Climate Mitigation and England Peatlands

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Author

Ian Crosher

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This strongly builds on the peatland & scientific communities' work to map out where peatlands exist, how to restore them and what are the greenhouse gas emissions (Carbon dioxide, Methane and Nitrous oxide) being released from different peatland types. Particularly the amazing work the IUCN UK Peatland Programme continue to do.

It represents much of the peatland emission factors work done by CEH and James Hutton Institute in a different way to hopefully make it more accessible to a wider group of people.

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Foreword

This work explores the greenhouse gas emissions being released by England's Peatlands. The aim of the report is to make the peat emissions evidence more accessible to a wider audience. It was originally started to support delivery of Biodiversity 2020 Outcome 1D target and further developed in January 2016 for work on the EU Integrated LIFE Peatland Bid. These projects were looking at how to integrate delivery & funding for peatland restoration along with the best solutions for climate, biodiversity and water delivery to understand the priority areas for delivery and how funding can be spent more effectively to reduce peatland emissions. It builds from workshops on how we should approach the peat and climate issue. Much of this inputted into the UK Peatland Strategy[1] and the continuing great work of the IUCN UK Peatland Programme.

The report was originally based on the scientific findings within the draft Peat Emission Factors[2] from 2016 and then published more widely in (Evans et. al 2017), but only available externally from 2019. This version uses the most current data and Emissions Factors from the 2023[3] 'Aligning the Peatland Code with the UK Peatland Inventory' this third update to the Peat Emissions Factors.

It has always been a working document, developed for informing internal work and has fed into numerous Natural England work streams around peat emissions and peat restoration strategies across England in 2017. Along with Parliamentary select committee responses, other wider policy briefings; work around Environmental Land Management Scheme (ELMS) options; Nature recovery delivery mechanisms and wider climate change mitigation related work.

It should be seen very much as a stop gap in our evidence base until the release of the updated England Peat Map in 2025 which will significantly improve our underlying peatland data used here. With improved data inputs and new mapping, this will increase our understanding of peat emissions from different sites and locations. Further updates can be made to this analysis as our data and knowledge on peat emissions increases.

This recent update is looking to take much of the scientific reports and make it more widely accessible to a greater non-technical audience. This will help make the link between Nature recovery and Net zero delivery on our peatland areas, highlight how early action reduces cost and delivers greater public & climate benefits. Permanent emissions reductions by restoring peat ecosystems now, is worth much more than doing it in later decades. Although this analysis only looks at the GHG emissions as a single issue, it still

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[1] https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2022-04/UK%20Peatland%20Strategy%202018_2040.pdf
[2] https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1904111135_UK_peatland_GHG_emissions.pdf
[3] https://nora.nerc.ac.uk/534668/1/N534668CR.pdf

needs to be linked with delivery outcomes for biodiversity and water quality and quantity to deliver a more effective integrated approach.

Executive summary

To limit global temperature rise to 1.5 degrees C, global emissions must peak before 2025, and then be halved by the early 2030s (IPCC, 2022). The UK has already committed to reducing carbon emissions by 68% by 2030 and 78% by 2035 compared to 1990 levels, before reaching net zero by 2050.

Peatlands offer an opportunity to contribute to the UK's statutory targets over the next 10 years. It is also important that we stop further degradation of these ecosystem now, so that rehabilitation at least starts from the best possible place. This will also help them adapt to climate change and prevent further biodiversity loss.

England's peatlands cover an estimated 1.2 million Ha and are made up of remaining deep peat soils of 495,000 ha, with an additional 186,000 ha of wasted peats that were previously deep peats but are now reduced in depth to below 40cm. In addition, there are 527,000 ha of shallow peat soils (< 40cm depth); although very important for climate mitigation, they are not included in this analysis due to lack of emissions & land use data and the greater uncertainty and variation around their estimated emissions.

England presently releases about 9.8 million t CO^2 e yr^{-1} from its deep peats.

- Of England's total peat area, approximately 9,000 ha (1.3%) is estimated to remain in a near-natural condition with low emissions or a small sequestration rate.
- A further 165,307 ha (24.2 %) of the English peat area remains under some form of semi-natural heather or grass vegetation but has been affected to varying degrees by human activities including drainage, burning-management, peat cutting and livestock grazing. This has led to drying of the peat, loss of peat-forming species and erosion, converting these areas into net greenhouse gas (GHG) sources. Although the emissions per unit area of modified peatland are relatively low when compared with some other land uses, their greater extent makes them significant contributors to overall peatland GHG emissions (449,962 t CO^2 e yr^{-1}, being 4.6% of England's total peat emissions).
- Interspersed in these same areas, upland moorland that are more severely eroded, with bare peat areas of 49,213 ha responsible for 878,641 t CO2e yr-1, i.e. 9% of England's total peat GHG emissions.
- Arable cropland occupies 26.8% of England's peat area but has the highest GHG emissions per unit area of any land-use, with high rates of both CO2 and N2O emissions due to drainage and fertilisation. As a result, cropland is estimated to emit 5.3 million tonnes CO^2 e yr^{-1} (54% of England's total peat GHG emissions). Around two thirds of the cropland area is on 'wasted' peat (shallow residual organic soils where much of the original peat has already been lost), predominantly in the Fenlands of East Anglia and other actively pump-drained areas in Lancashire and

Lincolnshire. Together, these account for, 35% of England's total peat GHG emissions - the highest of any area, and a priority for action.

- Peatlands converted to grassland occupy a further 7.8% of the England's peat area, and emit 1.65 million t CO^2 e yr^{-1}, which is 17% of England's total peat GHG emissions. Drained intensive grasslands in lowland areas are the primary source of these emissions.
- Around 9.6% of England's peat area is covered by trees; much of this is drained conifer plantation or recent woodland establishment on degraded sites. Both the area estimates and emissions factors associated with afforested peatlands have some uncertainty, and the Tier 2 emission factors cannot take into account factors such as the age of forest, differences between tree species or forest management practices. However, the Tier 2 emission estimates suggest that peat under forestry in England could be emitting around 357,500 t CO^2 e yr^{-1} (3.7% of England's total peat GHG emissions). This figure does not take into account CO2 uptake into tree biomass, or the after-use of harvested timber, so, where trees are obtaining higher growth rates (yield classes), this will be offsetting some of these emissions.
- Industrial peat mining for horticulture through the creation of milling flats, was reasonably widespread from the Second World War and cover over 23,000 Ha, which are now releasing over 462,768 t CO^2 e yr-1. The majority of the peat extraction has now stopped in England, often through the government buying out the extraction rights to meet its European Biodiversity commitments on the largest sites. Notably many of these larger sites, such as Thorne & Hatfield Moor NNR and Bolton Fell Moss NNR, have started the process of restoration. Most of the horticultural peat used in the UK is now shipped in from similar sites abroad, exporting the issue and the GHG emissions onto other countries.
- A similar area (24,451 ha) has been affected by current or historic domestic peat cutting for fuel over centuries. The resulting modification of vegetation and hydrology is very varied but is thought (in the absence of subsequent restoration) to have converted these areas into GHG sources releasing 365,383 t CO^2 e yr-1.

Summary Table - Peatland land use types, their areas covered and GHG emissions being released.

Peatland Land Use	Area (Ha)	% Area	2023 Emission Factors (t CO2-eq ha-1 yr-1)	Present Emissions (t CO2-e yr-1)	% Emissions
Cropland – Wasted peat	132,107	19.4	26.1	3,447,993	35.2
Cropland – Deep peat	50,594	7.4	37.17	1,880,579	19.2
Intensive Grassland	73,681	10.8	22	1,620,982	16.6
Eroded Modified Bogs (Bare peats)	49,213	7.2	17.72 to 18.86	878,641	9.0
Extracted Industrial	23,784	3.5	18.86	462,768	4.7

Peatland Land Use	Area (Ha)	% Area	2023 Emission Factors (t CO2-eq ha-1 yr-1)	Present Emissions (t CO2-e yr-1)	% Emissions
Modified Bogs Heather & Grass	165,307	24.2	2.51 to 3.32	449,962	4.6
Extracted Domestic	24,451	3.6	15.18	365,383	3.7
Forest	65,492	9.6	5.46	357,586	3.7
Extensive Grassland	1,895	0.3	15.88	30,093	0.3
Rewetted Bog	86,278	12.7	3.42	295,071	3.0
Near Natural Bog	4,254	0.6	0.32	1,405	0.01
Near Natural Fen	4,627	0.7	-0.36	- 1,666	-0.017

Contents

1 - Introduction

Peatlands are wetland ecosystems characterised by a naturally accumulated layer of peat formed from carbon-rich dead and decaying plant material under waterlogged conditions. There are three main types of peatland ecosystems in the UK: Blanket bogs, Raised bogs and Fens. Mosses, mainly *Sphagnum* species, are the main peat formers in the acid UK bogs, whereas fens have higher amounts of sedges, rushes and reeds within the peat deposits.

What sets peatlands significantly apart from other ecosystems is their capacity for long-term carbon storage. In undamaged peatlands carbon is removed from the atmosphere by the plant tissues via photosynthesis and stored in the dead plant remains. Waterlogging slows down decomposition and enables semi-decomposed plant remains to be laid down, often over millennia as a thick peat layer.

The UK's peatlands are estimated to cover a total area of around 3.0 million hectares (12.2 % of the total UK land area) (Artz et. al. 2019). While England is estimated to hold around 1.2 million Ha of peat soils (Natural England, 2010), made up of the remaining deep peat soils of 495,000 ha, with an additional 186,000 ha of wasted peats that were previously deep peats but are now reduced in peat depth to below 40cm (Natural England, 2010) (JNCC, 2011). In addition, there are 527,000 ha of shallow peat soils (<40cm peat depth), which do not have emission factors available and so sit beyond this analysis.

In total, the UK's peatlands are estimated to be emitting approximately 23.1 million tonnes CO^2 e yr-1 (carbon dioxide equivalent per year) of greenhouse gas (GHG) emissions (Evans, et. al. 2017) in the form of carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). Unfortunately, nearly all England's peatlands are in a degraded state and in need of intervention or land use change in order to prevent ongoing GHG losses (Evans et. al, 2011) (Artz, 2019). Of England's total GHG emissions from peat, an estimated 71% comes from peatland areas under arable and grassland cultivation.

Less than 1.3% of England's peatlands remain in a near-natural state, having been affected by peat extraction, grazing, fire and drainage for agriculture and forestry planting. Peatlands require high water tables to function properly, once drained, they will continue to dry out, deteriorate and erode, unless remedial action is taken to rewet them. (Evans et al, 2021) As a result, we not only lose the benefits that peatlands provide, but also impose additional costs on society, as the degrading peatlands become a major source of GHG emissions (Trenbirth & Dutton, 2019). A changing climate exacerbates these problems, placing more stress on these less resilient peatlands, which leads to more rapid loss of carbon.

2 - Why early action to secure the carbon in peatlands is essential.

We are at a pivotal moment where failure to act now to address the state of our peatlands will cost society billions of pounds in the future, through the resulting climate impacts alone (Figure 1). If we are to embrace peatland restoration and manage them sustainably, we must establish a strategic, long-term approach where resources are in place so that the peatland benefits to society are reflected in the support given to land managers and the bodies that can deliver peatland restoration.

Through putting in place an overarching long-term delivery strategy, we can direct resources to the peatlands that play the greatest role in tackling climate change emissions, ensure they are valued for their natural functions, and are passed on to future generations in a more resilient and beneficial state.

Figure 1: Comparing gains and costs in the transition between peatlands in different conditions. (from the IUCN UK Peatland Strategy) see https://www.iucn-uk-peatlandprogramme.org/uk-strategy

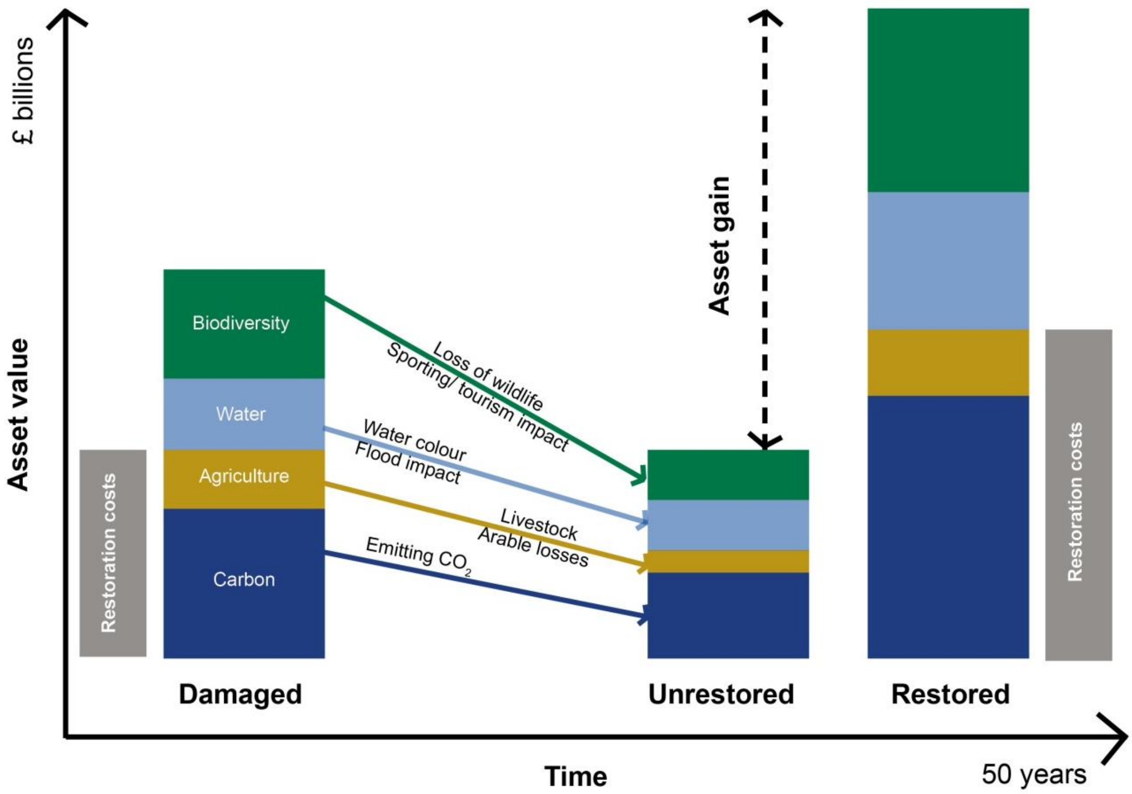

Figure 1 highlights how early action reduces cost and deliver's greater public & climate benefits for the long term. Once recovery action has been started it delivers permanent emissions reductions, which substantially helps us achieve Net Zero targets and emissions reduction pathways. Action now is much more beneficial than doing it in the 2030's & 2040's.

3 - Peatlands and climate change

In addition to urgent action on reducing fossil fuel use, the management of our natural environment has been identified as a priority in the fight against climate change, and is essential from an economic perspective (CCC, 2019), as the benefits of strong, early action on climate change far outweigh the costs of not acting (Stern et al., 2006).

More than 98% of England's peatland is in an ecologically damaged condition because of past peat extraction, drainage, grazing, fire and peat cutting [by hand], as well as atmospheric pollution (Natural England, 2010; IUCN, 2019). Whilst there are some threats to UK peatlands from new damaging developments, the most significant and widespread carbon emissions come from past drainage activity and the ongoing deterioration of peatlands that have not been brought under restoration management. As a result, much of our peatland is no longer sequestering and storing carbon and has instead become a significant carbon source (Birkin 2011, Evans C, 2016). Unlike forest clearance, where emissions are largely instantaneous, GHG emissions from drained peatland continue as long as the peatland remains drained, and the peat is oxidising; potentially this can last for centuries in the deepest peats (Artz. 2012 & 2014). The UN Convention on Biological Diversity (CBD) recognises the importance of peatlands in supporting rare and threatened species and highlights their role in mitigating for climate change, through a requirement for signatories to engage in peatland conservation and restoration (Kunming-Montreal Biodiversity Framework[4]). The two roles are complementary; peatland biodiversity depends on the same wet conditions that enable peat formation to occur and to maintain the peat carbon store that established over thousands of years. Peatland biodiversity is an indicator of the health of the ecosystem and its ability to function in support of climate change mitigation.

The UK Carbon Budget[5] and the amount of emissions that can be released within any given year now includes peatlands (Worrell, 2011; Birkin 2011). All restoration activity helps us balance the carbon loss with any carbon gains also being possible as the ecosystem recovers.

Whilst peatlands have a role in sequestering carbon, it is the rapid carbon loss from the long-term carbon store when peatlands are drained or the mantle of peatland vegetation is damaged, when the largest GHG emissions occur. Losses as much as 37.17 tonnes CO2e per ha per year from highly degraded systems have been

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[4] https://www.cbd.int/gbf/targets

[5] https://www.gov.uk/guidance/carbon-budgets

reported (Evans et. al 2023). Halting the loss of carbon emissions can be achieved relatively quickly (within years) and almost as soon as the water table has been restored to a higher annual level (Evans et al 2021). The full restoration with active peat formation, when carbon again starts to build, takes much longer, generally over a few decades depending on the initial state of the peatland. Once restoration is initiated, the reduction in carbon emissions provides year on year carbon budget savings that are later augmented by sequestration once new peat begins to form, providing the peatlands remain wet and that any management activity is sensitively carried out to support peat forming vegetation. Areas of very deep peat (0.4 – 12m + of range) protect large carbon stores, and the carbon savings benefits of rewetting can continue to be accounted for in future years, as the baseline, of allowing the peat to continue to degrade, would take a long time for the peat to be exhausted.

Carbon mitigation benefits can also be achieved in circumstances where intensive management for agricultural production occurs, such as in lowland arable and grassland areas. Changes in management that help raise water levels can reduce carbon loss, with further improvements possible through changes in tillage patterns. Shifts from arable to grassland can also bring large savings in the short term. Agricultural peats are often on shallower wasted peats (less than 30cm) that have suffered major peat loss over the last 100 years or so, with annual peat loss as much as 1-2 cm per year. Any carbon benefits of land management change to a better GHG emission state are quickly realised in these areas. The option of paludiculture[6] has the potential to help with this transition (Wichtmann, W. et al, 2016). On England's agricultural peats the traditional farming approach has been taken, resulting in drainage; paludiculture proposes to adapt cultivation to permanently wet conditions, resulting in significantly lower GHG emissions while still producing useful products from the land (Mulholland, 2020)

Peat Ecosystems and Carbon cycling

Bogs are dependent on direct precipitation for its supply of water and inputs (ombrotrophic). Fen habitats are comprised of wetlands that can occur on either peat or mineral soils. Unlike rain fed peatlands, fens receive water and nutrients from both groundwater and collected surface water, creating mineral rich growing conditions that support a more diverse range of flora and fauna compared to ombrotrophic peatlands (McBride et al, 2011).

[6] https://en.wikipedia.org/wiki/Paludiculture

How Bogs work
Bogs should be covered with vegetation, especially with a high percentage of *Sphagnum* mosses. The upper active growing layer of these systems (the 'acrotelm') controls exchanges of moisture with the atmosphere and has greater importance in the health of the ecosystem compared to the lower permanently waterlogged peat store (the 'catotelm') layer (Lindsay et al., 2014). A healthy acrotelm will maintain the wetness level of peat above the water table at or near saturation even in dry periods, as long as the catotelm is also healthy. The amount of damage to this layer affects the likely GHGs that will be released, so slight damage will release less GHGs than severely damaged bare or eroding peat surface. Bogs containing a well-established active acrotelm are likely to have the lowest emissions release and be best for biodiversity. (Lindsey, 2010)

On bogs devoid of vegetation, the absence of an active acrotelm promotes radiative heating and increased rates of evaporation, drying the peat and lowering water tables, thus causing the stored carbon to be lost to the atmosphere. Deep erosional gullying and hagging is a major additional factor responsible for increasing carbon release.

How Fens work

Fen habitats are widely distributed across the UK and can be found from sea level up to mountainous regions, so are influenced by numerous different formation processes. The geomorphological and ecological processes can be used to make predictions on the likely carbon cycling within the fens. Long-term carbon storage is affected by both vegetation production and decomposition processes, both of which are generally higher in fens than in bogs. Areas that have mineral soils, shallow peat and short vegetation will store less carbon, compared with much deeper peats and tall vegetation which will have higher carbon storage. Higher nutrient status is also usually associated with greater vegetation height in these tall herb fens, where vegetation is above chest and head height (McBride et al., 2011). This will have an influence on carbon dynamics, as more carbon dioxide is removed from the atmosphere through photosynthesis and is subsequently stored within the plant (Evans et. al 2016). The waterlogged conditions reduce decomposition rates of fen vegetation, with the denser plant materials of fen vegetation being more carbon dense. The more variable conditions fens are found within, often with higher temperatures and more water table variation increasing decomposition rates in the summer in most fen types.

As fen habitats are reliant on the quantity and quality of the water inputs, water table fluctuations will impact the ecosystem processes as such climate driven changes will influence carbon cycling within the system. Fen habitats have been significantly impacted by landscape management and land use change, all of which impact on the ability to store and sequester carbon (Morrison et. al. 2013). As such one of the largest factors affecting the ability of a fen habitat to function as a carbon sink is its water supply. Extensive drainage of surrounding landscapes & water extraction, within the habitat itself and of surrounding freshwater ecosystems all impact on the natural functioning of a fen habitat.

Fen peat is more carbon rich than bog peat. In bogs the carbon input rate is much lower, but the carbon accumulation is higher due to far less decomposition by microbes. Fens have predominantly much higher carbon input rates but with associated higher decomposition rates seasonally along with much more variability in types and conditions that influence these ecosystem processes. As these ecosystems become degraded through peatland drainage or defoliation, historic carbon is re-released back into the atmosphere as GHG emissions. Preventing this carbon release by reactivating the peatland ecosystem processes, so the carbon is once again isolated back into the long-term carbon store, is a very important way of delivering carbon abatement.

4 - Carbon Emissions from England's peatlands

This section investigates the different peatland types, both the emissions being released and the area of each that is present in England. It uses the land use figures from Department for Energy Security and Net-Zero (DESNZ) work on LULUCF (land use, land-use change, and forestry) to bring peatland into the IPCC emissions reporting framework (IPCC, 2014 & 2019) and the peat emissions inventory for the UK (see Evans et al., 2017; Evans et al., 2023)., The information is based on data that Natural England created initially for NE 257[7] (Natural England , 2010). The Updated England Peat Map will be released in 2025, at which time the land use on peatlands can be updated to give a more accurate picture of emissions from England peatlands than is currently available.

To calculate where peatlands are emitting GHGs, we need two types of information:

- the peatland land use by area;
- the emissions factors (EF's) as tonnes of GHG loss expressed in CO_2 equivalents per ha each year for that land use (Evans, 2017 & 2023);

In practice, restoration will not immediately change peatland from its present state to the best (natural) condition but will improve step-wise from poor to better condition. It is the carbon equivalent saved with each of these restoration steps that is the key information. We call this the abatement potential and, once restored to a new state, the GHG savings continue annually going forward. The other important consideration is the time lag; due to these being natural systems, the emissions saving is not instant from the point of restoration and will take approximately five years before the full abatement is realised of the restoration action.

Peatland Condition or Land Use of England Peatlands

The condition and land use of the peatland affects the emissions that are released. Using land use data and previous work on peatland condition we can make a reasonably accurate estimate of the areas of each peatland type. We can then split these up by our knowledge of the emissions of each land use type.

[7] http://publications.naturalengland.org.uk/publication/30021

Table 1: Peat Condition by Land Use Area for Deep and Wasted Peat from NE257 Natural England, (2010) & Evans et. al, (2017)

Peat condition category	Drainage status	Deep peat (Ha)	Wasted* peat (Ha)	Total (Ha)
Forest	Drained	51,764	13,728	**65,492**
Cropland	Drained	50,594	132,107	**182,701**
Eroded modified bog	Drained	5,653	0	**5,653**
Eroded modified bog	Undrained	43,560	8	**43,568**
Heather dominated modified bog	Drained	19,208	0	**19,208**
Heather dominated modified bog	Undrained	87,166	55	**87,221**
Grass dominated modified bog	Drained	24,053	0	**24,053**
Grass dominated modified bog	Undrained	32,992	1,833	**34,825**
Extensive grassland	Drained	1,377	518	**1,895**
Intensive grassland	Drained	38,416	35,265	**73,681**
Rewetted bog	Rewetted	83,930	2,348	**86,278**
Rewetted fen	Rewetted	0	0	**0**
Near natural bog	Undrained	4,254	137	**4,391**
Near natural fen	Undrained	4,627	1	**4,628**
Extracted domestic	Drained	23,784	286	**24,070**
Extracted industrial	Drained	24,451	86	**24,537**
	Totals	**495,829**	**186,372**	

*Wasted peat – a technical term for deep peat that has been substantially degraded following years of drainage and cultivation.

In Table 1 the area of peatland under different land uses and conditions has been estimated. There are uncertainties associated with these numbers, but this gives us a good basis to develop targets from. Even if these figures change in future, as our data and knowledge increases, the area restored will always be a set figure and so the total emissions can be adjusted as our evidence base improves.

IPCC Guidelines for National Greenhouse Gas Inventories[8] Background Context setting.

Overview on the IPCC guidance on the estimation of emissions and removals of CO2 and non-CO2 for the Land Use, Land-Use Change and Forestry (LULUCF) sector, (IPCC, 2014 & 2019)

The Tier 1 uses the default emission factors provided in the IPCC Guidelines. Tier 1 methodologies use activity data that are spatially coarse, such as nationally or globally available estimates of deforestation rates, agricultural production statistics, and global land cover maps.

Tier 2 can use the same methodological approach as Tier 1 but applies emission factors and activity data which are defined by the country for the most important land uses/activities. Tier 2 can also apply stock change methodologies based on country-specific data. Country-defined emission factors/activity data are more appropriate for the climatic regions and land use systems in that country. Higher resolution activity data are typically used in Tier 2 to correspond with country-defined coefficients for specific regions and specialised land-use categories.

At Tier 3, higher order methods are used including models and inventory measurement systems tailored to address national circumstances, repeated over time, and driven by high-resolution activity data and disaggregated at sub-national to fine grid scales. These higher order methods provide estimates of greater certainty than lower tiers and have a closer link between biomass and soil dynamics. Such systems may be GIS-based combinations of age, class/production data systems with connections to soil modules, integrating several types of monitoring. Pieces of land where a land-use change occurs can be tracked over time. In most cases these systems have a climate dependency, and thus provide source estimates with interannual variability. These models must undergo quality checks, audits, and validations.

[8] guidance on the estimation of emissions and removals of CO2 and non-CO2 for the Land Use, Land-Use Change and Forestry (LULUCF) sector. https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/Chp3_1_Introduction.pdf

Peat Emission factors (EFs)

This uses the latest emission factors (EFs) used in Evans, *et al* (2023) which are a combination of LULUCF, IPCC Tier 1 default emission factors and Tier 2 country specific emission factors for wetlands[9], and included new Tier 2 EFs for direct emissions of CO2, CH4 and (in most cases) N2O for all of the UK-relevant drained land-use categories.

In two cases, grassland and extraction sites, the data could be further separated. i.e. intensive & extensive grasslands along with domesticated & industrial extraction. For undrained semi-natural peatlands, separate EFs for undrained ('near-natural') and re-wetted systems were derived. Based on the available flux data, from the research carried out, separate EFs for heather-dominated and grass-dominated modified bogs were not able to be derived (primarily due to a lack of measurements from grass-dominated sites). Consequently a single, 'modified bog' EF for each GHG, but retained both categories in the UK reporting hierarchy in recognition of the importance of (and likely difference in emissions from) these two condition categories of UK bogs, in the expectation that it will become possible to derive separate EFs in the future.

The uncertainties associated with these emission factors come from the fact that they are created from a handful of sites that match the peat condition categories best. These categories are of land uses that are largely similar but will have variation between individual site characteristics and so represent the mean of slightly different emissions factors for each grouping. They do really help us understand the breadth of the different emissions being released from peat and the places where action can be focused.

[9] https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp3/App_3a3_Wetlands.pdf

Table 2: Emissions Factors 2023[10] and 2017[11] and expressed in tonnes CO2 equivalents per ha per year.

Peat condition category	Drainage status	OLD 2017 - Emission Factors (t CO_2-eq ha^{-1} yr^{-1})	2023 Emission Factors (t CO_2-eq ha^{-1} yr^{-1})
Forest	Drained	**9.91**	**5.46** (2021 update)
Cropland (peat <40cm)	Drained	**38.98**	**37.17**
Cropland wasted (peat < 40cm)	Drained	N/A	**26.1**
Eroded modified bog	Drained	**4.85**	**18.86**
Eroded modified bog	Undrained	**3.55**	**17.72**
Heather & grass dominated - modified bog	Drained	**3.40**	**3.32**
Heather & grass dominated - modified bog	Undrained	**2.08**	**2.51**
Extensive grassland	Drained	**19.02**	**15.88**
Intensive grassland	Drained	**29.89**	**22.0**
Rewetted bog	Rewetted	**0.81**	**3.42**
Rewetted fen	Rewetted	**6.37**	**3.31**
Near natural bog	Undrained	**0.01**	**0.32**
Near natural fen	Undrained	**-0.61**	**-0.36**
Extracted domestic	Drained	**7.91**	**15.18**
Extracted industrial	Drained	**13.84**	**18.86**

All fluxes are shown in tCO2e ha-1 yr-1. Note that a positive EF indicates net GHG emission, and a negative EF indicates net GHG removal from the atmosphere (sequestration).

[10] https://nora.nerc.ac.uk/id/eprint/534668/1/N534668CR.pdf

[11] https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1904111135_UK_peatland_GHG_emissions.pdf

Table 3: Deep Peat – Emissions factors for peat condition types.
All fluxes are shown in tCO2e ha-1 yr-1. Note that a positive EF indicates net GHG emission, and a negative EF indicates net GHG removal from the atmosphere (sequestration).

Peat condition category	Drainage status	Area of Deep peat (Ha)	2023 Emission Factors (t CO_2-e ha^{-1} yr^{-1})	GHG Emission Equivalent (t CO2-e yr-1)
		Area (Ha)	*EFGHG*	*EFGHG x Ha*
Near natural fen	Undrained	4,627	**-0.36**	- 1,666
Near natural bog	Undrained	4,254	**0.32**	1,361
Rewetted fen	Rewetted	0	**3.31**	0
Rewetted bog	Rewetted	83,930	**3.42**	287,041
Grass dominated modified bog	Drained	24,053	**3.32**	79,856
	Undrained	32,992	**2.51**	82,810
Heather dominated modified bog	Drained	19,208	**3.32**	63,771
	Undrained	87,166	**2.51**	48,212
Eroded modified bog	Drained	5,653	**18.86**	106,616
	Undrained	43,560	**17.72**	771,883
Extracted domestic	Drained	23,784	**15.18**	361,041
Extracted industrial	Drained	24,451	**18.86**	461,146
Forest	Drained	51,764	**5.46**	282,632
Cropland	Drained	50,594	**37.17**	1,880,579
Extensive grassland	Drained	1,377	**15.88**	21,867
Intensive grassland	Drained	38,416	**22.0**	845,152
	Total Area	495,829	**Emissions**	5,293,967
			Sequestration	- 1,666

Table 3: Deep Peat – Emissions factors for peat condition types.

All fluxes are shown in tCO2e ha-1 yr-1. Note that a positive EF indicates net GHG emission, and a negative EF indicates net GHG removal from the atmosphere (sequestration).

Peat condition category	Drainage status	Area of Deep peat (Ha)	2023 Emission Factors (t CO_2-e ha^{-1} yr^{-1})	GHG Emission Equivalent (t CO2-e yr^{-1})
		Area (Ha)	*EFGHG*	*EFGHG x Ha*
Near natural fen	Undrained	4,627	**-0.36**	- 1,666
Near natural bog	Undrained	4,254	**0.32**	1,361
Rewetted fen	Rewetted	0	**3.31**	- 0
Rewetted bog	Rewetted	83,930	**3.42**	287,041
Grass dominated modified bog	Drained	24,053	**3.32**	79,856
Grass dominated modified bog	Undrained	32,992	**2.51**	82,810
Heather dominated modified bog	Drained	19,208	**3.32**	63,771
Heather dominated modified bog	Undrained	87,166	**2.51**	48,212
Eroded modified bog	Drained	5,653	**18.86**	106,616
Eroded modified bog	Undrained	43,560	**17.72**	771,883
Extracted domestic	Drained	23,784	**15.18**	361,041
Extracted industrial	Drained	24,451	**18.86**	461,146
Forest	Drained	51,764	**5.46**	282,632
Cropland	Drained	50,594	**37.17**	1,880,579
Extensive grassland	Drained	1,377	**15.88**	21,867
Intensive grassland	Drained	38,416	**22.0**	845,152
	Total Area	495,829	**Emissions**	5,293,967
			Sequestration	- 1,666

Table 4: Wasted Peat – Emissions factors for peat condition types.

All fluxes are shown in tCO_2e ha^{-1} yr^{-1}. Note that a positive EF indicates net GHG emission (lost to atmosphere), and a negative EF indicates net GHG removal.

Peat condition category	Drainage status	Area of Wasted peat (Ha)	2023 Emission Factors ($t\ CO_2\text{-}e\ ha^{-1}\ yr^{-1}$)	GHG Emission Equivalent ($t\ CO2\text{-}eyr^{-1}$)
		Area (Ha)	*EFGHG*	*EFGHG x Ha*
Forest	Drained	13,728	5.46*	74,955
Cropland	Drained	132,107	38.98	5,149,531
Eroded modified bog	Drained	0	4.85	-
Eroded modified bog	Undrained	8	3.55	28
Heather dominated modified bog	Drained	0	3.40	0
Heather dominated modified bog	Undrained	55	2.08	114
Grass dominated modified bog	Drained	0	3.40	0
Grass dominated modified bog	Undrained	1,833	2.08	3,813
Extensive grassland	Drained	518	19.02	9,852
Intensive grassland	Drained	35,265	29.89	1,054,071
Rewetted bog	Rewetted	2,348	0.81	1,902
Rewetted fen	Rewetted	0	6.37	0
Near natural bog	Undrained	137	0.01	1
Near natural fen	Undrained	1	-0.61	-1
Extracted domestic	Drained	286	7.91	2,262
Extracted industrial	Drained	86	13.84	1,190
	Total Area	186,372	**Emissions**	6,297,719
			Sequestration	0

Tables 1-4 suggest that England presently releases 11,591, 686 t CO2e yr-1 from its peatlands, as, deep peat emits 5,293,967 t CO2e yr-1 and wasted peat emits 6,297,719 t CO2e yr-1.

Peatland Condition Categories by Rank of GHG being lost from deep peats.
By using all these peatland types, we can create a prioritised list for addressing GHG emissions reduction from peatland, from most important reductions (ranked 1) to least important (ranked 30). Ranks 31 and 32 represent net sequestration (i.e a gain from the atmosphere to the biosphere). These ranks represent a combination of land use area (extent) and the emission being released by the condition categories.

Rank	Peat type	Peat condition category	Drainage Status	GHG Emission (t CO2-eq yr-1)
1	Wasted peat	Cropland	Drained	5,149,531
2	Deep peat	Cropland	Drained	1,880,579
3	Wasted peat	Intensive grassland	Drained	1,054,071
4	Deep peat	Intensive grassland	Drained	845,152
5	Deep peat	Eroded modified bog	Undrained	771,883
6	Deep peat	Extracted industrial	Drained	461,146
7	Deep peat	Extracted domestic	Drained	361,041
8	Deep peat	Rewetted bog	Rewetted	287,041
9	Deep peat	Forest	Drained	282,632
10	Wasted peat	Forest	Drained	136,044
11	Deep peat	Eroded modified bog	Drained	106,616
12	Deep peat	Grass dominated modified bog	Undrained	82,810
13	Deep peat	Grass-dominated modified bog	Drained	79,856
14	Deep peat	Heather-dominated modified bog	Drained	63,771
15	Deep peat	Heather-dominated modified bog	Undrained	48,212
16	Deep peat	Extensive grassland	Drained	21,867
17	Wasted peat	Extensive grassland	Drained	9,852
18	Wasted peat	Grass-dominated modified bog	Undrained	3,813
19	Wasted peat	Extracted domestic	Drained	2,262
20	Wasted peat	Rewetted bog	Rewetted	1,902

Rank	Peat type	Peat condition category	Drainage Status	GHG Emission (t CO2-eq yr-1)
21	Deep peat	Near-natural bog	Undrained	1,361
22	Wasted peat	Extracted industrial	Drained	1,190
23	Wasted peat	Heather-dominated modified bog	Undrained	114
24	Wasted peat	Eroded modified bog	Undrained	28
25	Wasted peat	Near-natural bog	Undrained	1
26	Deep peat	Rewetted fen	Rewetted	0
27	Wasted peat	Eroded Modified Bog	Drained	0
28	Wasted peat	Heather-dominated modified bog	Drained	0
29	Wasted peat	Grass-dominated modified bog	Drained	0
30	Wasted peat	Rewetted fen	Rewetted	0
31	Wasted peat	Near-natural fen	Undrained	-1
32	Deep peat	Near-natural fen	Undrained	-1,666

5 - Abatement of Carbon Emission from Peat

A reduction in the amount or degree (abatement) of the peatland emissions can be viewed as the rungs of a ladder. As we step down the ladder from the highest emitting peatland states (bare dry peats) we gradually reduce the emissions lost at each land use change that occurs, from cropland through intensive grassland to extensive grassland and onto semi-natural habitat states. This may be through incremental changes, one rung at a time, or through transformational change, top land use emitters to lower semi-natural states in one major jump, i.e. from an arable peatland landscape through to a natural fen.

Emission savings from restoration (per hectare)

The most important focus for the condition types is a reduction in the amount of greenhouse gases being released into the atmosphere. Table 5.1, below, indicates what can be saved per hectare of delivery when we move from one peatland state to another. Some of the emission reductions will be saved relatively fast (3-5 years), as land use change will happen quickly, such as going from an extracted site to a vegetated one, while others will take longer (5-20+ years) as vegetation adjusts and changes as management changes take effect.

Time lags for benefit realisation of peatland emissions reductions

It is unrealistic to apply the changed emission factor at the point in time at which the restoration activity takes place (Artz et. al 2019; Evans, 2016). This is a natural system and will not move to the restoration end point immediately. The time point at which the benefits will be realised will vary by restoration type and due to context, location and site-specific factors. The evidence base we have for the timeframe over which this occurs is limited and highly variable. As such a realistic five-year lag is needed to be applied to restoration end points that are dependent on changes in vegetation.

A minimum lag time of one year is needed for all restoration activities, i.e. reductions in emissions are assumed not to occur in the year that restoration activities take place. The only exception is halting peat extraction, which is assumed to have immediate impact on the volume of peat extracted in that year and, therefore, emissions.

It is likely that the development of the abatement potential over time for any restoration project is heavily dependent on the starting condition, for example, carbon savings from a severely drained peatland may take longer to materialise than from a less affected peatland (Artz, *et al*, 2012). Lindsay (2010) suggested a timeframe of 42 years before peatland restoration achieved net C gain.

Table 5.1 - Abatement of Drained Peatland States between starting conditions and restoration end points.

Drained Starting condition	Emissions Factors [2023]	Restoration end point	Emissions Factors [2023]	Abatement (t CO_2-eq ha^{-1} yr^{-1})
Cropland drained- deep peat	37.17	Rewetted fen	3.31	**33.86**
Cropland drained- Deep peat	37.17	Extensive grassland drained	15.88	**21.29**
Intensive grassland drained	22	Rewetted fen	3.31	**18.69**
Eroded modified Bog drained	17.72	Rewetted bog	3.42	**14.3**
Eroded modified bog drained	17.72	Near natural bog	0.32	**17.4**
Extracted industrial	18.86	Rewetted fen	3.31	**15.55**
Eroded modified bog drained	18.86	Grass & heather dominated modified bog - drained	3.32	**15.54**
Extracted industrial	18.86	Rewetted bog	3.42	**15.44**
Cropland drained- deep peat	37.17	Intensive grassland drained	22	**15.17**
Extensive grassland drained	15.88	Rewetted fen	3.31	**12.57**
Extensive grassland drained	15.88	Grass & heather dominated modified bog - drained	3.32	**12.56**
Extensive grassland drained	15.88	Rewetted bog	3.42	**12.46**

Drained Starting condition	Emissions Factors [2023]	Restoration end point	Emissions Factors [2023]	Abatement (t CO_2-eq ha^{-1} yr^{-1})
Extracted domestic	15.18	Rewetted fen	3.31	**11.87**
Extracted domestic	15.18	Rewetted bog	3.42	**11.76**
Intensive grassland drained	22	Extensive grassland drained	15.88	**6.12**
Forest drained	5.46	Grass & heather dominated modified bog - undrained	2.51	**2.95**
Forest drained	5.46	Rewetted fen	3.31	**2.15**
Forest drained	5.46	Grass dominated modified bog - drained	3.32	**2.14**
Forest drained	5.46	Rewetted bog	3.42	**2.04**
Grass & heather dominated modified bog - drained	3.32	Rewetted bog	3.42	**-0.1**
Grass & heather dominated modified bog - drained	3.32	Near natural bog	3.42	**-0.1**
Extensive grassland drained	15.88	Eroded modified bog drained	18.86	**-2.98**

Table 5.2 - Abatement of Undrained Peatland States between starting condition and restoration end points.

Un-drained Starting condition	Emissions Factors [2023]	Restoration end point	Emissions Factors [2023]	Abatement (t CO_2-eq ha^{-1} yr^{-1})
Rewetted fen	3.31	Near natural fen	-0.36	**3.67**
Eroded Modified Bog Undrained	3.55	Near natural bog	0.32	**3.23**
Rewetted Bog	3.42	Near natural bog	0.32	**3.1**
Grass & Heather dominated modified bog - undrained	2.08	Near natural bog	0.32	**1.76**
Eroded modified bog undrained	3.55	Grass & heather dominated modified bog - undrained	2.51	**1.04**
Eroded modified bog undrained	3.55	Rewetted bog	3.42	**0.13**
Grass & heather dominated modified bog - undrained	2.08	Rewetted bog	3.42	**-1.34**

6 – Exploring Scenarios of Abatement option delivery

This section takes a simplified look at what might be possible in-terms of areas of peatland restoration and the estimated GHG emissions reductions that will result from changes to these land uses. The focus on climate emissions in this report does not prevent the later inclusion of other biodiversity and water targets that would also be delivered through restoration of many of these same locations.

The CCC recommended in the 2023 progress report to parliament[12] that restoring the greatest area of peatlands is needed within the next 10-15 years, and by 2045 at the latest to achieve any net zero goals:

> Implement a comprehensive delivery mechanism to address degraded peatland and extend current restoration ambition set out by the UK government and the devolved administrations beyond existing timeframes, including through addressing barriers to increasing capacity. Peat restoration targets include the need to remove all low-productive trees (i.e. less than YC8) from peatland (equivalent to 16,000 hectares by 2025) and restore all peat extraction sites by 2035 (equivalent to 50,000 hectares by 2025).

The restoration of degraded peatlands is a key area of land use change as once restoration has started abatement of emissions, gives annual and ongoing emission reductions for the long term. They will massively help achieve our ‘Nature Net Zero’ pathways (see NECR 569) and make future carbon budgets much more attainable along with actions to reduce fossil fuel emissions from other areas.

Abatement options for nature recovery in peatlands should focus on restoring whole peat bodies to create bigger functioning sites and so protecting our carbon stores for the long term. As this approach delivers the widest (multiple) benefits and is the most cost-effective approach over the longer term. This often fits well with a larger landscape recovery approach to link other surrounding habitats and landscapes.

To explore this in greater detail several plausible abatement scenarios were created. As we know the land use areas, we can work out some options for what could be deliverable over time. As such we can make estimations of the likely GHG abatement from implementing these land use changes for the scenarios.

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[12] https://www.theccc.org.uk/wp-content/uploads/2023/06/Progress-in-reducing-UK-emissions-2023-Report-to-Parliament.pdf

End Point Land Use

End Point Land Use (table 6.1) refers to the more natural, semi-natural and restored peatland areas. As carbon emissions are largely controlled by the hydrology of the peatland these restored peatlands are referred to as rewetted bog or fen. Ideally, in emissions and net zero terms, this is where we want all our peatlands to end up and so these figures should only increase in future. In a broader sense we would call these active peat-forming ecosystems[13] (active raised bog, active blanket bogs or active fens), ones that are gaining carbon or are likely to in the near future.

Table 6.1 - End Point Land Use

	Deep Peat	Wasted Peat	Total	% of total peatland area
Near natural bog	4,254	137	4,391	0.58
Near natural fen	4,627	1	4,628	0.61
Rewetted bog	83,930	86,278	170,208	22.3
Rewetted fen	0	0	0	0.0
Total	**92,811**	**86,416**	**179,227**	**23.49**

Degraded Peatland Starting Point Land Use

Regrettably for peatlands our starting point is of land uses with widespread anthropogenic disruption having taken place, often over considerable timescales. These degraded peatlands where vegetation is lost or fundamentally changed, is hydrologically compromised through drainage and the physical structure of the peatland has changed. The degraded peatland areas are losing carbon and so are the focus for abatement of the emissions they are releasing. Ideally, we are wanting to move these into the end point land use categories above, where emissions are much lower or negligible.

13 https://sac.jncc.gov.uk/habitat/H7110/#:~:text=Active%20raised%20bogs%20are%20peat,peat%20irrigated%20solely%20by%20rainfall.

Table 6.2 Starting Point Land Use

	Deep Peat	Wasted Peat	Total	% of total peatland area
Intensive grassland	38,416	35,265	73,681	9.7
Extensive grassland	1,377	518	1,895	0.2
Grass dominated modified bog	57,045	1,833	58,878	7.7
Heather dominated modified bog	106,374	55	106,429	14.0
Eroded modified bog	49,213	8	49,221	6.5
Cropland	50,594	132,107	182,701	24.0
Forest	51,764	13,728	65,492	8.6
Extracted industrial & domestic	48,235	372	48,607	6.4
TOTAL	**403,018**	**183,886**	**586,904**	**77.1**

Peatland Type Categories by % Area

To create the scenarios, we have used these assumptions:

- We don't expect to do 100% of any land use change.
- A good working maximum plausible change is 75%, the minimum is 0%.
- We can create 3 estimates of different amounts of change (25%, 50% & 75%) using % of the area (ha) that is delivered.

Table 6.3 - Percentage of Peatland Type Categories used in the scenarios

	Estimated Area	75% of Area	50% of Area	25% of Area
Intensive grassland	73,681	55,261	36,841	18,420
Extensive grassland	1,895	1,421	948	474
Grass dominated modified bog	58,878	44,159	29,439	14,720
Heather dominated modified bog	106,429	79,822	53,215	26,607
Eroded modified bog	49,221	36,916	24,611	12,305
Cropland	182,701	137,026	91,351	45,675
Forest	65,492	49,119	32,746	16,373
Extracted industrial & domestic	48,607	36,455	24,304	12,152
TOTAL	**761,740**	**571,305**	**380,870**	**190,435**

Peatland emissions reduction by changing land use

The abatement, or reduction in emissions from going from one degraded peatland land use to another better state land use with lower emission release, can be calculated; taking the lower emission factor from the higher emission state to work out the emission reduction that would be delivered by moving from this one state to another.

In table 6.4 the starting land use state to restoration land use has also been applied at the 75%, 50% & 25% land use area, to provide some emissions reduction figures.

Table 6.4 – Abatement Reduction of drained land use to restoration end point

Degraded Starting land use state	Restoration land use	Abatement reduction (t CO_2-e ha^{-1} yr^{-1}) [2023 EF applied]	Emissions Reductions for 75% of Area t CO2 - e yr-1	Emissions Reductions for 50% of Area t CO2 - e yr-1	Emissions Reductions for 25% of Area t CO2 - e yr-1
Forest drained	Rewetted Bog	2.04	100,203	66,802	33,401
Forest drained	Grass & heather dominated modified bog - drained	2.14	105,115	70,076	35,038
Forest drained	Rewetted fen	3.31	162,584	108,389	54,195
Forest drained	Grass & heather dominated modified bog - undrained	2.51	123,289	82,192	41,096
Cropland drained	Rewetted fen	33.86	4,639,700	3,093,145	1,546,556
Cropland drained	Intensive grassland drained	15.17	2,078,684	1,385,795	692,890
Cropland drained	Extensive grassland drained	21.29	2,917,284	1,944,863	972,421
Intensive Grassland drained	Extensive grassland drained	6.12	338,197	225,467	112,730
Intensive Grassland drained	Rewetted fen	18.69	1,032,828	688,558	344,270
Extensive grassland drained	Rewetted bog	12.46	17,706	11,812	5,906
Extensive grassland drained	Rewetted fen	12.57	17,862	11,916	5,958

Table 6.4 continued.

Degraded Starting land use state	Restoration land use	Abatement reduction ($t\ CO_2$-e $ha^{-1}\ yr^{-1}$) [2023 EF applied]	Emissions Reductions for 75% of Area t CO2 - e yr-1	Emissions Reductions for 50% of Area t CO2 - e yr-1	Emissions Reductions for 25% of Area t CO2 - e yr-1
Extensive grassland drained	Grass & heather dominated modified bog - drained	12.56	17,848	11,907	5,953
Extracted domestic	Rewetted bog	11.76	428,711	285,815	142,908
Extracted domestic	Rewetted ben	11.87	432,721	288,488	144,244
Extracted industrial	Rewetted bog	15.44	758,397	505,598	252,799
Extracted industrial	Rewetted fen	15.55	286,163	190,775	95,388
Eroded modified bog drained	Grass & heather dominated modified bog - drained	15.54	65,886	43,924	21,962
Eroded Modified Bog Drained	Near Natural Bog	17.4	73,772	49,181	24,591
Eroded Modified Bog Drained	Rewetted Bog	14.3	467,267	311,511	155,756
Grass & Heather Dominated Modified bog - Drained	Rewetted Bog	No measured change found	N/A	N/A	N/A
Grass & Heather Dominated Modified bog - Drained	Near Natural Bog	No measured change found	N/A	N/A	N/A

Table 6.5 – Abatement reduction of undrained peatland land use

Undrained Starting condition	Restoration end point	Abatement ($t\ CO_2$-e $ha^{-1}\ yr^{-1}$) [2023]	Emissions Reductions for 75% of Area t CO2 - e yr-1	Emissions Reductions for 50% of Area t CO2 - e yr-1	Emissions Reductions for 25% of Area t CO2 - e yr-1
Eroded Modified Bog Undrained	Grass & Heather Dominated Modified bog - Undrained	1.04	33,983	22,655	11,328
Eroded Modified Bog Undrained	Rewetted Bog	0.13	4,248	2,832	1,416
Eroded Modified Bog Undrained	Near Natural Bog	0.13	4,248	2,832	1,416
Grass & Heather Dominated Modified bog - Undrained	Rewetted Bog	-1.34	- 43,477	- 32,608	- 24,456
Grass & Heather Dominated Modified bog - Undrained	Near Natural Bog	1.76	57,105	42,828	32,121
Rewetted Bog	Near Natural Bog	3.1	200,596	133,731	66,865
Rewetted Fen	Near Natural Fen	3.67	0	0	0

Creating Delivery Options Scenarios

In any one area of work, it is unlikely that we will be able to deliver 100% across all areas. The reality is that we may get some 50% delivery in places and even 75% (e.g. on upland grip blocking areas), but in others we will struggle to get to 25%, with some very low (0% returns) in some abatement activity.

TASK: We need to explore options that are realistic and plausible and see what the figures give us. If we get a number of options giving a similar emissions reduction target per year (and ongoing in subsequent years), this could help guide us to what a likely delivery trajectory can be.

Here are some possible options as illustrations:

See Appendix below – for more context & detail on these options calculations

Trees & Uplands deep peat **Total= 567,944** (t CO2 - e yr-1)

- 75% Forest to rewetted bog
- 50% Grass & Heather bog to rewetted bog
- 50 % Eroded bog to rewetted bog
- 25% Eroded bog to heather bog

Uplands **Total= 338,531** (t CO2 - e yr-1)

- 75% Grass bog to rewetted bog
- 50% Heather bog to rewetted bog
- 75% Eroded bog to rewetted bog
- 25% Eroded bog to heather bog

Improved Grassland **Total= 659,339** (t CO2 - e yr-1)

- 25% Intensive grassland to Extensive grassland
- 25% Intensive grassland to Rewetted Fen
- 25% Intensive grassland to Rewetted Bog

Attacking the top 5 Hard **Total= 3,526,722** (t CO2 - e yr-1)

- 1. 25% Cropland to rewetted fen & 25% Cropland to extensive grassland
- 2. 50 % Intensive grassland to rewetted Fen
- 3. 50% Forest to rewetted Bog
- 4. 50% Extracted Industrial to rewetted Fen
- 5. 50% Heather Dominated Modified Bog

Cropland **Total= 2,816,321** (t CO2 - e yr-1)

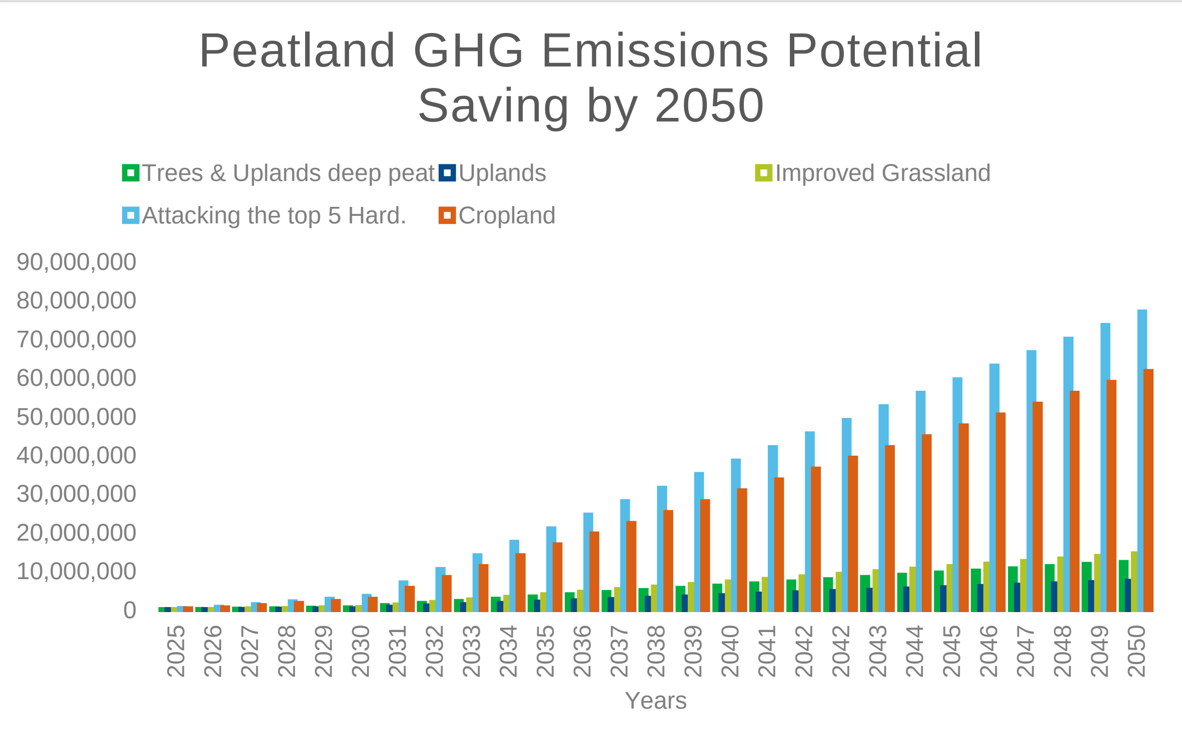
- 25% Cropland to Intensive Grassland
- 25% Cropland to Extensive Grassland
- 25% Cropland to Rewetted Fen

Abatement Options Combined emissions over the next 25 years

Throughout this process we are looking at using figures of tonnes CO_2-e ha^{-1} yr^{-1}. These are figures for the savings each year on average. As such, if we save these in year one to five years, i.e., between now and 2030, the savings keep accruing each and every subsequent year thereafter [presuming we factor in a time lag for restoration to be successful & how effective the restoration has been]. As it is unlikely that we will deliver maximum savings at year 1 (between 2025 and 2030), we have only used a % of the delivery total to calculate the figures in Table 6.6 below.

A key fundamental concept around reducing peatland GHG emissions is that once we have delivered restoration, there will be direct savings year on year into the future. This highlights that investing early in peatlands leads to much bigger overall emissions savings before 2050, along with helping to support nature recovery and water targets in the process.

Figure 2: Graph showing some Peatland GHG emissions savings potential by 2050 using the 5 illustrative scenarios above (see table 6.6 for figures)



This demonstrates clearly that we need to invest to save. Doing this as early as possible leads to bigger greenhouse gas savings over time, greater climate resilience for these restored areas and the added public benefits that lead from these actions. This is without considering the biodiversity gains and added water management benefits that are outside the scope of this report.

Table 6.6 the possible GHG emissions savings over time 25 years (until 2050). Note: Figures have been rounded up, to get rid of any false accuracy being implied.

Year	Uplands	Trees & Uplands deep peat	Improved Grassland	Cropland	Attacking the top 5 Hard
Delivery option scenarios emissions (t CO2 e yr-1)	338,500	560,000	659,000	2,800,000	3,500,000
2025 (10% delivered)	33,850	56,000	65,900	280,000	350,000
2026 (20% delivered)	67,700	112,000	131,800	560,000	700,000
2027 (40% delivered)	135,400	224,000	263,600	1,120,000	1,400,000
2028 (60% delivered)	203,100	336,000	395,400	1,680,000	2,100,000
2029 (80% delivered)	270,800	448,000	527,200	2,240,000	2,800,000
2030 (100% delivered)	**338,500**	**560,000**	**659,000**	**2,800,000**	**3,500,000**
2031	677,000	1,120,000	1,318,000	5,600,000	7,000,000
2032	1,015,500	1,680,000	1,977,000	8,400,000	10,500,000
2033	1,354,000	2,240,000	2,636,000	11,200,000	14,000,000
2034	1,692,500	2,800,000	3,295,000	14,000,000	17,500,000
2035	2,031,000	3,360,000	3,954,000	16,800,000	21,000,000
2036	2,369,500	3,920,000	4,613,000	19,600,000	24,500,000
2037	2,708,000	4,480,000	5,272,000	22,400,000	28,000,000
2038	3,046,500	5,040,000	5,931,000	25,200,000	31,500,000
2039	3,385,000	5,600,000	6,590,000	28,000,000	35,000,000
2040	**3,723,500**	**6,160,000**	**7,249,000**	**30,800,000**	**38,500,000**

Year	Uplands	Trees & Uplands deep peat	Improved Grassland	Cropland	Attacking the top 5 Hard
2041	4,062,000	6,720,000	7,908,000	33,600,000	42,000,000
2042	4,400,500	7,280,000	8,567,000	36,400,000	45,500,000
2042	4,739,000	7,840,000	9,226,000	39,200,000	49,000,000
2043	5,077,500	8,400,000	9,885,000	42,000,000	52,500,000
2044	5,416,000	8,960,000	10,544,000	44,800,000	56,000,000
2045	5,754,500	9,520,000	11,203,000	47,600,000	59,500,000
2046	6,093,000	10,080,000	11,862,000	50,400,000	63,000,000
2047	6,431,500	10,640,000	12,521,000	53,200,000	66,500,000
2048	6,770,000	11,200,000	13,180,000	56,000,000	70,000,000
2049	7,108,500	11,760,000	13,839,000	58,800,000	73,500,000
2050	**7,447,000**	**12,320,000**	**14,498,000**	**61,600,000**	**77,000,000**

Conclusions

Peatlands offer an opportunity to contribute to the UK's statutory targets over the next 10 years. They can play a small but important part in the UK National Determined Contributions[14] to reduce greenhouse gas emissions by at least 81% by 2035, but early investment can increase its contribution considerably. Although not one of the big sectors of fossil fuel emissions, like transport or energy, land use change also delivers many wider and bigger public benefits.

Peatland restoration can also make a major contribution to our Biodiversity Targets and help the UK achieving its Convention on Biological Diversity (CBD)[15] targets by 2030. Particularly with a focus on Target 2: Restore 30% of all Degraded Ecosystems [*Ensure that by 2030 at least 30 per cent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration, in order to enhance biodiversity and ecosystem functions and services, ecological integrity and connectivity.]*

It is also important that we stop further degradation of these peatland ecosystems now, so that rehabilitation at least starts from the best possible place. Investment now reduces the overall cost in future. By reducing the degradation, we also prevent further damage to wider ecosystems services such as water supply & flood reduction. This will also help them adapt to climate change and prevent further biodiversity losses. But we need a clear nature recovery plan for all peatland ecosystems along with a carbon reduction plan that jointly deliver. As these two major drivers offer different pathways to get to various restoration end points to be able to achieve their targets.

As we have explored briefly, peatland were formed after the last ice age through the hydrological and biological ecosystem processes that made them possible. Many of these processes have been severely compromised and we now need to restore them at a large ecosystem scale, to be able to restore the ecosystem function of the whole peat body. This will involve transformational change in some of the most important locations.

Peatlands offer a great opportunity to reduce emissions further. But where and what peatland areas we focus our restoration efforts on can make a difference to the

[14] https://questions-statements.parliament.uk/written-statements/detail/2024-11-12/hcws206

[15] https://www.cbd.int/gbf/targets

outcomes we achieve and how much emissions savings and nature recovery are delivered.

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Appendix 1- Abatement Delivery Options

Trees & Uplands deep peat **Total= 567,944** (t CO_2 - e yr-1)	**Uplands** **Total= 338,531** (t CO_2 - e yr-1)	**Improved Grassland** **Total= 659,339** (t CO_2 - e yr-1)
75% Forest to rewetted bog **446,983 (t CO_2 - e yr-1)**	75% Drained Eroded bog to Rewetted Bog **132,011 (t CO_2 - e yr-1)**	25% Drained Intensive grassland to Drained Extensive grassland **200,225 (t CO_2 - e yr-1)**
50% Undrained Grass & Heather bog to rewetted bog **30,905 (t CO_2 - e yr-1)**	75% Drained Grass & Heather Dominated Modified bog to Rewetted Bog **84,034 (t CO_2 - e yr-1)**	25% Drained Intensive grassland to Rewetted Fen **433,238 (t CO_2 - e yr-1)**
50 % Drained Eroded Modified bog to rewetted bog **88,007 (t CO_2 - e yr-1)**	75% Undrained Eroded Modified Bog to Rewetted Bog **89,532 (t CO_2 - e yr-1)**	75% Drained Extensive grassland to Rewetted Bog **25,876 (t CO_2 - e yr-1)**
25% Drained Eroded bog to heather bog **2,049 (t CO_2 - e yr-1)**	50% Undrained Grass & Heather Dominated Modified bog to Rewetted Bog. **30,905 (t CO_2 - e yr-1)**	
	25% Drained Eroded bog to heather bog **2,049 (t CO_2 - e yr-1)**	

Attacking the top 5 Hard. **Total= 3,526,722** (t CO_2 - e yr-1)	**Cropland** **Total= 2,816,321** (t CO_2 - e yr-1)
25% Drained Cropland to Rewetted Fen **1,489,462 (t CO_2 - e yr-1)**	25% Drained Cropland to Rewetted Fen **1,489,462 (t CO_2 - e yr-1)**
25% Drained Cropland to extensive grassland **415,186 (t CO_2 - e yr-1)**	25% Drained Cropland to extensive grassland **911,673 (t CO_2 - e yr-1) (t CO_2 - e yr-1)**
50% Intensive Grassland to Rewetted fen **866,500 (t CO_2 - e yr-1)**	25% Drained Cropland to Intensive grassland **415,186 (t CO_2 - e yr-1)**
50% Forest to rewetted bog **297,989 (t CO_2 - e yr-1)**	
50% Extracted Industrial to rewetted bog **426,680 (t CO_2 - e yr-1)**	
50% Undrained Grass & Heather Dominated Modified bog to Rewetted Bog. **30,905 (t CO_2 - e yr-1)**	

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