Peatlands of Cheshire East

An Assessment of Greenhouse Gas Emissions and Biodiversity

June 2021

Acknowledgements

This report was commissioned by Cheshire East Council (CEC) as a baseline report in support of the Council's Environment Strategy and Carbon Neutrality Action Plan; in order to provide a single reference source for peatland in Cheshire East to inform future consideration by the Council and others. It was commissioned with reference to the need to 'Review existing data on land-use and carbon sequestration to identify opportunities (for) nature based solutions with particular reference to the Green Infrastructure Plan'. It is intended to form part of an evidence base for the Council regarding the feasibility and desirability of peatland restoration in the borough.

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Executive Summary

This study provides a desk-based collation of the best available evidence of the extent, condition, greenhouse gas (GHG) emissions and biodiversity value of Cheshire East (CE) peatlands and should be read with reference to the accompanying GIS dataset: "*Cheshire East Peatlands - CWT_region.shp*".

There are approximately 3,603 ha of deep peat across Cheshire East, representing around 0.5% of the national extent. A large proportion of Cheshire East's peatlands are in a degraded condition and therefore emit 48,021 tCO2e yr^{-1}. Around 74% of total CE peatland emissions (equivalent to over 36,000 tCO2e yr^{-1}) occur as a result of agriculture, yet this only accounts for 33% of the peatland extent. Rewetted bogs make up the largest area of the semi-natural condition categories (684 ha or 19% of the peat extent), however these habitats still emit a small amount of GHGs (2,674 tCO2e yr^{-1} or 5.5% of total annual emissions). Only 46 ha (1.3%) of Cheshire East's peatlands currently sequester GHGs, providing a saving of -4.44 tCO2e yr^{-1}, equivalent to 0.01% of the total CE peatland emissions. Just under half of the borough's deep peats are designated for nature conservation (1,696 ha or 47%), with the overall area split relatively evenly between statutory and non-statutory designations.

The agricultural use of lowland deep peats is the largest source of peatland emissions across the borough, with one third of the peatland extent contributing three quarters of the total emissions. These areas represent the most significant opportunities for emissions avoidance through the implementation of sensitive management regimes and restoration. Restoration of all intensive grasslands on deep peat across Cheshire East back to 'grass-dominated' bogs (drained modified grass dominated bogs) could result in an emissions saving of 21,570 tCO2e yr^{-1}, equivalent to a 44% reduction in total CE peatland emissions. If they were also rewetted they could potentially begin to sequester carbon over time, resulting in an emissions saving of approx. -18 tCO2e yr^{-1}, equivalent to a saving of around 51% of total CE peatland emissions. To avoid potentially permanent emissions the extraction and development of peatlands should be stopped immediately across Cheshire East.

Targeted restoration of highly degraded deep peat in close proximity to existing semi-natural peatland habitat, or sites designated for nature conservation, can have significant benefits in terms of reducing emissions and improving biodiversity value. Rewetting all undrained modified bogs across the borough, a relatively simple management process, could result in these habitats sequestering approximately -11 tCO2e yr^{-1}, resulting in saved emissions of 1,259 tCO2e yr^{-1}. Tree planting on areas of deep peat or in areas that have the potential to affect the hydrology of a peatland is inappropriate and should be stopped immediately. Implementing a borough wide ban on the burning of upland blanket bog through local strategic policy would improve the level of protection of this habitat and result in emissions savings through an increase in peat accumulation and a decrease in peat erosion (Glaves *et al.* 2013).

Achieving the targets set out in the Carbon Neutrality Action Plan (Anthesis 2020) and the Sixth Carbon Budget (CCC 2020) would result in a significant reduction in peatland GHG emissions and substantial benefits to biodiversity, flood management and water quality across the borough. Peatland restoration provides very high value for money green infrastructure improvement. However, there are likely to be significant barriers to restoration at the scale required. The formation of effective and inclusive stakeholder partnerships to access new funding, alongside the development of strong local policy, will be vital in order to influence and support landowners to adopt a more sustainable approach to peatland management, while protecting the cultural identity and heritage of these land-use sectors.

Background

Peatlands are a wetland ecosystem where a net accumulation of organic matter, known as peat, occurs as a result of waterlogging (Gregg *et al.* 2021). However, the term ‘peatland’ is also used to describe the physiographic, geomorphological, ecological and biogeographical setting of peat (Bonnett *et al.* 2009). Peatlands can be classified into two major types; bogs (generally rain fed and nutrient poor) and fens (generally fed by surface or ground water and more nutrient rich) (Parish *et al*. 2008). Peat itself is formed of the remains of a range of wetland plants and mosses that build up under almost permanently waterlogged conditions (Natural England 2010). The rate of primary production exceeds the rate of organic matter decomposition, which is limited as the result of a high water table, leading to an accumulation of peat (Kivimäki *et al*. 2008). This process gradually locks carbon into the soil, with peat typically accumulating at a rate of around 0.3 – 2 mm per year depending on conditions (Gregg *et al.* 2021). Peatlands are therefore areas of land characterised by an organically accumulated layer of peat, although the term peatland also encompasses the whole ecosystem including the soil layer and the habitat it supports (IUCN 2018).

Peatlands can be naturally forested or more open and vegetated with a diverse range of mosses and sedges. The term applies both to areas where peat is actively forming, known as mires, and areas where peat formation has stopped due to human intervention or changes in the climate (Parish *et al*. 2008). Expanding international consensus defines peat soils as “a wetland soil composed largely of semi-decomposed organic matter deposited in-situ, having a minimum organic content of 30% and a thickness greater than 30 cm.” (Finlayson & Milton 2016). In the UK national peat depth definitions differ slightly; expanding to a thickness greater than 40 cm in England and Wales (which has been used for the purposes of this report) and 50 cm in Scotland and Northern Ireland (Evans *et al.* 2017).

Peatlands are present on every continent. Ranging from tropical swamps in South East Asia through to tundra permafrost across Canada and Russia. They represent the largest natural terrestrial store of carbon on Earth, covering approximately 3% of global land surface (IUCN 2017). Near natural peatlands store more than 550 gigatonnes (550,000,000,000 tonnes) of carbon and sequester an additional 0.37 gigatonnes of carbon dioxide (CO_2) per year; more than all other vegetation types in the world combined (IUCN 2017). Due to their ability to sequester and store atmospheric carbon over thousands of years; peatlands are considered to be the most important long-term carbon store in the terrestrial biosphere (Parish *et al*. 2008) and the most carbon dense terrestrial ecosystems on earth (IUCN 2018).

UK Peatland Biodiversity and Carbon

In the UK peatland is categorised into three broad types: Blanket bog, raised bog and fen. All these habitats are recognised as being a priority for conservation under UK law, and in many instances they are designated as Sites of Special Scientific Interest (SSSI) or under the Conservation of Habitats and Species Regulations 2017 (as amended). They cover approximately 10% of the UK’s land area; equivalent to over 2.5 million hectares (IUCN 2018) and are estimated to contain approximately 584 million tonnes of carbon (Natural England 2010). Upland peatlands are dominated by blanket bog with peat depths ranging from c. 0.5 m to 10 m (IUCN 2018). In the lowlands all three types of peatland exist, with examples of blanket bog occurring at sea level in Scotland, although most commonly raised bog is associated with lower altitudes (also referred to as lowland raised bog). The UK’s peatlands are of international importance; blanket bog forms the largest expanse of any semi-natural habitat in the

UK and this area represents 13% of the global distribution (Littlewood *et al.* 2010). In addition to the mapped 2.5 million ha, there is thought to be an equivalent area of shallow peaty-soils distributed across the UK; supporting Annex 1 priority habitats while also providing ecosystem services and natural capital benefits in the form of carbon storage (IUCN 2018).

Peatlands are crucial in the context of national biodiversity conservation; they support an extensive range of specialised species and provide shelter to others displaced as a result of habitat degradation and climate change. In the UK, *Sphagnum sp.* mosses are the main contributors to peat formation in bogs, whereas fen peats are mainly formed of sedges, graminoids and brown mosses (Gregg *et al.* 2021). They support many species exclusively found in peatlands, many of which have adapted to the specific acidic, nutrient poor and water-logged conditions of bogs (Parish *et al*. 2008). These include species with distinctive features, such as the carnivorous round-leaved sundew *Drosera rotundifolia*, or seasonally associated species such as the golden plover *Pluvialis apricaria* (IUCN 2018). Peatlands have been found to help maintain the micro-climatic and hydrological features of areas outside their boundaries, underpinning their value as an ecosystem at the landscape scale (Parish *et al*. 2008). A study conducted in 2017 (Lindsay & Clough 2017) found 444 designated sites in the UK with at least one peatland habitat present, demonstrating their importance to nature conservation. However, there are also large areas of peatland habitat that remain undesignated, many of which are subject to unsustainable management practices.

Despite the inherent importance of peatlands to both biodiversity and carbon on a global scale, the national picture is concerning. There is very little remaining peat cover across central and southern England, excluding Cornwall, and the majority is restricted to more remote areas in Scotland, Wales, Northern England and Northern Ireland. Only 20% of UK peatlands remain in a near natural state, with the remaining 80% modified as a result of unsustainable historical and ongoing management practices (IUCN 2018). In England near natural state peatlands drop to less than 1.3% of the total extent (Gregg *et al.* 2021). In the lowlands, attempts to drain peatlands for use as agricultural land plus the encroachment of infrastructure and extraction for horticulture have led to severe losses and declines in the condition of remaining peatland (IUCN 2018). In the uplands, blanket bog has historically been drained to facilitate commercial forestry and large swathes are regularly burned on rotation by land managers to facilitate driven shooting of red grouse *Lagopus lagopus scotica* (Thompson *et al.* 2016). Because of their dependence on a high-water table and vegetation cover, bare or drained peatlands are subject to continual drying, leading to deterioration and erosion as a result (Gregg *et al.* 2021). The status of a peatland as either a carbon sink or a carbon source is dependent on the balance between biomass decomposition and production (Joosten *et al.* 2016). The combined effect of widespread anthropogenic impacts has profoundly impacted that balance and transformed the UK's peatlands from natural greenhouse gas (GHG) sinks to modified GHG sources. Research undertaken by Evans *et al.* (2017) to develop specific 'tier 2' emissions factors for UK peatlands estimate they have transitioned from a pre-anthropogenic influence net-sink of -0.25 $MtCO_2e$ per year to a net-source; with an estimated emissions range of between 21 $MtCO_2e$ per year (CCC 2020) and 16 $MtCO_2e$ per year (BEIS 2021), equivalent to 3.5 - 4.5% of national emissions. This emissions contribution has resulted in the entire UK 'Land use, Land use change and Forestry' sector transitioning from a net GHG sink to a net GHG source (Gregg *et al.* 2021).

Climate Change, Natural Capital and Ecosystem Services

There is however a growing recognition of the economic value of peatlands, particularly in terms of the range of stacked ecosystem services they provide and natural capital value they hold. In addition to supporting rare biodiversity and sequestering carbon from the atmosphere, peatlands in good condition also intercept and store greater volumes of water; mitigating flood risk and providing a sustainable supply of high-quality drinking water (DEFRA 2021a). The Office for National Statistics (ONS) estimate the annual value of water supply from UK peatlands to be £208 - £888 million (DEFRA 2021a). However, over the past 30 years dissolved organic carbon (DOC) being released into water has increased as a result of ongoing peatland degradation. This process causes discolouration and a reduction in water quality which can cost millions of pounds per year to remove during treatment (DEFRA 2021a).

Highlighting the importance of the natural capital value of semi-natural habitats, a recent publication from the RSPB investigating the economic consequences of conserving or restoring sites for nature found that conservation or restoration benefits (e.g. greenhouse gas regulation and flood protection) tended to outweigh private benefits (e.g. profits from agriculture or logging) (Bradbury *et al.* 2021). More significantly, the HM Treasury funded Dasgupta Review concluded that our relationship with nature to supply us with the goods and services we need is highly unsustainable. It went on to suggest that our economies, livelihoods and well-being all depend on nature and that we must increase nature's supply to ensure our demands do not exceed its supply (Dasgupta 2021).

The importance of peatlands across the UK is beginning to be recognised at a political level. Peatlands were included in the HM Treasury's 2020 Budget, in which the Nature for Climate Fund was announced in order to invest £640 million in tree planting and peatland restoration across England (HM Treasury 2020). December 2020 also saw the publication of the Sixth Carbon Budget (CCC 2020). Required under the Climate Change Act 2008; this budget provides the UK government with advice on the volume of greenhouse gases the UK can emit during the period 2033-2037. Within it were significant recommendations for how peatlands can contribute to a balanced net-zero pathway for the UK, including:

- Increasing the UK peatland area restored from 25% (current level) to 58% in 2035 and 79% by 2050, with a further 35% of lowland cropland sustainably managed.
- All upland peat restored by 2045 (or stabilised if degradation is too severe to restore to halt carbon losses).
- 25% of the area of lowland grassland is rewetted by 2035, rising to half by 2050.
- 75% of lowland cropland is either rewetted or sustainably managed by 2050:
- A quarter of the area is rewetted to near natural condition (and crop production ceases), and a further 15% is rewetted but conventional crop production switches to paludiculture crops.
- Water-table management options are deployed to 35% of the lowland cropland area.
- All low-productive trees of less than Yield Class 8 (YC8)[1] are removed off peatland by 2030 and all peat extraction sites are restored by 2035.

The government's 25 Year Environment Plan included a goal to restore vulnerable peatlands and end the use of peat in horticultural products by 2030 (DEFRA 2018). These goals have been carried forward

[1] Yield class is an index used in Britain of the potential productivity of even-aged stands of trees.

and set out in more detail in the recently published England Peat Action Plan DEFRA (2021a). This action plan sets out goals for England's peatlands to meet the needs of wildlife, people and the planet, stating that all uses of peatland should keep the peat wet and in the ground. In the action plan DEFRA have committed to:

- Work to ensure all peatlands, not just deep or protected peat, are responsibly managed, or, in good hydrological condition or under restoration management.
- Set a target for peatland restoration as part of the forthcoming Net Zero Strategy which, as indicated by the Secretary of State, will be in line with the action required to meet the Sixth Carbon Budget (summarised above).
- Develop a more up to date and detailed England peat map by 2024.
- Immediately fund at least 35,000 ha of peatland restoration by 2025, through the Nature for Climate Fund and other sources (the government's new Sustainable Farming Incentive, Local Nature Recovery and Landscape Recovery Schemes will provide the main delivery mechanism for peatland restoration after 2024-25).
- Publish recommendations for a more sustainable future for our lowland agricultural peatlands by 2022, developed by the Lowland Agricultural Peat Task Force.
- Consult on banning the sale of peat and peat containing products in the amateur sector by the end of this parliament (2021).
- Continue to protect peat from fire by both phasing out managed burning and reducing the risk of wildfire.

The recent announcement by the government committing to bringing forward legislation to prevent the burning of heather and other vegetation on protected blanket bog (DEFRA 2021b) shows that this recognition of the importance of peatlands is translating into policy and action, albeit less urgently and less radically than is currently required. However, it is clear that the economic benefits of peatland restoration exceed the costs. The ONS estimate that the cost of restoring all UK peatlands to near natural condition would range from £8.4 - £21.3 billion while delivering carbon benefits of £109 billion alone, outweighing the costs of doing so by 5 to 10 times (DEFRA 2021a). When considered alongside the provision of additional ecosystem services, such as flood management and water quality, peatland restoration provides very high value for money green infrastructure improvement.

Introduction

Peatlands of Cheshire East

Cheshire East has a rich and diverse landscape of which peatlands form a distinctive component. The mosaic of meres and relict mosses across Cheshire East developed approximately 15,000 years ago as a result of glacial drift (Davies 2018). As a result, a variety of peatland types are present across the borough; ranging from numerous un-named basin mires west of Macclesfield, to the larger, recognisable mosses such as Danes Moss or Lindow Moss (Leah *et al.* 1997). As well as variety in type, the borough's peatlands also show extensive variety in condition and preservation. Brookhouse Moss is designated as a SSSI and is considered to be an outstanding example of a schwingmoor moss at an advanced stage of development (Natural England 2021b). On the other hand, parts of Lindow Moss, made famous by the discovery of the an Iron Age bog body dubbed 'Lindow Man' in 1984, are still subject to planning consents for peat extraction up to 2042 (Wilmslow Town Council 2021). The region even includes examples of an alarming national phenomenon; mosses that have vanished entirely in recent history such as Lifeless Moss formerly north of Alderley Edge. Peat is no longer mapped in this area and field investigations have revealed no surviving organic deposits (Leah *et al.* 1997).

In general, over time, many of Cheshire East's peatlands have been drained for agricultural use, extracted, used as landfill or colonised by willow or birch woodland. Many now only survive as small peat blocks or fragmented remnants of larger peat bodies (Davies 2018). Disregarding those extracted or converted for agriculture, the remaining peatlands of Cheshire East can be generalised into three landscape character types (LCT); typically recognisable landscape features identifiable across the borough (Davies 2018):

- LCT 6: Woodland, heath, meres and mosses
    - "This well wooded character type is associated with an area of former grazed heathland and still retains a heathy character. It is defined by blocks of mixed woodland interspersed with small relict heath, meres and mosses and is located in the northern half of the Borough, either side of the A535 south of Chelford. The landscape is crossed by brooks, with large water bodies created more recently through sand and gravel extraction. Beyond the woodlands and water bodies, the flat or undulating landscape consists of large fields defined by straight hedgerow boundaries."
- LCT 9: Mosslands
    - "The Mossland is a small but distinctive landscape type which occurs in five locations across the Borough. The type relates to surviving fragments of peat bog, known locally as mosses. Mosses were once a widespread natural habitat in Cheshire East but drainage in particular, as well as peat cutting and settlement expansion has subsequently reduced this rare habitat to a handful of areas."
- LCT 14: Moorland hills and ridges
    - "The Moorland Hills LCT forms a small area of unenclosed moor, which extends across into the Peak District National Park. It is located on the eastern boundary of the Borough, south of Macclesfield Forest. This wild unsettled landscape has panoramic views to the surrounding hills and over the undulating farmland to the west."

A number of these surviving peatlands form a network of internationally important sites for the conservation of nature, including: the Midland Meres and Mosses Ramsar (Natural England 2020a), South Pennine Moors Special Area of Conservation (SAC) (Natural England 2020b) and the Peak District Moors Special Protection Area (SPA) (Natural England 2021a). Several more are designated as nationally important SSSIs and Local Wildlife Sites (LWS) of regional importance.

Local Political Context

In May 2019 Cheshire East Council (CEC) approved Notice of Motion relating to climate change; committing to the target of Cheshire East Council being carbon neutral by 2025. In response to this motion the Cheshire East Environment Strategy 2020 - 2024 (Cheshire East Council 2020) and the Carbon Neutrality Action Plan for Cheshire East 2020 - 2025 (Anthesis 2020) were produced and published in 2020. The Environment Strategy sets out strategic environmental goals and summarises the key strategies and action plans that will ensure their delivery. Of relevance to the borough's peatlands within this strategy is Goal one 'Cheshire East Council will be carbon neutral by 2025' to be implemented through the Carbon Action Plan (discussed in more detail below) and Goal six 'Protect and enhance our natural environment' to be implemented through the 'Green Infrastructure Plan'.

The Carbon Neutrality Action Plan for Cheshire East 2020 - 2025 (Anthesis 2020) focuses on actions that CEC should consider deploying directly in support of the carbon neutral 2025 target. Included in the action plan was the need to address the management of peatland ecosystems specifically at a local scale, in order to protect and enhance natural capital on both Council and non-Council owned land:

- Action 4.1: Protect and enhance natural capital (Council land)
    - Target: Enhance green infrastructure to provide natural climate solutions on Council land, including tree planting and peatland restoration.
        - a) Plan and develop natural climate solutions such as tree planting and peatland management to sequester carbon on at least 100 ha of Council owned land by 2025.
- Action 4.2: Protect and enhance natural capital (borough-wide)
    - Target: Enhance green infrastructure to provide natural climate solutions on non-Council land, including tree planting and peatland restoration.
        - a) Plan and develop natural climate solutions such as tree planting and peatland management to sequester carbon on between 41 and 1,347 ha of non-Council owned land by 2025.
        - b) Develop and implement restoration and/or management plans for 100% of peatlands in Cheshire East.

This report was commissioned by Cheshire East Council (CEC) as a baseline report in support of the Council's Environment Strategy and Carbon Neutrality Action Plan; in order to provide a single reference source for peatland in Cheshire East to inform future consideration by the Council and others. It was commissioned with reference to the need to 'Review existing data on land-use and carbon sequestration to identify opportunities (for) nature based solutions with particular reference to the Green Infrastructure Plan'. It is intended to form part of an evidence base for the Council regarding the feasibility and desirability of peatland restoration in the borough. This is presented in the form of a Geographic Information System (GIS) dataset (*Cheshire East Peatlands -*

CWT_region.shp) with an accompanying appraisal of the borough's peatland resource, including; its extent, condition, greenhouse gas emissions and biodiversity.

Approach

This study provides a desk-based collation of the best available evidence of the extent and condition of peatland across Cheshire East, presented alongside an assessment of greenhouse gas emissions and biodiversity value.

Extent

The extent of peatland across Cheshire East was primarily derived from the national dataset reported in the Natural England NE257 'England's Peatlands' report (Natural England 2010). Following a review of relevant literature, this dataset was considered to be the best currently available to determine the extent of peatland across the borough in the absence of detailed or recent data at the local scale. However, it should be noted that this dataset will likely be updated by 2024 as set out in the England Peat Action Plan (DEFRA 2021a). The NE257 dataset includes a range of peatland soil types: deep peaty soils, shallow peaty soils and soils with peaty pockets. For the purposes of this assessment only deep peaty soils (i.e. areas covered with a majority of peat >40cm deep) were retained in the dataset. As described by Evans *et al.* (2017); despite being extensive across the UK shallow peaty soils and soils with peaty pockets do not meet the national definitions of peat (i.e. they are shallower than true peat or have a lower carbon density). They differ from wasted deep peat (peat lost through agricultural drainage, leading to loss of peat through erosion and decomposition), which are included in this assessment. The NE257 dataset was then compared against the Cranfield University NATMAP[2] national soils dataset to check for any discrepancies or any additional deposits of deep peat.

Condition and Greenhouse Gas Emissions

Peat condition category was assigned across the peatland extent as described in the 2021 review[3] (National Inventory Report, Brown *et al*. 2021) of the 'Implementation of an Emissions Inventory for UK Peatlands' (Evans *et al.* 2017), as reported in 'Carbon storage and sequestration by habitat: a review of the evidence (second edition)' Natural England Research Report NERR094 (Gregg *et al.* 2021). The original report by the Centre for Ecology and Hydrology (CEH) provides estimates of GHG emission factors (EF), expressed as tonnes of carbon dioxide equivalent per hectare per year, from a number of peat condition categories that are informed by land cover types on UK peatlands. This report and its subsequent review in 2021 present the most recent and encompassing overview of GHG emissions from UK peatlands that is currently available, as shown below in Table 1.

[2] Soil data © Cranfield University (NSRI) and for the Controller of HMSO [2021]
[3] https://unfccc.int/ghg-inventories-annex-i-parties/2021

Table 1. Emissions factors for peat condition types taken from the 2021 review of Evans et al. (2017), as reported in the Natural England Research Report NERR094 (Gregg et al. 2021). A positive EF indicates net GHG emission and a negative EF indicates net GHG removal.

Peat Condition Category	Drainage Status	Emissions Factor ($tCO_2e\ ha^{-1}\ yr^{-1}$)
Forest	Drained	5.46 to 1.15
Cropland	Drained	37.61
Eroding Modified Bog (bare peat)	Drained	13.28
	Undrained	12.17
Modified Bog (semi-natural heather & grass dominated)	Drained	3.54
	Undrained	2.31
Extensive Grassland (combined bog/fen)	Drained	13.03
Intensive Grassland	Drained	27.54
Rewetted Bog	Rewetted	3.91
Rewetted Fen	Rewetted	8.05
Rewetted Modified (semi-natural bog)	Rewetted	-0.02
Near Natural Bog	Undrained	-0.02
Near Natural Fen	Undrained	-0.93
Extracted Domestic	Drained	13.37
Extracted Industrial	Drained	13.28
Settlement	Drained	1.61

The NE257 dataset contains additional attribute data including land cover and management. Despite being based on a number of robust sources (including phase 1 habitat survey data, aerial imagery, the National Inventory of Woodland and Trees and a range of other dataset sources) this dataset is now over 10 years old and as discussed by Evans *et al.* (2017) contains a number of instances of incompatible attributes within the same location (e.g. peatland parcels with afforested and improved grassland land cover). Therefore, to update and resolve errors in the NE257 additional attribute data, an updated land cover assessment was undertaken as described below.

The updated land cover assessment of peatland across Cheshire East was derived in a hierarchical manner using a combination of historic survey data held by Cheshire Wildlife Trust (CWT) in addition to licensed and open source data. As described above, land cover influences peatland emissions, as it relates directly to the condition of the peat body. Therefore, the more accurate the land cover assessment, the more accurate the GHG emissions assessment. Land cover over deep peat deposits was derived from the following datasets:

1. Phase 1 habitat survey data held by CWT for nature reserves and LWS was used where available. This is primary survey data historically collected and stored by the Trust and, despite its age[4], is therefore considered to be the most accurate dataset used to determine land cover.
2. In locations where no CWT phase 1 habitat data was available, the UK Government Priority Habitats Inventory dataset (Natural England 2020c) was used to determine land cover.
3. In locations where no CWT phase 1 habitat survey or Priority Habitat Inventory data was available, the Land Cover Map 2019 (LCM2019) vector dataset (Morton *et al.* 2020) provided by CEH was used. This is a parcel-based land cover map covering the entirety of the UK, created by classifying satellite data into 21 land cover classes based on the UK Biodiversity Action Plan Broad Habitat definitions.

Following the updated land cover assessment, the land cover for each peatland parcel was compared to the additional attribute data within the NE257 dataset. Any discrepancies between the NE257 land cover and the updated land cover assessment were reviewed against open source aerial imagery (© Microsoft Bing[5]) and resolved where possible.

Determination of the drainage status of peatlands was primarily derived from the NE257 dataset unless otherwise identified during the updated land cover assessment as described above. Any discrepancies between the NE257 data and the updated land cover assessment that could not be resolved through the use of aerial imagery were assigned to the highest-emitting category, as per Evans *et al.* (2017). This followed the order:

Pristine < rewetted < burned < drained < bare (eroded) < extracted < extensive grassland < improved grassland < cropland

Depth

Recent peat depth data across Cheshire East is relatively sparse and not all sites have historically been subject to detailed surveys. As the approach to assessing greenhouse gas emissions described above does not require an estimate of depth (other than to distinguish between deep and shallow peats which is already accounted for in the NE257 dataset); an accurate depth for the entire peatland resource across the borough is not required for this assessment. However, to add context, a sample of historic peat depths across 30 of Cheshire East's peatlands have been included in this report for reference. All peat depth estimates are taken from auger cores collected by Burton and Hodgson (1987) and Leah *et al.* (1997), and offer a historic insight into peat depth across a number of sites throughout the borough. This data is for reference only and does not represent a definitive list of all the peatland across Cheshire East. This is anecdotal historical data that has been gathered to provide context where available and has not been used to estimate greenhouse gas emissions.

Biodiversity

The biodiversity value of peatlands across Cheshire East was derived by determining the extent of peatland that lies within areas designated as sites of importance for nature conservation. A

[4] Only data from phase 1 habitat surveys undertaken in the last 10 years was used.
[5] ©Microsoft Corporation © 2021 Maxar ©CNES (2021) Distribution Airbus DS

combination of Local Wildlife Site (LWS) data held by CWT and open source data was used to determine the boundaries of statutory and non-statutory designated sites:

- LWS boundary data held by CWT on behalf of the Cheshire LWS Partnership;
- Ramsar boundary open data (Natural England 2020d);
- SAC boundary open data (Natural England 2020b);
- SPA boundary open data (Natural England 2021a);
- SSSI boundary open data (Natural England 2021b), and;
- Local nature reserve (LNR) boundary open data (Natural England 2021c).

Limitations

There are a number of limitations associated with the assessment of the peatlands of East Cheshire, particularly in regard to the extent, establishing land cover and the associated emissions factors. Limitations encountered while undertaking the assessment are reported here for transparency.

As highlighted within Evans *et al.* (2017) there are limitations associated with the NE257 Natural England dataset:

"For England, the digital data derived for the Natural England (2010) report on peatland carbon storage and greenhouse gases in England, subdivides the peat resource into blanket bog, lowland raised bog and fen peats (deep and wasted). However, these area figures when combined do not make up the total of the deep peat soils (blanket bog, inclusive of upland Valley Mire = 355,300 ha; raised bog = 35,700 ha; lowland fen (deep) = 95,800 ha; lowland fen (wasted) = 1,922 ha; no data = 900 ha). All of the above bog/fen types combine to 489,622 ha not the 679,900 ha total deep peat soils). It may be that Natural England have access to complete maps of blanket and lowland raised bog peat, and can therefore assess all land cover on these classes, but lack an equivalent map of fen peat. Hence there may only be mapped areas of 'fen habitat' but not other land-use on fen peat, or wasted fen peat. Since the unmapped area potentially includes very large areas of deep and wasted peat under cropland and grassland, it is likely to be of high significance for overall UK peat emissions."

As this study utilised the same dataset some of these unmapped areas of fen may be located within Cheshire East and therefore may be significant in the overall peatland extent and total GHG emissions across the borough.

In line with national peat definitions, this study did not take any shallow peats or soils with peaty pockets into consideration when establishing the peatland extent across the borough. As highlighted in Evans *et al.* (2017):

"Soils with a peaty organic horizon over mineral soil (often confusingly referred to as 'shallow peats' or 'peaty soils') were not included. These organo-mineral soils are very extensive in the UK, covering a large part of the uplands, but do not meet national definitions of peat as they are either shallower than true peat or have a lower carbon density, and in most cases are not thought to have ever been peat (i.e. they are not wasted former deep peat). They differ from true peat in important respects with regard to their hydrology and carbon cycle, and are subject to different land-use pressures."

As a result, as well as influencing the extent of peatland across Cheshire East this will also affect the total peatland GHG emissions across the borough.

The approach taken in this assessment to establish peatland condition was based on assigning an accurate land use type (e.g. cropland) for each peatland land parcel, which was undertaken in a hierarchical manner as discussed above. While primary ground-truthed phase 1 habitat survey data was prioritised, the coverage of this data across Cheshire is not extensive and is limited to some Local Wildlife Sites and Cheshire Wildlife Trust managed nature reserves only. Therefore, land use across a significant proportion of the peatland extent was informed by either the UK Government Priority Habitats Inventory dataset (Natural England 2020c), land cover data (LCM2019) (Morton *et al.* 2020) or aerial imagery. Due to potential inaccuracies in all these datasets and on occasions where aerial imagery was not useful in resolving a land use, the peatland condition category assigned to a land parcel may be inaccurate. It is also important to note that although the NE257 dataset provided some information on land use (e.g. extracted) which was used to infer peat condition, and management (e.g. gripped) which was used to identify whether the peat had been drained, not all peat land parcels contained this information. Additionally, the age of the NE257 dataset may also limit the accuracy of identifying the peatland condition category when considering land use and management. However, this assessment provides a desk based estimate of extent, emissions and biodiversity, and is based on the most current and reliable datasets available at the time of writing. There are likely to be some discrepancies between the peatland condition categories assigned to land parcels in this study and their 'real-life' condition, but this is to be expected when undertaking a large scale desk-based assessment and is not thought to be a significant limitation to this assessment.

In the 2021 review (Brown *et al*. 2021) of the 'Implementation of an Emissions Inventory for UK Peatlands' (Evans *et al.* 2017), as reported in 'Carbon storage and sequestration by habitat: a review of the evidence (second edition)' Natural England Research Report NERR094 (Gregg *et al.* 2021), the "forest" condition category is given an emissions factor range of 5.64 to 1.15 tCO2e ha^{-1} yr^{-1}. This range of implied emission factors for forested organic soils are derived from the Forest Research CARBINE model[6], which implies that inputs to the soil from litter, deadwood and exudates will become greater than the losses from the existing soil, given the increasing number of years since afforestation of UK forests on deep peats. Cheshire Wildlife Trust does not have the resources or expertise to model carbon flow through woodlands using the CARBINE model as undertaken in the 2021 NIR (Brown *et al*. 2021). Therefore, a worst case scenario approach has been taken to inform emissions across forested peatlands; by applying the upper limit of the emissions factor range (5.64 tCO2e ha^{-1} yr^{-1}) to all woodland on deep peat across the borough. As a result this will affect the calculation of the total peatland GHG emissions across the borough.

The 'settlement' peat condition category also encompassed any road verges and drainage ditches adjacent to development, as per the methodology set out in (Brown *et al*. 2021). It is important to bear in mind that although they are included in the same peat condition category, these linear features are valuable as ecological corridors and some may also have lower GHG emissions factor than that of the actual developed area.

As this project was undertaken at a local level, as opposed to a national level, an additional peat condition category for open water was created. This included all areas of standing and running water including canals, rivers, ponds and ditches (those not adjacent to development included in the settlement category) that are located on peat. This included small stretches of Local Wildlife Sites such as the Shropshire Union Canal near Wybunbury Moss and the Macclesfield Canal which borders Danes Moss. Due to a lack of published research, there are no accepted GHG emission factors associated with open water on deep peat, therefore this area is included in the total extent for completeness but it is presented without an accompanying emissions factor.

It is also important to understand that the NE257 dataset and the research behind the implied emissions factors across each condition category represent reporting at a national level. Therefore, some caution is needed when applying these figures at a local scale as has been done in this

[6] https://www.forestresearch.gov.uk/research/forestry-and-climate-change-mitigation/carbon-accounting/forest-carbon-dynamics-the-carbine-carbon-accounting-model/

assessment. However, this is a typical limitation when applying a national methodology at a local scale and the implied emissions factors are considered to be the most current and reliable available to estimate peatland GHG emissions. As it is likely any subsequent local level study of peatland GHG emissions would also use the implied national emissions factors, this is not considered to be a significant limitation to this assessment.

Although not used to inform GHG emissions, estimating peat depth can be subject to a considerable amount of error depending on the methodology used (Parry *et al.* 2014). Therefore, historical estimates of peat depth provided in the results section provide valuable insight across a number of sites in the borough, but should not be assumed to be highly accurate. Any requirement to understand the current depth of peat at any sites across the borough should be informed by an updated, site specific survey. This limitation extends to the estimates of carbon stocks in peat across the UK and England, as reported by Gregg *et al.* (2021); estimates are highly uncertain due to the considerable variation in the depth of peat soils. Peat depth is not uniform and varies over short distances due to the underlying topography. This, along with nationally mandated reporting standards, is why peatland GHG emissions are routinely presented at the national level rather than peatland carbon stocks. Peat depths are included in this report as anecdotal data, and therefore any potential inaccuracies associated with these figures are not considered to be a significant limitation to the overall assessment.

Results

This report should be read with reference to the accompanying GIS dataset: "*Cheshire East Peatlands - CWT_region.shp*"

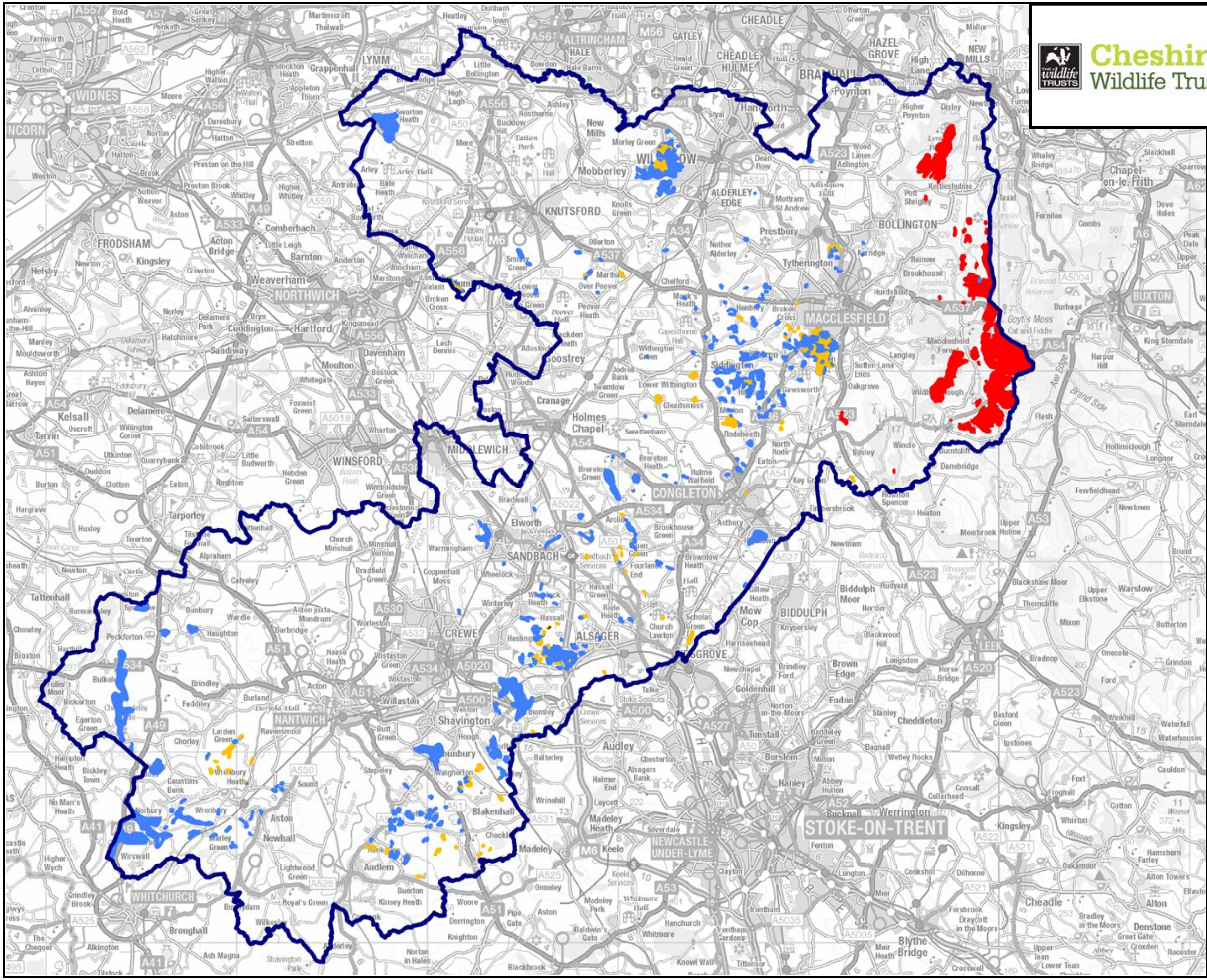
Extent

The extent and type of deep peat across Cheshire East is shown below in Map 1 and summarised in Table 2. The Natural England NE257 data indicates there is approximately 3,603 ha of deep peat across Cheshire East, representing around 0.5% of the national extent. Cheshire East's deep peat resource originates primarily from fens, accounting for 50.6% (1,823 ha) of the borough's peatland. This is followed by blanket bog (37.8% or 1,361 ha) and lowland raised bog representing the remaining 11.6% (419 ha).

Table 2. Extent and habitat of origin of Cheshire East's peatlands.

Deep Peat Habitat of Origin	Area (ha)	Area (%)
Fen	1,823	50.6
Blanket Bog	1,361	37.8
Lowland Raised Bog	419	11.6
Total	3,603	-

The majority of Cheshire East's lowland peatland is located in a band that spans south west from Macclesfield through Congleton to the south of Crewe. There are two other significant areas, located in Wilmslow and south west of Nantwich. The borough's blanket bog is confined to the north-east, associated with the upland areas of the Leek Moors SSSI, Goyt Valley SSSI, Peak District Moors SPA and the South Pennine Moors SAC.



Map Name

Cheshire East Peatlands Peat Type

Map Number

Map 1

Cheshire East Peatlands Legend

Cheshire East Boundary

Blanket Bog

Raised Bog

Rich Fen

Scale 1: 260,000

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Condition and Greenhouse Gas Emissions

The area, condition and associated greenhouse gas emissions of deep peat across Cheshire East are shown below in Table 3 and Figure 1.

Table 3. Emissions factors (EF) and annual emissions of Cheshire East peatlands. Positive annual emissions indicates net GHG emission and negative annual emissions indicates net GHG removal.

Peat Condition Category	Drainage Status	Emissions Factor ($tCO2e\ ha^{-1}\ yr^{-1}$)	Area (ha)	Area (%)	Annual Emissions ($tCO2e\ yr^{-1}$)	Annual Emissions (%)
Forest[7]	Drained	5.46	**397**	11	**2,169**	5
Cropland	Drained	37.61	**279.1**	8	**10,497**	22
Eroding Modified Bog (bare peat)	Drained	13.28	**109**	3	**1,448**	3
	Undrained	12.17	**3**	0.1	**39**	0.1
Modified Bog (semi-natural heather & grass dominated)	Drained	3.54	**49**	1	**174**	0.4
	Undrained	2.31	**540**	15	**1,248**	3
Extensive Grassland (combined bog/fen)	Drained	13.03	**179**	5	**2,333**	5
Intensive Grassland	Drained	27.54	**895**	25	**24,647**	51
Rewetted Bog	Rewetted	3.91	**684**	19	**2,674**	5.6
Rewetted Fen	Rewetted	8.05	**92**	3	**739**	2
Rewetted Modified (semi-natural bog)	Rewetted	-0.02	**33**	1	**-0.65**	-0.001
Near Natural Bog	Undrained	-0.02	**10**	0.3	**0.19**	-0.0004
Near Natural Fen	Undrained	-0.93	**4**	0.1	**-3.60**	-0.01
Extracted Domestic	Drained	13.37	**136**	4	**1,820**	4
Extracted Industrial	Drained	13.28	**0**	0	**0**	0
Settlement	Drained	1.61	**147**	4	**237**	0.5
Open water[8]	-	-	**46**	1	**-**	-
Total	**-**	**-**	**3,603**	**-**	**48,021**	**-**

[7] In the absence of detailed forestry modelling, the upper value of the forest peat condition category EF range (5.46 $tCO2e\ ha^{-1}\ yr^{-1}$) was used as a worst case scenario estimate as discussed in the limitations section.

[8] There is a lack of published research on emissions arising from open water on peatland. Therefore, the area of this condition category has been provided without a GHG emission factor.

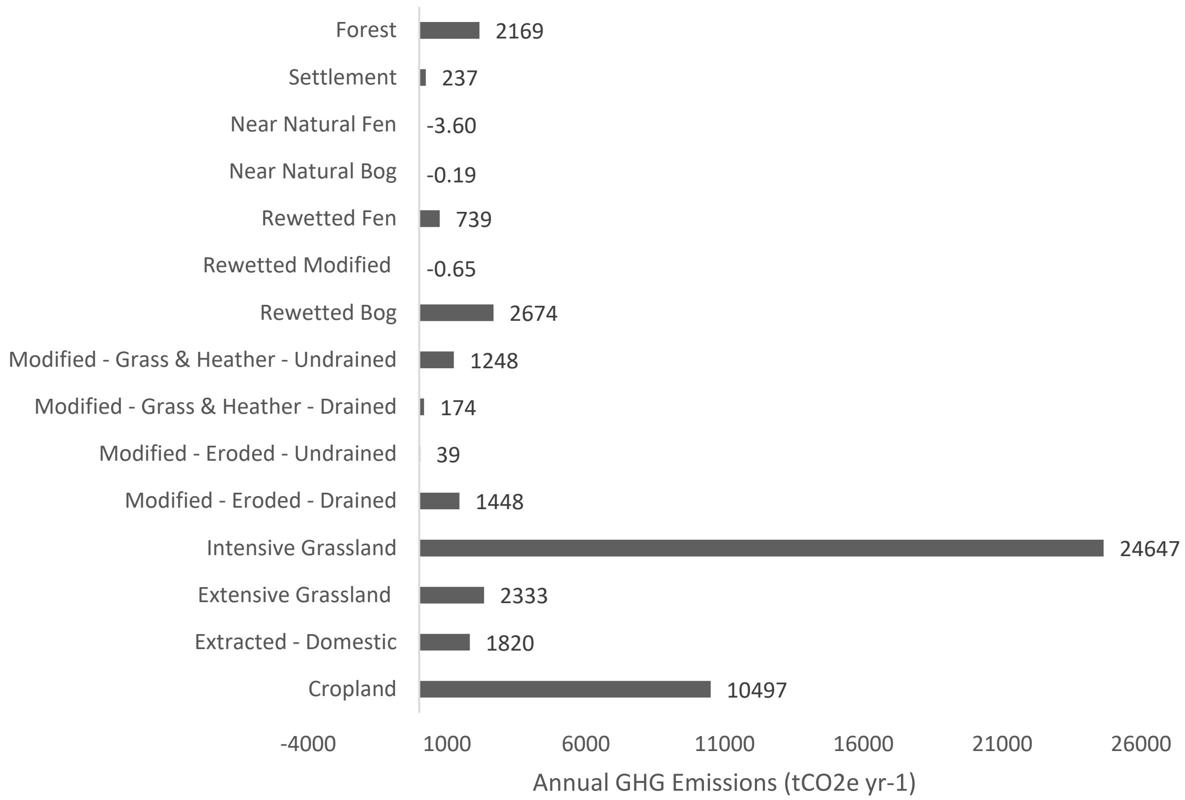


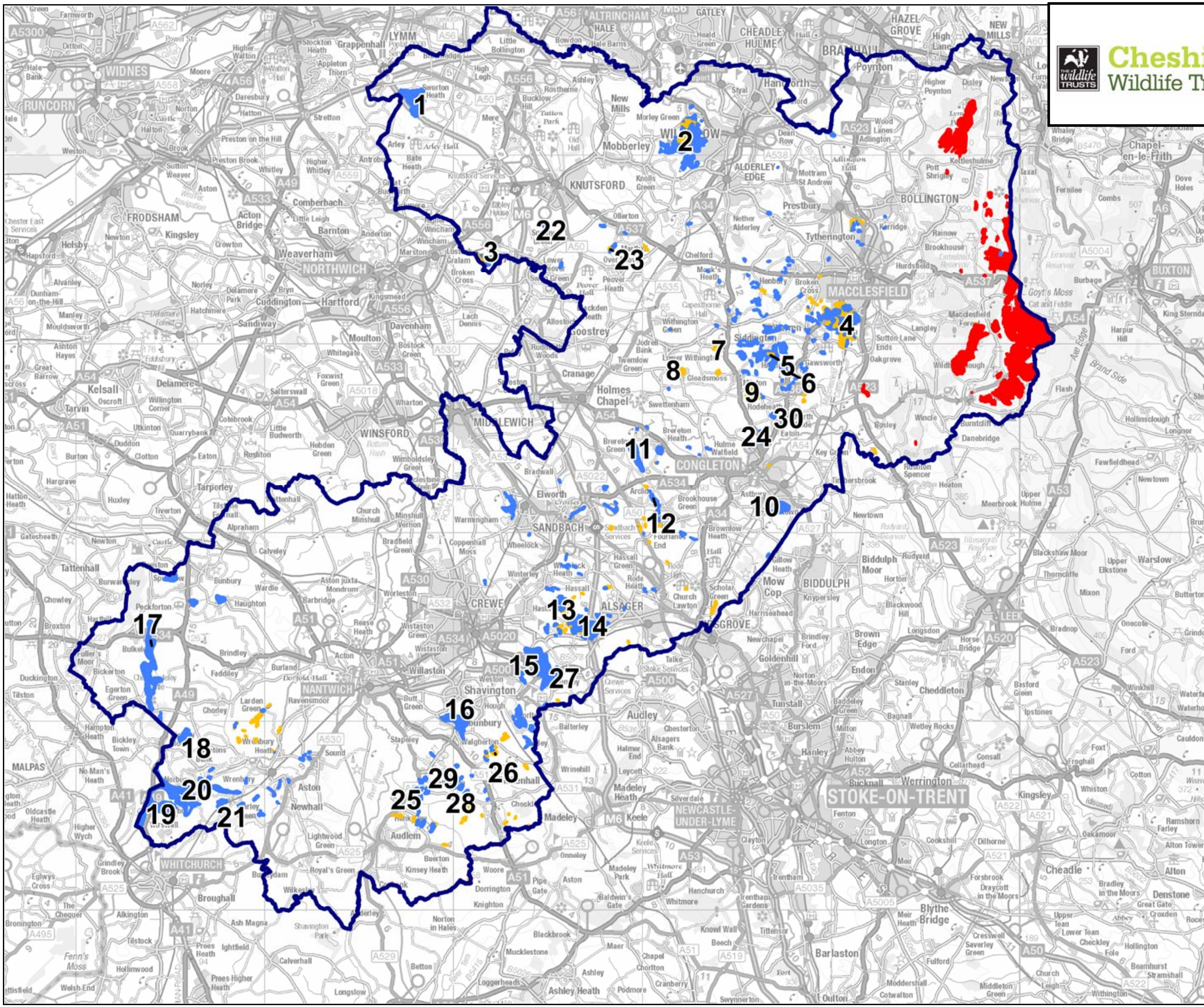
Figure 1. Annual GHG emissions (tCO2e yr^{-1}) of Cheshire East Peatlands. Positive annual emissions indicates net GHG emission and negative annual emissions indicates net GHG removal.

The majority of the borough's deep peat is in a degraded state: 62% is drained, 23% has been rewetted and only 15% is currently undrained. The most expansive land-use associated with deep peat across Cheshire East is agricultural; with intensive grassland accounting for 895 ha (25% of the total extent) and cropland accounting for an additional 279 ha (8%). Rewetted bog accounts for the largest extent of the semi-natural categories (684 ha or 19%), followed by undrained modified bog (540 ha or 15%). However, only 0.4% (14 ha) of the entire peatland resource in Cheshire East is in a near natural condition.

Cheshire East's peatlands emit 48,021 tCO2e yr^{-1}. Around 74% of the total CE peatland emissions (equivalent to over 36,000 tCO2e yr^{-1}) occur as a result of the agricultural use of peatlands, yet this only accounts for 33% of the peat extent across Cheshire East. Intensive grasslands are the greatest emitter, generating 24,647 tCO2e yr^{-1}, equivalent to 51% of the total CE peatland emissions but representative of only 25% of the total extent. This is followed by croplands which release 10,497 tCO2e yr^{-1}, equivalent to 22% of emissions but only accounting for 8% of the total extent. Rewetted bogs make up the largest area of the semi-natural peatland condition categories (684 ha or 19% of the peat extent) and as a result are the third largest source of emissions, accounting for 2,674 tCO2e yr^{-1} (5.5% of total annual emissions). This is closely followed by extensive grasslands (2,333 tCO2e yr^{-1} or 4.8%) and forests which emit 2,169 tCO2e yr^{-1} (4% of total emissions). Only 46 ha (1.3%) of Cheshire East's peatlands are currently sequestering GHGs; the near natural bog, near natural fen and rewetted modified (semi-natural bog) habitats are acting as a net sink, providing a saving of -4.44 tCO2e yr^{-1} equivalent to 0.01% of the borough's total peatland emissions.

Depth

Available peat depth data for 30 sites across Cheshire East is included in Map 2 and summarised in Table 4 below. As discussed, this data is for reference only and does not represent a definitive list of all peatland across Cheshire East. This is anecdotal historical data that has been gathered where available and has not been used to estimate GHG emissions.



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Cheshire East Peatlands
Peatland Sites

Map Number

Map 2

Cheshire East Peatlands Legend

Cheshire East Boundary

1 - Sink Moss
2 - Lindow Moss
3 - Holford Moss
4 - Danes Moss
5 - Tidnock Wood, Crabmoss & Martonheath
6 - Buttymoss
7 - Mere Moss
8 - Gleadmoss
9 - Cocks Moss
10 - Congelton Moss
11 - Bagmere
12 - Brookhouse Moss
13 - Oakhanger Moss
14 - White Moss
15 - Monneley Mere & Henbury Moss
16 - Wybunbury Moss
17 - Upper Weaver & Gowy Valley
18 - Norbury Meres
19 - Quoisley Meres
20 - Big & Little Meres
21 - Marley Moss
22 - Toft Moss
23 - Lower Moss Wood
24 - Eaton Hall Moss
25 - Birchall Moss
26 - Blackenhall Moss
27 - Englesea Basin Mire
28 - Pepperstreet Moss
29 - Speakmans Moss
30 - White House Moss

Scale 1: 260,000

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Table 4. Historic peat depth data taken from Burton & Hodgson (1987) and Leah et al. (1997). Presented alongside peatland name, location, peatland type, area and historic land use.

Peatland	**O.S. Grid Reference**	**Peatland Type**	**Area (ha)**	**Land use**	**Peat Depth**	
					(Burton & Hodgson 1987)	**(Leah *et al.* 1997)**
Sink Moss	SJ 680830	Basin mire (B)	-	Arable or Horticultural (A)	-	Limited deposits of peat.
Lindow Moss	SJ 825810	Raised mire (R)	150	Grassland (G),Excavated (E), Tip (T)	>5 m	Up to 7.15 m deep in areas where 3 m had already been removed, suggesting up 10 m in some central areas. Away from these areas 2 - 5 m deep.
Holford Moss	SJ 715745	R	24	Woodland (W)	Estimated 2 m	Heavily desiccated peats 1 - 2 m typical. Restricted areas of deeper peat up to 3 m exist along uncut baulks.
Danes Moss	SJ 905710	R	210	Nature reserve or SSSI or mire or semi-natural vegetation (N), G, T	0.45 - 0.7 m in places but 1.2 m average	Deepest areas reach 6.3 m. Average range from 3 - 4 m. Approx. 4 - 5 m remaining over CWT reserve.
Tidnock Wood, Crabmoss & Martonheath	SJ 868694 SJ 870697 SJ 860692	B, Spring mire (S)	45	W,G	2 m	0.5 – 2 m
Buttymoss	SJ 874686	-	-	G	3 m	-
Mere Moss	SJ 840698	B	8	W, E	2 m	-
Gleadmoss	SJ 821685	-	-	-	Little peat	-
Cocks Moss	SJ 860673	B	17	W	1.5 - 2 m	-
Congleton Moss	SJ 872613	R	32	G	2 - 2.5 m	Up to 3 m
Bag Mere	SJ 796642	B, Open water transition mire (O)	28	N, G	7 - 8 m	-
Brookhouse Moss	SJ 806618	B, Schwingmoor (Sch)	9	N, W	At least 8.5 m	Up to 3.5 m
Oakhanger Moss	SJ 768551	R	18	W, E	0.7 - 1 m	-
White Moss	SJ 773549	R	27	E	1 - 1.2 m but originally up to 3 m before cutting.	-

Monneley Mere & Henhury Lee	SJ 750530 SJ 743536	B, Valley mire (V)	20	G	3 m	-
Wybunbury Moss	SJ 697502	B, Sch	11	N, W	1.8 - 7 m	-
Upper Weaver & Gowy valleys	SJ 536513 SJ 540518 SJ 541508 SJ 540540 SJ 540551 SJ 536522 SJ 542577	V, B	121	G, A, W	<1 - 2 m	-
Norbury Meres	SJ 557491 SJ 560493	B, O	31	G	1 - 2.5 m	-
Quoisley Meres	SJ 546455 SJ 550456	B, O	17	N, G, W	>6 m	-
Big & Little Meres	SJ 560454 SJ 563457	B, O	13	N, G, W	7 - 8 m	-
Marley Moss	SJ 577457	B	8	W	1.5 - 2 m	
Toft Moss	SJ 748763	-	-	W	-	1.5 m
Lower Moss Wood	SJ 783731	R	-	W	-	2 - 2.5 m
Eaton Hall Moss	SJ 864648	B	-	W	-	1.7 m
Birchall Moss	SJ 681461	-	-	G	-	3 m
Blakenhall Moss	SJ 722483	-	-	W	-	0.2 m
Englesea Basin Mire	SJ 754525	B	5	W	-	>7m
Pepperstreet Moss	SJ 704465	-	-	W	-	3.7 - 4.6 m
Speakman's Moss	SJ 702475	-	-	-	-	2.8 - 3.5 m
White House Moss	SJ 870664	B	-	W	-	0.7 m

The historical data shows that the deepest peat reserves in the borough could potentially be located at Lindow Moss, with auger cores showing a depth of 7.15 m in areas where up to 3 m of peat had already been excavated, suggesting that in some locations the depth may be >10 m. Surveys undertaken at Brookhouse Moss, Englesea Basin Mire, Wybunbury Moss and Danes Moss also returned cores showing peat extending to significant depths; at least 8.5 m at Brookhouse Moss, >7 m in some areas of Englesea Basin Mire, up to 7 m at Wybunbury Moss and up to 6.3 m in the deepest areas of Danes Moss. Results from the area of Danes Moss managed by CWT at the time (1997) showed slightly deeper peat deposits (4 – 5 m) than the average depth recorded across the site as a whole (3 – 4 m). There are also significant peat depths associated with the meres of Cheshire East; surveys showed depths of 7 – 8 m at Bagmere, 7 – 8 m at Big & Little Meres and >6 m at Quoisley Meres.

In contrast, the shallowest peat reserves across the borough recorded during the surveys were at Blakenhall Moss (0.2 m) or Gleadmoss (little peat recorded). Surveys at Oakhanger Moss and White House Moss revealed peat depths of >1 m at each site, while a further seven sites were only found to have peat depths up to 2 m.

While there is some discrepancy between the depth of peat at the same sites recorded across the two survey years, this could be a result of limitations of the survey methodologies (as discussed earlier) rather than the effects of peat formation or loss. Therefore no comparison or conclusions should be drawn from the difference in depth recorded at some sites between the two survey years.

Biodiversity

The area of deep peat within sites designated for nature conservation across Cheshire East is shown below in Table 5, Figure 2 and on Map 3. Lists of both statutory and non-statutory sites that contain deep peat deposits are included in Appendix 1.

Table 5. Extent of Cheshire East's peatlands designated for nature conservation.

Designation	**Number of Sites**	**Area of Deep Peat (ha)**	**Area of Deep Peat (% of total extent)**
Statutory designated sites (LNR, SSSI, SPA, SAC, Ramsar)	20	842	23
Non-statutory designated sites (LWS)	64	854	24
Total	84	1,696	47

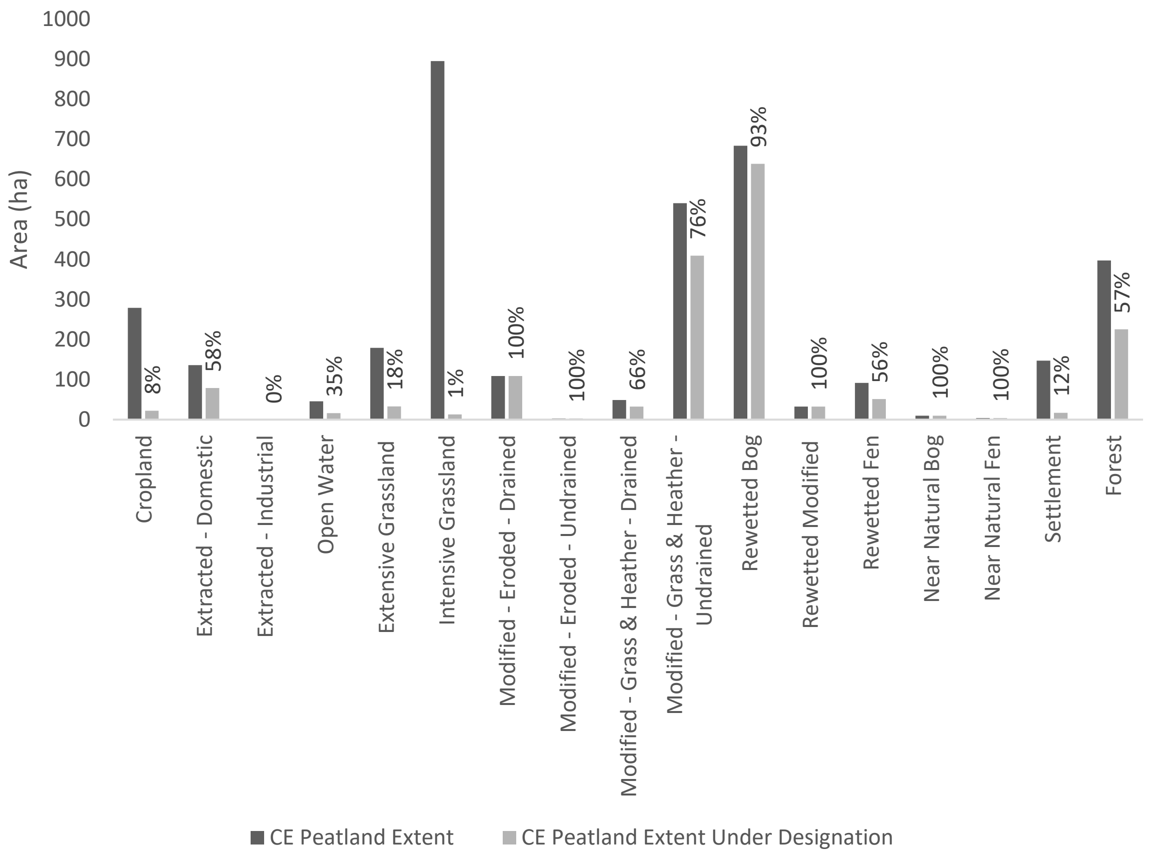
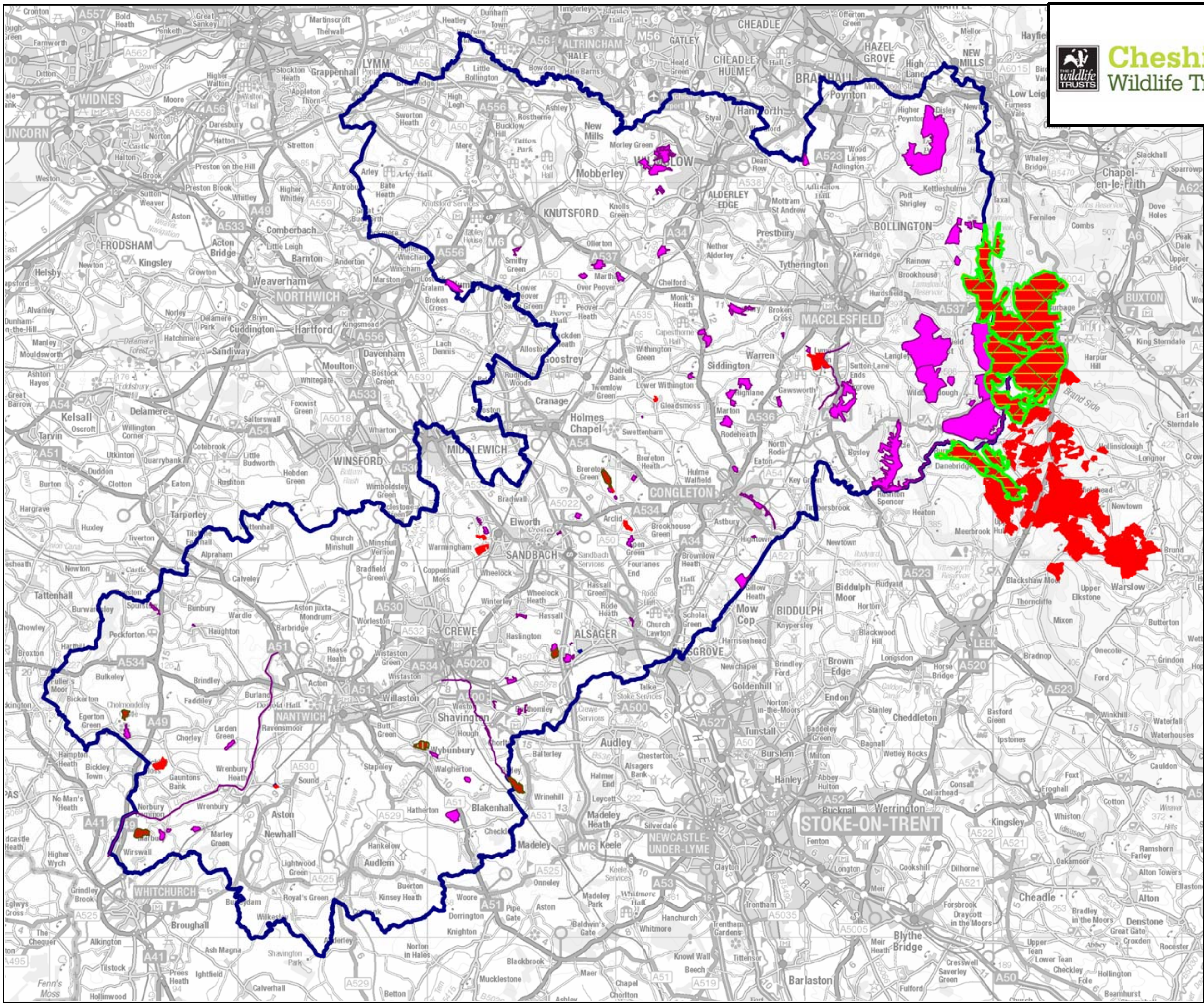


Figure 2. Total extent of Cheshire East's peatland (ha) vs. extent of peatland sites designated (includes statutory and non-statutory sites) for nature conservation (ha & % of total extent).



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Statutory & Non-stautory Sites on Cheshire East Peatlands

Map Number

Map 3

Legend

Cheshire East Boundary

Statutory Sites Legend

- Site of Special Scientific Interest
- Special Protection Area
- Special Area of Conservationd
- Local Nature Reserves
- RAMSAR

Non-statutory Sites Legend

- Local Wildlife Sites

Scale 1: 260,000

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As shown in Table 5, just under half of the borough's deep peats are designated for nature conservation (1,696 ha or 47%), with the overall area split relatively evenly between statutory and non-statutory designations. The number of LWS (64) greatly outnumber the number of statutory designated sites (20), although this is to be expected due to the nature of the non-statutory designated site system. Many areas of deep peat across the borough often comprise multiple statutory designations, for example a large area (approx. 448 ha) is designated within the Leek Moors SSSI, the Peak District Moors SPA and the South Pennine Moors SAC.

All (100%) of the borough's eroding modified bogs (bare peat), rewetted modified (semi-natural bogs), near natural bogs and near natural fens are designated as statutory sites. A further 62% of rewetted bogs and 46% of rewetted fens are also designated as statutory sites, as are 23% of undrained modified bogs (semi-natural heather & grass dominated) and 14% of forested areas. In comparison to non-statutory designated sites; 64% of drained and 53% of undrained modified bogs (semi-natural heather & grass dominated) are designated as LWS. A large proportion (58%) of peatland currently subject to domestic extraction is designated as LWS, this is mainly due to extraction at White Moss and Lindow Moss, part of which is designated as a LWS. As with statutory designated sites, a large area of the borough's forested peatland is also designated as LWS, 43%, highlighting that some of the woodland on deep peat in Cheshire East may be of semi-natural origin.

Discussion

Cheshire East peatlands cover a total area of 3,603 ha and represent approximately 0.5% of England's total peatland extent. They are a net-source of GHGs, emitting 48,021 tCO2e yr^{-1}, equivalent to 0.01% of the UK's total annual emissions or 0.81% of the UK's Land Use, Land Use Change and Forestry Sector (LULUCF) as reported in the UK NIR 2021 (Brown *et al.* 2021).

In the context of Cheshire East, deep peat covers approximately 3% of the total local authority area and the emissions arising from these reserves are highly significant. The total peatland emissions are equivalent to 311% of emissions under the Council's direct control (15,447 tCO2e yr^{-1})[9] or 31% of the Council's entire Scope 1, 2 and 3 emissions (155,103 tCO2e yr^{-1}), as reported in the Carbon Neutrality Action Plan for Cheshire East 2020 – 2025 (Anthesis 2020). Only 0.4% of the borough's peatlands are in a near natural condition, considerably lower than the national extent of 1.3% (Gregg *et al.* 2021).

Lowland Fen and Raised Bog Peats (42,456 tCO2e yr^{-1} / 2,242 ha)

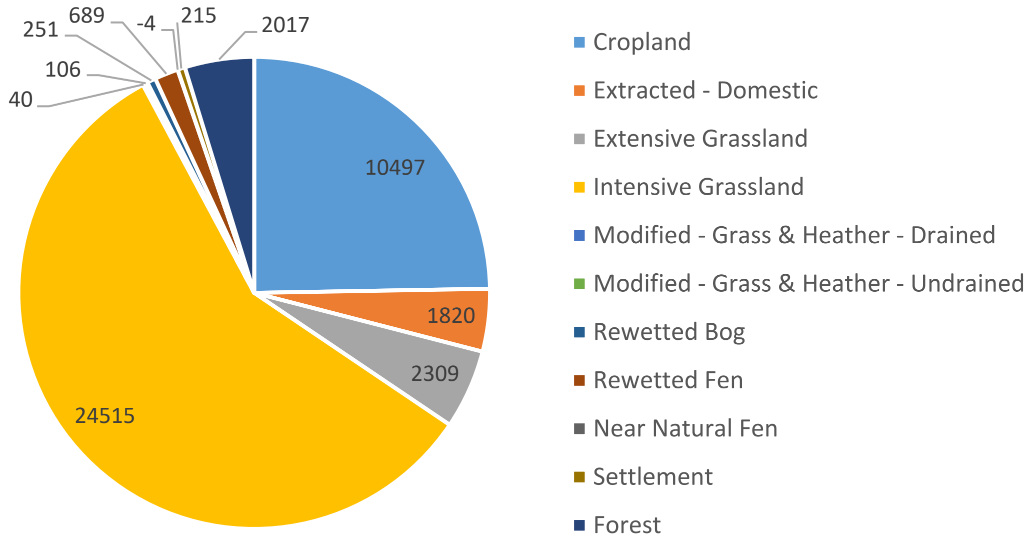


Figure 3. Annual GHG emissions (tCO2e yr-1) of Cheshire East peatlands originating from fen and raised bog. Positive annual emissions indicates net GHG emission and negative annual emissions indicates net GHG removal.

As shown in Figure 3, the majority of the borough's lowland deep peat is in a severely degraded condition. The use of land situated on deep peat for agriculture has resulted in significant losses of semi-natural peatland habitats including 49% of fen peats and 25% of raised bog peats. As a result, more than three quarters of the borough's total peatland emissions (35,011 tCO2e yr^{-1} or 81%) arise from one third of the borough's lowland fen and raised bog peatland extent (1,169 ha or 33%). This is due to unsustainable agricultural land use and management, i.e. intensive grasslands and croplands, found almost exclusively across the lowlands of Cheshire East. An additional 15% of fen peats and 25% of raised bog peats are covered by woodland across the lowlands. Although some of this is likely to be of semi-natural origin any afforested areas may potentially be negatively impacting the hydrology of the underlying peat body, resulting in ongoing degradation. Domestic extraction and settlement is

[9] Elements that are classed under 'direct control' will relate to the core emission sources that the Council considers 'in scope'. This covers all scope 1 (primarily related to natural gas for heating and fuel used by owned or controlled vehicles) and scope 2 (purchased electricity) emissions. It also covers scope 3 waste treatment emissions.

also an issue found almost exclusively across the lowlands, accounting for 1,820 $tCO_2e\ yr^{-1}$ or approx. 4% of the borough's total peatland emissions. Settlements on peatland are of particular concern as they are unlikely to ever be returned to a semi-natural condition.

Only 0.2% (3.9 ha) of lowland fens are in a near natural condition. These areas are acting as natural carbon sinks and sequestering -3.6 $tCO_2e\ yr^{-1}$. None of the borough's lowland raised bogs are considered to be in a near natural condition, however 15% are classified as rewetted bogs although this means they still act as a net GHG source, emitting 251 $tCO_2e\ yr^{-1}$.

Upland Blanket Bog Peats (5,565 $tCO_2e\ yr^{-1}$ / 1,361 ha)

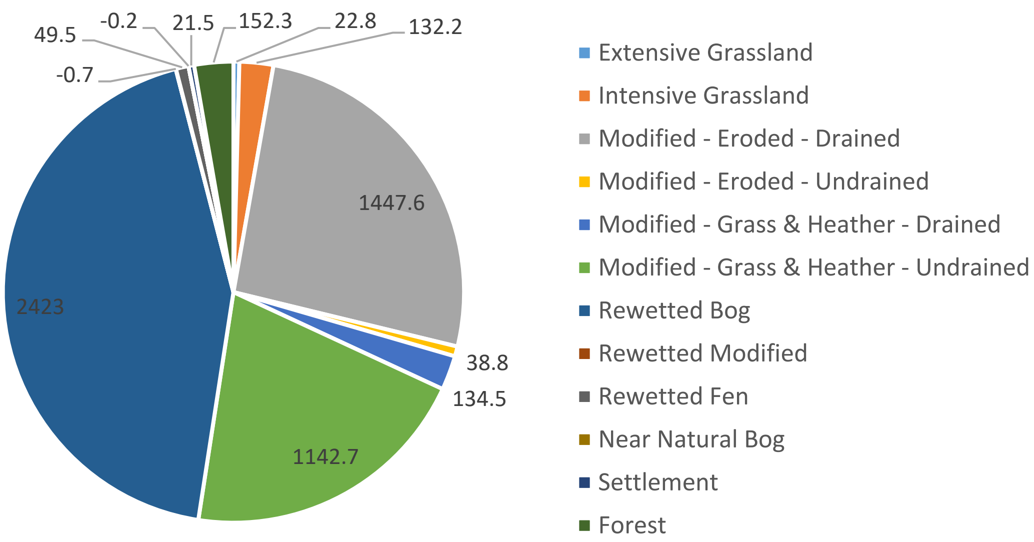


Figure 4. Annual GHG emissions (tCO2e yr-1) of Cheshire East peatlands originating from blanket bog. Positive annual emissions indicates net GHG emission and negative annual emissions indicates net GHG removal.

As shown in Figure 4, the upland deep peat resource across Cheshire East is generally in much better condition than across the lowlands, mainly due to the absence of agricultural land uses, although still only 0.1% (10 ha) is in a near natural condition. Just under half of the upland deep peat across Cheshire East is classified as rewetted bog (620 ha or 46% of the total extent of blanket bog), however it still acts as a net GHG source emitting 2,423 $tCO_2e\ yr^{-1}$ (the largest source of blanket bog emissions - 44%). The second largest source of emissions in the uplands arise from areas of actively eroding drained blanket bog. While these areas only cover 109 ha (8% of the area of blanket bog), they account for over a quarter of all emissions arising from upland blanket bog peats (1,448 $tCO_2e\ yr^{-1}$ or 26%). Attribute information within the NE257 dataset suggests that all of the actively eroding blanket bog showed signs of being subjected to rotational burning to facilitate driven grouse shooting and 91% had evidence of drainage grips within 50 m. The second most expansive condition category associated with upland blanket bog peats are undrained modified bogs (semi-natural heather and grass dominated). Around 260 ha of blanket bog peats (26% of the area of blanket bog) are in this condition leading to emissions of 830 $tCO_2e\ yr^{-1}$ (15% of emissions arising from blanket bog peats). This highlights the importance of peatland condition when considering GHG emissions in the uplands, as despite covering less than half the area of the undrained modified bogs, the actively eroding areas are the source of 1.7 times more emissions.

Carbon Savings through Reduced Emissions

As a result of the peatlands of Cheshire East acting as a net source of GHGs, there are substantial opportunities for emissions reductions across the borough through the implementation of sensitive management regimes and restoration. The greatest GHG reductions, and therefore the largest carbon savings, can be made by facilitating the transition of highly degraded deep peats to modified or rewetted habitats. There are a number of ways that this could be achieved depending on the appetite of the Council and the willingness of landowners to engage.

Agricultural Lowlands

As discussed, the agricultural use of lowland deep peats is the largest source of peatland emissions across the borough, with one third of the peatland extent contributing three quarters of the total emissions. Therefore, these areas represent the most significant opportunities for emissions savings.

While recognising that agriculture is an essential provisioning sector across Cheshire East, and that deep peats can be associated with higher Agricultural Land Classification (ALC) grades, the use of deep peats for intensive farming is highly unsustainable in the context of peatland GHG emissions. Intensive grasslands on deep peats are the greatest GHG emitter. With an emissions factor of 27.54 tCO2e ha^{-1} yr^{-1} they generate 24,647 tCO2e yr^{-1}, equivalent to 51% of the total CE peatland emissions. This is followed by croplands that, with an emissions factor of 37.61 tCO2e ha^{-1} yr^{-1}, generate 10,497 tCO2e yr^{-1} (equivalent to 22% of all CE peatland emissions). In comparison, the emissions factors of agricultural land not located on deep peats are significantly lower, highlighting the unsustainability of using peatlands in this way. Arable land (equivalent to cropland in this assessment) that is not located on deep peat is thought to have an emissions factor in the range of 0.29 to 0.7 tCO2e ha^{-1} yr^{-1} (Gregg *et al.* 2021); equivalent to approximately 36.91 tCO2e ha^{-1} yr^{-1} less than croplands located on deep peats. Emissions factors of intensive grasslands not located on deep peat are less well understood, although they are thought to have the potential to sequester carbon. Some examples of grazed intensive grasslands in Central Europe have been estimated to sequester -0.24 to -4.9 tC ha^{-1} yr^{-1} (Gregg *et al.* 2021).

Most restoration work to date has focussed on blanket bog (DEFRA 2021a). However, given that most of the GHG emissions from CE peatlands come from the lowlands, the approach to restoration needs to be broadened. If the intensive management of grasslands on deep peat was stopped, and appropriate management plans were put in place to transition these areas to the next least degraded condition category (extensive grassland i.e. unfertilised permanent grassland, lower-density grazed or hay-cropped), this could translate to an emissions saving of over 13,000 tCO2e yr^{-1}, equivalent to a 27% reduction in overall peatland emissions. If areas currently utilised as croplands were also converted to this condition category the emissions could be reduced further by approx. 7,400 tCO2e yr^{-1}, equivalent to an additional 15% reduction in total peatland emissions. Greater savings still could be made by transitioning to the less degraded rewetted categories: if all intensive grasslands on deep peat across Cheshire East were restored and managed back to ‘grass-dominated’ bogs (drained modified grass dominated bogs with a high cover of semi-natural species such as graminoids, including *Molinia caerulea* and *Deschampsia flexuosa*, or sedges such as *Eriophorum*, and a low cover of peat-forming mosses), this could result in an emissions saving of 21,570 tCO2e yr^{-1}, equivalent to a 44% reduction in overall peatland emissions. If these were eventually rewetted (transitioning further to the rewetted modified semi-natural bog category) these areas would eventually begin to sequester carbon, resulting in an emissions saving of approx. -18 $tCO_2e\ yr^{-1}$ and reducing total peatland emissions across the borough to 23,885 $tCO_2e\ yr^{-1}$, equivalent to a saving of around 51%. These are relatively extreme approaches to attempt to reduce emissions but illustrate the potential savings well; even a transition of 25% to 50% of intensive grasslands or croplands to less degraded condition categories would result in significant emissions savings and therefore implementing stricter management and attempting restoration across these areas should be considered seriously.

Due to the significant emissions arising as a result of drainage based agriculture on deep peat reserves, and the need to maintain productivity, research in this field is ongoing and a recently published study from Evans *et al.* (2021) offers an alternative approach to that discussed above. The team found that the mean annual effective water-table depth (the average depth of the aerated peat layer) overrides all other ecosystem and management related controls on greenhouse gas fluxes. The research team estimate that reducing the mean annual effective water depth could reduce emissions by at least 3 $tCO_2e\ ha^{-1}\ yr^{-1}$ for every 10 cm, i.e. raising the water table in order to reduce the amount of aerated peat results in significant emissions savings. The team conclude that using this approach, GHG emissions from peatlands drained for agriculture would be greatly reduced without necessarily halting their productive use. Additional research into how this approach could be applied across Cheshire East and how it could reduce the borough's peatland emissions as a result is required.

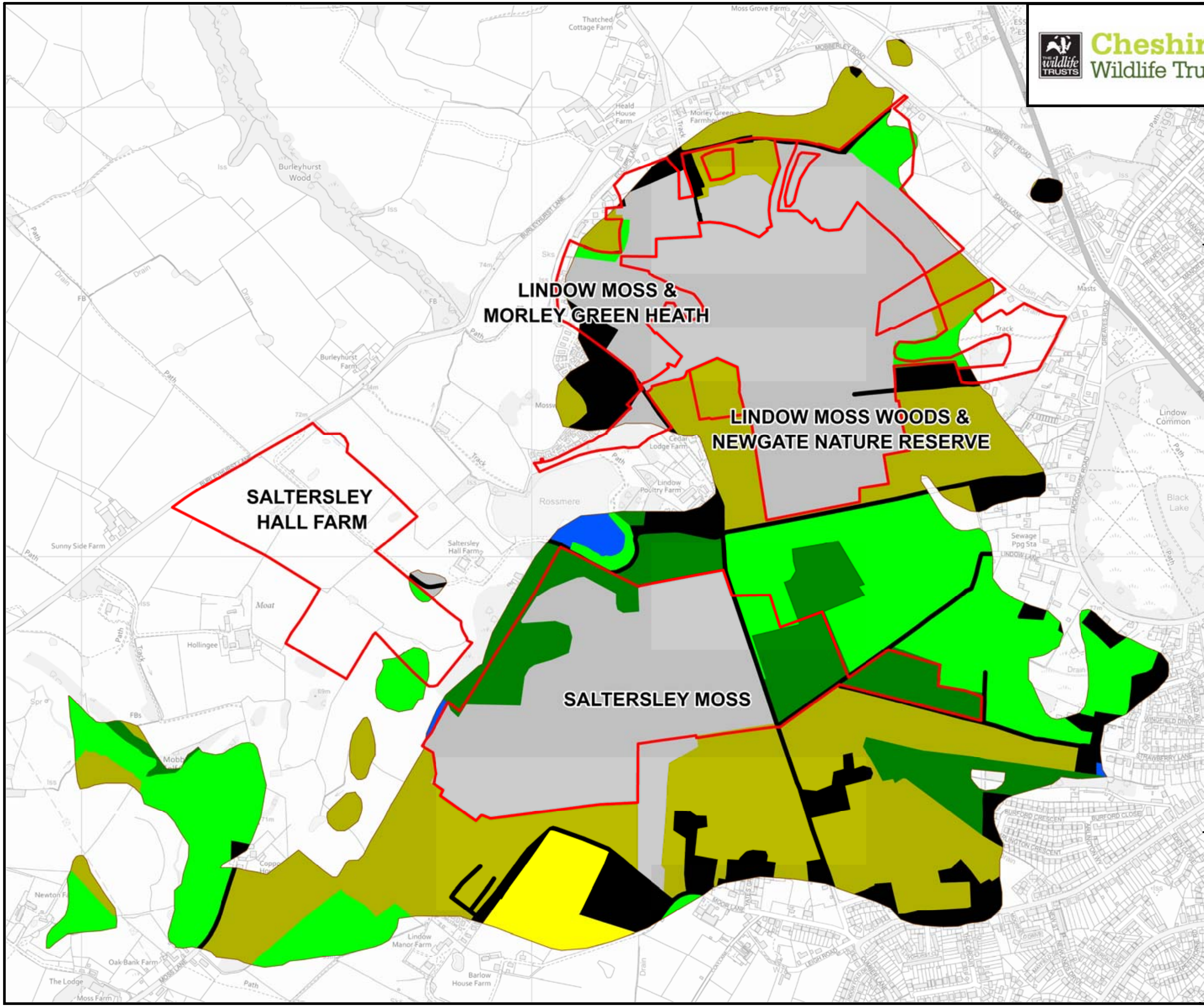
Extraction and Development

Where deep peat is extracted domestically (i.e. manual extraction), extracted to facilitate development or developed over, it is essentially lost forever. Currently, around 283 ha or 8% of Cheshire East's total peatland extent has been lost to extraction and settlement. An example of this is shown in the map below (Case Study 1 – Lindow Moss). Settlement is defined in accordance with the 2006 IPCC Agriculture, Forestry and Other Land Use Guidance[10], including all developed land i.e. residential, transportation, commercial and production (commercial manufacturing) infrastructure of any size. Importantly, the emissions factor for settlements does not account for any potential emissions or loss of stored carbon in vegetation or soil associated with the construction of new infrastructure (i.e. the emissions associated with the land use change from undeveloped to developed land). The loss of peat to extraction and settlement, while not accounting for a particularly large area across the borough, still results in significant emissions over time. Extraction of peat has a high emissions factor compared with emissions arising as a result of settlement, however both are equally damaging when consideration is given to time as a limiting factor. The time an area of deep peat is extracted over is finite (e.g. 50 years) whereas the lifetime of a development such as a housing estate can be much longer or even permanent. Emissions associated with extraction can potentially eventually be reversed with restoration (assuming not all peat has been extracted), whereas those associated with development cannot.

If domestic extraction of peat (currently the source of 1,820 $tCO_2e\ yr^{-1}$) across the borough was banned and halted immediately, and the extraction areas and any remaining deep peat was rewetted (to create rewetted modified semi-natural bog), over time these areas could potentially begin to sequester carbon at a rate of -2.72 $tCO_2e\ yr^{-1}$. When compared to deep peat located beneath settlement (currently the source of 237 $tCO_2e\ yr^{-1}$), despite being a smaller GHG source these emissions are essentially permanent and cannot be reversed. When considering both over a 50 year

[10] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

time period the difference becomes significant: the peat under settlement will have emitted over 11,500 tCO_2e, whereas the post-extraction rewetted modified semi-natural bogs could have sequestered up to -136 tCO_2e. This highlights the importance of peatlands as potential carbon sinks and finite natural capital assets that, if impacted by extraction or development, are essentially lost forever along with their potential for carbon sequestration. To avoid additional potentially permanent emissions the extraction and development of peatlands should be stopped immediately across Cheshire East. This should also extend to the inclusion of deep peats within future strategic development allocations (e.g. local plan allocations). Where strategic development allocations have already been approved (e.g. the South Macclesfield Development Area) the loss of stored carbon and any GHG emissions associated with the development of deep peat should be considered as part of the planning decision process, with consideration to how offsetting increased emissions can be demonstrated.



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Lindow Moss Extraction Site

Map Number

Case Study 1

Cheshire East Peatlands Legend

Peat Condition Catergory

- Cropland
- Grassland - Extensive
- Grassland - Intensive
- Woodland
- Freshwater
- Extraction - Domestic
- Settlement

Designation

- Local Wildlife Site

Scale 1: 11,000

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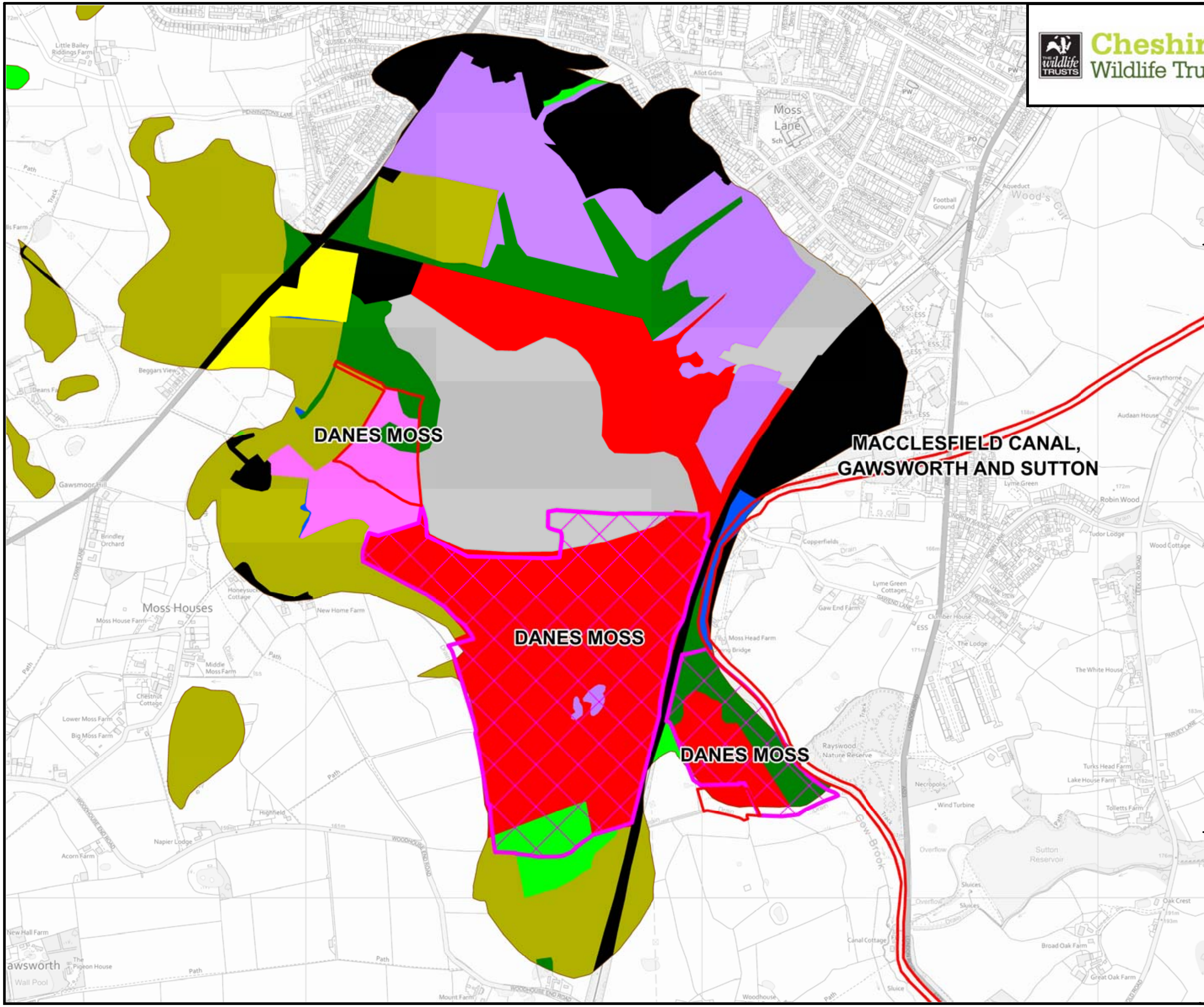
Restoration and Management

In addition to transitioning Cheshire East's highly degraded peatlands to modified or rewetted habitats, the ongoing restoration and appropriate management of semi-natural peatland habitats is essential to ensure emissions from these habitats do not increase. Modified, rewetted and near natural peatland habitats account for 42% of the peat extent in Cheshire East, emitting 6,317 tCO_2e yr^{-1} or 13% of the total emissions. This is highly significant as it demonstrates how important the ongoing management of semi-natural habitats is in terms of limiting emissions; inappropriate land use on just over half of the borough's deep peat is the source of 87% of its GHG emissions.

There is however still potential for significant emissions reductions across semi-natural peatland habitats through a range of different approaches. Undrained modified bogs account for around 540 ha or 15% of the total peatland extent and are the source of 1,248 tCO_2e yr^{-1}. While these habitats have a relatively low emissions factor (2.31 tCO_2e yr^{-1} ha^{-1}) due to their semi-natural vegetation cover and undrained status, there is potential to manage them even more effectively to convert them to carbon sinks. If all these areas across the borough were transitioned to rewetted modified bogs, a relatively simple management process, it would result in these habitats sequestering approx. -11 tCO_2e yr^{-1}, a significant saving of 1,259 tCO_2e yr^{-1}.

Targeted restoration of highly degraded areas of deep peat can also have significant benefits in terms of improving, buffering, expanding and linking existing semi-natural peatland habitats. Many of the less degraded peatland sites across the borough are isolated, and the underlying deep peat is surrounded by and encroached on by unsustainable land uses, such as intensive and extensive grasslands or croplands, as demonstrated in the example shown in the map below (Case Study 2 – Danes Moss). This can lead to complications that reduce the effectiveness of management efforts at a restoration site; in particular where nutrient rich habitats, such as intensive grasslands, border nutrient poor habitats, such as lowland raised bog. A number of ditches that drain water off the intensively farmed grasslands surrounding Danes Moss SSSI are nutrient rich and therefore cannot be utilised to rewet the site. If the surrounding areas of degraded peatland were subject to a suitable restoration programme, the nutrient inputs surrounding the SSSI would reduce and the existing drainage ditches could be used to redirect additional water on to the core site, thereby further repairing the hydrology of Danes Moss. This demonstrates how the targeted restoration of highly degraded peatlands adjacent to existing semi-natural peatland habitats has the potential to result in significant benefits to both the restoration areas (as they would no longer be degraded) and any existing hydrologically linked restored or semi-natural peatlands in close proximity.



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Danes Moss Restoration Site

Map Number

Case Study 2

Cheshire East Peatlands Legend

Peat Condition Catergory

- Cropland
- Grassland - Extensive
- Grassland - Intensive
- Woodland
- Freshwater
- Modified - Semi-natural Habitats - Undrained
- Modified - Semi-natural Habitats - Drained
- Rewetted Bog
- Extraction - Domestic
- Settlement

Designation

- Local Wildlife Site
- Site of Special Scientific Intrest

Scale 1: 12,500

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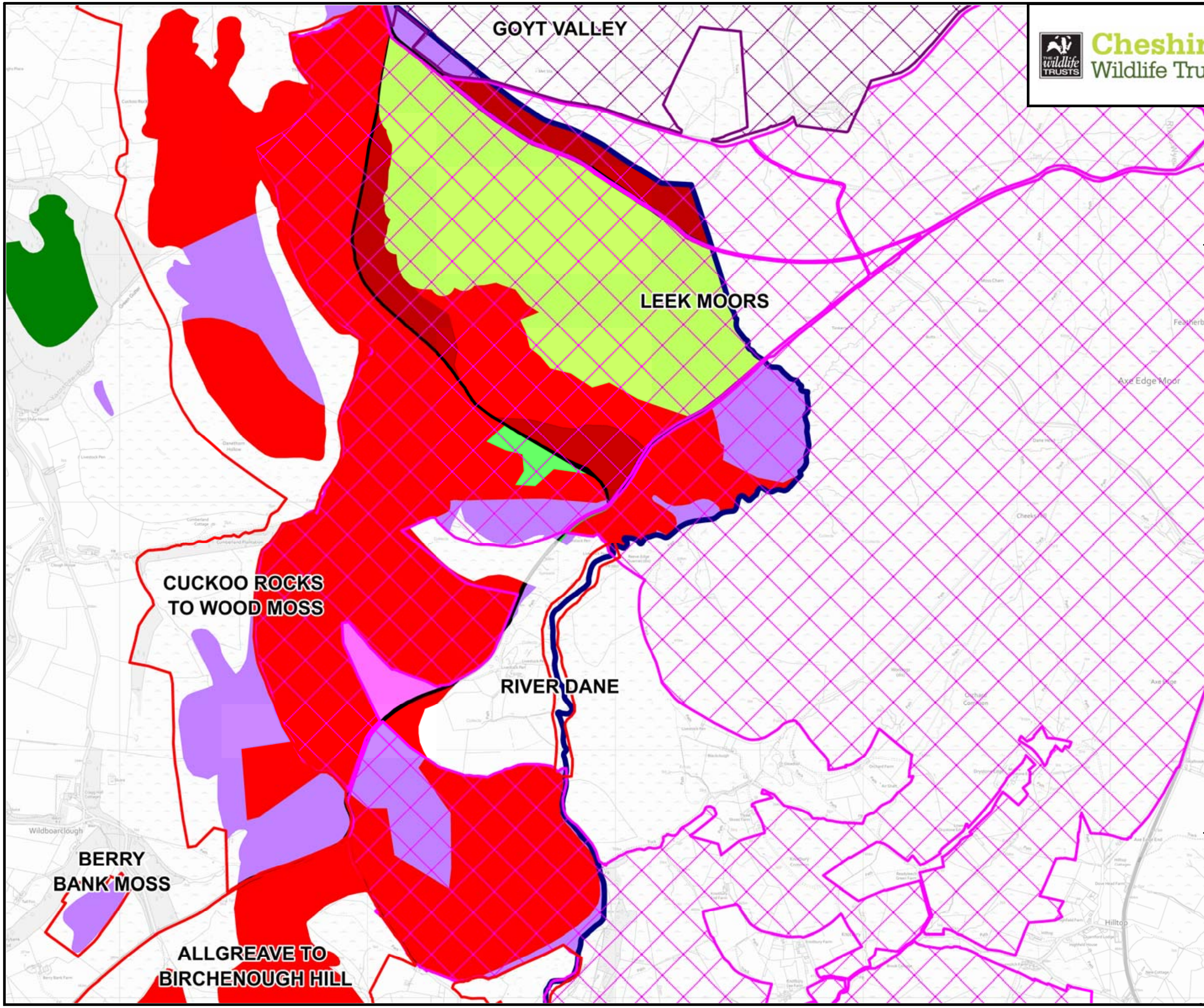
Tree planting on areas of deep peat or in areas that have the potential to affect the hydrology of a peatland is also highly inappropriate and should be stopped immediately throughout Cheshire East. Tree roots draw moisture out of the ground, lowering the water table which results in accelerated degradation of the underlying peat body. This is particularly important in light of the significant national and local targets and incentives for tree planting to offset emissions. A suitably qualified ecologist and the dataset presented in this report should be consulted prior to any tree planting taking place across Cheshire East. As highlighted in the biodiversity results, a large proportion of the forested peatland condition category within Cheshire East is likely to be of semi-natural origin. Therefore, due to the inherent biodiversity associated with this semi-natural habitat type, further assessment of peatland areas in this condition is required to establish if there are opportunities for deforestation of plantations to facilitate the restoration of bog or fen habitats across the borough.

Actively Eroding Blanket Bog

Despite accounting for only 12% of the total annual CE peatland emissions (5,565 $tCO2e\ yr^{-1}$), there are still important opportunities for restoration and management of upland blanket bog peats in Cheshire East. As discussed, the borough's upland deep peats are in better condition than across the lowlands, due mainly to the absence of agricultural land uses. However, a significant proportion of the upland emissions arise from areas of actively eroding drained blanket bog. While these areas only cover a relatively small area (109 ha or 8% of the area of blanket bog), they account for over a quarter of all emissions arising from upland blanket bog peats (1,448 $tCO2e\ yr^{-1}$ or 26%). As well as substantial emissions savings, managing and transitioning these actively eroding areas to modified or rewetted semi-natural habitats could also result in additional benefits such as improvements to water quality and flood attenuation.

Precipitation acting on areas of exposed bare peat (i.e. actively eroding areas of deep peat caused by activities such as overgrazing, burning or drainage) can result in the formation of deep erosional gullies. These gullies, also referred to as hags, have negative implications for both water quality and downstream flood risk in the wider catchment. Blanket bog peatlands are 'flashy' systems, as water flowing through them responds quickly to precipitation events. However, peatland degradation can further increase the 'flashiness' of the system, leading to higher storm-flow peaks and a greater downstream flood risk (Pilkington *et al.* 2015). Additionally, dissolved organic carbon arising from the peat (known as DOC) and eroded particles of peat (known as Particulate Organic Carbon or POC) are transported down erosion gullies during these precipitation events. This process is a major source of fluvial carbon loss from degraded blanket bogs (Pilkington *et al.* 2015) that causes water discolouration, reduces water quality and ultimately ends up having to be removed further down the catchment by water companies at significant cost. An example of where this could potentially be happening within the borough is in the Leek Moors, where a substantial area of actively eroding peat is located in proximity to the River Dane, as is shown in the example in the map below (Case Study 3 – Leek Moors). Therefore, restoring existing gullies and hags while taking preventative measures to stop new ones from forming should be a priority across the borough's upland peatland extent.



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Leek Moors, Blanket Bog Site

Map Number

Case Study 3

Cheshire East Peatlands Legend

Cheshire Boundary

Peat Condition Catergory

- Woodland
- Modified - Eroded - Drained
- Modified - Eroded - Undrained
- Modified - Semi-natural Habitats - Undrained
- Modified - Semi-natural Habitats - Drained
- Rewetted Bog
- Rewetted Modified Bog
- Settlement

Designation

- Local Wildlife Site
- Leek Moors
- Goyt Valley

Scale 1: 12,500

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Restoring existing gullies and hags is a common upland restoration practice and can be achieved by installing blocks or dams throughout the gully and reinstating semi-natural vegetation to stabilise the bare peat. The blocking and re-vegetation of gullies has been shown to have statistically significant effects on peatland hydrology and storm-flow behaviour, with a reduction in downstream flood risk as a result of 'slowing the flow' of precipitation in peatland headwater catchments (Pilkington *et al.* 2015). This essentially causes catchments to become wetter and store more water during precipitation events. The blocking and re-vegetation of gullies has also been shown to be highly successful in controlling the loss of POC from damaged peatlands (Pilkington *et al.* 2015). This can result in better water quality downstream, translating into significant financial savings associated with water treatment.

Stopping the formation of new gullies and hags is a more complicated process that requires changes to how upland peatlands are managed. As discussed, erosional gullies are formed by precipitation acting upon bare peat. Bare and eroding peat can form for a number of reasons but they are often associated with the widespread and unsustainable management practices common across the uplands; such as historic drainage grips, rotational burning or overgrazing (DEFRA 2021a). Therefore, transitioning away from these unsustainable management practices by stopping rotational burning, reducing grazing and blocking drainage grips across the borough's upland peatland extent will contribute to a reduction in the extent of bare peat that is susceptible to erosion. Consequently, this should translate into GHG emissions savings, improved water quality and a reduction in downstream flood risk.

The recent announcement by the government committing to bringing forward legislation to prevent the burning of heather and other vegetation on protected blanket bog (DEFRA 2021b) is a welcome addition to the other protections associated with SSSI status. However, over half of Cheshire East's blanket bogs (746 ha or 55%) are currently undesignated and therefore will not receive the added protections as a result of this proposed legislation. As highlighted in the results, all of the actively eroding blanket bog in the borough shows signs of being burned on rotation to facilitate driven grouse shooting. Therefore, implementing a borough wide ban on the burning of upland blanket bog through local strategic policy would improve the level of protection of this habitat and result in emissions savings through an increase in peat accumulation and a decrease in peat erosion (Glaves *et al.* 2013).

Biodiversity

Just under half (1,696 ha or 47%) of Cheshire Easts peatlands are designated as statutory or non-statutory sites for nature conservation. Overall, 1,274 ha or 84% of the borough's semi-natural peatlands[11] are designated as statutory designated sites for nature conservation (842 ha or 49%) or as non-statutory LWS (522 ha or 34%). A large proportion of the borough's semi-natural peatland habitats fall within statutory designated sites for nature conservation including all (100%) of the borough's eroding modified bogs (bare peat), rewetted modified (semi-natural bogs), near natural bogs and near natural fens, equivalent to an area of 158 ha. Additionally, substantial areas of rewetted bogs (639 ha or 93%) and rewetted fens (52 ha or 56%) also fall within statutory or non-statutory sites designated sites. Of the LWS, 33% (21 of 64 sites) are designated in part for their woodland component, highlighting the likelihood that a significant proportion of the forest peatland category is

[11] Semi-natural peatland condition categories include: undrained modified bogs (semi-natural heather & grass dominated), drained and undrained eroding modified bogs (bare peat), rewetted bogs, rewetted fens, rewetted modified (semi-natural bogs), near natural bogs, near natural fens and freshwater.

of semi-natural origin. Only 28% of LWS (18 of 64 sites) are designated for their wetland habitats while 9% (6 of 64 sites) are designated for the presence of acid grassland or heathland habitats. However, just under half of the 64 LWS (48%) have not been surveyed against the Cheshire LWS Selection Criteria (Giles 2012) within the last 10 years.

Additional Sites Suitable for Designation

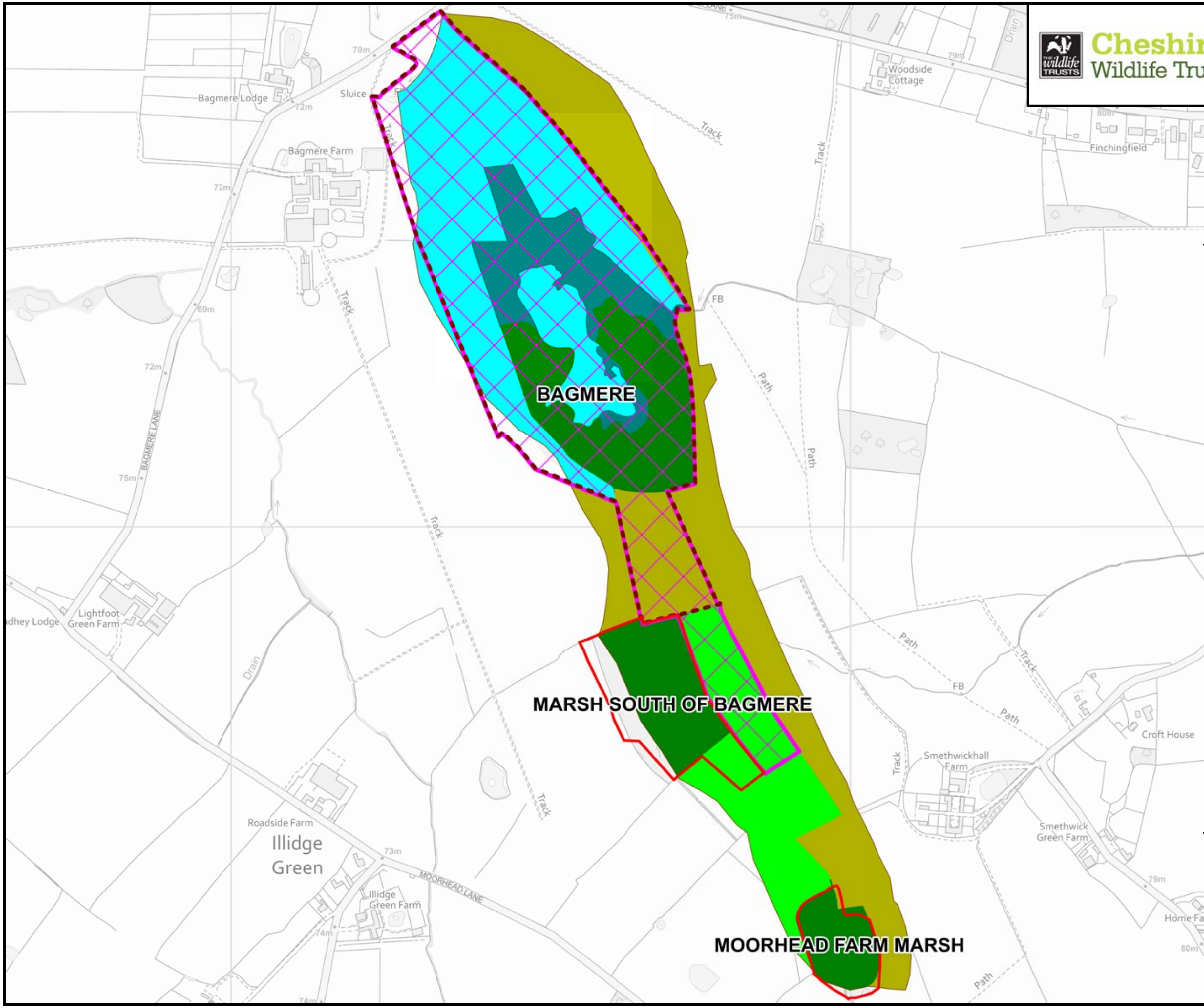
The assessment has revealed that there are potentially some areas of semi-natural peatland across the borough that could potentially already meet the criteria to be designated as either statutory or non-statutory designated sites for nature conservation: 246 ha of semi-natural peatlands are currently undesignated. Included in these figures, and of particular interest, are 45 ha of rewetted bog and 40 ha of rewetted fen that are currently undesignated. These areas should be surveyed against the Cheshire LWS Selection Criteria (Giles 2012) as a priority in order to ascertain whether they meet the criteria to be designated as LWS. The added protections afforded from LWS status will help to ensure these sites are managed appropriately for their biodiversity value.

An additional 131 ha of undrained modified bog (semi-natural heather & grass dominated) is also currently undesignated. Some of these areas may also hit the Cheshire LWS Selection Criteria (Giles 2012) for grassland and heathland and should also therefore be subject to further survey. If, as previously discussed, any of these areas were rewetted and transitioned to the rewetted modified (semi-natural bogs) condition category, then they may also be suitable for designation under the fens, swamps, bogs and reedbeds LWS habitat criteria.

Expansion and Connection of Designated Sites

In line with the Lawton Principles (Lawton *et al.* 2010) a step change in the approach to wildlife conservation is required if ongoing national declines in biodiversity are to be halted and reversed. Large-scale habitat restoration and recreation, underpinned by the re-establishment of ecological processes and ecosystem services, for the benefits of both people and wildlife should be the ambition for nature's recovery across Cheshire East. The borough's wildlife and semi-natural habitats, including peatlands, have become increasingly fragmented and isolated, leading to declines in the provision of ecosystem services and declines in semi-natural habitat extent and species populations. Ecological networks or Nature Recovery Networks (NRN) have become widely recognised as an effective way to conserve wildlife in environments that have been fragmented by human activities. Peatlands are a finite natural capital asset that provide both ecosystem services and benefits to biodiversity and should form a core component of any ecological or nature recovery network across Cheshire East.

As previously discussed, the targeted restoration of highly degraded areas of deep peat can have significant benefits in terms of improving, buffering, expanding and linking existing semi-natural peatland habitats. Targeting areas of highly degraded deep peats surrounding sites designated for nature conservation can also bring about additional benefits to biodiversity as a result of the principles behind landscape scale habitat connectivity. As demonstrated in the map below (Case Study 4 – Bagmere), Bagmere SSSI and Ramsar is a good example of a well-managed statutory designated peatland site in Cheshire East. The underlying peat body at Bagmere supports both semi-natural (areas of freshwater, near natural and rewetted fen habitats and woodland) and highly degraded (intensive and extensive grassland) peatland habitats. It also encompasses two non-statutory LWS (Marsh South of Bagmere and Moorhead Farm Marsh), both located to the south of the core Bagmere site. Targeted restoration of the highly degraded (extensive and intensive grassland) peatland habitats currently separating the three sites could result in the connection and potential expansion of a SSSI, Ramsar and two LWS. This could potentially result in both emissions savings and significant improvements to the connectivity of semi-natural habitats in and around the designated sites, thereby providing additional benefits to the biodiversity within and throughout the wider area. This demonstrates how the targeted restoration of highly degraded peatlands adjacent to designated sites has the potential to result in significant benefits to biodiversity within both the restoration areas (as a result of the creation of additional semi-natural habitat) and the existing designated sites (as a result of improved connectivity between the sites).



Cheshire Wildlife Trust

Cheshire East Council

Map Name

Bagmere, Near Natural Site

Map Number

Case Study 4

Cheshire East Peatlands Legend

Peat Condition Catergory

- Grassland - Extensive
- Grassland - Intensive
- Woodland
- Rewetted Fen
- Near Natural Fen

Designation

- Local Wildlife Site
- Site of Special Scientific Intrest
- RAMSAR

Scale 1: 8,000

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Management and Restoration Targets

The target's set out in the Carbon Neutrality Action Plan for Cheshire East 2020 – 2025 (Anthesis 2020) are ambitious and could potentially be difficult to achieve within the set timeframe. They are also highly variable; with the aim of planning and developing natural climate solutions to sequester carbon on 100 ha of council owned land and between 41 and 1,347 ha on non-council owned land. However, it is anticipated that this will be achieved through a combination of nature based solutions, including tree planting on appropriate sites and working with others to enhance natural capital borough-wide, rather than relying solely on the restoration of peatlands. Nevertheless, to give a sense of scale in the context of peatland management and restoration only, these spatial targets for nature-based offsetting (141 to 1,347 ha) equate to between 4 and 40% of Cheshire East's total peatland extent. The restoration or rewetting of agricultural or other highly degraded peatlands will not contribute to these targets as they are unlikely to begin sequestering carbon by 2025. All areas of eroding modified bog, modified bog (semi-natural heather & grass dominated), rewetted bog, rewetted modified bog (semi-natural bog) and rewetted fen account for approximately 41% of the borough's peatlands. Although highly ambitious, it may be possible to manage and restore these areas so that at least some sequester carbon within five years. However, this depends on the feasibility of restoration and management of these areas which must be assessed on a site-by-site basis. Therefore, a balance of nature based solutions of which peatland restoration and management form a key part but not all, will be required to meet these targets. The third peatland action set out in the Carbon Neutrality Action Plan; to develop and implement restoration and/or management plans for 100% of peatlands in Cheshire East, is again also highly ambitious but achievable.

The peatland management and restoration targets as set out in the Sixth Carbon Budget (CCC 2020), which could be formally adopted by government as part of commitments within the England Peat Strategy (DEFRA 2021a), are also highly ambitious. In the context of Cheshire East, these targets would equate to the equivalent areas shown in Table 6 below.

Table 6. Peatland management and restoration targets as set out in the Sixth Carbon Budget (CCC 2020) and the equivalent areas in Cheshire East.

Sixth Carbon Budget Peatland Target	Equivalent area in Cheshire East
Increasing the UK peatland area restored from 25% (current level) to 58% in 2035 and 79% by 2050, with a further 35% of lowland cropland sustainably managed.	Existing area restored in Cheshire East is 822 ha (23%) increasing to 2,090 ha (58%) by 2035 and 2,847 ha (79%) in 2050, with an additional 98 ha (35%) of lowland cropland sustainably managed.
All upland peat restored by 2045 (or stabilised if degradation is too severe to restore to halt carbon losses).	1,361 ha (100%) of blanket bog[12] restored by 2045.
25% of the area of lowland grassland is rewetted by 2035, rising to half by 2050.	169 ha (25%) of lowland grassland is rewetted by 2035, rising to 537 ha (50%) by 2050.
75% of lowland cropland is either rewetted or sustainably managed by 2050.	209 ha (75%) of lowland cropland is either rewetted or sustainably managed by 2050.
A quarter of the area is rewetted to near natural condition (and crop production ceases), and a further 15% is rewetted but conventional crop production switches to paludiculture crops.	70 ha (25%) of the area is rewetted to near natural condition (and crop production ceases), and a further 42 ha (15%) is rewetted but conventional crop production switches to paludiculture crops.
Water-table management options are deployed to 35% of the lowland cropland area.	Water-table management options are deployed to 98 ha (35%) of the lowland cropland area.
All low-productive trees of less than YC8 are removed off peatland by 2030[13] and all peat extraction sites are restored by 2035.	All peat extraction sites (136 ha) are restored by 2035.

Achieving the targets set out in the Cheshire East Carbon Neutrality Action Plan or those set out in the Sixth Carbon Budget would result in a significant reduction in peatland GHG emissions and substantial benefits to biodiversity across the borough. However, there are likely to be significant barriers to restoration at the scale set out above. Difficulties associated with peatland restoration can range from; a lack of land ownership or a lack of influence over peatland land-owners; a lack of incentives for landowners to implement land-use change; ongoing funding to mitigate the economic consequences of a loss of productive land, and; the loss of the cultural identity and heritage associated with both upland management for grouse and lowland management for agriculture. However, with new funding sources such as the UK Government's Nature for Climate fund, carbon credits through The Peatland Carbon Code[14] and the Environmental Land Management or Biodiversity Net-gain schemes proposed in the forthcoming Environment Bill, opportunities for mitigating the economic consequences of a loss of productive land are available. The formation of effective and inclusive stakeholder partnerships to access this funding, alongside the development of strong local policy, will be vital in order to influence

[12] Blanket bog is used as a proxy here for upland peat
[13] This target could not be calculated based on the findings of this report and will require more detailed woodland modelling to estimate.
[14] https://www.iucn-uk-peatlandprogramme.org/funding-finance/introduction-peatland-code

and support landowners to adopt a more sustainable approach to peatland management, while protecting the cultural identity and heritage of these land-use sectors.

Conclusion

The peatlands of Cheshire East are in a highly degraded state. They cover an area of 3,603 ha and are the source of 48,021 tCO2e yr^{-1}. The majority of peatland emissions are the result of unsustainable land use and management across the borough. As a result of agriculture one third of the total deep peat extent contributes three quarters of all CE peatland emissions. When compared to the GHG emissions of agricultural habitats away from deep peats, the unsustainability of using peatlands for agriculture is evident. Arable land that is not located on deep peat is thought to have an emissions factor in the range of 0.29 to 0.7 tCO2e ha^{-1} yr^{-1} (Gregg *et al.* 2021), compared to an emissions factor of 37.61 tCO2e ha^{-1} yr^{-1} when croplands are located on deep peat. The emissions factor of intensive grasslands located away from deep peats is less well understood, although they are thought to have the potential to sequester carbon (Gregg *et al.* 2021) as opposed to emitting 27.54 tCO2e ha^{-1} yr^{-1} when located on deep peats. Raising the water table in order to reduce the amount of aerated peat beneath agricultural land can also result in significant emissions savings without necessarily halting its productive use (Evans *et al.* 2021). Just under half (1,696 ha or 47%) of the borough's peatlands fall within 84 sites designated for nature conservation, with the overall area split relatively evenly between statutory and non-statutory designations. As a result of the degraded nature of Cheshire East's peatlands there are significant opportunities for emissions reductions and improved biodiversity, flood management and water quality through the implementation of a combination of the following measures:

- Implementing and managing the transition of highly degraded agricultural peatlands to modified or rewetted semi-natural habitats in the lowlands;
- Implementing and managing the transition of actively eroding blanket bog peatlands to modified or rewetted semi-natural habitats in the uplands;
- Stopping the domestic extraction of peat;
- Stopping development and tree planting on peatlands;
- Targeting additional peatland habitat restoration efforts and continuing with ongoing semi-natural peatland habitat management;
- Raising the water table of agricultural land on peat, and;
- Designating additional peatlands for nature conservation.

In order to achieve the management and restoration targets as set out in the Carbon Neutrality Action Plan for Cheshire East 2020 – 2025 (Anthesis 2020) and the Sixth Carbon Budget (CCC 2020), significant changes to land use will be required across a large extent of the borough's peatland. However as a result of the range of ecosystem services peatlands provide, restoration on the scale required will deliver very high value for money green infrastructure improvement, including reduced GHG emissions, increased carbon storage and benefits to biodiversity, flood management and water quality. Nevertheless, the formation of effective and inclusive stakeholder partnerships to access new funding, alongside the development of strong local policy, is vital in order to influence and support landowners to adopt a more sustainable approach to peatland restoration and management, while protecting their cultural identity and heritage.

The next steps for peatland recovery across Cheshire East will involve identifying specific peatland opportunity areas potentially suitable for implementing the range of recovery measures identified in this assessment. This could be done as part of, or to inform a Carbon Neutral Strategy for the borough, but will also need to be included in the Cheshire East Local Nature Recovery Strategy and Nature Recovery Network.

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Appendices

Appendix 1 – Statutory and Non-Statutory Designated Sites for Nature Conservation on Deep Peat within Cheshire East

1. Midland Meres & Mosses Ramsar
2. Peak District Moors SPA
3. South Pennine Moors SAC
4. West Midlands Mosses SAC
5. Wybunbury Moss NNR/SSSI
6. Bagmere SSSI
7. Betley Mere SSSI
8. Brookhouse Moss SSSI
9. Chapel Mere SSSI
10. Danes Moss SSSI
11. Gleads Moss SSSI
12. Goyt Valley SSSI
13. Leek Moors SSSI
14. Norbury Meres SSSI
15. Oakhanger Moss SSSI
16. Quoisley Meres SSSI
17. Sandbach Flashes SSSI
18. Sound Heath SSSI
19. Cranberry Moss LNR
20. Sound Common LNR
21. Allgreave to Birchenough Hill LWS
22. Baddiley Meres LWS
23. Basford Brook LWS
24. Berry Bank Moss LWS
25. Bexton Wood LWS
26. Bibbys Moss LWS
27. Big Wood, Henbury LWS
28. Blakenhall Moss LWS
29. Brookhouse Swamp LWS
30. Bunbury Heath Marsh LWS
31. Carr Woodland LWS
32. Cheshire's Close LWS
33. Cobbs Moss and Wybunbury Mere LWS
34. Cocksmoss Wood LWS
35. Congleton Moss LWS
36. Cranberry Moss LWS
37. Crofton Knoll Meadow LWS
38. Cuckoo Moss to Wood Moss LWS
39. Danes Moss LWS
40. Deer Park Mere LWS
41. Doddington Pool LWS
42. Dragons Lake & Moston House Fields LWS
43. Dunge Farm LWS
44. Gawsworth Common, Whitemoor Hill and Ratcliffe Wood (south - west) LWS
45. Haughton Moss LWS
46. Henbury Lee Meadows LWS
47. High Moor and Piggford Moor LWS
48. Highbirch Wood LWS
49. Holfords Moss Wood LWS
50. Isles Wood LWS
51. Lindow End LWS
52. Lindow Moss and Morely Green Heath LWS
53. Lindow Moss Woods & Newgate Nature Reserve LWS
54. Little Marbury Mere LWS
55. Lower Moss Wood LWS
56. Lyme Park, Grassland and Woodland LWS
57. Macclesfield Canal LWS
58. Macclesfield Forest LWS
59. Marbury Big Mere LWS
60. Marley Moss LWS
61. Marsh South of Bagmere LWS
62. Marton Heath Wood LWS
63. Mere Moss LWS
64. Moorhead Farm March LWS
65. Moss Farm Wood LWS
66. Pinfold Farm Mere LWS
67. Redesmere LWS
68. Redmoor LWS
69. Saltersely Hall Farm LWS
70. Saltersey Moss LWS
71. Shell Brook LWS
72. Shellow Wood LWS
73. Shropshire Union Canal (Burland to Marbury) LWS
74. Shutlingsloe LWS
75. Sossmoss Wood LWS
76. Stockin Moss LWS
77. Taxmere LWS
78. The Moss Somerford LWS
79. Tidnock Wood LWS
80. Todd Brook LWS
81. Town House Wood LWS
82. White Moss LWS
83. Winterley Pool LWS
84. Yew Tree Farm, Moss End LWS