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Version: Published Version

Monograph:
Ferré, M and Martin-Ortega, J orcid.org/0000-0003-0002-6772 (2019) A User Guide for Valuing the Benefits of Peatland Restoration. Yorkshire integrated Catchment Solutions Programme (iCASP) report, developed in collaboration between University of Leeds, Moors For the Future Partnership, and Yorkshire Peat Partnership. Report. University of Leeds: integrated Catchment Solution Programme (iCASP) , Leeds.

https://doi.org/10.5518/100/9

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A User Guide for Valuing the Benefits of Peatland Restoration

Introduction

Peatlands are the most efficient terrestrial carbon store. They also provide multiple benefits such as clean water and habitat for wildlife. However, historically peat has been used for fuel and today peatland landscapes continue to be adversely affected by burning, drainage, and forest plantation. These activities result in very large areas of peatlands being damaged and their benefits being undermined or threatened.

To redress this damage, peatland restoration is increasingly recognized in UK policy, with important investments being planned or discussed. In this context, it is crucial to understand whether investments in peatland restoration generate net benefits to society.

The main purpose of this guide is to provide guidance on state-of-the-art methods for the economic valuation of the societal benefits provided by peatlands.

The guide will assist practitioners, policy makers, and potential investors in the application or commissioning of valuation assessments as part of peatland restoration planning. It includes case-study illustrations and it points to the existing evidence on the value of the benefits of healthy peatlands.

Although the guide does not provide values that are applicable to all peatland sites or restoration interventions, it will help users to understand how these values can be calculated to optimise peatland restoration works.

This guide has been prepared by Marie Ferré and Julia Martin-Ortega (University of Leeds) in collaboration with the Yorkshire Peat Partnership (YPP) and Moors For the Future Partnership (MFFP). January 2019. For any enquiry please contact icasp@leeds.ac.uk.

Main menu

How to use this guide

This **User Guide** describes valuation methods that are relevant to peatland ecosystem services. It provides an overview of the methods and the resources needed to apply them, such as time, costs, sampling requirement and skills needed. Each valuation method is accompanied by at least one illustration that uses, whenever possible, a UK peatland case.

This is an interactive guide. You can use it selectively by clicking on the section relevant to your particular interest:

- The Valuation methods and illustrations section will help you **understand how to value benefits from peatland restoration and apply suitable methods of valuation**.
- The Evidence of values section will help you **establish an economic case for investment in peatland restoration**, **prioritise expenditure**, **or communicate about peatland benefits**.
- The How to use ecosystem services values to inform decision-making for peatland restoration section will help you **understand possible uses of the estimated values**. It describes and illustrates the concept of cost-benefit analysis applied to peatland restoration as well as the use of benefit values for designing economic incentives.

Before that, we recommend that you get an overview of Why value peatland restoration.

You can also consult the FAQs and the Additional resources section.

Why value peatland restoration

Peatland restoration is gaining prominence in environmental policy agendas. At the global level, peatlands are part of the target of the UN Convention on Biological Diversity and can be accounted for in national climate change mitigation targets under the UN Framework Convention on Climate Change (Land Use, Land-Use Change and Forestry framework). At the EU level, the reform of the Common Agriculture Policy, the delivery of the Water Framework Directive, and goals of the EU Biodiversity Strategy 2020 are also key opportunities to help restore peatlands. In the UK, the Peatland Action plan (2015) emphasizes the need for an improved understanding of peatland restoration and management in Scotland. In its 25 Year Environment Plan (Jan. 2018), Defra announced its long-term commitment to protecting peatlands and its intention to deliver a new framework for peat restoration in England. Against this policy background, it is important to understand the benefits that investments in peatland bring to society.

Valuation is useful as part of a Cost – benefit analysis. Analysing whether the benefits of peatland restoration are larger than its costs helps to support decisions on conservation expenditure, i.e. to compare alternative peatland restoration schemes or prioritise peatland restoration interventions across sites. Valuation can also help businesses and public agencies to make investment decisions, and help with Designing incentive mechanisms for restoration.

Placing a value on peatland restoration requires an assessment of how restoration enhances delivery of ecosystem services and what this means for people's wellbeing.

Valuation commonly uses a monetary indicator to estimate changes in wellbeing so that they can be compared with other costs and benefits. This does not mean putting a price on nature, but using a simple way of measuring changes in wellbeing associated with changes in the environment. However, it is important to acknowledge that wellbeing is much more complex than any single simplified metric can fully capture.

Valuation of ecosystem services is meant to support decision making but not replace it.

Valuation can only be one of the streams of information used when taking decisions about the environment. Other factors, such as distribution of these benefits, distribution of costs, and access to ecosystem services are essential elements to take into consideration as well.

Benefits from peatlands: a complex picture

Peatlands are complex ecosystems, with stocks and flows of ecosystem services varying over time and within space. This has consequences for the way in which benefits of peatland restoration are realised:

- Recovery of ecosystem services following restoration happens on different time scales, e.g. improvements to water quality might be visible in the short term while carbon storage can take decades.
- Some services can be enjoyed on-site (e.g. landscape beauty) and others are enjoyed off-site (e.g. drinking water quality).
- Peatland ecosystem services provide benefits across the population range from local inhabitants (e.g. recreational value) to the global population (e.g. climate change mitigation from carbon storage)
- Peatlands benefit individuals directly (e.g. drinking water quality) or indirectly (e.g. regulating service such as nutrient cycling).

A successful valuation requires a prior understanding of ecosystem services and how they respond to restoration interventions. This guide is about how to value those ecosystem services once their delivery has been established.

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Valuation methods and illustrations

You are interested in understanding **how** to value the benefits that peatlands generate to society and in choosing suitable valuation methods to plan your restoration activities.

This section provides an overview of the various valuation methods, illustrated with at least one case study. You can use the table below to navigate the list of benefits that you might be interested in valuing and the methods.

We also recommend that you have a look at the section Methods: pros & cons to get a picture of the advantages and disadvantages of the methods.

Benefits of peatland restoration	Valuation Methods
Carbon benefits	Abatement cost – page 6
Drinking water quality benefits	Avoided-cost method – page 9
Water quality ecological benefits	Contingent valuation method – page 11
Flooding risk mitigation benefits	Avoided-cost method – page 14
	Contingent valuation method – page 16
Recreational and cultural benefits	Contingent valuation method – page 18
	Travel cost method – page 20
Bundle of ecosystem services associated with improved peatland condition	Choice experiment method – page 21

Note that:

- These methods use monetary valuation to assess the value of ecosystem services.
- While well-established in the environmental economics literature, these methods will always be limited by the fact that human wellbeing is more complex than any simplified single metric can ever capture. These methods are also criticised because, while they are not meant to set a price on ecosystem services, they can be used as an argument for the commodification of nature.
- The estimated value of ecosystem service often represents a lower bound of its actual value. Under-estimation of values is common for services delivered at large scales.
- The values presented in the illustration cases cannot serve as direct value estimates of other cases. Values are not universally valid and are specific to the context in which they are estimated, e.g. they are dependent on the conditions of the peatland ecosystem that are considered in the valuation. Yet, they can serve as illustrations, e.g. of order of magnitude, or as a reference point.
- If not stated otherwise, all the values are expressed as present values of the year of the study. To translate those values into present values, you need to consider economic inflation from the year of study to the present.

Methods are described using a “key”. Go to the
KEY Menu before exploring the methods

KEY

Difficulty of implementation

Easy

Medium

Difficult

Resources

Implementation costs (excluding staff time requirements)

£	< £1,000
££	£ 1,000 - £5,000
£££	> £ 5,000 - £10,000

Labour cost = Minimum time requirements*

'Skilled' labour		*'Unskilled' labour*	
	> 1 month		> 1 month
	> 2 months		

Sampling requirements

 Desk based, no sample population needed

 Reduced number of people or limited groups

 Large sample population (% of overall population – possibly >100 individuals)

 Field measurement

Skills

 Basic calculation skills

 Medium level statistics

 Advanced econometrics

 Facilitation skills (for focus groups)

Valuation type

 To predict benefits of restoration on a site (ex-ante valuation)

 To evaluate benefits of restoration on a restored site (ex-post valuation)

*Labour requirement times include method preparation, implementation and analysis. They are indicative and can vary substantially. They refer to the amount of time that needs to be dedicated to the task but do not reflect duration of the task because for some methods, it might take long to obtain or collect data. The time needed also depends on sample size, whether the survey implementation is outsourced, and whether it is online or face to face. Interpretation and write-up time beyond mere reporting of results are not accounted in this estimation. Skilled labour refers to a person with skills specific to the undertaking of the task (see item on skills requirements); unskilled labour refers to supporting staff that can work under the direction of skilled staff (e.g. interviewers trained ad-hoc for the survey). However, a skill such as ability to manage a database may still be needed in unskilled labour.

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Valuing carbon benefits using the abatement cost method

The benefits that peatlands produce in the form of **carbon sequestration** can be measured using the **abatement (or mitigation) cost method**. This method is based on the idea that if carbon is sequestered by peatlands, there would be cost savings from not having to abate that carbon by other means. It consists of appraising the economic value of estimated net carbon dioxide equivalents (CO_{2e}) savings from peatland restoration in a given year.

Application of this method is possible because there exists a market price for carbon. The estimation uses carbon values and consists of multiplying the estimated net CO_{2e} savings, i.e. the differential in emissions between a damaged site and a near-natural site or between a damaged site and a restored site, by the price of carbon in that year.

Calculating carbon savings: Carbon storage in peatlands is quantified based on the balance between C losses from the system through gaseous emissions, that is, carbon dioxide (CO_2) and methane (CH_4), aquatic pathways (Dissolved and Particulate Organic Carbon, DOC and POC, respectively), as well as C accumulation processes related to vegetation.

Data requirements for applying the abatement cost method to carbon benefits

- Market price of carbon
- For predicting carbon benefits on a site to be restored: a measure of on-site carbon and other greenhouse-gas emissions, and estimation of the potential differential that can be achieved after restoration
- For evaluating carbon benefits of restored sites: a measure of rates of carbon emissions and carbon sequestration on the restored site and an estimation of the differential (estimation of the GHG emissions before restoration)

Be aware that: The method depends on the accuracy of estimated measures of rates of emissions and sequestration of carbon for the studied area. Such measures are complex as they need to account for the losses of carbon to water and the increased presence of CH_4 under wetter conditions, among other things. In fact, actual field measurements of GHG emissions are not many, current estimated GHG emission factors for different peatland categories in the UK vary, and there is a natural year-on-year variation for a peatland site. Thus, calculating the emission differentials before/after restoration is open to large potential variations.

See Methods: pros & cons for an overview of the method's advantages and disadvantages.

Data sources - suggestions:

- Estimates of emission differentials for different initial land uses, like forest and grasslands, in Hoosten et al., 2016, in Bonn et al., 2016. Peatland restoration and ecosystem services. Chapter 4, page 75 (table 4.3) (not open access)
- Estimations of emission differentials can be computed for different types of peat and levels of degradation using the "Peatland Code Emission Calculator" available in http://www.iucn-uk-peatlandprogramme.org/node/2523 (open access)
- Estimates of GHG balance after peatland restoration in Harlow, J., Clarke, S., Phillips, M., Scott, A., 2012. http://publications.naturalengland.org.uk/publication/1287625 (open access)
- Emissions factors for restored wetland and arable land for different GHG in Peh et al., 2014. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.1248 (open access)
- Carbon prices: DECC. 2011. A brief guide to the carbon valuation methodology for UK policy appraisal (open access): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/48184/3136-guide-carbon-valuation-methodology.pdf

Illustration: Estimation of the value of carbon benefits of peatland restoration - UK

The prices of carbon used in the study stem from the UK government's agreed set of carbon values for policy appraisal and evaluation (based on Department of Energy and Climate Change, DECC 2011). The traded carbon value ranges from 6 to 17 £/t carbon while the non-traded carbon value (outside the European Union Emission Trading System) ranges from 28 to 83 £/t.

The study assumes that i) a methane spike is equivalent to 2.5 tCO_{2e}/ha/year for each of the first ten years, and ii) the differential emission profiles for non-restored and restored sites is between 1 tCO_{2e}/ha/year and 20 tCO_{2e}/ha/year. It is achieved ten years after restoration commences and it is maintained thereafter.

Carbon dioxide equivalent (CO_{2e}): is used to describe different GHG in a common unit. For any quantity and GHG, CO_{2eq} signifies the amount of CO_2 which would have the equivalent global warming impact. Thus, net flux of each gas in t/ha/year can be converted into tonnes CO_{2eq}/ha/year and added up to give a net global warming potential over 100 years – GWP_{100} ha/year under various land uses.

Traded and non-traded carbon: EU climate and energy package introduces separate emission reduction targets for the traded sector (emissions covered by EU ETS) and the non-traded sector (emissions not covered by ETS). This corresponds to different types of emissions. The prices of carbon in the two sectors are different but are predicted to converge by 2030. The valuation illustration uses the non-traded value of carbon (much higher than prices observed in voluntary or compliance carbon markets) as it represents the societal benefits of emission savings.

Results

The study accounts for estimated costs of peatland restoration to understand whether restoration of peatland is worthwhile, considering the carbon services only, for the UK.

High carbon differentials are sufficient to justify peatlands restoration (without considering non-carbon benefits), even if on-going (recurrent) and/or capital costs are also high. On-going costs capture on-going management and monitoring costs of the process as well as opportunity costs. Very low carbon differentials are only sufficient to justify restoration if on-going and/or capital costs are low.

KEY RESULT

Estimated benefits of carbon from restored peatland considering a differential of 5.0 tCO_{2e}/ha/year and a central carbon price of £13/tC (traded market price) = £65/ha/year. For a carbon price at £56/tC (non-traded market price), the value = £280/ha/year.

Be aware that: Different unit prices for carbon benefits could be used. Higher prices would increase the case for restoration and lower prices would reduce it. Moreover, carbon prices rise over time.

Reference: Moxey, A., Moran, D., 2014. Peatland restoration: Some economic arithmetic. Science of the Total Environment 484: 114-120. https://doi.org/10.1016/j.scitotenv.2014.03.033 (open access)

Sphagnum and Cotton Grass. Photo credit: Yorkshire Water

Water quality benefits

Water quality related benefits derived from peatland restoration can be categorized in two broad categories: 1) reduced drinking water treatment costs and 2) benefits associated with the good ecological condition of water bodies.

Valuing drinking water quality benefits using the avoided-cost method

Monetary estimates of reduced treatment costs of water utilities associated with peatland restoration are rare. Due to this lack of data, we first provide an understanding of the cause-effect link and logic between peatlands management, catchment water quality, and water treatment costs. We refer to this as qualitative evidence. We then present case studies to illustrate the method.

Qualitative evidence - Reduced water treatment costs from peatland restoration

Seventy percent of drinking water in the UK originates from uplands. These upland areas are often peat dominated. Upland peatland management therefore has a direct influence on water quality across catchments. Peatland restoration benefits water quality through reducing concentration of suspended sediments or fine particulate organic matter and reducing microbial breakdown of peat, leading to decreased concentrations of colour in the water. This reduces the amount of chemical dosing needed and results in cheaper water treatment. Removal of Dissolved Organic Carbon (DOC) is a key treatment process for the supply of drinkable water from peat-dominated catchments and it represents the largest cost to UK water utilities. It is recognized that the need for DOC removal decreases where there is a higher level of peat restoration involving blocking drains and increasing the amount of peat-forming Sphagnum.

The quantitative and monetary relationships between increased water quality and decreased treatment costs are not yet well established. Such financial quantification is particularly hard for water utility companies because of the difficulty of disentangling other factors such as treatment costs associated with pesticides. An understanding of these relationships is as follows. Water utility companies' treatment variable/operational costs are partly determined by the need for a rapid response to a change in water quality. There might be minimal treatment if the water quality is good, but treatment costs may increase sharply and suddenly if the quality deteriorates, e.g. after heavy rainfall. The level of these costs will therefore substantially depend on whether minimum treatment has to be maintained regardless of quality. Capital costs include investments in treatment infrastructure. Any reduction in capital costs implies an understanding of how a change in water quality affects infrastructure over time. Thus, savings in water treatment may only be significant when a treatment facility has to be replaced, enabling scale-back on capital requirements. Furthermore, given that water colour is increasing at a national level due to a decline in acid rain, the gain from peatland restoration might in fact consist of stable treatment costs.

Water companies are increasingly aware of the benefits of peatland restoration for reducing their water treatments. Multiple schemes are in place or in development across the UK.

Data source - suggestion

Detailed overview of the potential effects of peatland restoration on water quality related final ecosystem services in Martin-Ortega, J., Allott, T.E.H., Glenk, K., Schaafsma, M., 2014. Valuing water quality improvements from peatland restoration: Evidence and challenges. Ecosystem Services 9, 34-437. https://doi.org/10.1016/j.ecoser.2014.06.00 (not open access)

Quantitative valuation – The avoided-cost method

The benefits that peatlands produce in the form of improved water quality in the catchment can be measured using the **avoided-cost method**. This method is based on the principle that peatland's contribution to filtering and cleaning water in the uplands results in cost-savings from not having to treat that water through other means. The method consists therefore of evaluating the economic value of water treatment costs savings from peatland restoration by calculating how much it would cost to treat that water with one of the existing treatment systems.

Data requirements for applying the avoided-cost method to drinking water quality benefits

- Water quality indicator, before and after peatland restoration
- Cost of the various water treatment works, including fixed and variable costs, before and after peatland restoration

Data sources: Water utilities companies

Be aware that: The application of the method depends on the availability of data on reduced water treatment costs attributed to a change in the management of a peatland (i.e. over a long time period). A good understanding of the different types of costs and investments that come into play is necessary. These estimates are often not publically accessible due to terms and conditions around commercial data confidentiality.

See Methods: pros & cons for an overview of advantages and disadvantages of the method.

Illustration: Valuing drinking water quality improvement from peatland restoration - Keighley Moor and Watersheddles catchments - Yorkshire - UK

The Keighley and Watersheddles catchments are covered by 1,345 ha of peatlands and deliver 8 to 10 megalitres/day into the water treatment system. The study focuses on the costs of treating DOC in the water using MIEX - a type of water treatment technique. According to Yorkshire Water, embodied carbon in a typical MIEX water treatment plant is 1147 t/CO_{2eq}. Improvement of water quality means that there would be no need for expensive treatment solutions like MIEX plants. This means that initial capital costs are avoided as well as part of the operational costs to which MIEX contributes.

The study considers three scenarios of peatland conditions in the catchment - status quo, decline, and improve - determined by land management and rewetting interventions. For each scenario, different rates of DOC reduction in water are calculated. The valuation of improved water quality is based on the capital and operational costs of meeting drinking water utility standards. The benefit of reducing the rate of DOC in water (or reducing raw water colour) through an improved condition corresponds to cost avoided: 1) by deferring capital investment in MIEX and 2) from operational cost increases for chemicals.

Results

As compared to a status quo situation (baseline), a decline scenario characterised by a 30% increase in DOC generates a value of -£2,5 million in the catchment (estimated present values benefits), while an improve scenario with a 15% decrease in DOC generates a value of £2,2 million.

Be aware that: MIEX is not a standard technique and is relatively expensive. Hence the estimates should be understood as particularly high. Second, treatment costs vary across locations and types of treatment considered. Third, valuing one type of service, e.g. measuring the cost of building an additional water treatment mechanism, is generally a minimum estimate of the value of ecosystem services coming out of the peatland ecosystem.

References:

- Harlow, J., Clarke, S., Phillips, M., Scott, A., 2012. Valuing land-use and management changes in the Keighley and Watersheddles catchment. http://publications.naturalengland.org.uk/publication/1287625 (open access)
- Eftec. 2015. The Economic Case for Investment in Natural Capital in England: Land use appendix.https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/517006/ncc-research-invest-natural-capital-final-report.pdf (open access)

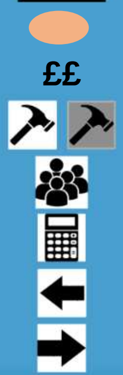
Valuing water quality ecological benefits using the contingent valuation method

Water quality benefits provided by peatland that concern the achievement of a good water ecological status are not traded on the market. Survey-based methods are used to value these benefits. Ecosystem services can be estimated using **a contingent valuation method**, which means directly asking people for their willingness-to-pay for an improved ecological status of the water. This is a stated-preference method where respondents are asked for their maximum willingness to pay for a predetermined increase or decrease in the condition of an ecosystem or environmental quality. Respondents can be asked to either state how much additional tax they are willing to pay to preserve a particular ecosystem service and avoid its degradation, or to state the amount of compensation they would be willing to accept to give up the service. Questions either present a bid amount to respondents who state whether or not they are willing to pay/accept it, or simply ask respondents how much they are willing to pay or accept.

Data requirements for applying the contingent valuation method to water quality benefits

- Understanding of downstream water bodies that will benefit from increased water quality through peatland restoration upstream
- The services provided by the increased water quality
- The population that benefits from the increased water quality, and how

KEY



See Methods: pros & cons for an overview of the method’s advantages and disadvantages.

Be aware that: People's background affects how they value peatland and its benefits. Assessing the willingness-to-pay of a population for an improvement in water quality requires therefore to carefully consider individuals' socio-economic characteristics such as gender and income, as well as spatial characteristics such as where people live. In addition, the improvements of peatland-induced water quality vary across space since water quality responds differently to restoration across locations.

Note that the two illustrations below do not use the case of peatland ecosystem.

Illustration 1: Valuing river water quality environmental improvement - Ouse catchment - North Humber basin - UK

The study uses the contingent valuation method to determine the aggregate benefit value of the Water Framework Directive that promotes improved ecological quality of water bodies, on waterways in the Humber. Using data from the Environment Agency General Quality Assessments of river, four quality levels are defined: pristine rivers, good quality, fair quality, and poor quality. In the survey, respondents visualised the ecological qualities of the site through images depicting the different water quality levels. They were asked to separately value a small and a large water quality improvement on a river stretch by identifying the maximum willingness-to-pay to achieve it (a list of monetary values was used).

Results

In total, 439 answers were collected. Respondents give a similar willingness-to-pay for water quality improvement response for the small and large improvement - on average £21/respondent/year. While personal characteristics like age and gender do not influence willingness-to-pay, the study finds a significant effect of distance: the further away a respondent lives from the site, the lower the willingness-to-pay and the closer the respondent lives to another (substitute) site (river site or coast), the less (s)he is willing to pay for the site under valuation.[1]

KEY RESULT

Average estimated ecological benefits of water quality of the Humber river = £21/respondent/year. Benefits vary according to individuals' characteristics and distance to site from place of residence.

Be aware that: The survey accounted for spatial distribution as location is an important driver of values for change in river condition. The order in which the scenarios are presented matters too.

Reference: Bateman, I.J., Ferrini, S., Hime, S., 2008. Aquamoney: (open access): https://www.ivm.vu.nl/en/Images/D38_Case_study_report_Humber_UK_tcm234-188871.pdf

Illustration 2: Valuing river water quality environmental improvement - River Tame - UK

The study determines improvements to the water quality of the River Tame. Three levels of river quality improvement are used: small, medium, and large improvement. Details are provided of the impacts of each improvement on three water quality attributes: fishing; plants and wildlife; and boating and swimming. The improvements are alternatives to each other and are evaluated relative to a common baseline of the current situation.

[1] Values have been converted to pounds (£) at a rate of £1 = €1.10.

Respondents valued all three improvements using a direct open-ended question asking the respondent to state their maximum willingness-to-pay for the improvement in question. The monetary trade-off was an annual increase in council tax paid by respondents.

Results

Out of 675, 23.1% of the respondents were unable to state a willingness-to-pay and 39% stated a zero willingness-to-pay for the three water quality levels. The study finds that willingness-to-pay for River Tame water quality improvements is equal to £9.60/household/year for the small improvement, £15.34/household/year for the medium improvement and £22.89/household/year for the large improvement, excluding zero bids.

KEY RESULT
Average estimated ecological benefits of water quality of the River Tame = £15.9/household/year.

Reference: Bateman, I.J., Cole, M.A., Georgiou, S., Hadley, D.J., 2006. Comparing contingent valuation and contingent ranking: A case study considering the benefits of urban river water quality improvements. Journal of Environmental Management 79: 221-231 (not open access).

Water running through Bishopdale. Photo credit: Jenny Sharman

Flooding risk mitigation benefits

Studies that value the benefits of peatlands in mitigating the risk of flooding are scarce. We provide illustrative examples of the benefits of mitigating flood risks to humans directly (including reduction in psychological stress, and property and business losses) and wider ecological benefits, considering the maintenance of cultural and recreational services provided by water bodies.

Valuing flood protection benefits using the avoided-cost method

The benefits that peatlands produce by reducing flooding risks in the catchment can be measured using the **avoided-cost method**. This method is based on the idea that upland peatland's contribution to storing water results in a lower likelihood of flooding downstream and cost-savings from not having to provide compensation for the losses and damages caused by flooding. Flood damages mainly include damages to: agricultural crops (loss in harvest, soil degradation); buildings (decline in property values); and businesses.

Data requirements for applying the avoided-cost method to flood protection benefits

- Area at risk of flooding
- Flood risks (e.g. X in a 100 year time flood)
- Property values, and crop production and value
- Businesses within the risk area including their value
- Number and value of insurance claims

Data sources: Secondary data, e.g. statistics from Defra for the values of crops: https://www.gov.uk/government/statistical-data-sets/commodity-prices), and surveys

See Methods: pros & cons for an overview of the method's advantages and disadvantages.

Be aware that: The application of the method depends on the availability of data. Some of the value related to these damages can be relatively easily estimated (e.g. property values, annual crop harvest value) while others such as business values are not easily available.

Illustration 1: Estimation of flood protection benefit from restored peatlands as avoided damage to crops and properties - Cambridgeshire, Wicken Fen National Nature Reserve - UK

The restored wetland in Wicken Fen acts as a flood storage area. It has the capacity to protect 2000ha of farmland and the 10 homes in the area. Of this area, 50 ha would be flooded during a 1-in-20-year flood event: it consists of cereal (71%) and general cropping farms (29%) that would change to lower value sheep grazing if flooded. In the adjacent arable land (1,950 ha), indirectly affected by higher water tables, general cropping would be replaced by lower value cereal farms.

Results

Based on crop values and area flooded, the total cost to farmers of a flood is estimated at £188,665. Based on the Environment Agency's estimates of damage cost of £15,410 for a flooded home and using 132,000 insurance claims associated with a past flood event, the cost to the 10 homeowners is £166,339. The total flood protection benefit to the farmers and homeowners from restoring the wetland - equivalent to avoided damage to crops and property - is therefore estimated at £355,004. Considering the risk of flooding of the area (once every 20 years), the avoided damage cost is £17,750/year or £37/ha/year.[2]

KEY RESULT

Average estimated benefits of mitigating flooding through restoring the Wicken Fen wetland = £37/ha/year.

Reference: Peh et al., 2014. Benefits and costs of ecological restoration: Rapid assessment of changing ecosystem service values at a U.K. wetland. Ecology and Evolution 4, 3875-3886. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.1248 (open access)

Illustration 2: Estimation of flood protection benefit from restored peatlands as avoided damages to businesses - Calderdale and Upper Calder Valley, West Yorkshire - UK

The study assesses the economic costs of the floods of Boxing Day 2015 focusing on small and medium sized businesses. The types of costs featured in an online questionnaire sent to businesses in the borough of Calderdale included structural, stock, equipment, staff wages and cleaning up. The total value of the benefits of flood risk reduction are estimated through summing up the total costs generated by the flooding event, which could have partly been avoided if upland water storage capacity, via peatland restoration, had been available.

Results

The costs of the flood include the value of 1600 businesses; the average loss per firm during the 2012 flood is £47,000. Furthermore, for every £1 reported in direct losses, another £0.6 on average was lost indirectly throughout the regional economy. Thus, the damages to the businesses represent about £47 million losses to the local economy, which can be used as an estimate of the value of flooding mitigation through peatland restoration.

Be aware that: This method requires a clear understanding of the businesses in the area, their respective risk of being flooded, and the mean size of each commercial property and its value. Some of the data may be difficult to obtain because of confidentiality issues.

Reference: Sakai, P., Holdsworth, A., Curry, S., 2016. Economic Impact Assessment of the Boxing Day Floods (2015) on SMEs in the Borough of Calderdale. Final report 44. https://www.see.leeds.ac.uk/uploads/media/Economic_Impact_Assessment_of_Boxing_Day_floods.pdf (open access).

[2] Values have been converted to pounds (£) at a rate of £1 = $1.30.

Valuing flood protection benefits using the contingent valuation approach

Peatland's contribution to upland water storage results in a lower likelihood of flooding downstream, leading to fewer negative impacts on human health (e.g. psychological stress linked to flood uncertainty) and a higher ecological status level for the rivers that are subject to flooding in the catchment. The benefits that peatlands produce in the form of **reducing flooding risks in the catchment** can also be measured using the **contingent valuation method**, which means asking people directly what their willingness-to-pay for a reduced risk of flooding is. This is a stated-preference method where respondents are asked for their maximum willingness to pay for a predetermined increase or decrease in the condition of an ecosystem or environmental quality. Respondents can be asked either to state how much additional tax they are willing to pay to preserve a particular ecosystem service and avoid its degradation, or to state the amount of compensation they would be willing to accept to give up the service. Questions either present a bid amount to respondents who state whether or not they are willing to pay/accept it, or simply ask respondents how much they are willing to pay or accept.

Data requirements for applying the contingent valuation method to flood protection benefits

- Understanding the area likely to be flooded, including degrees of flooding risks
- Health effects due to the stress of facing flooding event
- Recreational services provided by the rivers at risk of flooding

Data sources: Survey of local population

See Methods: pros & cons for an overview of the method's advantages and disadvantages.

Illustration: Estimation of flood protection benefit on people's health - UK

Tangible impacts of flooding on households are relatively easy to estimate in monetary terms and include the cost of reinstating or replacing damaged items. Intangible impacts cannot readily be valued and include the loss of irreplaceable items or items of sentimental value, health impacts and psychological effects of flooding, including anxiety about the need to be relocated. Values for these negative health effects are difficult to obtain. This study applies the contingent valuation method to investigate the maximum willingness-to-pay of floodplain residents to avoid or reduce the identified intangible impacts of flooding on their households. Using a survey, the study assesses how much respondents (n=280) are willing to invest in the intangible benefits of Property Level Flood Risk Adaptation (PLFRA) measures.

Results

The study finds that the average willingness-to-pay per household to avoid or reduce the intangible impacts of flooding, including psychological impacts, is estimated at £653/household/year. This is the value of the intangible benefits of investing in PLFRA measures, and an estimate of the value of flooding risk mitigation through peatland restoration. It is important to note that for higher levels of stress from flooding and a higher level of worry about future flooding, willingness-to-pay value is also likely to be higher.

Reference: Joseph, R., Proverbs, D., Lamond, J., 2015. Assessing the value of intangible benefits of property level flood risk adaptation (PLFRA) measures. Natural Hazards 79, 1275-1297. https://link.springer.com/article/10.1007%2Fs11069-015-1905-5 (no open access).

Note: The monetary value of flood protection ecosystem service from a peatland may be also valued on the basis of the cost of building man-made defences for flood protection of equal effectiveness (**replacement-cost method;** see Methods: pros & cons for an overview). Figuring out the type of defence that would have the same efficiency as a given peatland acreage is, however, difficult.

Timber Dam. Photo credit: Yorkshire Water

Recreational and cultural benefits

Valuing recreational services using the contingent valuation method

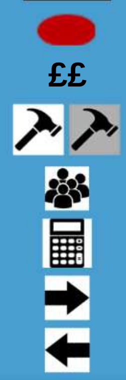
Recreational services provided by peatlands are not traded on the market. The benefits that peatlands produce in the form of **recreation and amenities** can be measured using the **contingent valuation method**, which means asking people for their willingness-to-pay for an increased level of recreational benefits delivery. This is a stated-preference method where respondents are asked for their maximum willingness to pay for a predetermined increase or decrease in the condition of an ecosystem or environmental quality. Respondents can be asked either to state how much additional tax they are willing to pay to preserve a particular ecosystem service and avoid its degradation, or to state the amount of compensation they would be willing to accept to give up the service. Questions either present a bid amount to respondents who state whether or not they are willing to pay/accept it, or simply ask respondents how much they are willing to pay or accept. This method involves interviewing people in a survey and determining their willingness-to-pay to conserve peatland's recreational benefits.

Data requirements for applying the contingent valuation method to recreational services

- Map of the area including the features that contribute to the ecosystem being used for recreational purposes and recreational activities
- Information on whether individuals have visited the site previously (in order to distinguish use and non-use values)

Data sources: Representative sample of the population (to collect information on socio-economic characteristics of the respondents)

KEY



See [Methods: pros & cons] for an overview of the method's advantages and disadvantages.

Be aware that: There are not many studies on the recreational services delivered by peatlands but there are a few more for other wetland areas that can also be used as reference.

Illustration 1: Valuing recreational services of blanket peat bog - 'Flow' Country - UK

Peat bog in the 'Flow Country' in Scotland covers over 400,000 ha and is characterised by unique plants and important bird habitats. The study compares the option of conserving the bog area against converting it to block plantations (pine and spruce). The latter results in habitat damage, disruption of water and soil regimes, and increased sedimentation and erosion. Using a survey, the study assesses the regional residents' willingness-to-pay for conserving the area by asking respondents whether they would be willing to contribute a one-time amount to a trust fund established to conserve the area, and if yes, how much. The results of the survey enable a valuation of the conservation option of the area.

Results

60% of respondents stated a positive willingness-to-pay. The mean willingness-to-pay was estimated at £16.79/household but those who had visited the site expressed a higher willingness-to-pay than non-visitors (£24.59/household vs. £12.15/household). By extrapolating the average willingness-to-pay over the entire regional population, the study finds a **Net Present Value** of conserving the area at £327/ha.

KEY RESULT
Average estimated benefits of conserving the bog area and its biodiversity = £327/ha (considering the entire regional population).

The **Net Present Value** is the value today of a given stream of costs and benefits through time in the future.

Reference: Barbier, E. B., Acreman, M., Knowler, D., 1997. Economic valuation of wetlands. Journal of environmental biology http://archive.ramsar.org/pdf/lib/lib_valuation_e.pdf (open access).

Illustration 2: Valuing recreational services of wetlands - Norfolk Broads, East Anglia, UK

The Norfolk Broads wetland provides recreational opportunities. In the past the area was drained and peat was extracted but the management of the area changed to protect it. Using a survey, the study estimates the value of the benefits of such a management strategy to determine the willingness-to-pay to conserve the recreational benefits of the wetland area. Using a second survey across the UK, the study assesses non-use values associated with the wetland.

Results

KEY RESULT
Average estimated benefits of the recreational services of the Norfolk Broads wetlands = £94/household.

In the first survey (n = 3000), mean willingness-to-pay of the respondents is £94/household, which captures the recreational and amenity use value estimates for the Norfolk Broads. For the non-use values, the study finds a 'decay factor': willingness-to-pay values decline with the distance of the respondent to the area. The average willingness-to-pay of respondents located close to the wetland is £12.45/household, while it is estimated at £4.08/household for respondents located elsewhere in the UK. Aggregate willingness-to-pay estimates over the UK for non-use values of the wetland are estimated in this study as £32.5 million and £7.3 million, respectively.

Be aware that: Non-use estimate values of the wetland must be interpreted carefully as the study was not able fully to distinguish non-users from past users.

Reference: Barbier, E. B., Acreman, M., Knowler, D., 1997. Economic valuation of wetlands. Journal of environmental biology http://archive.ramsar.org/pdf/lib/lib_valuation_e.pdf (open access).

Illustration 3: Valuation of cultural services of peatlands - Ireland

Using a contingent valuation survey, the study determines the value that the public attaches to Ireland's peatlands, to establish the public good value of a national policy of peat bog protection.

Results

The survey (n=500) reports an average willingness-to-pay of £51/person/year for a National policy of peatland protection.

Reference: Bullock, C.H., Collier, M.J., Convery, F., 2012. Peatlands, their economic value and priorities for their future management - The example of Ireland. Land Use Policy 29, 921-

928. https://doi.org/10.1016/j.landusepol.2012.01.010 (not open access); Bullock, C.H., Collier, M., 2011. When the public good conflicts with an apparent preference for unsustainable behaviour. Ecological Economics 70, 971-977. http://dx.doi.org/10.1016/j.ecolecon.2010.12.013 (not open access)

Valuing recreational services using the travel cost method

The benefits that peatlands produce in the form of **recreation** can be valued using a **travel cost method**. This method is based on the observation that recreational services can only be realised through physical access to nature. This implies that individuals seeking to enjoy the service will need to spend time and money to travel to the site. The method assumes that people value recreation at that site, at least as much as how much it costs them to get there. Thus, the recreational value of a peatland equals the costs of reaching the peatland.

Data requirements for applying the travel cost method to recreational services

- Direct expenditure by visitors: spending on fees, travel, food, and accommodation (minimum value a visitor places on a site for recreation)
- Time spent to travel and visit the site
- Amount that visitors would be prepared to pay for a visit

Data sources: Population/individuals

KEY

See Methods: pros & cons for an overview of the method's advantages and disadvantages.

Illustration: Valuation of improved river quality - UK

The study estimates two travel cost models to value recreational benefits of selected British rivers (river quality indicators included chemical, biological and habitat-level attributes): one to predict the numbers of trips and the other one to predict angling site choice. The models estimate the welfare associated with a unit of change in river quality. Based on age, gender, occupation and home postcode, and names of angling clubs that respondents belong to, the study calculates the respondent's travel cost in terms of the distance travelled to the fishing site, and wage rate, in order to estimate the value of their leisure time. Respondents were also asked about the five main rivers fished in the last year including name, site, and approximate number of visits made to that site.

Results

Higher flow rates, biological quality, and nutrient pollution levels affect site choice and influence the likelihood of a fishing trip (n = 500). Consumer surplus values per trip for a 10% change in river attributes range from £0.04 to £3.93 depending on the attribute[3].

Reference: Johnstone, C., Markandya, A., 2006. Valuing river characteristics using combined site choice and participation travel cost models. Journal of Environmental Management 80, 237-247. https://doi.org/10.1016/j.jenvman.2005.08.027 (not open access).

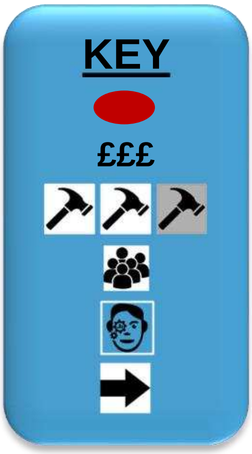
[3] Values have been converted to pounds (£) at a rate of £1 = €1.10.

Bundle of ecosystem services

Valuing bundles of ecosystem services associated with peatland conditions using the choice experiment method

Peatlands provide many overlapping services simultaneously so if we are interested in the overall value of these services, we cannot simply sum up the value estimated for each of them individually. This would risk double counting. Instead, we consider the services as a bundle and estimate their joint value.

We illustrate how to value **a bundle of ecosystem services** associated with peatland condition using **the choice experiment method**. It is a stated-preference approach but unlike the contingent valuation that assesses the value of a specified change, it allows an estimation of several aspects of change. It therefore applies well to ecosystems that produce many services simultaneously. For that, it presents a series of choice sets to individuals, who pick within each choice set their 'preferred' alternative. The alternative is characterised by a number of attributes representing different levels of improvement in the ecosystem condition, and by a monetary cost. By applying statistical methods, it is then possible to infer average preference over the attributes and average willingness to pay for those.



Be aware that: 1) You need to consider a representative sample of your target population; 2) this method requires relatively large sample sizes; 3) you need to decide on the time frame when assessing people's value; and 4) people's stated preferences, and therefore estimated values of the benefits, vary with, e.g. socio-economic characteristics and places of residence.

Limitations: While having a hypothetical market may lead to individuals saying that they are willing to pay while they would not do it in reality, an important result is the understanding of the order of magnitude of the willingness-to-pay (qualitative aspect). Second, people's willingness to pay depends on a great number of factors, e.g. socio-economic characteristics such as income, and behavioural factors such as those associated with past experience or place of residence. Choice experiments can incorporate those factors with technical methodological adjustments, but there is a limit to how much variation in individuals' characteristics they can include.

See Methods: pros & cons for an overview of the method's advantages and disadvantages.

Illustration: Estimates from a national level choice experiment survey in Scotland - UK

A national level survey was applied to a representative sample of Scotland's population to estimate the benefits provided from peatland restoration. Participants were provided with a description of three peatland conditions (poor, intermediate and good) and were asked to choose between three alternative situations: two in which there was an improvement in the peatland condition (e.g. from bad condition to good condition) at a certain cost, and one situation with no improvement at no cost (Fig. 1 below). Each of the improved peatland conditions represented improvements in the delivery of three ecosystem services: climate change mitigation (carbon storage), water quality improvement and changes to wildlife (Fig. 2 below).

Respondents were given eight choice sets, each containing three alternatives corresponding to different levels of restoration, and a monetary trade-off in the form of a cost to the tax payer towards a hypothetical Peatland Trust. In each choice set, the respondent chose his/her preferred alternative. Applying statistical methods to analyse the choices made by the survey respondents, it is then possible to understand their preferences regarding the peatland conditions and the ecosystem services associated with them. Because there is a monetary trade-off, those preferences can be associated with their willingness-to-pay hence estimating the monetary benefit that they see from those environmental improvements.

Figure 1: Peatland condition improvements

Each peatland condition was described to survey participants as follows: **'Good condition' peatlands** are wet and support plants characteristic of peatland ecosystems like moss. The peat layer grows as more carbon is sequestrated. Water that flows is usually clear and of good quality, which means little need for water treatment, and life downstream (salmon, trout) flourishes. Such peatlands also support various wildlife species like birds, hen harrier, and red kite. '**Intermediate condition' peatlands** are characterised by rare surface water, due to drainage channels established for agricultural activities. Taller plants can grow like cotton grass and some areas may be burned to enable grouse shooting. In such condition, peat layers gradually shrink as carbon is released to the atmosphere. Water flowing from such peatlands can be of low quality, affecting the fish population downstream and increasing the need for water treatment. Wildlife is likely not to be abundant. '**Bad condition' peatlands** have usually been drained for a long time, leading to the exposition of large areas of bare peat, and to substantial carbon emissions contributing to climate change as the peat disappears. Water that flows downstream is of bad quality. It negatively affects fish populations and needs a lot of treatment to be suitable for human consumption. Wildlife is rare.

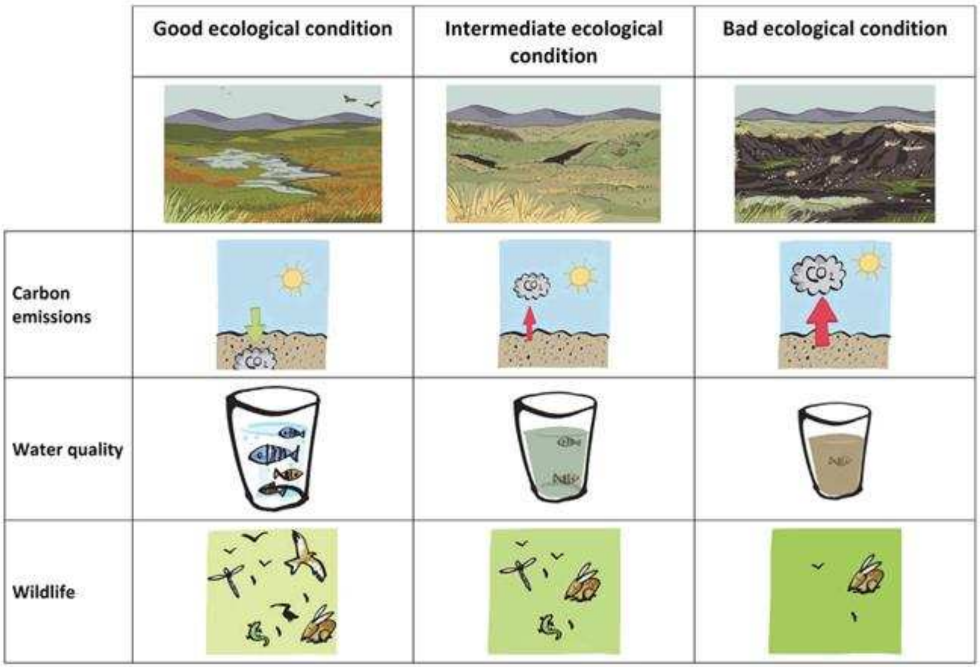


Figure 2: Ecosystem services delivered in each of the peatland conditions

Web link: http://www.see.leeds.ac.uk/peatland-modules/?type=learning

Results

91% of respondents (n = 1,795 respondents) selected a restoration option at least once while 9% always chose the 'no restoration' option. Assuming high peat concentration, the shift **from poor to good condition peatland** was valued as around £246/ha/year. The shift from intermediate to good condition peatland was valued as between £127 and £414/ha/year. These values correspond to the average willingness-to-pay of the sample population for this particular level of restoration per year and until 2030. It is therefore an estimated monetary value of the benefits of this level of restoration.

KEY RESULTS

Average monetary value that people attach to the benefits associated with peatland restoration (in terms of carbon storage, water quality and wildlife habitat) ranges from £127 to £414/ha/year, depending on the degree of improvement and location of restoration.

Be aware that: Only the Scottish population was sampled, but the whole of the UK population could have been sampled, or even the whole 'world' since carbon storage benefits the whole world. Second, the pictures - bad, intermediate and good peatland states - can mean very different things to different audiences; hence the importance of having a representative sample of the population.

Reference Glenk, K., Martin-Ortega, J., 2018. The economics of peatland restoration, Journal of Environmental Economics and Policy. https://doi.org/10.1080/21606544.2018.1434562 (open access)

➢ Return to **Main menu**

Evidence of values

Drawing on existing studies, this section highlights the values of the different peatland benefits. Remember that some of the values may represent a lower bound of its actual value. This might be due to the scale of analysis. Each of the values is derived from a specific location and a specific group of people surveyed. Therefore, the values cannot be directly plugged in for other cases of valuation; the estimated values presented here are for illustration purposes only. It is also not possible to sum up values that were measured individually. To estimate the value of multiple services, the services need to be considered jointly in the valuation.

If not stated otherwise, all the values are expressed at present values of the year of the study. To translate those values into present values, you need to consider economic inflation from the year of study to the present.

You can click in the table below to access the type of evidence that you are interested in.

Evidence of values
Carbon benefits
Water quality benefits
Flooding risk mitigation benefits
Recreational and cultural benefits
Bundle of benefits

You can find here a Summary of the evidence of values presented in the guide.


Bishopdale: Photo credit: Joanna Richards

➢ Return to **Main menu**

Carbon benefits

The benefits that peatlands produce in the form of carbon sequestration can be measured using the abatement cost method (page 6), which consists of appraising the economic value of estimated net carbon dioxide equivalents (CO_{2e}) savings from peatland restoration in a given year. The value is obtained by multiplying the carbon prices by the estimated net CO_{2e} saving/year for the given area.

In the UK, estimated benefits of carbon from restored peatland considering a differential of 5.0 tCO_{2e}/ha/year and a central carbon price of £13/tC (traded market price) is equal to £65/ha/year. For a carbon price at £56/tC (non-traded market price), the value is equal to £280/ha/year. High carbon emission differentials are sufficient to justify peatlands restoration (without considering non-carbon benefits) even if on-going and/or capital costs are also high.

Reference: Moxey, A., Moran, D., 2014. Peatland restoration: Some economic arithmetic. Science of the Total Environment 484: 114-120. https://doi.org/10.1016/j.scitotenv.2014.03.033 (open access)

In Exmoor National Park - England - UK, considering a restoration rate of 400 ha/year for 5 years and stable thereafter, the value of the emission reduction is £311,700 after 5 years and £421,800 after 20 years. This value is calculated assuming that degraded peatlands emit about 2.9 tCO_{2e}/ha/year, carbon emissions reduction through restoration are 2.6 tCO_{2e}/ha/year, and 2011's projections of the price of carbon considering climate change effects are £56 in 2012 and £81/tCO_{2e} 20 years later.

Reference: Grand-Clement, E., Anderson, K., Smith, D., Luscombe, D., Gatis, N., Ross, M., Brazier, R.E., 2013. Evaluating ecosystem goods and services after restoration of marginal upland peatlands in South-West England. Journal of Applied Ecology 50: 324-334. https://doi.org/10.1111/1365-2664.12039 (open access)

Sphagnum and Heather. Photo credit: Yorkshire Water

Water quality benefits

The benefits that peatlands produce in the form of **improved drinking water quality** in the catchment can be measured using the avoided-cost method (page 9). It is based on the principle that peatland's contribution to filtering and cleaning water results in cost-savings from not having to treat that water by other means. The value of enhanced water quality from peatland restoration is therefore derived from estimating the economic value of water treatment cost savings from the restoration by calculating water treatment costs.

In the Keighley Moor and Watersheddles catchments - Yorkshire - UK, the rates of DOC in water and therefore the quality of the drinkable water depends on land management and on rewetting interventions on the peatland. As compared to a status quo situation, a decline scenario characterised by a 30% increase in DOC generates a value of -£2,5 million in the catchment. An improve scenario with a 15% decrease in DOC implies that there are no capital costs associated to MIEX plants' DOC treatment of meeting drinking water standards and that operational costs are reduced; it generates a value of £2,2 million. These values are based on the assumption that catchments deliver 8 to 10 megalitres/day into the water treatment system.

References:

- Harlow, J., Clarke, S., Phillips, M., Scott, A., 2012. Valuing land-use and management changes in the Keighley and Watersheddles catchment, http://publications.naturalengland.org.uk/publication/1287625 (open access)
- Eftec. 2015. The Economic Case for Investment in Natural Capital in England: Land use appendix https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/517008/ncc-research-invest-natural-capital-land-use-appendix.pdf (open access)

Although it is difficult to value water quality improvements, an estimate can be obtained if part of the cost of operations necessary to reach drinking water standard are available. **In the Bamford catchment - West England/East Wales - UK**, the costs that could be avoided in the presence of healthy peatlands, and therefore the value of water quality benefits provided by peatlands is estimated at £2000 to £4000/week (cost of removing peaty sediment from drinking water) and £160,000/year (2010 value) (cost of removing 11,500 tonnes of sediment to meet drinking water standards on particulates). This is based on the Severn Trent Water company, which is a water authority responsible for water management and supply, and for waste water treatment and disposal.

Reference: Goodyer, E., 2016. At a glance briefing - Peatlands and the water industry. http://naturalcapitalscotland.com/docs/070_342__finalscottishforumonnaturalcapitalbrief_peatlandsandwaterquality_february2016_1454923025.pdf (open access)

Water quality benefits provided by peatland in regard to achieving a good water ecological status can be estimated using a contingent valuation survey asking people for their willingness-to-pay for a water quality improvement.

In River Tame – UK, willingness-to-pay for River Tame water quality improvements is equal to £9.60/household/year for a small improvement, £15.34/household/year for a medium improvement and £22.89/household/year for a large improvement, excluding zero bids.

Reference: Bateman, I.J., Cole, M.A., Georgiou, S., Hadley, D.J. 2006. Comparing contingent valuation and contingent ranking: A case study considering the benefits of urban river water quality improvements. Journal of Environmental Management 79: 221-231 (not open access)

In the Ouse catchment - North Humber basin – UK river water quality environmental improvement is valued at £21/individual/year based on the average willingness-to-pay for different degrees of water quality improvement. The further away a respondent lives from the site, the lower the willingness-to-pay and the closer the respondent lives to another site (river or coast), the less (s)he is willing to pay for the site under valuation.

Note: Values have been converted to pounds (£) at a rate of £1 = €1.10.

Reference: Bateman, I.J., Ferrini, S., Hime, S. 2008. Aquamoney: UK Case Study Report. https://www.ivm.vu.nl/en/Images/D38_Case_study_report_Humber_UK_tcm234-188871.pdf (open access)

Blanket bog of the Flow country, Forsinard, UK, Photo credit: IUCN

Flooding risk mitigation benefits

The benefits that peatlands produce in reducing flooding risks in the catchment can be measured using the avoided-cost method, based on the idea that peatland's contribution to store water in the uplands results in lower likelihood of flooding downstream and cost-savings from not having to compensate the losses and damages caused by flooding. Flood damages include damages to agricultural crops (loss in harvest, soil degradation), to buildings (decline in property values), and to businesses.

In Cambridgeshire - Wicken Fen National Nature Reserve - UK, the flood protection benefit to the farmers and homeowners from restoring the wetland - equivalent to avoided damage to crops and property - is estimated at £17,750/year or £37/ha/year. This is based on the fact that the restored wetland has the capacity to protect 2000ha of farmland and 10 homes by acting as a flood storage area. The value is calculated based on the costs to farmers using crop values, the cost to homeowners using the Environment Agency' estimates of damage cost of a flooded home and insurance claims associated with past flood events, and a risk of flooding of the area of once every 20 years.

Note: values have been converted to pounds (£) at a rate of £1 = $1.30.

Reference: Peh et al., 2014. Benefits and costs of ecological restoration: Rapid assessment of changing ecosystem service values at a U.K. wetland. Ecology and Evolution 4, 3875-3886. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.1248 (open access)

In Calderdale and Upper Calder Valley - West Yorkshire - UK, the estimated value of flooding mitigation through peatland restoration is £47 million, which represents the losses generated by the flooding event of Boxing Day 2015 to the local economy - calculation based on the damages/costs to 1600 small and medium sized businesses. It assumes an average loss per firm of £47,000 and that for every £1 reported in direct losses another £0.6 on average was lost indirectly throughout the regional economy.

Reference: Sakai, P., Holdsworth, A., Curry, S., 2016. Economic Impact Assessment of the Boxing Day Floods (2015) on SMEs in the Borough of Calderdale. Final report44 https://www.see.leeds.ac.uk/uploads/media/Economic_Impact_Assessment_of_Boxing_Day_floods.pdf (open access)

In England and Wales – UK, annual average damage from flooding is £1.4 billion, considering 4 million people with property valued at more than £200 billion, and a risk of a 1 in 100 year flood.

Reference: Werritty, A., 2006. Sustainable flood management oxymoron or new paradigm. Area. 38.1: 16-23 (not open access)

Intangible impacts of flooding on households include health impacts and psychological effects of flooding, which can be estimated using a contingent valuation method.

In the UK, the value of flooding mitigation benefits on health of people at risk of being affected by flooding is estimated at £653/household/year, which is the average willingness-to-pay per household to avoid or reduce psychological impacts from flooding by investing in Property Level Flood Risk Adaptation measures, based on the 2007's flood.

Reference: Joseph, R., Proverbs, D., Lamond, J., 2015. Assessing the value of intangible benefits of property level flood risk adaptation (PLFRA) measures. Natural Hazards 79, 1275-1297. https://link.springer.com/article/10.1007%2Fs11069-015-1905-5 (not open access)


Photo credit: Mark Reed

Recreational and cultural benefits

The benefits that peatlands produce in the form of recreation, amenities, and culture can be measured using the contingent valuation survey, which involves assessing people's willingness-to-pay to conserve the recreational benefits.

In Scottish 'Flow' Country - UK, the value of the benefits of the recreational services provided by the wetland is estimated at £327/ha. This is based on the calculation of the mean willingness-to-pay of regional residents for conserving the area (£16.79/household) and on an extrapolation of the average willingness-to-pay over the entire regional population.

Reference: Barbier, E. B., Acreman, M., Knowler, D., 1997. Economic valuation of wetlands. Journal of environmental biology http://archive.ramsar.org/pdf/lib/lib_valuation_e.pdf (open access).

In Norfolk Broads - East Anglia - UK, the recreational and amenity use value estimates of the wetland is estimated at £94/household, which is the mean willingness-to-pay to conserve the recreational benefits of the wetland area. Moreover, the non-use values associated with the wetland are estimated at £12.45/household for households located close to the wetland and £4.08/household for households located elsewhere in the UK. The aggregate willingness-to-pay estimates over the UK are £32.5 million and £7.3 million, respectively.

Reference: Barbier, E. B., Acreman, M., Knowler, D., 1997. Economic valuation of wetlands. Journal of environmental biology http://archive.ramsar.org/pdf/lib/lib_valuation_e.pdf (open access).

In Ireland, the value of cultural services that peatlands provide to the public is estimated at £51/person/year, which is the average willingness-to-pay of people for a national peatland protection policy.

Note: Values have been converted to pounds (£) at a rate of £1 = €1.10.

References: Bullock, C.H., Collier, M.J., Convery, F., 2012. Peatlands, their economic value and priorities for their future management - The example of Ireland. Land Use Policy 29, 921-928. https://doi.org/10.1016/j.landusepol.2012.01.010 (not open access); Bullock, C.H., Collier, M., 2011. When the public good conflicts with an apparent preference for unsustainable behaviour. Ecological Economics 70, 971–977. http://dx.doi.org/10.1016/j.ecolecon.2010.12.013 (not open access)

The benefits that peatlands produce in the form of recreation can also be valued using a travel cost method, which is based on the fact that individuals spend resources (time and money) to enjoy the recreational services provided by the peatland area. The minimum value of the recreation services is equal to the cost incurred to people who visit the site.

In the UK, consumer surplus values per trip for a 10% change in river attributes influencing recreational benefits (i.e. flow rates, biological quality, nutrient pollution level) range from £0.04 to £3.93 depending on the attribute.

Reference: Johnstone, C., Markandya, A., 2006. Valuing river characteristics using combined site choice and participation travel cost models. Journal of Environmental Management 80, 237-247. https://doi.org/10.1016/j.jenvman.2005.08.027 (no open access)


Photo credit: Mark Reed

Bundle of benefits

A bundle of benefits provided from peatland restoration can be valued using a choice experiment describing different peatland conditions associated with different levels of ecosystem service delivery (e.g. carbon storage, water quality, wildlife) from which respondents to a survey are asked to choose. An improvement in the peatland condition is associated with a certain payment required from the survey respondents. An analysis of people's choices of the offered alternatives enables an understanding of their preferences about the peatland condition and to associate those preferences with their willingness-to-pay, hence estimating the monetary benefit that they see from those environmental improvements.

In Scotland - UK, 91% of respondents are in favour of improved peatland condition. The average monetary value that people attach to the benefits associated with peatland restoration in terms of carbon storage, water quality and wildlife habitat ranges from £127 to £414/ha/year, depending on the degree of improvement and location of restoration.

Reference: Glenk, K., Martin-Ortega, J., 2018. The economics of peatland restoration. Journal of Environmental Economics and Policy. https://doi.org/10.1080/21606544.2018.1434562 (open access)

Photo credit: Yorkshire Water

Summary of the evidence of values

Benefit	Area	Method	Value/Unit	Year	Basis of comparison
Carbon benefits	UK	Abatement Cost method - page 6	£65/ha/year (traded emissions); £280/ha/year (non-traded)	2014	Degraded vs. restored peatland
Drinking Water Quality	Keighley Moor & Watersheddles catchments - Yorkshire - UK	Avoided-Cost method - page 9	£2,2 million for the catchment	2012	Degraded vs. restored peatland
	Bamford catchment - West England/East Wales - UK		£160,000/year for the catchment	2016	Degraded vs. healthy peatland
Water Quality - Ecological Status	River Tame - UK	Contingent Valuation method - page 11	From £10 to £23/household/year	2006	Low vs. improved quality of water
	Ouse catchment - North Humber basin - UK		£21/individual/year	2008	Low vs. improved quality of water
Flood Risk Mitigation	Cambridgeshire - Wicken Fen National Nature Reserve UK	Avoided-Cost method - page 14	£37/ha/year (avoided damage to property and farmland)	2014	Degraded vs. restored peatland
	Calderdale and Upper Calder Valley - West Yorkshire - UK		£47 million (avoided damage to businesses)	2016	Degraded vs. healthy peatlands
	UK	Contingent Valuation method - page 16	£653/household/year (reduced psychological impacts from flooding)	2015	Degraded vs. healthy peatlands
Recreation & Cultural	Scottish 'Flow' Country - UK	Contingent Valuation method - page 18	£327/ha for the wetland (or £16.79/regional household resident) for conserving the area	1997	Degrading vs. conserving use of wetland. One-time amount
	Norfolk Broads - East Anglia - UK		£94/household	1997	Degrading vs. conserving use of wetland. One-time amount
	Ireland		£51/person/year	2012	Degrading vs. conserving use of peatland
Bundle	Scotland - UK	Choice Experiment method - page 21	From £127 to £414/ha depending on degree of improvement and location	2018	Degraded vs. improved peatland condition

Remember that the values are context dependant and cannot be plugged in in another site; you need to refer to the full illustration to understand how these values were calculated. The values are on the year of study.

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How to use ecosystem services values to inform decision-making for peatland restoration

Estimating the value of the ecosystem services derived from peatland restoration (or equally the value of losses derived from the degradation of peatlands) can be used to inform decision-making. There are various situations in which this might be relevant. Two broad areas are of particular interest:

- Making the business case to invest in peatland restoration by understanding if benefits of restoration exceed its costs (Cost – benefit analysis)
- Designing incentive mechanisms for restoration, such as the Peatland Code.


Photo credit: Mark Reed

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Cost – benefit analysis

Making the case for investments in peatland restoration can require comparing the costs of restoration with the benefits generated from the enhanced ecosystem service(s).

Cost Benefit Analysis (CBA) is a decision support tool for decision makers to compare alternative management scenarios, such as the ones involved in peatland restoration.

CBA involves calculating in monetary terms the costs and benefits of each peatland restoration alternative to compute their respective net benefits (i.e. benefits minus costs). The **Net Present Value** is a measure of the entire stream of net benefits from peatland use over time (e.g. 10, 50 years). This acknowledges that both costs and benefits do not just happen at the moment of restoration but extend over time (e.g. benefits of carbon storage are realised as long as the peatland accumulates carbon).

Comparing Net Present Value estimates of different restoration scenarios or across different sites therefore helps in the selection of the best option for the delivery of social value.

Net Present Value (NPV) is the value today of a given stream of costs (C) and benefits (B) over a future time period (t). Through discounting (r), it accounts for the fact that individuals tend to value less what is placed in a further future.

$$NPV = \sum \frac{(B_t - C_t)}{(1+r)^t}$$

Discount rates are unique and depend on time preferences. Recommended discount rates usually vary between 3 and 5%.

CBA requires an accurate quantification of benefits and **a good understanding of the costs of restoration practices**. Those include upfront capital costs required for the implementation, on-going costs associated with the maintenance and monitoring of restoration sites, and transaction costs. Upfront and maintenance costs vary greatly across techniques (e.g. blocking grips, drains and gullies, re-profiling of peat, stabilisation of bare peat) and depend on the type of machinery, and accessibility of the peatland area. The private land manager also faces an opportunity cost in terms of income foregone from alternative land uses such as crop production. A precise understanding of these costs is not easy. There is currently a lack of information about the cost-effectiveness of peatland restoration, maintenance costs, and opportunity costs that vary across contexts.

Costs of restoration - some existing estimates: Capital cost estimates range from £200/ha to £10,000/ha and aggregate average annual on-going (or recurrent) cost estimates vary from £25/ha to £400/ha (Moxey & Moran, 2014). Implementation and management costs vary from about £300 to £5,000/ha (Glenk & Martin-Ortega, 2018).

More details on costs in Glenk, K., Novo, P., Roberts, M., Martin-Ortega, J., Potts, J., 2017. The costs of peatland restoration in Scotland - considerations for data collection and systematic analysis, SEFARI, https://www.see.leeds.ac.uk/fileadmin/Documents/research/sri/peatlands/The_costs_of_peatland_restoration_in_Scotland_report.pdf (open access)

Be aware that: 1) The choice of the discount rate is subject to discussion as it raises ethical and theoretical considerations about whether it is appropriate to attribute lower importance (i.e. higher discount rates) to costs and benefits of future generations in relation to current ones. 2) The unit used for the benefits needs to be the same as the one used for the costs (e.g. per hectare). 3) Besides CBA, other considerations such as risks and unmonetisable costs and benefits, and distribution effects are relevant when deciding between land management options.

Next are illustrations of the application of CBA to peatland restoration. If you want to know how the benefits are calculated, you need to check the Valuation methods and illustrations section.

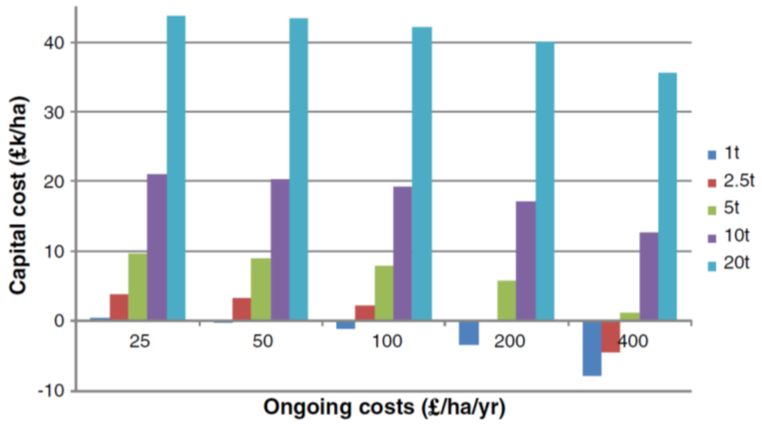
Determining how much to invest in peatland restoration based on carbon benefits

The estimated values of carbon benefits from peatland restoration can be used to calculate the maximum capital costs that can be invested in restoration so that it still generates net benefits to society.

Be aware that: Using CBA to determine the maximum level of capital costs depends on the accuracy of the value estimates upon which it relies. This includes the accuracy of the carbon emission rates and the accuracy of the on-going costs of restoration. The former affects the calculation of the carbon benefits as explained in the abatement cost method (Valuing carbon benefits using the abatement cost method). The latter depends on whether there are accurate on-site costs data. For broader level analysis (e.g. national assessment), cost information is still fragmented and anecdotal.

Illustration: Net benefits of carbon sequestration

Considering estimates of carbon benefits from peatland restoration at 280/ha/year (with a differential of 5.0 tCO_2e/ha/year and a central carbon price of £56/tC) and on-going costs of restoration ranging from £25 to £400/ha/year, the study computes the present value of the net carbon benefits and analyses how it varies for different on-going costs, time frames, and carbon prices (figure below). Thus, it captures the maximum (or break even) capital cost that can be justified for restoration in different contexts.



Emission differentials is the difference in the rate of CO_2e emissions between restored (or healthy) and degraded peatlands.

Maximum capital cost justified from carbon benefit values alone, by emission differentials and on-going costs for central C prices and for 40 years' time period. This maximum capital cost represents the breakeven point that can be justified for restoration (i.e. benefits would need to be at least as large as that to justify the capital expenditure). Source: Moxey and Moran (2014).

The study finds that if carbon differentials are high, capital costs are lower than the net present benefits of carbon, which are therefore sufficient to justify peatland restoration without considering other benefits and even if on-going and/or capital costs are also high. If the carbon differentials are very low then on-going and/or capital costs also need to be low to justify restoration.

Reference: Moxey, A., Moran, D., 2014. Peatland restoration: Some economic arithmetic. Science of the Total Environment 484: 114-120.
https://doi.org/10.1016/j.scitotenv.2014.03.033 (open access)

Identifying economically efficient restoration projects based on multiple benefits: The Net Present Value Space

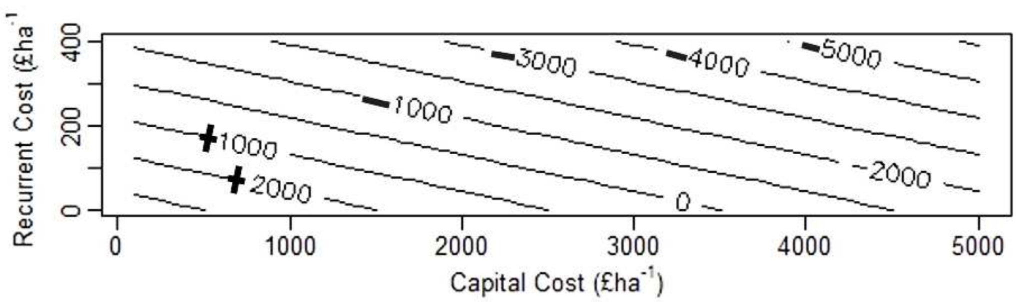
To understand whether investments in the restoration of degraded peatlands are economically efficient and to guide restoration decisions, the costs and benefits of restoration need to be compared. Ideally, the multiple benefits of peatlands need to be included in the valuation.

Calculating the **net benefits** of peatland restoration means to subtract the costs of restoration from the valued benefits. Given that restoration has an impact over a period of time, costs and benefits are to be aggregated over time, resulting in the Net Present Value (NPV). If the NPV is positive, the restoration would generate welfare gains to society, i.e. Cost < Benefits.

Be aware that: The accuracy of the CBA depends on the accuracy of the value estimates upon which it relies. This includes the accuracy of estimated values of the multiple ecosystem services, as well as the on-going costs of restoration. The former affects the calculation of benefits as explained in the section Valuing bundles of ecosystem services associated with peatland conditions using the choice experiment method. The latter depends on whether there are accurate on-site costs data. For broader level analysis (e.g. national assessment), cost information is still fragmented and anecdotal.

Illustration: Net Present Value space based on the valuation of a bundle of benefits

Based on a national level estimation of the non-market benefits of peatland restoration using the choice experiment method (Valuing bundles of ecosystem services associated with peatland conditions using the choice experiment method), the study compares benefits of improved peatland condition in Scotland with a range of varying capital and on-going (recurrent) costs of restoration on a per hectare basis. These figures are captured into a “space of Net Present Values” that provides a picture of the combinations of cost that yield an outcome that generates net benefits to society (figure below). Net Present Values are estimated on a per hectare basis under varying capital and on-going costs for eight combinations of peatland condition and spatial criteria (annual discount rate = 3.5% over a 25-year time period). For instance, for capital costs lower than 2500 £/ha and on-going costs lower than 300£/ha, an improvement of the peatland from poor to good condition, as defined in the study, generates positive net benefits (Net Present Value < 0), which means that the restoration would be economically worthwhile.



Net present values space: Net Present Values (NPV) in £/ha depending on baseline condition. Note values on the lower left side of the graph show positive NPV, while values on the upper right side of the graph show negative NPV.

The space is therefore helpful for informing decision makers across a variety of restoration decisions. Project managers who have a precise idea of costs can ‘navigate’ in the space to identify whether a particular restoration activity at a particular site makes economic sense (i.e. if its Net Present Value >0) and would generate welfare gains to society. It can also enable policy makers to understand how costs affect economic efficiency of national programmes.

Be aware that: With better information on costs and spatial distribution of peatland condition (e.g. related to GHG emissions, provision of other ecosystem services), the Net Present Values space can be updated and narrowed down to different locations, peatland conditions, and restoration activities. The higher the level of detail, the more targeted the restoration decisions will be, and the higher the efficiency of the resource allocation.

Reference: Glenk, K., Martin-Ortega, J., 2018. The economics of peatland restoration, Journal of Environmental Economics and Policy, https://doi.org/10.1080/21606544.2018.1434562 (open access)

Designing incentive mechanisms for restoration

The estimated values of peatlands' ecosystem services and cost-benefits information can serve as a basis for investment decisions, such as in the form of monetary incentives for restoration. Monetary incentives like agri-environmental schemes or payment for ecosystem services (PES) rely on price signals to change farmer behaviour, for example, towards more environmentally friendly practices. Such incentives help to 'internalise' the value of these ecosystem services in land management decisions.

Designing restoration incentive mechanisms requires an understanding of i) private benefits under both land management options considered, ii) social benefits, iii) beneficiaries of the ecosystem services, which will help to identify potential financing sources for the peatland restoration, iv) costs of restoration including opportunity costs, and v) transaction costs.

Illustration: Design of Payment for Ecosystem Services

Payment for ecosystem services (PES) is a new way of thinking about those incentives. They are based on the idea that beneficiaries can compensate land managers for changes in land management practices to secure the delivery of ecosystem services. For example, downstream beneficiaries can invest in peatland restoration upstream to ensure the delivery of hydrological services in the catchment.

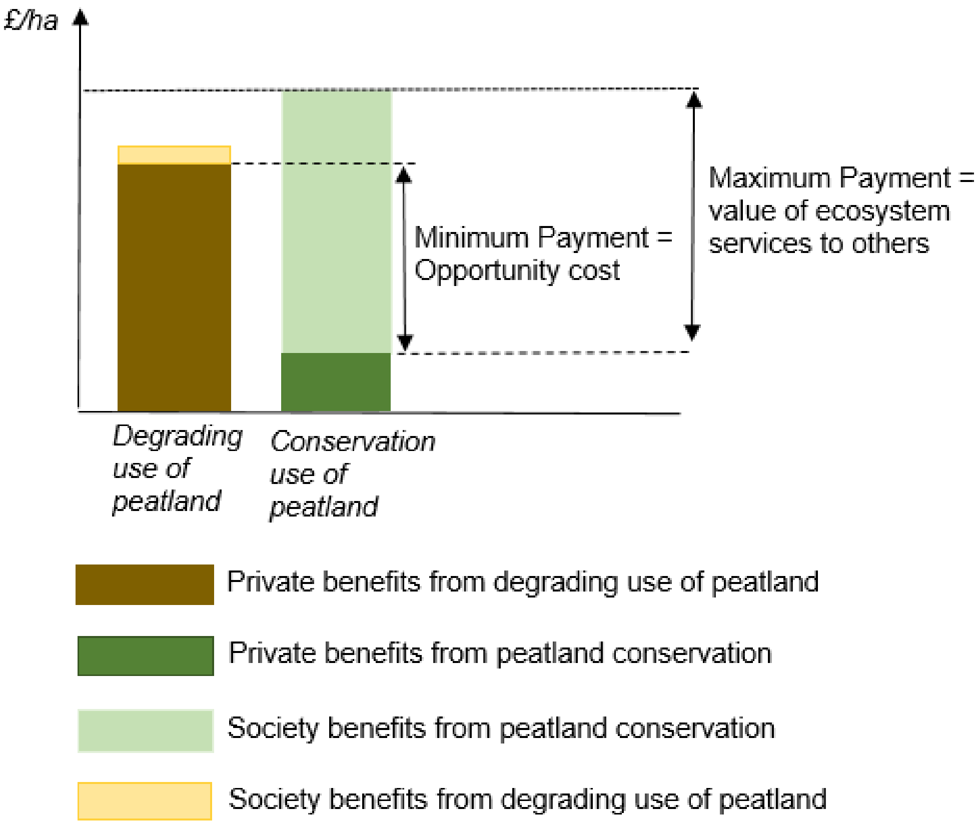
"PES schemes involve payments to the managers of land or other natural resources in exchange for the provision of specified ecosystem services (or actions anticipated to deliver these services) over-and-above what would otherwise be provided in the absence of payment. Payments are made by the beneficiaries of the services in question, for example, individuals, communities, businesses or governments acting on behalf of various parties." (Defra, 2010)

The figure below illustrates the theoretical minimum and maximum levels of PES to incentivise a change in the peatland use and therefore a switch from a degraded to an improved peatland condition. The minimum payment is the difference in private returns between the current and the envisaged land use. It is equivalent to the **opportunity cost** and the transaction costs incurred by the change. PES maximum value is determined by the value of the the services provided by the improved condition. In other words, it is at maximum equal to the overall social value that society would obtain if all ecosystem services were realised. In practice, the PES made to land users as an incentive to protect the peatland may lie anywhere in between these two extremes.

Note that PES should cover costs above and beyond complying with existing regulation and binding rules. They are aimed at providing additional services that would not be delivered otherwise.

Opportunity costs is how much less profit the land manager will make by changing land use from its current use to one that does not degrade peatlands. It is equal to the difference between the net profits from the current land use and that of the restored land.

Transaction costs involved in the design of a PES are costs incurred by the search for information, the bargaining, e.g. if agreements on the terms of transaction are required, and the monitoring and enforcement of the PES contract.



Design of Payment for Ecosystem Services (PES), inspired from Engel, S, Schaefer, M., 2013. Ecosystem services - a useful concept for addressing water challenges? Current Opinion in Environmental Sustainability 5 (6): 696-707 (not open access).

Be aware that: Factors other than opportunity and transaction costs and value of ecosystem services are important to consider in the design of PES. The actual implementation of a PES scheme necessitates: i) participation of all relevant stakeholders and identification of who benefits and who is willing to pay; ii) clarity over the property rights; iii) an adequate monitoring system; and iv) a careful design of contractual obligations of buyers and sellers of the ecosystem services (e.g. length, performance measure, etc.).

An overview of how PES are defined, designed, and implemented in the UK can be found in "Payments for Ecosystem Services: A Best Practice Guide" (Defra, 2010): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/200920/pb13932-pes-bestpractice-20130522.pdf.

There are still debates about the exact definition and characteristics that a PES scheme should have. That is why schemes are often referred to as PES or PES-like schemes, when they follow some but not all of the theoretical principles.

Practical examples

We provide examples of two PES or PES-like schemes involving peatlands in the UK.

The Sustainable Catchment Management Programme

Water companies play an important role in PES for peatlands because they recognise the hydrological services that these provide. The water and wastewater company United Utilities set up a Sustainable Catchment Management Programme (SCaMP) in England in 2005, which is the first PES financed by the UK water industry. The PES scheme aims primarily at protecting and improving the water quality to avoid additional water treatment. It entails a number of interventions implemented on United Utilities owned catchment land, which primarily consists of upland moorland. Financing is provided by United Utilities customers through increases in their water bills and by public agri-environment payments within Country Stewardship schemes. As an indication, for SCaMP 1 (2005-2010) United Utilities invested about €12 million in moorland restoration, woodland management, farm infrastructure improvements and watercourse protection across 27,000 ha in the Peak District and the Bowland. SCaMP 2 (2010-2015) invested ca. € 13 million across 30,000 ha in Cumbria and South Lancashire. SCaMP 3 (2015-2020) extends investment to non-owned catchments using drinking water safeguard zones designated by the Environment Agency to target measures, advice and incentive schemes for land managers.[4]

Other water companies are involved in similar catchment programmes which can be considered a form of PES-like scheme.

The Peatland Code

The Peatland Code is a voluntary standard for UK peatland restoration projects issued by the UK International Union for the Conservation of Nature. It allows the marketing of climate benefits from peatland rewetting. Land owners can enter the Code by proposing peatland restoration projects on their land that meet certain pre-requisites (regarding peatland type (blanket or raised bog), minimum peat depth (> 50 cm), and current degrading conditions ('Actively Eroding' or 'Drained'). An independent body is in charge of predicting greenhouse gas emissions reductions from these projects, and the peatland code attests to the carbon benefits. The landowner of a validated project is then responsible for the carbon sale and for the contracts with buyers, which are usually businesses motivated by corporate social responsibility. In return for investing, these buyers receive pending Issuance Units that are then transferred to verified Peatland Carbon Units. Marketed like this, social climate benefits are therefore internalised through these private investments.

Countryside Stewardship provides financial incentives for farmers to look after their environment by e.g., conserving and restoring wildlife habitats, reducing widespread water pollution from agriculture, or preserving historical features in the landscape.
(see https://www.gov.uk/government/collections/countryside-stewardship-get-paid-for-environmental-land-management)

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[4] Values have been converted to pounds (£) at a rate of £1 = €1.10.

FAQs

Answers to the questions below should help you understand how much the design and implementation of survey-based methods will influence the accuracy of the value that you obtain, as well as help you with other aspects of the methods implementation.

How large does my survey sample need to be in stated preference methods

Just as in any other survey, the accuracy of your results depends on the population size, the confidence level and the error you are willing to accept. Most commonly, social science researchers use an error margin of between 4% and 8% with a 95% confidence level.

The desirable sample size also depends on the expected variation in the data: the more varied the data are, the larger the sample size you need to attain the same level of accuracy.

For sample size indications given particular errors, see Smith, S. M., 2017. Determining sample size. https://www.ndsu.edu/gdc/wp-content/pdf/Determining-Sample-Size.pdf (open access).

How far out do I need to sample

The boundary of your sample depends on both the type of ecosystem service you are valuing and on your interest. If for example, you are interested in assessing the value of ecosystem service(s) for a particular group of people, e.g. from a local population, people who spend leisure time in a particular area, you can sample that group only. If, on the other hand, you are interested in deriving the societal value of an ecosystem service, you need to consider surveying the entire population that benefits from this service. For instance, the whole world population benefits from carbon benefits of peatland since climate change is a global issue. Often and for practical reasons, a smaller population is considered (e.g. England or a region instead of the whole of the UK). You will, however, obtain a lower bound of the value, which you need to acknowledge; the obtained value will not take into account the value that other beneficiaries attach to it.

How should I deal with different values of different people

People differ in how they value ecosystems and the services they provide. This is partly explained by differences in social background, education, location, and other social-economic characteristics. If you have a good representative sample of the overall population, these differences will be well accounted for and the estimated value that you obtain will be a good representation of the overall value of that population.

Some methods, such as stated-preference methods, allow you to control for some of these influencing socio-economic factors, which will then allow you to obtain differentiated values per socio-economic groups. This is most commonly done through additional survey questions gathering personal characteristics and then testing, using statistical models, the effect that these socio-economic variables have on the estimated values. Group analysis can also be done depending on people's attitudes and behaviour (e.g. you can test if people belonging to nature conservation organisations place a higher value on ecosystems than those who do not).

What can I do if I cannot afford a full valuation study

There are alternatives to some of the valuation methods presented here if you have limited resources. For instance, you could consider using the **benefit transfer method**, which can provide an illustration of the value of the ecosystem services (see Methods: pros & cons for a description). Note that this method is subject to significant transfer errors and should only be applied if primary valuation is not possible.

While being a method on its own right, the **deliberative monetary valuation** is an alternative stated preference method that can also be applied when there are limited resources to produce a full survey-based method. Note that this method is not exactly the same as the other stated preference methods and it provides different type of information. Its relevance depends on the aims of the study (see Methods: pros & cons for a description).

An extensive valuation of all ecosystem services is sometimes simply not possible or even useful. In some cases, it might be easier and more relevant to assess relative differences in impacts of alternative management schemes on the delivery of ecosystem services. This can be done through the quantitative description of changes, followed by the qualitative description of impacts, see the National Ecosystem service Assessment in the United Kingdom (UK NEA) for examples. However, this approach needs to include a description of key uncertainties, potential risks, and their significance for the results.


Photo credit: Moors For the Future Partnership

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Methods: pros & cons

Below is an overview of the main advantages and disadvantages of the valuation methods that can be used to value the benefits of peatlands. These concern valuation methods that use money as a simplified metric to value changes in human wellbeing, so that they can be compared with costs and used as part of economic decisions. While well-established in the environmental economics literature, these methods will always be limited by the fact that human wellbeing is more complex than any simplified single metric can ever capture. These methods are also criticised because, while they are not meant to set a price on ecosystem services, they can be used as an argument for the commodification of nature.

Cost-based valuation approach

Cost-based valuation methods rely on estimating the costs that would be incurred if the service were no longer provided. The **avoided-cost method** consists of measuring the costs that would have been incurred in the absence of the ecosystem service; it uses either the value of property or assets protected, or the cost of actions taken to avoid damages, as a measure of the benefits provided by an ecosystem. The **mitigation (abatement) cost method** consists of measuring the cost of mitigating the effects of loss of the ecosystem services (i.e. the adverse environmental impacts resulting from the absence of the service).

Pros & Cons:

The first advantage of a cost-based approach is that it is easier to measure costs of producing benefits than to value the benefits themselves, especially when benefits are non-marketed. Second, such a method does not necessitate a high level of resource and is relatively simple to apply and analyse. It relies on secondary data on benefits from ecosystem services and the cost of alternatives. However, one disadvantage of this approach, for the avoided-cost method in particular, is that very often estimates of damages remain hypothetical.

Other cost-based approaches, not illustrated in this guide, rely on estimating the costs that would be incurred if the service provided by an ecosystem would have to be re-created. The value of an ecosystem service can be inferred by estimating how much it costs to replace (using artificial means) or restore it. Thus, the **replacement cost method** consists of estimating the costs incurred by replacing the ecosystem services with man-made technologies. It is based on the idea that an alternative artificial technology has to be found to provide the lost service (e.g. the value of a peatland acting as a natural reservoir can be estimated as the cost of constructing and operating an artificial reservoir of a similar capacity). The **restoration cost method** consists of measuring the cost of restoring the ecosystem service. One limitation of these approaches is the focus on the positive benefits of man-made alternatives, and the lack of consideration of potential negative externalities. It further assumes that the net benefits generated by expenditure on man-made alternatives match the original level of benefits from the ecosystem, which is not necessarily accurate.

Revealed preferences approach

The **revealed preferences approach** consists of capturing how people value non-marketed ecosystem services by observing the consumption pattern of goods and services with which they are associated and that do have a market. Thus, **the travel cost method** aims to derive the recreational value of a site, such as a national park, based on the travel time and costs people spent to visit the site. It captures people's implied willingness to pay by understanding how much people spend to use ecosystems for recreational purposes. Data on site visits are used to derive a demand curve for recreational services, and to value, e.g. the beauty of a peatland landscape.

Pros & Cons:

The main advantage of the travel cost method is that it draws on observed data. However, the method requires statistical analysis and modelling, and large datasets related to recreational activities, travel costs, and site characteristics in order to construct information on visitor demand. Travel cost surveys are usually expensive and time consuming to carry out. In addition, the method provides the value of only one overall factor linked to recreation and it is difficult to disentangle the effects of, e.g. landscape beauty vs. water. The results are also sensitive to assumptions about cost of time.

Not illustrated in this guide, the **hedonic value approach** consists of estimating economic values of ecosystem services that directly affect the price of marketed goods using the idea that the price of a good is related to its (environmental) characteristics. Thus, correlations can be conducted to analyse the relationship between housing values and environmental features, and derive a willingness-to-pay for scenery/landscape. The method may not suit peatlands well because it deals with the amenities of land for housing environment. Yet, it could be possible to value, for instance, the spiritual and cultural services of a peatland similarly to the price difference between a residence near peatland and a similar property which isn't near such clear air, beautiful views, and iconic landscape.

Stated preference approach

For ecosystem services like biodiversity and wildlife, no associated market can be found. The only way to measure their values is to create hypothetical markets through surveys in which the public is asked to state their willingness to pay. Alternative scenarios representing various statuses or conditions of the ecosystem (e.g. various levels of peatland restoration) are presented to the respondent, who is asked how much (s)he would be willing to pay for the environmental improvement, as if they would be able to buy such improvement. **The contingent valuation method** requires people to say how much they would be willing to pay for an ecosystem service, under the theoretical condition that, e.g. biodiversity could be bought. People can also be asked for the amount of compensation they would be willing to accept to give up an ecosystem service. **The choice experiment method,** on the other hand, allows a valuation of various attributes including bundles of services. It is based around the idea that a good can be described in terms of its attributes/characteristics, and it focuses on the value of a change in these attributes. Respondents need to select between a set of alternatives, and values are derived from the responses by including a money indicator as one of the attributes. Economic values are inferred by the trade-offs respondents make between different combinations of attributes and between monetary and non-monetary attributes.

Pros & Cons:

The contingent valuation method is relatively easy to implement. Yet, it is best used for estimating the value of services that are easily identified and understood by users. Choice experiments allow individuals to evaluate non-market benefits described in an intuitive and meaningful way. The results of both methods are highly sensitive to the design of choice scenarios and how the survey is conducted. One main disadvantage of the approach is that responses to willingness-to-pay questions are hypothetical and may not reflect true behaviour.

Hypothetical scenarios described in the survey might be misunderstood or found to be unconvincing to respondents, which can result in 'protest votes': i.e. respondents state zero willingness-to-pay (zero bids). It is therefore important to carefully design and pre-test the questionnaires in order to avoid or mitigate these biases. Moreover, aggregate value over individual-level willingness-to-pay measures may mask potential distributional effects. One possibility for overcoming these is to attribute different weights across the different groups of the sample population. Furthermore, the results are often dependent on the policy context described in the survey. Thus, the value of ecosystem services estimated in one context is not easily transferable to another case. Finally, a choice experiment requires complex data collection including large-scale surveys, and sophisticated statistical analysis and modelling.

Valuing marketed ecosystem services

If the ecosystem service is marketed, you can consider applying the market price approach or the production function approach. The **market price approach** consists of measuring what it costs to buy or sell a good or product. It estimates people's actual willingness-to-pay and therefore uses observed data of actual preferences. The major advantage of this technique is that it is relatively easy to apply, as it makes use of generally available information on prices. In the **production function approach**, ecosystem services are modelled as inputs into the production of marketed goods and services, or as a joint output in production. Note that this method implies a quantification of the biophysical relationship that links changes in supply or quality of ecosystem services with environmental changes or management options, which is not always easy. It also has substantial data requirements.

Deliberative Monetary Valuation Method

The **Deliberative Monetary Valuation (DMV) Method** is a 'hybrid' valuation method that incorporates deliberative processes into conventional stated preference methods. This typically entails a deliberative group process that involves discussion and learning, and generates agreed group-based values (shared values) of the benefits of an ecosystem.

It developed as a response to critiques of more established methods such as contingent valuation, and on the argument that a small group discussion can help with preference formation and inclusion of non-economic values. In DMV method, participants explore the values that should guide their group decisions through a process of reasoned discourse. Debates can focus on what the benefits mean, which benefits are most important in the short vs. long-term, and who would benefit. The outcomes of DMV method depend on whether values are provided by individuals in a group setting, or by the group as shared expressions of value, and whether individual amounts are established that are akin to individual willingness-to-pay, or whether participants establish a pre-aggregated amount. Because of its deliberative nature, DMV method is resource intensive and cannot be applied to very large populations. To date, only a few studies have applied a DMV approach.

For an example of application of the method, see Kenter, J.O., Reed, M.S., Irvine, K.N., Brien, L.O., 2014. UK National Ecosystem Assessment Follow-on. http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=l0%2FZhq%2Bgwtc%3D (open access)

Benefit (or value) transfer method

When it is not possible to estimate the value of peatland restoration at a given site, e.g. because of budget constraints, the '**benefit (or value) transfer'** method may be used. This method is an indirect way of valuing ecosystem services that relies on 'borrowing' the values as estimated in a pre-existing valuation study, and transferring them to the site of interest. The values that are used need to be obtained at a site that is as similar as possible to the site that one is trying to establish a value for. Thus, willingness-to-pay estimates from one site can be used as proxies for another site.

Pros & Cons:

Given the limited resources that may be available for conducting valuation studies, value transfer can provide a fast and affordable process to estimate values for ecosystem services. Other advantages include the fact that value transfer can also be applied on a scale that would not be feasible for primary research in terms of valuing large numbers of sites. Methodologically, it also provides consistency in the estimation of values across sites to be valued.

However, **even if one identifies a very similar site, because benefits and beneficiaries are always site specific, the value transfer method ALWAYS incurs errors (so-called transfer errors)**. These errors may stem from measurement error in primary valuation estimates, transfer of the values between sites (if those differ in population or environmental/physical characteristics, e.g. quantity and/or quality of the service), or temporal effect: preferences and values for ecosystem services is often not constant over time. Thus, the method should only be applied if there are no other options. In the case of peatlands, because there are not yet many pre-existing valuation studies, you are unlikely to find many existing values to ‘borrow’. However, for some types of services, values from wetlands more generally might be useful.

For an example of application of the method, see Brander, L., Brouwer, R., Wagtendonk, A., 2013. Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis. Ecological Engineering 56: 89-96 (not open access)


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Additional resources

Understanding delivery of benefits provided by peatland restoration

- A comprehensive review on how to measure the various impacts of restoration on provision of ecosystem services from a biophysical perspective can be found in "A review of techniques for monitoring the success of peatland restoration", by Natural England. Report NECR086: http://publications.naturalengland.org.uk/publication/46013.
- For a quantitative description of changes in the delivery of ecosystem services and corresponding impacts, the National Ecosystem service Assessment in the United Kingdom http://uknea.unep-wcmc.org/ provides data and material to help you estimate the impact of alternative measures or scenarios on the value of ecosystem services.

Complementary information on valuation methods and valuation tools

- The Toolkit for Ecosystem Service Site-based Assessment (TESSA) provides a framework for a rapid assessment of ecosystem services: http://www.birdlife.org/worldwide/science/assessing-ecosystem-services-tessa;
- The natural capital toolkit presents various types of methodologies, approaches, and case studies for natural capital measurement and valuation: https://www.naturalcapitaltoolkit.org/search?keywords=&sortBy=name&toolTypes%5B%5D=4&category=3;
- The Environmental Valuation Reference Inventory (EVRI) provides a broad range of summaries of environmental and health valuation studies, including information about the study location, the valued environmental assets, the method of valuation, and estimated monetary values: https://www.evri.ca/en/content/about-evri;
- The Outdoor Recreation Valuation (ORVal) Tool uses spatial data to model the visitation rates and recreational welfare benefits provided by accessible green sites in England and Wales. It aims to capture the fact that the recreational value of the natural environment varies with the type of habitat, location, population density and the availability of substitute recreational opportunities: https://www.leep.exeter.ac.uk/orval/;
- An introduction to environmental economics and guidance on how to value the environment in small islands can be found in Van Beukering, P., Brander, L., Tompkins, E. and McKenzie, E. (2007): "Valuing the Environment in Small Islands - An Environmental Economics Toolkit": http://jncc.defra.gov.uk/page-4065 (open access);
- An introduction to environmental economics for exploring the valuation techniques in more details is available in "Environmental Economics: An Elementary Introduction" by David W. Pearce (1993).

Communicating peatlands benefits to the general public

If you are interested in communicating the importance of peatlands to the public and raise awareness of the value of peatland ecosystem services, you can use the learning module http://www.see.leeds.ac.uk/peatland-modules/?type=learning (Martin-Ortega, J., Glenk, K., Byg, A., 2017) developed for Scotland.

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Acknowledgements

This work was funded by the iCASP programme (Yorkshire Integrated Catchment Solutions Programme, NERC Grant NE/P011160/1 led by the University of Leeds) and in-kind contribution of the Yorkshire Peat Partnership (YPP) and Moors For the Future Partnership (MFFP). We are very thankful to Tim Thom, Jenny Sharman, and Mark Brown from YPP and to Mike Pilkington and Matt Buckler from MFFP for a productive collaboration, insightful constructive feedback, and enthusiasm. Thanks to the iCASP team for support and to Martin Dallimer for reviewing the guide. Special thank you to Susan Ballard for improving the design of the guide.

How to cite this document

Ferré, M. and Martin-Ortega, J. (2019). A User Guide for Valuing the Benefits of Peatland Restoration. An iCASP (integrated Catchment Solutions Programme) report developed in collaboration with Yorkshire Peat Partnership and Moors For the Future Partnership. https://icasp.org.uk/resources/peat-resources/

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