Restoration of Blanket bogs; flood risk reduction and other ecosystem benefits

Annex 7. Sustainable management of peatlands: An ecosystem services assessment

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Final report of the Making Space for Water project

Prepared for

By

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CONTENTS

SUMMARY

The Dark Peak is characterised and defined by its peatlands. These areas have been shaped for centuries by human activities and are a product of linked ecological and sociological processes. Peatlands provide a wide range of benefits to society and are also important habitats in their own right. However, large areas are degraded and are not currently delivering the full range of ecosystem services that are possible. How can these areas be managed more sustainably and how will key policy and environmental pressures impact upon them? These questions were addressed through a series of stakeholder workshops. This report describes a simple, expert-based ecosystem services assessment performed on eight key policy and environmental drivers for the Upper Ashop Catchment in the Dark Peak.

Workshop participants consistently identified water provision, water purification, climate regulation, erosion prevention, natural hazard regulation, recreation and tourism, aesthetic value, intellectual and scientific knowledge, and provision of habitat to be the key ecosystem services either currently or potentially delivered by the site. A large number of additional ecosystem services were considered relevant at the site, highlighting the multiple benefits that such areas can provide.

An assessment of the consequences of eight alternative policy and environmental drivers on peatland management practices highlighted the likely management response. An assessment of change in ecosystem service provision under the same policy and environmental drivers then identified the key trade-offs, synergies and impacts that would likely occur under each driver. Four of the policy drivers were predicted to result in an overall increase in ecosystem services – Water Framework Directive, Increase in safeguard zones, Water company objectives, and Adoption of peat in carbon code. In each of these cases the policy driver had been aimed at improving only one ecosystem service, but many other ecosystem services were expected to increase as well. One policy driver – Decrease agri-environment Pillar 2 funding – and all three environmental drivers – More storm events, More droughts, and Increased risk of wildfire – were expected to results in an overall decrease in ecosystem services. Key management actions to achieve these policy objectives and to mitigate the negative impacts of the environmental drivers include gully blocking, revegetating bare peat and controlling livestock density.

It is clear that the restoration and sustainable management of degraded peatlands can deliver multiple benefits to society. Whether the primary reason for doing so is to enhance water quality, carbon sequestration, biodiversity, flood risk management, or to mitigate the impact of future storms and droughts, each will deliver broader benefits. It is important that the key stakeholders in such areas are fully aware of the potential impacts of major drivers of change over the coming years and an assessment of ecosystem services provides a suitable framework to gain this understanding. It can also be used as a first step for setting up Payments for Ecosystem Services (PES) schemes.

1. INTRODUCTION

The assessment described in this report forms part of a wider piece of work being conducted by Moors for the Future and the University of Leeds to examine the sustainable management of peatland in the Dark Peak area of the Peak District. The project is being run as a series of workshops engaging with the stakeholder community of the Dark Peak to examine:

- Peatland structure, function and resilience
- Drivers of change affecting peatland management
- Impact on ecosystem services delivered by peatlands
- The value of peatland; leading towards the development of a Payments for Ecosystem Services (PES) scheme.

The conceptual framework for this work is shown in Figure 1. It can be seen that pressures and policy drivers influence management practices in peatland areas. These management practices impact on peatland structure and function, which in turn affects the ecosystem services delivered and the benefits and values that are derived. The values placed on peatland services are ultimately determined by society, and changing attitudes and values lead to changes in policy drivers. Hence the process is cyclical, with impacts and feedbacks cascading through the system.

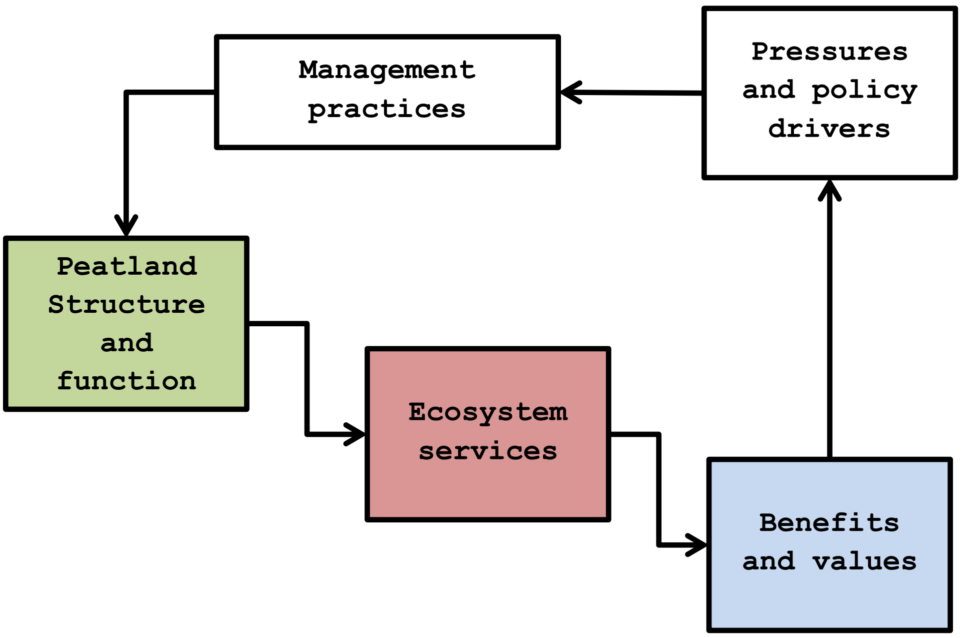


Figure 1: Workshop conceptual framework, showing the management of peatlands and subsequent cascade of effects on peatland structure and function, ecosystem services, and the values and benefits derived (adapted from Potschin & Haines-Young 2011).

This remainder of this report is concerned with part of the conceptual framework; the impact of changing pressures and policy drivers on management practices and, particularly, on the ecosystem services delivered by peatlands. To address this issue a workshop was organised for the 7th February 2014 for a cross-section of stakeholders, including landowner and farming organisations, regulators, wildlife and countryside organisations, and water companies. The full list of participants and organisations represented is included in Appendix 1. In an earlier workshop session the participants identified the key pressures and policy drivers that are, or are likely to, affect peatlands, and the impact of these drivers on management practices. Attention was then turned to ecosystem services. The aim of the workshop was to provide participants with the necessary background for performing an ecosystem services assessment, to determine the ecosystem services currently being delivered by a study site in the Dark Peak, and to perform a simple ecosystem services assessment of the key pressures and policy drivers deemed most likely to impact upon peatlands. This report begins with a brief description of the study site, then outlines the policy and environmental drivers and their impact on management practices, before focussing on the results of the ecosystem services assessment of these drivers.

2. THE STUDY SITE

The ecosystem services delivered at a site vary from place to place, hence it was necessary to choose a specific location for this assessment. Furthermore, by choosing a location, the project team at Moors for the Future were able to supply a large number of maps providing background physical, habitat and land management information, which was required to make informed decisions during the assessment process. However, although exact ecosystem service delivery is site specific, the site chosen is representative of large parts of the Dark Peak and the results are therefore representative of many other areas with similar conditions.

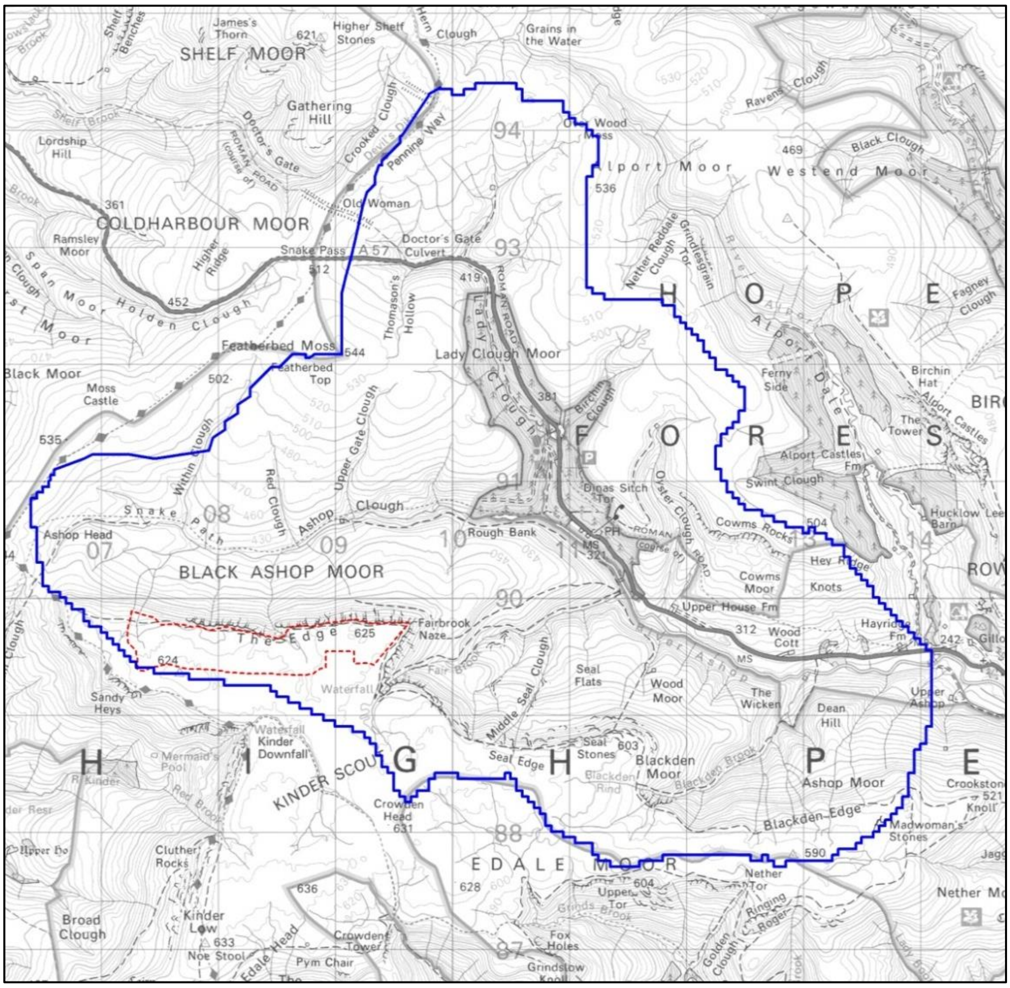


Figure 2: Boundary of the study site, the Upper Ashop Catchment in the Dark Peak. The red boundary indicates the area restored as part of the first phase of the Making Space for Water project.

The study site chosen was the Upper Ashop Catchment, a tributary of the River Derwent. This lies in the heart of the Dark Peak, with Kinder Scout forming the catchment boundary to the south (Figure 2). The A57 road bisects the catchment, following one of the stream channels from Snake Pass to Ladybower Reservoir, which is just downstream of the study site boundary. The vast majority of the study site is owned by the National Trust (Figure 3a). Most of the area is underlain by peat and a model of peat depth is shown in Figure 3b. The depth of peat varies considerably across the site and there are significant areas of bare and degrading peat, particularly on the slopes of Kinder Scout (Figure 3c). A large number of gullies exist throughout the area (Figure 3d), which exacerbate peat erosion, speed up runoff and result in decreased water quality and increased colouration of drinking water.

Most of the peatland consists of blanket bog, with a periphery of upland heathland, both of which are BAP priority habitats. In addition, a small amount of clough woodland lies close to the stream in lower elevations. The vegetation of the peatland is dominated by heather in much of the central area of the study site, with cotton grass and bilberry dominating areas to the north and south (Figure 4a). The condition of the heather has been mapped (Figure 4b). Much of the heather is managed through controlled burning (Figure 4c), hence the wildfire risk is relatively low in these areas, but high in some of the areas without burning (Figure 4d).

Almost the entire area has been managed for decades under agri-environment schemes, initially through Environmentally Sensitive Area (ESA) agreements and more recently through the Higher Level Scheme of

Environmental Stewardship. The vast majority of the area is managed by extensive low density grazing, with parts fenced off as grazing exclosures, to permit revegetation of degraded sections. In addition, significant areas are undergoing active restoration works, particularly focussed around gully blocking and re-vegetation of bare peat. The area has a number of environmental designations, including SSSI and is part of a SAC. The adjacent Kinder Scout plateau is also a National Nature Reserve. The whole of the peatland area in the study site is designated as Open Access land and the Pennine Way follows close to the catchment boundary on the west side. The whole area is also part of the Dark Peak Nature Improvement Area, which aims to restore and reconnect nature at a landscape scale.

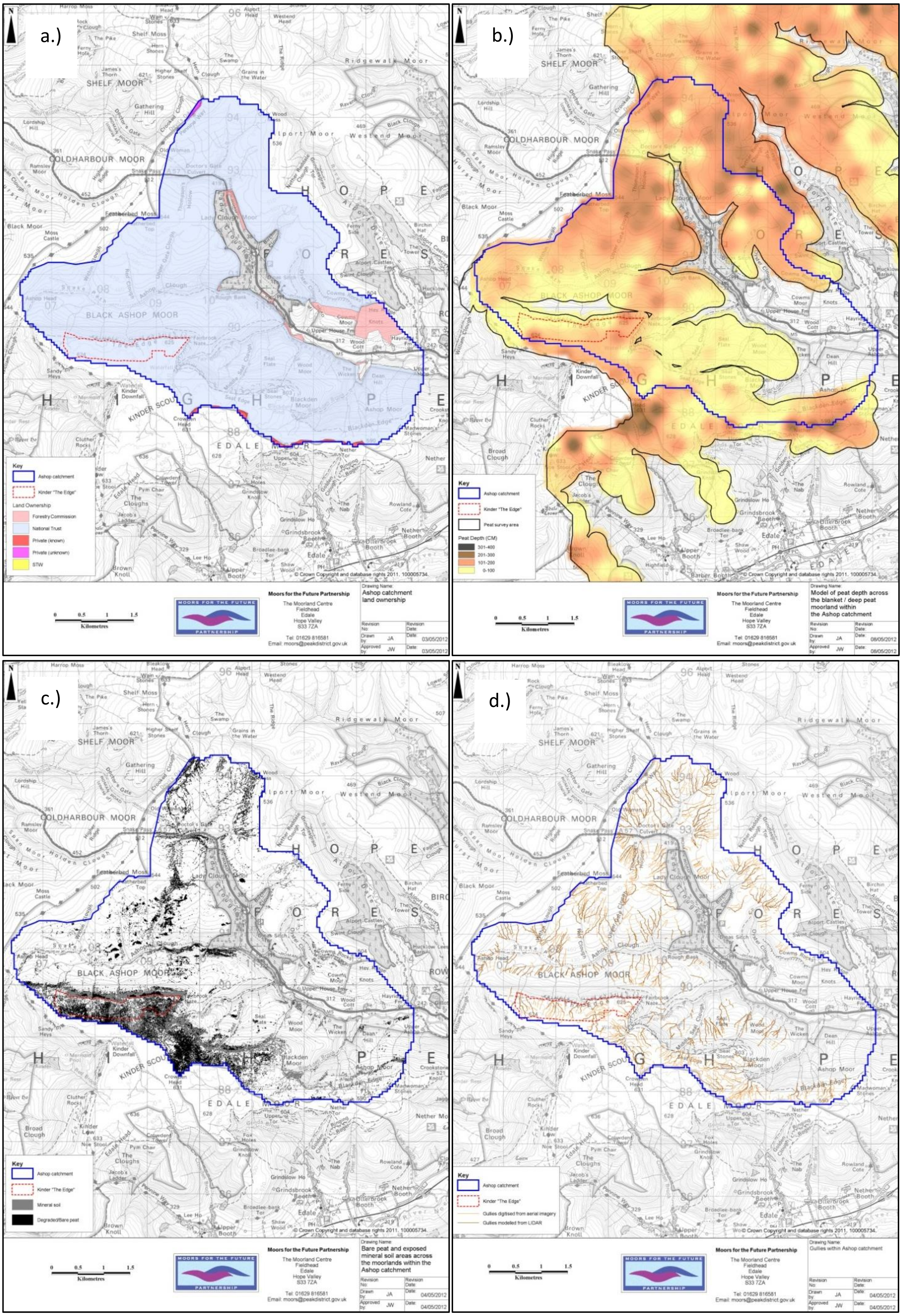


Figure 3: Features of the Upper Ashop Catchment in the Dark Peak, showing a.) ownership, b.) a model of peat depth, c.) areas of bare peat, and d.) the location of gullies.

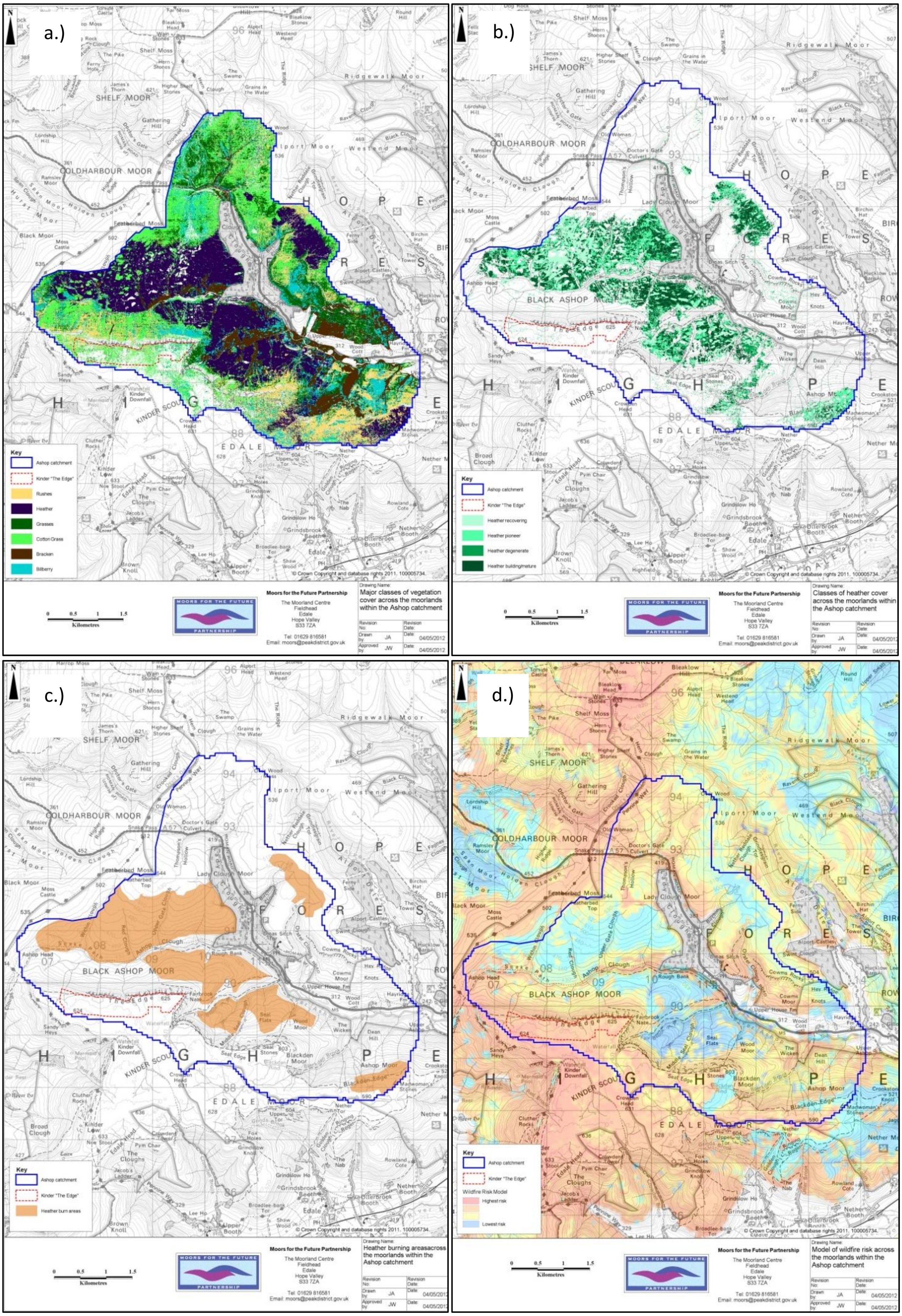


Figure 4: Further features of the Upper Ashop Catchment, showing a.) dominant vegetation types, b.) condition of heather, c.) areas where heather undergoes managed burning, and d.) a model of wildfire risk.

3. Key pressures and policy drivers acting in the Dark Peak

During an earlier part of the workshop, participants were asked to identify the main drivers of change that will impact management of peatlands in the Dark Peak. Then, through group discussion, each driver was scored according to its likelihood of occurrence and overall impact on land management. In total, eight drivers were identified as being of high likelihood to occur and having a high impact, and these were used in the ecosystem services assessment. Five of these are policy drivers, whilst the remaining three are environmental drivers and are listed below:

Policy drivers:

- Water Framework Directive – alteration in management adopted to increase the ecological status of the waterbody in response to obligations under the EU Water Framework Directive.
- Decrease agri-environment Pillar 2 funding – this refers to the part of the Common Agricultural Policy spent on environmental objectives (until very recently the Environmental Stewardship Scheme). A new agri-environment scheme is currently under development.
- Adoption of peat in carbon code – the carbon code is the means by which companies will be obliged to offset the carbon that they emit through their business. Currently it has primarily been developed for woodlands, but work is ongoing to produce a Peatland Code.
- Increase in safeguard zones – this is a non-statutory scheme set up by the Environment Agency and the water companies to target action to address water contamination. The aim is to improve drinking water quality without the need for extra treatment works.
- Water company objectives – similar to the above, this is aimed at increasing drinking water quality through catchment works, rather than through chemical treatment. But in this case work is more targeted, usually through active management or the setting up of Payments for Ecosystem Services (PES) schemes to alter management practices.

Environmental drivers:

- More storm events – projected to occur under climate change, rainfall events are predicted to be more intense in both summer and winter.
- More droughts – also projected to occur due to climate change, drought is particularly likely to occur in the summer.
- Increased risk of wildfire – may occur through a combination of factors; an increase in hot, dry summers due to climate change, an increase in recreational use during such conditions, and a decrease in managed burning.

The remainder of the workshop considered the impact of these policy and environmental drivers, first on key management factors affecting peatlands, and then on ecosystem service provision.

4. IMPACT OF POLICY AND ENVIRONMENTAL DRIVERS ON KEY MANAGEMENT FACTORS

Workshop participants assessed the impact of these policy and environmental drivers on key mnagement factors during small group dicussions. The key management factors had been identified in the first workshop of the series, held in summer 2013, and led by Dylan Young from the University of Leeds. In this first workshop, participants had produced mind maps decribing peatland structure and fucntion and the mangement factors affecting these. From these maps, Dylan extracted the key management factors that were then assessed in the current workshop. These are shown in Box 2:

Box 2: Key management factors affecting peatlands	
➢ Stocking density	➢ Domestic animals
➢ Grouse numbers	➢ Game Keeping
➢ Managed burning	➢ Burning intensity
➢ Heather cutting	➢ Gully blocking
➢ Restoration	➢ Drainage
➢ Native woodland	➢ Access

The consequence of the policy and environmental drivers on each management factor was assessed on a scale from +3 (indicating a major increase) to -3 (indicating a major decrease) in each particular management activity. Results are shown in Figure 5 (overleaf). The main changes predicted to occur as a consequence of each policy driver are:

- Water Framework Directive – substantial changes are predicted to occur as a result of this policy driver, with changes occurring to almost all the management actions. In particular, a major increase in gully blocking and peatland restoration, with a concomitant reduction in peatland drainage is expected, as well as moderate reductions in livestock, and a shift from managed burning to heather cutting.
- Increase in safeguard zones – fewer changes are predicted to occur than under the previous policy driver, with this policy option being delivered primarily through a major increase in native woodland, and a moderate decrease in drainage and stocking density.
- Water company objectives – a similar response to Water Framework Directive is expected, except that a major increase in native woodland is also predicted, and there is less impact on livestock farming.
- Adoption of peat in carbon code – similar to WFD, with a major increase in gully blocking and restoration, a major decrease in drainage and burning, and a moderate decrease in livestock farming.
- Decrease agri-environment Pillar 2 funding – a very different pattern to all those above, with a major increase in stocking density predicted, together with a moderate increase in game keeping and managed burning and a reduction in restoration practices, presumably as land managers attempt to recoup lost income through intensification.
- More droughts – it is predicted that this environmental driver would lead to a moderate decrease in grouse numbers and in peatland drainage, a moderate increase in public access, as well as some decrease in livestock and native woodland.

- More storm events – is expected to lead to a major increase in gully blocking (presumably to reduce flood risk downstream), moderate increases in domestic animals and native woodland, and a moderate decrease in access.
- Increased risk of wildfire – is predicted to lead to a major increase in restoration, a moderate decrease in managed burning, and a slight negative impact on a number of other management actions.

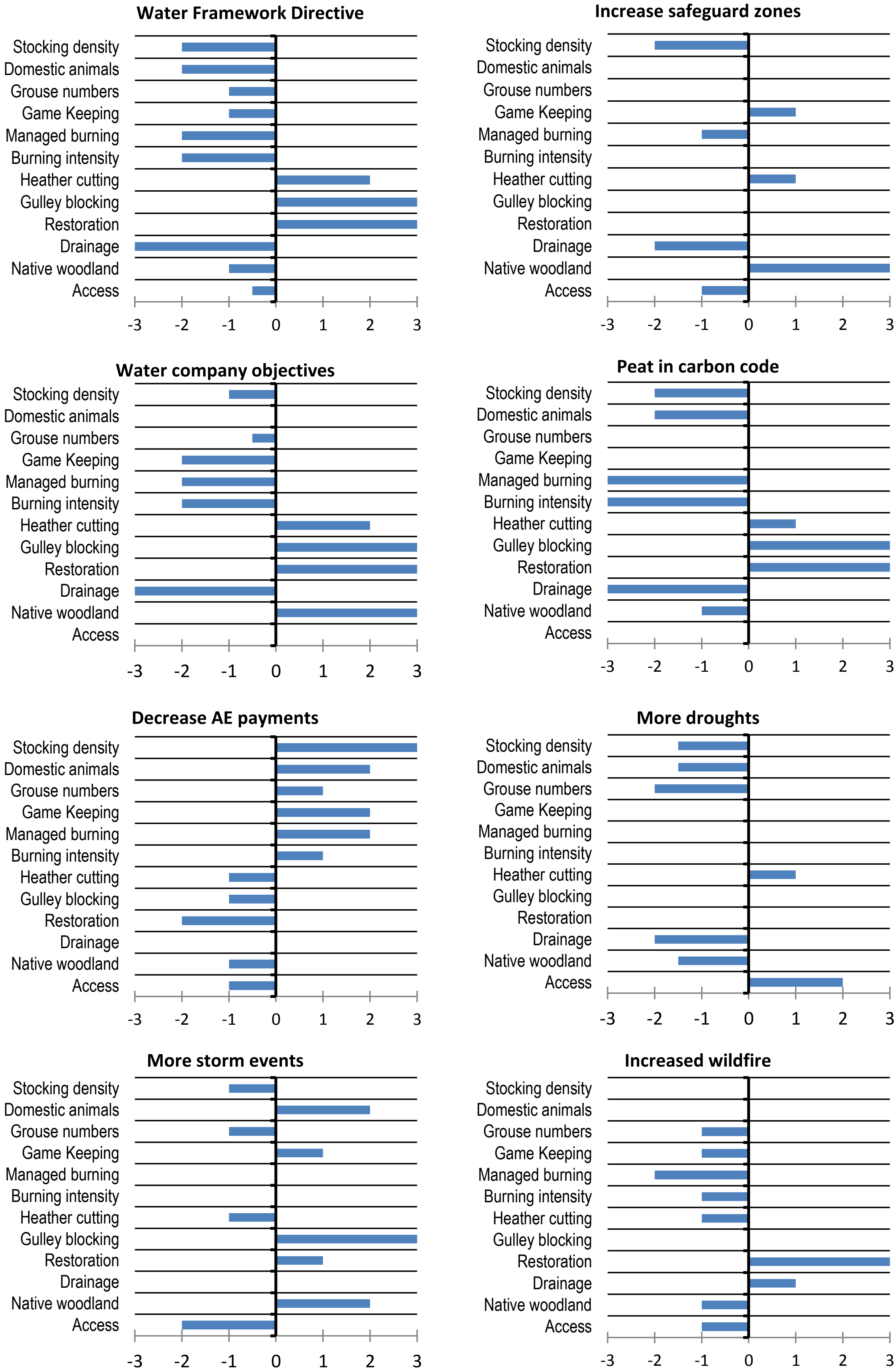


Figure 5: Predicted impact of policy and environmental drivers on key management factors. Scores range from +3 (major increase) to -3 (major decrease). Data courtesy of Dylan Young.

5. Ecosystem services assessment

Ecosystem services are most simply defined as the benefits that people derive from the natural environment. Different types of ecosystem service are shown in Box 1:

Box 1: Different types of ecosystem service

- **Provisioning services:** tangible physical and energetic goods obtained from ecosystems, e.g. food and fibre.
- **Regulatory services:** benefits obtained from ecosystem processes that regulate aspects of the environment, e.g. air quality, climate and water regulation.
- **Cultural services:** non-material benefits people obtain from ecosystems, e.g. recreation, aesthetic experiences, health and wellbeing.
- **Supporting services:** services comprising internal processes within ecosystems essential for the production of all other ecosystem services, e.g. soil formation, primary production, nutrient cycling.

Most ecosystem services frameworks in use today are based on the typology published in the Millennium Ecosystem Assessment (MEA 2005). However, recent developments in the ecosystem services concept described in the UK National Ecosystem Assessment (2011), The Economics of Ecosystems and Biodiversity (TEEB 2010) project and in the academic literature have led to some changes. In particular, the majority of the Supporting Services are usually no longer included in assessments. They are considered to be ecosystem processes or 'intermediate ecosystem services' rather than 'final ecosystem services' that directly deliver welfare benefits to people, hence should not be assessed due to the risk of double counting. TEEB retains 'habitat services' instead of the broader concept of supporting services, and it is useful to include this concept in the present assessment (referred to as 'provision of habitat' here), particularly as it is so integral to the management of peatlands. The ecosystem service of 'food' was divided into 'agricultural produce' and 'wild produce' due to the importance of game in some part of the Dark Peak, and the different management that it requires. Thus the final list of ecosystem services assessed in this project (shown in Table 1, with definitions provided in Appendix 2) was based on the MEA and TEEB, with a few amendments to fulfil the requirements of this project.

Workshop participants were divided into 4 groups and provided with the list and description of ecosystem services described above (Appendix 2). Each group was asked to determine the current relevance of each ecosystem service at the site and scores were assigned through discussion and consensus within each group.

Results are shown in Table 1 (below). Participants identified water provision, water purification, recreation and tourism, aesthetic value, intellectual and scientific knowledge, and provision of habitat as currently being of greatest relevance at the site, followed closely by climate regulation, erosion prevention and cultural heritage. A further 11 ecosystem services were considered to be of moderate relevance at the site (score 1.5-2.5), whilst four ecosystem services were judged to be of little or no relevance at the site at present.

Table 1: Current <u>relevance of ecosystem services</u> in the Upper Ashop Catchment (mean of 4 groups), shown in order of importance within each category. Scores were: not relevant at site = 0, minor relevance=1, moderate relevance =2, great relevance =3.

Ecosystem service	Current relevance at study site
Provisioning services	
Water (e.g. for drinking, agriculture, industry)	3.0
Wild produce (e.g. game, fish, berries etc.)	2.3
Agricultural produce (e.g. crops, livestock, etc.)	1.8
Fibre and fuel (e.g. timber, wool, peat etc.)	1.8
Genetic resources (used for crop/stock breeding and biotechnology)	1.5
Biochemicals, natural medicines, pharmaceuticals	0.0
Ornamental resources (e.g. artisan work, flowers, etc.)	0.0
Energy harvesting (e.g. wind power, hydropower)	0.0
Regulating services	
Water purification and waste treatment	3.0
Climate regulation (local temperature / precipitation, carbon sequestration)	2.8
Erosion prevention	2.8
Pollination	2.1
Natural hazard regulation (i.e. flood prevention, storm protection)	2.0
Pest and disease control	1.6
Air quality regulation (e.g. capturing chemicals, particulates, etc.)	1.5
Noise and light regulation	0.5
Cultural services	
Recreation and tourism	3.0
Aesthetic value	3.0
Intellectual, scientific, knowledge, educational	3.0
Cultural heritage	2.8
Inspiration of art, folklore, architecture, etc.	2.3
Social relations (e.g. grazing or cropping communities)	2.3
Spiritual, ethical and religious value	1.5
Supporting services	
Provision of habitat	3.0

6. CHANGE IN ECOSYSTEM SERVICES UNDER ALTERNATIVE POLICY AND ENVIRONMENTAL DRIVERS

Workshop participants next assessed the impact of the policy and environmental drivers on ecosystem service provision. Following group discussion of the drivers, scores were assigned individually and were based on expert judgement. To make this task manageable, each participant assessed the impact of five out of the eight drivers. Decrease agri-environment Pillar 2 funding and Adoption of peat in carbon code were assessed by all participants, whilst the remaining six drivers were assessed by a minimum of eight people, assigned randomly. The following scoring system was used for all ecosystem services:

Major increase	+3	Major decrease	-3
Moderate increase	+2	Moderate decrease	-2
Minor increase	+1	Minor decrease	-1
No overall change	0	Unknown	?

The results of the individual scoring exercise were discussed briefly at the workshop and full scores calculated afterwards. The results presented here are the average scores provided by all of the individual workshop participants. The full results are shown in Table 2 and presented graphically in Figures 6-8.

Figure 6 highlights the overall cumulative impact of the policy and environmental drivers and positive or negative responses of individual ecosystem services, with bars to the right of the vertical line at 0 indicating a positive impact, and bars to the left indicating a negative impact. Figures 7 and 8 show the results in a series of spider diagrams, with better outcomes indicated by lines closer to the outside. Lines to the outside of the thick black line indicate an increase in ecosystem service provision, whereas lines to the inside indicate a decrease in provision. It is able to show the overall pattern of the response and highlights some of the key similarities and differences between the alternative options.

Four of the policy drivers were predicted to result in an overall increase in ecosystem services – Water Framework Directive, Increase in safeguard zones, Water company objectives, and Adoption of peat in carbon code (Figures 6 and 7). In each of these cases the policy driver had been aimed at improving only one ecosystem service, but many other ecosystem services were expected to increase as well.

One policy driver – Decrease agri-environment Pillar 2 funding – and all three environmental drivers – More storm events, More droughts, and Increased risk of wildfire – were expected to result in an overall decrease in ecosystem services (Figures 6 and 8).

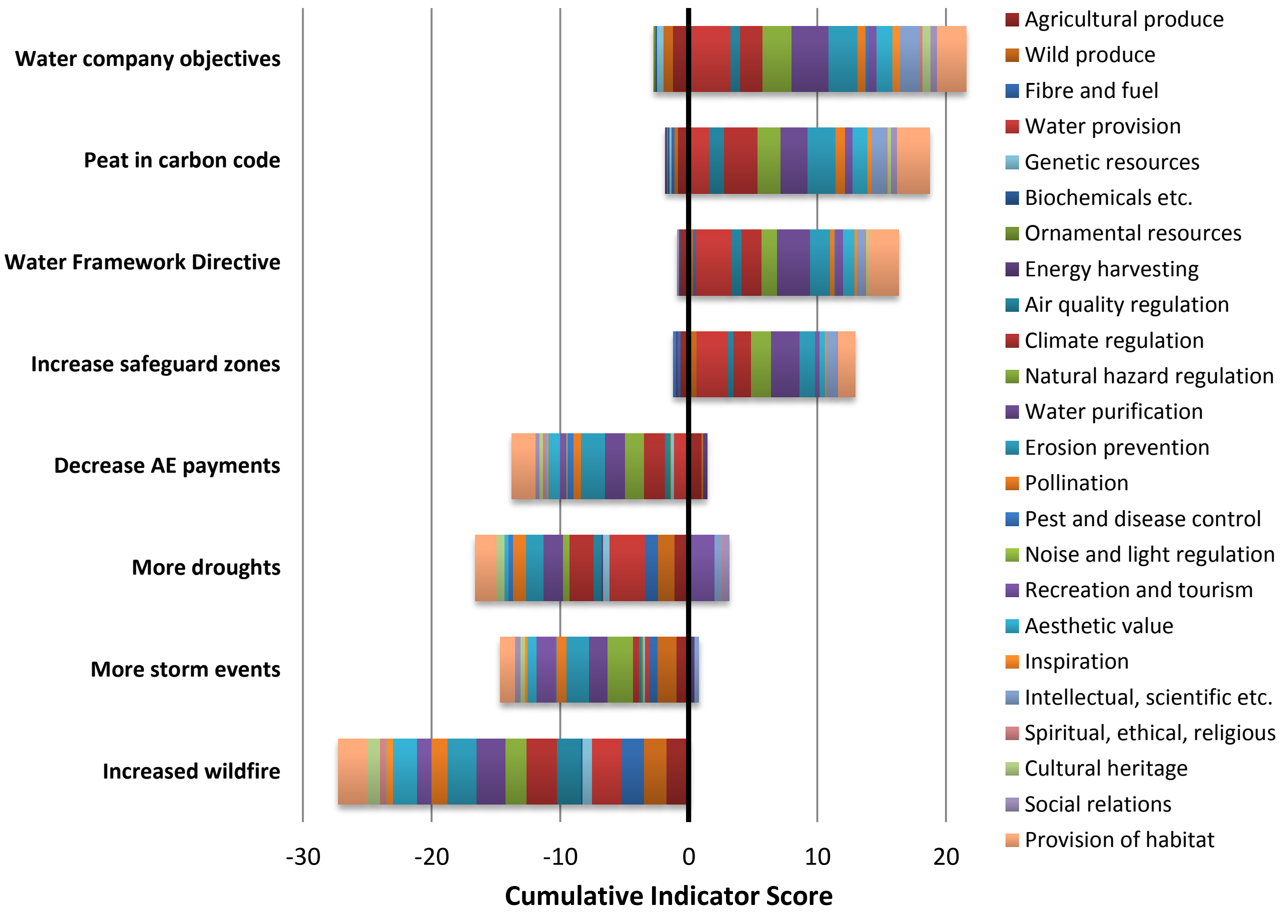


Figure 6: Change in ecosystem service provision in the Upper Ashop catchment predicted to occur under alternative policy and environmental drivers, highlighting positive or negative responses and cumulative impact.

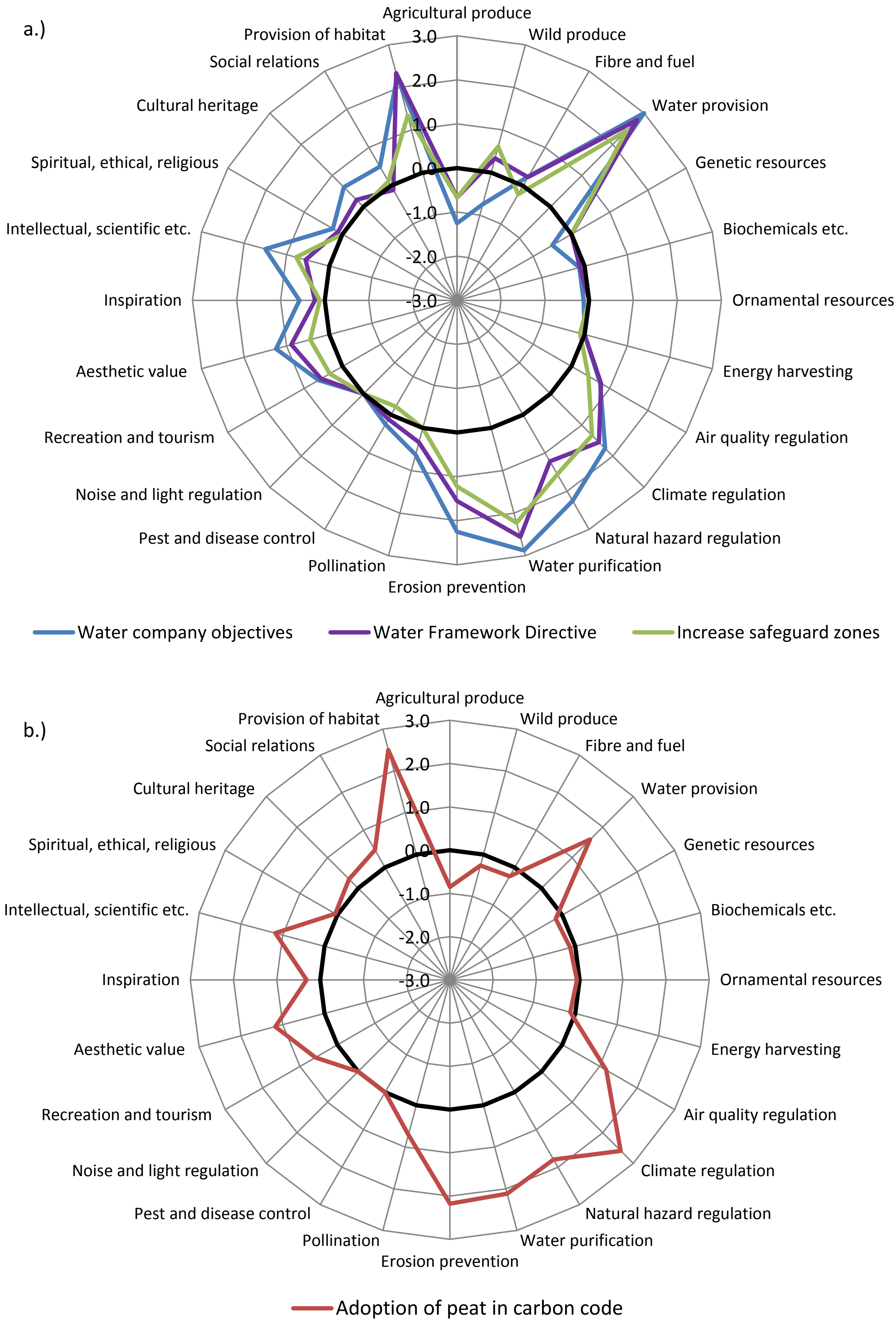


Figure 7: Change in ecosystem service provision under alternative policy drivers for the Upper Ashop Catchment, showing a.) policy drivers focused on water issues, and b.) a climate policy driver.

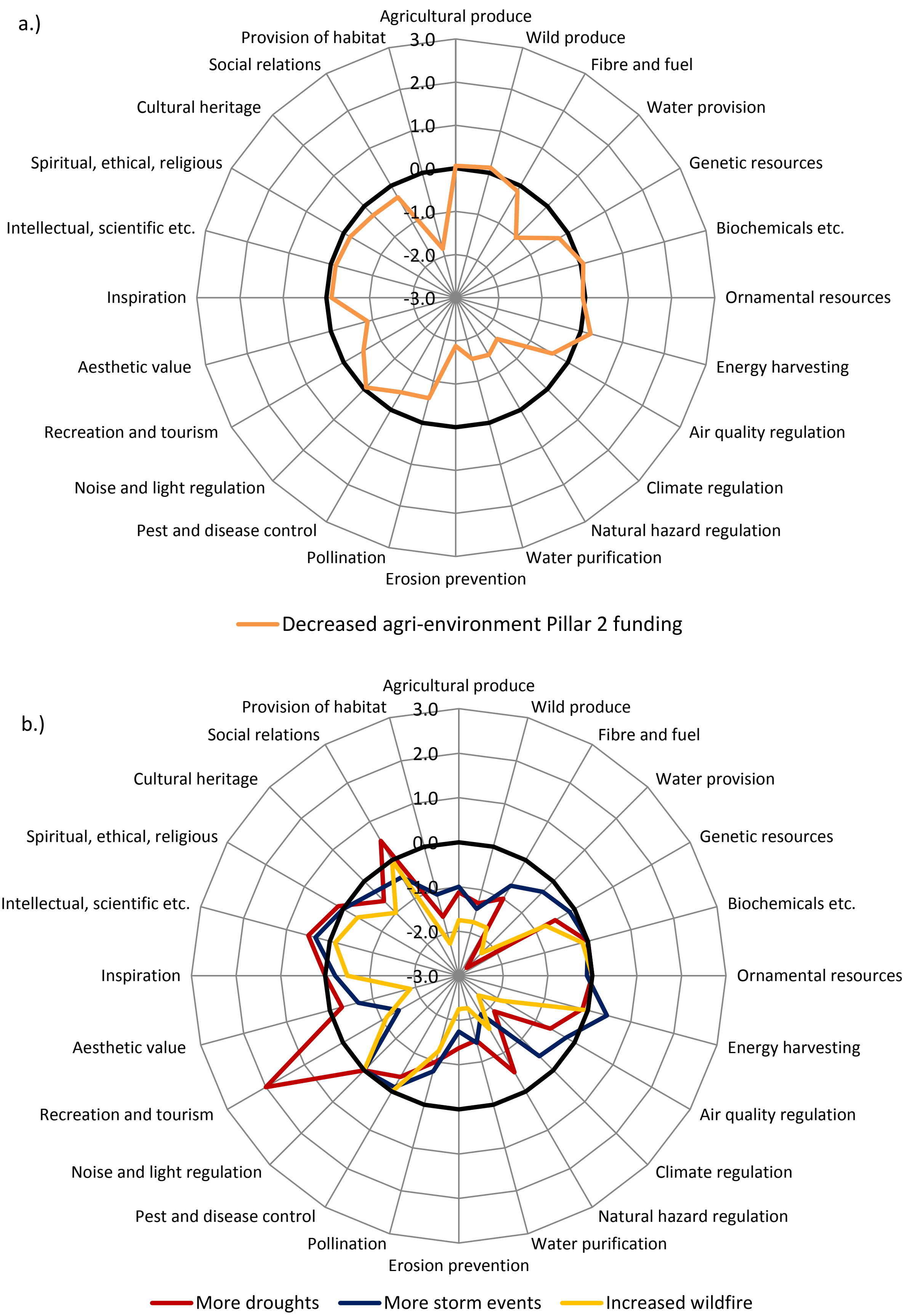


Figure 8: Change in ecosystem service provision under alternative policy and environmental drivers for the Upper Ashop Catchment, showing a.) decreased agri-environment scheme funding, and b.) three possible environmental drivers.

The following characteristics are clear from the results:

- Water Framework Directive, Increase in safeguard zones and Water company objectives are all concerned with enhancing the water environment and all gave similar results, hence these are grouped together in Figure 7a. In all cases the target of enhancing water quality was expected to also deliver an enhancement in almost all ecosystem services. In particular, water provision was expected to increase significantly, along with the regulatory services of climate regulation, natural hazard regulation, and erosion prevention, and the supporting service of provision of habitat. Almost all of the cultural services were also expected to increase. Only one ecosystem service was expected to decrease across all three drivers – agricultural produce – which was predicted to show a minor decrease and was almost certainly driven by the reduction in stocking density predicted in the assessment of management factors (Figure 5). Of the three policy drivers, Water company objectives was predicted to cause the largest changes, both positive and negative, with Increase in safeguard zones resulting in the least impact of the three.
- The objective of Adoption of peat in carbon code (Figure 7b) is to enhance the provision of the climate regulation ecosystem service. However, as well as achieving a major increase in this service, this policy driver was expected to deliver a major increase in provision of habitat, a moderate increase in natural hazard regulation, erosion prevention, water quality, and water provision, and a minor increase in aesthetic value, scientific and educational value, air quality regulation and some other services. It was predicted to result in a minor decrease in agricultural produce.
- Decrease agri-environment Pillar 2 funding was considered to have a neutral or negative impact on all ecosystem services (Figure 8a). The largest negative impacts were predicted to occur on erosion prevention, provision of habitat, natural hazard regulation, climate regulation, and water quality, which all showed a moderate decrease.
- More storm events are predicted to have a negative effect on the provision of many ecosystem services (Figure 8b). Unsurprisingly, the largest (moderate) impact is expected to be on natural hazard regulation (i.e. flooding) and erosion prevention, but minor decreases are expected on eight further ecosystem services including wild produce, agricultural produce, water quality, recreation and tourism, and provision of habitat.
- More droughts are expected to lead to a major decrease in the provision of water and a moderate decrease in climate regulation, water quality, and provision of habitat (Figure 8b). Minor decreases are expected in a further nine ecosystem services. On the other hand, this driver is expected to lead to a moderate increase in recreation and tourism and a slight increase in social relations.
- Increased risk of wildfire was expected to have the most detrimental impact of all the policy and environmental drivers with a moderate negative impact on 11 ecosystem services and a minor negative impact on a further seven (Figure 8b). The most negative impact is predicted to be on climate regulation, water quality, erosion prevention, water provision, and provision of habitat. It is not expected to have a positive impact on any ecosystem service.

The overall average score for all 24 ecosystem services (bottom line of Table 2) showed that Water company objectives was expected to have the greatest positive impact, followed by Adoption of peat in carbon code, Water Framework Directive, and Increase in safeguard zones. Increased risk of wildfire was the driver with much the worst overall impact, whilst Decrease agri-environment Pillar 2 funding, More storm events, and More droughts all had a similar overall negative impact.

Table 2: Change in ecosystem service provision under the policy and environmental drivers. Scores range from +3 (major increase) to -3 (major decrease).

Ecosystem service	Water company objectives	Peat in carbon code	Water Framework Directive	Increase safeguard zones	Decrease AE payments	More droughts	More storm events	Increased wildfire
Provisioning services								
Agricultural produce	-1.3	-0.9	-0.7	-0.7	1.0	-1.1	-1.0	-1.8
Wild produce	-0.8	-0.3	0.3	0.6	0.1	-1.3	-1.4	-1.8
Fibre and fuel	0.3	-0.2	0.2	-0.2	-0.1	-1.0	-0.7	-1.8
Water resources	3.0	1.6	2.8	2.4	-1.0	-2.8	-0.3	-2.3
Genetic resources	-0.5	-0.2	0.0	0.0	-0.2	-0.5	-0.1	-0.8
Biochemicals etc.	-0.1	-0.1	-0.1	0.0	0.1	0.0	0.0	-0.1
Ornamental resources	-0.1	-0.1	0.0	0.0	-0.1	0.0	-0.1	0.0
Energy harvesting	0.0	-0.1	0.0	-0.1	0.2	-0.1	0.4	0.0
Regulating services								
Air quality regulation	0.8	1.2	0.8	0.4	-0.4	-0.6	-0.2	-1.9
Climate regulation	1.8	2.6	1.6	1.3	-1.6	-1.9	-0.4	-2.4
Natural hazard regulation	2.3	1.8	1.2	1.6	-1.5	-0.5	-2.0	-1.6
Water purification	2.9	2.1	2.6	2.2	-1.5	-1.5	-1.4	-2.3
Erosion prevention	2.3	2.2	1.6	1.2	-1.9	-1.4	-1.8	-2.3
Pollination	0.6	0.7	0.3	0.0	-0.6	-1.0	-0.8	-1.3
Pest and disease control	0.3	0.0	0.1	-0.2	-0.5	-0.4	-0.1	0.0
Noise and light regulation	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Cultural services								
Recreation and tourism	0.6	0.6	0.6	0.3	-0.5	2.0	-1.4	-1.1
Aesthetic value	1.3	1.2	0.9	0.4	-0.9	-0.3	-0.7	-1.9
Inspiration of art etc.	0.6	0.3	0.2	0.1	-0.1	0.0	-0.2	-0.5
Scientific, knowledge etc.	1.5	1.2	0.6	0.8	-0.1	0.5	0.3	-0.1
Spiritual value	0.3	0.1	0.1	0.0	-0.2	0.1	0.0	-0.4
Cultural heritage	0.6	0.3	0.2	0.0	-0.3	-0.6	-0.3	-1.0
Social relations	0.5	0.5	-0.1	0.1	-0.3	0.5	-0.4	0.0
Supporting services								
Provision of habitat	2.3	2.5	2.3	1.3	-1.8	-1.6	-1.1	-2.3
Total score	18.8	16.9	15.4	11.7	-13.3	-13.5	-13.9	-27.3
Rank	1	2	3	4	5	6	7	8
Mean scores								
Provisioning services	0.1	0.0	0.3	0.3	-0.1	-0.9	-0.4	-1.1
Regulating services	1.3	1.3	1.0	0.8	-1.0	-0.9	-0.8	-1.5
Cultural services	0.8	0.6	0.3	0.3	-0.3	0.3	-0.4	-0.7
Supporting services	2.3	2.5	2.3	1.3	-1.8	-1.6	-1.1	-2.3
All services	0.8	0.7	0.6	0.5	-0.6	-0.6	-0.6	-1.1

6.1 Ecosystem service importance

At the end of the workshop individual participants were asked to score the potential importance of each ecosystem service at the study site. This was intended to highlight participant's views on what services the site *should* provide, rather than what was currently being provided (current relevance). The scores were:

0 = No importance
1 = Low importance
2 = Moderate importance
3 = High importance
4 = Very high importance

Results are shown in Figure 9 (below). Provision of habitat was considered to be the single most important ecosystem service. This was followed by water provision, water purification, climate regulation, recreation and tourism, and aesthetic value, which were all considered to be of high to very high importance, followed closely by erosion prevention, natural hazard regulation, and intellectual / scientific value. Agricultural produce and wild produce were also considered to be of high importance, along with cultural heritage. A further seven ecosystem services were considered to be of moderate importance.

It should be noted that the ecosystem services that are considered to be potentially important are very similar to those that are considered currently relevant at the site (Table 1). This may be due to the fact that the overall way of managing the peatlands is not expected to change, or that participants were already considering the site's potential when they scored the ecosystem services currently relevant in Upper Ashop.

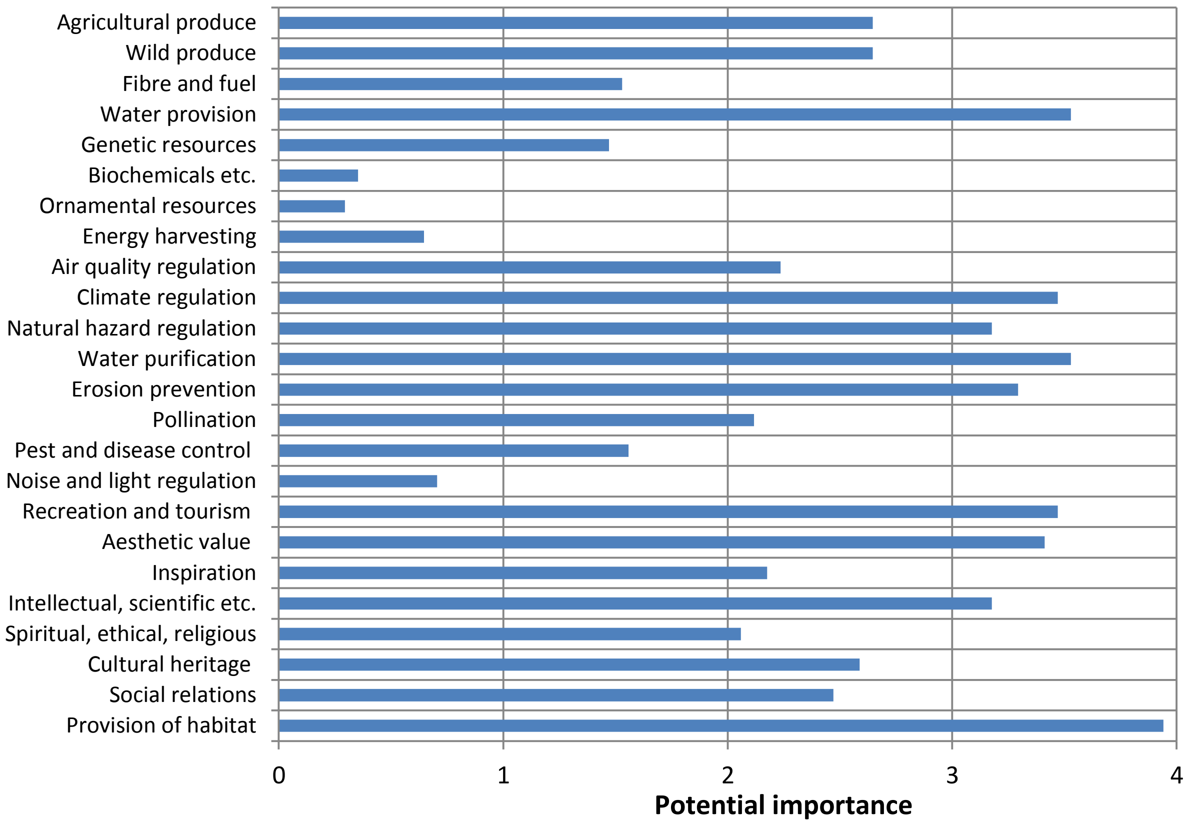


Figure 9: <u>Potential importance of ecosystem services</u> in the Upper Ashop Catchment. Scores were: no importance = 0, low importance=1, moderate importance=2, high importance=3, very high importance = 4.

6.2 Weighting and ranking the possible management options

The results presented to this point have used the unweighted scores for all ecosystem services. This means that all ecosystem services are assumed to be equally important and hence have equal influence on the outcome. However, it is likely that some ecosystem services will be considered more important than others. It is therefore useful to examine the results using a number of different possible weightings.

It is possible to use the current relevance or potential importance of ecosystem services at the site to weight the scores. These two measures actually give almost identical results, hence only the results for current relevance are shown here. In Figure 10a (overleaf), the change in ecosystem service scores under the different drivers have been multiplied by the current relevance of each ES at the study site (from Table 1). This now gives the greatest weighting to water provision, water purification, recreation and tourism, aesthetic value, intellectual and scientific knowledge, and provision of habitat. However, the effect of this change in weighting on the overall results is minimal. This is probably because the ecosystem services that are considered most relevant are also the ones showing greatest change, and the ones that are least relevant already had little impact on the results.

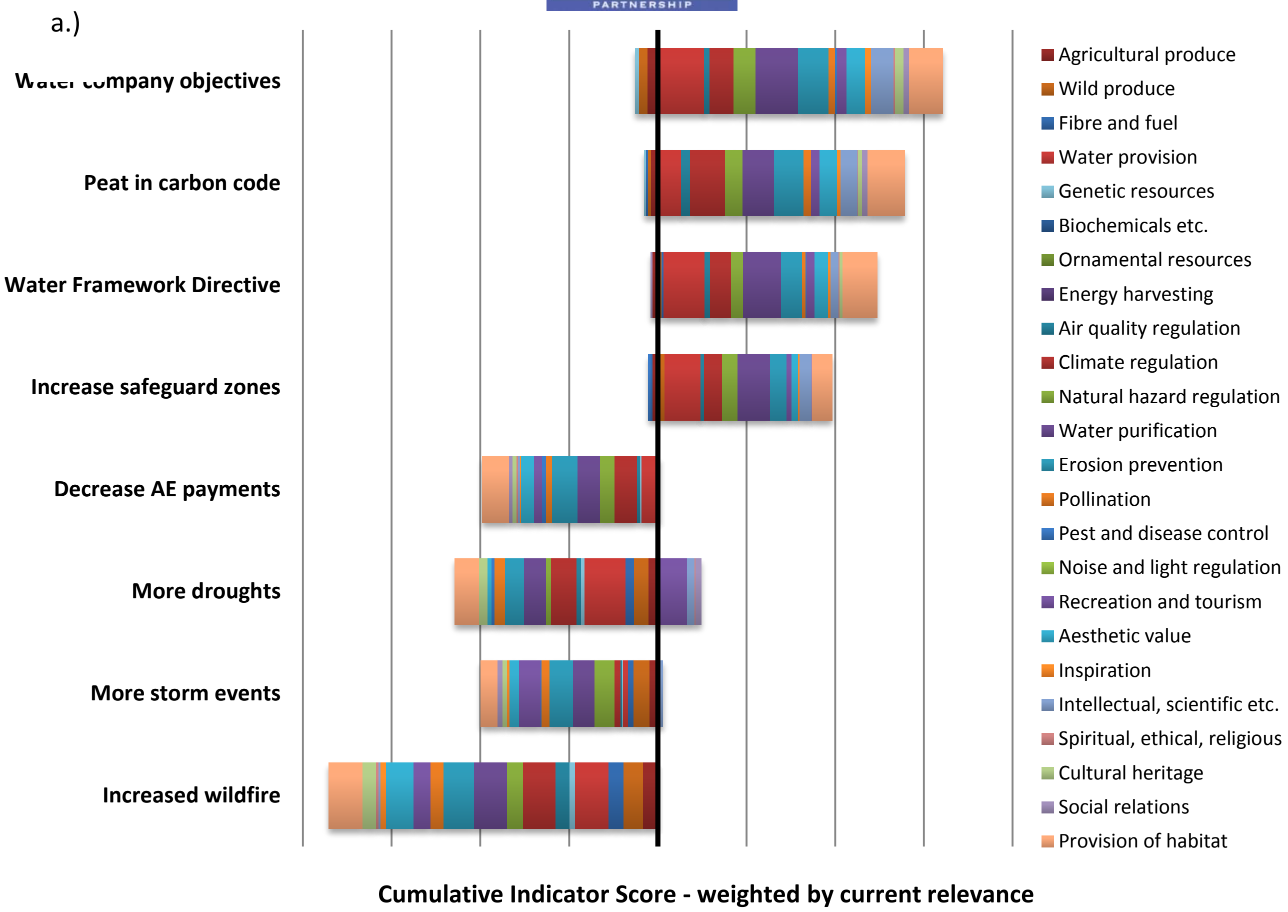
A further weighting was applied so that the results provided by subject experts was weighted more highly than those provided by non-experts. To do this, all workshop participants were asked to provide an assessment of their own knowledge confidence for each ecosystem service. The scores used were:

No knowledge = 1
A little knowledge = 2
Some knowledge = 3
Knowledgeable = 4

The scores provided by each participant were then multiplied by the self-reported knowledge confidence scores, and final scores averaged across all participants as before. This meant that the scores given by those people who considered themselves to be an expert in a topic counted for more than the scores given by someone who felt they had little or no knowledge of that subject. This method is obviously biased as the self- reported score is likely to be based to a certain extent on personality and self-confidence / modesty, but is probably the only practical way of weighting knowledge in a workshop setting.

Knowledge confidence did vary both between participants and between ecosystem services. The mean score for participants ranged from 1.9 to 3.1. For ecosystem services, the mean score was 2.6, ranging from 1.4 for the provisioning service of biochemicals, natural medicines and pharmaceuticals, up to 3.6 for provision of habitat. Interestingly, however, the overall impact of this weighting system was again minimal. Figure 10b shows the overall results and once again the pattern is almost identical to Figure 10a and to the unweighted results (Figure 6).

When the different environmental and policy drivers were ranked in terms of their overall impact on ecosystem services, the order of the top four was identical under all the different weighting methods used. Thus Water company objectives was predicted to result in the most significant positive impact, followed by Adoption of peat in carbon code, Water Framework Directive, and Increase in safeguard zones. Increased risk of wildfire always resulted in the most negative impacts under all weightings used. The ranking of the remaining three drivers was changeable under the different weighting systems, but this is not surprising as their scores were very similar.



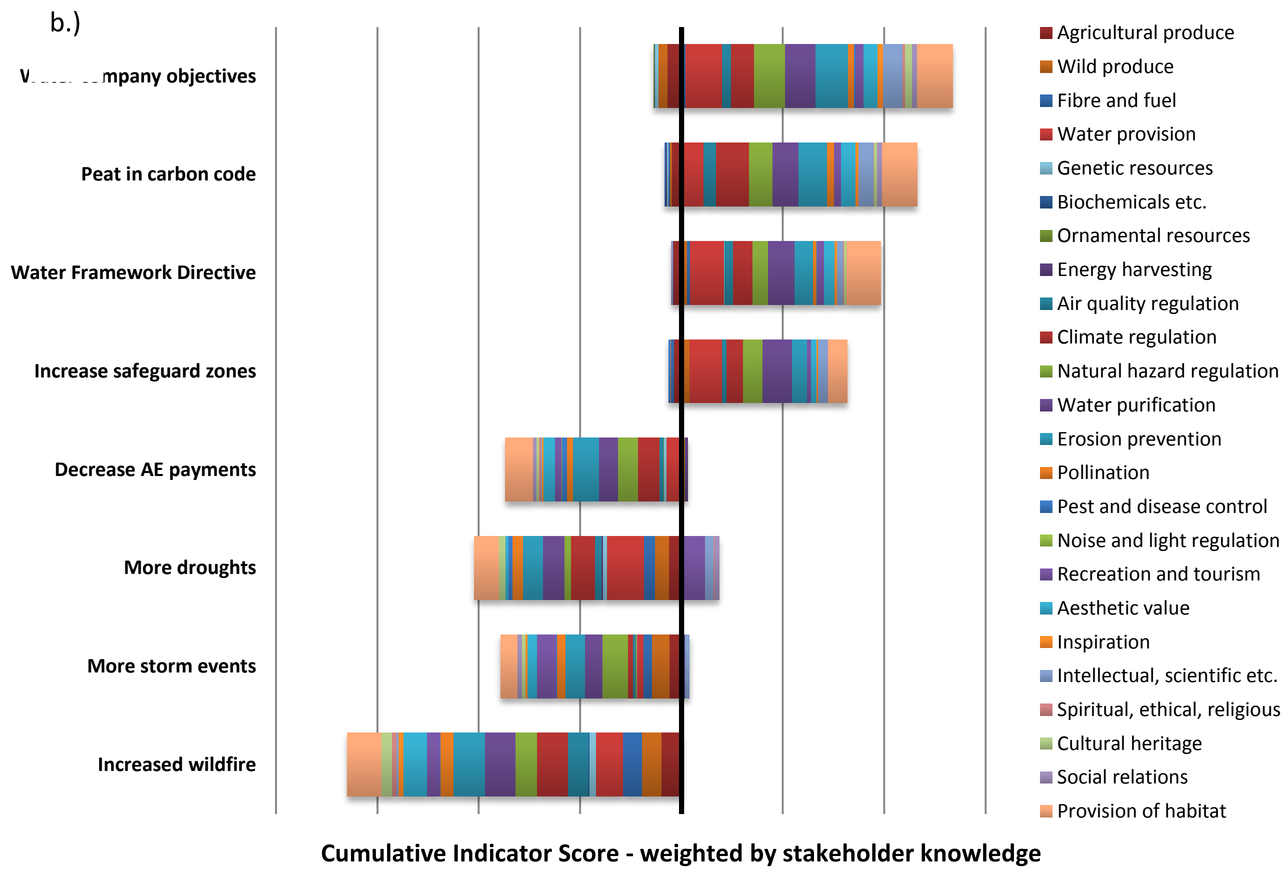


Figure 10: Change in ecosystem service provision under alternative policy and environmental drivers, weighted by a.) current relevance at the site, and b.) individual stakeholder's self-reported knowledge.

6.3 Considering only the most important ecosystem services

The overall score produced by an ecosystem services assessment depends partly on the range of ecosystem services assessed. It can be argued that if many unimportant ecosystem services are included in the assessment then this can obscure the results for the ecosystem services that stakeholders consider to be more important or those that are showing the greatest change under the environmental and policy drivers. Although this has been partially addressed by examining weightings in the last section, it may be clearer to illustrate only these most significant changes.

In Figure 11, only the 11 ecosystem services that were considered to be of high importance or very high importance at the study site and showed a moderate or major increase or decrease under any of the environmental or policy drivers are included. The overall pattern of the results is the same as before but the particular differences can be highlighted more easily, and it is easier to identify the impact on individual ecosystem services.

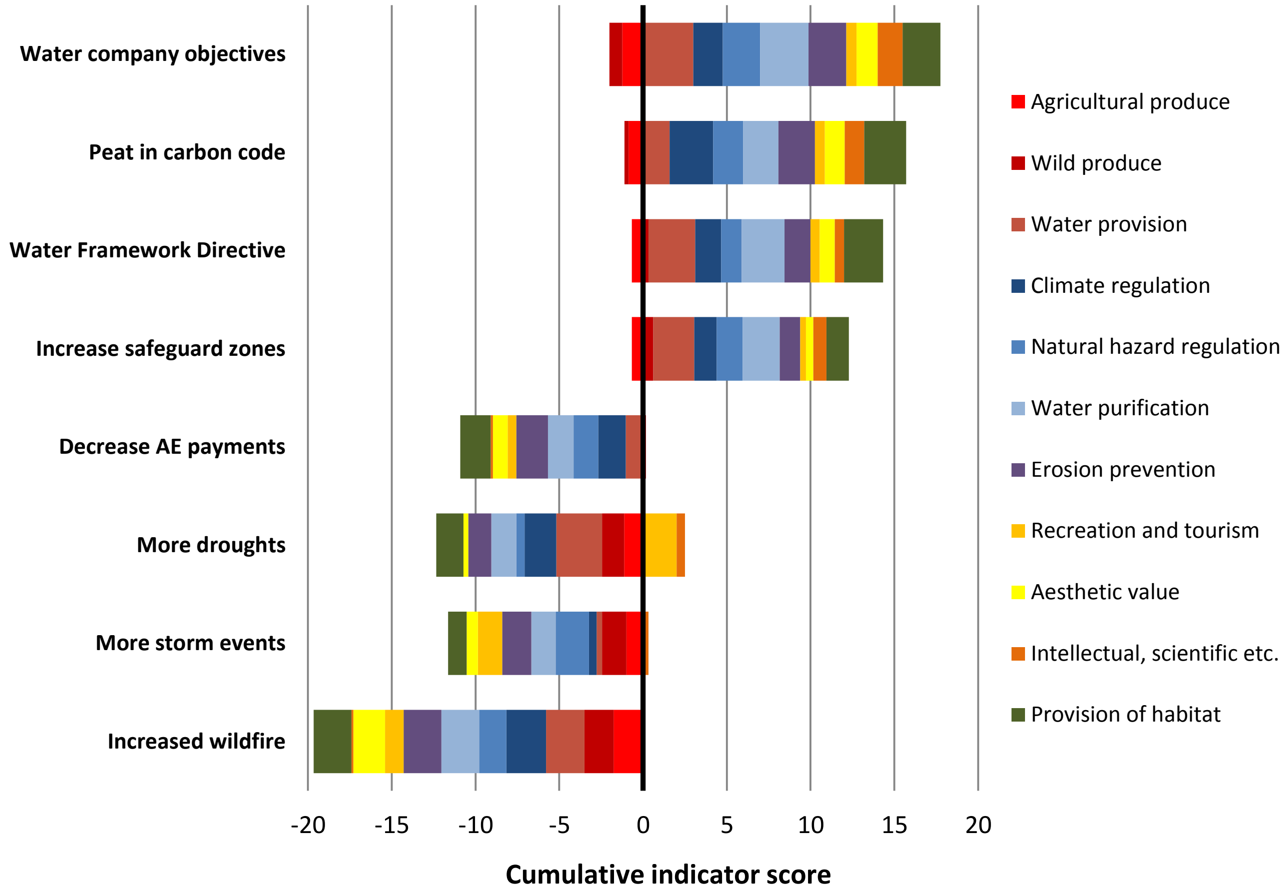


Figure 11: Change in ecosystem service provision under alternative environmental and policy drivers for the Upper Ashop Catchment, illustrating only the 11 ecosystem services showing the greatest change at the site.

7. Conclusions

7.1 Managing peatlands in the Dark Peak

A simple, expert-based ecosystem services assessment was carried out on eight policy and environmental drivers for the Upper Ashop Catchment in the Dark Peak. The site consists of a complex of degraded and intact peatland and is typical of many publicly-owned parts of the Dark Peak. The suite of ecosystem services delivered at any given location is site specific and often varies from place to place. For instance, a publicly-owned area receiving large number of visitors would deliver a different set of ecosystem services compared to a privately owned area managed for shooting. Despite that, it is likely that large parts of the publicly-owned peatland in the Dark Peak are similar in their delivery of ecosystem services and in the pressures that they face. Hence the assessment described here is almost certainly applicable to much of the Dark Peak.

Workshop participants consistently identified water provision, water purification, climate regulation, erosion prevention, natural hazard regulation, recreation and tourism, aesthetic value, intellectual and scientific knowledge, and provision of habitat to be the key ecosystem services either currently or potentially delivered by the site. A large number of additional ecosystem services were considered relevant at the site, highlighting the multiple benefits that such areas can provide. It is clear that all of the broad categories of ecosystem service (provisioning, regulating, cultural and supporting services) are considered to be of high importance in the peatland of the Dark Peak.

An assessment of the consequence of eight alternative policy and environmental drivers on peatland management practices has highlighted the likely management response. An assessment of change in ecosystem service provision then identified the trade-offs, synergies and impacts that would likely occur under each driver. Three of the policy drivers were concerned with water policy, and all three were considered to have wide ranging benefits far beyond that of water quality. The differences that did occur under these three drivers is probably due to the scale of works that are likely to be achieved and some differences in the management response. Water company objectives was considered to have the greatest benefits, probably because it would likely involve actively setting up schemes to alter the management of the peatlands, with the water companies paying land managers for these actions. This would be achieved primarily by gully blocking, revegetation of degraded bogs, and planting native woodland in appropriate locations. Water Framework Directive also scored well, but less than the above, whilst Increase in safeguard zones scored lowest of the water policy drivers, although still positive. This latter policy driver is concerned with designating areas to be targeted for action to improve drinking water quality. However, this is a voluntary initiative and it is unclear what action will follow, or how it will be paid for. At least some of the participants assumed that there would be little extra money available, hence the impact may be less. Furthermore, fewer management actions were expected to be altered by this policy driver, with changes primarily limited to increases in native woodland plantings and decreases in stocking density. Adoption of peat in the carbon code, like the water policy drivers, was considered to have a strong positive impact across a wide range of ecosystem services. Note, however, that for all four of the policy drivers just described, a minor decrease in agricultural produce was expected, almost certainly caused by an expected reduction in livestock stocking densities. It is clear that schemes set up to deliver these policy objectives would need to compensate farmers for a reduction in income from agricultural produce, in addition to the costs of the management works.

Decrease agri-environment Pillar 2 funding was the only policy driver assessed that was expected to have a negative or neutral impact across all ecosystem services. This highlights the current importance of agri-environment schemes in supporting the provision of multiple ecosystem services, especially in upland areas, and the potential impact if such funding was withdrawn or reduced. Workshop participants' expected farming and game management activities to increase and restoration activities to decrease if such a situation occurred, as farmers are likely to intensify production to offset their reduced income from agri-environment schemes. The present environmental stewardship scheme has now closed and a new environmental land management scheme is being developed. Details are still being finalised, although according to Defra (2014):

> *"New funding will be available to support biodiversity, and other areas such as water quality, landscape, flood risk management, the historic environment and access to the countryside."*

Thus the new scheme has the potential to fund a wider range of ecosystem services than the old scheme, with wide potential benefits. Unfortunately, the overall amount of funding is slightly less than under the previous scheme and it is unclear at this stage how the new scheme will be targeted, hence decreased funding in certain areas is a real possibility.

It was notable that all three of the environmental drivers assessed (More storm events, More droughts, Increased risk of wildfire) were expected to have a negative impact on a broad range of ecosystem services. By anticipating the likely effects of these threats, it will be possible to plan actions to lessen their impacts. Indeed, one of the most effective ways to mitigate negative impacts will be through restoring degraded peatlands by gully blocking, revegetating bare peat and controlling livestock density; exactly the same management actions required to deliver other policy and management objectives. Although it is not possible from this study to disentangle the precise impact of each management technique, gully blocking and peatland restoration both appear to deliver a wide range of ecosystem services, with few drawbacks aside from the cost. Planting native woodland in appropriate locations was also considered to be beneficial, although this technique is only appropriate in limited parts of the Dark Peak. Reducing stocking density or game keeping activities are likely to be more mixed in their outcomes, resulting in a reduction in agricultural and wild produce, but an enhancement of other ecosystem services.

It is clear that the restoration and sustainable management of degraded peatlands can deliver multiple benefits to society. Whether the primary reason for doing so is to enhance water quality, carbon sequestration, biodiversity, flood risk management, or to mitigate the impact of future storms and droughts, each will deliver broader benefits. Such synergies are advantageous when planning and seeking funding for such initiatives.

The conceptual framework underpinning this work (Figure 1) shows that policy and environmental drivers influence management practices, which in turn influence peatland structure and function, the ecosystem services provided, and hence the values and benefits derived by society. The system is cyclical, and once we understand the key mechanisms and linkages in the system, we are in a position to improve outcomes. Hence if society chooses to value certain ecosystem services more highly, or to recognise a wider range of benefits from peatlands, it is possible to alter the policy framework to influence certain management practices, enabling that goal to be achieved. Payments for Ecosystem Services (PES) schemes provide one such policy mechanism, as these encourage an alteration of management by explicitly providing payment for ecosystem services that may have previously been unvalued or undervalued.

7.2 Expert-based assessment of ecosystem services

Performing an ecosystem services assessment of policy and environmental drivers using expert judgement has a number of advantages. A particular strength is that it provides a quick and easy initial assessment that may provide an early warning of upcoming challenges. It highlights the wider costs and benefits of the drivers and provides a means of engaging people with different backgrounds with the issues. It can also be used as a focus for future work, for example in carrying out a more detailed assessment of particular aspects, or as a way of developing a Payments for Ecosystem Services (PES) scheme for the area. On the other hand, it should be acknowledged that it is a crude assessment. Some participants commented that it is difficult to assess the impact of drivers such as More storm events, when the actual increase (number of events, duration, amount of precipitation) has not been defined. Also, it is not based on empirical data, hence pre-existing biases and perceptions will form a part of the judgement. These biases will be reduced by involving a large number of participants with different backgrounds, but will never be eliminated. This is not really a problem so long as it is recognised and acknowledged.

Expert-based assessments can also be criticised as the results may vary depending on the people taking part. In our case, the majority of participants had an environmental background, hence there may be a bias towards environmental outcomes at the expense of farming or other outcomes. This should be most evident in the scores that participants provided of potential importance at the study site. However, it was interesting to note that all participants rated provision of habitat most highly, including farming representatives and more traditional land managers. Furthermore, the effect of the various weightings that were applied was minimal. This seems to indicate that there was considerable consensus amongst participants with different backgrounds and that the assessments were relatively robust. Participants did differ in the degree of impact that they predicted, but there was broad agreement over which drivers would have greater impact and whether this was positive or negative.

Overall, performing an expert-based assessment of ecosystem services was positively received by workshop participants. All participants agreed that assessing change in ecosystem services was helpful for understanding the possible impact of the drivers. The majority of participants also agreed that the assessment of ecosystem services was a useful way of engaging with stakeholders and members of the public, particularly as a means of highlighting the wider benefits of the area and raising awareness of the issues.

It is important that the key stakeholders in the Dark Peak and other such areas are fully aware of the potential impacts of major drivers of change over the coming years. An assessment of ecosystem services provides a suitable framework to gain this understanding, and to highlight the multiple benefits that these areas provide to society. This type of assessment can be used as a first step for considering the monetary costs and benefits of alternative peatland management practices. The third workshop in the series took these ideas forward in just this way to investigate the development of a Payments for Ecosystem Services (PES) scheme that could lead to improved management of peatlands in the Dark Peak. Such a scheme needs to balance the costs of restoration activities and any loss of earnings through decreases in agricultural production, against the benefits delivered across a range of ecosystem services. For such a scheme to be successful it is vital that all relevant stakeholders are engaged in this approach and help to shape its design. The whole workshop series has been concerned with developing a greater understanding of the socio-ecological system at play in the peatlands of the Dark Peak, for the researchers, land managers and stakeholders. It is hoped that this will ultimately lead to more sustainable management that delivers multiple benefits for both people and biodiversity.

8. ACKNOWLEDGEMENTS

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10. APPENDIX 1: LIST OF WORKSHOP PARTICIPANTS

Name	Role	Organisation
Amanda Anderson	Director	The Moorland Association
Penny Anderson		Penny Anderson Associates
Helen Armstrong	Project Officer	National Trust
Andrew Critchlow	County Adviser	National Farmers Union
Hazel Crowther	Ecologist	Peak District National Park Authority
Madeline Davey	Assistant Project Officer, Exmoor Mires Project	South West Water
Tom Harman	Kinder Catchment Project Officer	National Trust
Mark Haslam	Area Environment Manager	Environment Agency
Stephanie Hinde	Project Officer	National Trust
Eifion Jones	Adviser	Natural England
Kait Jones	Ranger	National Trust
Ed Lawrance	Wildlife Warden	United Utilities
Angela Mayson	Catchment Co-ordinator	Environment Agency
Dave O'Hara	Dove Stone Project Manager	RSPB
Matt Scott-Campbell	Project Manager	Moors for the Future
Emma Turton	Student	University of Derby
Andrew Walker	Catchment Manager	Yorkshire Water

11. APPENDIX 2: DEFINITION OF ECOSYSTEM SERVICES USED AT THE WORKSHOP

Adapted from the Millennium Ecosystem Assessment and TEEB

Provisioning services	The products obtained from ecosystems, including:
Agricultural produce (e.g. crops, livestock)	Agricultural produce from ecosystems including cereals, vegetables, fruit, meat, dairy produce. Animal feed.
Wild produce (e.g. game, fish, berries etc.)	Wild (and stocked) produce including game animals, freshwater fish, honey harvested from wild populations, wild berries, wild fruits, mushrooms.
Fibre and fuel (e.g. timber, wool, peat etc.)	The production (or potential for production) of sustainable/ renewable natural resources such as wood, thatch, straw and fibres and compounds (latex, gums, oils, waxes, dyes, etc.), industrial materials, energy sources (wood, organic matter).
Water (e.g. for drinking, agriculture, industry)	The natural storage, retention and supply of freshwater. Fresh water extracted (or potential for extraction) for human uses.
Genetic resources (used for crop/stock breeding and biotechnology)	Actual or potential genetic diversity in wild or stock species. Cultivated crops and domesticated animals originated as wild species. For some species, genetic resources of their wild relatives are still needed to maintain productivity or alter characteristics such as taste, pest resistance, or environmental adaptation (used for crop/stock breeding and biotech).
Biochemicals, natural medicines, pharmaceuticals	The sustainable production (or potential for production) of chemicals by natural sources that are important to human health as drugs or as models for synthetic drugs or by providing animals that are used as tools (leeches) or test specimens.
Ornamental resources (e.g. artisan work, flowers, etc.)	Sustainable/non-destructive production of ornamental resources such as shells, flowers, display fish, plants etc.
Energy harvesting (not included in MEA)	Sustainable use of the environment to provide energy. For instance hydropower, thermal power, wave power.

Regulating services	The benefits obtained from the regulation of ecosystem processes, including:
Air quality regulation (e.g. capturing chemicals, particulates, etc.)	Natural regulation of the quality of air and the oceans. Moderating CO_2, O_2, SO_x, and O_3. Lakes for instance act as sink for industrial emissions. Vegetation mitigates effects of pollutants from PM10 particles. Trees in urban areas provide surface area for PM10 capture up to 12 times the area of land that they cover.
Climate regulation (moderation of local temperature / precipitation, carbon sequestration, etc.)	Regulation of both microclimate and global climate (including both carbon sequestration and adaptation to climate change). Regional and global circulation patterns, topography, vegetation, ability to reflect sunlight, determine local and global weather (temperature /precipitation). GHG sequestration, etc. Transpiration from leaves. Forests and other vegetation can trap warm air and provide shelter from wind. Local heat island effects.
Natural hazard regulation (i.e. flood prevention, storm protection)	Buffering of the impacts of natural hazards and disruptions (such as the 'wind break' effect of trees and hedges). Structure and storage capacity of vegetation can reduce the effects of storms, floods and droughts.
Water purification and waste treatment	Natural processes that break down and/or assimilate waste materials, including physico-chemical and microbial purification of water. While the flow and cycling of water also influences supply, this function relates mainly to the filtration and storage of water. Vegetation and soil filter pollutants from water, while the topography and underground structure of ecosystems determine the storage capacity of lakes, streams, and aquifers.
Erosion prevention	Regulation of the erosion of soil (for example through vegetative cover). Soil retention depends on the structure of vegetation and root systems of ecosystems. Roots stabilize the soil and foliage intercepts rainfall, preventing erosion and compaction of the soil. Soil retention allows agriculture to remain productive and prevent damages caused by landslides or wind erosion.
Pollination	Natural pollination, for example provided by bees and a wide range of other insects. Insects, birds, and bats can all provide pollination services. Pollination is crucial to plant reproduction, without which many wild plant species would go extinct and current levels of agricultural production would be impossible or very expensive.

Pest and disease control	Natural regulation of potential pests (such as wasp predation on aphids). Plants and animals that provide natural pest control function (bats, various birds, various insects, frogs and toads, hedgehogs etc). About 99% of crop pests, including insects, rodents, fungi, snails, nematodes, and viruses are controlled by natural enemies such as birds, spiders, wasps, lady bugs, fungi, and viruses, providing a great service to farmers. The vegetation/ habitats of these are also important. Natural regulation of disease organisms (including potentially pathogenic microbes as well as parasite transmission). Could protect human health, livestock, wildlife and domestic pets.
Noise and light regulation (not included in MEA)	Natural features such as forests, woods, trees etc. regulating excessive noise and light pollution from industrial and building sites, roads, entertainment districts, airports etc.

Cultural services	**The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience, including:**
Recreation and tourism	Human values derived from recreational uses of ecosystems, including their often substantial tourism potential. Natural ecosystems are often used as places for relaxation and recreation, including hiking, camping, fishing, and nature viewing. With increasing wealth and leisure time, recreation also increases. In some areas the demand for recreation provides economic opportunities through eco-tourism.
Aesthetic value	Most people enjoy natural scenery and landscapes. This is important not just for human enjoyment but can also have economic importance by influencing property prices.
Inspiration of art, folklore, architecture, etc.	Natural environment provides motivation and inspiration for all forms of folklore and art, including books, movies, photography, fine art, music, dance, fashion, and architecture.
Intellectual, scientific, knowledge, educational	Natural areas provide numerous opportunities for study, education, and research, as well as references for monitoring environmental change. This increases the generation of knowledge and understanding of the natural world. Further, this understanding has benefits in areas of science and technology.
Spiritual, ethical and religious value	Ecosystems and their elements can provide humans with a sense of continuity and place, and can also be an important part of religion. Religious sites such as springs. Religious uses such as water baptisms.
Cultural heritage	Contribution of ecosystems to local and regional heritage (such as historic mills, ports, riverside cityscapes, etc.). Archaeological interest- artefacts etc.
Social relations (grazing / cropping communities etc.)	The role of ecosystems and natural resources as a focal point for community activities, both through formal (e.g. fishing) and informal (such as volunteer activities) pursuits.

Supporting services	**Ecosystem services that are necessary for the production of all other ecosystem services, including:**
Provision of habitat	Provision of habitat supporting ecosystems of conservation value as well as responsible production of other ecosystem services. Refugium function: Natural systems provide living space for plants and animals, allowing for biological and genetic diversity. The diversity of plants provide a variety of cover, structure, and food sources that allows a diverse number of animals to thrive. A certain level of biological diversity is essential for maintaining all other functions and services, although the exact relationship is yet unclear. In this diversity is stored information from millions of years of evolution, as well as the potential for future evolution. With the possibility of future climate change, genetic diversity, and the evolutionary potential is contains, may become extremely important to the adaptation of plants and animals, allowing them to continue to provide the services we depend on. Nursery function: Ecosystems also provide breeding and nursery grounds for species that are harvested elsewhere as adults. This function is important for commercial and subsistence uses of many species.
NB. A number of other supporting services are described in the Millennium Ecosystem Assessment, but are now considered to be ecosystem processes or intermediate services and it is therefore recommended that they are not included in an ecosystem services assessment.	