



The Peak District National Park Authority owned and managed Estate Carbon Project 2021/22



Carbon footprint by the Environmental Quality Mark
Community Interest Company

The Peak Carbon Tool

A bespoke carbon footprinting tool for the UK uplands

Summary - The Peak District National Park owned Estate Carbon Project 2021/22

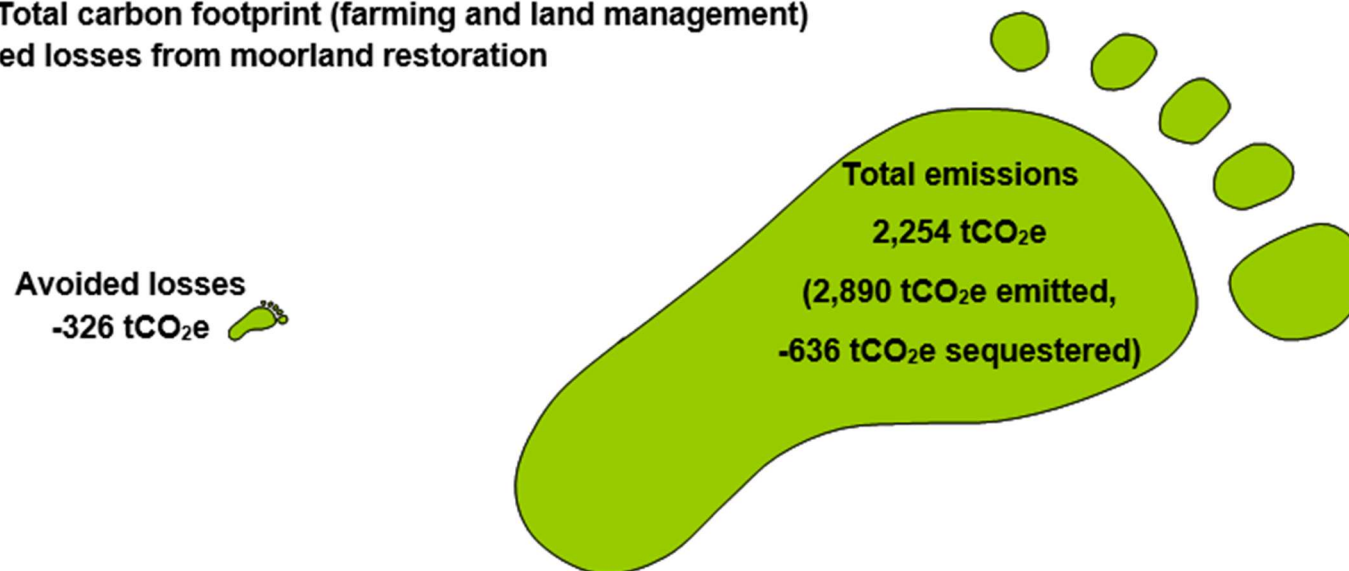
The Peak District National Park Authority (PDNPA) have measured and modelled carbon emissions, sequestration and storage for their owned and managed Estate. PDNPA owns 6,070 ha (15,000 acres), including the Warslow Moors Estate, North Lees, the Monsal, High Peak, Tissington and Thornhill trails, Eastern Moors Estate, The Roaches various woodland and some operational properties. The Eastern Moors Estate, The Roaches and part of the Warslow Moors Estate are managed by third parties on long term tenancies and therefore are excluded from this study. Emissions from PDNPA's own operations (for example PDNPA office and building energy use and staff vehicles) and let domestic and commercial properties across the owned and managed Estate are captured by existing carbon reporting so are also excluded from the scope of this study. The study focuses on the 2,550 ha (6,300 acre) of the Estate that is managed by the PDNPA for conservation of the high-quality wildlife habitats and heritage, and also access and recreation, in line with National Park purposes.

A conventional carbon footprint measures greenhouse gas emissions. However, this is not the whole story in a protected upland landscape such as the Peak District. The amount of carbon annually sequestered (absorbed) and stored over the long term by different habitats and soils adds an extra dimension. Furthermore, the significant reductions in carbon emissions from peat associated with moorland restoration projects, referred to as 'avoided losses', play an important role in the carbon management story for this type of extensively managed upland landscape.

This study used the PDNPA's bespoke Peak Carbon Tool to measure and model carbon for the Estate for 12 months, from 1 April 2021 to 31 March 2022.

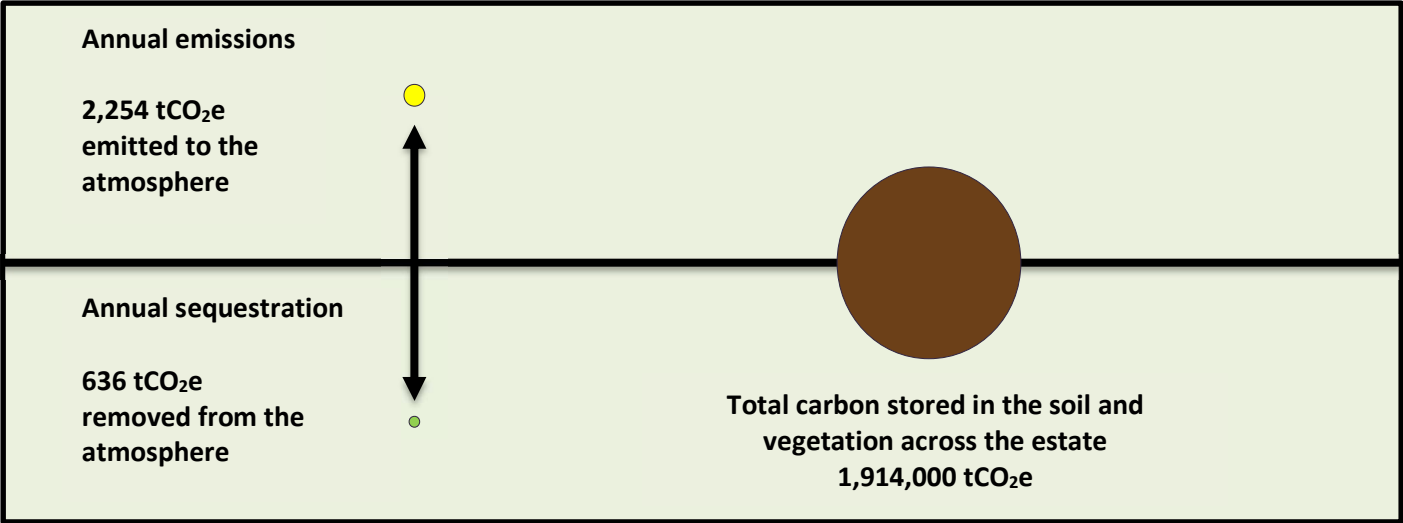
The overall footprint of the Peak District National Park owned and managed Estate is 2,254 tCO₂e, comprising 2,890 tCO₂e emissions minus -636 tCO₂e sequestration. There are also -326 tCO₂e of avoided losses. If these emissions are divided up across the area of the Estate this gives rise to emissions of **0.88 tCO₂e per hectare**.

Figure 1: Total carbon footprint (farming and land management) and avoided losses from moorland restoration



Carbon dioxide equivalent (CO₂e) is a unit used to compare the climatic effect of various gases to that of carbon dioxide. It gives the mass (kg or tonnes) of CO₂ that would have the same climatic effect. For example, the global warming potential of methane is 25 times greater than carbon dioxide and this unit of measurement takes this difference into account.

The study also showed that carbon stored in the Estate soils and vegetation is significant compared to annual emissions or sequestration (absorption from the atmosphere). Indeed, over 660 times more carbon is stored compared to the amount emitted or sequestered in a year. The following graph shows this:



This project highlights the role of upland farmers and land managers as ‘carbon stewards’. The current management of the Peak District National Park owned Estate delivers a range of already well recognised public benefits, e.g. habitats, species, cultural heritage and access. This report also highlights the importance of the Estate in terms of carbon storage.

1. About this report

This report sets out the findings of an innovative and holistic study to measure carbon emissions, sequestration and storage for the Peak District National Park owned and managed Estate.

Until this study, the impact of PDNPA's approach to land management across its estate on carbon emissions and climate change had not been fully known. A previous study modelled carbon for the Warslow Moors Estate for the period 2016/2017. Since this time the UK government have published data on carbon emissions, storage and sequestration by various habitats (Natural England publication NERR094 - Carbon Storage and Sequestration by Habitat 2021). The PDNPA has commissioned this report to quantify the carbon impact of its Estate management using the most up to date UK government adopted carbon data.

A conventional carbon footprint calculation identifies the quantity and source of carbon dioxide, methane and nitrous oxide (greenhouse gases) emitted by a given product or activity. However, the Peak District Environmental Quality Mark Carbon Project demonstrated in 2009 that carbon emissions are not the whole story in a protected upland landscape such as the Peak District. The amount of carbon annually sequestered (absorbed) and stored over the long term by different habitats and soils adds an extra dimension to the carbon management story for this type of extensively managed upland landscape.

This report therefore not only reports the carbon emissions for a year in the life of the Peak District National Park owned and managed Estate, it also explores the extent to which the Estate is sequestering and storing carbon in its soils and vegetation, and whether the activity on the land has led to significant emission reductions or avoided losses. This study used the Peak District National Park Authority's Peak Carbon Tool to measure and model carbon.

2. About the Peak Carbon Tool

The carbon footprint for the Peak District National Park owned Estate was measured using the Peak District National Park Authority's bespoke Peak Carbon Tool. In 2009 the Peak District National Park Authority commissioned ADAS (one of the country's leading agri-consultants) to build a bespoke carbon footprinting tool for the uplands as part of a study of Environmental Quality Mark farms. It has periodically been updated by ADAS at PDNPA's request, with the most recent 2023 update now including the officially adopted UK carbon data from the Forestry Commission's Woodland Carbon Code and also the Peatland Code, as well as Natural England publication NERR094 - Carbon Storage and Sequestration by Habitat 2021.

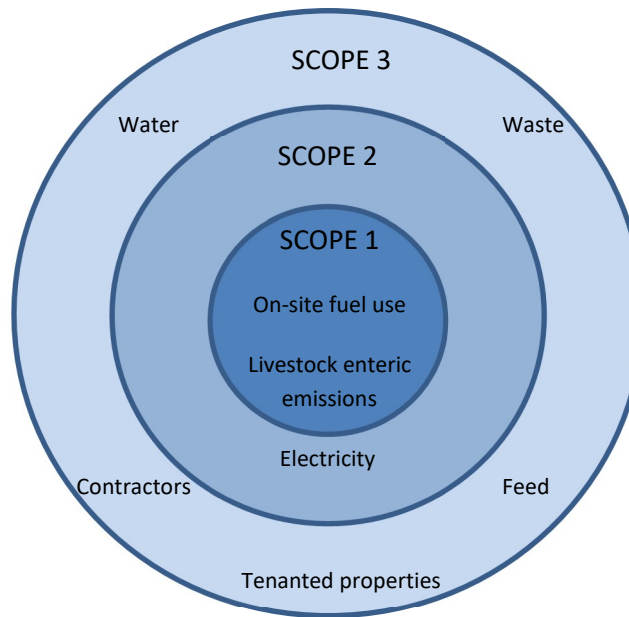
The tool was developed to better assess the story of carbon in the uplands. Other methods for measuring the carbon footprint of farming and land use focus on carbon emissions, whether this be from an annual cycle of activity or emissions relating to a product, e.g. a kilogram of meat. The PDNPA's Peak Carbon Tool takes an innovative and holistic perspective of carbon emissions, the annual rate of sequestration, the amount of carbon stored in the soils and vegetation on farm on a long term basis, and also avoided losses resulting from moorland restoration projects. As many Peak District farms have diversified to support the farming income, the tool also measures carbon associated with diversification activities, whereas other land-based carbon footprinting tools exclude this.

2.1 The Peak Carbon Tool scope

The scope of a carbon footprint is often defined according to the level of control possible over the emissions being measured, and are categorised as scope 1, 2 or 3. Scope 1 and 2 cover direct emissions from operation and include the use of fuels and electricity. Scope 3 includes emissions arising from sources such as waste or water and are generally emissions over which there is no direct control (for instance, it is possible for the consumer to control the amount of water used but not the amount of emissions caused during water treatment and supply). It is usual to include scope 1 and 2 emissions as standard and the scope 3 emissions which are appropriate to the focus of the carbon measurement.

The PDNPA's Peak Carbon Tool includes scope 1, 2 and 3 emissions, as shown in the diagram below.

Examples of the types of emissions measured by the Peak District National Park Authority's Peak Carbon Tool that fall into scope 1, 2 and 3



How the Tool assesses carbon emissions

The tool takes account of emissions that occur up to the farm gate, but excludes emissions for subsequent product processing, use in food manufacture, retail, cooking, consumption, and end-of-life disposal of waste.

How the Tool assesses carbon sequestration

Soil and vegetation carbon sequestration is the transfer of carbon from carbon dioxide in the atmosphere to organic matter in soil and vegetation. The amount of carbon sequestration is expressed in units of mass of CO₂e per year and can be subtracted from the emissions expressed as CO₂e per year.

How the Tool assesses carbon storage

The Tool estimates the amount of carbon stored in soil and vegetation (i.e. carbon at the start of the assessment year and not emitted during that year) and reports this in units of mass of CO₂e, separately to the carbon footprint. This stored carbon is not part of the carbon footprint because it is neither emitted to the atmosphere, nor sequestered from the atmosphere within the assessment period, so has no impact on global warming. However, the assessment of this stored carbon raises awareness of the potential for this stored carbon to be emitted to the atmosphere if land use change occurs.

2.2 Methodology

The Peak District National Park owned and managed Estate farm tenants were invited to participate in this study by providing their data (for example, energy and fuel use and livestock types and numbers). This data was collected through interviews, either by telephone or face-to-face during farm visits. Data was added to the Peak Carbon Tool, which calculated the carbon footprint for that farm and presented the results in a series of graphs and charts. Farmers that had not previously participated in the Warslow Moors Estate carbon study were provided with an individual carbon footprint report, with hints and tips for reducing their carbon emissions and for saving money.

For the Estate land that is managed in-hand by the PDNPA, a series of interviews were conducted with the relevant staff to gain information about habitat areas, type and management. Information was also collated from agri-environment agreement data and annual grazing and mowing licence documentation where relevant.

The data from all the tenanted farms was then collated, along with data from the in-hand Estate land including woodlands, trails and operational properties, to form an Estate-wide carbon calculation.

Emissions from PDNPA's own operations (for example PDNPA office and building energy use and staff vehicles) and let domestic and commercial properties across the owned and managed Estate are captured by existing carbon reporting so are excluded from the scope of this study. The study focuses on the Estate land that is owned and managed by the PDNPA.

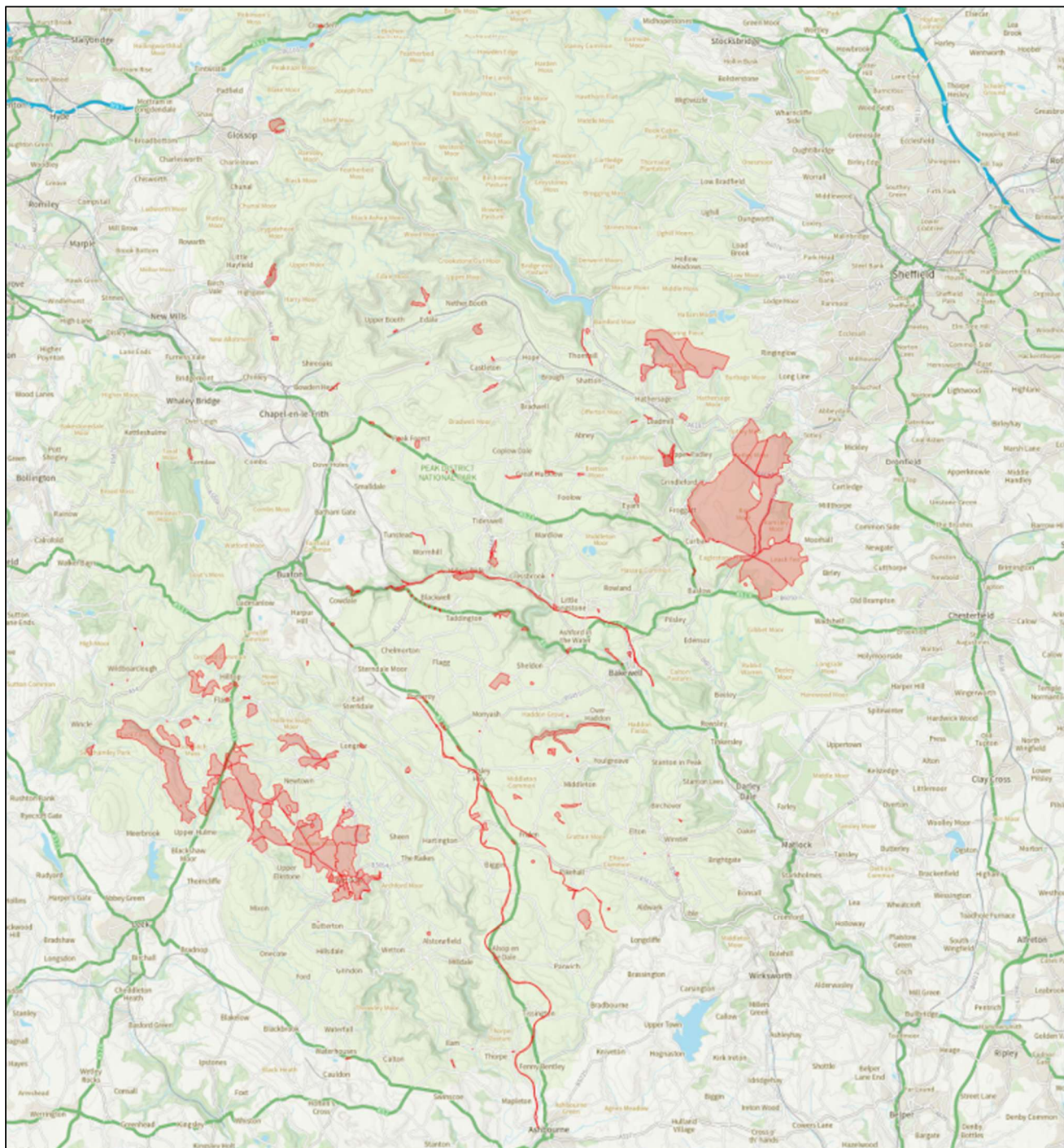
3. About the Estate

The Authority owns or leases a diverse range of property within the National Park including about 6,070 hectares (15,000 acres) of land, largely comprising moorland, woodland and grass farmland, and approximately 330 'built assets'.

The land is around 5% of the whole National Park area and includes four rural estates: Warslow, North Lees, Eastern Moors and The Roaches; land associated with cycle trails, car parks and operational bases; 65 woodlands including estate woodlands and individual woods; 21 'Minor Properties' being a range of sites usually with some heritage or ecological interest; and 20 car parks some of which are pay and display.

The built assets include 21 operational buildings such as office sites, Visitor Centres, Cycle Hire Centres, public toilets, ranger and estate bases, campsites, holiday cottage and volunteer accommodation; 32 residential buildings on the Authority's rural estates, mostly being of traditional vernacular construction and providing a home for over 80 people; 135 agricultural buildings being a mix of traditional and modern construction; 4 former railway lines used as cycle trails which included 140 structures ranging in scale from cattle creeps to the iconic Monsal Dale viaduct and 7 former railway tunnels.

The Authority has acquired the properties over many years, either for specific operational reasons or because acquisition was seen as the best or only means of achieving National Park purposes. The 'peak period' was in the 1980s when the Monsal Trail, Eastern Moors and Warslow Moors estates were acquired. Ownership and management of assets now allows the Authority to directly achieve its purposes, demonstrate best practice, generate income, enable engagement and recreation in the National Park and generate income.



3.1 The scope of this study

The Eastern Moors Estate, The Roaches and part of the Warslow Moors Estate are managed by third parties on long term tenancies and therefore are excluded from this study. Emissions from PDNPA's own operations (for example PDNPA office and building energy use and staff vehicles) are captured by existing reporting and are also excluded from the scope of this study. The study focuses on the 2,550 ha (6,300 acre) of the Estate that is managed by the Authority for conservation of the high-quality wildlife habitats and heritage, and also access and recreation, in line with National Park purposes.

Map 1: The Peak District National Park owned Estate

Map centre grid ref: 417,434 374,487

Scale at A2: 1:125,000

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4. Farming activity and diversification

The 15 tenanted farms on the Estate are all livestock enterprises and comprise:

- 11 beef and sheep, one of which is a sub-let for grass feeding
- 2 beef & poultry
- 1 beef
- 1 dairy

There is some limited diversification activity on the Estate farms: one of the Warslow Moors tenants has a pub, another has holiday accommodation, one has a cutting room and does direct meat sales and another does direct egg & potato sales. The tenants of North Lees Farm also do direct meat sales and sell their meat at events through a catering van. Five farming tenants have part time or full time off-farm work in addition to their farming activities.

5. What is a carbon footprint?

A carbon footprint can be defined as an impact on global warming, and can be assessed for nations, organisations (e.g. businesses) or products. A carbon footprint is expressed as a quantity of greenhouse gas emissions per unit of production for a product, or as a total for an organisation. An assessment includes emissions of CO₂, and other gases that have global warming potential (i.e. greenhouse gases), such as nitrous oxide (N₂O), methane (CH₄) and some refrigerant gases. The quantity of greenhouse gas emissions is given as mass (e.g. kg or tonnes) of carbon dioxide equivalent (CO₂e). This is the mass of CO₂ that would have the equivalent global warming potential as the mass of all greenhouse gases emitted.

Emissions of N₂O and CH₄ are important in agriculture because they have high global warming potential relative to CO₂. For example, the global warming potential of methane is about 25 times greater than carbon dioxide and a carbon footprint takes this difference into account.

In this project a carbon footprint has been assessed for the Peak District National Park Authority's Peak District National Park owned and managed Estate. The UK has ambitious, legally binding targets to meet as part of the UK Climate Change Act, and agriculture and land management have an important role in meeting these targets.

How much carbon is emitted, sequestered or stored is a function of the type of land (i.e. soil type, habitat type) and land use, for example whether and how the land is farmed or managed. The numbers and type of livestock form a significant element of the carbon emitted from land, as does energy use for heating and lighting buildings and for vehicles and machinery. There is also embedded carbon in goods purchased and used, such as animal feeds.

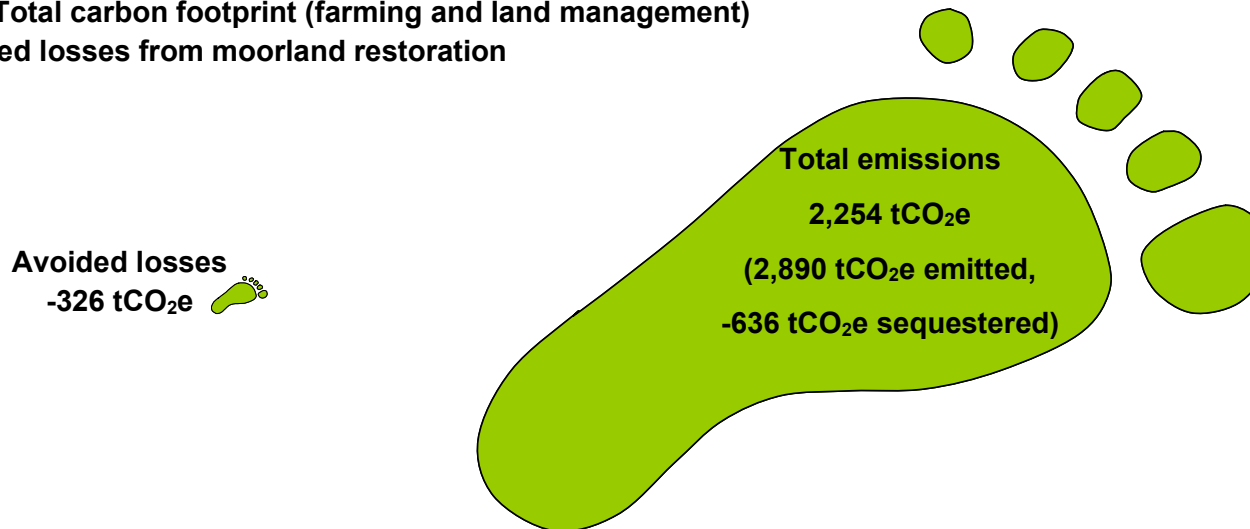
6. Results

6.1 Total owned and managed Estate footprint: what does it include?

- Emissions from all energy (fuel and electricity) for farming and land management activity
- Farming activity emissions including:
 - emissions from livestock
 - emissions associated with livestock feed (produced on farm or purchased/delivered)
 - emissions from livestock manures
 - emissions from soils
- The annual increase in sequestered carbon across the Estate (carbon taken up by the soil).
- The total amount of carbon stored in the soils and vegetation year after year.

The overall footprint of the Peak District National Park owned and managed Estate is 2,254 tCO₂e, comprising 2,890 tCO₂e emissions minus -636 tCO₂e sequestration. There are also -326 tCO₂e of avoided losses.

Figure 1: Total carbon footprint (farming and land management) and avoided losses from moorland restoration

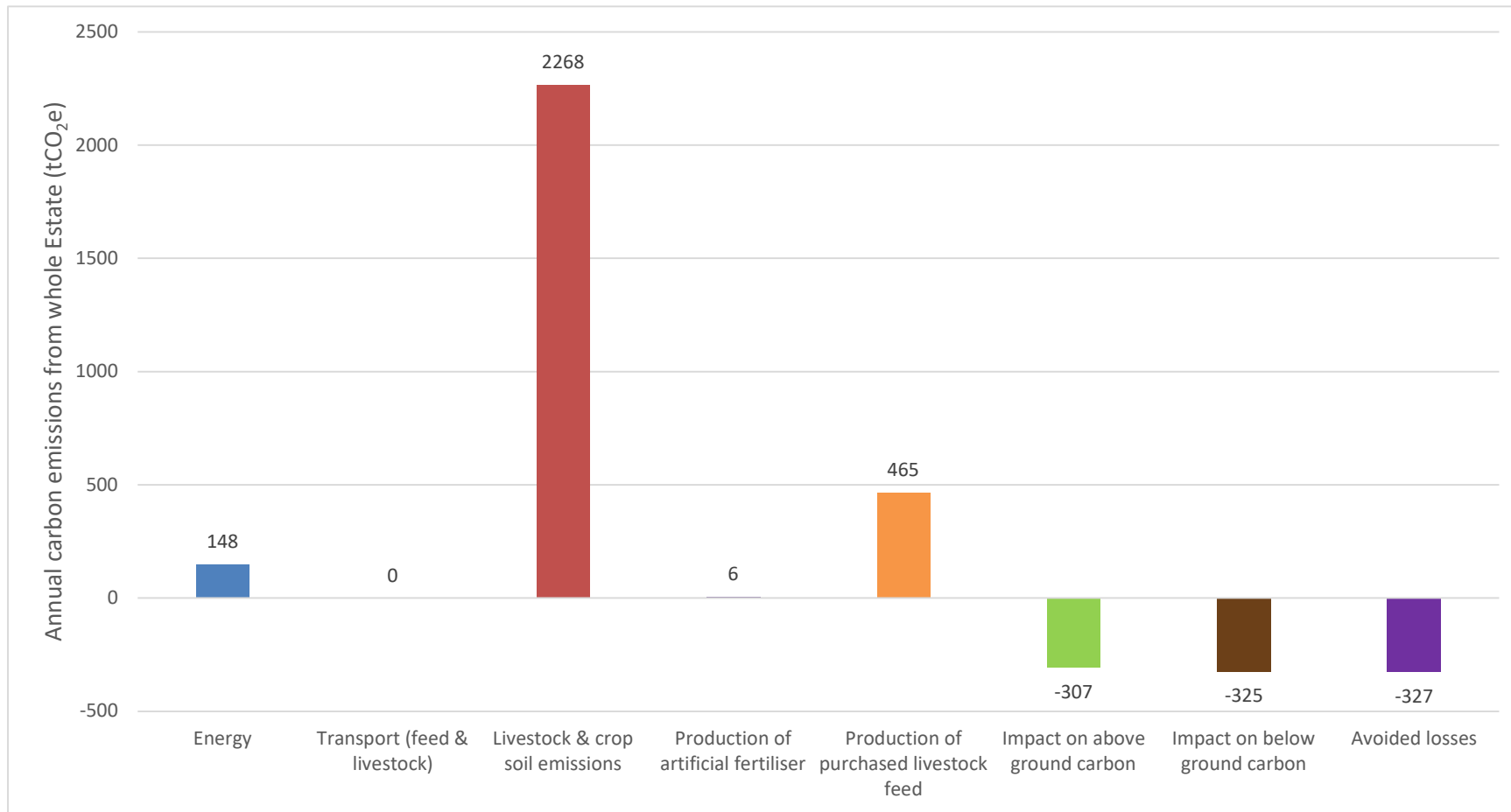


Moorland greenhouse gas emissions and 'avoided losses'

A number of carbon codes and studies relating to peat soils have been published by conservation bodies, including the 'Peatland Code' and 'Implementation of an Emissions Inventory for UK Peatlands 2017', the data from which has now been adopted and incorporated into UK carbon emissions reporting. These documents show UK peatland, on the whole, to be emitting carbon, even for many years following restoration, although on the path to a near natural state sequestering habitat. Moorland restoration projects therefore refer to the carbon savings resulting from their work as 'avoided losses' rather than 'sequestration', as in the short to medium term they are substantially reducing the emissions rather than establishing a sequestering habitat.

Figure 2 below shows how the overall owned and managed Estate carbon footprint is made up, showing emissions from farming and land management, farm diversification and domestic emissions and highlighting the carbon 'hotspots' which could be further investigated.

Figure 2: Annual carbon balance - emissions and sequestration from different sources (tCO₂e)



6.2 Farming and land management footprint

The total emissions for the farming and land management for the Estate are 2,890 tCO₂e per year. A total of 636 tCO₂e must be subtracted because it is sequestered (absorbed by) the grassland, moorland and woodland each year. This gives an overall carbon balance for the owned and managed Estate land of 2,254 tCO₂e per year. If these emissions are divided up across the area of the Estate this gives rise to emissions of **0.88 tCO₂e per hectare**.

Figure 2 above shows the main carbon hotspot for the Estate is the farming activity with livestock emitting most greenhouse gases, followed by the production of purchased livestock feed, though these are an order of magnitude less than livestock emissions. The next greatest source of emissions is energy use, including electricity and fuel used during farming activities. Smaller again by two orders of magnitude are the emissions from the production of artificial fertiliser.

There is a significant negative value for impact on below and above ground carbon, showing that overall the Estate land sequesters (absorbs) large amounts of carbon each year, either via the soil or the vegetation. However, this is still a much smaller amount than is emitted by the livestock used for the management of the Estate.

There are also avoided losses, which are carbon emissions that have been avoided as a result of moorland restoration. These equate to approximately half the annual sequestration rate for the owned and managed Estate. They do not form part of the carbon footprint, as they are emissions that would have happened had it not been for moorland restoration. They are reported alongside the footprint.

Figures 3, 4 and 5 below give further detail of the greatest source of emissions (livestock and soil) and the greatest sources of sequestration (land use and habitats).

Figure 3: Total nitrous oxide and methane emissions from livestock (tCO₂e / year)

Figure 3 shows that enteric methane emissions, arising from fermentation of feed in the rumen of cattle and sheep, form the greatest proportion (71%), followed by nitrous oxide emissions from animals grazing (22%). The remaining livestock emissions arise from storage and application of manures and slurry.

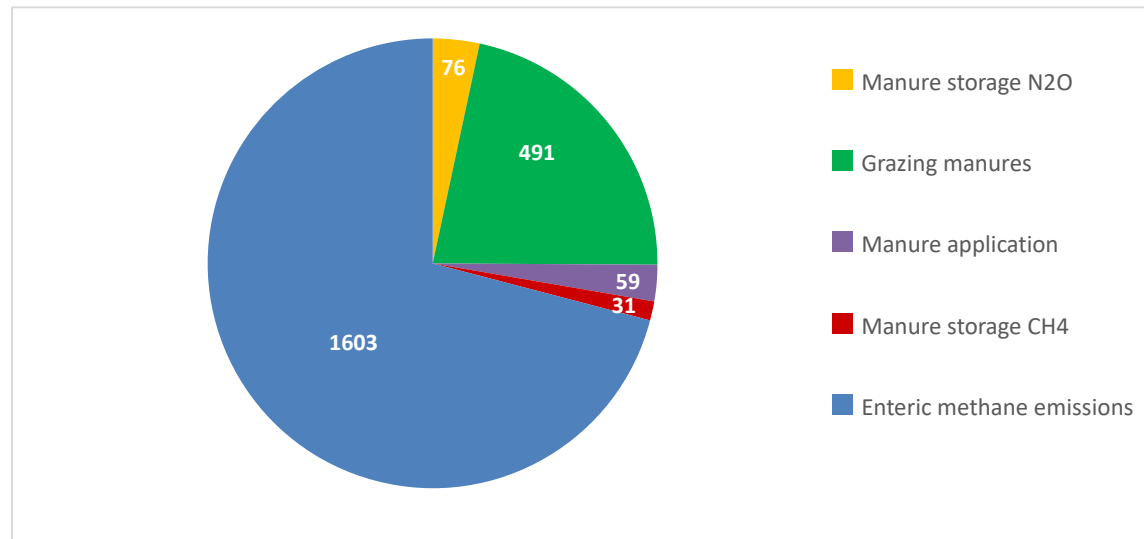


Figure 4 below shows further details about the source of emissions from livestock. Nitrous oxide and methane from beef cattle comprise the highest proportion of total livestock emissions, followed by dairy cattle and then sheep, which both cause very similar amounts of emissions. The makeup of livestock needs to be considered with caution, as a full audit of livestock present on the Estate was not conducted for this study. A picture of livestock numbers and types was created from information provided by the 15 farming tenants, and from assumptions made based on data from grazing licences for land managed in-hand. The proportion of beef cattle, dairy cattle sheep across the owned and managed Estate is not therefore accurate and may well overestimate beef cattle and underestimate sheep. However, irrespective of the break-down between livestock types, grazing livestock form the largest source of emissions arising from the Estate. The application of artificial nitrogen fertiliser also contributes to the emissions.

Figure 4: Further detail of livestock and soil emissions including methane and nitrous oxide

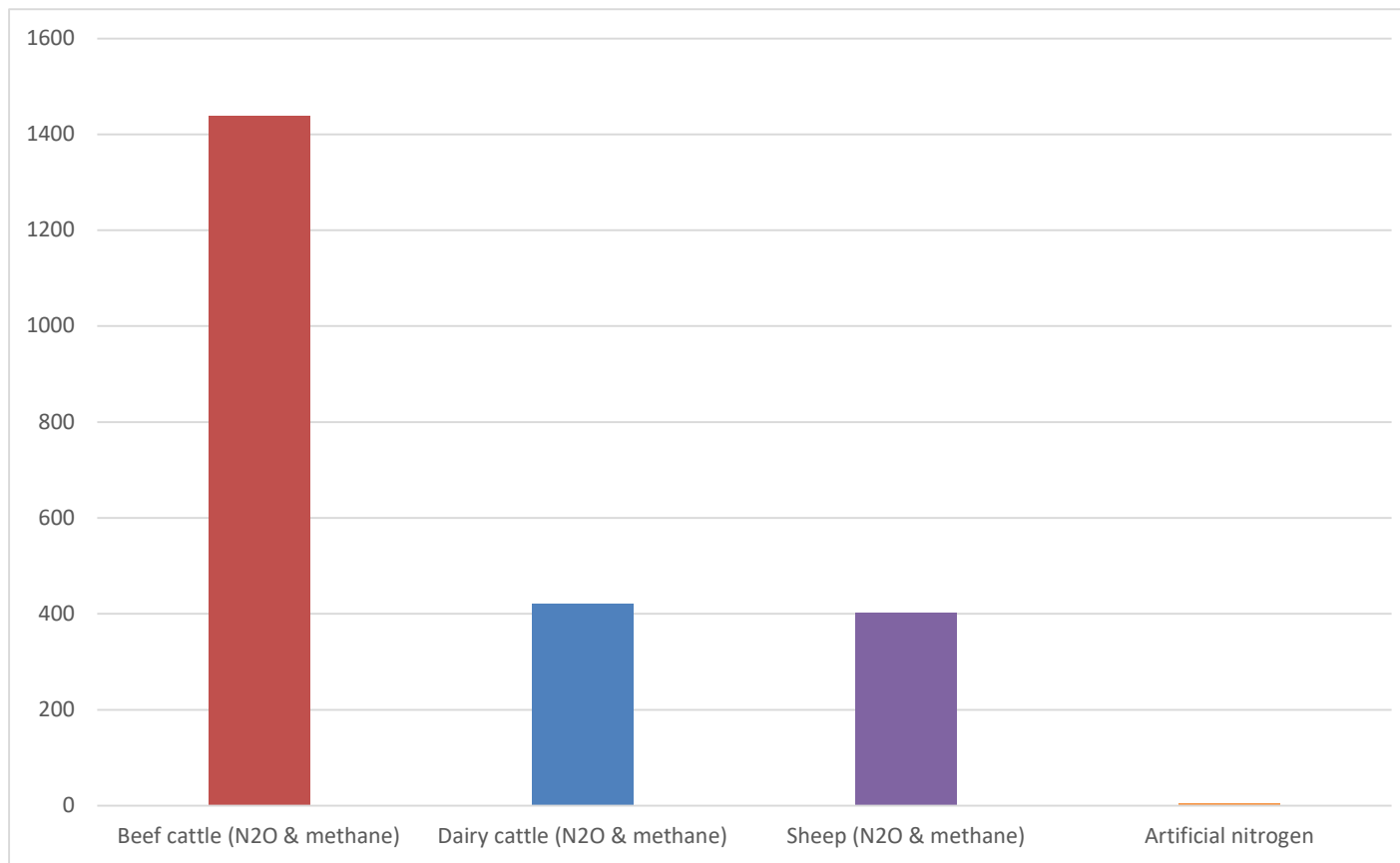
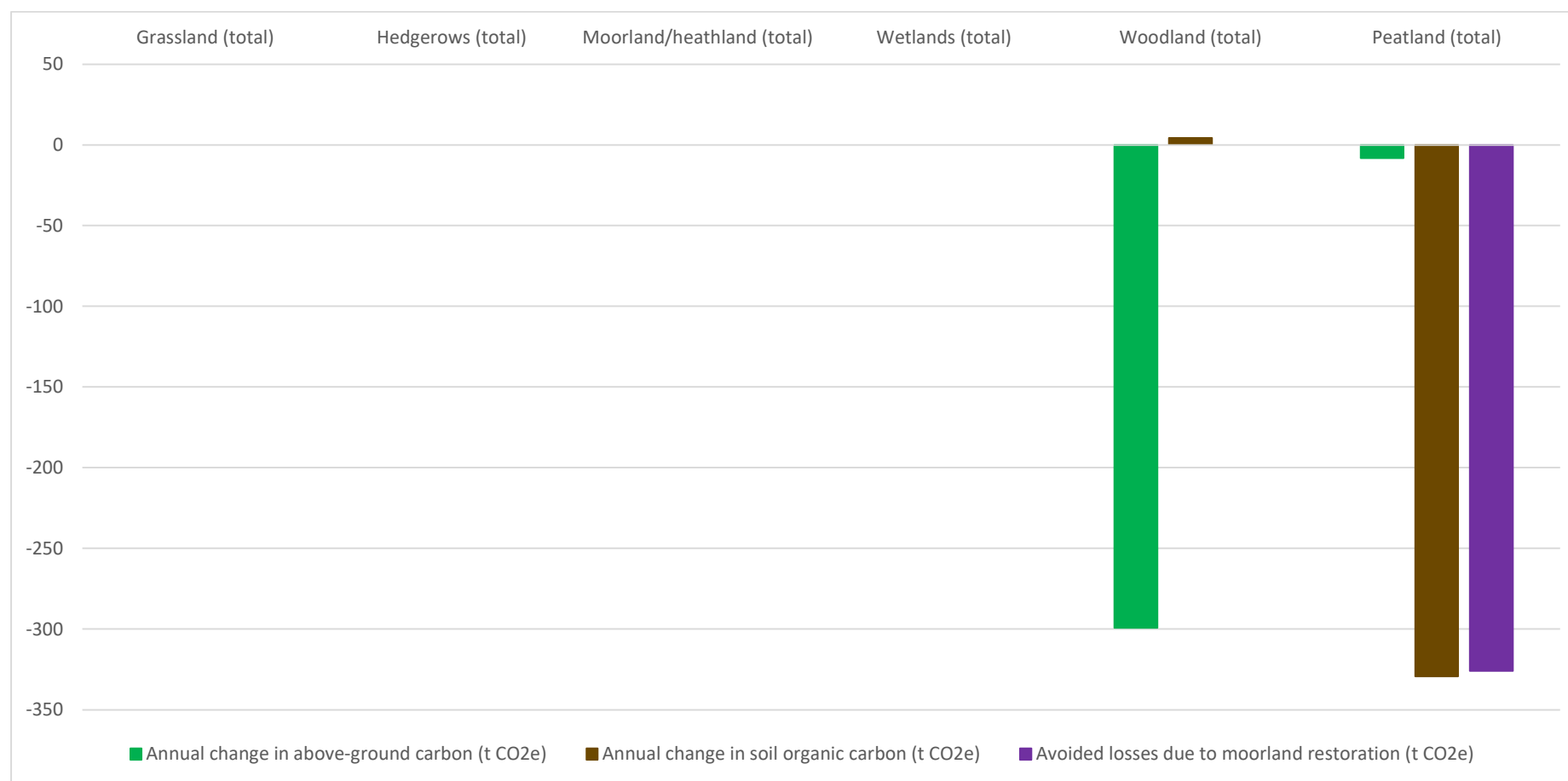


Figure 5 below shows the woodlands across the Estate sequester significant amounts of carbon, along with moorland in good condition. Woodland soils also emit comparatively small quantities of CO₂e. Other habitats do not have significant enough emissions or sequestration to show on the graph in comparison to these habitats. Indeed grassland is considered to be in equilibrium, in other words, it is in balance between the amount of carbon sequestered and the amount of carbon emitted throughout the year. The graph also shows avoided losses – the emissions that have been avoided as a result of moorland restoration work. Avoided losses do not form part of the carbon footprint, but are reported alongside it.

Figure 5: Further detail of emissions and sequestration from land use and habitats across the Estate, as well as avoided losses



6.3 The overall picture: carbon emissions, carbon sequestration and carbon storage across the owned and managed Estate

Carbon sequestration occurs as a result of the rate of biomass accumulation (plant growth) exceeding the rate of decomposition (plants dying and breaking down). It is estimated that the rate of sequestration for the Estate is **-636 tCO₂e** per year.

Farmland stores carbon in the soil and vegetation. If there is no land use change this carbon remains in the soil and vegetation, with little added or lost. Across the Estate there is an estimated **1,914,000 tCO₂e** stored in the soils and vegetation.

Land management is important in protecting this carbon. If any significant land use change occurs, e.g. ploughing of permanent pasture, or degradation of moorland, there is the potential for stored carbon to be lost to the atmosphere in much greater amounts than the emissions from the livestock. There has been little land use change on the Estate in the last 20 years, so large quantities of stored carbon remain intact. Moorland restoration has resulted in -326 tCO₂e of avoided losses.

The diagram in Figure 6 below shows the annual emissions and sequestration (small dots) from the farming and land management in relation to the stored carbon (large circle) across the Estate. The size of the bubbles relates to the amount of carbon. The larger the bubble the more carbon is present. Bubbles above the line are emitted into the atmosphere, whereas those below the line are removed from the atmosphere. The very large bubble for soil carbon is the amount of carbon that is stored over the long term within the soil and vegetation.

Figure 6: Total carbon balance for the owned and managed Estate – aggregated carbon emissions, sequestration and storage

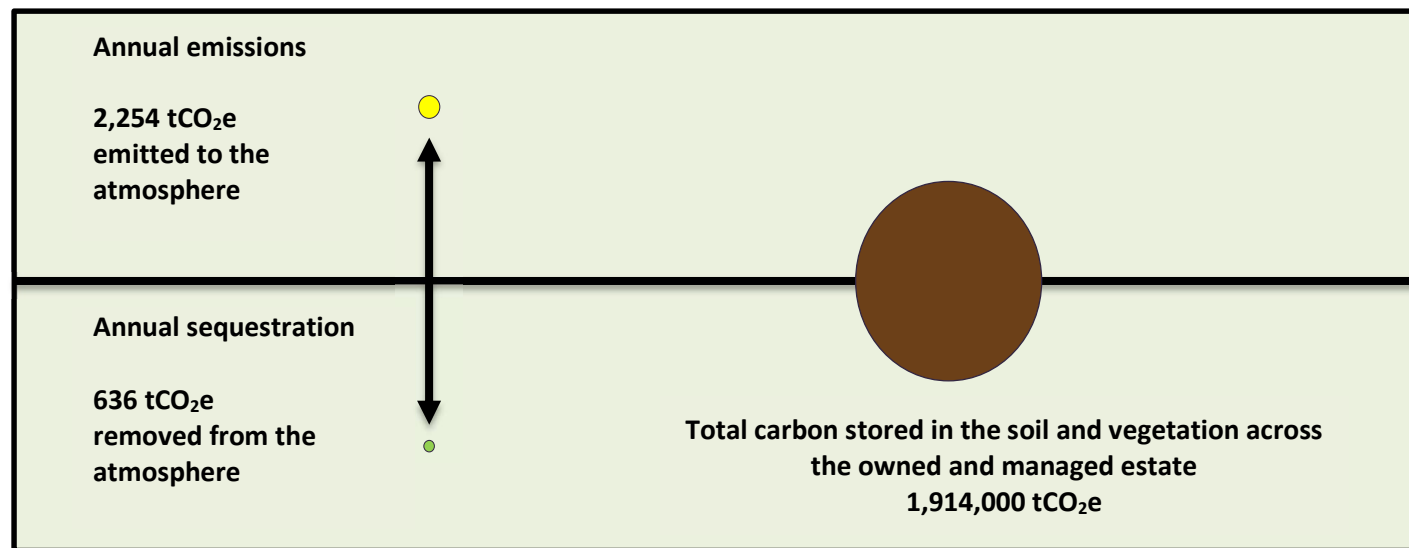
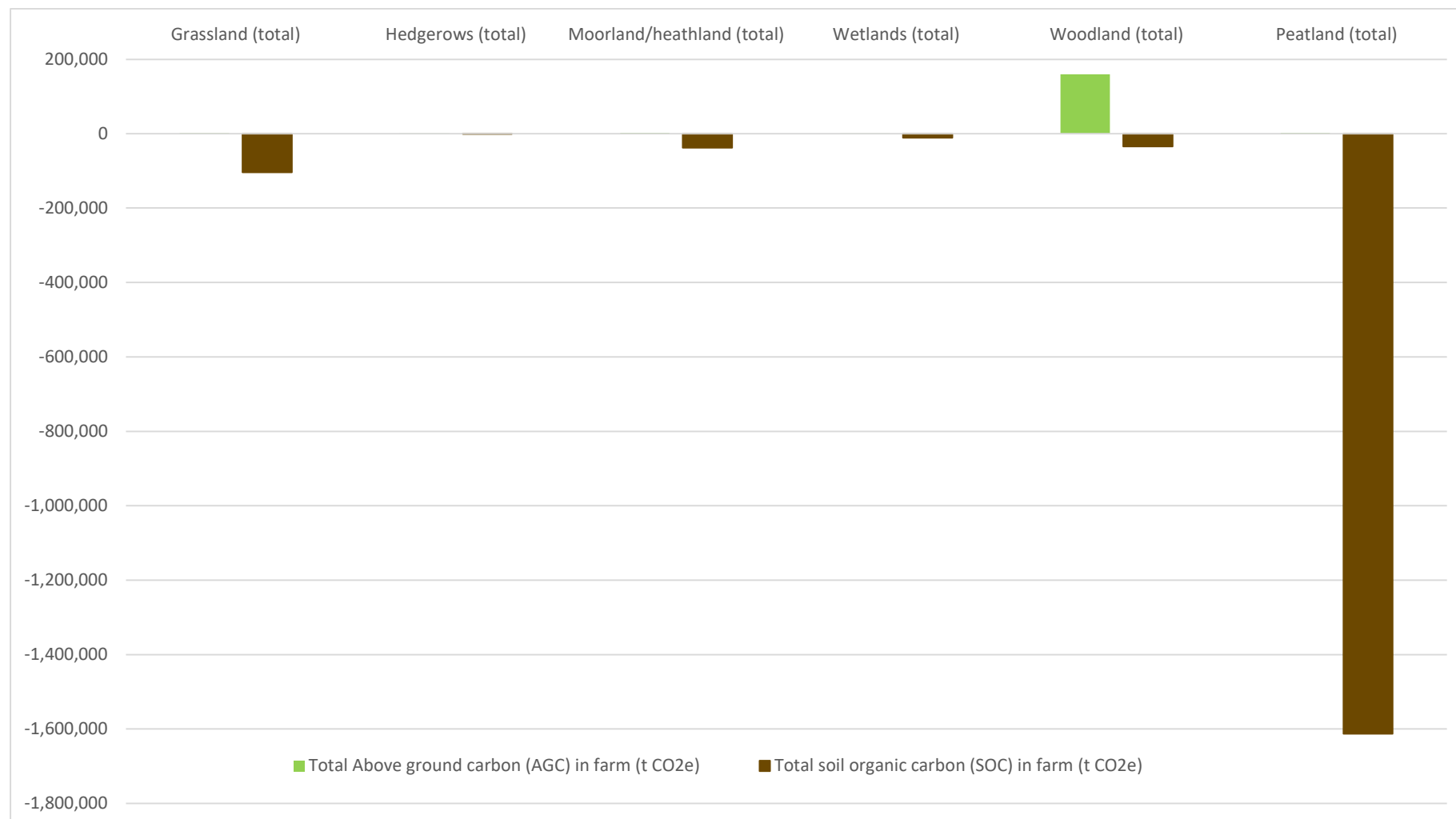


Figure 7 further breaks down which habitats store carbon across the Estate and whether it is stored above ground in plant biomass or below ground in soils. The graph shows that moorland stores by far the most carbon below ground in peatland soils, around 1.6 million tonnes of the 1.9 million total. Woodlands store eight times less carbon than moorland, but still significant amounts (around 195 thousand tonnes). Grassland soils also store over 100 thousand tonnes of carbon, with other habitats storing smaller amounts both in biomass and soils.

Figure 7: Stored carbon across the Estate, by habitat type - above and below ground



7. Conclusions

This study demonstrates that managing the Peak District National Park owned and managed Estate for conservation of the high-quality wildlife habitats and heritage, also confers carbon management benefits. It shows that the overall emissions for the Estate are relatively low: only 2,254 tCO₂e per year overall for the year of the study, which is 0.88 tCO₂e per hectare. The study also shows that significant amounts of carbon are stored within the soils of the Estate, particularly the moorland peat soils. Indeed, over 660 times more carbon is stored, compared to the amount emitted in a year.

As with many upland protected landscapes, extensive grazing of livestock is currently used across the Estate to deliver environmental management of key habitats. The carbon footprint for meat from extensive grazing systems is generally higher than for intensive systems. This is because extensively grazed livestock typically grow more slowly and live for longer and therefore produce less meat and emit more CO₂ equivalent during their life. However, the amount of carbon annually sequestered and stored over the long term by the Estate habitats and soils adds an extra dimension to the carbon management story: the present day extensively farmed approach protects important stored soil carbon.

This study highlights the role of upland farmers and land managers as ‘carbon stewards’, which is perhaps something to raise awareness about and celebrate, as many will not be aware of the positive role they are playing. By storing carbon, preventing its release to the atmosphere and thus avoiding its contribution to climate change, the current management of the Peak District National Park owned Estate is delivering carbon management as a public benefit.

8. Carbon context

- The UK Agri-Climate Report 2023 states that agriculture accounted for around 11% of UK greenhouse gas emissions in 2021¹.
- Farming is different to other sectors in that the majority of farming emissions come from methane produced by livestock and their manure, or nitrous oxide produced from fertilisers.
- The UK adopted the Climate Change Act in November 2008, which following amendment in 2019 sets the UK legally binding targets to achieve net zero carbon emissions by 2050².
- To provide some context to the carbon dioxide equivalent (CO₂e) values used in this report, an average family diesel car travelling 10,000 miles in one year will emit 3 t CO₂e / year³.
- The average family home (1930s) emits 8 t CO₂ / year⁴
- Typical emissions from 1 ha for feed wheat are 4.4 t CO₂e / year⁵

¹ <https://www.gov.uk/government/statistics/agri-climate-report-2023/agri-climate-report-2023>

² <https://www.legislation.gov.uk/ukpga/2008/27/contents>

³ <http://www.defra.gov.uk/environment/business/reporting/conversion-factors.htm>

⁴ <https://heatable.co.uk/boiler-advice/average-carbon-footprint>

⁵ Defra FO0404 report – PAS2050 assessments

9. Glossary of terms

Carbon footprint	A 'carbon footprint' measures the total greenhouse gas emissions caused directly and indirectly by a person, organisation, event or product. The main types of carbon footprint are: <u>Organisational / Farm</u>: emissions from all the activities across the organisation, including energy use, industrial processes and business vehicles. <u>Product</u>: emissions over the whole life of a product, from the extraction of raw materials and manufacturing right through to its use and final reuse, recycling or disposal.
Carbon dioxide equivalent (CO ₂ e)	Carbon dioxide equivalent (CO ₂ e) is a unit used to compare the climatic effect of various gases to that of carbon dioxide. It gives the mass (kg or tonnes) of CO ₂ that would have the same climatic effect. For example the global warming potential of methane is 25 times greater than carbon dioxide and this unit of measurement takes this difference into account.
Carbon sequestration	The long term removal of carbon from the atmosphere, e.g. by the soil and plants, expressed on an annual basis.
Carbon storage, or stored carbon	Carbon that is present in soil and vegetation.
Carbon balance	This is used in this report to indicate the difference between the emissions arising from the business and the sequestration of carbon.
Net zero	The UN definition ⁶ of net zero is cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance. Net zero must cover scope 1, 2 & 3 emissions, i.e. both direct emissions e.g. from burning fuel on farm and indirect emissions e.g. from electricity use, purchased goods and waste.

10. Acknowledgments

The project team for this study comprised Matthew Freestone, Catherine Johnson and Chris Manby of the Peak District National Park Authority, and Faith Johnson, John Moseley, Gemma Powell and Jack Weston of the Environmental Quality Mark Community Interest Company. Data was gathered from tenant farmers and extracted from grazing licences by Faith Johnson, with additional input from Chris Manby. Carbon modelling was undertaken by Faith Johnson, John Moseley and Gemma Powell with individual reports for the participating tenant farmers compiled by Faith Johnson. Gemma Powell and Jack Weston undertook final data compilation and created the graphs for the final report. This report was written by Faith Johnson and Gemma Powell, with additional input from Matthew Freestone.

⁶ <https://www.un.org/en/climatechange/net-zero-coalition>