Peatlands and Climate Change

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Scientific Review
December 2010

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This review was commissioned by the IUCN UK Peatland Programme's Commission of Inquiry on Peatlands. The IUCN UK Peatland Programme is not responsible for the content of this review and does not necessarily endorse the views contained within.

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Summary

1. Peatlands probably represent the single most important terrestrial carbon store in the UK biosphere and store carbon equivalent to many times annual UK atmospheric emissions of CO_2.
2. The greenhouse gas (GHG) budget of a peatland consists of the direct release of carbon gases (CO_2 and CH_4) as well as mineralisation of fluvial carbon (eg. from dissolved organic carbon – DOC) and nitrous oxide (N_2O). The GHG budget of a peatland is not the same as the carbon, not only because there are non-carbon greenhouse gases but also because the different components of the GHG budget have different greenhouse gas warming potentials.
3. Unlike many areas of peat soils in the northern hemisphere those of the UK have been heavily impacted by a legacy of intense management, atmospheric deposition and visitor pressure. This means that UK peats represent both a threat and an opportunity with respect to greenhouse gas emissions because correct management and restoration could lead to enhanced storage of GHG in these soils while mismanagement or neglect could lead to net sinks becoming net sources of greenhouse gases.
4. This review considers both the carbon and the GHG budgets of UK peatlands across the management spectrum from the almost pristine, low impacted peatlands to most impacted and considers the probability that a range of land uses or land use changes will bring benefit to both greenhouse gas or carbon budgets. This component of the review draws upon the more extensive review prepared for JNCC (Worrall et al. 2011).
5. This review assesses the potential for additional GHG storage in UK peatlands and how resilient our peatlands will be to climate change.
6. The meta-analysis from the JNCC review (Worrall et al. 2011) shows that many interventions on managed peatlands will not necessarily result in an improvement in the GHG balance of peat soils.
7. Potential capacities for additional GHG storage are considerable (in one example more than doubling present sink size) but only when well targeted and even then they may require subsidy above and beyond that which might be available from carbon offsetting or trading.
8. Peatland restoration, when appropriately targeted, can offer considerable resilience against ongoing climate change, the example used here suggests that almost 60 years of additional GHG storage could be gained by acting now.
9. At present there is no policy mechanism for claiming financial support for the additional storage of GHG from peatland restoration.

1. Introduction

The purpose of this review for IUCN UK Peatland Programme is to consider the capacity and resilience of peatlands in mitigating and adapting to climate change and the implications this may have on current policy for peatland restoration. This Review examines the evidence, to date, on C and GHG budgets in UK peatlands under differing land management. This review draws heavily upon work undertaken for a separate review of the impacts of management upon carbon and greenhouse gas budgets of peatlands commissioned by JNCC (Worrall et al 2011).

2. Background

Peatlands cover only a small portion of the Earth's surface, estimated at between 2% and 3% (Charman, 2002; Gorham, 1991), but they comprise a large accumulation of terrestrial organic matter, fixed from the atmosphere by photosynthesis, and are therefore important carbon (C) stores, representing up to one third (between 250 and 450 Pg; 1 Pg = 1Gt = 10^{15}g) of the World's terrestrial carbon pool (Gorham, 1991). Thus peatlands represent an important long-term sink for atmospheric carbon dioxide (CO_2) (Gorham, 1991; Roulet et al., 2007) and have the potential to moderate the long-term build up of atmospheric CO_2 (Moore et al., 1998). However, many northern peatlands, including those in the UK (Holden et al., 2007a), have suffered from disturbance such as drainage, agricultural improvement, peat cutting, afforestation, burning and increased atmospheric nutrient deposition. Disturbance can significantly alter C cycling within peatlands (e.g. Roulet et al., 2007) such that peatlands can become a large and persistent source of (i) C to the atmosphere (as CO_2,e.g. Waddington et al., 2002) and (ii) C to aquatic ecosystems (Dawson & Smith, 2007). Therefore, protection and restoration of these degraded peatlands is being pursued by national and regional agencies in order to conserve existing C stocks and to help mitigate climate change.

Restoration usually involves techniques to stabilise eroding surfaces, re-establish peatland vegetation cover and raise the water table, and hence encourage waterlogged conditions that will enable peat to form again. Research at the plot-scale suggests that restoration of degraded peatlands can reduce C losses to both the atmosphere (e.g. Tuittila et al., 1999) and the aqueous environment (e.g. Waddington et al., 2008; Holden et al., 2007b). However, it may lead to an increase in methane (CH_4) emissions (e.g. Waddington and Day, 2007), at least in the short term, which is a more potent greenhouse gas than CO_2, with a global warming potential (GWP) of around 23 (i.e. 1kg of CH_4 is 23 times more potent than 1kg of CO_2 in terms of radiative forcing [climate warming] over a 100 year time horizon; Houghton et al., 1995, Forster et al., 2007). When accounting for this higher GWP, increases in CH_4 emissions may reduce C savings associated with peatland restoration. In addition, water-borne fluxes of C (particulate, dissolved and gaseous forms) from peatlands are rarely, if ever, considered as part of the peatland C budget (Worrall et al., 2003). Quantification of aqueous C loss, in addition to gaseous C losses, from peatlands is, therefore, critical in determining C budgets for sites, and in understanding the potential of restoration to reduce C losses and greenhouse gas (GHG) flux (Worrall et al., 2003).

3. Carbon Budgets for Peatland Sites

Carbon budgets of peatlands have generally been estimated by two types of method: dating of peat accumulation, and measuring C fluxes between the ecosystem and the atmosphere (Smith et al., 2008a). Dating methods give a rate of C accumulation in accumulating peatland systems (e.g. Tolonen and Turunen, 1996) but cannot be used to estimate C losses in degrading systems. Furthermore, the approach averages over long periods, typically tens to hundreds of years depending upon the particular dating technique, and therefore gives no indication to the shorter-term temporal variation in C accumulation that may have occurred due to environmental change. Therefore, this approach is not suitable for understanding the impact of land management change on the C budget. The second approach is to calculate a present day C budget which is based on measuring/estimating fluxes of C exchange with the atmosphere and fluxes of C to the fluvial system. Figure 1 represents all key fluxes of C that need to be considered in order to calculate a C budget for a site and to determine whether it is acting as a C sink or source.

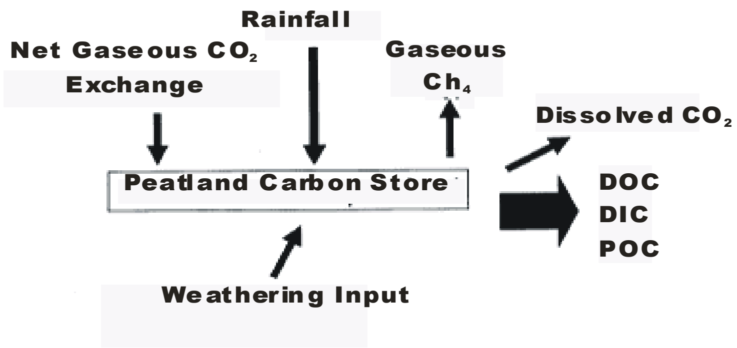

***Figure 1** Principal C fluxes from organic soils (after Worrall et al. 2003)*

The apparent simplicity of Figure 1 hides very significant complexity in the processes controlling C flux in peatlands. Of the major organic C fluxes, the CO_2 flux and dissolved organic carbon (DOC) flux are the best studied, with CH_4, particulate organic carbon (POC) and dissolved gaseous flux having received considerably less attention. In addition, very few studies include fluxes of nitrous oxide (N_2O), which is a major GHG (GWP ~296 over a 100 year time horizon – Houghton et al., 1995). There is very limited data on the fluxes of N_2O from peatlands and although this study considered it in most cases there was no evidence to go on.

Gaseous exchange between the atmosphere and the peat surface is dominated by photosynthetic fixation of CO_2 from the atmosphere and by soil and vegetation respiration losses of CO_2. The balance between these is known as the net ecosystem exchange (NEE) of CO_2. The other major gaseous loss of C to the atmosphere is CH_4 which is produced via anoxic decay of the soil organic matter. However, as highlighted by Baird et al. (2009), CH_4 is often omitted from C budgets because it represents a relatively small proportion (<10%) of the total C budget. In addition, it is harder to measure and its production across a peatland is spatially very variable. However, CH_4 is a much more potent greenhouse gas than CO_2 and it is possible for a peatland to be a net sink for C but at the same time to have a net positive radiative forcing (i.e. warming) effect on climate.

The loss of C to the fluvial system should include: POC, DOC, and dissolved gaseous carbon (CO_2 and CH_4). However, most studies investigating the transfer of C between peatlands and the aquatic system only quantify the DOC flux, which is usually the dominant component of the aquatic flux (Dawson et al., 2002). Gorham (1995) estimated that the DOC loss from northern peatlands was about 20 tonnes C km^{-2} yr^{-1}. However, a complete aquatic C flux should include measurements of POC, DIC, dissolved CO_2 and CH_4 and CO_2/CH_4 evasion from the stream surface. Measurements of POC and CO_2 evasion have been found to significantly increase the aquatic C flux from peatlands (Hope et al., 2001; Dawson et al., 2002; Billett et al., 2004) and their inclusion may well determine whether a peatland is acting as a C sink or source. Furthermore, the POC flux from disturbed catchments may be substantially greater than in more pristine sites and so ignoring those fluxes may be result in very erroneous C budgets for peatland systems. For example, Pawson et al. (2008) observed that 80 % of the fluvial C loss was in the form of POC in a heavily eroding peat catchment in the south Pennines. However, the impact of fluvial carbon losses on the atmosphere depends upon whether fluvial components react to give CO_2 or CH_4. While certain fluvial fluxes, such as dissolved CO_2 and CH_4, (Billett et al., 2004; McNamara et al., 2008) are likely to return to the atmosphere quite rapidly the fate of DOC and POC are less clear, but their role in the GHG budget of a peatland should not be considered negligible; Worrall et al. (2006) observed a reduction in the DOC flux across an 11.4 km^2 catchment of 32% by mass and 40% by mass over an 818 km^2 catchment – this observed loss may have been due to loss to the atmosphere.

It should be noted that the carbon, or GHG, budget measured for a managed peatland may reflect a transition from one management to another rather than an equilibrium position. Therefore, the benefit of peat restoration or changed management can be considered to be threefold. Firstly, the peatland could presently be a net source of carbon and a change in management or restoration could result in this source being diminished in magnitude. Such a decrease represents a carbon saving that we can consider as an avoided loss. Secondly, between the state of a damaged peatland or under one management, which is a net source of carbon, and a pristine peatland, or another peatland management style, there is a transitionary stage. This transitionary stage can be of carbon benefit due to both avoided losses and net gains of carbon. For example, this transitionary sink could be the period during which an eroded gully refills with peat. Thirdly, many studies have demonstrated that well-managed or pristine peatlands accumulate carbon and provide long-term sinks. Therefore, an intervention on a managed peatland could be a carbon, or GHG benefit, in a maximum of three ways – avoided loss, transitionary gain and a perpetual gain. The potential for ongoing accumulation of carbon makes the peat environment unique in carbon benefit terms in comparison to other ecosystems. Other ecosystems, such as forests, can accumulate biomass and store carbon, but the system will achieve a steady state equilibrium at which there is no ongoing net sink of carbon.

4. Methodology

The JNCC-commissioned review (Worrall et al. 2011) that has informed this piece of work adopted the following assumptions and definitions to bound the systematic approach used:

a. The soils of concern are peat soils where peats are defined as deep peats with an organic layer deeper than 40 cm depth which coincides with the definition used within the Soil Survey of England and Wales, or 50 cm deep in Scotland. For highly organic soils (peats) the %SOC (soil organic carbon) does not change and so managing soil organic matter is about managing the fluxes of C to and from the soil.

b. The study is not limited to just upland peat soils but includes raised bog as well as blanket bog and mires. The study defines fens as wetlands with large expanses of standing water. Although fens converted to agriculture are considered.

c. In geographical terms, the study considers data from the UK as a priority but also considered data from Europe and North America, but data from the Arctic or which could be considered as tundra were excluded. Literature is considered by the region from which it originates and where a study from without the UK is considered then the location of the study is listed in the text.

d. The context in which peat soils are considered is not stationary, especially in the light of climate change, but given the scarcity of studies it was decided not to discriminate on the grounds of age of the study.

e. The study considered the following land use/land management types: pristine, drainage, drain-blocked, managed burning, afforestation, deforestation, removal of grazing, revegetation and restoration of cutover peatlands. This is not an exhaustive list of possible management types, but the management types that could be considered were partly dictated by data availability. Furthermore, some of these management types could be considered to be the reverse of each other, e.g. afforestation and deforestation, while for others in the list, their reversal is not considered due to lack of evidence in the literature, e.g. managed burning was listed, but not the cessation of managed burning.

f. The study does not consider wasted peats, where wasted peats are here defined as areas where the peat layer has been removed by agriculture or deliberately buried in an attempt to improve agriculture. Although these areas may have the capacity to sustain a peat soil there is no longer any peat at the surface.

g. The study recognises that effects of management intervention or change maybe transitionary, however, the lengths of the studies considered in this review make it impossible to assess whether any affect reported is transitionary.

h. Pristine areas are included but cannot be considered in terms of change of GHG or C budget, rather the magnitude and direction of the flux of each component is recorded. These data provide a baseline against which management impacts can be assessed. Pristine is defined as an area in which there is no management at the time during, or preceding, the study that could affect the peat. Pristine does not mean that the site has been unaffected by external factors such as climate change or atmospheric deposition.

i. The study focused upon the greenhouse gas and C budget of peat soils where the C budget is defined as

$$F_C = PP + R + POC + DOC + dissCO_2 + CH_4 \qquad \text{(i)}$$

Where: F_c = the total C budget (tonnes C/km^2/yr); PP = primary productivity; R = net ecosystem respiration; POC= the annual flux of POC (tonnes C km^{-2} yr^{-1}); DOC = annual DOC flux (tonnes C km^{-2} yr^{-1}); diss.CO_2 = the annual flux of excess dissolved CO_2 (tonnes C km^{-2} yr^{-1}); and CH_4 = the annual methane flux (tonnes C km^{-2} yr^{-1}). The sum of PP and R is taken as the net ecosystem exchange (NEE) and studies that use this measure were included. In addition to C greenhouse gases (i.e. CO_2, CH_4), N_2O is considered. Dissolved CH_4 does appear in a few studies but it is rarely measured and where studied its flux is negligible even allowing for its GWP (Dinsmore et al., in press).

j. The approach includes any study that considers any one of the above components of the GHG and C budget for any of the above managements or a pristine peatland.

k. Between studies, the exact definitions of each of these components of the budget may vary and we have to rely on the individual authors and a critical assessment of data quality. This means that imposing any sub-divisions of peatland classification upon the dataset may well be fruitless as such sub-divisions may not be represented in the data.

l. The findings of any study are recorded as the magnitude and direction of any component of the GHG flux for any year of the study; the magnitude and direction of change upon management change.

m. All fluxes of all components are judged relative to the atmosphere, e.g. PP flux is negative. Therefore, a net sink of greenhouse gases from the atmosphere would be given a negative value.

n. Multiple years of any study are recorded separately.

The meta-analysis contained within the JNCC-commissioned review (Worrall et al. 2011) exploits the method of Worrall et al. (2010). The method of Worrall et al. (2010) considers any study relative to any of the C pathways defined above (plus NEE whenever that is reported instead of GPP or NER) and for any of the managements defined above. The approach means that a probability of improvement can be ascribed to each management considered and by combining information it is possible to estimate equivalent sample size, i.e. the number of equivalent complete carbon or GHG budgets that the reviewed literature would represent. This review is different from the approach presented by Worrall et al. (2010) in two ways. Firstly, this study considers grey literature in addition to literature in peer-reviewed journals, and secondly, where studies have presented multiple years of data, the separate years are considered as distinct. This latter change in approach means that the study can capture inter-annual variation.

Wherever possible this report quotes all budgets and export values (budget per unit area) in terms of CO_2 equivalents (e.g. tonnes $CO_{2\ eq}$./km^2/yr) where the conversion to GHG warming potential (GWP) has been achieved by reference to Houghton et al. (1995) and Forster et al. (2007). However, because of the manner in which results are reported this conversion is not always possible and so the C budget, or export, is reported. As a rough conversion the C budget, or export, can be multiplied by 3.667.

For further detail on the methodology used see Worrall et al. (2011).

5. Spatial Extent of Peatland Types and Land-uses

The spatial extent of peatland types in the UK are considered in a separate review for the IUCN enquiry.

For the JNCC-commissioned study (Worrall et al. 2011) which informs this review, the simple spatial extent and flux-weighted spatial extent were used to assess the impacts of peatland type, management and intervention on climate change and adaptation potential. Information on areal extent of different types and sub types of peatlands, management types and emission factors was derived from from four main sources and used to estimate GHG fluxes for peatlands under different uses, land covers and conditions.

Full results of this analysis are available in Worrall et al. (2011).

6. Carbon Stock in UK Peatlands

It should be emphasized that just because the peat soils of the UK are a large store of carbon this does not in itself mean that these soils are either a sink or a source.

It is impossible to give a definitive estimate of the amount of carbon stored in UK peatlands. In order to estimate the stock of carbon in UK peatlands requires 4 basic facts:

Area of UK peats – there is no agreement on the area of peats in the UK, however, the most recent reviews come quite close to common estimate of between 17000 and 18000 km^2 of deep peat (UK Biodiversity Group, 1999; - Natural England, 2010; Scottish Executive, 2007; Defra, 2009; JNCC, 2010).

Depth of peat – even by definition we do not know the minimum depth of peat in the UK, as definition of peat differs even between England and Scotland. However, if we assume that peat depth is at least 50 cm and the average is no greater than 2m even though we know that some UK peats could many times deeper.

Density of peat – the density of peat will vary with depth, but for the sake of this study we will assume that the top 40 cm of peat has a density of 100 kg/m^3 of dry mass and that catotelmic peat, i.e. peat below 40 cm has a density of 300 kg/m^3 of dry mass. Carbon content of peat – for this study we assume that peat it is between 45 and 50% carbon.

It is assumed that these ranges do not vary between management or peat or at least we do not sufficient information to make a calculation. Given the ranges above we calculated 500 values drawn randomly from within each of these ranges assuming a uniform distribution between the extreme values given above. The ranges then suggest that the stock of carbon in UK peats is 3200 ± 300 Mtonnes C.

7. "Pristine" Peatlands

For the purposes of both this review , "pristine" is defined as an area in which there is no management at the time during, or preceding, the study that could affect the peat. Pristine does not mean that the site has been unaffected by external factors such as climate change or atmospheric deposition.

There are only a small number of studies that have attempted to measure a complete C budget for "pristine" peatlands, particularly within the UK. Worrall et al. (2003; 2009a) constructed a C budget that considered both fluvial and gaseous exchange, for the Trout Beck blanket peatland catchment at Moor House in the North Pennines. The estimated C budget proposed by Worrall et al. (2003) had a number of limitations; the study did not measure all possible uptake and release pathways; in-stream losses were not included; the study only considered one year; the fluxes of CH_4 had to be modelled for the catchment based upon results from outside the study area; and the budget was for C and not a complete GHG assessment as no N_2O fluxes were considered. The first three of these issues were addressed in an updated and revised budget by Worrall et al. (2009a), who reported that the 13 year (1993-2005) average C budget for Trout Beck was -59 tonnes C km^{-2} yr^{-1} (i.e. the catchment was acting, on average, as a sink for C), with annual budgets ranging between -20 and -91 tonnes C km^{-2}. Another catchment scale blanket peat C budget was presented by Billet et al. (2004) for Auchencorth in central Scotland. The C budget was compiled over 2 years, October 1996 to September 1998 and was found to be 8.3 tonnes C km^{-2} yr^{-1}, suggesting that the system was acting as a source of C or at best C neutral. In addition, Billett et al. (2004) observed that the export of total organic carbon (TOC= POC + DOC) is of a similar magnitude to the net CO_2 exchange. Dinsmore et al., (in press) have subsequently shown that the Auchencorth peatland is a net sink for GHGs (-352 tonnes CO_2-eq km^{-2} yr^{-1}) and C (-69.5 tonnes C km^{-2} yr^{-1}), similar to the 13 year average of -59 tonnes C km^{-2} yr^{-1} reported by Worrall et al. (2009a). Here too they showed that the aquatic fluxes of C were very important, representing 41 % of NEE C.

A number of other C budgets of pristine sites are now submitted for publication or in press; these show a considerable range in values. Clay et al. (in press) compiled a C budget for the Hard Hill plots at Moor House in order to study the impact of managed burning and grazing in comparison to control (unmanaged) plots on C fluxes. The control plots in this case have been unmanaged since 1954, and therefore represent mature and degenerate *Calluna vulgaris*. In this context, the plots are considerable sources of C. Similarly, as part a study into the impact of revegetation on the C budget of blanket peat, Billett et al. (in press b) monitored two control plots that represent the range of normal conditions for the study region (Peak District). The two plots in this study differed in their sink/source status with the *Eriophorum*-dominated plot acting as a net sink of C over 2 years while the shrub-dominated plot was a net source of C over the same period. The variation in budgets from this range of sites suggests that when considering changes in management in order to improve the C or GHG budget of an ecosystem it must be considered that the local "pristine" peatland might actually be a net source of C or GHG. It is, therefore, important that local controls are included in any study of management impacts.

Other studies outside of the UK, but still on what might be considered pristine peatlands, include a six year study by Roulet et al. (2007) on a Canadian raised bog who found the peat acted as net C sink of -21 tonnes C km^{-2} yr^{-1} although this varied significantly between years and a two year study of a Swedish peat bog by Nilsson et al. (2008) who found that the peats acted as a net C sink of between -20 and -27 tonnes C km^{-2} yr^{-1}. Similarly, Koehler et al. (2010) report six years of carbon budget from an Irish blanket bog as being -29.7 tonnes C km^{-2} yr^{-1}. However, data from Canada and Sweden are unlikely to be readily applicable to UK peatlands; both sites were raised bogs, while most of the UK data is for blanket bogs and water throughputs are considerably higher in the UK context leading to higher comparative fluvial fluxes. Indeed, and even despite the fact that value for an Irish blanket bog should be more comparable with the rest of the UK, the fluvial budgets of Koehler et al. (2010) seem remarkably low at 14 tonnes C km^{-2} yr^{-1} and their budgets do not consider POC, dissolved CO_2 or in-stream losses.

8. Influence of Land Management on C and GHG Fluxes from Peatlands – Field Evidence

The JNCC-commissioned review (Worrall et al. 2011) considers the influence of a range of land management types and interventions and gives the meta-analysis for each management with sufficient data.

9. Influence of Other Factors on C and GHG Fluxes from Peatlands

Other factors not directly related to management can also affect C and GHG fluxes from peatlands, and the most important of these are probably changes in atmospheric sulphur and nitrogen deposition and climate. We assume that economic changes that result in shifts in the viability of one land management over have been considered above in the review and meta-analysis of the management impacts.

Further consideration of each of these factors are published in Worrall et al (2011)

10. Potential for Enhanced Carbon or GHG Storage

A few studies have considered the potential for carbon storage in peatlands. Worrall et al. (2009) considered the capacity for additional carbon and GHG storage of the peat soils of Peak District National Park and results maybe very different elsewhere in wetter or colder parts of the UK. It was possible in that study to consider: revegetation; managed burning, grazing, and drain and gully-blocking. The modelling could consider combination of these interventions and the targeted combinations where the optimal combination of interventions is chosen to maximise GHG storage. The study estimates that the region is presently a net sink of –62 Ktonnes CO_2 eq at an average export of –136 tonnes CO_2 eq/km^2/yr. If management interventions were targeted across the area the total sink could increase to –160 Ktonnes CO_2 eq./yr at an average export of –219 tonnes CO_2 eq/km^2/yr. However, not all interventions resulted in a benefit; some resulted in increased losses of CO_2 equivalents and it was possible to assess the comparative efficiency of single types of intervention. This modelling exercise suggests that the most efficient interventions were via revegetation and cessation of burning and the least efficient was drain-blocking.

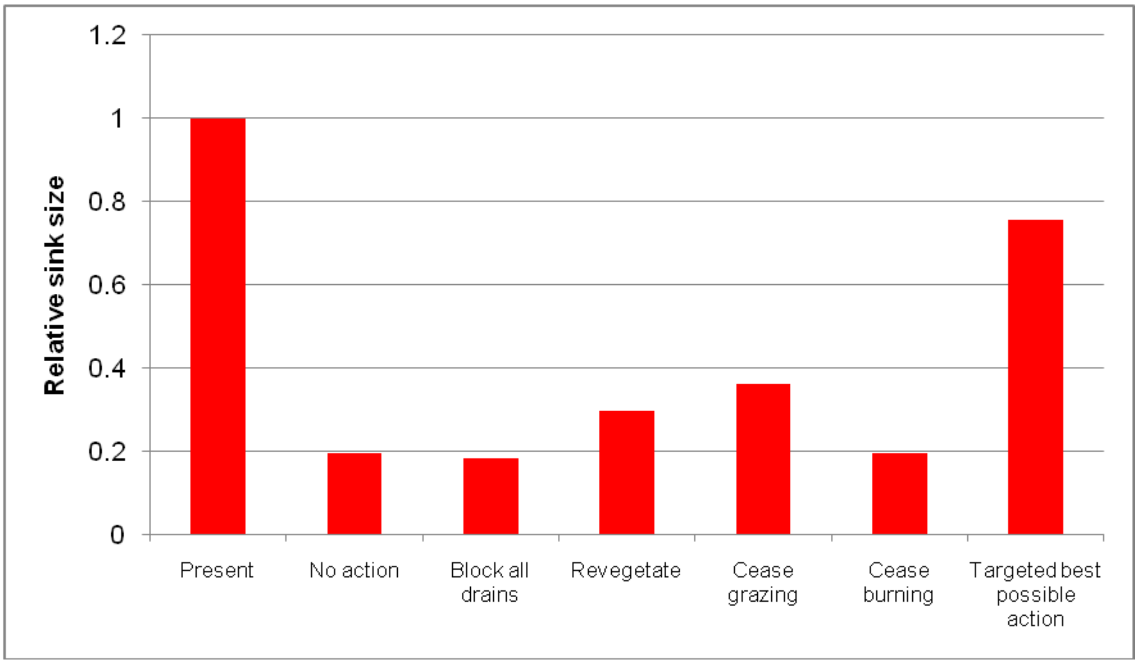

Figure 2 *The projected equivalent CO_2 budget of the study area by 2030 expressed relative to the present.*

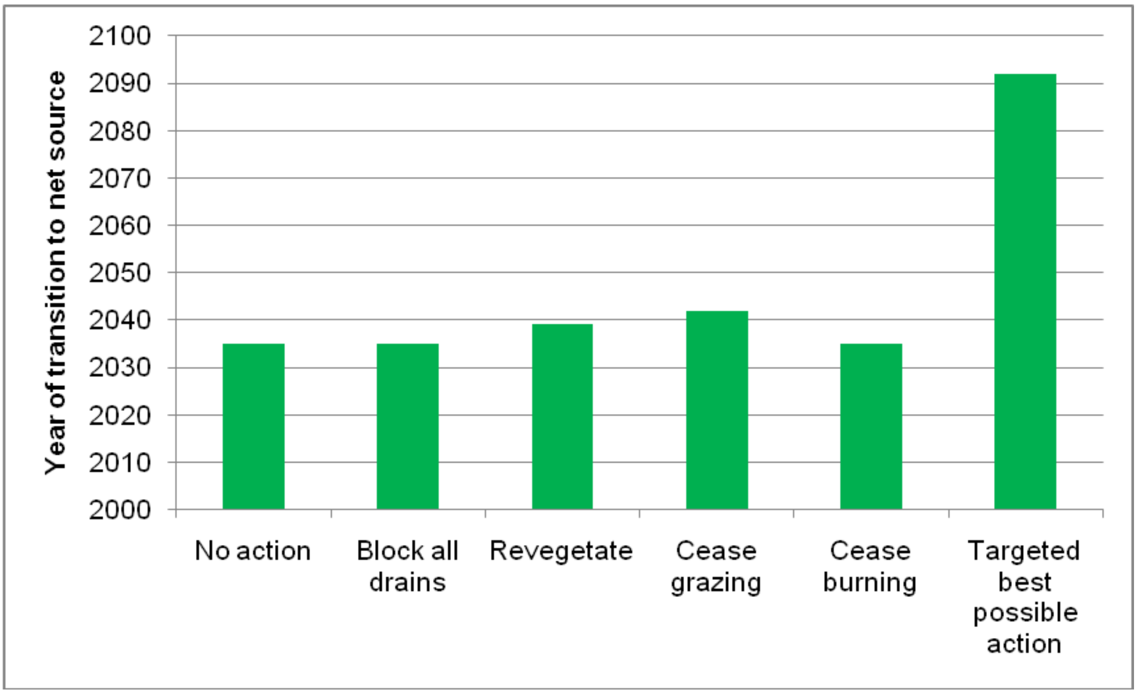

Figure 3 *The projected year of transition from net sink to net source for the Peak District study area under the range of management scenarios*.

The results of the future projections show that by 2030 the area is still a net sink of equivalent CO_2 though the magnitude of the sink has declined by then due largely to climate change. The rate of decline of equivalent CO_2 sink is 0.4 ktonnes C/yr^2 giving a predicted transition to a net source of greenhouse gas of 2036. It should noted that far from being a general decline in the equivalent CO_2 budget there are many areas that show an improvement in the greenhouse gas budget. In general improvements in the greenhouse gas budget is due to fact that primary productivity increases with warmer temperatures.

As with the present greenhouse gas budget it is possible to assess the impact of a range of scenarios on the future greenhouse gas budget. The same scenarios as before have been applied and show that going forward the overall greenhouse gas sink size for the area if management changes were made now. The relative size of the net sink when compared to present budgets is illustrated in Figure 2 and again illustrated that only targeted action makes a real difference and offers considerable resilince to climate change. Given the best possible intervention the rate of decline would only be 0.17 ktonnes CO_2 equivalent /yr and would suggest that the area would not become a net sink until 2091 (i.e. management intervention would provide for an extra 55 years of resilience – Figure 3).

11. Policy

There has been considerable interest in the potential for peatland restoration to claim the GHG that it saves and so generate new sources of revenue. Worrall et al. (2009) have considered the possibility of carbon offsetting within the Peak District National Park and suggests that about 51% of the study site areas that could show an improved GHG budget upon restoration would generate a profit under a reasonable range of carbon prices and restoration costs (£26 /tonnes CO_2 eq ± 50%). There is no formal mechanism for including peatland restoration in any form of carbon trading in the UK. However, the recent Terracarbon report suggests several ways forward (Settelmyer and Eaton, 2010):

i) A number of alternatives to traditional carbon offsetting such as carbon reduction could be considered as recommended by Rabinowitz and Este d’Hoare (2009).
ii) A UK peatland Carbon Code could be developed along the lines to the recent Woodland Carbon Code (Forestry Commission, 2010) and build upon existing guidelines (Voluntary Carbon Standard, 2010).
iii) At present there are no studies of the carbon leakage of restoration projects, i.e. what are the consequences of any displacement of activities curtailed by restoration. For example, if a restoration a project restricts grazing what are the consequences of increased grazing elsewhere?

The Terracarbon report suggests that the greatest hope for opening up a new stream of funding is that Peatland projects can be included in company reporting of GHG emissions. Readers are also recommended to refer to IUCN Technical Review no. 7. “Policy measures for sustainable management”.

12. Conclusions

It is possible to make the following tentative general conclusions based on the evidence compiled:

- Not all modified peatlands are C or GHG sources just as not all “pristine” Peatlands are presently net sinks of C or GHG. Additionally, peatland restoration does not necessarily lead to a peatland becoming a C or GHG sink. Although peatland restoration may proceed for reasons toehr than GHG storage.

- The reason that many restoration or management interventions do not provide an immediate benefit in terms of GHG is because CH_4 is often an important component of the C balance of restored peatlands when considered in terms of global warming potential even when, in terms of mass, CH4 losses are only a few percent (3-5%) of the net exchange of CO_2 between the peatland and the atmosphere.

- Potential capacities for additional GHG storage are considerable but only when well targeted and even then they may require subsidy above and beyond that which might be available from carbon offsetting or trading.

- Peatland restoration, when appropriately targeted, can offer considerable resilience against ongoing climate change.

- It is clear that the evidence base for this review is small, and in particular there is a lack of studies that consider complete carbon budgets with appropriate interventions and control.

References

This list is only of those references used directly in the above text, studies included in the meta-analysis are listed in the appendices.

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