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ORIGINAL PAPER

The emergence of biodiversity conflicts from biodiversity impacts: characteristics and management strategies

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Abstract Conflicts between the conservation of biodiversity and other human activities occur in all habitats and can impact severely upon socio-economic and biological parameters. In a changing environment, with increasing pressure on ecosystem goods and services and increasing urgency for biodiversity conservation, these conflicts are likely to increase in importance and magnitude and negatively affect biodiversity and human well-being. It is essential, however, to better understand what is meant by 'biodiversity conflicts' in order to develop ways to manage these effectively. In view of the complexity of the social and ecological contexts of conflicts, this paper explores 'biodiversity impacts' linked to agricultural, forestry and other sectoral activities in the UK. The paper then describes the transition from 'biodiversity impacts' to 'biodiversity conflicts', illustrating this concept with specific examples. While generalisations relating to conflict management are made difficult by their unique contextual settings, this paper suggests approaches for their management, based on the experiences of scientists who have been involved in managing conflicts. We consider the role of science and scientists; trust and dialogue; and temporal and spatial scales in biodiversity conflicts and highlight the combined role they

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play in successful biodiversity conflict management. Recommendations are also made for future research on biodiversity conflicts in a changing environment.

Keywords Agriculture · Biodiversity conflicts · Biodiversity impacts · Conflict management · Conservation policy · Forestry · Livelihoods · Participation · Predator management · Sustainability

Introduction

Biodiversity is an essential provider of ecosystem goods and services, contributing directly to national economies and providing employment through agriculture, forestry, fishing, tourism, recreation and hunting (Millennium Ecosystem Assessment 2005). Consequently, it has been referred to as 'the insurance policy for life itself—something especially needed in this time of fast-paced global change' (WEHAB Working Group 2002). However, global change has resulted in a widespread decline in recent decades (Millennium Ecosystem Assessment 2005). Rockstrom et al. (2009) argued that biodiversity losses exceed the limits of planetary sustainability more than any other human impact. The rapid loss of species and habitats is increasing worldwide, including Europe, where biodiversity "remains greatly impoverished and continues to decline" (European Commission 2006). This decline is due to a suite of anthropogenic pressures including pollution, climate change and land use change (Brooker et al. 2007; Haines-Young 2009; Young et al. 2005).

Human activities can lead to '*biodiversity impacts*', defined here as circumstances where people, consciously or unconsciously, impact negatively on biodiversity, or alternatively, where wildlife or other aspects of biodiversity impact negatively on the well-being or livelihoods of people (Young et al. 2005, 2007). Here we distinguish between biodiversity *impacts* and biodiversity *conflicts*, the latter describing conflicts between people about wildlife or other aspects of biodiversity (White et al. 2009, see also Knight 2000). This definition acknowledges the different and potentially divergent values held by individuals or groups of people in relation to biodiversity. The central role of people in biodiversity conflicts conveys the need to understand the socio-economic and political context of conflicts, rather than restricting consideration to ecological context solely (Carss et al. 2009). Consequently, while the underlying ecology and drivers of biodiversity impacts might often be similar, the emergence and management of conflicts will be influenced by their unique socio-economic context. While conflicts are often perceived negatively, they can have positive influences. For example, conflicts can provide opportunities for increased dialogue, and influence EU and national-level governance.

A recent review (Young et al. 2009a) highlighted the current misunderstanding in the literature regarding the issue of biodiversity conflicts: many papers interpret biodiversity impacts as conflicts. Here we argue that an understanding of, and agreement on, the concept of 'biodiversity conflict' is an essential precursor to best manage biodiversity conflicts. Furthermore, many of the papers highlighted in an earlier review of biodiversity conflicts in the UK (Young et al. 2009a) focussed on (i) addressing biodiversity impacts through scientific solutions, or (ii) scientific ideas or technical solutions without practical applications or recognition of socio-cultural context. This shows a disconnection between scientific understanding of conflicts and knowledge exchange and applicability of use to practitioners, emphasising the potentially key role for scientists as stakeholders in conflict management.

In addition to the desk-based review of literature highlighted earlier, the evidence for this paper comes from two other sources. The first source builds on the results of a multi-disciplinary pan-European project (BIOFORUM). BIOFORUM identified, through a series of workshops and reviews, the drivers of biodiversity impacts in five broad habitat types: agricultural landscapes, forests, grasslands, uplands and freshwater habitats (Young et al. 2005, 2007). Whilst this project was pan-European in scale, it identified several specific policy drivers also applicable in the UK, namely agriculture, forestry, other sectors (e.g. transport) and conservation policy. The second source of information is derived from the outputs of an e-conference that contributed specific examples of biodiversity conflicts (Young et al. 2009b), two of which are presented later in this paper. Hence, while this paper builds on broad reviews of biodiversity impacts and their drivers, it also draws on the experience of the authors who have been involved, often over long periods of time, in understanding biodiversity impacts and the characteristics and complexity of biodiversity conflicts.

This paper will address two research questions. First, when, where and why do biodiversity conflicts emerge from biodiversity impacts? Second, how can we manage best biodiversity conflicts for more effective biodiversity conservation and other benefits? These questions are answered in two sections. Firstly, biodiversity impacts are explored in the UK context but including a consideration of the major influences of European and international policies. Within the UK, several of the examples focus on recent policy changes in Scotland. High levels of biodiversity occur in Scotland and devolution and decentralisation of the political administration have led to a revision of conservation policy and management encouraging a closer attention to biodiversity concerns (Scottish Executive 2004). This section is sub-divided according to policy drivers of biodiversity impacts. We then distinguish between biodiversity impacts and conflicts, providing examples of the latter and describing their characteristics. We focus explicitly on the transition from biodiversity impact to biodiversity conflict in this paper. In the second section, while acknowledging the complexity and context-dependence of biodiversity conflicts we highlight important factors to be taken into account in biodiversity conflict management, and identify key natural and social science research priorities needed to improve our understanding and management of biodiversity conflicts.

Biodiversity impacts and the emergence of biodiversity conflicts

Biodiversity impacts linked to agricultural policy

Farmland, including arable land and permanent grassland, is one of the dominant land uses in Europe, covering over 45% (173 million hectares) of the EU-27 (Henle et al. 2008), whilst an estimated 74% of the UK is dedicated to agricultural use (DEFRA 2005). With an estimated 50% of all species in Europe dependent on agricultural habitats (Kristensen 2003), some of the most critical conservation impacts today relate to changes in traditional farming practices on habitats such as hay meadows, lowland wet grasslands, heathlands, chalk and dry grasslands, blanket bogs, moorlands and arable land. All of these habitats have been created, and thus need to be maintained, by farming (Bignal and McCracken 1996; Bignal and McCracken 2000). However, despite the emphasis on farmland biodiversity over the last 25 years since the introduction of agri-environment schemes within the Common Agricultural Policy (CAP), it is clear that halting biodiversity loss on farmland by 2010 in the UK, as in the rest of the EU, will not be achieved fully.

In Scotland, as in other parts of the UK and Europe, there has been an increased focus on the protection of designated sites (such as Special Protection Areas under the EU Birds Directive and Special Areas of Conservation under the EU Habitats Directive). Targeted actions for particular species have improved habitats within the designated sites and markedly increased the populations of a number of species of high nature conservation concern, such as wintering geese *Anserinae* and corncrake *Crex crex* (Mackey and Mudge 2010). However, this has been offset by a continuing decline in the quality of much of Scotland's wider countryside, with resulting adverse impacts on many other habitats (such as hedgerows, lowland grasslands and fields margins) and species (such as butterflies and farmland birds like curlew *Numenius arquata*, lapwing *Vanellus vanellus* and kestrel *Falco tinnunculus*) associated with Scottish farming systems (Mackey and Mudge 2010; McCracken and Midgley 2010; Norton et al. 2009). Hence High Nature Value (HNV) livestock grazing systems in the islands and uplands of Scotland are increasingly under threat from the abandonment of farm management practices and there is increasing concern as to the adverse impact this will have on farmland biodiversity in those areas (Scottish Agricultural College 2009). Conversely, the majority of intensively managed farms have not made the large-scale changes to their farming systems which are necessary to halt landscape simplification and produce the diversity of habitats and conditions required for farmland biodiversity to recover.

Scotland, like all EU Member States, has an agri-environment programme built into the Scottish Rural Development Programme (SRDP) and has government departments and agencies charged with developing and overseeing these schemes. But the goal of addressing farmland biodiversity concerns competes with other government policy issues. Alternative government priorities have limited the funding directed towards agri-environment schemes, which is thus insufficient to address the scale of the actions required (Cao et al. 2009). In addition, while it is mandatory for every EU Member State to offer agri-environment schemes, it is not mandatory for farmers and land-managers to participate in them (McCracken and Midgley 2010).

Within the Scottish RDP there is also the potential for increasing conflicts over where best to target agri-environment funding. Indeed, funds for wider countryside and protected area management currently sit within the same budget of the SRDP. This raises the wider question of how relatively limited agri-environment funds should be used to best effect in Scotland. There is therefore a potential for conflict, given the likelihood that the more intensive farmers in Scotland, as elsewhere in Europe, are likely to be reluctant to see their CAP payments eroded further (McCracken and Midgley 2010).

Effective support to HNV livestock grazing systems to benefit farmland biodiversity in the Scottish uplands and islands and achieve the marked increases in habitat and landscape diversity is required to increase biodiversity in and around intensive lowland grassland and arable farming systems. However, this is unlikely to occur until political decisions are taken with regard to what the current and future CAP funding should be used for, what additional environmental conditions need to be placed on the receipt of such support and, just as importantly, what type of farming systems should receive such support. There is therefore a need for a fundamental reassessment as to how actions to benefit biodiversity on farmland in Scotland are targeted and supported. This reassessment would result in winners and losers, not only because of overall CAP funding limitations but also because of the recent move away from providing public funding support for agricultural production per se to providing such support for the delivery of farmland biodiversity benefits and a wider suite of other public goods.

Biodiversity impacts linked to forestry policy

Changes in policy also affect other significant land uses in the UK. The second most important land use is forestry, covering approximately 14% of the UK (DEFRA 2005). One example of a potential impact involves the proposed expansion of woodland cover across the UK following on from efforts in the early twentieth century to increase tree cover. Prior to the inauguration of the Forestry Commission (FC) in 1919, much of the UK forest had suffered heavily from over-exploitation resulting in wide-scale clearance and fragmentation of wooded areas. The FC's remit was to manage state-owned woodlands and to promote the interests of forestry, develop afforestation and the production of timber. Landowners were encouraged to plant trees but the FC also embarked on land acquisition for planting. Much of the woodland expansion involved planting of conifers on less favourable agricultural land, particularly on marginal land (Forestry Commission 2010; Ray et al. 2007). However, selection of sites for this expansion, particularly in the uplands (including the Flow Country of North Scotland), had some biodiversity impacts on semi-natural habitats such as peatland and heathland (Ray et al. 2007). For example, more intensive drainage is required to prepare the open ground for afforestation and resultant shade and litter fall from growing trees can transform original vegetation (Lindsay et al. 1988), and potentially the species that rely on that habitat (Thompson et al. 1988), leading to the loss of open ground flora and fauna. These biodiversity impacts caused through land use change led to discussions between nature agencies and the FC.

Late twentieth century management of issues over afforestation on upland areas have included the removal of tax relief on planting on afforestation and a ban on large-scale forestry in the English uplands. Formal consultation and greater collaboration with other relevant environmental agencies is now a standard feature in policy, planning and practice and Environmental Impact Assessment regulations assess whether consent can be given for afforestation and deforestation programmes. There are a range of guidelines, standards and certification relating to forestry and biodiversity such as Forest Nature Conservation Guidelines (Forestry Commission 1990) and the Forest and Water Guidelines (Forestry Commission 2003), which draws on relevant research relating to environmental effects of different land-use and silvicultural options. Tree planting on peat bogs, a major habitat for carbon storage is now actively discouraged (Reed et al. 2009) and restoration of peatland and heathland through deforestation is ongoing.

Climate change is currently high on the government agenda and presents a key driver for current afforestation policies (Reed et al. 2009). Although there are concerns about declines in tree planting (Milmo 2010), plans for the expansion of forests have been recently announced with 50,000 hectares in Scotland by 2015, 10,000 hectares per year in England over 15 years and 100,000 hectares of new woodland to be planted in Wales by 2030. It is unclear where this expansion will occur and therefore the extent to which achieving an increase in forest cover might impact upon biodiversity, food production or other values. Thus, an expansion of forests upon biodiversity-rich habitats would impact upon the biodiversity there or forests on arable land would impact on food production. There may be concerns on the part of some interest groups over the biodiversity impacts of afforesting open ground. There are already diverging opinions over the type of forest that should be created and the value of different tree species for biodiversity. For example, should the new woodland be formed of exotic conifer species with high growth rates or native woodland with lower growth rates that are perceived in some circles to be more appropriate habitat for native species (Quine and Humphrey 2003)?

Forest policy and management also have to consider increasing pressure from competing uses of forests in the future, and forestry will need to respond to growing demands from sectors such as tourism and recreation and energy. Public opinion of forests has repeatedly identified woodlands and forests as important places for wildlife to live and many welcome the opportunity to see wildlife (Forestry Commission Scotland 2009). Thus government initiatives to encourage more people to seek recreation opportunities in the outdoors for improved health and wellbeing are likely to increase visits to woodlands and forests. Forests will have to meet multiple objectives, including managing potential impacts of human disturbance on biodiversity (e.g. see Summers et al. 2007 for a discussion on the impacts of human disturbance on capercaillie). The increasing popularity of woodfuel as a source of sustainable energy has highlighted benefits for some biodiversity by stimulating management of lowland woodlands and encouraging new growth through, for example, active coppicing (Fuller et al. 2007). However, while increased management of these woodlands has the potential to increase some biodiversity, potential impacts on other species and habitat could include loss of deadwood, and old growth woodlands. Some difficult choices will have to be made concerning the management of forests for different uses and there is potential for conflicts to emerge.

Biodiversity impacts linked to other sectoral and conservation policy drivers

While agriculture and forestry constitute the UK's two most important land uses, biodiversity impacts are also present in other policy areas. Planning and development drivers, for example, are likely to become more important in the future as new housing programmes across the UK could potentially affect negatively a range of mammal species (Baker and Harris 2007). Likewise, developments such as quarries or funicular railways (Warren 2002b) can cause biodiversity impacts.

The UK's energy profile is changing rapidly, with the drive for renewable energy schemes potentially causing biodiversity impacts and biodiversity conflicts. For example, a major current impact exists between the development of wind farms, both inland and at sea, and their effects on biodiversity (Fielding et al. 2006), particularly birds (Bright et al. 2008). This was reflected in the controversy surrounding the proposed Lewis Wind Farm, the perceived impacts of which on the Lewis Peatlands Special Protected Area and its associated bird populations led to almost 11,000 objections being sent to Scotland's Energy Minister and contributed to consent being refused (Scottish Government 2008). Tidal energy also has the potential to impact on biodiversity, for example in the case of the proposed models for the Severn barrage (Friends of the Earth Cymru 2007).

Recent greater access to the countryside through the Countryside and Rights of Way Act 2000 and the Land Reform (Scotland) Act 2003, has also caused concern, with a growing number of studies focussing on the impact of recreation on bird conservation (Bathe 2007; Finney et al. 2005; Mallord et al. 2007) and potential issues that might be associated with increased recreational activities in environmentally important areas (Roe and Benson 2001).

The introduction (whether accidental or deliberate) or reintroduction of species can also cause many potential biodiversity impacts. The reintroduction of large carnivores in the UK, for example, may engender biodiversity impacts due to perceived risks to humans and predation on livestock and, as such, would require extensive ecological and sociological research to determine possible risks and attitudes towards them (Wilson 2004). The spread of invasive species can also lead to biodiversity impacts and highlights some inconsistencies between different legislative tools, such as those concerning biodiversity conservation and trade.

Finally, many biodiversity impacts in the UK revolve around the driver of biodiversity conservation legislation. The UK has one of the world's oldest and strongest nature conservation movements (Dixon 1998). As early as 1949, the UK had established the Nature Conservancy and passed the National Parks and Access to the Countryside Act (1949), providing the "key area" concept of conservation (Warren 2002a) by establishing national parks, as well as other protected areas, in England and Wales. The adoption of the EU Birds Directive implemented through the Wildlife & Countryside Act (1981), allowed establishment of two key concepts in UK conservation: for scientific expertise to drive the selection and development of the protected areas system and the creation of Voluntary Management Agreements between landowners and statutory agencies (Fairbrass and Jordan 2001). The Habitats Directive was later adopted and integrated into UK legislation under the 1994 Conservation (Natural Habitats, &c) Regulations. A number of issues have emerged from these various forms of legislation. One such revolves around predator–prey interactions where either predator or prey are protected (in some cases both are) and where one species has a perceived adverse impact on another or on a habitat and its associated human activities. In addition, the population expansion of protected species can initiate serious impacts on other biodiversity (Amar et al. 2010; Simms et al. 2010).

To understand more fully the circumstances under which biodiversity impacts become biodiversity conflicts, the following sections explore the transition between biodiversity impacts and biodiversity conflicts by outlining existing typologies of biodiversity conflicts, two examples of biodiversity conflicts drawn from the experiences of scientists involved directly and, finally, characteristics of biodiversity conflicts.

Typologies of biodiversity conflicts

While many of the biodiversity impacts described above may not develop into conflicts, on some occasions they will lead to conflicts between people about wildlife or other aspects of biodiversity. We thus provide some typologies of biodiversity conflicts, consider examples of them and use these to address our first research question, namely to determine the underlying reasons why, and when, biodiversity impacts become conflicts.

Numerous typologies of biodiversity conflict exist, many of which are described by Sidaway (2005) and Jones et al. (2005). These typologies often relate to the visibility of conflicts, the relationships between actors involved in the conflicts, and their underlying causes. A useful tool when exploring these underlying causes is to explore the dimensions of conflict. Taking this perspective, six broad, often overlapping, categories can be identified (Jones et al. 2005; Sidaway 2005):

- Conflicts over beliefs and values, where differences exists over normative perceptions;
- Conflicts of interest, when two groups want different things from the same habitat or species;
- Conflicts over process, relating to the different approaches to decision-making and fairness taken by different people, groups, or agencies;
- Conflicts over information, relating to situations where data are lacking, misunderstood, or perceived in different ways by different actors;
- Structural conflicts referring to social, legal, economic and cultural arrangements;
- Inter-personal conflicts relating to personality differences between individuals or groups, including issues of communication and mistrust.

A key difficulty with typologies is that conflicts often occur in unique and often complex contexts. To illustrate both how biodiversity impacts develop into conflicts and the complexity involved in managing these conflicts, two case studies, from the e-conference mentioned in the introduction (Young et al. 2009b), are presented below. These case studies are written by scientists involved closely in the conflicts and are based on their experiences.

Examples of biodiversity conflicts

The conflict over hen harrier management

The conflict between game managers and conservation organisations over the management of hen harriers *Circus cyaneus* in the UK uplands has been the target of ongoing research for over 30 years. Initially, research focused on the ecological issues (e.g. Picozzi 1978; Redpath and Thirgood 1997; Thirgood et al. 2000a, b, c) but stakeholder consensus on ecological conclusions remains elusive and increasingly the focus has been on social science aspects (Marshall et al. 2007; Redpath et al. 2004; White et al. 2009).

This conflict is primarily between game managers and conservation organisations. The former want more red grouse *Lagopus l. scoticus* in the environment and this aim is perceived as being threatened by the presence of legally protected hen harriers. In contrast, conservation organisations demand full legal protection for hen harriers and want to increase hen harrier populations. Conflicts arise because game managers are believed by many conservationists to continue to illegally remove harriers from grouse moors, and because game managers object to the enhanced conservation activities.

This longstanding biodiversity conflict demonstrates that despite 30 years of ecological science, there are still ecological uncertainties and there is still dispute over the results of science (Marshall et al. 2007; White et al. 2009). The different world views of participants are caused by differences in background and belief and enhanced by land-ownership, power and socio-economic issues. Solutions therefore cannot simply focus on the ecological, but must take into account stakeholder values and perceptions. This conflict varies in intensity locally, with conflict being greatest where the livelihood of game managers is perceived to be most threatened, in areas where grouse shooting contributes a significant income (Marshall et al. 2007).

In this predator conflict, these elements are starting to come into place after several decades and possible solutions are currently being debated and explored in the field (see Anderson et al. 2009; Redpath and Thirgood 2009; Sotherton et al. 2009; Thirgood and Redpath 2008; Thompson et al. 2009). There will need to be flexibility and compromise. In some cases it may not be possible to reach a consensus as to how to move forward and there will be winners and losers. Ultimately, solutions will be found if there is willingness from those with the power to explore all the options and leadership to drive forward management plans.

The conflict over cormorant management

The Great Cormorant *Phalacrocorax carbo* has increased dramatically across Europe in the last three decades. This population increase is considered to be a great conservation success by some people but an ecological disaster for others (van Eerden et al. 2003). The cormorant has many of the hallmarks of an invasive/alien species (e.g. flexible breeding/foraging behaviour, rapid population growth, speedy geographic spread/colonisation) and, whilst it is not one, it is perceived as such by many stakeholders. This conflict is particularly virulent across Europe and there have been periods of high tensions in the UK.

Cormorants, like almost all European wild birds, are afforded legal protection. Their annual post-and pre-breeding migrations mean they are widely distributed across the European continent, particularly during the winter (Carrs 2003). Despite this, the problems they are thought to cause appear to be relatively localised both in space and time.

In association with the cormorant's increasing numbers and geographical spread, many of Europe's coastal and freshwater fisheries (both commercial and recreational) have declined. There is, however, little (if any) rigorous scientific evidence to suggest this relationship is causal (van Dam and Asbirk 1997). The lack of evidence does not necessarily mean that there is no impact of cormorants on fish populations; there are significant time, cost and methodological challenges with collecting sufficient ecological data to quantify the impact. However, human activities, particularly over-fishing, habitat modification and the associated changes in fish community structure, have undoubtedly contributed heavily to fish declines (Carss et al. 2009). For example, one of the ways people have tried to increase fish stocks (in freshwaters at least) and to make their fisheries 'sustainable' is through the artificial stocking of hatchery-reared (sometimes 'domesticated') fish. In many European waterways, hundreds of thousands of these fish are released each year. Many of these hatchery-reared fish have lost their anti-predator behaviour in favour of risk-taking (i.e. feeding and growing) behaviour. Consequently, these fish may be especially vulnerable to predators such as cormorants (Carss et al. 1997). At the same time many artificial fisheries (often with unnaturally high densities of fish) have been established to offer high catch rates to recreational anglers, for payment. Similarly, many European fish farms hold unnaturally high densities of fish in waters lacking cover and much protection from predators. These fish are both more vulnerable than wild ones born and grown under natural conditions and have a higher economic value. Thus losses of fish to cormorant predation are often felt keenly by fisheries interests (Carrs 2003; Carss and Marzano 2005).

The biodiversity conflict here is around the management response to the increased continental cormorant population. Conservationists see a success story in terms of this species' return to 'favourable status', but some fishermen see cormorants as a cause of fish catch declines and demand a reduction in cormorant numbers. There is however a spectrum of potential management approaches; at one end is the immediate adoption and development of site-specific, labour-intensive methods to protect vulnerable fisheries (at certain places and certain times) and, at the other, calls for the reduction of overall cormorant numbers through a coordinated international population cull. At its simplest, the former approach is constrained by immediate cost and the necessity of experimenting with site-specific techniques and the latter by well-founded ecological concerns that a reduction in cormorant numbers (even if achieved) would not result in a reduction in their numbers at those fisheries where protection is most sought (van Dam and Asbirk 1997), and by the lack of political will at the EU level for such an approach.

Characteristics of biodiversity conflicts

A number of characteristics of biodiversity conflicts emerge from the broad typologies and the two examples of conflicts above.

The first is the issue of scale: while biodiversity impacts may be driven by different scales of governance (international, European or national), conflicts are generally localised. Hence, higher densities of cormorants (Carss et al. 2009) or a greater dependence on livelihoods supported by red grouse (Marshall et al. 2007) may increase the likelihood of biodiversity conflict in a particular location. This does not mean to say, however, that all potential stakeholders will be local. Indeed, while sustainability is increasingly being addressed through the integrated concept of social-ecological systems that incorporate social and natural systems (Berkes et al. 2003), there is a potential misfit between the scales of these two aspects (Newig and Fritsch 2009). As such, while biodiversity conflicts may be localised, effective conflict management may not be achieved by working only at the local scale due to the effects of regional, national and international policies and economies.

Second, biodiversity conflicts are often exacerbated both by the difficulties and costs associated with collecting sufficient ecological data and by the communication of those data to inform the debate to the satisfaction of all stakeholders. In the cormorant case study, for example, the actual impact of cormorant predation on fish populations, stocks and catches is notoriously difficult to quantify (Carss et al. 2009). Even when substantial ecological data are collected, these can be mistrusted by some, as for example in the hen harrier case study. In both case studies, there is no consensus on management options supported by science, despite decades of study. So, while the application of new technologies; management practices (Edgar et al. 2005); or spatial planning methods (e.g. Anderson et al. 2009; Bright et al. 2008; Eppink et al. 2004; Matthiopoulos et al. 2008) may provide some potential solutions to biodiversity impacts, they are unlikely to be accepted easily in biodiversity conflict situations.

Third, political and legislative tools may ease biodiversity impacts. For example, agri-environment schemes have been suggested as a policy solution to promote more ‘environmentally-friendly’ farming practices (Riley 2008), thereby acting as a management mechanism to minimise the impacts on farmland biodiversity. However, legislative and political tools can often be at the root of many conflicts (Young et al. 2005). Legislation protecting birds such as the cormorant and hen harrier has brought both case study conflicts to a head. Given the multi-level governance framework operating from the EU level, to countries, to regions, to local areas, to specific sites, the contribution of political, legislative and economic means to biodiversity conflicts is not straightforward. Indeed, in the case of biodiversity conflicts, a broader understanding of the context in which conflicts are embedded will be required before any such solutions can be considered.

This brings us to the fourth, and perhaps most important characteristic of biodiversity conflicts, namely their complexity. Indeed, as was reflected in the grouse-harrier and the cormorant-fisheries conflicts, a vital consideration is the need to acknowledge and understand different world views held by stakeholders, as well as socio-political issues. Biodiversity conflicts do not occur in a vacuum, but arise from a wide range of interacting factors, including biological, economic, social and cultural issues. These wider issues contribute to the manifestation of conflicts and need to be acknowledged and understood better in order to offer more effective management solutions.

Biodiversity conflict management

Biodiversity conflict management approaches emerge from the discussion of characteristics of biodiversity conflicts and from the description of biodiversity conflicts by scientists' experiences, collected during the e-conference. In this section, we consider the role of science and scientists; trust and dialogue; and temporal and spatial scales can have in biodiversity conflicts and highlight the combined role they play in successful biodiversity conflict management.

Science and the role of scientists in biodiversity conflict management

According to one participant of the e-conference, "*clear, rigorously collected knowledge about the biodiversity conflict is vital, otherwise arguments revolve around opinion and anecdote*" (Young et al. 2009b). While this may sound simple in theory, in practice, there are a number of challenges to overcome linked to limited funding, lack of certainty of scientific results, problems with communication between scientists and other stakeholders, and translating the results of scientific enquiry to management practices.

In biodiversity conflicts, scientific enquiry is costly and funding may be difficult to find, particularly if long-term datasets are required. In addition, one of the perennial difficulties is communicating complexity (biologically, socially, culturally, and economically), uncertainty and issues of scale to stakeholders involved in conflicts. Another challenge for scientists is acknowledging the importance of *perceptions* held by stakeholders, either of impacts or other stakeholders (Marshall et al. 2007). Because of these perceptions, managing a conflict will rarely be achieved merely by presenting stakeholders with the results of scientific investigations. An essential criterion for conflict management must be a broad agreement about the parameters of the biodiversity impact and the effects of likely management strategies. However, the ontology and epistemology of scientists and practitioners may differ markedly, so that obtaining trust in the scientific method used to collect and analyse ecological data can pose a challenge. Even when scientists offer their results, there can be very different interpretations of their value or relevance. For example, in the red grouse–hen harrier conflict, earlier responses to ecological data exploring reasons for the decline of red grouse (e.g. lack of heather) were very different between stakeholders. A response from the Scottish Gamekeepers Association stated that "*I find constant reference… to the loss of heather… tedious- it is obvious they are diverting attention from the main problem, which is raptor predation of the grouse*". In response to the same ecological study, a comment from Royal Society for the Protection of Birds was that "*[the study] shows that birds of prey cannot be blamed for the long-term decline in grouse bags….high densities of hen harriers and peregrines made driven grouse shooting economically unviable. The more serious long term problem is loss of good quality heather because of overgrazing which reduces habitat for grouse and can attract high densities of hen harriers*."

Due to the above challenges linked to scientific data, the role of scientists in conflict management is complex. Ideally, scientists should be trusted by all stakeholders who would have involvement in the design and some ownership of the data. Scientists are, however, sometimes perceived to be at the root of many conflicts (Alphandery and Fortier 2001), or seen by land managers and landowners as imposing management options (Chaineux and Charlier 2003). A first step towards increasing the involvement of social and natural scientists and building trust between them and other stakeholders, is for the scientists involved to recognise that they themselves have become stakeholders in the conflict (or at least in its management (Carrs 2003)). A second step is to collect targeted and interdisciplinary data, and communicate the data simply but efficiently. In the case of the cormorant conflict, scientists are able increasingly to communicate ecological complexity and the numerous issues affecting fishery productivity and catches. This communication should not, however, be simplistic. According to one scientist who took part in the e-conference, "*a common cry is 'we do not need science to tell us what we see with our own eyes'*" (Young et al. 2009b). In addition, scientists involved in conflict situations may need to accept that their data may be difficult for stakeholders to understand and accept, and that it may be totally ignored (or be misrepresented), particularly in those situations where politics or legal issues dominate (Carrs 2005). Finally, scientists have a role in involving stakeholders in the identification and testing of new management options (e.g. in Redpath et al. 2004).

To summarise, scientists have a vital role to play in biodiversity conflict management, becoming advocates for the role of science and highlighting its importance in providing objective data. As such, while it is not the job of scientists to impose solutions, scientists need to provide information as to what is likely to happen when stakeholders choose between different scenarios. Improving the quality of information will require stronger interdisciplinary partnerships between natural and social scientists, the latter providing important conceptual frameworks (White et al. 2009) and understanding of the perceptions, role and potential contributions of stakeholders involved in biodiversity conflicts (e.g. Zinn et al. 1998; Weiss 1999). The re-thinking of science towards Mode 2 knowledge production, i.e. context-driven, problem-focused and interdisciplinary (Nowotny et al. 2001) could contribute to a more interdisciplinary management of biodiversity conflicts.

Building dialogue and trust

Conflicts are often drivers of participation (Griffin 1999), as was the case in the implementation of Natura 2000, where the scientifically-driven designation of sites sparked conflicts and led to a push towards 'stakeholder involvement' (Rauschmayer et al. 2009). In this sense, conflicts can be viewed in a very positive way, being an impetus for encouraging dialogue and improving relationships.

Increased stakeholder dialogue is often hailed as a positive way forward in conflict management, leading to a number of deliberative and participatory processes being developed. They include participation, co-management (Chase et al. 2000), and community natural resource management (Kellert et al. 2000). Participation can help improve relationship building between participants, not only between managers and the public, but also between experts and the public (McCool et al. 2000). The process of bringing people together can lead to a deeper understanding of different perspectives and viewpoints thus increasing trust between participants (Parkins and Mitchell 2005). Finally, studies have shown that participation can help minimise interpersonal conflicts, conflicts over particular interests, and conflicts over more fundamental values (Beierle and Konisky 2001; Griffin 1999; Tuler and Webler 1999).

Despite these potential advantages, a number of issues need to be considered in the development of dialogue and trust. As discussed in the e-conference: "*participation and the development of effective dialogue between the main stakeholders is fundamental to moving forward, but is fraught with challenges – who holds the power? Who should lead the discussions? Who should be involved? Who should fund the meetings?*" (Young et al. 2009b). In addition to these practical and power-related issues, a number of possible problems such as 'consultation fatigue' (Richards et al. 2004) and disenchantment (Mosse 2001) can develop and can lead, for example, to increased mistrust and suspicion amongst stakeholders (Mutamba 2004). These arguments have led certain authors to imply that, if poorly implemented, rather than acting as an empowerment tool, deliberative and participatory processes may only be a means to project implementation (Mahanty and Russell 2002). Worse still, some authors contend that deliberative and participatory processes can be a highly formulaic and empty process dominated by pragmatic policy interests (Mosse 2001).

A first step in building dialogue and trust is that all sides recognise the need for increased communication. In the red grouse-raptor conflict, effective dialogue took many years to get started. A representative forum, the Moorland Forum, permitted discussion amongst representatives for several years. However, further progress was only made through the main stakeholders funding an independent facilitator to organise and run the meetings, where all partners had equal status in discussions.

A second step is addressing issues of power, interest and representation, which are crucially important in any situation in which dialogue ensues (Richards et al. 2004). Delays in addressing the red grouse-hen harrier conflict were partly due to the lack of interest of a major stakeholder. It is crucial in certain situations that the appropriate policy makers/advisers are actively involved and are willing to explore solutions, as they hold considerable power (Richards et al. 2004). However, it is also important that dialogue is not dominated by certain interests. A diversity of views in a conflict, such as those identified in the red grouse-hen harrier conflict (Marshall et al. 2007), provides a challenge for effective representation of views on a national forum. This is further complicated in large-scale conflicts such as the cormorant-fisheries situation where dialogue has to be undertaken on a continental scale. While dialogue is obviously important, it thus requires careful consideration of who the so-called 'stakeholders' are, and the need to involve and to exchange information with all interested parties, across local and national scales.

Scientists have a role to play in improving dialogue in conflict management situations by gaining in-depth knowledge of who the 'stakeholders' are, how best to involve them and what their role might be. Concurrently, whilst building trust is a critical part of effective dialogue (Richards et al. 2004), there is little documentation of how trust between stakeholders, including scientists, has been developed and maintained in previous conflict management cases. A role for scientists would be to explore the development and role of trust by gathering (with the help of practitioners) and evaluating wide ranging approaches to conflict management.

Considering the impact of temporal and spatial scales on conflict management

Making real progress in conflict management takes time: time for the science to provide useful data, time for the facilitators to build up their knowledge of the ecological and social system and time for trust to develop between parties and individuals. Many of the solutions to the cormorant conflict, for example, are likely to be long-term but this does not address the real, urgent problems that many feel they face. It is therefore important to ensure that stakeholder expectations are managed throughout the conflict management process and that progress is being made, however small, so that people continue to feel the need to continue their involvement. An important aspect to take into account, particularly in terms of scientists' involvement in conflict management, is that conflict management needs to be accepted as an ongoing process. As such, the evaluation or monitoring of conflict management strategies is an important aspect of the conflict management cycle (Niemela et al. 2005; Young et al. 2005), and one which should be better understood and integrated into conflict management strategies. Some biodiversity conflicts may in fact never be resolved fully and always require negotiation and dialogue amongst stakeholders.

The issue of spatial scale is also integral to many biodiversity conflicts. Many species range over large trans-boundary geographical areas and often cause problems at the local scale. Also, the environmental scale which is best suited to a particular species might not be the ideal scale at which to implement management actions. As one contributor to the e-conference remarked: "*to be effective and successful, biodiversity management - at least in many cases - needs to be adjusted to the regional bio-geographical level. However this is problematic because the politico-administrative limits do not follow the bio-geographical units*" (Young et al. 2009b). Ultimately, scientists have an important role in understanding the impact of spatial and temporal scale on the perceptions of conflicts and their management. In addition, research will increasingly need to focus on integrating better the scale of governance and the ecological scale of conflicts.

Conclusions

Biodiversity conflicts emerge from biodiversity impacts, usually in response to an effect on human livelihoods, the introduction of a new policy or other triggers. Conflicts are essentially differences in peoples' views on the source and scale of 'the problem' and possible management options. It is essential to acknowledge and manage biodiversity conflicts in view of their perceived and actual effects on biodiversity conservation, ecosystems and livelihoods. While more work needs to be done on the identification, understanding and management of these conflicts, a first step is to develop a common understanding of 'biodiversity conflict' in academic, policy and practitioner contexts, an issue still not addressed currently.

In order to inform policy on biodiversity conflicts and ways to manage them, the evidence-base should rely on a variety of information sources. As such, any future work on reviewing biodiversity conflicts, and ways of managing them, should aim to draw information directly from practitioners, scientists (both natural and social) and other stakeholders, including land managers (including country agencies) and decision-makers. This places a responsibility on social and natural scientists to work with a range of stakeholders towards understanding the contexts of biodiversity conflicts (social and ecological) and engage as active stakeholders to suggest options for sustainable management strategies.

Biodiversity conflicts are likely to become more widespread because of the manifold and increasing pressures on biodiversity (e.g. agriculture, forestry, energy development). Furthermore, the need to halt potentially catastrophic biodiversity losses may cause further biodiversity conflicts, therefore a shift towards participatory methods of governance that address stakeholder concerns may be a way to mitigate such future conflicts. Conflicts should be seen as an integral component of biodiversity conservation; currently conflicts are perceived as an obstacle and so are often unaddressed in biodiversity management. Conflicts need to be acknowledged and actively addressed in biodiversity conservation. To address such conflicts, however, their complexity—temporal and spatial scale, the role of science, policy and legislative effects—needs to be acknowledged and understood better. Conflict management strategies clearly require an interdisciplinary approach building on the experience of practitioners, natural and social scientists and local actors.

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