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Using scenarios to explore UK upland futures

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Abstract

Uplands around the world are facing significant social, economic and environmental changes, and decision-makers need to better understand what the future may hold if they are to adapt and maintain upland goods and services. This paper draws together all major research comprising eight studies that have used scenarios to describe possible futures for UK uplands. The paper evaluates which scenarios are perceived by stakeholders to be most likely and desirable, and assesses the benefits and drawbacks of the scenario methods used in UK uplands to date. Stakeholders agreed that the most desirable and likely scenario would be a continuation of hill farming (albeit at reduced levels) based on cross-compliance with environmental measures. The least desirable scenario is a withdrawal of government financial support for hill farming. Although this was deemed by stakeholders to be the least likely scenario, the loss of government support warrants close attention due to its potential implications for the local economy. Stakeholders noted that the environmental implications of this scenario are much less clear-cut. As such, there is an urgent need to understand the full implications of this scenario, so that upland stakeholders can adequately prepare, and policy-makers can better evaluate the likely implications of different policy options. The paper concludes that in future, upland scenario research needs to: 1) better integrate in-depth and representative participation from stakeholders during both scenario development and evaluation; and 2) make more effective use of visualisation techniques and simulation models.

1. Introduction

Upland landscapes have been the subject of policy debate for decades. In the UK, they are typically managed under livestock systems that would be commercially unviable without large government subsidies. However, these regions are highly valued for biodiversity, carbon storage, water supply, physical beauty, game shooting and other recreational opportunities [1]. Uplands around the world have experienced significant and often rapid socio-economic changes in recent years. In the EU in particular,

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uplands are facing an uncertain future due to new national, European and international policy. For example, reforms to the European Union's Common Agricultural Policy (CAP) have 'decoupled' subsidies from agricultural production, and this has uncertain consequences for farmers, other land managers, and the rural environment, the character of which owes much to millennia of management. Changes in land use practices may also be required in many upland catchments if countries are to meet the requirements of the EU Water Framework Directive and the Kyoto Protocol is a potential driver that has only recently been recognised as an opportunity by policymakers and land managers. The voluntary carbon offset market may provide additional income where agricultural management increases carbon stored in soils [2]. If further links between water discolouration (caused by dissolved organic carbon, DOC) and land management practices are shown, water companies may also require those managing their land for grouse and sheep to make significant changes to their practices. In the UK, a number of conservation organisations are interested in "re-wilding" dry heath and blanket bog habitats that are currently managed for grouse and sheep. The ecological consequences of such a policy are unclear, especially under future climate change, and might possibly lead to scrub and forest ecosystems encroaching onto marginal blanket bog habitats. Natural England are increasingly requiring managers of blanket bog Sites of Special Scientific Interest (SSSI) to reduce levels of managed burning, and this adds further uncertainty for both the local ecology [3] and the livelihoods of those who generate income on blanket bog habitats. These policies are being implemented in the context of ongoing socio-economic (e.g. demographic) and environmental (e.g. climate) change. In this context, decision-makers from both policy and land management circles are keen to understand how potential future changes may affect them, and how they can best adapt to maintain upland goods and services.

As we gaze into an uncertain future, traditional modelling approaches, which use recent trends to make future predictions, are proving to be a poor basis for policy [4,5]. As a result, scenario studies are increasingly being used to help decision-makers better understand, anticipate and respond to the sorts of dynamic and uncertain futures that uplands face. Although the number and sophistication of scenario-driven methods have increased substantially in recent years, there have been few comparative analyses of outputs from such exercises. The British uplands offer a unique opportunity to do this, due to the significant number of scenario studies that have been conducted for this system. Taken separately, these studies provide a fractured picture of what the future may hold for UK uplands. However, by drawing together the results from these studies, using a combination of literature review and interviews with researchers involved in conducting the studies, this paper aims to provide a more coherent picture of what the future might hold. To do this, the paper aims to make an empirical and methodological contribution: i) the empirical contribution is to draw together all the scenarios published to date for UK uplands, and evaluate which scenarios are perceived by stakeholders to be most likely and desirable for this important socio-ecological region; and ii) the methodological contribution is to assesses the benefits and drawbacks of the scenario methods used in the UK uplands to date.

2. Background: UK uplands past and present

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The UK uplands have been grazed by livestock for thousands of years. Mesolithic hunter-gatherers contributed to woodland clearance in areas that were originally forested, to assist their foraging and stalking. In combination with pedogenesis and climate change this assisted the spread of blanket peat [6]. Iron Age and Medieval farmers continued to clear more of the remaining woodland, and the moorland edge advanced and retreated in response to changes in demographic, climatic and commercial pressures. Although the medieval wool industry was well-developed in many upland areas, prior to the 19th Century, much hill-farming was less intensive and did not take place year-round [7]. Economic and social incentives led in the 19th and 20th century to growing flocks and in some places overgrazing by sheep, subsequently combined with conflicting demands by grouse-moor owners, ramblers, and foresters. While in the second half of the twentieth century sheep numbers vastly increased, rising input costs and lack of skilled labour meant that some more extensive forms of management, like shepherding, became less widespread. The character of the uplands has thus been shaped by many centuries of management, many driven by subsistence and economic factors. Today, the latest changes to agricultural policy and the changing way that uplands are perceived and valued, pose challenges for the future of these landscapes.

The tenor of agricultural policy in Britain over the last 60 years was firmly set by the 1947 Agricultural Act that aimed to meet the nation's need for indigenous food at reasonable prices with fair rewards to farmers and agricultural workers. This began a period of agricultural enhancement promoted by guaranteed prices, farm capital grants, publicly funded research and free advice to farmers. In 1973, when Britain joined the EU, the Common Agricultural Policy (CAP) shared similar aims but had a somewhat different funding mechanism. Both policy regimes included incentives for upland farmers to increase output by improved grassland management and increased stocking rates and animal liveweight. As a result, the Peak District alone saw a 275% increase in sheep numbers between 1950 and 1976 and there was a further dramatic increase in the 1980s [8]. High, guaranteed prices for lamb encouraged farmers to graze more sheep on moorlands. Despite attempts to address market imbalances though 'headage' quotas and payments for 'extensification' in the mid 1980s, major reform did not begin until the early 1990s. The most recent CAP reform began in 2003. It seeks to remove production-based subsidies and replace them with decoupled direct payments attached to cross-compliance with environmental and health standards and "Good Environmental and Agricultural Conditions" [8,9]. In response, upland stocking rates decreased by 8% between 2004-2006 in the UK and there is now a move towards less intensive sheep farming on moorlands coupled with more intensive farming in valley bottoms [8]. It is still unclear whether the CAP reforms and other schemes will encourage management that can deliver the desired ecosystems and economic goods and services. For example, in areas that have been overgrazed for decades, habitat recovery may require more active interventions aimed at increasing *inter alia* pasture biodiversity than just a reduction in sheep numbers.

Upland farmers can receive further payments through Less Favoured Area (LFA) (where proactive capacity is limited) and Environmentally Sensitive Area (ESA) schemes, designed to supplement upland farming incomes and maintain distinct landscapes. Since 2001, farmers have received payments linked to good farming practice rather than payments per head of livestock. ESAs aim to establish sustainable stocking rates in sensitive uplands. The scheme is voluntary and farmers are paid to reduce their stock to between 0.1-0.225 livestock units per hectare and remove 25% of their stock from the moors between October-February [10]. Although

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existing ESA agreements are beginning to reach the end of their term, they have now been replaced by a two-tier "Environmental Stewardship Scheme" [8] where farmers receive subsidy for developing and maintaining agro-environmental plans.

These policies to protect and enhance upland ecosystems are important. Uplands support a range of internationally rare species, including birds like dunlin and peregrine. Red grouse are economically important for game shooting and increasingly important for conservation. The species was added to the UK Biodiversity Action Plan in 1997 because their populations had declined by more than 25% in the last 25 years. Due to their biodiversity value, many uplands are protected under national and international conservation law. In the UK, 16% of uplands are designated as SSSIs. In 2003, English Nature suggested that only 14% of moorland SSSIs in England were in favourable condition due to overgrazing and inappropriate burning [11], and management has therefore been prescribed to maintain or improve current conditions.

A critical aspect of this debate is the role of rotational burning which is used by land managers to maintain mosaics of heather at different stages of maturity to provide habitat for grouse, an important game bird. Although historically practiced around the world, this management practice is now unique to Britain and Ireland. Regulations regarding burning extend back to the medieval period, at least, with an Act of Scottish Parliament referring to "muirburn" passed in 1400 [12]. Managed burning has continued to this day, with codes to control when and how moors can be burned (e.g. the Scottish Muirburn Code and the English Heather and Grass Burning Code and Regulations). Appropriate burning of heather moorland can protect against wildfire risk by reducing the quantity of combustible material while creating a mixture of habitats that improve biodiversity. However, in some areas, long-term grouse management may have converted blanket bogs into heather moorland and so reduced diversity of shrubs with a reduction in the moss and lichen layer [e.g. 13]. The impact of grouse moor management on breeding moorland birds is unclear. Whilst heather burning and predator control are likely to benefit some species (e.g. Golden Plover favour short vegetation), others (e.g. species requiring tall heather and the predators themselves) are likely to be disadvantaged. In reality, burning rotations and access limitations on most grouse moors mean there is a mosaic of areas burned at different times, and some areas are never burned, providing habitat for a range of species. Very little is known about the effects of burning on peat erosion, water quantity and quality [14]. However, recent data suggests that inappropriate burning (hot as opposed to cool fires) drives changes in vegetation patterns, and the vegetation then has a strong influence on water quality, in particular water discolouration [15].

Water discolouration is a growing problem in the UK with some studies showing a 65% increase in DOC over the last 12 years [16]. While water running off peat catchments containing drains is more discoloured than undrained catchments, the relationship with other forms of land management remains unclear [14]. The Water Framework Directive, through the use of integrated River Basin Management Plans, aims to protect and improve the environmental status of all river catchments in the EU, promote sustainable use, and reduce the effects of floods and droughts so that all catchments achieve 'good status' by 2015 [17]. Challenges to achieving good status include effects of changing agricultural subsidies on land use, the uncertain impacts of climate change and scientific uncertainly around what controls water discolouration in the uplands and how it can be managed.

Many degraded upland peatlands currently lose more carbon than they absorb through gaseous and fluvial pathways. Peatlands represent one of the few long-term

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stores of carbon that can accumulate on the land surface through good management, so the identification and restoration of damaged peatlands to functioning ecosystems could have significant beneficial impacts. Models suggest that across the UK as much as 400,000 tonnes of carbon a year could be stored in this way [18] or the equivalent of the carbon emissions of 2% of car traffic in England and Wales per year.

Finally, the importance of the tourism industry to the upland economy should not be underestimated. In 2005 £9.4 billion was spent on tourism and leisure services in England. During the Foot and Mouth crisis in 2001, when much of the uplands were off limits, it is estimated that the tourism industry in the UK as a whole lost as much as £8 billion and many businesses either closed or were severely scaled back as a result [19].

3. Study Design

We undertook a review of academic and grey literature and identified eight studies that had used scenarios to explore UK upland change [20]. It should be noted that the majority of scenario studies that were identified refer to English and Welsh uplands, and there are quite different issues in different parts of the UK. For example, in Scotland large areas of the uplands are managed for grouse and deer stalking with agriculture having relatively less importance compared with England. The identified studies were systematically compared to elucidate methodological differences, and to summarise differences in the content of the scenarios they developed. Where stakeholders were consulted, the scenarios that they deemed to be most and least desirable were assessed. Alongside this analysis, nine semi-structured interviews were conducted to gain opinions on the use of scenarios and to better understand the scenarios used in each study. Interviewees were chosen on the basis of their involvement with the scenario studies and debates surrounding upland futures. The interviewees included academics, upland policy advisors from major NGOs and government agencies, representatives from Department for Environment, Food and Rural Affairs and the National Farming Union.

Interviews were transcribed and analysed using Grounded Theory Analysis. Grounded Theory is a qualitative method used to systematically analyse texts such as interview transcripts to construct theoretical models [21]. This is performed by reading interview transcripts with specific questions in mind and coding passages with keywords. By sorting quotes using keywords, it is possible to develop an understanding of how different respondents perceive the interaction of different phenomena. The whole process is carried out iteratively to ensure internal consistency which helps increase the outcomes' reliability and validity. Finally, the resulting manuscript was sent to four stakeholders representing different interests in different parts of the country for pre-review and where relevant, co-authorship.

4. Empirical contribution: the Future of the UK Uplands

The empirical contribution of this paper draws together and integrates the wide range of information currently available about possible futures for UK uplands. The following section synthesises findings from each of the studies under headings that follow the quadrants in Figure 1.

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An overview of each study is provided in Table 1. Table 2 lists the wide range of possible futures for UK uplands described in the eight studies, showing their relative desirability according to the stakeholders who were consulted in each study (for information about methods used by studies to do this, see section 5). Despite following very different approaches, the majority of scenarios developed in these studies fall into four key groups (Figure 1). Figure 1 shows how the scenarios differ along an environmental-economic continuum, depending on the level of support for a pro-environment policy agenda, and varying levels of financial support for farmers.

Although this summarises most scenarios well, it does not capture all the scenarios that were investigated. For example, study 5 considered changes in food markets and prices, as well as changes in yields under different scenarios. Study 8 considered scenarios based on drivers such as demographic change (leading to changes in labour availability), climate change, and the effects of a grouse shooting ban on upland management. This reflects the diverse range of concerns about the future that were expressed by stakeholders through semi-structured interviews during study 8. Such an approach may also capture "surprise" scenarios, which may help prepare stakeholders for, and increase resilience, to unexpected future events [33,34]. For example, although not deemed very likely within the study period, stakeholders in study 8 suggested the expansion of arable land into uplands (due to global food shortages) as a surprise scenario that would have a significant impact.

[insert Figure 1 around here]
[insert Tables 1 and 2 around here]

4.1. Withdrawal of agricultural management and re-wilding

All the studies included a scenario where financial support was withdrawn from upland agriculture, leading to the withdrawal of agricultural management and/or farm diversification (the lower two quadrants in Figure 1). In both these scenarios, land is most likely to be abandoned on the poorest, highest and most remote land. Without alternative support, re-wilding scenarios suggest that as the amount of land entered into agri-environmental agreements declines, farms will go out of business and land will be abandoned. It is anticipated that under this scenario, farmland may be replaced by conservation management and/or reforestation through planting or natural regeneration.

In studies 1, 2, 4, 6 and 7, where stakeholders were invited to express an opinion, the re-wilding scenario (without any alternative funding for conservation programmes) was deemed to be the least desirable future for UK uplands. Study 6 described this scenario (which they called the "liberalisation" scenario) as "a nightmare for biodiversity" that would be hard to reverse, with negative impacts on biodiversity, landscape amenity value and historic features for years to come. Study 5 however, identified environmental benefits arising from this scenario (which they called 'world markets') due to the release of land from farming in the lowlands and particularly in the uplands. Using spatially differentiated modelled results, Study 5 identified reductions in stocking rates, farm incomes and employment associated with agricultural abandonment in the uplands. Using the HillPlan model [35], they predicted that a reduction in grazing pressure under re-wilding might improve upland species composition in the short-term, leading to an increase in heath communities and reduction in bracken. In the long-term, however, other studies recognised that a

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significant reduction in grazing pressure may cause many heath communities to be replaced by scrub and eventually be converted into forest. Given the international significance of these habitats for biodiversity, this was a major concern for most of the stakeholders that were consulted in the studies. In addition, during the early phases of this change, ecosystems are likely to experience an increase in biomass and hence fuel-load, and this may increase accidental fires [36]. These may cause significant, sometimes long-term damage to upland soils and plant communities.

Perhaps due to the negative implications and the perceived political unacceptability of re-wilding for most stakeholders, it was believed to be the least likely scenario to occur. However, this view was not shared by everyone. Sotherton *et al.* [1] explore the public spending priorities that upland farming will have to compete against in the future. They question whether future generations will concur with the stakeholders consulted in the studies reviewed in this paper, given ever-increasing pressures on Government to raise budgets for health, education, pensions and security. Although the socio-economic effect of withdrawing financial support is relatively clear, the environmental implications are less clear-cut. Many conservationists favour re-wilding certain upland habitats, particularly blanket bogs [36], to maintain biodiversity and encourage certain species (e.g. raptors). Although the cessation of grazing and burning on dry heath would almost certainly increase scrub, leading to eventual reforestation, the effects are less clear cut on blanket bog. Evidence about the effect of burning on blanket bog plant diversity is contradictory [3] and a combination of historic management and climate change may alter the future hydrology of blanket bogs, making them respond to changes in management in a similar way to dry heaths [36], with implications for carbon sequestration and water quality, for example. As such, there is an urgent need to understand the full implications of this scenario, so that upland stakeholders can adequately prepare, and so that policy-makers can better evaluate the likely implications of different policy options.

Most studies agreed that any process of re-wilding would most likely consist of some form of active conservation management (including the maintenance of fire breaks) replacing sheep or grouse management, rather than land being completely "abandoned", and that this would need to be facilitated through some kind of alternative funding. Study 6's "managed change for biodiversity" scenario suggests that change may be facilitated through funding equivalent to current levels, targeted at nature conservation in the form of "cross-compliance" where farmers would need to undertake conservation activities to continue to receiving government support [27].

Stakeholders in Study 8 perceived that a ban on burning blanket bog habitats, and hence withdrawal of active management from more limited areas, was more probable than the kind of broad scale re-wilding described above. Such a policy would address many of the concerns and priorities of conservationists, and matches the kind of tighter regulation that Natural England lobbied for during Defra's 2007 review of the Heather & Grass Burning Code.

4.2. Significantly reduced levels of hill farming supported by diversification

In the studies, re-wilding scenarios were often coupled with income diversification (though they were sometimes presented separately; bottom-right quadrant in Figure 1). Under the reduced hill farming scenario, it is assumed that there would be support from a range of alternative enterprises including off-farm income. New sources of income could include, for example: tourism, recreation and leisure activities (e.g. Bed

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and Breakfast establishments); direct marketing and processing of local produce (e.g. "fell-bred" lamb); alternative crops or other products (e.g. planting bioenergy crops in upland valleys); and new business ventures (e.g. wind farms). The associated fall in the demand for agricultural inputs and services such as feed, fertilizers, vets and auction marts, would be offset to some extent by demands for alternative inputs and services associated with new enterprises and land uses under this scenario. Studies differ over the extent to which support from diversification would lead to a reduction in the number of farms and livestock in UK uplands. Where this leads to abandonment of land for agricultural purposes, natural regeneration to scrub and forests, and management for nature conservation would be anticipated.

Although varying levels of diversification entered many of the scenarios developed by the studies reviewed here, only study 4 developed a scenario focussed specifically on the effects of diversification. Compared to the other scenarios evaluated in study 4, the diversification scenario was deemed to be most desirable, but on the assumption that it would lead to a lower impact on farm and livestock numbers than "reduced levels of hill farming based on cross-compliance with environmental measures" (section 4.4). The "local stewardship" scenario developed by study 5 included significant diversification, with agricultural support reflecting local needs, self-reliance and local social and environmental objectives. This goes beyond the diversification scenario of study 4 to suggest greater contact between consumers and producers through local markets and brands, and farmer co-operatives and marketing schemes designed to add value and raise prices. This could, however, mean that due to relatively low yields, the agricultural area could increase, with the dominance of extensive systems on mainly family farms. Although desirable from a social perspective, potential environmental benefits could be compromised by the relatively high occupancy of land, and significant increases in stocking rates in the uplands.

Many farming households already have more than one source of income. A study conducted by the [37] found that in the 1990s nearly 60% of farming households were engaged in additional activities outside conventional farming, such as speciality crops, accommodation, recreation and leisure. However, diversification was found to be less likely on smaller farms and less likely in uplands. For upland farmers a remote location will restrict their ability to exploit opportunities in the tourism and leisure sectors. At the same time in the last ten years the demand for leisure in the countryside has fallen [19]. The danger is that encouraging more farmers to diversify into the tourism industry may not be sustainable if they are competing for a decreasing number of visitors. Location may also limit the ability of farmers to take advantage of the growing biofuels industry. Poor soils, high rainfall and difficult access mean that most upland farms, particularly those inside LFAs, are unsuitable for biofuels at the present time. Marketing local produce may provide the best opportunity for upland farmers to increase the value of their products. Currently the market is small and although there is strong interest it has not yet been translated into a change in buying habits for most people. It requires strong, dynamic and committed farmers to make it a success but there is strong evidence of a positive impact for small producers [38].

4.3. Continued levels of hill farming supported by pre-reform Common Agricultural Policy style subsidies

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Although deemed unlikely given current policy trajectories, this scenario assumes that it would be possible to halt (and possibly reverse in some areas) the existing trend towards declining upland farms, livestock and labour availability. It assumes that the area of land used for hill farming and entered into agri-environmental agreements will remain largely unchanged from current levels, with minimal shifts towards alternative land uses such as forestry. Diversification into tourism and recreation would continue at current levels, with limited levels of direct marketing and processing, and the majority of farm incomes would come from agricultural production. There would be limited controls on agro-chemicals and farming practices on environmental grounds. There would be a focus on commercial outputs and production with relatively intensive farming to provide self-sufficiency.

As the scenario that most closely represents past and current conditions (as opposed to what is deemed most likely to happen – see section 4.4), it seems likely that this should have been one of the most preferred scenarios. There is a well developed literature about "status-quo bias" that explores why most people prefer the status-quo to change [39]. Various arguments are proposed, including people's natural aversion to risk and the unknown. However, this bias cannot be assumed: Study 5 ranked this protectionist oriented scenario high in terms of production and social benefits, but relatively low on economic and environmental performance. This scenario required continuation of 'deficiency' payments in order to compensate farmers for low market prices. However, in the last year world prices for rice and wheat have seen sharp increases and there are many in the agricultural sector who believe that this may be a precursor for increasing prices across the board, including livestock, and a return to more intensive agriculture. In a situation where livestock prices reflect the costs of inputs and give farmers better profit margins then such a "status-quo" scenario may well be preferred.

4.4. Reduced levels of hill farming based on cross-compliance with environmental measures

Most of the stakeholders who were consulted believed that government financial support would continue in some form for upland farming in the future. Given the growing prominence of environmental concerns in policy-making, a scenario where reduced levels of hill farming based on cross-compliance with environmental measures was deemed by stakeholders to be the most likely to occur (top left quadrant in Figure 1). Despite a reduction in hill farm production, this scenario would contribute to local, regional and global ecosystem goods and services, including a comprehensive approach to the minimisation of diffuse pollution from agriculture and an emphasis on the multi-functionality of upland landscapes. However, there could be significantly fewer farms. Although there would be some amalgamation into larger farms, a limited number of family farms would remain viable. It is also assumed that large tracts of land (concentrated in the highest and most remote areas) could cease to be grazed or managed in any way for agriculture, where some afforestation and management for nature conservation may occur. The demand for agricultural inputs and services would decline, offset to an extent by demand for new goods and services to support diversification.

Most of the projects reviewed here also agreed that some level of continued public support for hill farming would be the most desirable future scenario. Study 2 came to this conclusion on the basis of environmental criteria alone. However, other

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studies came to the same conclusion using broader criteria. For example, the "global sustainability" scenario in study 5 scored highest on environmental, social and economic criteria on the basis of simulation model outputs. Initially developed by the UK Foresight programme [40,41], this scenario consisted of a low intervention, market-oriented regime, with targeted sustainability "compliance" requirements and programmes. Critically, this scenario, which included bio-energy cropping, involved high occupancy of lowland areas such that the demand for upland livestock production remains relatively strong. Similarly, study 7 found that members of the public in the Southern Uplands were most willing to pay for landscapes where "Environmentally Sensitive Area" schemes had significantly reduced grazing levels. Like many of the scenarios in this group, these scenarios broadly match the emerging funding regime under CAP reform, with the Single Farm Payment requiring hill farmers to comply with various environmental and other standards and opportunities for additional funding linked to environmental work through the Stewardship scheme. On the other hand, study 6 estimated that this scenario (their business as usual scenario, assuming continuing trends) was significantly more expensive than the complete withdrawal of government support for upland agriculture. They also concluded that this scenario would provide fewer biodiversity benefits than re-wilding, whether re-wilding was supported financially through cross-compliance (their "managed change for biodiversity" scenario) or not (their "liberalisation" scenario).

5. Methodological contribution: comparative analysis of scenario methods

The significant number of scenario studies conducted to date in UK uplands, each using different methods, provides an opportunity for comparative analysis in this final section of the paper. It starts by comparing the temporal, geographical and thematic scope of the scenarios developed. It then covers methods: comparing methods for identifying stakeholders; the extent to which stakeholders were engaged at different stages of scenario development; and methods to visualise, explore and elaborate scenarios in more depth. It concludes by discussing the limitations of the methods used, and makes recommendations for future scenario development for uplands.

The time horizons covered by these projects ranged from less than 10 years into the future in study 1, up to 2050 in study 5. Although all focussed on UK uplands, some were restricted in their geographical scope (e.g. to England or Cumbria) and in the issues or stakeholders they targeted.

Table 3 shows the range of different methods that were used to create the scenarios and assess their implications in these studies. Choice of stakeholders may affect the outcome of scenario studies, especially when involved in both scenario development and evaluation. Although all the studies reviewed here identified farmers, other upland stakeholders appeared to be selected on a more *ad-hoc* basis by most research teams (only studies 6 and 8 identified stakeholders systematically while other studies did not always specify the stakeholders involved in the study). No individual study identified all the categories of upland stakeholder that had been identified between the studies. However, studies 1 and 8 identified most categories (7 and 8 respectively compared to an average of 4.5), including water companies, grouse moor managers and forestry. These may represent significant omissions from the other six studies, given the significant economic role of uplands as the main source of potable water for the UK, the role of grouse moor management in maintaining heather

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moorland in many uplands, and the significance of forest cover in other uplands. Although many of the interviewees suggested that members of the general public should be involved in scenario evaluation, very few of the studies actually involved representatives from the general public. One of the problems of involving stakeholders in evaluating scenarios was illustrated by Study 7, where respondents displayed a preference for the *status-quo* over scenarios that involved change [*c.f.* 39]. It may also be questioned whether participants always possess sufficient knowledge to predict environmental and ecological changes in this complex system, hence a requirement for a varied range of perspectives and expertise in the planning of scenario approaches.

[insert Table 3 around here]

Stakeholder engagement in the scenario studies reviewed here typically took place during scenario development but was also used to evaluate scenarios in some studies (Table 3). The depth of consultation varied from a single workshop (e.g. studies 3 and 5) to a combination of workshops and in-depth interviews (e.g. study 8). The most participatory approach was followed by study 8, where scenarios were developed from a combination of grounded theory analysis of interview transcripts and literature review, which they then evaluated in workshops with stakeholders. Each workshop followed a three-step process: i) evaluating the likelihood and impact of individual scenario components; ii) evaluating the likelihood and impact of full scenarios (consisting of the components evaluated in the previous step); and iii) discussion of possible other scenarios not considered.

A range of techniques was used to explore and elaborate scenarios in greater depth. Economic valuation was used by studies 2 and 7 to develop scenarios with greater emphasis on economic impacts. Study 8 went a step further by considering a range of non-economic indicators using an Agent-Based Model to simulate how land managers are likely to respond to different scenarios. Such models represent human decision making by deriving "rules of behaviour" from the actual experiences, opinions and perceptions of land managers ("social agents") through interviews. By examining the knock-on effects of likely land manager behaviour on the environment, it should be possible to provide more realistic computational simulations of different scenarios. Study 8 was also the only study that integrated simulation models with stakeholder participation [30].

Visualisation techniques are sometimes used to communicate scenarios to stakeholders. For example, digitally manipulated photographs were used in study 7 to communicate the effects of varying subsidy levels on ecological succession and biodiversity. However, visualisation techniques pose the risk of visual bias. Aspects of scenarios that can easily be represented visually (e.g. land cover change) may receive more attention from focus group participants than other aspects (such as cultural or demographic change).

The limitations of scenario studies are well documented [e.g. 42,43,44] and were emphasised by those interviewed for this research. For example, there is a danger that decisions may be biased by scenarios that lack a sufficient evidence base, downplay uncertainty, or that do not consider sufficiently different time-horizons or perspectives. Scenarios may lack transparency if they do not make their assumptions explicit. For example, respondents may fail to differentiate between different upland habitats and regions, assuming that a scenario may have similar effects across both. It may also be difficult to effectively communicate the levels of uncertainty associated

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with different scenarios, for example due to their dependence on links with external systems e.g. global food markets. The choice of criteria against which scenarios are evaluated may also bias the outcome, although there was no evidence that this occurred in the studies reviewed above, since those using environmental criteria alone favoured similar scenarios to those using environmental, social and economic criteria.

Although it is difficult to generalise from so few studies, more in-depth participation from stakeholders appeared to broaden the scope of the scenarios developed. However, without systematic and representative stakeholder selection, there is a danger that participation may bias results [29]. Skilled facilitation is also necessary to ensure stakeholders with vested interests do not bias outcomes, and to ensure balanced representation of views from all interested parties. Although computational simulation models can enhance detail and add a predictive component to scenario development, there is a danger that these are seen as a "black box" by stakeholders, reducing scenario credibility [45]. Even with involvement from stakeholders during model development (e.g. Study 8) computational models to some extent always remain a black box as the internal logic, assumptions and shortcomings are only known to the modeller [30]. Land managers who have developed a good understanding of their actions and consequences are asked to believe that the model represents their 'stylized actions' – which requires a considerable amount of trust on the part of stakeholders. To involve stakeholders in the model development process, referred to as mediated modelling, might help to reduce this problem [30].

6. Conclusion

Uplands around the world are facing significant socio-economic and environmental change and decision-makers need to better understand what the future may hold if they are to adapt and maintain upland goods and services. Although the impacts of such exercises on policy are notoriously hard to quantify [46], scenario exercises of the sort explored in this paper offer upland managers, policy-makers and stakeholders a useful tool to evaluate future practice and policy options in order to prepare for different futures. While the case studies reviewed in this paper mainly focus on UK uplands, scenario development has the potential to inform policy and strategy in uplands throughout the EU [27].

On the basis of the methods comparison in this paper, it would appear that upland futures research could better integrate in-depth participation from stakeholders during both scenario development and evaluation in order to explore the range of futures that really concern the people who live and work in these environments and those that enjoy their leisure time in the uplands. In doing so, systematic and representative stakeholder selection is essential to avoid biasing results. To date, few studies have used visualisation techniques in uplands, but these methods must be used with care to avoid visually biasing results.

Although it is difficult to directly compare the scenarios from the studies reviewed here, we can extract a number of common threads that stakeholders were particularly concerned about. Figure 1 depicts the main drivers, on two axes, that show how most of the scenarios fall into four key groups. Stakeholders agreed that the most desirable and likely scenario would be a continuation of hill farming, albeit at reduced levels, based on compliance with environmental measures. The least desirable scenario was a complete withdrawal of government financial support for hill farming. Although this was deemed by stakeholders to be the least likely scenario, it

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warrants close attention due to the significance of its implications. There is an urgent need to understand the full implications of this scenario, so that upland stakeholders can adequately prepare, and so that policy-makers can better evaluate the likely implications of different policy options. This will require further interdisciplinary research and collaboration between researchers and stakeholders.

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Table 1
Overview of UK upland scenario studies

Project Title	Project Team & Duration	Scenario Time Horizon	Description	Reference
1. Consultation on the Future Uplands Reward Structure	Defra, 2006	2007-2013	Scenarios focussed on options for future structure of the Uplands Reward Scheme to help inform policy decisions in England and Wales	[22]
2. Economic valuation of environmental impacts in the SDAs	Eftec Consultants funded by Defra, 2005	2007-2013	Scenarios focussed on different economic effects of changes in SDA environmental characteristics arising from changes in Less Favoured Area support in England and Wales	[23]
3. Assessment of CAP reform and other key policies on upland farms and land use implications in SDAs and DAs in England	Cumulus Consultants, IEEP and CCRU funded by Defra, 2005	2007-2013	Designed to supplement [23] by assessing how a variety of policy scenarios might affect upland areas in England and Wales, and develop consultation options for Defra	[24]
4. An assessment of the impacts of hill farming in England on the economic, environment and social sustainability of the uplands and more widely	Institute for European Environmental Policy, Land Use Consultants and GHK Consulting, funded by Defra, 2003	Not specified	Used scenarios to evaluate the implications of different future hill farming activities in England and Wales	[25]
5. Scanning Agricultural Futures in England and Wales and Implications for the Future	Cranfield University, Silsoe Research Institute and Macaulay Land Use Research Institute, funded by Defra, 2005	2005-2030	Developed scenarios for arable and pastoral agriculture to explore possible environmental impacts and policy interventions that could promote more sustainable future agriculture in England and Wales	[26]
6. Bioscene	Imperial College and other partners, funded by EU FP5, 2002-2006	2005-2030	Used scenarios to evaluate effects of agricultural restructuring on biodiversity conservation in mountain areas of Europe, in order to enhance EU agri-environmental and rural development policy and implementation	[27]
7. Preservation and Change in the Upland Landscape: the Public Benefits of Grazing Management	Macaulay Land Use Research Institute funded by the Scottish Office Agriculture, Environment and Fisheries Department, 1993-1994	Not specified	Evaluated Scottish public preferences for future landscapes based on willingness to pay for the subsidies that create them	[28]
8. Sustainable Uplands	Universities of Leeds, Durham, Sheffield & Sussex with Moors for the Future and Heather Trust, funded by UK Research Councils with Defra & SEERAD, 2005-2008	2005-2025	Developing scenarios to evaluate the likely effects of key socio-economic, environmental and policy drivers and develop innovative land management adaptations, usng case studies in England and Scotland	[29,30,31,32]

Table 2
UK upland scenarios developed by eight studies, not including Business as Usual scenarios (LFA = Less Favoured Areas; SDA = Severely Disadvantaged Area; CAP = Common Agricultural Policy; ESA = Environmentally Sensitive Area). Note: Scenarios have not yet been finalised for Study 8.

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Most preferred scenario**	**Least preferred**	**Most probable**
1. Defra [22]	Abandonment-Intensification: LFA support withdrawn from uplands	Environment only: existing LFA support focussed on enhancing habitats in SDA uplands	Environment -Agri: existing LFA support focussed on producers in existing agri-environment schemes on SDA land		Mixture of 2 and 3	1	-
2. Eftec [23]	Redistribution of support to more marginal land in LFA on condition of joining agri-environment scheme	Redistribution to agri-environment measures only	Complete withdrawal of support		2	3	-
3. Cumulus, IEEP and CCRU [24]	Redistribution of support to more marginal land in LFA on condition of joining agri-environment scheme	Redistribution to agri-environment measures only	Complete withdrawal of support		2 (from environmental perspective)	3 (although could have environmental benefits	-
4. IEEP *et al.* [25]	Maintain production	Reduction in hill farming: less but larger farms and remote areas abandoned	Diversification of hill farming: farming continues supported by off-farm income and increased uptake of agri-environmental agreements		3	2	1
5. Morris *et al.* [26]	World Market: all financial support withdrawn, relying on markets only	Global Sustainability: support for farming based on cross-compliance with environmental measures	National Enterprise: price support and protection to serve national and local priorities (similar to pre-reform CAP)	Local Stewardship: locally defined support schemes reflect local priorities for food production, incomes & environment	Environmental = 1 & 2 Economic = 2 Social = 2, 3, 4 Overall = 2	-	-
6. Bioscene [27]	Liberalisation: all financial support withdrawn from uplands	Managed Change for Biodiversity: support for farming based on cross-compliance with			2	1	1

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		environmental measures					
7. Bullock & Kay [28]	Landscape A-policy off: ESA agreements not renewed, leading to higher grazing pressure	Landscape B-Policy-on-extensified: ESA support leads to lower grazing pressure in line with current trends	Landscape C-Policy-on very extensified: ESA support leads to significant reduction in hill farming and grazing pressure		3	1	
8. Sustainable Uplands (Peak District)[1] [29,30,31]	Farmers as ecosystem providers: a decline in levels of agricultural support (based on cross-compliance with environmental measures) leads to a significant loss (50% current levels) of hill sheep from the Peak District (levels and nature of managed burning remains relatively constant)	Arable uplands: arable crops are planted across wide tracts of upland valleys and in-by land (assumes industrial agriculture and periods of low vegetation cover)	Hill farming collapse: removal of agricultural support with no alternative Government funding leads to a cessation of hill farming (but levels of managed burning remain relatively constant)	Blanket Bog Burning Ban: burning is restricted mainly to dry heath habitats (assuming the Natural England definition of blanket bog, and that inactive blanket bog acts like dry heath)	-	-	4
8. Sustainable Uplands (Yorkshire Dales)[1] [32]	Farmers as ecosystem providers	Arable uplands	Hill farming collapse	Bird disease/shooting ban: a ban or major disease outbreak without cure (causing long-term decimation of grouse populations) leads to the collapse of grouse moor management nationally	-	-	3

[1] Each of these scenarios includes climate change and includes a version with or without large-scale restoration works (gullies and grips blocked and bare peat revegetated)

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Table 3
Methods used to develop and evaluate scenarios of upland change in eight UK studies

Study / **Method**	1. Defra [22]	2. Eftec [23]	3. Cumulus, IEEP and CCRU [24]	4. IEEP *et al.* [25]	5. Morris *et al.* [26]	6. Bio-scene [27]	7. Bullock & Kay [28]	8. Sustain-able Uplands [29,30,31,32]
Scenario development based on:								
Evidence from literature	X	X	X	X	X	X		X
Consult-ation with stakeholders	X	X			X	X	X	X
Economic valuation		X					X	
Computer simulation models					X	X		X
Scenario evaluation based on:								
Case study areas	X			X		X	X	X
Consult-ation with stakeholders				X		X	X	X
Comprehen-sive sustain-ability assessment						X		X
Visualis-ations						X	X	X

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Continuing financial support to farmers from government	*Reduced levels of hill farming based on cross-compliance with environmental measures*	*Continued levels of hill farming supported by pre-reform Common Agricultural Policy style subsidies*
Financial support from government withdrawn	*Withdrawal of agricultural management and re-wilding*	*Significantly reduced levels of hill farming supported by diversification*
	Strong environmental policy agenda	*Weak environmental agenda*

Figure 1
Scenarios from Table 3 grouped according to levels of support for a pro-environment policy agenda and varying levels of financial support for farmers.

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