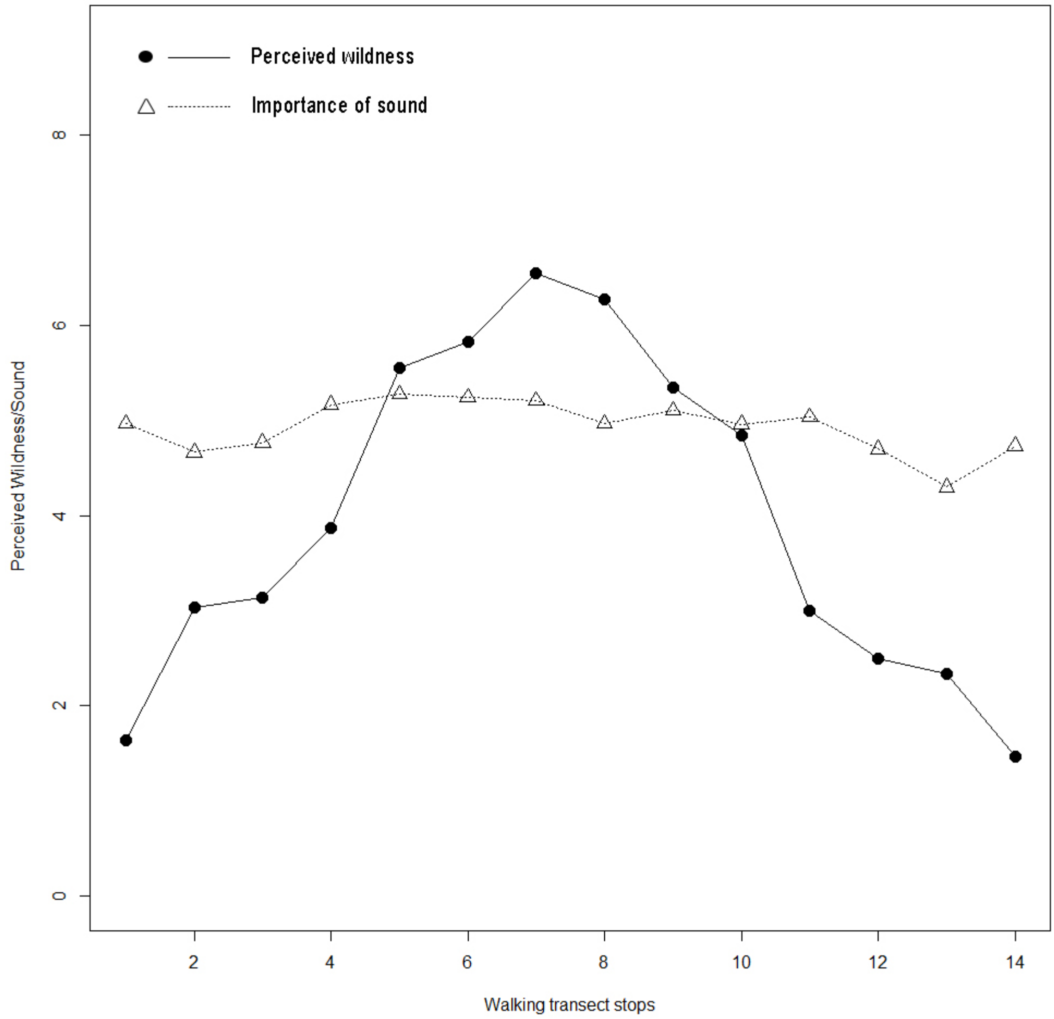

Figure 6.1: Study site Lesponne (LES). Participatory walking scores for the question on the importance of sound to participant experience of wildness on a scale of 1 (very low) to 7 (very high) (dotted line). Perceived wildness for the same stop is also shown (solid line).

I used six acoustic indices for the analysis of the sound recordings collected along the transects at the four study sites. I chose three ecological indices which have been demonstrably linked with biodiversity (biophony) in temperate biomes as biodiversity proxies: Acoustic Complexity Index (ACI); Bioacoustics Index (BAI) and Acoustic Evenness Index (AEI). I used the Relative Technophony Index (RTI) here as a measure of man-made noise (technophony). Finally, I used two standard acoustic indices to measure overall sound energy: Root Mean Square (RMS) and Spectral Centroid (SC), which measure the overall distribution of sound energy across the frequency spectrum (see methods Section 3.6, & Appendix E for details of AIs used).

6.3 Do acoustic indices differ along urban-wild gradients?

Acoustic indices (AIs) plotted by WC for all sites combined reveal a large degree of scatter for individual AI values (see Figure 6.2), suggesting a wide range of variation within and between wildness classes across sites. SC shows the strongest increasing trend overall. RMS and BAI show the strongest decreasing trend.

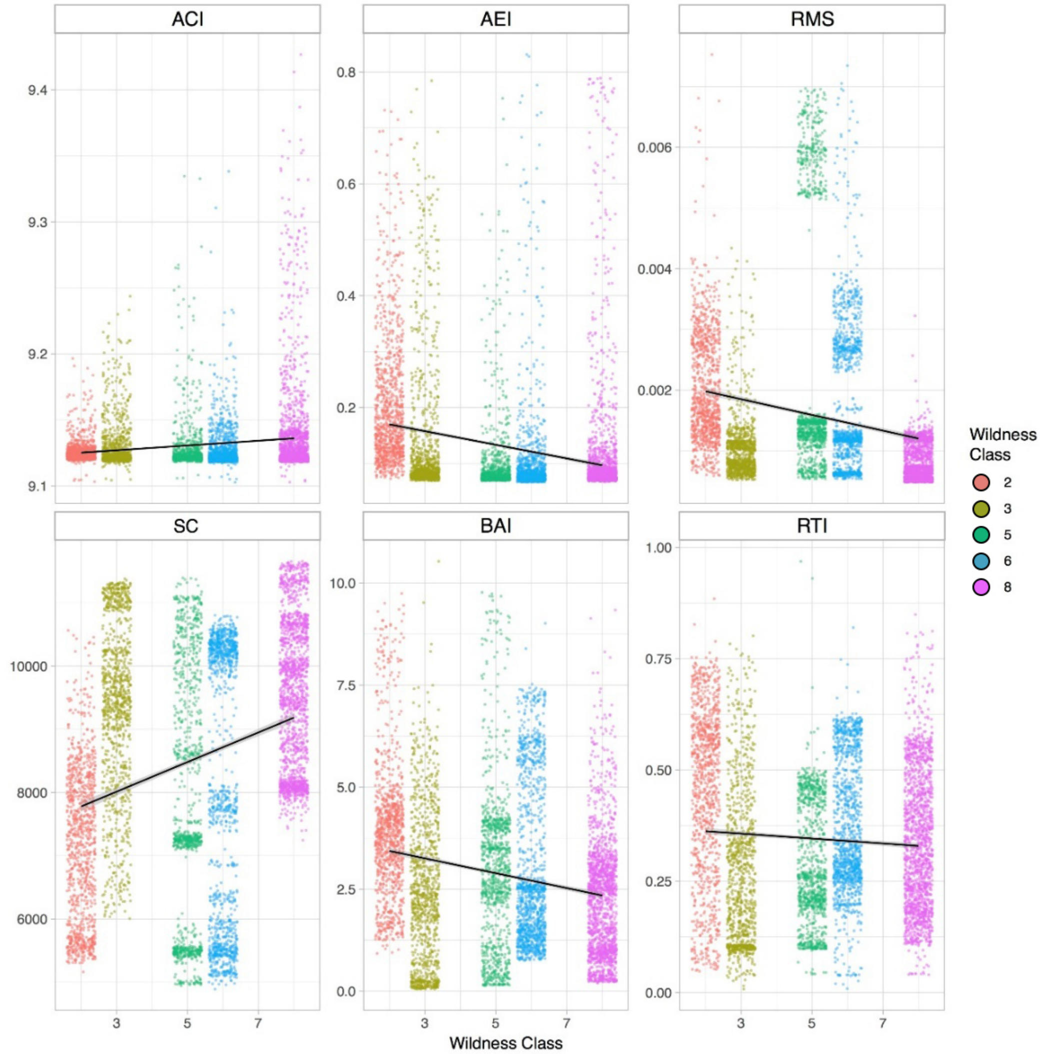

Figure 6.2: All study sites. Scatter plots of all AIs (rows) across Jenks wildness class (WC) for all four study sites combined with linear model fitted (in black). See text for details.

Comparisons among sites (see Figure 6.3) show significant differences between Jenks wildness class (WC) in five out of six AIs, demonstrating strong variation in acoustic environment across the four urban-wild gradients studied. In all but one case

(AEI at BEN), there are significant differences between extremes of wildness along the gradient (WC2 and WC8), but none vary as a simple monotonic function of WC. Considerable variation is observed in the patterns of significant difference between sites, suggesting that there are variations in the soundscape beyond those reflected in current wildness quality maps.

The clearest trend is observed for SC, which tends to increase, reflecting an overall reduction in low-frequency energy as we move along urban-wild gradients. RMS similarly tends to decrease, reflecting an overall reduction in amplitude of all sound signals. Within this general trend, median values for some survey points are significantly above (POT 3) and below (LES 5 and LES 6, BEN 6) values at the ends of the gradient in urban and most wild sites. Others show markedly larger variance (BEN 6). RTI largely mirrors SC, showing significant decreases from peri-urban (WC2) to remote sites (WC8) across locations. BEN is the exception here, where there is a significant increase with increasing wildness. The same sites, LES 5 and LES 6 and POT 3, show marked deviations from otherwise almost linear trends. Biophonic activity, as indicated by the ecological indices (BAI, AEI and ACI) tends to decrease from urban to wild sites, with significantly greater values between WC2 and WC8 at each site except BEN, which shows an increase. The clearest trend is visible at I&I.

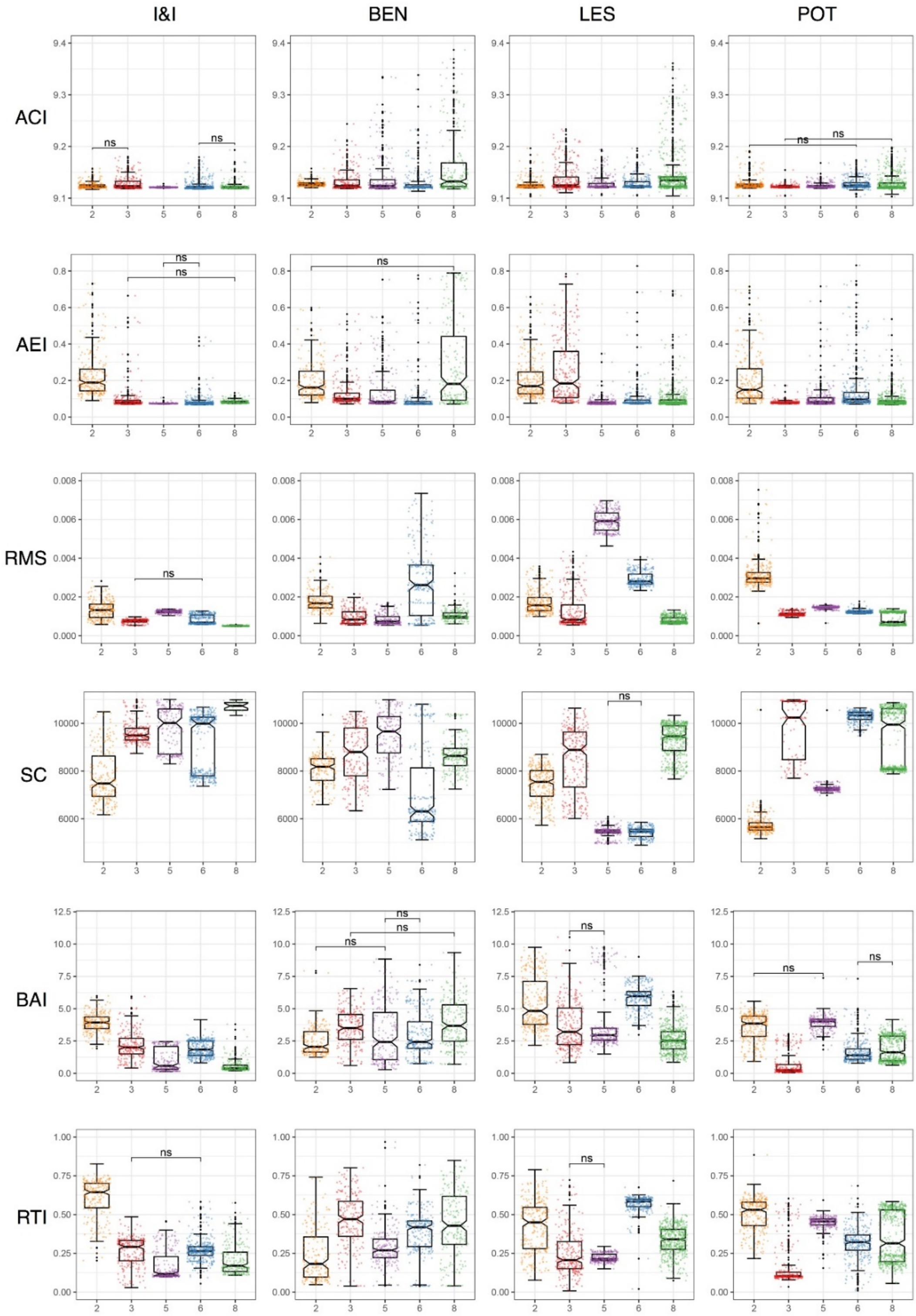

Figure 6.3: All study sites. Tukey's box and whisker plots for AI values (rows) across days for each WC for each study site (columns). Horizontal lines represent medians; the box represents the interquartile range; whiskers represent min and max values within 1.5 IQR. Non-significant differences ($p < 0.05$) between sites are denoted by bars **ns**. Individual AI values are shown as points.

6.4 What is the relationship between AIs and 1) Jenks wildness classes, and 2) human subjective perceptions of wildness and biodiversity?

Correlation analyses (see Figure 6.4) suggest that WCs largely reflect human perceptions of wildness and biodiversity, with strong positive correlations in all sites tested. AIs show predominantly moderate, significant correlations with WCs, but these vary in magnitude and direction across sites (see Figure 6.4, top rows).

In line with analyses of AI against wildness class (see Figure 6.3), acoustic features SC and RMS show the strongest and most consistent relationships. SC shows a moderate, positive relationship with WC and distance from road at sites I&I, LES and POT. Relationships with human perceptions of wildness and biodiversity are similar at I&I and LES. However, BEN shows no relationship between SC and WC, or SC and human perceptions of wildness, but a moderate negative relationship with biodiversity. RMS shows a moderate (I&I, LES) to strong (POT) negative relationship with WC and distance from road.

The relationship between WC and ecological indices ACI, AEI and BAI are significant, but vary in magnitude and direction across sites, suggesting variation in levels of biodiversity along the urban-wild gradient between sites. This pattern of relationships seen with WC is the same for distance from road and human perceptions, except at BEN, where fewer significant relationships are observed.

Finally, RTI shows significant relationships. But contrary to my prediction that low-frequency signals will decrease with increasing wildness, it does not show a clear relationship with WC or distance from road: I observed moderate negative correlations with all four measures in I&I, small positive relationships in BEN, and no significant correlations in LES (WC) or POT (WC or road).

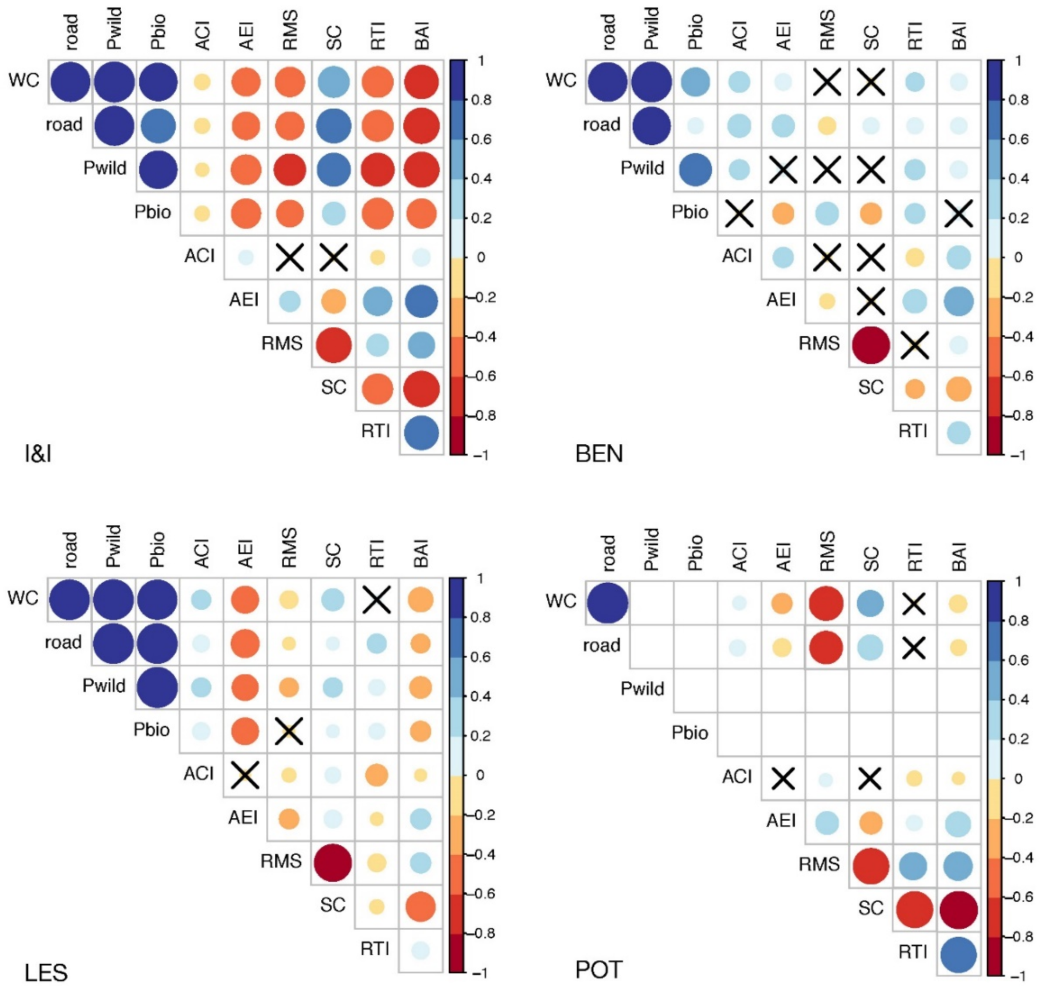

Figure 6.4: All study sites. Correlation matrices of Spearman's rank coefficients for correlations between wildness class (WC), distance from road (road), human perceptions of wildness (Pwild), human perceptions of biodiversity (Pbio) and acoustic indices for all sites (I&I top left, BEN top right, LES bottom left, and POT bottom right). Crosses denote non-significant correlations (95% confidence intervals). Circle size and colour denote strength and direction of correlation respectively. Note that no human data are available for POT.

6.5 Do acoustic indices predict mapped and perceived wildness?

Multivariate regression models show that the six AIs tested strongly predict wildness class at each site with low error (see Figure 6.5). Variance explained for all sites combined is lower than for any individual site apart from BEN, suggesting that variation between sites is stronger than that along the urban-wild gradient. Variable importance varies between sites (see Table 6.1). However, RMS and SC are in the top three most important indices at all sites, together explaining over 50% of the variance, in line with the prediction that sound levels will decrease and dominant frequency will increase along urban-wild gradients.

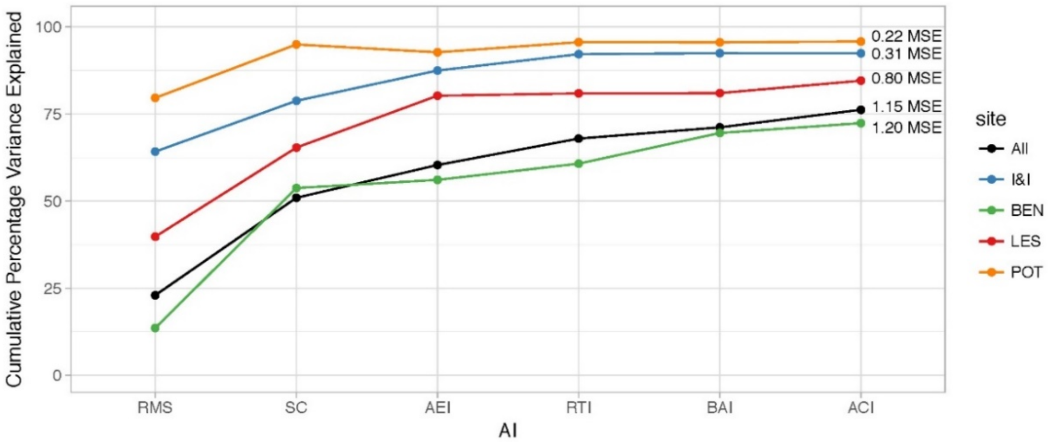

Figure 6.5: All study sites. Cumulative percentage variance explained by multivariate random forest regression models with six AIs as predictors and wildness class as response for all sites combined (76.21% MSE 1.15) each site (I&I 92.44% MSE 0.31, BEN 72.37% 1.2 MSE, LES 84.56% 0.8 MSE, POT 95.81% 0.22 MSE). Out-of-bag error rates for the six AI model are detailed at the right of each curve. AIs were added to each model in the order of variable importance for all sites combined (X axis).

Table 6.1: All study sites. Relative variable importance for AIs as predictors of wildness classes at each site and all sites combined

	Relative Variable Importance				
AI	**ALL**	**I&I**	**BEN**	**LES**	**POT**
RMS	1.00	0.96	1.00	0.88	0.89
SC	0.66	1.00	0.62	1.00	1.00
AEI	0.56	0.41	0.74	0.95	0.04
RTI	0.50	0.37	0.58	0.27	0.29
BAI	0.48	0.54	0.50	0.23	0.36
ACI	0.43	0.11	0.61	0.45	0.09

Finally, a comparison of models built for all components found that for all sites combined, compound AIs predict human subjective judgements of biodiversity (82.22%; MSE 0.25) and wildness (77.29%; MSE 0.64) even more strongly than mapped wildness classes (76.21%; MSE 1.15), and are surprisingly poor predictors of distance from road (69.81%; MSE 599.59).

6.6 Discussion of ecoacoustics results

In this project I investigated the relationships between AIs, currently designated Jenks wildness classes, and human subjective judgements of wildness and biodiversity. I used a range of statistical analyses to investigate how sound levels, frequency content and soundscape components varied along urban-wild gradients at four different sites. The results demonstrate that i) the soundscape varies significantly over wildness classes; ii) there are significant variations in soundscape across wildness classes between study sites; iii) biophonic activity does not necessarily increase with increasing wildness; and iv) AIs predict human perceptions of wildness more strongly than current wildness classes.

6.6.1.The soundscape varies significantly over wildness class

The simple acoustic features I investigated are in line with the first prediction: that overall sound levels and presence of low-frequency signals will decrease with increasing wildness. The increase in SC at all sites (see Figure 6.3) suggests that peri-urban sites are dominated by lower frequency components than wilder locations.

The decrease in RMS across the same gradient suggests that sites generally get quieter as wildness class increases. These results demonstrate that the soundscape varies with human influence, and that acoustic metrics recapitulate existing components of wildness mapping.

The relative technophony index (RTI) was introduced as a measure of the relative dominance of low-frequency energy, and an explicit proxy for distance from human influence. It was predicted (see Section 3.6) that RTI would decrease as we move from urban to wild spaces, mirroring SC, as traffic noise decreases with increasing distance from roads. This trend is observed at I&I (see Figures 6.3 & 6.4), but is far from consistent across sites. Auditioning of the sound recordings (see Section 3.8.4) revealed that there are high levels of car noise at WC2, and that WC8 is relatively quiet, without plane or wind noise, which may explain the clear predicted trend found at this site.

Conversely, the opposite trend is evident at BEN, and a review of the sound recordings reveals that this is driven by two factors. Firstly, the low value of RTI at WC2 and WC3 is not due to the absence of traffic, but rather the close proximity of cars, and increased noise from wet roads generating high-frequency energy (up to 8kHz), and therefore lower values of RTI. Secondly, at the wilder locations, WC6 & WC8, jet fighter activity (low frequency) is clearly audible in the sound recordings at the higher, more exposed locations, leading to higher values for RTI. Derived from the NDSI (Kasten et al. 2012), this band-limited index is based on the assumption that the sound of human industry (technophony) contains predominantly low-frequency components. This is true at landscape scales, or where sample sites may be surrounded by vegetation cover which attenuates high-frequency components of signals. In urban settings, where traffic is in close proximity to sample points, these assumptions of band-limited sound signals break down, and so new approaches to acoustic monitoring may be needed across urban-wild gradients.

6.6.2 There are significant variations in soundscape across urban-wild gradients and between sites.

Within these overall trends, there are significant differences in soundscape along gradients, and differences in the magnitude and direction of correlations, suggesting there is wider environmental variation than that captured in current wildness quality mapping methods. The ecological relevance of these variations requires further study. Auditioning the recordings reveals that the anomalous trends in BEN are due primarily to gusting winds at WC6 and WC8, which generates broadband energy, resulting in the large variance in both SC and RMS at WC6. The anomalous patterns observed at LES 5 and LES 6 (high RMS, low SC) are due to river noise and running water near the site, which generates acoustic energy in the low-frequency band.

The need for high-quality biophysical naturalness metrics linked to land use and management, as well as broader ecological approaches to measuring the intensity and biophysical impact of anthropogenic activities, have been cited as key future challenges for the mapping of wildness (Lesslie 2016). The considerable variation observed in the patterns of significant difference between sites (see Figure 6.3) suggests that AIs are sensitive to differences between recorder locations that are not captured by current wildness class mapping schema. As with the interpretation of the participatory mapping scores for perceived wildness, systematic interpretation of these differences requires more detailed ecological data sets as a baseline.

6.6.3 Biophonic activity does not necessarily increase with increasing wildness class

Values for ecological indices BAI, ACI and AEI do not show either strong positive correlations, or significant increases across gradients, as predicted under the assumption that biodiversity increases along urban-wild gradients. This could be due to absence of biophonic activity or inadequacy of the indices. Auditioning of the recordings for site BEN suggests that the trend from other sites is confounded here by high wind noise (gusts) and rain (drops) creating acoustic energy within a range that is commonly associated with bird vocalisation, especially at sites WC6 and WC8. BAI fell from WC2 to WC8 at all sites except BEN, suggesting lower levels of biophonic activity at the wild end of the urban to wild gradients measured. Auditioning for site I&I revealed much higher levels of biophonic activity (abundance and species richness) at WC2 compared with all other sites at I&I, and WC8 was effectively silent.

It is proposed that this pattern is driven by a number of factors. Firstly, as a general trend, all high wildness sites were also higher in terms of altitude than low wildness sites. Biodiversity is known to fall with altitude and the resultant lower temperatures, as is evidenced by the importance to avian richness of summer temperature (Lennon et al. 2000; Marzluff et al. 2012). Other studies have shown that avian richness is higher in urban areas with diverse habitats than in upland areas (Rosenfeld 2013); and more widely, that biodiversity can be higher in urban gardens than in semi-natural landscapes (Thompson et al. 2003). Furthermore, the high wildness sites of the type found at WC8 in I&I and BEN, for example, are recognised as being ecologically impoverished compared to their original post-glacial state (Hobbs 2009; Fisher et al. 2010).

A second key factor is the deployment period for the recorders, which for practical reasons did not coincide with peak annual avian activity. This was compounded by unseasonably bad weather at both the Pyrenees study sites. Auditioning revealed that bird vocalisation across these two sites was much lower than would be expected based on expert knowledge of the sites.

The results for the AIs designed to capture biophonic activity were also confounded by the high-frequency components of noise from cars, wind and rain, as outlined above. AIs such as BAI, for example, were originally designed for monitoring use in more remote, tropical areas, low in technophony. In the current study, the higher frequencies resulting from technophony are also detected by the sound recorders at the low wildness peri-urban sites (WC2 & WC3).

6.6.4 Acoustic indices predict human perceptions of biodiversity more strongly than wildness classes

AIs strongly predicted wildness class, but human perceptions of wildness and biodiversity are even more strongly predicted (see Figure 6.4) . As discussed above, further work is needed to validate the use of acoustic methods for biodiversity monitoring in wild mountain areas, but these results suggest that acoustic methods are sensitive to the same factors which influence human experiences of wildness, to which current mapping methods are insensitive. This suggests that the methods used in this study do indeed have potential to address the limitations of current approaches to mapping wildness, as proposed in Chapter 2. The methodological potential of combining results from participatory mapping and ecoacoustics to improve the way we measure wildness is discussed in Chapter 7.

6.6.5 Recommendations

The complexity and dynamically evolving nature of the relationship between humans and their landscape requires us to change our perspectives and seek new ways of understanding these complex spaces, that are also better suited and more robust for use in planning, nature conservation and policy making (Hennig & Künzl 2016). The results from this project should stimulate further work in the application of ecoacoustic methods in wildness mapping methodologies in order to ensure that they better reflect ecological and human processes and values.

The next important steps are: firstly, the development of new AIs better suited to assessing the components of soundscape relevant to measuring wildness across urban-wild interfaces; secondly, validation of these acoustic methods with baseline data from biodiversity and local habitat assessment in order to establish the ecological significance of the variations across sites observed here.

New acoustic analyses for wildness mapping are also needed to deal with geophonies associated with extreme weather and water in upland areas. The results show that simple acoustic features (RMS and SC) are more strongly correlated with changes in the soundscape across urban-wild gradients than ecological indices. This is in line with previous work in which these simple descriptors were also stronger predictors of avian species richness (Eldridge et al. 2018). The results also suggest that technophony (e.g. cars passing) contains high-frequency components, and that geophonic components (e.g. wind, rain and rivers) are similarly broad spectrum, rendering band-limited indices unsuitable.

These methodological developments will require repeated local spatial replications, as well as replications across different biomes. The transects selected for this study spanned a continuum of low to high wildness across a relatively short distance of around 10km. Whilst this was necessary in order to enable human participants to walk the transects in a single day, future iterations of the methodology may benefit from using a protocol with short, medium and long transects across a more diverse range of habitats/ecotones. At some study sites the issue of scale could be further explored by using a nested protocol so the long transect would contain a short and a medium transect.

Using longer transects would allow spatial replication of acoustic surveys within a given wildness class, and thus provide better understanding of the characteristics of these areas, how acoustic events relate to local environmental data, as well as highlighting any possible edge effects. More specifically, the use of precisely positioned and configured arrays of sound recorders inside a particular wildness class would also add greater resolution to the analyses, capturing the ‘near field’ ecoacoustic events which may better reflect the detail of the localised variation in the perceptual experience of a wild soundscape for both humans and other resident vocal species (Farina 2019).

Combining this multi-scalar approach with longer term deployment of the recorders over the period of a full year is also recommended to capture seasonal variation in acoustic events, and would also reduce sensitivity to extreme weather or other ephemeral events. Incorporating iterations of this type into the existing transect-based methodology would allow greater understanding of the subtleties of how remote sensing and machine listening measurements of these ‘near field’ and seasonal variations relate to human experience of wildness. This is discussed further in the context of how the results from the individual disciplinary methods can be integrated as part of a transdisciplinary approach to improve maps of wildness (Chapter 7), and how this is of importance to decision-making on the conservation of wild spaces and wild species (Chapter 8).

Chapter 7 – Discussion: Integrating the methods

7.1 Summary

In this chapter I discuss how the results from the individual disciplinary methods in Chapters 4, 5 and 6 can be integrated as part of a transdisciplinary approach to measuring and mapping wildness. I discuss the conceptual basis for situating this transdisciplinary approach along a path or transect, and how this framing can improve the representation of wildness by integrating remote sensing, ecoacoustics and human perception of landscape attributes (see Section 7.2). I take the current model for mapping wildness (see Figure 2.2) and situate it within a broader, more integrated conception of wildness mapping. I discuss how the results from this PhD project fit into this model, and how integrating them provides useful insights into how we can offer more detail and subtlety in the way we measure wildness (see Section 7.3).

I discuss the challenges and limitations of integrating these results using the current methods as part of a transdisciplinary framework (see Section 7.4). I close the discussion with a proposal for how these limitations could be addressed in future research, and a preliminary report on attempts to pilot an iteration of the methods in the Swedish Arctic (see Section 7.5). I discuss the importance of participatory methods and the co-production of wildness mapping to more effective decision-making on the conservation of wild spaces and species in Chapter 8.

7.2 Transdisciplinary methods for mapping wildness

Within the wider call for more integrated research on global environmental change, there is a clear need for research that reflects the plurality of representations of landscape and the diversity of human values these represent (Castree et al. 2014). Situated in the academic discipline of geography, cartographers have traditionally focused on the map as a communication tool, designed by experts and using spatial data to create an accurate tool that represents reality (MacEachren 2004). The goal of geographical research of this type is to develop improved methods and collect more data in the hope of generating a complete representation of 'reality' (Montello 2018). As such, this research outlook is preoccupied with accuracy, even down to the level of the symbols used to represent that reality (Bertin 1983; Perkins 2014).

Whilst this aim of objective scientific accuracy is a necessary component of any attempt to represent wildness, I argue that it is, in and of itself, not sufficient (see Section 2.3.2). In constructing representations of wildness for use in decision-making, in this project I have explored methods that as a minimum include both the objective 'reality' of the landscape (ecoacoustics) as well as subjective human perceptions of that landscape (participatory mapping). In recent decades, the growth of cognitive psychology within the social sciences has heralded the emergence of the fields of cognitive mapping and cognitive cartography. Both these fields research map design, how individuals create mental maps of their environment, and how individuals engage with these maps (Caquard 2015). One specific research goal within this field is to understand how cognitive regions are built and function within the mind, reflecting the way that cultural groups and the individuals within them organise and construct their understanding of landscape (Montello et al. 2014). Yet research is often limited to consideration of simpler landscape attributes such as distance, boundaries, or basic elements of place (Montello 2009; Zhang et al. 2018).

Measuring a complex landscape attribute like wildness is without doubt challenging, and requires multiple disciplinary lenses that go beyond a simple objective/subjective division. Situating our conceptualisation of how we measure and represent wildness within wild spaces themselves has been used in this project as a methodological framework which can accommodate multiple framings of the problem at hand, including the disciplinary boundaries of the academy, the subjective/objective divide, top-down vs bottom-up approaches, qualitative vs quantitative data. This is also crucial if we are to consider wildness outside of the academy and explore how integrated representations, developed in a participatory way, can support resilient and sustainable conservation of wild spaces and wild species. As part of this place-based approach, how people move through these wild spaces along a path is the methodological key I have used in this project to weave together the machine-based measures of wildness and the human experience of wildness in the landscape itself.

The idea of a path situated in the landscape speaks to multiple disciplinary approaches and ways of describing data or knowledge. Within environmental history, it is considered to be a way of both accessing knowledge on 'mobility heritage' as well as a potential mechanism for resolving conflicts arising from competing land uses in remote locations (Svensson et al. 2016). Paths are also shared, co-evolving from human and non-human use of the landscape, serving as an anthropological lens through which to research shared land use and cultural knowledge of places (Van Dooren 2014). In this sense, humans and the wild species which inhabit the wild spaces we humans seek out often move along the same paths, wayfaring though the landscape (Ingold 2000). In ecology, scientific research in animal behaviour uses GPS tracking to build agent-based models of how a given species moves through the landscape, with the aim of identifying least-cost paths or connectivity corridors of conservation importance (Bocedi et al. 2014; Blazquez-Cabrera et al. 2019). Animal biologists and conservationists survey butterfly populations along a path which is walked repeatedly year after year to collect longitudinal data on the presence and absence of butterfly species, supporting long-term monitoring of a more quantitative and objective kind (Brereton et al. 2011). Within these scientific disciplines, the path serves as a transect along which to sample data for a particular species.

A key obstacle in current methods for mapping wildness in the landscape is that they are incommensurable in scale with the experience of the populations which inhabit them, intrinsically prioritising one perspective over another (Eldridge et al. 2019). Land management decisions are predominantly based on maps created from satellite imagery which provides visual representations of broad vegetation cover and macro-structures of the built environment, yet these maps are blind and deaf to the details of the lives of the myriad critters (humans among them) which flourish in wild spaces. Site-based ecological surveys capture detail of which flora and fauna dwell at particular sites and times, but are intrinsically small-scale, and traditionally focus on non-human species. At the same time, whilst participatory ethnographic methods are increasingly being explored to access the knowledge, perception, and values of local human actors (Hollowell 2009; Maginn 2007), they are documented in a way which limits the possibility to situate and analyse the insights generated in relation to the wider context of the actors involved (Reed et al. 2018; Pink 2010). Each individual disciplinary method is incomplete, spatially limited, and fails to provide a comprehensive representation of wildness across the local and landscape scales required. This limits their usefulness as a support tool in environmental decision-making and planning, which require standardised spatial data with homogenous coverage across their administrative remit.

Faced with this multi-inter-transdisciplinary (MIT) challenge (Stock & Burton 2011) of improving how we represent knowledge on wild spaces and species using maps of wildness, in this pilot study I tested a suite of methods, integrated by underlying spatial data on a gradient of wildness, and unified around a place-based transect approach. This approach built on the current model of wildness mapping (see Figure 2.2) and is conceptualised in Figure 7.1.

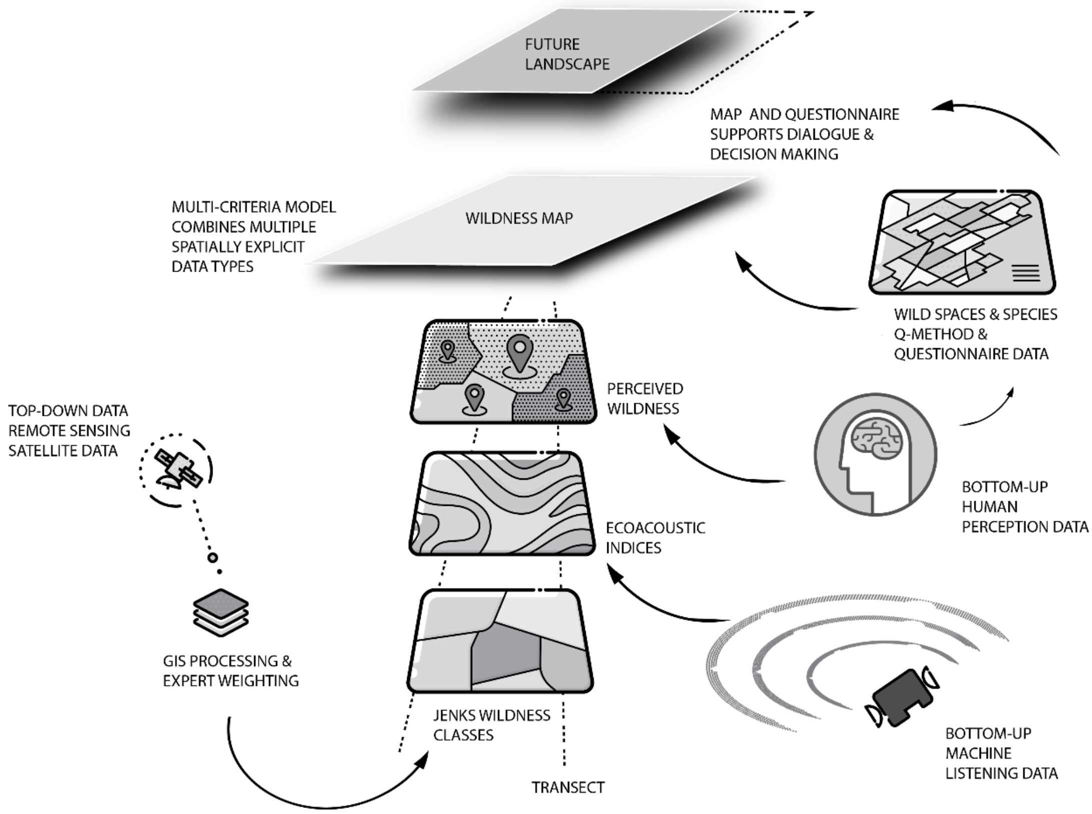

Figure 7.1: Conceptual representation of methodological approach showing multiple data sources considered, including existing satellite data, machine-listening ecoacoustics, human perceptions of wildness, and questionnaire data on wild spaces and species. Data are situated along the transect and integrated into a map of wildness to support decision-making on future conservation of wild spaces and species.

I have framed the path walked by participants in this project as a ‘transect’ along which different kinds of data are collected. I have vertically integrated multiple types of data collected laterally in this way, and analysed them as part of the process of constructing knowledge (Ingold 2011:153). In this project I measured multiple types of data on human perception, wildness quality maps and ecoacoustic indices at points along a lateral transect. I followed this with an analysis phase, where I moved data vertically into a more abstract analytical space where the research goal was to statistically analyse the data for their applicability at a more universal scale.

In this analytical space, I integrated other qualitative data types into the model, including the Q-Sort data on landscape perceptions of wildness and attitudes to wild species. I analysed each data set in terms of how it compares with the others from a given data layer, and then explored possible correlations between datum points across datasets, testing for significance, in an attempt to increase my knowledge and understanding of how we can represent wildness.

This research aim of integrating different types of data and exploring the potential of these research data for the wider population is challenged by Ingold, who observes that “knowledge is integrated not through fitting local particulars into global abstractions, but in the movement from place to place, in wayfaring” (Ingold 2011:154). This is in part because his interpretation of a transect as the site of data collection is based on the example of a scientific team which samples data along a transect of thousands of miles, moving from point to point in a helicopter, blind to the richness of other local knowledges that makes this possible.

In this project, participant activity is closer to the wayfaring mode he describes, with the vertical integration situated along a specific transect. I conducted this research along a transect which for the most part also followed actual paths through the landscape. In Beinn Eighe, for example, this included roads and pavements in the least wild areas, structured footpaths in the national nature reserve as we moved away from the urban area, and then the old pony track as we moved up into the higher ground. This track has historically been used by stalkers to bring down the deer shot up in the hills. It is still used for this purpose today, although not with ponies. The wildest parts of the transect took the groups off the pony path, following animal tracks for the most part, until we reached the quartz plateau of the wildest sample site. Participants did not jump from point to point, they moved together through the landscape, discussing and reflecting on the themes of wild spaces and species. This participatory research method captured this knowledge, already integrated, and used the transect to explore how it related to other types of knowledge collected in the same place.

7.3 Transdisciplinary results from measuring wildness

I used a diverse set of methodological approaches to measure wildness. Given the contested nature of the term ‘wild’, and the ongoing heated debates on wild spaces and species in both countries studied, I had expected that these methodological approaches would reveal divergent results, especially compared to the existing mapping of wildness. I anticipated that a transdisciplinary perspective on the individual disciplinary methods would be challenging because the findings would be so different, incommensurable even, in spite of the methodological frame of a shared transect. There was, however, a surprising level of agreement in the results represented in each data layer of the overall conceptual model (see Figure 7.1).

As described in Chapters 4, 5 and 6, the objective quantitative data on Jenks wildness classes (WC), coming from the existing top-down approach, correlated with the results of the subjective qualitative methods coming from the bottom-up. The results of the participatory walking methods showed significant correlations between mean human perceptions of wildness, captured *in situ*, and these existing WCs. This is an important finding, as it suggests that the current mapping successfully captures a representation of wildness that corresponds to average human perceptions of wildness in the population sampled. Furthermore, this result was found at all three sites, across the two countries, using two separate wildness maps developed using almost identical methods.

Bottom-up data were not limited to subjective qualitative data types, and the quantitative ecoacoustic approach found that the simple acoustic descriptors such as RMS, ACI and SC also correlated with a gradient of wildness as defined by the existing WCs, especially for study sites such as I&I, where weather and other ephemeral acoustic events played a less significant role (see Figure 6.4). Some of the AIs also correlated with the data coming from the participatory mapping approach. For two of the three study sites with human participants, RTI and BAI correlated with human perceptions of wildness and biodiversity, captured along the same mapped gradient of wildness.

Whilst there were strong correlations between AIs and WCs for some study sites, there was significant variation in the values for all AIs at all sites studied for a given WC (see Figure 6.3). Similarly, whilst there were strong correlations between mean perceived wildness and WCs at all study sites, there was also variation in participant scores at all stops (see Figures 5.1, 5.2 & 5.3), and between two of the exploratory stakeholder groups (see Figure 5.15). This suggests that both these methods measure variability in the surrounding landscape which current mapping methods do not.

Furthermore, while the random forest models found that AIs strongly predicted wildness class (see Section 6.6.4), the same models even more strongly predicted human perceptions of wildness and biodiversity (see Section 6.5). As discussed above, further work is needed to validate the use of acoustic methods for monitoring wildness in remote areas, but these results suggest that acoustic methods are sensitive to factors which influence human experiences of wildness, to which current mapping methods are insensitive. I have highlighted the limitations of the standard approach to mapping wildness with regard to capturing human experience of wildness since the beginning of the thesis (see Chapter 2). The combined results of the acoustic and participatory *in situ* visual methods tested in this project show definite potential to address this issue going forward.

Both of these methods (participatory mapping and ecoacoustics) speak to key aspects of our experience of wildness. People who have spent time in a wild space are struck by the experience in ways which are not driven by sensory input coming only from a single channel. As Nan Shepherd observes in her classic text on the wild spaces of the Cairngorms 'The Living Mountain', "Each of the senses is a way into what the mountain has to give" (Shepherd 1977:97). Cognitive cartography has been, since its origins, pre-occupied with models of visual processing when describing how we experience our surrounding landscape (Marr 1979; Pinker 2003). I have consistently highlighted the need to move beyond the current visual, single-sensory channel focus in existing cartographic representations of wildness. Even within the wider literature on perception, we underestimate the importance of hearing in knowledge acquisition (Cauvin et al. 2013). If we consider the mapping of wildness only through a human perceptual lens, of which vision may be the most important (Adrienko 2006), our mental representations of environments require varied information beyond a single sensory channel (Taylor et al. 2018).

It has been suggested that it is not meaningful to discuss the idea of either sound or vision as distinct, because the two sensory modalities are so closely entwined (Ingold 2011:138). Yet, when questioned, participants at the French study site in Lesponne regularly rated sound as an important part of their experience of wildness whilst completing the participatory mapping task (see Figure 6.1). During this task, several participants also made comments in their notes about the impact of the smell of cars and fumes on their experience, and took this as a reminder that they were returning to less wild areas. Many participants wrote down comments during the participatory mapping task highlighting that non-visual sensory data were important to why they gave the score they did for perceived wildness. The majority of these were focused on aspects of the soundscape. These comments regularly noted anthrophony, such as the 'noisy road' or the fact that they could 'still hear the cars' as impacting negatively on their experience of wildness. Biophonic components of the soundscape such as birdsong also regularly emerged as one of these important attributes, with comments such as 'Birdsong :-) cars :-(', 'natural sounds of birds stronger', or 'Nice and quiet birdsong but I can still hear the plane'. Comments such as 'I love the sound of the stream' suggest that geophony is also a key aspect of participants' experience of wildness (RQ5).

The developing field of biosemiotics provides insights into the importance of sound to non-human and human perceptual experience of landscape (Farina 2019; Pieretti 2014). Animal species generate mental maps as they explore their acoustic habitat, and this process is based on the sum of their ‘near field’ experiences of the acoustic events in their surroundings. These ‘near field’ ecoacoustic events (measured using the acoustic index ACI) together constitute ‘sonotopes’, the detailed patch-level local variation in the acoustic perceptual experience of the animal species moving through the landscape (see Figure 7.2).

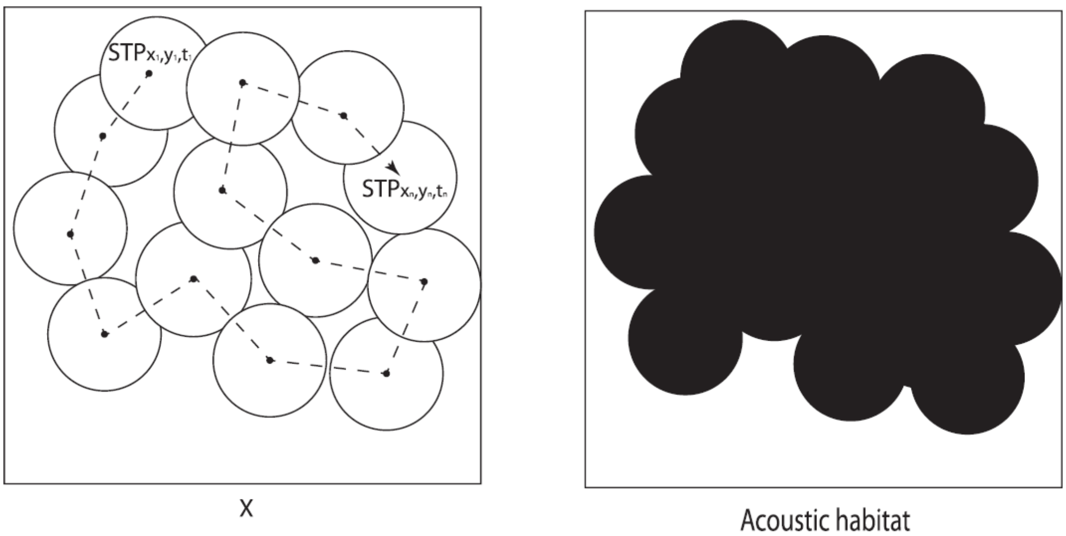

Figure 7.2: Sonotopes combine as animals move through the landscape to make a soundscape. Reproduced from Farina 2019:7.

These sonotopes, which may include occurrences of biophonies, geophonies and anthrophonies, combine together to form the soundscape. The bottom-up ‘near field’ ecoacoustic approach I have used in the current study captures a level of detail which is beyond the capacity of remote sensing. The aforementioned comments from participants in this study, labelling acoustic attributes of landscape, also identify highly localised acoustic events of relevance to the human experience of wildness. I highlighted above that the current study found that along a gradient of Jenks wildness classes, human-perceived wildness was more strongly predicted by AIs than mapped wildness for the same transect (see Section 6.5). I would suggest that the bottom-up ecoacoustic and participatory mapping approaches are sensitive to both audio and visual ‘near field’ attributes of wildness in the landscape that are not currently captured by existing remote-sensing approaches to mapping wildness.

How could this information be integrated with existing wildness mapping methods to improve their near-field resolution? Ecoacoustics is claimed to be a tool for rapid biodiversity assessment that is scalable and low-cost (Eldridge et al. 2018). Large-scale deployment is proposed for areas such as the Amazon rainforest where it could be used to monitor levels of biophony (avian and insect biodiversity) and anthrophony (chainsaw noise from logging). Such an approach cannot replace the spatial data coverage offered by the new generation of satellite systems such as Copernicus, but it can serve as a mechanism to test the way these data are interpreted (ZSL 2016). Similarly, participatory mapping could be scaled up beyond the methods trialled in this study, but cannot provide the complete data coverage that is required to support decision-making at the national scale (Brown et al. 2018). However, both of these methods have their place within test zones for measuring those attributes that cannot be captured from space, such as biodiversity and, ultimately, naturalness, as well as those attributes of the human experience that are not measurable using reflected light.

In practical terms, the multi-criteria models (MCE) used in current wildness mapping methods can be adapted to incorporate multiple data types. The results for the ecoacoustic and participatory methods used in the current study are spatially referenced and, as such, can be stored in a spatial database inside a Geographic Information System (GIS), along with other layers such as landcover. As discussed earlier (see Section 2.3.3), under the standard mapping approach individual habitat types within land cover data, such as different forest cover types, are given a wildness quality 'weighting' in the MCE. This weighting value for a given category is usually derived exclusively from expert opinion, but data from ecoacoustic and participatory methods could also be used to adjust these weightings. This would allow incorporation of 'near field' levels of resolution into national-scale mapping initiatives. It would also capture knowledge about local variability in wild landscapes that even experts may not have access to. Furthermore, the data captured by these methods are spatially explicit, removing the uncertainty in the weighting process that comes from using *ex situ* methods, such as public perception surveys (Habron 1998; Market Research Partners 2008).

7.4 Transdisciplinary methodological challenges

The main transdisciplinary challenge was a simple practical one: how to pilot the different methods with a whole group in a remote location on a single day? The participatory mapping was the most demanding task as it took at least five to six hours to walk a group from a low wild area to a high wild area and back again. The Q-Method task took at least 1½ hours to complete, even without the classic one-to-one post-sort interview. The questionnaire was intended to replace the post-sort interview, and included a section for participants to explain why they sorted the image statements the way they did. The participatory mapping task also required participants to make notes on why they had given a particular score, again replacing a more detailed one-to-one discussion.

The use of the Jenks wildness classes to structure the walking transect, and the use of the image statements, were designed to link the two activities via a shared spatial component. Within the individual methodological approaches tested, this worked well overall, producing interesting results, especially as a ground-truthing approach to the existing Jenks wildness classes (WCs). The results of the Q-Method in both countries suggested a significant correlation between the mean Q-Sorts for each country and the underlying Jenks wildness classes (WCs). Within this data I also found high levels of agreement amongst participants in the way they sorted the image statements into a continuum of wildness, with only two factors explaining almost all of the variance. Given that the results of the participatory mapping task also correlate strongly with the WCs, the way the image statements were sorted is likely to also correlate with perceived wildness for the same study site.

Yet I found that using the results of one method to explore the results of the other was challenging. The main issue was with the use of comments and keywords to interpret the factors and the perception scores. Many participants completed these, but many did not. For the Q-Method task this was often because some participants took much longer to complete the task, and were conscious that others were waiting for them so they could leave for the participatory mapping task. The lack of comments for the participatory mapping task was linked to a number of factors including fatigue, the weather, and even shyness in expressing their inner thoughts, with many participants confiding to me that they did not feel their opinion was sophisticated enough to warrant writing it down. Of those that did complete the mapping comments, the range of features noticed in the landscape was quite diverse, and so analysis of what drove people to score high or low in terms of perceived wildness for a given stop on the transect was difficult.

Interpretation of the factors in the Q-Method was also challenging, and heavily dependent on the other questionnaire results such as the Likert scores for the importance of key attributes of wildness. Participants found these much more straightforward and therefore quicker to complete than describing in a few words why they sorted the image statements the way they did. The question set on key attributes of wildness was identical to the criteria used by Scottish Natural Heritage (SNH) for the original wildness quality mapping project. Factor interpretation based on the results from this task was therefore very informative, highlighting differences between factors for attributes such as naturalness.

The participatory mapping task also asked participants to score the perceived naturalness of the surrounding landscape. SNH have published a spatial data layer on perceived naturalness which was one of the four component layers of the map of wildness quality (see Figure.2.1). Yet neither the Q-Sort image statements nor the participatory mapping task were analysed with regard to the existing spatial data on naturalness. Given the importance of naturalness in the results from this project, this would be an obvious future iteration for both methods. It would also allow a richer analysis of the links between results from both approaches beyond the use of the simple Jenks wildness classes.

One other approach to more closely integrate these two methods would be to separate the Q-Method task out onto a separate day to allow for proper interviews, opening up the possibility of more detailed and nuanced factor interpretation. Analysing the participatory mapping scores based on a more detailed understanding of the factor groups should in theory improve understanding of why these scores were given. Nevertheless, specific points of view, typical of a given factor, will always be difficult to link to the spatially explicit perceptions of wildness for a given individual, and will always require an intermediate step, thereby introducing uncertainty. In addition, the fact that Q-Method only identified at most two factors amongst the participants suggests that this overall approach of linking Q-Method with participatory mapping is in of itself limiting.

Another limitation of the Q-Method within the overall methodological framework is that it is desk-based. Q-Sort image statements are a single photographic perspective on the landscape in question. Every attempt was made to link the Q-Sorts to the other methods, and these images were carefully selected to ensure they were representative both of key attributes of the Jenks class in question, and the range of landscapes in the relevant country. However, a single two-dimensional image cannot capture a range of viewpoints nor 'near field' detail available to an individual assessing the landscape *in situ*. Future iterations of the participatory mapping method could instead use a more extensive qualitative method to capture the key attributes of the surrounding landscape considered by individuals, when giving their scores for perceived wildness. Doing this *in situ*, as an integrated part of the mapping process, would provide rich spatially explicit information that would improve the way MCE models represent wildness.

I conducted both the ecoacoustic methods and the participatory mapping *in situ* along the same transects. This integrated approach represents one of the first systematic attempts to include sound in the representation of wildness. The results reported already show interesting results of value to improving methods for measuring wildness. However, directly linking objective measures of sound, made using acoustic indices such as the relative technophony index (RTI), with meaningful human subjective correlates of those indices within the soundscape, such as silence, is not possible given the current methodological design. In simple terms, I would hypothesise that an experience of wildness would necessarily require very low if not non-existent levels of anthrophony as measured by RTI. An absence of mechanical noise is a core component in the experience of wildness, and silence, or extreme quiet, is considered to enhance a feeling of remoteness (Pheasant et al. 2010). A necessary future research direction would be to simultaneously measure the objective (AIs) and the subjective (human experience) *in situ*. This would provide a robust methodological point of departure for analysing the relationship between what AIs are measuring, what humans are hearing, and what these sounds mean to them in relation to their experience of wildness.

7.5 Recommendations for meeting transdisciplinary challenges

I have suggested that one way to address the limitations of the existing methods is to measure more qualitative data *in situ*, at the same time as the perceptions of wildness, establishing a stronger causal relationship between the two types of data (see Section 7.4). In order to address this point, and the challenge of assessing landscape naturalness using ecoacoustics (see Section 6.6.5), I adapted the methods used in this project, in collaboration with other researchers, as part of my ENHANCE doctoral fellowship placement at the Royal Technical Institute (KTH) Stockholm. We piloted these methodological developments in Abisko National Park in the Swedish Arctic in 2018, using additional funding from the International Network for Terrestrial Research and Monitoring in the Arctic (INTERACT).

This iteration of the main PhD project used an identical transect design along a gradient of wildness, but added several methodological improvements. Firstly, we left sound recorders *in situ* for longer (ten days, 100m from the transect), and they were also set to record while participants passed along the transect. Secondly, participants completed the landscape assessment task on perceived wildness (visual and audio) in silence for a period of one minute during which an additional 'near field' audio recording was made. Thirdly, participant interviews on why and how they scored perceived wildness were conducted immediately after they gave their scores, in the field. These were subsequently transcribed for analysis using a grounded theory approach (Glaser 2017). Finally, a complete habitat survey was conducted for the $100m^2$ area where the landscape assessment task was conducted.

Whilst these data are still being analysed, I anticipate that this will allow a more complete picture of how objective data on landscape intactness and AIs links to human-perceived visual attributes and ecoacoustic events in wild spaces. The methods used in this pilot project are being written up for an upcoming book on sonic methods (Eldridge et al. 2019). As an evolution of the methods tested in this PhD project, we designed this pilot project to deepen our understanding of wild spaces and species by adding other lateral data types, using additional disciplinary approaches, integrated vertically, as outlined above (see Section 7.2). This conceptual schema was built on the transdisciplinary approach which I trialled in the main PhD project, and was further inspired by a project on urban community mapping (Warner 2015). As a multidisciplinary team, we envisioned using these iterations of the methods to add additional data layers, further developing the current framework into a composite map that integrates five distinct layers of information (see Figure 7.3).

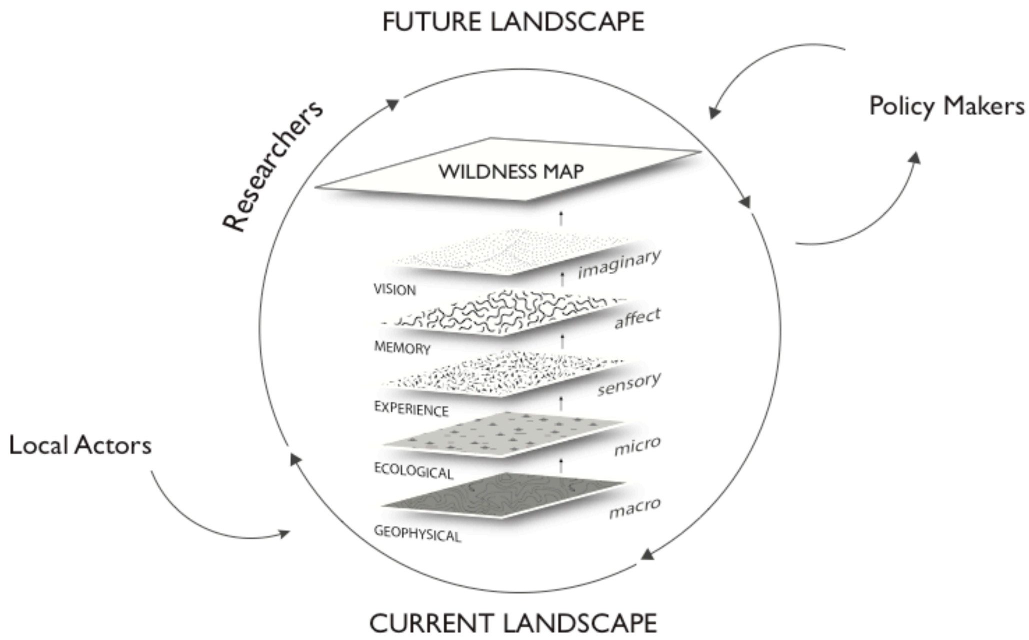

Figure 7.3: Conceptual framework detailing multiple data types considered in the iteration of the transdisciplinary methods for inclusive wildness mapping piloted in Abisko in the Swedish Arctic.

The geophysical base-layer is constructed from objective, remotely-sensed, publicly accessible satellite data that describe the macroscopic structures of the environment: the topology, broad vegetation cover, roads, and other structures in the built environment. Overlaid directly on this are local ecological details: the species data of the habitat assessments and biodiversity proxies derived from the ecological acoustic surveys. In this pilot study, we only surveyed five single points. Larger spatial replicates would be needed to account for spatial variation and to provide links between the local 'near field' micro detail and macro satellite data.

The remaining three layers represent the human perspective. The third layer represents the immediate multi-sensory experiences of people in the landscape, accessed through structured interviews carried out along the transect – what they see and hear (or smell) *in situ*. These data are similar to, but more comprehensive and detailed, than the data collected in the participatory mapping task (see Chapter 5). For example, when asked about her sensory perception at the first waypoint, one woman was particularly attentive to olfactory senses:

"… and also smell. It's so … well, now it's been raining so it's a very rainy smell but it's still a very nature-y smell, you can't feel any pollution or fumes. It's very airy, it's very clean."

Another woman at waypoint two commented:

"The river we can still hear quite loudly, which I thought was cars earlier. We've just passed that little trickle stream but I think that those sounds being so loud reminds you that it's really quiet here … there's no tractors, there's no strimming, [weeding], there's no drones, there's no people talking. We're getting these occasional helicopters and things … Maybe the roar of the river covers any other traffic residue that we might have from the road."

While these layers reflect fairly straightforward, perceptible phenomena, the fourth and fifth layers are more complex, speaking not just to human perception but also to human feeling and imagination. The fourth layer reflects participants' affective responses to the landscape: their current thoughts, feelings and emotions in relation to their memories of it. Finally, the fifth layer represents visions of the landscape for the future – hopes and fears for what may or may not come.

Any of these final three human-focused layers may be queried for references to the first two layers, by examining, for example, how human sensory impressions of the landscape are linked to the absence or presence of sounds of traffic, flora or fauna. As noted by Warner (2015), the final two layers, memory and vision, are the most challenging to analyse and represent, as they are by far the most subjective and most variable.

For this follow-on pilot study we deliberately recruited urban planners as a participant group. This was done with the explicit goal of both trialling the methods and assessing whether the approach captured sufficient information of clear relevance to support their decision-making. How these integrated and participatory mapping techniques could support more inclusive and sustainable approaches to the conservation of wild spaces and species was a key research aim of this project. The potential relevance of the results and the overall methodological approach to support decision-making are discussed in Chapter 8.

Chapter 8 – Discussion: Supporting decision-making on the conservation of wild spaces and wild species

8.1 Summary

In this PhD project I have proposed and tested methodological improvements to the way we measure wildness. A key wider research objective was to consider how these new integrated approaches could be used to support improved decision-making on the conservation of wild spaces and wild species. In this chapter I set out the conceptual model discussed in the previous chapter, and the methods which drive it, in the context of conservation (see Section 8.3). I discuss how the results are of relevance to the challenges inherent in the conservation of wild spaces and wild species, and how these methods could be used to support improved decision-making going forward (see Section 8.4). I review the before-and-after walking results, and discuss the specific relevance of immersion of this type to shifting baseline syndrome (see Section 8.5). I discuss challenges and limitations in the current transdisciplinary approach (see Section 8.6), and describe an early attempt I made to address these challenges in the Scottish Highlands (see Section 8.7).

8.2 Introduction

The resolution of the conflicting needs of human stakeholders and ecological imperatives poses a significant challenge globally (Vuceticha et al. 2018; Redpath et al. 2013). Policy and planning for wild spaces, like all conservation decision-making, must be evidence-based (McIntosh et al. 2018; Adams & Sandbrook 2013; Sutherland et al. 2004). The conservation of wild spaces and species is a complex, ‘wicked’ problem (Elia & Margherita 2018; Rittel & Webber 1973; Game et al. 2014) which cannot be solved within a single discipline. However, we currently lack the means to build evidence in a way that takes into account the needs of the multiple ecological processes, human and non-human beings living, working, playing, and otherwise becoming in wild spaces (Haraway 2008). The need for robust, transdisciplinary, integrated methods to support decisions on the conservation of wild spaces made in respect of national-level planning frameworks is growing.

In Scotland, national-level planning legislation considers wild land to be a nationally important asset, and this legislation is now being revised (Scottish

Government 2014). One key challenge will be how to reconcile competing land uses, such as wild land protection for conservation and renewable energy development, in these same landscapes (S. Brooks, personal communication, August 21, 2019).

IUCN France intends for their national-level wildness mapping to be implemented in the same way as in Scotland (T. Lefebvre, personal communication, June 22, 2017). The French president recently stated that he wanted to see an increase in the number of areas in France that are in a state of high naturalness (Macron 2019). In Iceland, the national government and NGOs are exploring the use of wildness mapping to protect their wild spaces from the impacts of tourism (S. Carver, personal communication, July 15, 2019). As already discussed in Chapter 2 (see Section 2.4) plans are underway in Germany to use a community-based approach for the identification and restoration of optimum areas for wildness.

Land abandonment in rural areas has also risen up the conservation agenda, and research suggests that when viewed as rewilding this may have a significant impact on the amount of wild land within Europe (Navarro & Pereira 2015; Corlett 2016). This trend is likely to become more pressing if the UK leaves Europe under Brexit, resulting in a predicted change in the existing system of farming subsidies with a significant potential impact on upland farming practices (Helm 2017; Wheeler 2018).

Even in mainland Europe, proposed reform of the Common Agricultural Policy (CAP), is likely to impact on upland hill farming, leading to a reduction in grazing pressure activity in these marginal areas, and an increase in the number and size of areas that are rewilding (Merckx & Pereira 2015; Pettorelli et al 2018). Accurate and inclusive mapping and monitoring of this process in support of the delivery of EU funding mechanisms, especially in large agricultural countries such as France, is likely to become a key function for mapping of this kind going forward. This could take a similar form to the way spatial data on ecosystem services have been used to support EU policy making (Maes et al. 2014; Norton et al. 2018). As the head of the United Nations Environmental Cooperation for Peace-building programme recently said, ".. you can't manage something if you cannot measure it' (Thompson 2019).

The results of this PhD project suggest that the methodological framework I have tested shows potential as a means to incorporate knowledge and data from multiple disciplines. Within the context of conservation, this can operate in three key ways: firstly, via ground-truthing as a way of testing whether current mapping techniques create an accurate representation of the theme at hand; secondly, as a way of adding additional place-based knowledge and data which are not accessible via any other means; and thirdly, by bringing together diverse actors in the place, greater understanding of different points of view can reduce the conflict surrounding these issues. Overall, I argue that this could increase the value of national-scale wildness mapping as a tool to support landscape planning, by both increasing its accuracy and doing so in an inclusive way which would reduce maps' contested status.

8.3 The importance of this integrated approach to support the conservation of wild spaces and species

Understanding the value and meaning that wild spaces have for particular human communities requires situated qualitative and quantitative knowledge. Mobile or participatory research methods have gained popularity in recent years in the social and environmental sciences because they address this knowledge gap, providing a means for incorporating the experiences, attitudes, and even ecological knowledges of local community members through research co-design (Probst et al. 2003; Calheiros et al. 2000).

However, the majority of participatory methods are deliberately unstructured. Researchers 'go along' with informants, allowing them to choose the path and the themes that emerge for discussion (Block 2005; Carpiano 2009; Myers 2011; Colley et al. 2016). This produces a wealth of insights and allows access to knowledge that a researcher may not even know is important to the theme at hand. But interpreting the knowledge gained via these unstructured approaches is challenging, and they are by definition difficult to integrate with other types of knowledge. This limits their usefulness in planning and conservation decision-making, which often requires standardised spatial data with homogenous coverage at the national scale.

Structured approaches to walking interview methods address this challenge, but have focused primarily on urban spaces (Middleton 2018; Pierce & Lawhon 2015). In this project I have responded to these limitations, testing a structured participatory mapping approach along a gradient of low to high wildness. At its simplest level, this has supported decision-making by ground-truthing the existing wildness mapping. Ground-truthing data of this kind are recognised as fundamental in many areas of environmental research, especially for remotely sensed data of multiple types (Nagai et al. 2017; Muller & Svenning 2015). This kind of information is also of practical interest to decision-makers. Landscape planners are regularly challenged when implementing decisions based on spatial mapping tools, which are often perceived by local communities as expert-defined and imposed from on high (S. Brooks, personal communication, August 21, 2019).

The results of the participatory mapping methods have highlighted the strengths of the existing mapping, as well as identifying areas where they can be improved and supplemented with other sources of data. *In situ* data of this type are far more difficult and time-consuming to collect, and brings with it numerous challenges such as weather and health and safety, in return for far lower numbers of participants relative to the effort expended. Nevertheless, it fundamentally addresses the disconnect between *ex situ* public participation surveys and the experience of wildness they aim to represent (Habron 1998; Market Research Partners 2008). These large-scale public perception surveys also struggle to capture local knowledge as well as near-field variability in human experience of wild spaces.

There have been attempts to address these limitations. As discussed earlier, detailed mapping of the wildness attributes of all 42 wild land areas in Scotland was recently undertaken (see Section 5.5.1). Capturing this level of detail is hugely valuable in advancing our understanding of wild spaces and our human experience of them. However, the wider value of this in terms of increasing public acceptability for the wild land areas is limited by the fact that the surveying of each area was conducted by a single individual.

In this project I have attempted to improve upon these existing bottom-up approaches, using structured, situated public involvement to map individual differences in wildness perception. In Scotland the research was conducted within wild land areas, and participants included members of the team that made the original wildness map of Scotland (see Section 5.5.1). The results showed that even within a wild land area there is a gradient of wildness present, and that this is detectable by expert and non-expert participants alike. Capturing this local variability in wildness helps to move the debates on wild spaces beyond the binary approach imposed by the presence of a simple line on a map (Gibbs et al. 2007; C. Harry, personal communication, October 2, 2017). The integrated approach to wildness mapping I propose in this PhD project has clear limitations, and I have proposed methodological improvements to improve, for example, our understanding of why these scores are given (see Section 7.3).

A key additional advantage of this participatory approach going forward is that it is compatible with other types of spatial knowledge and data, such as the biological and ecological aspects of wildness captured by ecoacoustics. Spatially explicit data from these approaches can be combined with spatial layers on species and habitat data of the type currently used by planners as part of environmental impact assessments (EIAs). Indeed one potential application for these methods to support conservation decision-making is to integrate participatory mapping into the existing environmental impact assessment (EIA) process.

In Scotland, for example, EIA currently uses expert evaluation of the potential impacts of a proposed development on habitat, water quality and wildness quality. Under the current system, SNH, the Scottish Environment Protection Agency (SEPA), Scottish Water and the Highland Council make visits to the proposed development site, reviewing each application case by case. A final decision is then made by the Scottish Government. But these decisions have regularly been contested, especially where the proposed development takes place in wild land areas (Monadhliath 2018). The resulting tribunals are expensive, and might in some cases be avoided if a broader group of those with a stake in the issue at hand were included. This could be done by participatory mapping of a transect into the proposed development area as part of the EIA, and a decision reached by combining spatially explicit data from a range of objective and subjective sources. This type of implementation addresses one of the key challenges to participatory mapping: how the knowledge can be applied and adopted within the planning process (Brown et al. 2018).

One of the main criticisms of renewable energy projects approved for development in wild land areas is that developers do not deliver on the mitigation measures promised to reduce negative impacts on the wildness quality of the site (M. Gibson, personal communication, August 8, 2017). In the event that an application was approved, this same process could be repeated during and following the construction phase. This would ensure both that developers fulfilled their stated obligations in line with the project, as well as ensuring that a more detailed and subtle understanding was developed of how renewable energy projects of this kind impact on wild spaces over time.

In France, spatial data layers on ecological connectivity have already been integrated in the local planning system (PLU) to supplement existing use of point-specific species presence data. Together these are used to evaluate whether a planning proposal, such as a development at a ski resort, is allowed to go ahead. There is significantly wider interest at the national level in France of the social, economic and environmental importance of wildness, and the French Committee of the IUCN have set up a working group to study how this could be protected within national planning frameworks. In collaboration with this group I am already exploring how the spatial data on wildness in France could also become part of the French PLU process. As part of this process we have organised a special session at the IUCN

World Congress next year in conjunction with WWF France and the French national mapping and forestry agency (IGN).

8.4 Participatory mapping as co-development to support sustainable decision making

I have argued that involving a more representative group of those with a ‘stake’ in the question at hand is a key advantage of using participatory mapping to improve the way we measure wildness. The literature on stakeholder participation suggests that wider involvement in decision-making on environmental planning, of the kind that is typified by participatory mapping, leads to community members having a stake in the long-term success of a project, ultimately increasing its chances of success (Reed 2008).

As discussed, wider implementation of the participatory mapping approach tested here would need to give much greater theoretical consideration to the design of the engagement process to ensure that a broader group of stakeholders was involved (Reed et al. 2018). Whilst public participation is a necessary component of conservation planning for wild spaces, the final decisions are often made in centres of power far from these spaces, and outside the local community’s borders. The Scottish Government’s National Planning Framework (NPF) recognises wild land as a nationally important asset (Scottish Government 2014). This type of framework is defined at the national level, yet the decisions made to meet these national objectives are ultimately implemented at the local level. This can be problematic, especially when the policies outlined in a strategy like the NPF also include objectives linked to developing renewable energy capacity and improving the economic status of rural areas. The economic needs of a local community may not be compatible with the national need to protect wild land as an important asset. This is especially true in remote communities, which are often to be found on the edge of nationally important wild land areas, but where local jobs and economic development opportunities are limited. This can lead to long and protracted disagreement over planning decisions.

In one recent example in Scotland, the Monadhliaths windfarm proposal, the national agency charged with managing the natural assets of Scotland, Scottish Natural Heritage, opposed the renewable energy project on the grounds that it would have a significant negative impact on the “landscape qualities of an identified core wild land area”. Their recommendation was overruled by the Scottish Government’s

Energy Minister, who placed priority on the economic development and renewable energy benefits of the windfarm case, and the boundaries of the wild land area that was impacted by the wind farm development were then moved to allow the development to go ahead (Munro 2015). Decisions of this kind are always complex and contentious, but in this particular instance the decision of the Energy Minister was initially overturned by a judge in the Court of Appeals, who ruled that the decision was not legal as there had been no public enquiry. Walking methods explore the interlinking of people with place, and aim to capture the breadth of these relations in a given community. It could be argued that complex planning decisions, of the kind typified by the Monadhliath case, might be simplified by involving local communities from the beginning in the co-production of the tools used to support those decisions.

In order to address 'wicked' problems of this kind, the success of stakeholder participation is contingent on involving as wide a range of participants as possible. While I have noted the challenges of recruiting a representative sample (see Section 4.5.1), I had anticipated much greater divergence in opinions and perceptions in the results, given the debates which rage around issues to do with wild spaces and species in both of the countries studied, and within Europe more widely (Carver 2019; Sandom & Wynne-Jones 2019). The results of this study, using multiple methods from a range of disciplines, suggest that amongst the participants there was overall far more agreement on what constitutes wildness than there is disagreement.

Several possible explanations exist for this divergence from my expectation: firstly, that the purposive sample of participants is not representative of the range of views on the issue at hand. However, I have noted significant differences between certain groups among the participants, as well as a balance of local and non-local participants. One other possible interpretation is that the agreement found in this study is in fact a reflection of high levels of agreement in the outside world. As is common in debates on nature conservation, the presentation of the debate in the media may in fact be artificially polarised (Nilsen et al. 2007). It has also been suggested that the motivation of some individuals who contest the conservation of wild spaces and species is driven not by fundamental disagreement over what 'wildness' consists of, but rather because its protection is seen by wealthy landowners as a barrier to personal financial gain (Monbiot 2013; Fisher 2019). Outside of the politics of the conservation of wildness, academic research on terms such as 'wildness' and 'rewilding', whilst obviously methodologically robust within a given discipline, may under the scholarly lens construct a social reality where there is greater divergence in opinions on wildness than is found in the daily life of the public (Law 2004).

I argue that situating the research in a particular place is one way of overcoming the influence of these polarising forces, especially when dealing with contested themes such as ‘wildness’. My practical experience testing the methods used in this pilot study suggested that the place-based approach created room for expression, even where participants had strongly opposing views. Participants, when reaching an impasse, would literally make space for each other, walking a little slower or faster. The ability to create space in this way is difficult in traditional community venues such as town halls, where the usual suspects take over the debate (Colvin et al. 2016).

On a practical level, I also observed that there is less scope for arguments that stem from misunderstandings of language and lexicon when the discussion occurs in the place being investigated. Whilst walking a path in a landscape, participants can literally point to the object under discussion, a useful way to clarify a point and avoid confusion, a necessary first step towards common understanding on contentious issues.

As a simple example, for the early stops in the participatory mapping task, many participants had differing points of view on whether the path we followed had an impact on how wild a place was. Some participants thought that as an obvious sign of human influence, it had a strong impact, and they adjusted their scores accordingly. Others disagreed, seeming almost oblivious to the presence of a path, let alone whether it had been constructed. Awareness of paths as built artefacts was definitely higher amongst those that worked outdoors, or in conservation and planning. Over the course of the day, as we moved along different types of paths, awareness of paths grew. Participants became aware of different types of path and often pointed out the signs of human management, such as measures to improve drainage. This awareness was heightened by key transition points, such as when we left the path at the study site in Beinn Eighe, and moved along the faint paths made by the movement of deer. At the end of the day it was clear that this sharing of space, *in situ,* and the discussions it provoked, resulted in less divergence in opinions between participants. As such, participatory mapping as a data collection method presents an opportunity for conversation and discovery. In this sense, the process of participatory mapping also provides an interface between landscape, policymakers and local actors. The act of taking part, of making space to listen to and reflect upon the landscape together, modifies the ways in which stakeholders (and policymakers) perceive and ultimately value wild spaces.

8.5 The potential of immersion to address key linked themes to the problems discussed above

I propose that shifting baseline syndrome poses two significant challenges to the success of conservation of wild spaces and wild species going forward. Firstly, via the process of 'generational amnesia', participants in conservation projects which explore possible future conservation scenarios may not consider habitats and species for which local memory has been lost, or indeed they will mistakenly focus on preserving 'natural' habitats which are in fact highly modified (Godet & Thomas 2013). Secondly, this process will then actively serve to reinforce this loss of knowledge, establishing reference baselines for monitoring conservation progress relative to the current 'normal' condition of the local environment, which exclude these forgotten native habitats and species (see Figure 2.5). Simply giving people information on historical landscape change may not be sufficient to change their attitudes on wild spaces, or to create empathy for wild species (Ahn et al. 2016). I argue that immersion in a wild space, via the process of participatory mapping, in combination with historical knowledge on landscape change, might offset generational amnesia. Understanding the potential and impact of immersing people in the landscape as part of participatory mapping is therefore of significant interest in conservation, especially with regard to contested themes such as the conservation of wild spaces and species (Schnitzler et al. 2008; Watson 2014; Carver & Fritz 2016).

The results of this study have shown that direct experience of being in a wild space for a day had a strong impact on perceived wildness for the majority of paired walking stops that were visited on the way out and the way back (see Table 5.1). More widely, the before-and-after questionnaire results show a similar effect: that after immersion in a wild space, people see the conservation of wild spaces as more important, and are more strongly of the opinion that there are not sufficient wild spaces, with more agreement (similar scores) amongst participants (see Figure 5.8).

In this sense, immersion could be argued to take participants back in time, restoring lost knowledge and resetting the wildness clock in a process that is analogous to the 'space for time substitution' studies used in ecology (Pickett 1989). These results for attitudes to wild spaces and species are in line with the wider literature, showing that immersion in nature increases environmental awareness and the value that people place on it, which may in turn increase their desire to protect it (Palmberg & Kuru 2000; Rosa et al. 2018). In this way, participatory mapping not only captures finely-grained local knowledge and perceptions, but immersing participants in a gradient of wildness empowers residents to envision future conservation scenarios based on more complete and even intimate knowledge of the landscapes in question (Pain 2004).

8.6 The challenges and limitations of the method to improve decision-making

In spite of the significant effort I invested to include all groups with a stake in the issues at hand, participants in this pilot study were to some degree self-selecting. This kind of study has three major challenges for recruiting participants: firstly, by necessity the research takes place in remote locations, making it time-consuming for people to reach the area; secondly, walking a gradient of wildness also takes time, requiring participants to give a whole day of their time; and thirdly, walking, especially uphill, limits the ability of certain groups to participate.

I made efforts to reach potential participants through local published print media, via working closely with gatekeepers within national organisations (Scottish Government, RSPB, National Trust for Scotland, SNH, Mountain Leader Training, Centre for Ecology and Hydrology, Ligue pour la Protection des Oiseaux), by visiting local organisations (outdoor centres, church and community centres, the Cairngorm National Park, the Wester Ross Biosphere, Nature Occitanie, the Pyrenees National Park), as well as by promoting the research using social media. A good balance of local and non-local people participated in the project. These included, as noted, one person with a visual disability and several people who had never been walking in the hills. As well as diverse members of the general public, the group also included people with expertise in mountains (conservation professionals, mountain guides).

Despite significant efforts, the hardest group to recruit was undoubtably the landowners/managers group. In Scotland this was in part due to the fact that the theme under discussion was considered to be too contentious, but also because this group often had significant constraints on their ability to sacrifice a whole day. The very different structure of land ownership in France meant that this group were not represented at all at the LES site, where land in the mountains is owned and managed primarily by local communes. Local sheep farmers and members of the hunting community were approached to participate, but declined, again on the grounds of the contentious nature of the themes at hand, as well as the time-intensive nature of the study. Including members from these groups is of course necessary for any attempt to inclusively map the perceptions of those with a stake in the debate on wild spaces and species. At the BEN study site where members of this group did participate, they had a significantly different perception of wildness than that of the environmental sector (see Figure 5.15).

The follow-on pilot project, trialled in Abisko National Park in the Swedish Arctic, faced similar challenges with regards to recruiting the local Sami reindeer herders, who were also too busy to participate in the study. One key improvement that we trialled in the follow-on project in the Swedish Arctic was to involve urban planners earlier on, during the design phase of the research project. Four members of the urban planning team in the local mining town of Kiruna completed the participatory mapping task, and an unstructured interview was conducted to understand the challenges and needs facing them in their day-to-day work. Following the mapping task, themes emerging from this discussion were addressed in light of their experience of completing the research. As a research team, we then explored how the methods might be adapted to better capture knowledge of relevance to the needs of this planning group.

8.7 Testing solutions to the challenges of participation at Inverewe Estate in north-west Scotland.

I tested a co-design approach to methodological development, along with possible solutions to the challenges of more representative participation, in an ENHANCE outreach project at the National Trust for Scotland, Inverewe Estate in February 2017. This also gave me the chance to work directly with an underrepresented group in this project: those who own and manage land. During a two-week artistic and scientific ‘residency’, a similar but shorter walking transect along a gradient of wildness was identified within the boundaries of the Estate. I conducted the transect design and recruitment of participants in collaboration with local artist Lynn Bennett-MacKenzie, the estate manager Kevin Frediani, members of the local community, as well as a colleague on the ENHANCE project, Anna Antonova. Forty local residents, including a large number of local schoolchildren, as well as the estate manager and other National Trust staff, participated in the mapping exercise, and the results of this formed the basis of an exhibition on the Inverewe Estate in June 2018 (See Figure 8.1).

Figure 8.1: Inverewe Estate. Conceptual map of wildness capturing the wildness gradient walked and the attitudes of participants expressed whilst completing the participatory mapping task.

Whilst again this was an exploratory way to apply the lessons learned during the course of my PhD research, the approach used here undoubtably created a joint sense of ownership in the project, which was shared by the research team and the local residents. It also provided access to points of view in the local community that a visiting research team could not hope to access.

The potential impacts and relevance of this kind of participatory mapping and community outreach approach on decision-making in landscape management are perhaps difficult to quantify. It is however worth noting that in the months that followed this mapping exercise the decision was taken by the Inverewe Estate management to move ahead with a project to restore native woodland, in collaboration with a neighbouring estate. One of the target locations chosen for this project was the same stretch of path used for the participatory mapping. Whilst it is of course difficult to attribute causality in such cases, it is at least arguable, based on the main results of this PhD, that taking people along a gradient of wildness and asking them to think about the potential of the landscape may impact on how they see it going forward. The importance of this project to the NTS property manager were summed up as follows:

"For me, this is more than an exhibition. It is a fusion of art and science, into an exhibition that asks a big question: How can modern civilisation find a way to realise a truly sustainable land use to support people and be home for a diversity of wildlife that can live there. This work allows not only those professionally engaged in concepts of wilderness or controversial concepts of rewilding, but critically those who live in the local community and our (inter-) national visitors, to help inform future exploration of our landscape. Inverewe Estate is a developed land use that I believe is sustainable, representing both manmade and 'wilderness' environments, and being one of the world's top heritage gardens located between a Marine Protection Area and Biosphere Reserve. In this small, valuable corner of our planet, the findings from this research, including your participation and feedback, will undoubtedly have an impact on how we manage the Inverewe landscape. The language created by Jonathan and Anna through this work is now being used at Inverewe in discussions on the management of the property, and we have already started taking a less interventionist approach to some areas of the garden; encouraging a more natural habitat to be enjoyed by plants, wildlife, and our visitors."

Kevin Frediani, Property Manager, Inverewe Estate and Gardens

Chapter 9 – Conclusion

9.1 Overall findings

The need for integrated research, embedded in its environmental context, to support sustainable conservation solutions, remains pressing (Grabherr et al. 2005; Perring et al. 2015; Gellie et al. 2018). Yet the environmental challenges this research responds to are often 'wicked', evolving in response to our attempts to study them as well as the solutions implemented to address them (Law 2004; Mason et al. 2018). Measuring wildness to develop maps that can be used to support decision-making on the conservation of wild spaces and species is typical of such an environmental challenge. Transdisciplinary approaches are required to capture and integrate the multiple types of data and knowledge necessary to research these challenges (Stock & Burton 2011).

This PhD project has tested such an approach, exploring how multiple disciplinary methods can be used and then integrated to improve the way we measure wildness. I used a gradient of wildness to provide a unifying spatial framework within which to explore these diverse methods and to examine both the differences and the commonalities of views on the theme of wild spaces and species. I linked the methods in this way to provide a conceptual nexus around which the results of the methods could be integrated and analysed in relation to other forms of 'objective' knowledge which are typically mobilised in the representation of wildness, such as remote sensing. I consider this to be necessary if we hope to understand and compare diverse perceptions, attitudes and views on wildness, and to make that understanding relevant to decision-makers and applicable within broader scale landscape planning.

Three broad methodological approaches were tested in the project. Firstly, photo-based Q-Method was used to measure and analyse the diverse range of viewpoints that exist on wild spaces and species. The results showed that there was a high level of agreement amongst participants in the way they sorted the image statements into a gradient of least wild to most wild. This was true for participants in both countries studied. Interpreting the 'factor' groups in each country was challenging because of the similarity in participant responses, as well as the limited time available to query participants on their reasoning for a given Q-Sort. A hybrid approach to interpreting the factors using linked questionnaire data suggested that the groups were distinguished by their attitudes to attributes of wildness such as ruggedness and naturalness. The image statements I used in this task were spatially linked to a gradient of wildness derived from existing mapping. The average position for an image statement along the Q-Grid correlated strongly with this existing mapping in both countries. This existing mapping linked the *ex situ* Q-Method task with the other *in situ* methods, but significant methodological challenges exist in integrating this approach with the other approaches.

Secondly, a participatory mapping method was also tested to measure human perceptions of wildness *in situ*, again along a transect of wildness based on the existing mapping. The results of this approach, measuring human subjective perceptions, found overall that:

1) values for human-perceived wildness changed significantly along the transect at all three study sites;

2) human perception scores for wildness correlated strongly with existing mapped values for wildness at all sites;

3) significant differences in values for perceived wildness were found for the majority of stops that were visited twice, on the way out and on the way back from the walk;

4) values for perceived wildness most closely matched those for naturalness and biodiversity, although there were differences between countries;

5) looking at the impact of the walk on attitudes, there was a significant shift in overall participant responses to the question ”Are there sufficient wild spaces?” after the walk; there was also a significant shift in Scottish participants' attitudes to whether there are sufficient wild species after the walk;

6) there was variance in perceived wildness scores across all sites, with significant differences between values for the environmental sector and landowners/manages at site Beinn Eighe; and

7) attitudinal ambivalence results are similar for both countries, with more ambivalence in attitudes to wild species than wild spaces.

The participatory mapping was a mixed-methods approach which used a quantitative approach to measure numerical scores for perceived wildness as well as a qualitative approach to measure participant comments on their own scores. Whilst overall the results of the method are promising, I recommend expanding the qualitative dimension of the approach.

Thirdly and finally, a more quantitative ecoacoustic approach explored how measurements made using acoustic indices (AIs) varied along the same transects of wildness. The results demonstrated that a small suite of AIs strongly predict mapped values for wildness, and reveal considerable environmental variation within areas of equal wildness as designated under current metrics. The potential ecological relevance of this variation requires further investigation, which I argue is best addressed by adding full habitat and bird surveys to the data collection methods reported here, as well as detailed transcription of soundscape components from site recordings as was piloted in Abisko National Park.

I also found that AIs predict human perceptions of biodiversity and wildness more strongly than mapped wildness, suggesting that acoustic methods capture important facets of the human experience of wildness. I argue that, overall, ecoacoustics captures key attributes of wild spaces which are not currently measured. As such, I suggest that ecoacoustics should be incorporated into future wildness mapping and management, and suggest new research directions to develop and validate acoustic methods suited to the unique conditions of wild spaces, across a range of biomes.

The individual results from these three methods all show potential for ground-truthing the current wildness mapping approaches based on remotely-sensed data. This is of direct relevance to landscape planners who are currently tasked with making decisions based on the existing maps of wildness. I further argue that the results of the individual methods provide additional, spatially explicit information on multiple attributes of wildness which are not currently measured by the current mainstream approaches to measuring wildness. Integrating the results of these three approaches showed that there were also strong similarities in the results from the three different methods. In particular, the participatory mapping and ecoacoustic approaches show promise for measuring 'near field' variability in wildness that cannot currently be captured using top-down remote sensing or *ex situ* public consultation approaches.

I argue that in recognising the path as the nexus of atmospheric, biospheric and anthropogenic processes, spatially explicit mobile methods of this kind provide a framework within which to integrate ecological and anthropogenic perspectives on wildness, answering calls for new approaches to conceptualising and measuring wild spaces as the site of complex and dynamic human-environment relations (Leslie 2016; Hennig & Künzl 2016). Following Ingold's concept of wayfaring (Ingold 2000), I have explored methods to measure these attributes as they interact along the path, and highlighted that they have potential to capture exactly the 'near field' variability in landscape and our human experience of it.

Early attempts to map wildness relied exclusively on the composite indices of remote-sensed data, described above, to capture what is present or absent at any one point. These have in recent years been improved by including viewshed analyses which measure what could be 'seen' from any one point in the landscape. This improves the more objective measures of landscape attributes by creating a meaningful correlate in the human experience by capturing attributes of wildness such as the visual experience of solitude and lack of visible human infrastructure, which is important to human experiences of wildness. I argue that simultaneously measuring acoustic indices along the same transect as human auditory perceptions of wildness measured *in situ* offers potential to create an additional sensory layer to this approach, an acoustic equivalent to the viewshed. Whilst I note the limitations of the current methodological design to deliver this spatial layer, the overall approach has potential to measure the auditory experience of solitude, absence of human noise, and presence of natural sounds which are important to human experiences of wildness.

9.2 The importance of this research to conservation

This PhD project has repeatedly highlighted the importance of situating the research in the place and using a participatory approach. Improving the way wildness is measured and mapped using participatory methods has the potential to support more inclusive dialogue on the conservation of wild spaces and species. Developing these methods in two different countries, where the theme at hand is highly contentious, was considered essential to assessing their relevance within the wider international debates on sustainable solutions to the conservation of wild spaces and species.

A situated participatory approach also speaks to the need for research to produce knowledge that is representative of a diverse range of opinions, scientifically robust and inclusive. This is essential if research knowledge is to be relevant and of practical use to conservation planning. The research attempted therefore to engage as widely as possible, beyond the local environs of the study sites, to ensure that the methods produced work of relevance to the wider community of people who live and work in the mountains. In Scotland, participants included representatives from organisations such as Scottish Natural Heritage who are actively involved in decision-making on the conservation of wild land areas. Members of the Mountain Leader Training Board were also involved, and discussions are ongoing with them about how the transect approach could be incorporated into training for future mountain leaders to heighten their awareness of landscape.

The follow-on pilot project in the Swedish Arctic sought out the planning community to assess the relevance of the overall approach and the results to their daily work. Feedback on the methods used was sought directly from these groups before, during and after the actual fieldwork. All of the groups involved stated that mapping a broader range of attributes on wildness, and doing so in a participatory fashion, was of clear value to their work going forward. All of them were keen to maintain an ongoing dialogue with a view to sharing the final results and exploring the potential for further collaboration.

Beyond this local operational planning level, I have highlighted that the conservation of wild spaces is of increasing importance nationally. In Scotland a new National Planning Framework is in preparation, and making progress on objectives in relation to wild land will be a key area for discussion. In support of global climate change objectives, President Macron has recently set targets for wildness within France. The wildness map of France I have developed in recent weeks has been presented to the French Ministry of Environment to help them assess how the existing levels of wildness in France could be increased.

Beyond the two countries studied for this PhD project, Germany is also pursuing ambitious targets for the protection and restoration of wildness (see Section 2.4). Germany currently ranks first globally for the indicator ‘Biodiversity & Habitat’, according to the Environmental Performance Index, and has a strong and long-standing domestic environmental movement (Keleman & Knievel 2015; Hsu 2016). The track record of the German government as leaders on environment policy, combined with a population receptive to green ideas, suggests that this proposal for setting aside 2% of the country as wild spaces could produce positive results, which in the longer term may have a significant impact on the wider re-wilding movement in Europe.

9.3 Closing summary

I argue that the results from the PhD project have advanced the mapping of wildness in two key ways. Firstly, I have developed methods that more comprehensively map human perceptions of wildness, thereby addressing the key challenge of subjectivity. Secondly, I have improved mapping of the intrinsic attributes of wildness by addressing the overemphasis on the visual through testing of ecoacoustic indices in relation to wildness. Finally, these approaches were combined in a conceptual framework that allows us to situate this knowledge in the place and integrate it with other types of knowledge and data. This is important if we are to develop integrated representations of wildness to support more accurate decision-making. Doing this in an inclusive participatory way as part of the co-production of knowledge has been highlighted as of critical importance to the success of conservation projects which depend on maps of wildness to support decision-making.

I have made multiple recommendations for the development of the methods tested in this PhD project with the goal of developing a more complete transdisciplinary integrated approach to measuring wildness. These recommendations discuss how the existing methods could be improved to allow greater understanding of how the results of the different disciplinary approaches can be compared and integrated. I have also discussed how additional knowledge types, such as historical and cultural knowledge, could be integrated into the same conceptual approach centred around the transect. This proposed framework would allow us to access knowledge on human perceptions of landscape, cultural values, historical knowledge, as well as data on species' presence and absence, landscape condition, and the intactness of ecological processes. In the integration of these different types of knowledge and data, we might begin to stake a claim to producing a more complete representation of wildness which is also of practical value to the conservation of wild spaces and wild species.

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List of Abbreviations

ACI -- Acoustic Complexity Index

AE -- Alice Eldridge

AEI -- Acoustic Evenness Index

AI -- acoustic index

BAI -- Bioacoustic Index

BEN -- Beinn Eighe National Nature Reserve

CAP -- Common Agricultural Policy

CFA -- confirmatory factor analysis

CMS -- Centre for Mountain Studies

EC -- European Commission

EIA -- environmental impact assessment

ELC -- European Landscape Convention

ENHANCE -- Environmental Humanities for a Concerned Europe

EU -- European Union

GIS -- Geographical Information Systems

IGN -- Institut Géographique National (the French national mapping and forestry agency)

INRA -- Institut National de la Recherche Agronomique

I&I -- Invereshie & Inshriach National Nature Reserve

IUCN – International Union for the Conservation of Nature

LES -- Lesponne, Hautes-Pyrenees

MCE -- Multi-Criteria Evaluation

MIT -- Multi-, inter- and transdisciplinary

NDSI -- Normalised Difference Soundscape Index

NNR -- National Nature Reserve

NPF -- National Planning Framework

NTS -- National Trust for Scotland

PCA -- principal component analysis

PG -- Patrice Guyot

PLU -- Plan Local d'Urbanisme (French local planning system)

PNP -- Pyrenees National Park

POT -- Pouey Trenous, Hautes-Pyrenees

PSP -- participatory scenario planning

Pbio -- human perceptions of biodiversity

Pwild -- human perceptions of wildness

RMS -- Root Mean Square

RQ -- Research Question

RSPB -- Royal Society for the Protection of Birds

RTI -- relative technophony index

SBS -- shifting baseline syndrome

SC -- Spectral Centroid

SG -- stakeholder group

SNH -- Scottish Natural Heritage

SRUC -- Scottish Rural College

VIMP -- Variable Importance

WC -- Jenks wildness class

Appendix A – Additional maps of study sites

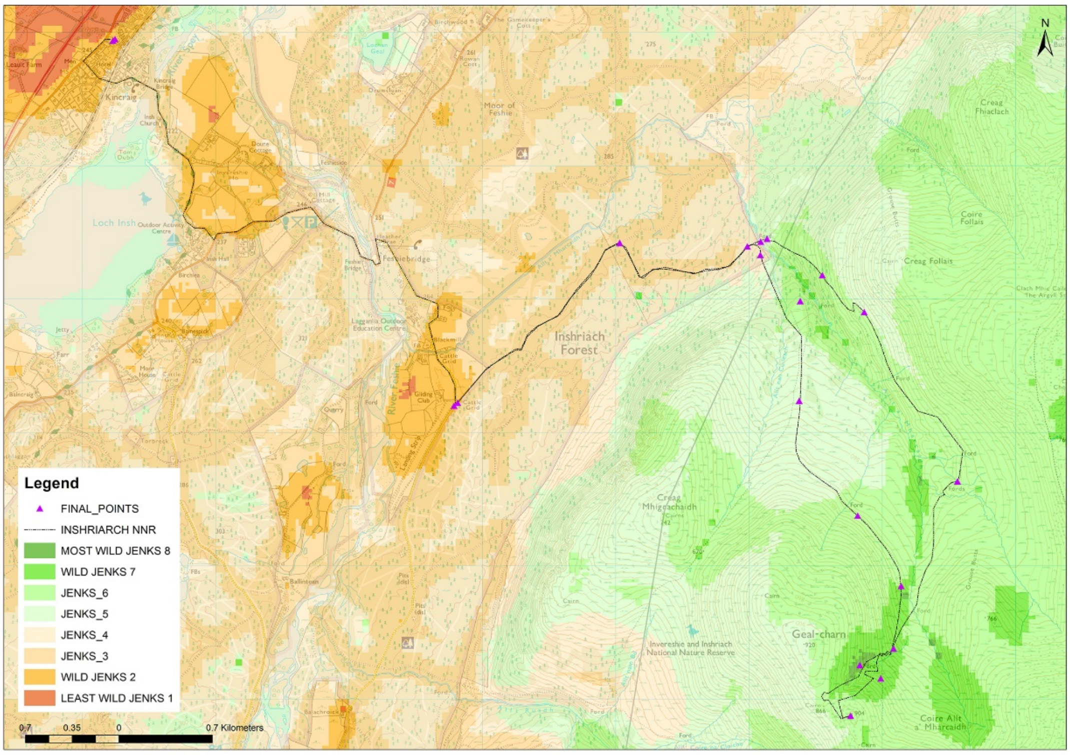

Fig. SMA1. Transect walk along gradient of Jenks Wildness Classes for Scottish site Invereshie & Inshriarch (I&I) showing human perception survey points.

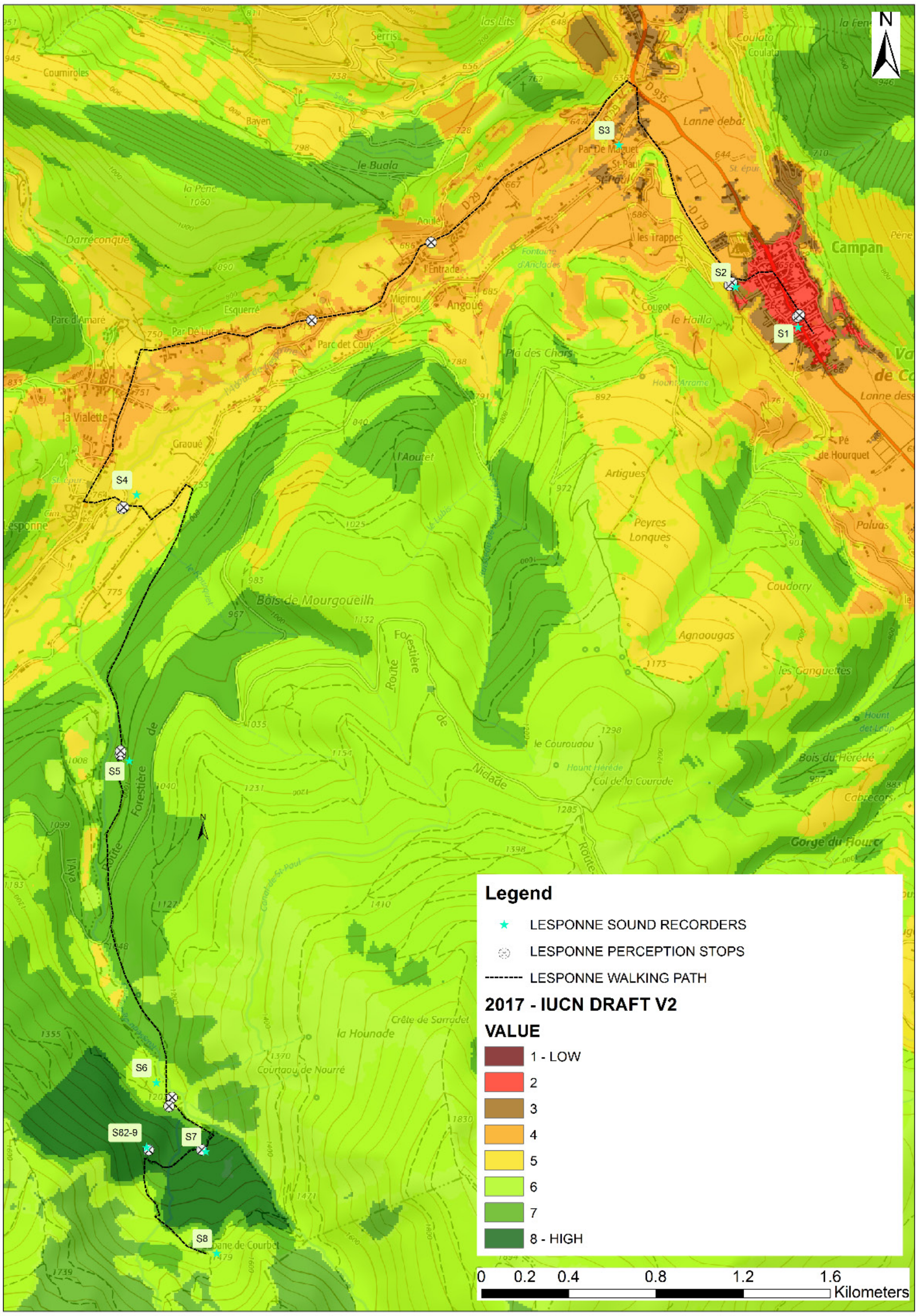

Fig. SMA2. Transect walk along gradient of Jenks Wildness Classes (low – high) for French site Lesponne (LES) showing human perception and acoustic survey points.

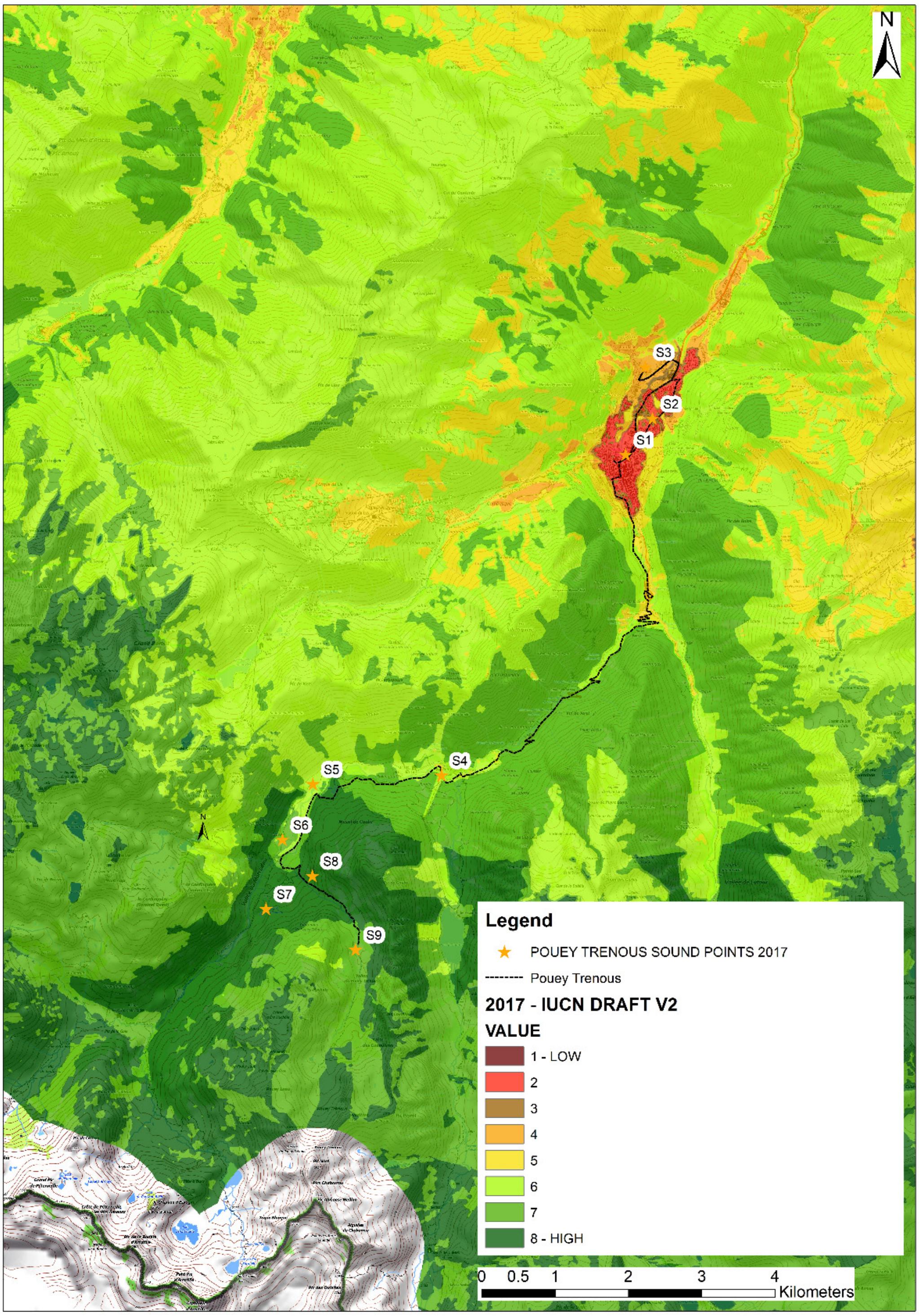

Fig. SMA3. Transect along a gradient of Jenks Wildness Classes (low – high) for French site Pouey Trenous (POT) showing proposed human perception path and acoustic survey points. Note that due to late lying snow human participants did not complete the participatory mapping task at this site.

Appendix B – Details of films of study sites

I produced two short films as part of this PhD project. These presented participants with a visual representation of the natural condition of the landscape they had just moved through during the transect walk.

The function of the two films in my PhD research project was to find a way to recreate the experience of moving through the landscape as it was before human presence impacted significantly on the habitats and species of the four case study areas used in this project. For the purposes of the research, and given the interest in shifting baseline syndrome (see Section 2.2.3 & Section 3.6.3), I was interested to understand whether walking a gradient of wildness, and knowing what the landscape looked like and which species were present before it was transformed by human beings, would have an impact on people's attitudes to wild spaces and species. I consulted with local experts from Scottish Natural Heritage (SNH) and the Pyrenees National Park (PNP) to identify film locations where the landscape remained as close as possible to this unmodified state, i.e. the most natural remnant landscapes in the general study areas. This resulted in two filming locations, one in Scotland (Beinn Eighe National Nature Reserve, near to the Beinn Eighe walking transect) and one in France (Vallee de Marcadau, near to the Pouey Trenous transect). I only selected a single filming site for each country as the experts consulted considered them to be accurate representations of intact landscapes which were of relevance to all four of the original walking transects. Making two films rather than four films was also much more practical in terms of the time and financial resources available to a PhD student.

In order to prepare for the filmmaking, I attended a ten-day course called 'Filmaking for Fieldwork'. This course is run by researchers from Manchester University who are now based at Granada Studios. The course trains participants in filmmaking for academic research or documentary film production, with a particular focus on how filmmaking can use a 'light touch' to describe events with a minimum of filming and production bias.

I adapted the techniques learnt on the filmmaking course to create a method that would capture the sensation of moving through the landscape, analogous to the experience of the participants walking the transect walk. A DJI Osmo film camera was used, which has a stabilising gimble and is highly portable. This allowed me to walk with the camera and film a steady image while moving over the rough ground and the altitudinal gradients typical of these wild landscapes. This approach also created a sensation of movement. A documentary filmmaker from the BBC (Rob Neil) also accompanied me early in 2017 on a preparatory filming trip to help address some of the methodological challenges in filming in wild and remote locations. I then made the films in the summer and autumn of 2017. I filmed at the location in the French Pyrenees during winter, as the wide extent of human influence in the lower areas of Pyreneen valleys means that using the cover provided by snow is the only way to remove obvious traces of human presence. The site identified in Scotland is the earliest designated National Nature Reserve (NNR) in the UK and, as such, the only evidence of human influence is a vague path. For this reason, I filmed this site without snow cover.

I prepared a short narration for each of the two sites which described how the landscape used to be and how it had changed, both in terms of habitats and species present. These scripts were prepared by consulting the available scientific and grey literature for the two sites and the mountainous regions in which they are situated. I kept the format for the two scripts as similar as possible, whilst adapting them for local historical accuracy. Whilst obviously there are incomplete data for these historical time periods, and some debate over the limited data that exists, I focused the narration on well-established data for which there is consensus. These texts were then reviewed by the same experts from SNH and PNP. During the film production phase I added the two scripts as a narration, over the top of the natural sounds recorded while filming, using a neutral and descriptive documentary style. The French script was translated from the English version below and read in French. Transcripts and a screengrab from both films are presented below.

Film transcript Scotland (running time 5.00)

<< NARRATION START

As is typical of many other habitats, the landscape of the highland areas of Scotland is widely thought to have looked significantly different historically than it does today.

Whilst picking any particular moment in time as a reference point is arbitrary, the native species of plants and animals which we still have today are often assessed in relation to a baseline of the ecological landscape that began to develop after the end of the last ice age, around 12,000 years ago. Many of our current native species of insects, birds, plants and mammals have been present since then, and so our current landscape remains strongly linked to this time.

Given the available scientific evidence on this period after the end of the last ice age, whilst many of the native plant and animal species from that time remain present in Scotland, what has changed is that the full range of those species is no longer present, either in terms of diversity or abundance.

After the retreat of the glaciers, the landscape was essentially bare. There remains a lot of debate about how the landscape has changed since then. But research on scots pine, for example, has estimated that they were first detected in the Beinn Eighe area around 9,500 years ago.

Around 8,000 years ago it is suggested that vegetation began to return in significant quantities, dependent on slope aspect, soils and the local climate, and that around 4,000 to

5,000 YEARS AGO a mosaic of woodland, bog and sheltered glades were the dominant landscape cover in the highland areas of Scotland.

In terms of specific habitats, most of the research on woodland, looking at pollen cores and lake sediments, suggests a far greater coverage of, for example, native Caledonian forest than that which we have today. This Caledonian forest included a range of species, such as scots pine, birch, aspen, rowan, oak, alder and juniper.

On the west coast this more temperate climate also supported large areas of predominantly oak woodland, small remnants of which are still found on the northern shores of Loch Maree today. Both of these woodland types supported a rich understory of other plants such as blaeberry, heather, mosses, ferns and grasses.

Based on recent surveys by the Scottish Forestry Commission, this Caledonian forest habitat currently covers only 1 percent of its former range - less than 20,000 hectares. Drivers of this decline in forest cover have varied. But in addition to climate change, felling and burning were key early factors as human populations increased in number and spread across the landscape.

We know that humans were present in this landscape 10,500 years ago, and the Vikings are believed to have been among the first to have had a significant impact, using burning to clear large areas of forest.

In the 16th and 17th centuries it is suggested that large areas of oak woodland in the Wester Ross area, such as in the Letterewe Forest, were felled for the ironworking industry.

In spite of occasional significant fires, remnants of Caledonian forest in the Beinn Eighe National Nature Reserve are believed to have been continuously present up to an altitude of around 300m throughout the last 8,000 years.

In suitable treeless areas within the reserve, where the landscape has also been protected from intensive grazing by deer, this mix of Caledonian forest species has begun to return without planting or the addition of seeds.

In terms of animal species, we know from fossil evidence that historically a wide range of wild species were present in the highlands. This included bears, eagle owls, wolves, lynx, boar, pine martens, moose, red deer, Capercaillie, wild cats, red squirrels, golden eagles, ospreys and mountain hares.

A reduction in available habitat such as woodland, as well as hunting, have been proposed as key factors that led to a reduction in the diversity and abundance of the different wild species to be found in these upland landscapes.

None of the former native large predators remain, with lynx and bear disappearing around 1,000AD, and the wolf finally disappearing in the early 1700s.

Nevertheless, pine martens, mountain hares, red squirrels, wild cats, and a number of large birds of prey remain to this day.

The open upland ground has perhaps changed less historically than the woodland areas, and still contains a range of dry, wet, alpine and sub-alpine heaths as well as important moss heaths. Other habitats include blanket bog, montane grassland and scree. These alpine heaths feature characteristic dwarf juniper as well as mosses and liverworts.

END>>

Film transcript French Pyrenees (running time 8.02)

<<NARRATION START

As is typical of many other landscapes the Pyrenees is widely thought to have looked significantly different historically than it does today.

Whilst picking any particular moment in time as a reference point is arbitrary, the native species of plants and animals which we still have today are often assessed in relation to a baseline of the ecological landscape that began to develop after the end of the last ice age, around 12,000 years ago. Many of our current native species of insects, birds, plants and mammals have been present since then, and so the current landscape remains strongly linked to this time.

Given the available scientific evidence on this period after the end of the last ice age, whilst many of the native plant and animal species from that time remain present in the Pyrenees , what has changed is that the full range of those species is no longer present, either in terms of diversity or abundance.

As the glaciers which covered this area began to retreat, they left behind a landscape which was essentially bare. There remains a lot of debate about how the landscape has changed since then, but there is a consensus that tree cover was already at its maximum levels around 8000-9000 years ago, dependent on slope aspect, soils and the local climate. This local variability produced a mosaic of woodland, bog and sheltered glades as the dominant landscape cover in the Pyrenees. This gave way to bare rock, snow and ice at higher elevations, and fragments of these glacial remnants are present even today.

In terms of specific habitats, most of the research on woodland, looking at pollen cores and lake sediments, suggests a far greater coverage of native forest than that which we have today. This forest included a range of species, such as pine, fir, birch, aspen, rowan, oak, alder, oak and juniper. The diverse geological make-up of the Pyrenees means that the trees species present in a given area vary dependent on the whether the soils are acidic or alkaline in nature. All these woodland types supported a rich understory of other plants such as bilberry, heather, mosses, ferns and grasses, as well as a significant range of native flora.

We know, based on cave paintings and archaeological evidence, that humans were present in this landscape as long as 27,000 years ago. However, their presence only began to have an impact on the vegetation around 7,500 years ago with small scale clearance of vegetation. It wasn't until around 5,500 years ago that human activities such as slash and burn cultivation began to make a significant impact on the landscape.

Mining and mineral production are detectable from around 4,500 years ago and reach significant levels around 2,500 years ago. This led to a marked increase in deforestation driven by the need to fell trees for the charcoal production that was necessary for smelting of copper, bronze and then iron. These activities spiked during the Roman occupation of the area around 2000 years ago. The combined activities of agriculture, grazing and mining peaked around 250-150 years ago before socio-economic factors began to reverse this trend and a phase of land abandonment began. Based on recent aerial surveys, woodland cover is now in a clear phase of expansion as these human pressures decline and climate change has led to milder winters. This is aided by the large size of the mountain area, as well as the fact that the clearing of forest areas never reached critically low levels, meaning that seed sources for reforestation are still plentiful when the conditions are right.

Indeed, a combination of topographical, climatic and geological factors combine in parts of the Pyrenees to create such favourable conditions for pine that it grows higher here than anywhere else in Europe, reaching up to 2600m. In terms of animal species, we know from fossil evidence that historically a wide range of wild species were present in the Pyrenees. These include bears, eagle owls, wolves, lynx, boar, pine martens, moose, red deer, Capercaillie, wild cats, red squirrels, golden eagles, vultures and mountain hares.

A reduction in available habitat such as woodland, as well as hunting, have been proposed as key factors that led to a reduction in the diversity and abundance of the different wild animal species to be found in these upland landscapes.

Again, the size of both the Pyrenees and the populations of these wild animal species has meant that the majority of these species remain present today. The size of their populations is however greatly reduced with only 10 brown bears remaining in the mid-1990s. The lynx, moose and wolf have completely disappeared from the Pyrenees although in recent decades some evidence of lynx has been reported although not validated. Young wolves have been seen in the eastern Pyrenees since the early 2000s and confirmed via DNA analysis as originating in the Italian Alps. Following two reintroduction programmes the bear population has now reached around 60 individuals.

Despite a trend of land abandonment and reforestation, signs of permanent human presence in the Pyrenees during earlier times remain, with the ruins of remote villages still visible today. Starting in the 1930s, a large number of mountain lakes and rivers were developed into hydro-electric installations which also remain today, along with a significant number of ski resorts.

The higher ground, above the grazing limit for most agricultural species has, in terms of species present and habitats, changed much less historically than the woodland and grazing areas, and still contains a range of dry, wet, alpine and sub-alpine heaths as well as important moss heaths. Other habitats include blanket bog, montane grassland and scree. These alpine heaths feature characteristic dwarf juniper as well as mosses and liverworts.

END>>

Appendix C – Questionnaire

UNIVERSITY OF LEEDS

INTRODUCTION

This project is designed to gather more detail on the wide range of opinions that exist on the themes of management, conservation, and landscape protection of wild spaces and wild species in mountain areas. This is a very hotly discussed subject and often raises strong emotions and opinions and it is hoped that your participation will help to facilitate dialogue about these issues in the future. As such it will discuss many of the key issues relating to mountain areas such as wildness, land management, naturalness, biodiversity and peoples preferences for their future.

1. PERSONAL INFORMATION

Instructions: please complete the following information. This data will be protected under University of Leeds data protection standards and not reused for any other purpose than that declared in the information sheet provided. This is to allow follow up questions, and also facilitate the dissemination of findings.

a) Age bracket: 18-25, 26-35, 36-45, 46-55, 56-65, 66-75, 75+
b) Full name:
c) E-mail address:
d) Occupation:
e) Do you have any educational qualifications for which you received a certificate?
   i. Yes
   ii. No

If you answered no, do you have any professional, vocational or other work related qualifications for which you received a certificate?

   i. Yes
   ii. No

If you answered yes to either please specify whether your highest qualification was:

a. at degree level or above
b. or another kind of qualification?
c. what was it called ?

f) Do you (tick all that apply) :

i. live locally ☐
ii. work locally ☐
iii. come from this area ☐
iv. visit this area regularly ☐
v. occasionally visit this area ☐
vi. go to the mountains often ☐
vii. rarely go to the mountains ☐
viii. work in the mountains ☐

2. SORTING PHOTOS OF MOUNTAIN LANDSCAPES

Instructions: You will find in front of you an empty grid and a group of photographs of the landscape.

First, sort them into three piles: those which you think are wild, those you think are not wild, and those that you think are somewhere in between.

Then please organise the photographs in terms of their wildness. Most participants find it useful to start with the wild and not wild images, rather than those in the middle. You can rearrange the photos as many times as you like until you are happy.

Least wild photos go towards the left, and most wild photos towards the right.

We have found that participants find it most helpful to **follow the shape of the grid** (see over), placing only as many photos in each column as there are boxes.

When you are finished please let the organiser know so they can photograph your choices.

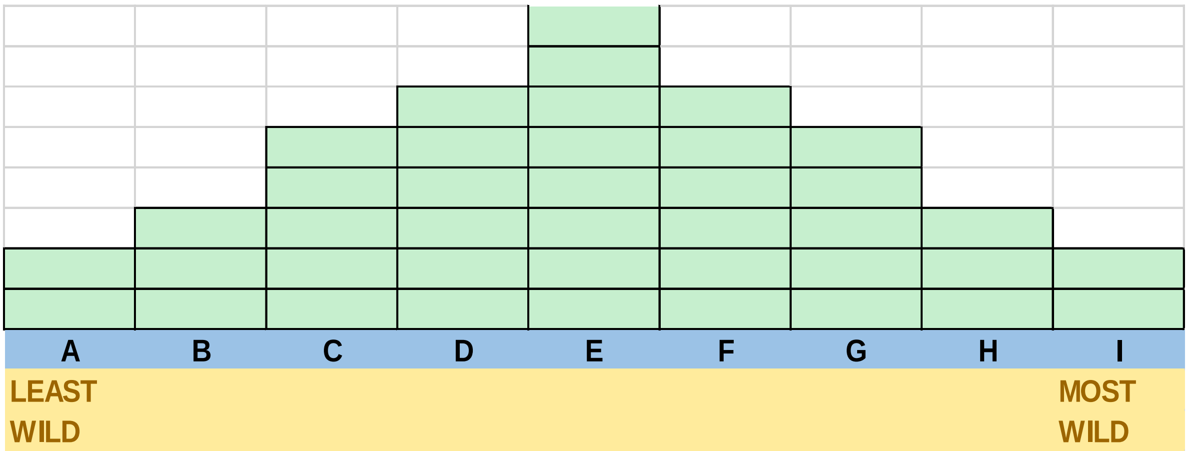

Figure 1. When you have finished **please enter the number codes from the front of the photos** in the relevant boxes above

<u>Comment box:</u>

Having completed the sort, are there any patterns you see in the way that you have organised it ? This could be as key words or phrases that come to mind when you are thinking about each column of photos, or just comments, or both. Use the table below:

PHOTO COLUMN	KEYWORDS OR PHRASES	COMMENTS
A		
B		
C		
D		
E		
F		
G		
H		
I		

3. BENEFITS LINKED TO MOUNTAIN AREAS

Instructions:

Please review the images in the columns furthest left (A,B,C) and the columns furthest right (G,H,I) from the photo exercise above and, for each of the following categories below, consider whether you agree or disagree that these types of landscapes provide these kinds of benefits:

	BENEFITS - AGREE OR DISAGREE	FURTHEST LEFT	FURTHEST RIGHT
1	Economic contribution - from renewable energy technologies		
2	Economic contribution - supporting local jobs such as in tourism, on estates etc		
3	Economic contribution - from quarrying or extraction of natural resources such as wood		
4	Recreational value - for a range of outdoor activities for locals and visitors		
5	Human health and happiness - from the beauty or aesthetic character of the place		
6	Conservation value - for nature and biodiversity		
7	Food supply - from agriculture		
8	Food supply - from wild foods		
9	Cultural heritage - important role in the history and identity of the local community		
10	Science - a place of importance for scientific research		
11	Pollination - providing good habitat for insects (e.g. bees; wasps; ants; flies; butterflies/moths; beetles)		
12	Value for future generations - a place worth protecting or preserving intact for our children		
13	Flood prevention - a place where nature reduces the risks from flooding		
14	Water supply – providing clean water		
15	Climate change - helping to reduce the drivers of climate change		
16	Clean air provision – a role in reducing pollution		

Comment box - Please write down any comments to explain your choices

4. MOUNTAIN AREAS & THE ENVIRONMENT

a. Past and present landscapes:

i. How would you describe your level of knowledge of current mountain environments in Scotland?

LOW	1	2	3	4	5	6	7	HIGH

ii. How would you describe your level of knowledge of historical mountain environments in Scotland?

LOW	1	2	3	4	5	6	7	HIGH

iii. Do you think that Scotland's current landscape and animal species have changed much since the last ice age ?

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

<u>Comment box - </u>Please write down any comments to explain your choices

b. Wild spaces in Scotland:

How important do you feel the following criteria for wild spaces are:

i. A high degree of perceived naturalness;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

ii. The lack of modern human artefacts or structures;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

iii. Little evidence of contemporary land uses;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

iv. Landform which is rugged, or otherwise physically challenging;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

v. Remoteness and / or inaccessibility.

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

vi. A sense of sanctuary or solitude;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

vii. Emotional response - risk or, for some visitors, a sense of awe or anxiety;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

viii. Perceptions that the landscape has arresting or inspiring qualities;

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

ix. Fulfilment from the physical challenge required to penetrate into these places.

NOT IMPORTANT	1	2	3	4	5	6	7	8	VERY IMPORTANT

c. The current situation in mountain areas in Scotland

Please review the following statements:

i. There are sufficient wild spaces in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

ii. There are sufficient wild species such as deer, mountain hare and birds in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

iii. There are sufficient wild species such as wild cat, pine marten, beaver and birds of prey in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

iv. There should be wild species such as lynx, bear and wolf in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

v. There is sufficient development of hard infrastructure (roads, renewable energy etc) to support economic development in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

vi. There is a good level of biodiversity (number of different habitats and species) in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

vii. There is sufficient development of infrastructure (such as roads, rail and energy) to support tourism development in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

5. TRANSECT WALK

Participants in the walking groups group will follow the transect walk as described.

At specified and predetermined spatial locations along the walk you will be asked to rank the surrounding landscape in terms of the following categories: (SCALE: VERY LOW: 1 – 7 VERY HIGH)

CATEGORY	THINK ABOUT
1. Biodiversity	How many different habitats and species are here
2. Naturalness	How close to its natural state is the surrounding area ? Post last glaciation
3. Connectivity	How well connected are the habitats here for wildlife to move
4. Wildness	How wild does this area feel to you ?
5. Land management	How heavily/intensely managed by man/woman is this landscape
6. Emotion	Do you like it ? Does it make you feel good ? Happy or sad ?

Please feel free during the walk to discuss or write down in the notebook any comments you would like to share with the group

STOP !!

PLEASE DO NOT COMPLETE THE REST OF THE QUESTIONNAIRE UNTIL AFTER THE WALK ☺

6. HIGH NATURALNESS FILM

We will now show you a short film. This film is a shortened video of a walk made in a relatively natural part of the Scottish highlands which reflects on what the natural landscape would probably have looked like historically.

7. THINKING ABOUT THE FUTURE OF MOUNTAIN LANDSCAPES

i. Landscape – wild spaces

Thinking about possible benefits to the general public, how much importance do you think should be given to the following when making decisions about how the mountains are managed in Scotland ?

a) Provision of food from agriculture (crops, meat)

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

b) Provision of wild foods (mushrooms, plants, berries)

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

c) Provision of flood management

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

d) Provision of employment

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

e) Provision of clean water

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

f) Provision of recreational spaces - for local people and visitors

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORATANT

g) Supporting resilience to climate change e.g. absorbing carbon from the atmosphere

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

h) Provision of clean air

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

i) Conservation of nature and biodiversity

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

j) Provision of resources - such as minerals or wood

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

k) Value for scientific research

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

l) Provision of renewable energy

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

m) Provision of places for human health and wellbeing

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

n) Protection of local cultural heritage

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

o) Protecting processes in natural systems such as pollination

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

p) Preserving landscapes in for future generations

NOT IMPORTANT	1	2	3	4	5	6	7	8	9	10	VERY IMPORTANT

Please review the following statements:

q) How much land do you think is currently allocated in Scottish mountain areas as places where natural processes develop without any active human management for either conservation or economic development ?

0%	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**

r) How much land do you think should be allocated in Scottish mountain areas as places where natural processes develop without any active human management for either conservation or economic development ?

0%	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**

s) In terms of wild spaces, there are currently already enough of these to be found in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

t) In terms of wild species such as deer, mountain hare and birds there are currently already enough of these to be found in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

u) In terms of wild species such as wild cat, pine marten, beaver and birds of prey there are currently already enough of these to be found in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

v) Wild species such as lynx, bear and wolf should be present in mountain areas in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

w) Biodiversity (number of different habitats and species) in mountain areas in Scotland is already at a good level

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

Comment box - Please write down any comments to explain your choices

ii. Wildlife - wild species

Beavers are an example of a species that was extinct and has recently been reintroduced. Other species such as lynx/wolves/bears are extinct but were once present.

Please give us your opinions on the following statements: (Scale - agree or disagree)

a) Beaver numbers should be allowed to grow in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

b) Populations of raptors such as buzzards/red kites/eagles should be allowed to expand in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

c) Water vole numbers should be allowed to grow in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

d) The amount of native woodland areas should be increased in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

e) Numbers of butterflies and dragonflies should be increased in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

f) Numbers of ravens should be allowed to grow in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

g) Capercaillie numbers should be allowed to grow in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

h) Fox numbers should be allowed to grow in Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

i) Lynx should be reintroduced to Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

j) Wolves should be reintroduced to Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

k) Bears should be reintroduced to Scotland

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

Comment box - Please write down any comments to explain your choices

iii. Attitudes to wild spaces and wild species in mountain areas

1. The protection of wild spaces:

a. My supporting the protection of wild spaces is:

BAD	1	2	3	4	5	6	7	GOOD
HARMFUL	1	2	3	4	5	6	7	BENEFICIAL
FOOLISH	1	2	3	4	5	6	7	WISE
UNIMPORTANT	1	2	3	4	5	6	7	IMPORTANT
UNPLEASANT	1	2	3	4	5	6	7	PLEASANT

b. I have mixed feelings about supporting the protection of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

c. If I only think about my negative thoughts about supporting the protection of wild spaces, I would say I am...

NOT AT ALL NEGATIVE	1	2	3	4	5	6	7	EXTREMELY NEGATIVE

d. If I only think about my positive thoughts about supporting the protection of wild spaces, I would say I am...

NOT AT ALL POSITIVE	1	2	3	4	5	6	7	EXTREMELY POSITIVE

e. Other people important to me would want me to support protection of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

f. Other people important to me themselves support the protection of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

g. I intend to support the protection of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

2. The reintroduction of extinct wild species:

a. My supporting the reintroduction of an extinct wild species such as lynx is:

BAD	1	2	3	4	5	6	7	GOOD
HARMFUL	1	2	3	4	5	6	7	BENEFICIAL
FOOLISH	1	2	3	4	5	6	7	WISE
UNIMPORTANT	1	2	3	4	5	6	7	IMPORTANT
UNPLEASANT	1	2	3	4	5	6	7	PLEASANT

b. I have mixed feelings about supporting the reintroduction of extinct wild species

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

c. If I just think about my negative thoughts about supporting the reintroduction of extinct wild species, I would say I am...

NOT AT ALL NEGATIVE	1	2	3	4	5	6	7	EXTREMELY NEGATIVE

d. If I just think about my positive thoughts about the reintroduction of extinct wild species, I would say I am...

NOT AT ALL POSITIVE	1	2	3	4	5	6	7	EXTREMELY POSITIVE

e. Other people important to me would want me to support the reintroduction of extinct wild species

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

f. Other people important to me themselves support the reintroduction of extinct wild species

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

g. I intend to support the reintroduction of extinct wild species

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

3. *The amount of wild spaces*

a. My supporting an increase in the amount of wild spaces is:

BAD	1	2	3	4	5	6	7	GOOD
HARMFUL	1	2	3	4	5	6	7	BENEFICIAL
FOOLISH	1	2	3	4	5	6	7	WISE
UNIMPORTANT	1	2	3	4	5	6	7	IMPORTANT
UNPLEASANT	1	2	3	4	5	6	7	PLEASANT

b. I have mixed feelings about supporting an increase in the amount of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

c. If I just think about my negative thoughts about supporting an increase in the amount of wild spaces, I would say I am...

NOT AT ALL NEGATIVE	1	2	3	4	5	6	7	EXTREMELY NEGATIVE

d. If I just think about my positive thoughts about an increase in the amount of wild spaces, I would say I am...

NOT AT ALL POSITIVE	1	2	3	4	5	6	7	EXTREMELY POSITIVE

e. Other people important to me would want me to support an increase in the amount of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

f. Other people important to me themselves support an increase in the amount of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

g. I intend to support an increase in the amount of wild spaces

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

4. The amount of natural spaces with well-functioning natural processes

a. My supporting an increase in the number of areas where natural processes are left to develop without active economic or environmental management is:

BAD	1	2	3	4	5	6	7	GOOD
HARMFUL	1	2	3	4	5	6	7	BENEFICIAL
FOOLISH	1	2	3	4	5	6	7	WISE
UNIMPORTANT	1	2	3	4	5	6	7	IMPORTANT
UNPLEASANT	1	2	3	4	5	6	7	PLEASANT

b. I have mixed feelings about supporting an increase in the number of areas where natural processes are left to develop without active management:

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

c. If I just think about my negative thoughts about supporting an increase in the number of areas where natural processes are left to develop without active management...

NOT AT ALL NEGATIVE	1	2	3	4	5	6	7	EXTREMELY NEGATIVE

d. If I just think about my positive thoughts about supporting an increase in the number of areas where natural processes are left to develop without active management...

NOT AT ALL POSITIVE	1	2	3	4	5	6	7	EXTREMELY POSITIVE

e. Other people important to me would want me to support an increase in the number of areas where natural processes are left to develop without active management

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

f. Other people important to me themselves support an increase in the number of areas where natural processes are left to develop without active management:

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

g. I intend to support an increase in the number of areas where natural processes are left to develop without active management:

STRONGLY DISAGREE	1	2	3	4	5	6	7	STRONGLY AGREE

8. Concluding group session

In a group please discuss the following (organiser will take notes on a white board).

a) What were the most important points of discussion for the day ?

b) What were the main areas of agreement with regard to these discussions ?

c) What were the main areas of disagreement with regard to these discussions ?

d) How do you think the ideas we have discussed today should be communicated ?

e) Who do you think it should be shared with ?

f) Do you think that immersion in wild spaces changes your attitude to how much of them we should have more of them in the future ?

g) Do you think that knowledge of the historical evolution of a landscape changes your preferences for its future ?

h) How important is what you can hear to your experience of the naturalness this place - so what you can or cannot - can you identify any particular features - what effect do these have ?

Appendix D – Images of key mapping stops

1. Recorder locations at study site Beinn Eighe National Nature reserve (BEN)

Figure. SMD1 Song Meter 2+ in situ at Beinn Eighe (BEN) study site - Wild Class Sound recorder location circled.

Figure. SMD2 Song Meter 2+ in situ at Beinn Eighe (BEN) study site - Wild Class 3

Figure. SMD3 Song Meter 2+ in situ at Beinn Eighe (BEN) study site - Wild Class 5

Figure. SMD4 Song Meter 2+ in situ at Beinn Eighe (BEN) study site - Wild Class 6.
Sound recorder location circled.

Figure. SMD5 Song Meter 2+ in situ at Beinn Eighe (BEN) study site - Wild Class 8

2. Recorder locations at study site KC – Invereshie & Inshriarch National Nature reserve (I&I)

Figure. SMD6 Song Meter 2+ in situ at Invereshie (I&I) study site - Wild Class 2.
Sound recorder location circled.

Figure. SMD7 Song Meter 2+ in situ at Invereshie (I&I) study site - Wild Class 3

Figure. SMD8 Song Meter 2+ in situ at Invereshie (I&I) study site - Wild Class 5

Figure. SMD9 Song Meter 2+ in situ at Invereshie (I&I) study site - Wild Class 6.
Sound recorder location circled.

Figure. SMD10 Song Meter 2+ in situ at Invereshie (I&I) study site - Wild Class 8

3. Recorder locations at study site LES – Lesponne, Hautes-Pyrenees, France.

Figure. SMD11 Song Meter 2+ in situ at Lesponne (LES) study site - Wild Class 2

Figure. SMD12 Song Meter 2+ in situ at Lesponne (LES) study site - Wild Class 3

Figure. SMD13 Song Meter 2+ in situ at Lesponne (LES) study site - Wild Class 5

Figure. SMD14 Song Meter 2+ in situ at Lesponne (LES) study site - Wild Class 6.
Sound recorder location circled.

Figure. SMD15 Song Meter 2+ in situ at Lesponne (LES) study site - Wild Class 8.
Sound recorder location circled.

4. Recorder locations at study site POT – Pouey Trenous, Hautes-Pyrenees, France.

Figure. SMD16 Song Meter 2+ in situ at Pouey Trenous (POT) study site - Wild Class 2.
Sound recorder location circled.

Figure. SMD17 Song Meter 2+ in situ at Pouey Trenous (POT) study site - Wild Class 3.
Sound recorder location circled.

Figure. SMD18 Song Meter 2+ in situ at Pouey Trenous (POT) study site - Wild Class 5.
Sound recorder location circled.

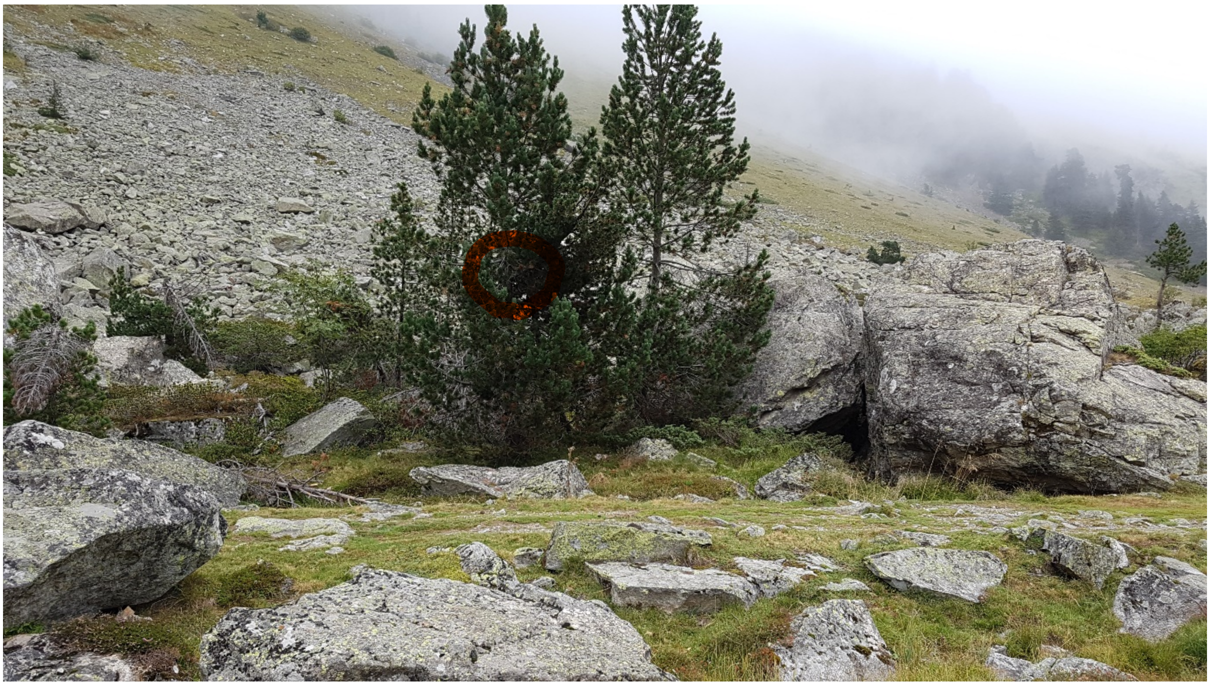

Figure. SMD19 Song Meter 2+ in situ at Pouey Trenous (POT) study site - Wild Class 6. Sound recorder location circled.

Figure. SMD20 Song Meter 2+ in situ at Pouey Trenous (POT) study site - Wild Class 8. Sound recorder location circled.

Appendix E – Details of acoustic indices

Acoustic indices

Acoustic Complexity Index (ACI) (Pieretti et al., 2011) was developed in response to observations that many of acoustic indices are over-sensitive to ‘background’ noise. ACI reports short-time averaged changes in energy across frequency bins, with the aim of capturing transient biophonic sounds, whilst being insensitive to more continuous technophonies such as airplanes and other engines. ACI has been reported to correlate significantly with the number of avian vocalisations in an Italian national park (Pieretti et al., 2011), with observed species evenness and diversity in temperate reefs (Harris et al., 2016) and to be positively related to observed changes in migratory avian species numbers in a multi-year Alaskan study (Buxton et al., 2016).

ACI is calculated as the average absolute fractional change in spectral amplitude for each frequency bin in consecutive spectrums (1kHz – 24kHz). The main ACI value is the average value over 5 mins using default parameters (J = 5 seconds).

ACI is employed it as a proxy for avian vocalisation in this study.

Acoustic Evenness Index (AEI) (Villanueva-Rivera et al., 2011) is based on an analogy drawn between species counts and distribution of energy in a spectrum, where each frequency band is seen to represent a specific species, thus they are designed to measure the spread of sound energy across the frequency range and by analogy act as a proxy for the diversity of a given acoustic community.

These were originally developed to assess habitats along a gradient of degradation under the assumption that ADI and AEI would be respectively positively and negatively associated with habitat status as the distribution of sounds became more even with increasing diversity (Villanueva-Rivera et al., 2011): ADI was shown to increase from agricultural to forested sites; AEI was shown to decrease over the same gradient, as expected. Negative, if weak, associations between AEI and biocondition (Eyre et al., 2015) have subsequently been corroborated (Fuller et al., 2015) and a significant positive association between ADI and avian species richness has been reported in the savannas of central Brazil (Alquezar and Machado, 2015).

AEI is calculated by first dividing a spectrogram into 10 bins (min–max 1–10 kHz), normalizing by the maximum, and taking the proportion of the signals in each bin above a threshold (-50 dBFS). AE is the Gini coefficient of the resultant vector providing a measure of evenness.

Bio-acoustic Index (BI) was designed to capture overall sound pressure levels across the range of frequencies produced by avifauna (Boelman et al., 2007). BI was originally reported to correlate strongly with changes in avian abundance in Hawaiian forests (Boelman et al., 2007), but subsequent assessments have been mixed, showing significant association with avian species richness (Fuller et al., 2015) and both positive and negative weaker correlations (Mammides et al., 2017) in areas with multiple vocalizing taxa.

BI is calculated as the area under the mean spectrum (in dB) minus the minimum dB value of this mean spectrum across the range 2–8 kHz for the 5 minute file.

BI was selected as a proxy for overall biophonic activity

Relative Technophony Index (RTI is derived from the Normalised Sound Difference Index (NDSI) (Kasten et al., 2012). The NDSI seeks to describe the level of anthropogenic disturbance by calculating the ratio of mid-frequency biophony to lower frequency technophony in field recordings. In long term studies, the NDSI has been shown to reflect assumed seasonal and diurnal variation across landscapes (Kasten et al., 2012). It has subsequently been shown to be sensitive to biophony and anthrophony levels in urban areas (Fairbrass et al., 2017) and to be an indicator of anthropogenic presence in the Brazilian Cerrado (Alquezar and Machado, 2015).

In WA mapping, relative levels of anthrophonic are of greater interest than the ratio between them. RTI is therefore calculated as the proportion of low frequency energy in a given sound file. RTI is computed from an estimated power spectral density using Welch's method (win = 1024) by first summing the energy in the range 1–2kHz and then dividing it by the sum of the energy in the total range 1-11kHz.

The Root-Mean-Square (RMS) of a raw audio (time domain) signal gives a simple description of signal amplitude; RMS has been demonstrated to track ecologically-relevant temporal and spatial dynamics in forest canopy (Rodriguez et al., 2014), and shown to be strongly positively correlated with percentage of living coral cover in tropical reefs (Bertucci et al., 2016), and to be a significant predictor of species richness in terrestrial tropical ecosystems (Eldridge et all., 2018).

(RMS) is calculated by taking the root of the mean of the square of samples in each frame (N = 512). The median value these means across frames is used, being more robust to minor fluctuations common in audio recordings than the mean.

RMS (median) is adopted here as in indicator of overall sound levels.

Spectral Centroid (SC) (Peeters, 2004) provides a measure of the spectral centre of mass; it is widely used in machine listening tasks where is it recognized to have a robust connection with subjective measures of brightness. This and related spectral indices have been shown to be effective in automated recognition of environmental sounds in urban environments
(Devos, 2016) as well as being significant predictors of overall chorus activity (Eldridge et all., 2018).

SC is calculated as the weighted mean of the frequencies present in the signal, per frame, determined from an SSFT where the weights are the magnitudes for each bin. The median value across frames is reported here.

SC median is adopted here as a potential proxy for distance from anthropogenic influence.

References

Alquezar, R. D., & Machado, R. B. (2015). Comparisons Between Autonomous Acoustic Recordings and Avian Point Counts in Open Woodland Savanna. *The Wilson Journal of Ornithology*, *127*(4), 712–723. https://doi.org/10.1676/14-104.1

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