ARTICLE IN PRESS

Ecosystem Services ■ (■■■■) ■■■–■■■

Contents lists available at ScienceDirect

Ecosystem Services

journal homepage: www.elsevier.com/locate/ecoser

# A framework for valuing spatially targeted peatland restoration

Klaus Glenk [a,*], Marije Schaafsma [b], Andrew Moxey [c], Julia Martin-Ortega [d], Nick Hanley [e]

[a] SRUC, Scotland's Rural College, King's Buildings, West Mains Road, Edinburgh EH9 3JG, United Kingdom
[b] School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, United Kingdom
[c] Pareto Consulting, Edinburgh EH13 0BX, United Kingdom
[d] The James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, United Kingdom
[e] Division of Economics, University of Stirling, Stirling FK 94LA, United Kingdom

ARTICLE INFO

*Article history:*
Received 3 April 2013
Received in revised form
11 February 2014
Accepted 23 February 2014

*Keywords:*
Peatland restoration
Ecosystem services
Spatial targeting
Valuation
Cost-benefit analysis

ABSTRACT

Recent evidence suggests that the degree of degradation of peatlands is substantial, and that there is a significant potential to enhance the delivery of a wide range of ecosystem services by investing in peatland restoration. However, little is known about the social welfare impacts of peatland restoration and in particular how to spatially target restoration activities to maximise net benefits from investments in restoration. This paper investigates the steps required to conduct a spatially explicit economic impact assessment of peatland restoration, and highlights and discusses key requirements and issues associated with such an assessment. We find that spatially explicit modelling of the biophysical impacts of restoration over time is challenging due to non-linear effects and interaction effects. This has repercussions for the spatially explicit assessment of costs and benefits, which in itself is a demanding task. We conclude that the gains of investing in the research needed to conduct such an assessment can be high, both in terms of advancing science and in terms of providing useful information for decision makers.



## 1. Introduction

Peatland restoration can, under certain conditions, act as a greenhouse gas (GHG) sink, thus generating benefits in terms of GHG emission reductions (Peacock et al., 2013; Quin et al., 2014). Restoration has also been found to enhance the delivery of other ecosystem services (ES) such as erosion control (Wilson et al., 2011), and ES related to water quality (Joosten et al., 2012), recreation and biodiversity (D'Astous et al., 2013).[1] Recently, peatlands have received much policy attention for their contribution to climate change mitigation and the potential of peatland restoration to achieve national emission reduction targets cost-effectively (Bain et al., 2011; ASC, 2013). Peatland restoration has indeed been globally recognised for its potential role in contributing to international climate change mitigation (Kyoto Protocol) and biodiversity conservation (Ramsar Convention on Wetlands; Nagoya Protocol of the UN Convention on Biological Diversity) commitments (Bonn et al., in this issue). It has also been suggested that peatland restoration can potentially contribute to compliance with the EC Water Framework Directive (Martin-Ortega et al., in this issue).

Given this policy interest in peatland restoration and conservation, limited restoration budgets and the spatially-varying costs of restoration, there is a need for information on how to spatially prioritise restoration and conservation efforts to deliver the greatest welfare gains to society. That is, there is a need to identify what should be done and where.[2] This paper contributes to a better understanding of the economics of peatland ES and identifies some of the key challenges that need to be addressed for prioritising peatland restoration and conservation[3] activities. In this article, we focus on peatland ecosystems in the UK, which

* Corresponding author. Tel.: +44 131 535 4176.

[1] Here, ES are defined as those outputs of the ecosystem that contribute directly to human well-being (Fisher et al., 2009).

[2] For example, the 2013 Green Stimulus Peatland Restoration Project in Scotland (http://www.snh.gov.uk/climate-change/what-snh-is-doing/green-stimulus-peatland-restoration/), with a budget of £1.7 million over 2 ½ years, and an additional £15m of funding recently proposed by the Scottish Government (http://news.scotland.gov.uk/News/Funding-for-peatlands-48d.aspx), illustrate the direct policy relevance of these questions.

[3] Reflecting the widespread degradation of UK peatlands, in the remainder of this paper, we – unless made explicit – refer only to restoration, i.e., improving the condition of previously degraded peatland, and related activities. The aspects covered in this paper equally apply to conservation, i.e., preserving peatland in good condition, and related activities. The main difference is that conserving sites in good condition may incur lower initial capital costs. Note that, within the UK, protected sites may be degraded (Bain et al., 2011). In fact, a considerable amount of effort has been dedicated in the past to restore degraded and protected Sites of Special Scientific Interest (SSSI) (Worrall et al., 2011).

http://dx.doi.org/10.1016/j.ecoser.2014.02.008
2212-0416 

contain over half of the UK's soil carbon store (Defra, 2009). However, the conceptual points and empirical methods referred to in this paper are also applicable to other geographic regions and ecosystems where peatlands are found globally, such as South-East Asia.

From an economic point of view, the main question is whether restoring peatlands increases overall social welfare, and if so, where and how the costs and benefits are generated. In this paper, we propose that Cost-benefit Analysis (CBA), which requires all costs and benefits associated with restoration to be identified and measured in monetary terms, would be a useful approach to evaluate peatland restoration. In particular, CBA offers a framework within which discrepancies between private and public costs and benefits can be accounted for explicitly.

Identifying those peatland areas with the greatest welfare gain from restoration requires recognition of a wide range of ES associated with this habitat. Besides changes in GHG emissions, peatland restoration may have beneficial impacts on a range of biodiversity indicators, food and timber provisioning services, recreation (e.g. via access and aesthetics), wild-fire risk, and water-related services (e.g. flood risk and water quality) (Bain et al., 2011; Tinch et al., 2010; Evans et al., in this issue; Martin-Ortega et al., in this issue).

The key contribution of this paper is to identify and discuss the multiple challenges for conducting an economic analysis that would allow peatland areas to be prioritised or targeted for restoration with regard to the social net benefit criterion (Hanley and Barbier, 2009). These challenges are related to the assessment of costs and benefits of peatland restoration over *space* and *time*, and the distribution of these costs and benefits across stakeholders at different spatial scales. CBA facilitates identification of and allowance for price distortions arising from, for example, subsidy transfers to certain land uses and the non-market values of environmental impacts. This allows discrepancies between private and public costs and benefits to be accounted for, and thus estimation of net values to society.

An important aspect of an ES approach should be the consideration of spatial variation in ES provision and benefits (see Bateman et al., 2003, Bateman, 2009; Turner et al., 2010). Specifically, the questions arising from spatial targeting of peatland restoration require the consideration of spatial variability in ecological response relationships and resulting benefits arising from changes in ecosystem quality; dependency of economic values on the spatial distribution of beneficiaries; and spatial variation in (opportunity) costs of restoration. Furthermore, the paper discusses how any analysis aimed towards the spatial prioritisation of restoration activities may be conditioned by aspects of risk and uncertainty.

## 2. State of UK peatlands, current management and restoration

Evidence on the current state of UK's peatlands is limited and has been summarised in Bain et al. (2011). According to the best available evidence (JNCC, 2011; Littlewood et al., 2010), less than 20% of the UK's peatlands are largely or entirely undamaged. Many peatlands are eroded, modified or destroyed through extraction or conversion to other land uses. Recent reviews of the ecological condition of peatlands in the UK (JNCC, 2011) suggest that the extent of disturbance and degradation is considerable for both nationally and internationally protected sites. There is thus much peatland that could potentially be restored. Given the scale and cost of this task, there is therefore an urgent need to provide information that can be used for prioritisation of restoration activities across the UK.

While anthropogenic external pressures such as climate change, nitrogen and sulphur deposition contribute to peatland degradation, management of peatlands in pursuit of a range of land management objectives is the largest source of degradation. Current management of peatlands includes livestock grazing with sheep and cattle, agricultural cultivation, and managed burning (JNCC, 2011). Heathlands are also managed for grouse and deer populations for shooting. Historically, many peatlands have been drained in order to increase returns to agriculture and game management. This drainage produces a range of environmental side effects, including oxidisation and shrinkage of peat, with associated increases in carbon losses (Rawlins and Morris, 2010).

Suggested restoration practices include changes in land management (e.g., cessation of moorland burning, reducing stocking density to prevent overgrazing); blocking of ditches to initiate re-wetting, which requires localised engineering interventions; and more intensive interventions associated with deforestation and re-vegetation of bare peat. Several restoration practices may be combined at a single site.

Peatland sites vary considerably in their characteristics – for example in terms of the size and density of drainage ditches or the proportion of bare peat present. This means that different restoration activities will be required for different sites. Also, the required volume and intensity of a given restoration activity and/or the combination of activities will vary by site (Lunt et al., 2010; Tanneberger and Wichtmann, 2011). For example, a lightly degraded site may require only limited ditch blocking whilst a more heavily degraded site may require more extensive ditch blocking but also stabilisation and re-vegetation of bare peat. Such differences lead to variation of restoration costs across sites. The costs fall into three broad categories – capital costs, on-going management costs and opportunity costs.[4] Opportunity costs reflect the displacement of whatever ES are derived from a peatland site prior to restoration, which in many cases will be commercialised provisioning services (e.g. livestock, timber or grouse production) including negative externalities associated with agricultural production. Such costs may be negative from a private and/or social point of view, if upland farming generates negative profits once subsidies and off-farm income are excluded (Ács et al., 2010). Restoration may or may not be associated with the continued delivery of commercialised provisioning services, depending on the degree to which production activities are displaced. Extensive grazing or grouse moors might be compatible with restoration in some cases, and indeed a sustainable agricultural use of rewetted peatlands could be an important option to consider (Joosten et al., 2012).

## 3. Economic impact assessment of peatland restoration: general framework

The general Cost-Benefit Analysis (CBA) framework for analysing changes in land management has been widely described and applied; for recent examples see Pattison et al. (2011) and Cortus et al. (2011). CBA enables the comparison of alternative courses of action, including the option to do nothing. It rests on the monetary valuation of all impacts of alternative courses of action, including valuation of the welfare impacts of changes in ES provision (Hanley and Barbier, 2009). It accounts explicitly for market distortions caused by, for example, market imperfections, externalities, taxes and subsidies to facilitate estimation of the net value

[4] At a practical level, some restoration projects face land acquisition costs – but these may be interpreted as the capitalised value of opportunity costs. That is, rather than paying annual compensation to a land owner for income forgone, ownership of the land is bought outright.

Please cite this article as: Glenk, K., et al., A framework for valuing spatially targeted peatland restoration. Ecosystem Services (2014), http://dx.doi.org/10.1016/j.ecoser.2014.02.008