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A greenhouse gas emissions assessment and target scenario for the Dartmoor National Park

A report by Small World Consulting Ltd

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Executive summary

Background

As the world wakes up to the climate and wider environmental emergency, rapid reduction of greenhouse gas emissions and sustainable land management are becoming increasingly central to the local, national and international policy agendas.

Together, the UK's 15 National Parks (NPs) and 46 Areas of Outstanding National Beauty (AONBs) are home to over 1.5 million residents, attract approximately 250 million visitors per year, and account for around 18% of the UK's land area. If these protected landscapes, many of which have high national as well as international profiles, can become exemplars of low-carbon transition and environment-conscious land management, they will not only be able reduce their own emissions and scale carbon sequestration rapidly, but are also going to have positive influence well beyond their geographical boundaries. The exciting and creative challenge for each protected landscape is to find a way to cut emissions in line with current science, and be leaders in land stewardship and planning low-carbon infrastructure and communities while simultaneously creating better places for people to live, work and visit.

This report

This report, for the Dartmoor National Park, is one of a series of methodologically compatible reports produced for each UK National Park and Welsh AONB, with the Cotswolds AONB and Cannock Chase AONB also joining. They are designed to provide a robust and consistent evidence basis for climate action, matched to the unique characteristics and circumstances of each protected landscape, as we enter an era in which climate mitigation and sustainable land management become ever more central to all our lives, our work and to all policy decisions.

This report contains a consumption-based assessment of the greenhouse gas emissions attributable to residents and visitors, including travel to and from the landscape (Figure 1), and a set of Paris-aligned target recommendations for transitioning to a low-carbon economy.

Consumption-based emissions reporting differs from more traditional production-based reporting, such as that used by the UK in setting its 2050 net zero target. A production-based assessment would cover all the emissions that are directly produced within the boundary of the landscape whether by people or businesses or from land (e.g. from use of fossil fuels or agricultural activities), plus those arising from production of the electricity used within the landscape. However, the consumption-based approach adopted here covers, in addition, all indirect emissions that are embodied in the goods and services consumed by residents and visitors within the landscape[1]. In doing so, it better reflects the full climate impact of people's lifestyles, and brings into focus for policymakers important areas of climate impact that a production-based assessment overlooks. The most important of these are the impact of food, of other purchased items (such as cars, clothes, IT equipment, household goods and furnishings), and of residents' and visitors' travel to and from the landscape, outside its boundaries. We also include elements of production-based emissions in our GHG baseline and emissions reduction targets, which represent some of the key emissions occurring withing the landscape that complement the consumption-based emissions and could be tackled through partnership work with local stakeholders (Section 6).

[1] These consumption-related emissions are referred to as the "upstream scope 3" footprint (Section 4).

This hybrid approach to setting the GHG baseline and targets for a landscape has been developed and piloted for over 10 years while working with the Lake District National Park and, more recently, with the Cumbria County Council. Even though the approach adopted here is not fully aligned with other established GHG accounting frameworks for landscapes such as the GHG protocol for cities[2], future updates will consider whether and how the scope of the assessment could be modified to better reflect on the needs of the designated landscapes in the UK. Continued improvements in the underpinning science and data are also expected to influence the accounting scope and help reduce the limitations and uncertainties in the current assessment (Appendix 10.2).

Accounting for emissions from land use and management is also crucial for National Parks and AONBs. These landscapes are mostly rural, with comparatively small population and large parts of land under various forms of agricultural management, in addition to non-agricultural habitats such as woodlands, wildflower meadows, heathlands and peatlands. Land-based emissions originate predominantly from ruminants (methane), synthetic fertiliser use (nitrous oxide), and degrading peatlands (mostly CO_2). These emissions are, to a degree, compensated by carbon sequestration in existing woodlands, meadows, hedgerows, and healthy peatlands, while agricultural soils could also sequester carbon under certain types of management. Reducing land-based emissions and scaling up land-based carbon sequestration efforts is going to be crucial for addressing the joint climate and ecological emergencies.

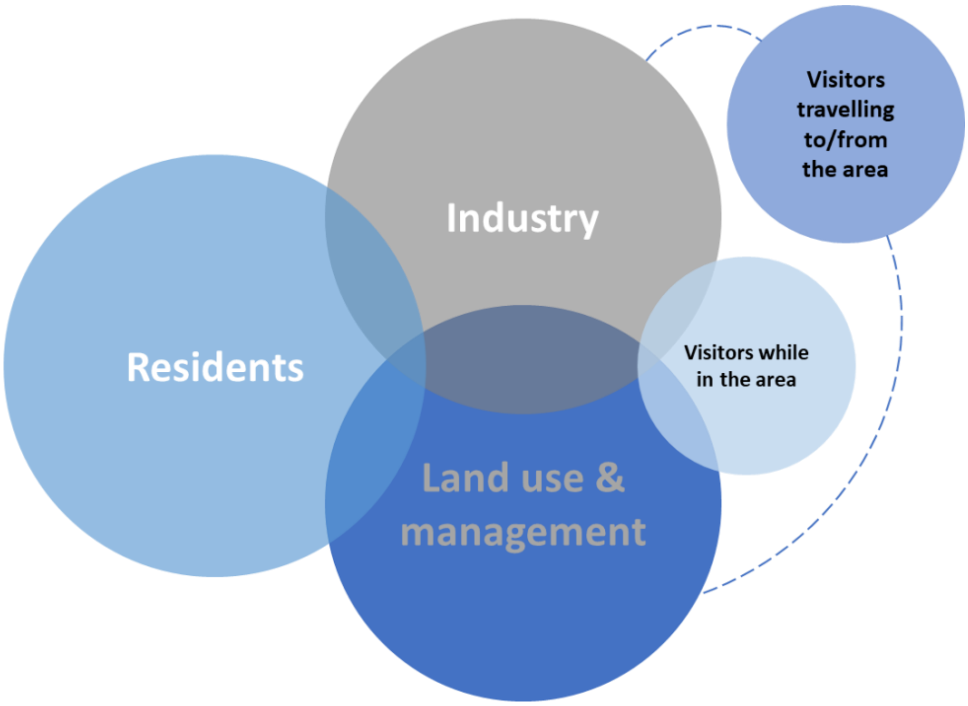


Figure 1: Boundaries of the greenhouse gas footprint assessment

One feature of consumption-based reporting is that it does not include emissions from industry (except where an industry's goods and services are consumed by residents and visitors in the same study area). Therefore, for perspective, this report also includes a simple estimate of emissions related to industries within the National Park or AONB, including their supply chains. It is important

[2] https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities.

to note that there is some inevitable overlap between industry-related emissions and residents' and visitors' emissions, for example when people buy from local businesses within the area. Likewise, there is an overlap between emissions from agriculture as an industry sector and land-based emission within each landscape. Figure 1 illustrates the relationship between the main components of our central assessment and the industry emissions.

This report also includes recommendations for greenhouse gas emission reductions across six priority areas, which are aligned with the main commitment of the Paris Agreement to keep global temperature rise to 1.5°C relative to pre-industrial conditions. These six priority areas were selected for the original Lake District National Park assessment, and have been chosen in order to find a "best fit" between competing desires: to cover everything of significance within the influence of local policymakers, to keep the emissions boundary simple to describe, to avoid double-counting, and to make use of any data readily available for tracking progress. As a result, the scope for the priority areas is slightly different from that of the overall emissions assessment, which is described in detail in Section 6.

The six priority areas are:

- Energy-only emissions by residents, visitors and industry
- Food and drink consumed by residents and visitors
- Other goods purchased by residents and visitors
- Visitor travel to and from the National Park or AONB
- Land use non-CO_2 component (including emissions from livestock and fertilisers)
- Land use CO_2 component

They include the following components of the broader set of GHG emissions assessed in the report:

Priority area	**Emissions components**	**Decarbonisation roadmaps**
Energy-only emissions by residents, visitors and industry	• Emissions from electricity, gas and other fuels consumed by residential and commercial properties within the landscape • Emissions from residents' road travel both within and outside of the landscape • Emissions from industry's road travel both within and outside of the landscape • Emissions from visitors' travel using all modes of transport within the landscape only	UK's Sixth Carbon Budget; Tyndall Centre Energy-Only Carbon Budget for UK's Local Authorities
Food and drink consumed by residents and visitors	• Full embedded emissions in food and drink consumed by residents • Full embedded emissions in food and drink consumed by visitors while travelling in the landscape	UK's National Food Strategy; UK's Sixth Carbon Budget

Priority area	Emissions components	Decarbonisation roadmaps
Other goods purchased by residents and visitors	• Embedded footprint of all goods other than food consumed by residents, including cars • Embedded footprint of all goods other than food consumed by visitors while travelling in the landscape, including cars	UK's Sixth Carbon Budget
Visitor travel to and from the National Park or AONB	• Footprint associated with fuel and electricity used by visitors while travelling to and from the landscape on land (no flights) • Embedded footprint of cars due to visitors travelling to and from the landscape	UK's Sixth Carbon Budget
Land use non-CO_2 component within the landscape	• Methane and N_2O emissions from livestock • N_2O emissions from fertilisers • Methane and N_2O emissions from degrading peat soils	UK's Sixth Carbon Budget; UK's National Food Strategy
Land use CO_2 component within the landscape	• Carbon sequestration in woodlands, hedgerows and other vegetation • Carbon sequestration in soils • CO_2 emissions from degrading mineral agricultural soils • CO_2 emissions from degrading peat soils	UK's Sixth Carbon Budget

Limitations and uncertainties

Due to the complexity of supply chains and the limitations of available data, consumption-based emissions estimates always contain a considerable degree of uncertainty. This includes limited scope to account for local variability as a result of insufficient geographical granularity of several key data sources available at present. Nevertheless, the estimates presented in this report are based on the latest science and data, and in our view represent one of the best possible sets of carbon footprint figures for the UK's designated landscapes. Both the datasets used and our implementation of them in the carbon footprint model have varying degrees of confidence, which are reflected in the data summary table in Appendix 10.2[3]. In view of the above, we believe that these estimates are sufficiently robust to provide an evidence basis for carbon management and target-setting. Ongoing improvements in the underpinning science and data will help reduce the limitations and uncertainties in subsequent assessments.

Results

[3] See also Section 4 and Appendix 10.8 for the associated methodological details.

Dartmoor National Park **(**Figure 2 **–** Figure 6**)**	
Annual consumption-based emissions from residents	**571,061 tCO_2e** (15.3 tCO_2e per person per year)
Annual consumption-based emissions from visitors while in the National Park	**60,023 tCO_2e** (17.5 $kgCO_2e$ per visitor-day)
Annual emissions from visitors travelling to/from the National Park	**99,107 tCO_2e** (38.4 $kgCO_2e$ per visit)
Annual industry emissions, including supply chains	**207,523 tCO_2e**
Annual emissions from through road traffic not related to the National Park	**23,824 tCO_2e**
Annual CO_2 emissions from land (including carbon sequestration)	**-52,129 tCO_2e**
Annual non-CO_2 emissions from land (including ruminants and fertiliser)	**159,193 tCO_2e**

Key highlights

Dartmoor National Park has a relatively high residential population and a small share of visitors compared to other UK National Parks. As a result, the total footprint of residents is estimated to be three and a half times higher than that of all visitors, in contrast to other National Parks where the visitors' footprint can match or even exceed the residents' footprint.

The Dartmoor residents' consumption of goods and services is estimated to be 12.7% above the UK average per capita (excl. public services), which is comparable to all National Parks and AONBs on the current programme (Section 3.3). Principal reasons for this are higher average wealth and spending among Dartmoor residents and the high proportion of retired population with high health expenditure, compared to the UK average.

In a given year, the carbon footprint of the residents of the Dartmoor National Park is estimated to be 24% higher than the UK average. The main cause of this disproportionately higher per capita footprint is the higher level of wealth in the National Park compared to the rest of the UK (Section 3.3), which is further amplified by the rural nature of the landscape and the associated excessive travel within. Several fossil fuel-based sources of greenhouse gas emissions are particularly high (Figure 2). The residents' emissions from flying are estimated to be over twice the UK average per capita, and the per-resident footprints from driving, other forms of transport, household electricity and household fuels (excluding driving) are, respectively, around 33%, 27%, 16% and 13% higher than the corresponding UK averages. It must be noted that our estimates for emissions from household fuel and electricity use do not include renewable energy solutions such as solar panels and heat pumps, nor do they factor in the uptake of electric vehicles. As of 2019, the share of these technologies across households was comparatively low and no suitable data with sufficient geographical detail was available. The footprint from household fuel use (excluding driving) is particularly uncertain since more properties are off the gas grid in Dartmoor compared to several overlapping unitary Local Authorities, and because there is insufficient data for residual fuel use (oil, coal, biomass).

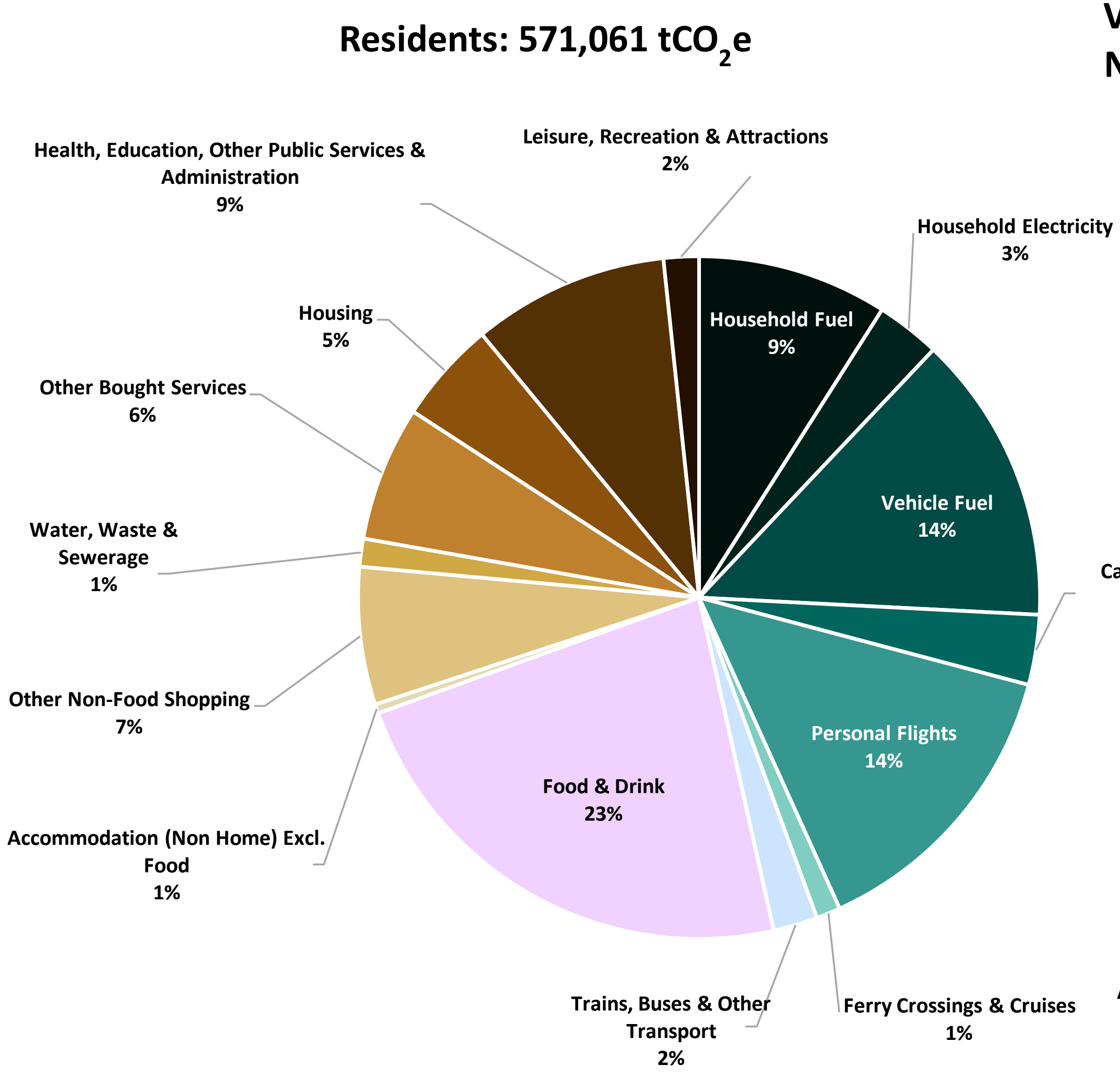
Dartmoor has relatively small share of visitors staying overnight (around 12%) among all National Parks and AONBs on the programme. Average duration of stay is approximately 4 days which is slightly below the average among the landscapes. The visitors' footprint while in the National Park (Figure 4) is dominated by food (50%), followed by driving (14%) and non-food shopping (12%). Estimated average mileage travelled on land to get to Dartmoor (around 110 miles) is just below the average across all National Parks and AONBs on the programme and is dominated by cars, while relatively few visitors come from overseas. The visitors' footprint while travelling to and from the National Park (Figure 3) is dominated by driving (64%). Overall, the visitors' footprints from travelling to and from Dartmoor is around 65% higher than their footprint within the Park.

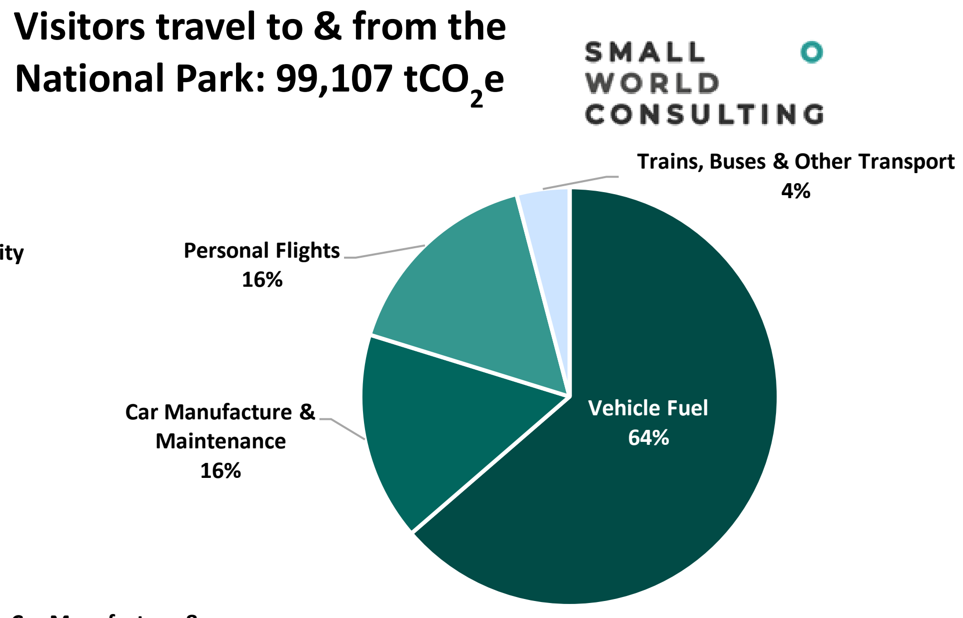
The Dartmoor National Park industry footprint (Figure 5) is dominated by production (35%) and agriculture & forestry (28%). A fundamental difficulty with estimating industry footprint is that locations where companies are registered and where the required business data is available do not always match with the locations of business activities and emissions. Furthermore, the insufficient number of sectors reported in the business data that matches closely to the boundary of a protected landscape forces us to apply generic UK-wide emissions factors.

Dartmoor is estimated to have a moderate traffic footprint from the major roads (A386, A385 and A382), which amounts to around 9% compared to the total footprint of the residents. Through-traffic emissions are estimated to account for nearly 50% of the total footprint of the major roads in the National Park, these emissions are excluded from the consumption-based GHG baseline presented in this report.

Recommended decarbonisation pathways

A target pathway broadly aligned with the remaining carbon budgets to keep global temperature rise to 1.5°C relative to pre-industrial conditions (following the Paris Agreement) has been constructed for each of the six priority areas for the emissions, as illustrated in Figure 6 and described in Section 6. When combined, the recommended decarbonisation pathways for each of the six priority areas result in a net zero date of 2037 for the Dartmoor National Park, using 2019 as the baseline year. The projected net zero date based on the six priority areas reflects the unique characteristics of the landscape, including the habitat types and their respective areas, the number of residents and visitors and their consumption patterns, and the level and type of industrial activity. It also assumes the recommended decarbonisation and carbon sequestration efforts, including land use change, ratchet up to the required levels immediately in the base year of the assessment. In reality, the high levels of ambition for different sectors explored in this report are likely going to take several years to achieve, given that post-COVID emissions have largely rebounded, and that decarbonisation trends to date have been relatively small in magnitude compared to what we know is required for keeping global warming below the safer 1.5°C limit from the Paris Agreement. These factors are expected to push the projected net zero year back by several years. The net zero date should therefore not be taken in isolation as a level of ambition.





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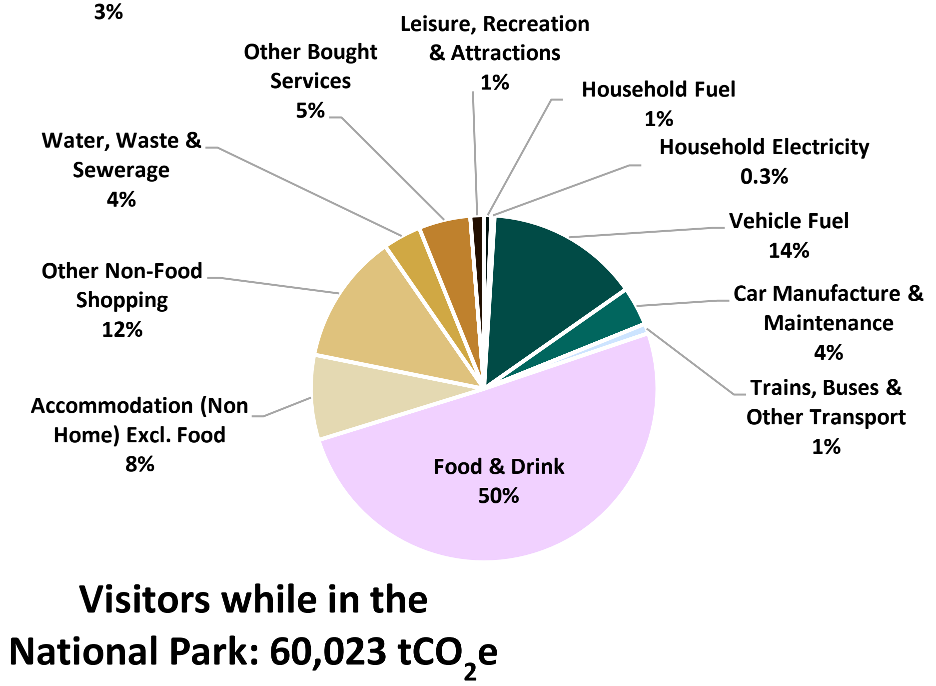

Figure 2: (left) Residents' GHG emissions in Dartmoor National Park by percentage

Figure 3: (top right) Visitors' GHG emissions on the way to & from Dartmoor National Park by percentage

Figure 4: (bottom right) Visitors' GHG emissions while in Dartmoor National Park

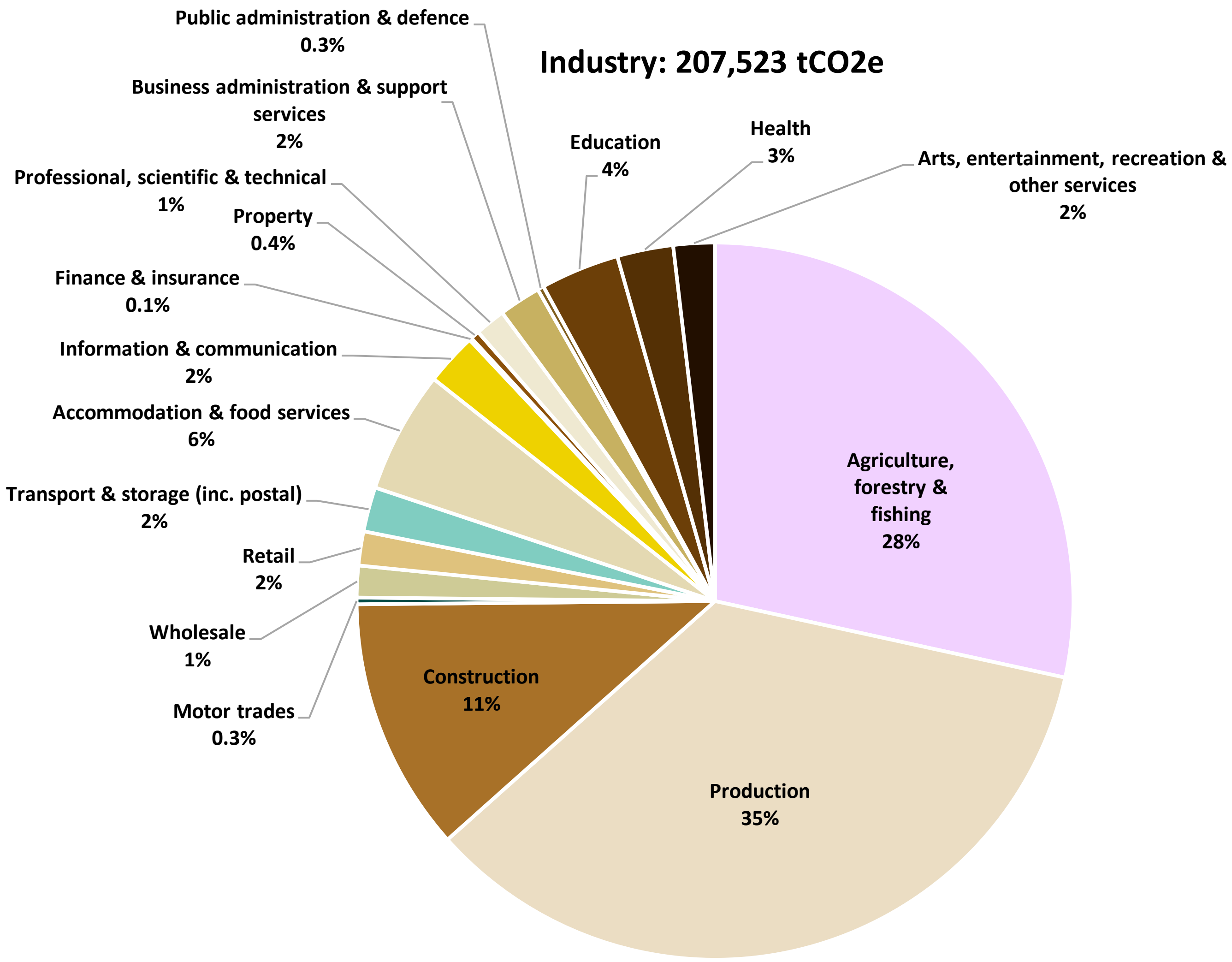

Figure 5. An estimate of emissions from industries within Dartmoor and their supply chains (scopes 1, 2 and upstream scope 3)

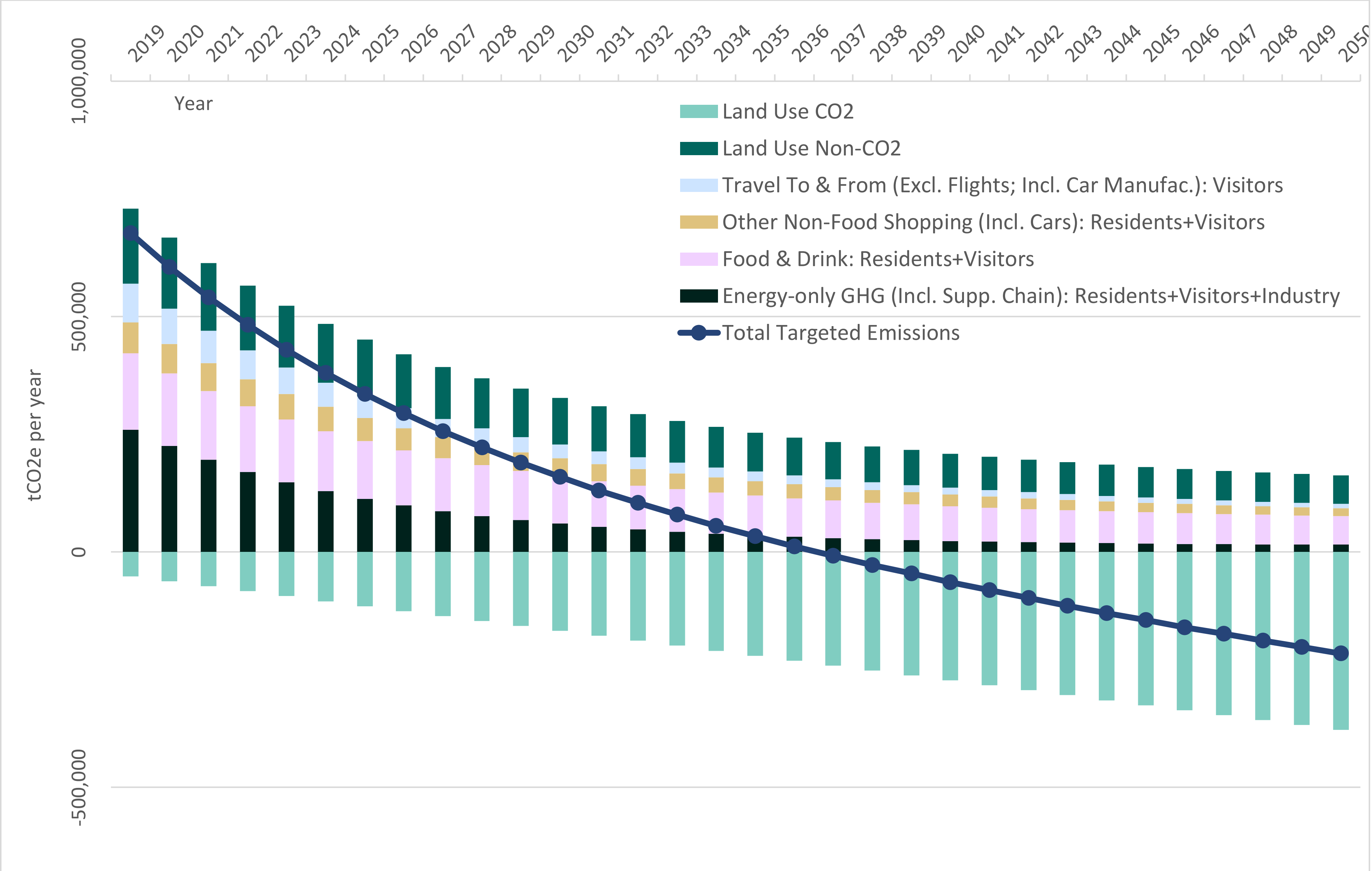

Figure 6: Recommended consumption-based target pathways resulting in net zero emissions in 2037 for Dartmoor National Park.

1. Introduction

As the world wakes up to the climate and wider environmental emergency, rapid reduction of greenhouse gas (GHG) emissions and sustainable land management are becoming increasingly central to the local, national and international policy agendas. In 2019, the UK strengthened its production-based targets, setting itself a legally binding target of net zero by 2050. This prompted the family of UK National Park Authorities and several Areas of Outstanding Natural Beauty (AONBs) to seek assessment of their greenhouse gas emissions collectively. The ambition of these protected landscapes was to go beyond the UK Government's production-based targets and identify the full consumption-based scale of the GHG emissions attributable to residents and visitors, including travel to and from the landscape.

This report, for the Dartmoor National Park, is one of a series of methodologically compatible reports produced for each UK National Park, each Welsh AONB, as well as the Cotswolds and Cannock Chase AONBs in England. The baseline year for the assessment is 2019, the most recent pre-COVID year. The report also includes recommendations for GHG emission reductions across six priority areas, including carbon sequestration through land-based climate mitigation measures. These reductions are aligned with the main commitment of the Paris Agreement to keep global temperature rise to 1.5°C relative to pre-industrial conditions. Together with the estimated 2019 GHG baseline, achieving these targets across the six priority areas would mean the Dartmoor reaching consumption-based net zero emissions by 2037, subject to the targets being fulfilled and to the considerable uncertainties remaining in the data. Emissions not included in the six priority areas are expected to be included in similar decarbonisation targets by other local authorities, by the UK Government and by the international community.

Together, the UK's 15 National Parks and 46 AONBs are home to over 1.5 million residents, attract approximately 250 million visitors per year, account for around 18% of the UK's land area, and contain significant amounts of peat. If they can become exemplars of low-carbon transition and environment-conscious land management, their national and international profiles could give them a level of influence that far outweighs the scale of their own emissions. The exciting and creative challenge for each protected landscape is to find a way to cut emissions in line with current science, and be leaders in land stewardship while simultaneously creating better places for people to live, work and visit.

Understandably, most of these emissions are not directly within the management responsibilities of the National Park Authorities or the neighbouring Local Authorities. However, through their partnership work, National Park Authorities and Local Authorities are often able to engage with a wide range of stakeholders, and, in addition to their statutory powers, use this influence to play a leading role in communicating the extent of greenhouse gas emissions and advocating for far-reaching measures to reduce them. While the need to transition from fossil fuels to renewable energy is the single greatest challenge in responding to the climate emergency, for the National Parks and AONBs in particular, land management is also a critical element of dealing with both the climate and biodiversity crises.

The unique characteristics of each protected landscape give rise to different priorities and opportunities for cutting greenhouse gas emissions and for sustainable land management. For example, the ratio of visitors to residents varies greatly. Some National Parks and AONBs have large industrial or military sites within their boundaries. To varying degrees, each landscape is traversed by major roads that carry considerable volumes of traffic (not necessarily stopping in the area). All these factors affect the economic makeup of each landscape's geography, and have strong implications for the associated GHG footprint and decarbonisation efforts. In terms of land management challenges and opportunities, the protected landscape vary greatly in their levels of peatland and woodland coverage, in their amount and types of agricultural land, and in the population densities of residents and visitors.

The main body of this report is designed for a broad audience, including some who may be less familiar with carbon analysis, but who have an active interest in the findings. This includes National Park Authority Members and AONB board Members, local businesses, partner organisations, and members of the general public who wish to participate in the transition to a low-carbon and sustainable economy. A technical appendix has been produced for those wishing to consult more methodological detail.

2. Policy drivers

2.1. Climate change policy

While the world has had to focus on dealing with the global pandemic since January 2020, climate change has nevertheless remained high on the international agenda. This section summarises key drivers for change which the National Park Authority may wish to respond to in delivering its statutory duties.

Climate change driven by anthropogenic GHG emissions, plus the wider ecological crisis, are two of the biggest challenges facing humanity today, and a joined-up response to tackling them is likely to improve both situations. A 2018 report by the Intergovernmental Panel on Climate Change (IPCC) outlined the need to reduce global greenhouse gas emissions by 45% (from 2010 levels) by 2030, and achieve net zero emissions by 2050[4]. It states that these reductions are necessary in order to limit the increase in global mean temperature to 1.5°C relative to pre-industrial levels. This is the more ambitious target of the Paris Agreement by the parties to the UN Framework Convention on Climate Change (UNFCCC); it is also understood to be a "safer" warming limit both for societies and ecosystems globally. In 2019, the UK Government agreed to a legally binding target of net zero greenhouse gas emissions by 2050, which is based on territorial (production-only) emissions within the UK.

Subsequently, the IPCC published its Sixth Assessment Report (AR6) in stages, with the final volume released in March 2022. Compiled by the world's leading climate scientists, this report provides a comprehensive update on the latest scientific learnings about climate change, and is intended to serve as a resource for global climate negotiations, national policies and business planning.

[4] IPCC (2018) Special Report: "Global Warming of 1.5°C: Summary for Policymakers." https://www.ipcc.ch/sr15/chapter/spm/.

The first part of the AR6, entitled "Climate Change 2021: The Physical Science Basis", was released ahead of the 26th UNFCCC Conference of the Parties (COP26) hosted in Glasgow in November 2021[5]. Notably, it affirms that the increase of carbon dioxide, methane, and nitrous oxide in the Earth's atmosphere through the industrial era, i.e. since the late 19th century, is the result of human activities. What is clear in the report is that our chance of limiting the increase in global mean temperature to 1.5°C above pre-industrial levels now appears small. Keeping warming below the "safer" 1.5°C limit will likely require the most ambitious actions – i.e. those at the top end of known technical feasibility – to reduce emissions and also upscale efforts on carbon sequestration.

The Department of Business, Energy and Industrial Strategy (BEIS) is the lead for reporting on GHG emissions in line with the UNFCCC requirements in the UK. An independent body, the UK Climate Change Committee, advises the whole of the UK, including devolved administrations, on emissions targets and progress. The Sixth Carbon Budget (2020) recommends that the UK set a budget to require a 78% reduction in UK greenhouse gas emissions by 2035 relative to 1990, which is a 63% reduction from 2019 levels[6]. Further detail relating to this is provided in Section 2.4 of this report, outlining associated real-world change towards decarbonisation.

Ahead of COP26, in October 2021, the UK Government published its Net Zero Strategy: Build Back Greener[7]. This outlines the Government's strategy to reduce emissions across the economy, including power, fuel supply and hydrogen, industry, heat and buildings, transport, waste, and greenhouse gas removals. It also considers supporting the wider transition across the economy.

COP26 concluded with the agreement of the Glasgow Climate Pact, with 153 countries putting forward new 2030 emissions targets ("Nationally Determined Contributions", NDCs)[8]. The NDCs pledged at COP26 are estimated to represent a trajectory towards a temperature *rise* of 2.4°C (relative to pre-industrial levels) by the end of the century, whereas the existing Net Zero pledges, if fully implemented, would limit global warming to 1.8°C.[9]

Prior to COP26 closing on the 13th of November, the UK's Environment Act 2021 received Royal Assent, becoming law on the 9th of November 2021 as an Act of Parliament. The broad aims of the UK Environment Act are to improve air and water quality, protect wildlife, increase recycling and reduce plastic waste. The Act also provides the means to set targets for particulate matter (affecting the quality of ambient air) and species abundance. More importantly, it sets environmental principles which the National Park Authorities will need to be familiar with as they fulfil their purposes and duty, namely:

- The principle that environmental protection should be integrated into policymaking,
- The principle of preventative action to avert environmental damage,
- The precautionary principle, insofar as it relates to the environment,

[5] IPCC (2021) Climate Change 2021: "The Physical Science Basis," https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
[6] Climate Change Committee (2020): "The Sixth Carbon Budget: The UK's Path to Net Zero," p. 13. https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf.
[7] HM Government (2021), "Net Zero Strategy: Build Back Greener" https://www.gov.uk/government/publications/net-zero-strategy.
[8] COP26, "The Glasgow Climate Pact," p. 8 https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf.
[9] https://climateactiontracker.org/global/temperatures/.

- The principle that environmental damage should, as a priority, be rectified at source,
- The "polluter pays" principle.

2.2. Health impacts of air pollution

In addition to the impact of climate change on the environment, some greenhouse gas emissions such as N_2O and soot also have an impact on human health and well-being. It is estimated that between 28,000 and 36,000 UK deaths each year are attributable to air pollution, which exacerbates ilnesses such as asthma and cancer[10]. Poor air quality can have a disproportionate impact on the health and well-being of children, older people and other vulnerable individuals. The NHS has identified that more than 2,000 GP practices and 200 hospitals are in localities affected by poor air quality.

2.3. Climate-driven impacts in the UK

The impact of climate change on our natural world is evidenced by higher temperatures, changing rainfall patterns, changes in ecosystems, sea level rise, increasing frequency and intensity of storm surges, retreating glaciers, and melting sea ice and ice sheets. In the UK we are seeing significant changes in the winter and summer rainfall patterns. The UK Met Office's latest report states that "Winters in the UK, for the most recent decade (2009-2018), have been on average 5% wetter than 1981-2010 and 12% wetter than 1961-1990", and that "Summers in the UK have also been wetter, by 11% and 13% respectively"[11]. Total rainfall from extremely wet days increased by around 17% in the decade 2008-2017 for the UK as a whole. However, the changes are most marked for Scotland, and not significant for most of southern and eastern England.

In addition to increasing precipitation volumes, climate change has already made it 12-25% more likely that the UK will again experience a hotter than average summer similar to that of 2018, which is projected to become 50% more likely with future warming. On the 19th of July 2022, the UK saw the hottest temperature ever recorded at 40.3°C, breaking the previous record by a staggering 1.6°C[12].

In terms of human responses to flooding, a recent report by Natural England also suggests that environmental inequality is greater within deprived communities, which experience the largest negative climate impacts, e.g. flood risk, air pollution, poor-quality river water and waste hazards. Research has shown that there are significant mental health impacts associated with flooding, including a 20.1% chance of probable depression within 12 months, 28.3% probable anxiety and 32.6% probable PTSD for those individuals who directly experience being flooded (based on the cost per household over a 2-year period, ranging from £3,144 to £6,980 dependent on flood depth)[13].

In addition, climate-driven changes in rainfall patterns and temperatures create significant adaptation challenges for species that depend on their local environmental conditions and habitats, posing an even greater risk to future biodiversity and food security. Furthermore, climate change

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[10] https://www.aacr.org/patients-caregivers/progress-against-cancer/air-pollution-associated-cancer/.

[11] Met Office (2015), "UK Climate Projections: Headline Findings", July 2021, version 3 p. 6-7. https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/research/ukcp/ukcp18_headline_findings_v3.pdf

[12] https://www.metoffice.gov.uk/about-us/press-office/news/weather-and-climate/2022/july-heat-review

[13] Priest, S., Viavattene, C., and Cotton, J. (2019) Environment Agency presentation: "New economic costs for the mental health impacts of flooding."

might increase emissions from soils and habitats, particularly peatland, due to faster decomposition of organic matter in soils driven by higher temperatures and drought conditions. Dartmoor's peatlands and peaty moorland soils are particularly vulnerable to this, because of their southerly position within the UK. Hotter and drier condition are likely to pose a problem for other habitats, too, particularly for wetlands. Some tree species may also struggle to adapt to the changing climate, which poses challenges both for existing woodlands and proposed new plantations.

2.4. Real-world action and behaviour change

The Sixth Carbon budget, together with sector reports, has responded to these policy drivers with high-level proposals that necessitate real-world planning, action and behaviour change. Key highlights from the report are listed below:

- By the early 2030s, all new cars, vans and pickups are electric.
- By the early 2030s , all domestic and non-domestic replacement boilers are low-carbon – largely electric heat pumps.
- By 2040 all new HGVs are low-carbon.
- UK industry shifts to using renewable electricity or hydrogen instead of fossil fuels.
- UK industry captures its remaining carbon emissions and stores them safely (and permanently).
- By 2035 the UK's electricity production is zero carbon.
- Low-carbon hydrogen is scaled up as a fuel for shipping, transport and industry, and for some buildings it replaces natural gas for heating (demand for natural gas is set to double/treble by 2050).
- UK wastes fewer resources and reduces its reliance on high-carbon goods.
- UK has a national programme to improve insulation of existing buildings[14].
- Fewer miles travelled by car and air.
- Diets change, reducing consumption of high-carbon meat and dairy products[15] by 20% by 2030.
- Agriculture and the use of farmland are transformed, while maintaining the same levels of food per head produced today.
- By 2035, 460,000 hectares of new mixed woodland are planted to remove CO_2 from the atmosphere and deliver wider environmental benefits.
- By 2035, 260,000 hectares of current farmland are dedicated to producing energy crops.
- Woodland coverage of the UK's land surface rises from 13% today to 15% by 2035 and 18% by 2050.
- Peatlands are widely restored and managed sustainably[16].

[14] Building regulations for new homes have been strengthened to require high energy performance and electric vehicle charging points.

[15] In the context of food, the term "high-carbon" means that GHG emissions from producing a unit of calories and nutrition ready for human consumption are high compared to other food types. For further details, see Poore & Nemecek (2018), "Reducing food's environmental impacts through producers and consumers," *Science*, 360(6392), 987-992.

[16] Further details on peatland restoration targets are provided in the 2021 England Peat Action Plan (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1010786/england-peat-action-plan.pdf), and in the 2017 UK Peatland Strategy (https://www.iucn-uk-peatlandprogramme.org/sites/default/files/header-images/Strategies/UK%20Peatland%20Strategy%202018_2040.pdf).

Detailed guidance is contained within eleven sector reports, namely: 1) Aviation, 2) Buildings, 3) Fluorinated gases (F-gases), 4) Electricity generation, 5) Fuel supply, 6) Greenhouse gas removals *i.e. a) Bioenergy with carbon capture and storage (BECCS), b) Direct Air Capture with Carbon Storage (DACCS) and c) Wood in Construction*; 7) Manufacturing and construction, 8) Shipping, 9) Surface transport, 10) Waste, and finally 11) Agriculture, Forestry and Other Land Use (AFOLU). In relation to agriculture and land, the report specifically comments that recommendations for policy "must be implemented in a way that is fair to farmers," and that "policy design must account for the challenges of the changing climate and reflect wider environmental priorities, including for biodiversity, to harness potential synergies and avoid unnecessary trade-offs. Policies are also needed to cut food waste and encourage a reduction in consumption of meat and dairy"[17].

The key challenge for Local Authorities and National Park Authorities will be translating the targets and initiatives to their geographical areas. In Devon, the Devon Carbon Plan provides a roadmap how Devon will reach net-zero emissions by 2050 at the latest[18].

2.5. Policy implications for local planning authorities

Planning is one of the tools the Authority can use to address GHG emissions, specifically through encouraging decarbonisation of the built sector. Regulation of building materials, energy efficiency and heating systems is the principal responsibility of Building Regulations in the UK. Planning policies within the Local Development Plan can further these standards where there is sufficient evidence and development viability. New-builds emit relatively small quantities of GHGs compared to existing buildings, and GHG savings achieved in new-build stock will minimise the need for expensive future retrofitting. They will also demonstrate the potential of – and stimulate the market for – building techniques and products that are more sustainable.

The largest impact Local Development Plans can have is planning communities that do not rely on private transport and which encourage the uptake of low/zero-carbon transport, albeit in deeply rural areas this is very challenging.

Planning can also provide information on which types of renewable energy technology will be appropriate and where to site them within the National Park, facilitating a transition by communities and businesses to non-fossil sources of power and heat. Dartmoor has a plentiful supply of wind and water, and its southern latitude in the UK means that solar irradiance is relatively high. Renewable electricity generation within the National Park currently consists of hydroelectric power through Mary Tavy power station, plus several small-scale hydro installations and small-scale rooftop solar PV arrays. Mary Tavy hydroelectric power station, operated by South West Water, is the only megawatt-scale installation in the National Park, providing electricity for thousands of local homes[19]. Dartmoor has a history of using the power of water in the landscape for mining activities. Many of the "leats" (artificial watercourses) built to convey water to the industry still exist, and may offer an opportunity to harness the power of the water for electricity generation.

The National Park Authority's stance on renewable energy in and around the National Park carries considerable weight. In line with the UK's other National Parks, the policy is to support renewable

[17] Climate Change Committee (2020), "The Sixth Carbon Budget: The UK's Path to Net Zero," p. 30.
[18] https://devonclimateemergency.org.uk/devon-carbon-plan/
[19] https://www.southwestwater.co.uk/siteassets/documents/mary_tavy_a5_leaflet.pdf.

energy development where it does not harm the National Park's Special Qualities[20]. Since the publication of the Dartmoor Design Guide Supplementary Planning Document[21], costs of solar photovoltaic electricity generation have dropped, making this technology more competitive. The National Park Authority is installing solar PV panels on its own buildings at Haytor Visitor Centre[22]. It is also worth noting that while biomass use for energy is often considered "renewable", careful sourcing of biomass is required to ensure that there is no use of old-growth wood, and that woodland is being replenished in its place, to avoid detrimental carbon and ecological impacts. Developments within the protected landscape remain subject to careful consideration, and consultation with statutory agencies and the public, to ensure that the special qualities of the National Park are not adversely affected. The National Park Authority works closely with adjoining Authorities to identify suitable sites for renewable energy development in the National Park setting, consistent with NPPF paragraph 176 which states development in the setting of National Parks "should be sensitively located and designed to avoid or minimise adverse impacts on the designated areas".

[20] "Dartmoor Local Plan 2018-2036," Policy 6.6, https://www.dartmoor.gov.uk/__data/assets/pdf_file/0015/410127/LP_Adopted.pdf.

[21] "Dartmoor National Park Design Guide, 2011," https://www.dartmoor.gov.uk/__data/assets/pdf_file/0026/74771/14781_111109_Dartmoor-Design-Guide.pdf.

[22] Dartmoor National Park Authority, "Climate Action Plan 2020," https://www.dartmoor.gov.uk/__data/assets/pdf_file/0032/157793/DNPA-Climate-Action-Plan-2020.pdf.

3. Dartmoor: demographic profile and key statistics

In this section we consider the key characteristics of people and landscape which may call for further reflection later in this GHG emissions assessment, in terms of the likely impact on land management and behaviour arising from the changes needed to create a more sustainable long-term future for both people and nature. These insights may benefit the delivery of projects by the programme partners.

3.1. People and key characteristics

Dartmoor has the fifth-largest residential population of all UK National Parks, estimated at 34,787 people, which is very similar to the populations of the Peak District, New Forest and Brecon Beacons National Parks[23]. For the purposes of this carbon footprint assessment, population estimates from mid-2019 were used, including residents in all unit-level postcodes (6- or 7- characters) that have at least 30% of their area within the geographical boundary of the National Park, which gives a total of 37,237 residents. This method provides a slightly higher population of the National Park than the property-level Census estimate of around 34,000 (8% lower).

The National Park has an ageing population, with a median age of 50, compared to the national average of 40. Over a quarter of the residents (26%) are aged 65 and over, and this proportion is projected to increase until 2035, with a corresponding decrease in the number of residents aged 15 to 64[24]. Dartmoor has a working population of approximately 10,000 people[25].

Dartmoor's economic profile includes 2,170 registered businesses (in 2016), of which the vast majority (91%) are micro-businesses, while most of the rest are small businesses (8%), and only a very small minority have more than 50 employees (1%)[26]. The largest sector by number of businesses is agriculture, forestry and fishing (30%), followed by professional, scientific and technical activities (13%), construction (8%) and accommodation and food services (7%). The largest sectors in terms of employment are accommodation and food services (18%) and education (17%), with the agriculture, forestry and fishing sector providing fewer jobs (13%)[26]. Almost a third of Dartmoor's working population are self-employed, which is higher than the average for England[27].

Located in the South West of England, the National Park overlaps the districts/boroughs of West Devon, Mid Devon, Teignbridge and South Hams[25]. When considering partnership-working on decarbonisation agendas, there are five local authorities represented within the National Park: Devon County Council, West Devon Borough Council, Mid Devon District Council, Teignbridge District Council and South Hams District Council.

Most of Dartmoor's larger settlements are located around the edge of the National Park (Figure 7). The most visited settlements within the National Park are Princetown and Widecombe-in-the-Moor[28]. Other prominent settlements attracting residents and visitors to the National Park include

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[23] ONS, National Park population estimates (Experimental Statistics) - Office for National Statistics (ons.gov.uk).
[24] Dartmoor National Park, 2016, Edge Document Template (dartmoor.gov.uk).
[25] Dartmoor National Park Partnership Plan 2021 – 2026, https://www.yourdartmoor.org.
[26] Dartmoor Local Plan, Topic Paper 8, Economy, Topic-Paper-8-Economy.pdf (dartmoor.gov.uk).
[27] Dartmoor Local Plan, Topic Paper 8, Economy, Topic-Paper-8-Economy.pdf (dartmoor.gov.uk).
[28] DNPA, Settlements Facts, https://www.dartmoor.gov.uk/__data/assets/pdf_file/0018/72063/lab-juniorfct-bw-1.pdf.

Chagford and Moretonhampstead to the north and north-east, plus Okehampton, Tavistock, Bovey Tracey and Ivybridge outside the National Park, and finally Ashburton, Buckfastleigh and Yelverton as gateways inside the National Park.

Figure 7. Dartmoor settlements

Indices of deprivation show disparities in levels across the National Park. There is a large "more deprived" area across the western-central area of Dartmoor including Princetown, with an area classified as mid-range immediately east, and "less deprived" areas further towards the north east, including the regions containing the settlements of Chagford and Moretonhampstead. The western areas crossing the National Park boundary are also classified as "less deprived"[29].

It is important to understand and reflect upon the diverse demographic profile of the landscape when considering potential opportunities to change behaviour in spending habits. Further detail pertaining to the key consumption and industry characteristics in Dartmoor can be found in Appendix 10.1.

[29] Indices of Deprivation, 2019, Indices of Deprivation 2015 and 2019 (communities.gov.uk).

3.2. Geography and landscape

Dartmoor spans an area of 95,300 ha (953 km^2)[30]. UK National Parks' average area is just over 154,000 ha. The landscapes of Dartmoor National Park are varied, encompassing open upland moors, valleys, pasture and enclosed farmland, and rivers[25]. Elevation within Dartmoor ranges from the lowest point – Doghole Bridge, at 30 metres above sea level – to the highest point on Dartmoor, which is High Willhays, at 621 metres above sea level. Dartmoor is known for its characteristic features, called "tors". These are hills on which the underlying granite (65% of Dartmoor's composition) is visible, and Dartmoor has more than 160 of them[31].

The various landscapes provide important habitats for wildlife. Grass and heather upland moorland, blanket bogs and valley mires support distinct plants, insects and birds including Vigur's eyebright, southern damselfly (one of the rarest damselflies in Britain[32]), skylark and cuckoo. Sheltered valleys feature upland oak woodland, which supports rare species including the blue ground beetle and rare mosses and lichens, and fast-flowing rivers containing salmon[25]. The valley mosaic landscapes include 1,200 hectares of rhôs pasture (20% of all of such habitat in England), a habitat dominated by purple moor-grass and rushes, which support distinctive plant species such as meadow thistle and heath spotted orchid, and insects including the rare marsh fritillary butterfly and narrow-bordered bee hawkmoth[32]. Enclosed pasture fields, bordered with hedge banks and dry-stone walls, create a mosaic of hay meadows and dry grasslands, home to distinct species including the greater butterfly orchid[25]. Caves and abandoned mines support western Europe's largest population of greater horseshoe bat (along with populations of other important bat species), and also the very rare blind shrimp, which is native to Britain, and the nationally-scarce luminous moss.

Dartmoor's upland peatland bogs support species of sphagnum moss, cotton grass and carnivorous sundew, and important bird populations including the threatened and most southerly breeding dunlin in Europe. Poor condition of these peatland habitats has wider impacts on downstream water quality and flow management, as many of Devon's major rivers originate in Dartmoor's peat bogs[33]. Dartmoor National Park is working to restore peatland condition across approximately 300 hectares, as a partner of the South West Peatland Project[34]. As Dartmoor is susceptible to flash flooding, mitigation strategies such as peatland restoration, tree planting and hedge bank creation are being implemented by the National Park Authority and its partners from the flood management project, Dartmoor Headwaters[35].

Many areas of the National Park are designated as national and international wildlife sites: a quarter of the land area is designated as Special Areas of Conservation (SACs) and a similar proportion of the land area (27%, across 42 sites) is designated as Sites of Special Scientific Interest (SSSIs)[33]. There is a high concentration of Scheduled Monuments in Dartmoor, totalling 1,082 and covering approximately 10% of the land area. The National Park Authority has identified 14 internationally

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[30] What are National Parks For? - UK National Parks Education Resource.
[31] DNPA, "Basic Factsheet," Basic factsheets | Dartmoor.
[32] DNPA, "Rhôs Pasture," https://www.dartmoor.gov.uk/wildlife-and-heritage/habitats2/farmland/rhos-pasture.
[33] DNPA, "A Landscape Character Assessment for Dartmoor National Park, 2017," https://www.dartmoor.gov.uk/__data/assets/pdf_file/0020/76142/Dartmoor-LCA-report2017-FINAL-web.pdf.
[34] DNPA, "Peatland," https://www.dartmoor.gov.uk/wildlife-and-heritage/our-conservation-work/the-south-west-peatland-project.
[35] DNPA, "NFM," https://www.dartmoor.gov.uk/wildlife-and-heritage/our-conservation-work/dartmoor-headwaters-project.

important Premier Archaeological Landscapes (PALs) across 7,000 hectares of moorland (almost 8% of the land area)[33].

A vast area of central Dartmoor is classified as Grade 5 agricultural land (poorly productive) and this is bordered and crossed by areas of Grade 4 land (also poorly productive). Regions of Grade 3 land largely surround these upland areas, following the National Park boundary. Comparatively small patches of non-agricultural land exist towards the eastern section of the National Park, such as Fernworthy, Bellver and Soussons Forests, Teign Valley woodland and Lustleigh cleave. Other non-agricultural areas include the wooded valleys of the River Teign and the River Dart, and the Kennick, Tottiford and Trenchford Reservoirs. The National Park encompasses the small urban area of Ashburton towards the east[36].

Farming is the primary land use on Dartmoor; about 90% of the total land area is given over to grazing by around 50,000 cows, sheep and ponies[31]. The majority of this land is moorland, and the remainder is fringe enclosed improved grassland[37]. The Dartmoor National Park Authority hosts the Dartmoor Hill Farm Project, which assists a community of farmers across a range of activities, supporting more than 400 farms[38]. Herds of ponies, including the iconic Dartmoor Pony, roam freely on the moor and are part of the unique character and cultural heritage of the landscape[39].

Land owithin the National Park is owned by a mix of public bodies and private individuals[40]. Within the National Park is a military training site, the Dartmoor Training Area, consisting of ranges to the north and south and located predominantly on land owned by the Duchy of Cornwall and other landowners[41]. Dartmoor's landscapes are accessible via 50,000 hectares of open access land and a network of public paths and routes[42].

3.3. Consumption and spending characteristics

When it comes to the National Park's residents, learning shared from a Catapult Energy Systems (2021) report suggests that people in vulnerable circumstances are at increased risk of experiencing barriers to adopting the behavioural changes identified as being key to achieving net zero GHG emissions[43]. The categories of vulnerability included: rural, low income, privately renting, residents with disabilities, pensionable age residents, the digitally excluded and those disproportionately affected by COVID-19.

A number of results, particularly around spending habits, may be influenced by levels of affluence and lack of means within the National Park or AONB. We therefore include a brief commentary on indices of deprivation as an indicator of economic wealth within the National Park, as this provides context for the spend-based consumption analysis and results, which may be influenced by such factors.

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36 DEFRA, https://magic.defra.gov.uk/MagicMap.aspx.
37 DNPA, "Farming," https://www.dartmoor.gov.uk/living-and-working/farming.
38 Dartmoor Hill Farm, https://www.dartmoorhillfarmproject.co.uk/.
39 DNPA, "Ponies," https://www.dartmoor.gov.uk/living-and-working/farming/ponies.
40 Your Dartmoor, "About," https://www.yourdartmoor.org/about.
41 DNPA, "Military," https://www.dartmoor.gov.uk/living-and-working/access-and-land-management/military-on-dartmoor.
42 DNPA, "Access and Land Management," https://www.dartmoor.gov.uk/living-and-working/access-and-land-management.
43 Catapult Energy Systems (June 2021). "Net Zero Societal Change Analysis: Summary report," p. 11.

According to the Office for National Statistics (ONS) Household Expenditure Survey for different demographic groups, the average affluence of residents in all the National Parks and AONBs who joined this programme is higher than the UK average, even though these landscapes tend to have pockets of deprivation. On average, Dartmoor National Park residents' private spending (excluding spend on public services) is estimated to be around 12.7% above that of average UK resident (Table 1). This is almost equal to the average across all National Parks. The consumption data supports the demographic profile of a mixture of working-age and retired populations, which is different from most other National Parks which tend to have predominantly older and, in many cases, more affluent residents.

A detailed summary of the key statistics and spending habits for Dartmoor residents is provided in Appendix 10.1.

Table 1: Relative difference in consumer spending per capita (excluding public services) between Dartmoor National Park and the UK average, and the relative difference between all 15 UK National Parks averaged and the UK average

Consumer Expenditure Category	Dartmoor NP vs. UK average Consumer Spending (excl. Public Services)	All NPs vs. UK average
Food & non-alcoholic drinks	9.8%	10.2%
Alcoholic drinks, tobacco & narcotics	9.9%	14.6%
Clothing & footwear	10.1%	9.2%
Housing, fuel & power	-9.6%	-8.3%
Household goods & services	18.7%	16.7%
Health	45.0%	41.9%
Transport	26.6%	29.8%
Communication	5.1%	4.7%
Recreation & culture	22.3%	22.1%
Education	-35.2%	-39.8%
Restaurants & hotels	5.1%	3.1%
Miscellaneous goods & services	8.3%	7.8%
Other expenditure items	23.2%	23.1%
Total	**12.7%**	**12.9%**

4. GHG reporting conventions and methods

The following part of this report provides an estimate of greenhouse gas (GHG) emissions resulting from consumption by residents and visitors, including travel to and from the National Park or AONB, along with a section introducing the methodology. By taking a consumption-based approach, we include embodied, indirect emissions in everything that residents and visitors buy and do while in the area (that is, a full footprint associated with their lifestyles). The assessment covers the six main types of greenhouse gases from the Kyoto Protocol (Figure 9), and the term "carbon footprint" is used as shorthand to mean the GHG emissions released both directly and indirectly within supply chains of goods and services.

More specifically, the following are within the scope of the assessment:

- all residents' personal travel and visitor travel to, from and around the area;
- fuel and electricity consumed in homes and places to stay;
- emissions from food and drink and other purchases;
- emissions resulting from the use of services, including public services; and
- the supply chains of all the above (e.g. fuel supply chains and embodied emissions).

The baseline year for the assessment is 2019, the most recent pre-COVID year.

Accounting for emissions from land use and management is also crucial for National Parks and AONBs. These landscapes are mostly rural, with comparatively small population and large parts of land under various forms of agricultural management, in addition to non-agricultural habitats such as woodlands, wildflower meadows, heathlands and peatlands. Land-based emissions originate predominantly from ruminants (methane), synthetic fertiliser use (nitrous oxide), and degrading peatlands (mostly CO_2). These emissions are, to a degree, compensated by carbon sequestration in existing woodlands, meadows, hedgerows, and healthy peatlands, while agricultural soils could also sequester carbon under certain types of management.

As a separate and overlapping analysis, we also include a simple assessment of emissions from industry within each protected landscape and associated supply chains (Scopes 1, 2 and upstream Scope 3). We provide this to give some sense of the relative scale of industry emissions compared to those linked to visitors and residents. However, important caveats apply to this assessment. Firstly, it is not possible to eliminate the double-counting of emissions, occurring when industries within the area sell to each other or to residents and visitors. Secondly, this crude estimate for industry has been made by applying generic, UK-wide emissions factors for each industry sector to local revenue data from businesses registered in the area. This may in some cases misrepresent actual industry-related activities within the landscape boundary.

Figure 8 illustrates the relationship between the main components of our central assessment and the industry emissions.

The datasets used in the assessment and the relevant methodological details are summarised in Appendices 10.2, 10.3 and 10.8. To estimate various components of the footprint, we use a hybrid of process-based life cycle analysis (LCA) and spend-based input-output methods, in conjunction with around 30 UK-wide and in-house datasets (Appendix 10.2). We keep to the principle of counting everything once and once only and without truncation error. Our in-house Environmentally-Extended Input-Output (EEIO) model has been developed in collaboration with Lancaster University over the last 15 years. We also maintain an extensive database of LCA emissions factors encompassing fuel and energy use, transport and travel, raw materials, and food.

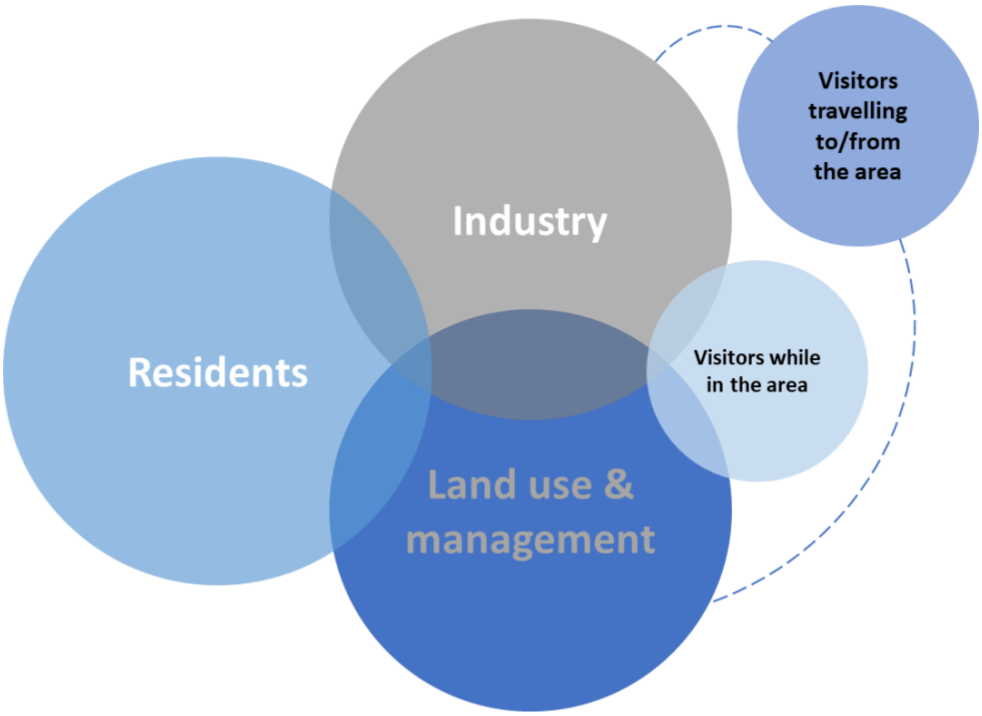


Figure 8: Boundaries of carbon footprint assessment (repeat of Figure 1)

This report also includes a recommendation for decarbonisation targets for six priority areas aligned with the main commitment of the Paris Agreement to keep global temperature rise to 1.5°C relative to pre-industrial conditions. These six priority areas have been selected in order to find a best-fit between the competing desires to cover everything of significance within the influence of policymakers, to keep the assessment boundary simple to describe, to avoid double-counting, and to make use of any data readily available for tracking progress. As a result, the scope for the priority areas is slightly different from that of the overall emissions assessment presented in this report, and is defined as follows:

- Energy-only emissions (incl. fuel supply chains) by residents, visitors and industry
- Food and drink consumed by residents and visitors
- Other goods purchased by residents and visitors
- Visitor travel to and from the National Park or AONB
- Land use non-CO_2 component (including emissions from livestock and fertilisers)
- Land use CO_2 component

The Greenhouse Gas Protocol considers six greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and Sulphur Hexafluoride

(SF$_4$). It also categorises company emissions into three scopes: Scope 1 for direct emissions from company facilities and vehicles; Scope 2 for indirect emissions from electricity and steam consumed in company activity but generated elsewhere; and Scope 3 for indirect emissions in the value chain[44]. Scope 3 can be split into two parts: upstream and downstream. Our assessment of Industry emissions includes scope 1, 2 and upstream scope 3 (Figure 9). This can be thought of as the full "carbon footprint" of industry up to the point of sale. Similarly, when residents and visitors buy goods and services, we include the embodied emissions of these purchases, most of which are likely to have originated elsewhere in the UK and overseas because of the nature of the existing supply chains. However, when residents and visitors buy local produce, parts of the resulting embedded emissions will also be accounted for by the local industry footprint, therefore leading to double counting. The six priority areas introduced above were defined to eliminate most of this double counting.

In the report, we measure greenhouse gas emissions in tonnes of carbon dioxide equivalent (tCO_2e)[45]. We have used 100-year global warming potential (GWP) conversion factors for all non-CO_2 gases, in line with established greenhouse gas accounting conventions. In other words, we consider the contribution that each gas makes over a one-hundred-year period. However, it should be remembered that if we are interested in climate impacts over a shorter timescale, the relative importance of some gases increases. In particular, the relative contribution of methane is roughly doubled if we are interested in climate impacts over a period of fifty years, or roughly three times as important as represented in this report if we are looking at climate impacts by 2050.

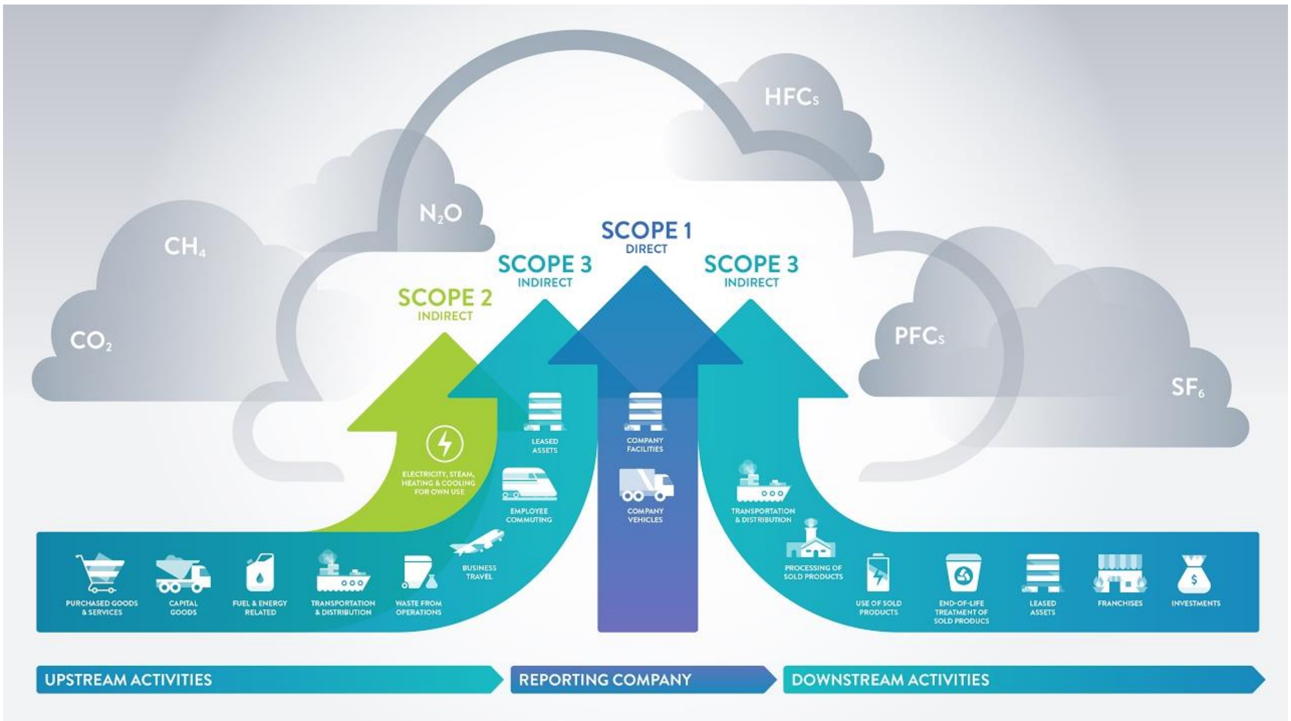


Figure 9: Types of greenhouse gas emissions used for carbon accounting.

[44] Greenhouse Gas Protocol, "Technical Guidance for Calculating Scope 3 Emissions: Supplement to the Corporate Value Chain (Scope 3) Accounting and Reporting Standard", https://ghgprotocol.org/sites/default/files/standards/Scope3_Calculation_Guidance_0.pdf.

[45] DEFRA (2014) Guidance: "Calculate the carbon dioxide equivalent of an F gas"; see https://www.gov.uk/guidance/calculate-the-carbon-dioxide-equivalent-quantity-of-an-f-gas, accessed 07.12.2021.

A National Park's or AONB's greenhouse gas emissions could be reported in three ways:

Consumption-based emissions: We assess the greenhouse gas "footprint" of residents, visitors and industry, including the supply chains of everything that residents and visitors buy and do while in the National Park. Consumption-based reporting attributes the emissions from product and service supply chains to the National Park, ***regardless of where emissions are physically released during production***. Consumption-based reporting is important for looking at the climate change impacts that people and businesses have through their entire lifestyles and operations, including the food they eat and the products and services they buy. For example, taking a consumption-based approach, the impact of driving includes not just the exhaust pipe emissions, but also emissions resulting from the manufacture and maintenance of cars, and emissions resulting from the extraction and refining of fuels and their transport to the pump. For businesses, it includes the full impact of business practices, including procurement supply chains. The footprint of the National Park's industry is reported separately, as there is some unavoidable double-counting with the footprint of residents and visitors, where people in the National Park buy from local companies.

Production-based emissions: These are the net emissions that are physically released in the National Park, most notably by burning coal, oil and gas; those arising from the production of electricity used in the National Park (wherever that power is generated), and direct emissions associated with land use within the National Park or AONB (parts of agriculture, peatland degradation, etc.). This is the UK Government's standard emissions-reporting approach and only CO_2 emissions are reported by the Department for Business, Energy & Industrial Strategy (BEIS) at the local level. However, it also excludes embodied emissions arising from production – outside the landscape – of goods and services that are used in the area by residents, visitors and industry. The approach also includes through-traffic emissions from vehicles that are passing through the National Park or AONB without stopping. We use the term "net emissions" because we subtract any negative emissions (i.e. removal of CO_2 from the air) that may result from Land Use, Land Use Change and Forestry (LULUCF).

Extraction-based emissions: These are the emissions produced by burning any fossil fuels that are extracted from the ground in the National Park, wherever they are burned. This type of emissions reporting is important for understanding the climate change implications of decisions relating to any fossil fuel extraction in the National Park.

As mentioned earlier, in this assessment we focus on a consumption-based approach and report the scope 1, 2 and upstream scope 3 GHG footprints of residents and visitors, including visitor travel to the area. Since we are including upstream scope 3 emissions, our parallel rough assessment of industry emissions can also be regarded as taking a consumption-based approach. The datasets used are summarised in Appendices 10.2 and 10.3, and the methodology is described in Appendix 10.8. The motivation behind adopting the consumption-based approach is to account for the full climate impact of residents' and visitors' lifestyles. This assessment framework is expected to lead to more far-reaching and rapid decarbonisation efforts that are better aligned with the Paris Agreement goal to keep global temperature rise to 1.5°C relative to pre-industrial conditions.

5. Dartmoor: Consumption-based GHG emissions

5.1. Results overview

Here, we outline our analysis of the Dartmoor residents and visitors' GHG emissions for 2019 (Figure 10). The estimates are based on around 30 UK-wide and in-house datasets (Appendix 10.2), and use the latest version of the GHG footprint model developed by Small World Consulting (Appendix 10.8). Household consumption of goods and services, which underpins many of the key results presented in this section, is based on postcode-level demographic data for the National Park coupled with UK-wide consumer survey for a range of demographic groups.

Residents' emissions in 2019 are estimated at 0.571 million tCO_2e (Figure 11) and visitors' emissions – from time spent in the area and during travel to and from – are estimated at 0.159 million tCO_2e (Figure 12 and Figure 13). The assessment uses all unit-level postcodes with at least 30% of the area within the geographical boundary of the National Park, which gives resident population of 37,237 people. It is estimated that that there were over 2.6 million visitors per year in 2019 (both single-day and overnight). A full breakdown of these figures is provided in Appendix 10.4. The analysis shows that the typical footprint resident of the Dartmoor resident is 24.1% higher than that of the average UK resident. The final annual consumption of goods and services per year for residents (including public services) is over 1.23 billion pounds.

To indicate the scale of annual GHG emissions from the Dartmoor residents and visitors, you would need to plant an area around the size of 1,970 Premier League football pitches (1,407 ha, or 1.5% of the National Park's area) with broadleaf trees, and let them grow for over 100 years, to mitigate the combined GHG emissions of the regions' residents and visitors for the single year of 2019. This shows the need to prioritise GHG emissions *reductions* to limit global warming, rather than just mitigating emissions through carbon removal. Emissions reductions, including decarbonisation of industry and personal consumer spending, will be challenging in our modern world, but represents the only practical option.

For simplicity in facilitating personal behaviour change, the typical UK resident's average carbon footprint can be split into four key categories: food, home and accommodation, travel, and everything else[46]. We shall use these four key categories to comment on the results, and to suggest where National Park Authorities, local councils and partners could target initiatives aimed at behaviour change.

[46] Berners-Lee, M. (2021), "How Bad Are Bananas? The Carbon Footprint of Everything", p. 149.

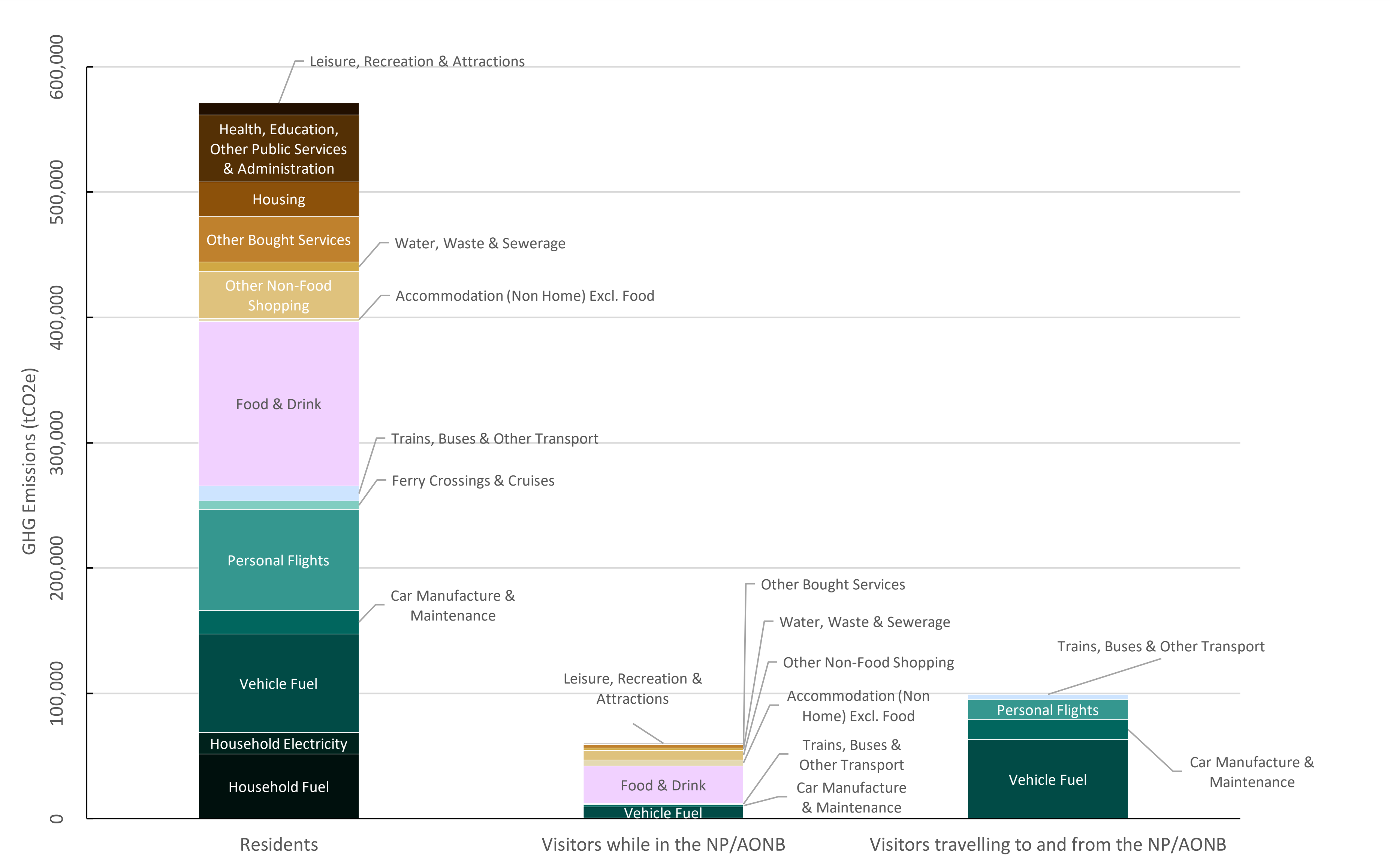
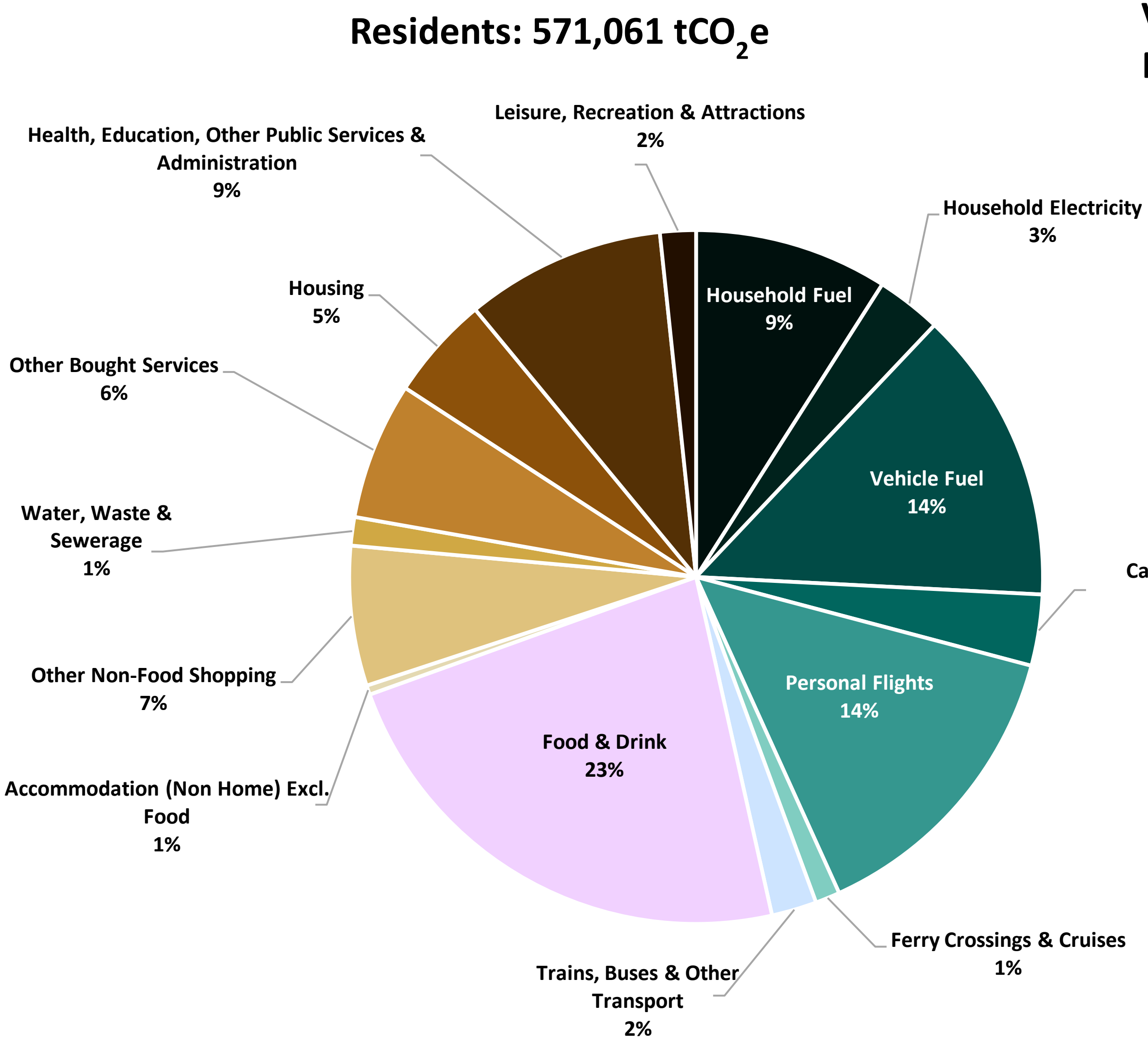
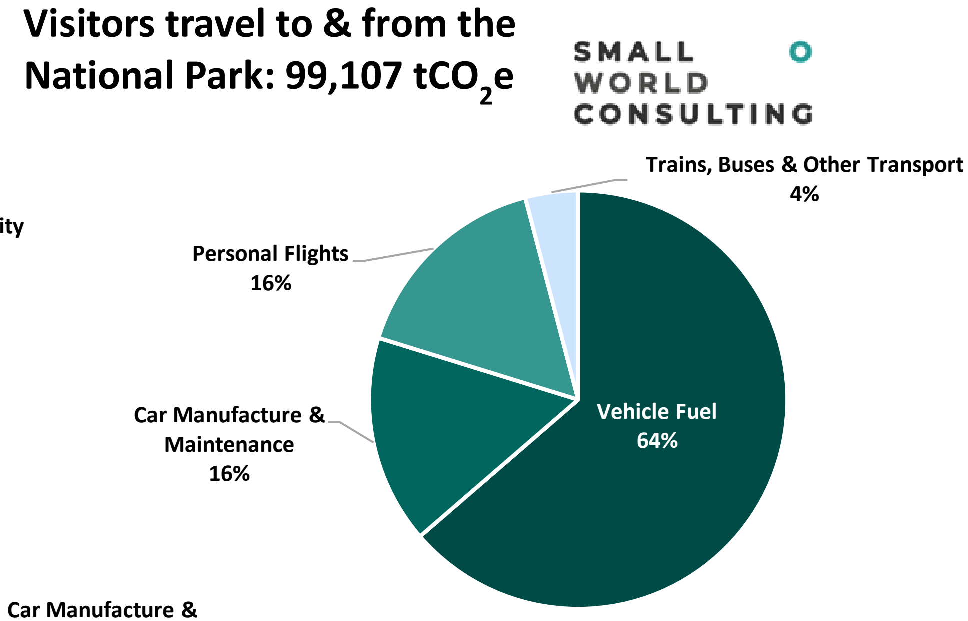


Figure 10: A consumption-based assessment of emissions relating to residents, visitors, and visitor travel to and from the Dartmoor.





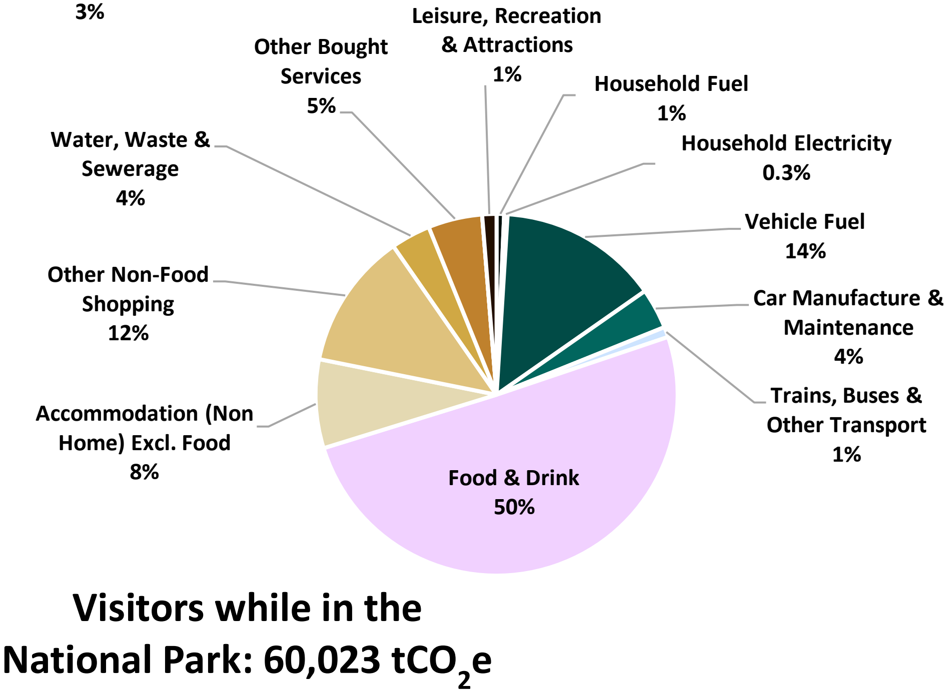


Figure 11: (left) Residents' GHG emissions in Dartmoor National Park, by percentage (repeat of Figure 2)

Figure 12: (top right) Visitors' GHG emissions on the way to and from Dartmoor National Park, by percentage (repeat of Figure 3).

Figure 13: (bottom right) Visitors' GHG emissions while in the Dartmoor National Park, by percentage (repeat of Figure 4).

5.2. Residents' and visitors' GHG footprint components

Dartmoor residents' emissions totalled 0.571 million tCO_2e in 2019, with the highest emissions arising from food and drink (23%), personal flights (14%) and vehicle fuel (14%).

GHG emissions produced by visitors to Dartmoor totalled 0.159 million tCO_2e in 2019, comprised of 99,107 tCO_2e from travelling to and from the National Park, and 60,023 tCO_2e produced while in the National Park. The chart presenting visitor travel to and from the National Park indicates that GHG emissions are dominated by vehicle fuel (64%) and personal flights (16%), with only 4% arising from public transport (excluding flights). Of the footprint of visitors while in the National Park, 50% is linked with food and drink, while vehicle fuel accounts for 14%.

5.2.1. Food

When considering behaviour change around food at its simplest level, we look at the sustainable choices available to us when we buy food and drink from shops, and when we "eat out". The carbon footprint from food and drink in the Dartmoor is considerable: for residents it is estimated to be 131,409 tCO_2e (23% of the residents' total), and for visitors 30,253 tCO_2e (50% of the visitors' total); see Appendices 10.4 and 10.5.

"Buy local, eat local" has become a common aspiration among the more environmentally aware, along with eating seasonal fruit and vegetables, and varying traditional eating patterns to include more plant-based protein and meal choices (a "flexitarian" diet). It is also possible to use carbon intensity as the basis for choosing which meat to consume, with beef having the highest intensity, then in descending order: lamb, pork and chicken. As well as alleviating the burden on the environment, these kinds of dietary choices can also help individuals live healthier lifestyles. This is because red meat (beef, lamb, pork) as a source of protein and fat is typically a moderate-to-high calorie density food, and therefore needs to be consumed in moderation for a balanced healthy diet. Lean protein sources like turkey and chicken, on the other hand, have a low calorie density. The number of calories people consume as they eat and drink has a direct impact on weight, with obesity being a key risk factor for long term conditions in later life; see section 5.2.4.

Eliminating food waste can reduce an individual's food footprint by a further 12%, as well as saving them money. Forgoing fruit and veg grown in hot-houses or air-freighted to the UK in favour of local, seasonal varieties could deliver a 5% reduction in the total food footprint[47]. Ship-transported and frozen produce are also good low-carbon alternatives, as the emissions per item are far lower than for air-freighted goods [48].

In farming communities in particular, the ongoing transition toward less intense farming systems, more local supply chains and reduced amount of meat and dairy products in the diets seem to be one of the hottest and most polarising topics, especially given the potential impact on farming livelihoods and traditional lifestyles. We suggest that these complex topics would benefit from a collaborative approach between the agricultural industry and other land managers, together with the NHS and public health bodies, to achieve a transition pathway that is acceptable to all and that

[47] Hoolohan, C. Berners-Lee, M., McKinstry-West, J. and Hewitt, C.N. (2013), "Mitigating the greenhouse gas emissions embodied in food through realistic consumer choices.." *Energy Policy* Vol. 63, p. 1065.

[48] Berners-Lee, M. (2010), "How Bad Are Bananas? The Carbon Footprint of Everything," p. 26-29.

acknowledges the issues pertaining to food production in the UK. Farmers are facing a difficult socio-economic context as they try to respond to climate change, achieve biodiversity gains and produce food, while also facing the challenge of an ageing workforce and workers opting to leave the industry.

Based on the latest science, the "National Food Strategy for England, Independent Review of England's food chain from field to fork" outlines a number of recommendations for government[49]. The recommendations are targeted on achieving shifts in the national diet by 2032 (compared to 2019) to meet commitments aimed at improving health, climate and nature, including: a 30% reduction in meat consumption; a 30% increase in the consumption of fruit and vegetables; a 50% increase in fibre intake; a 25% decrease in consumption of foods high in fat, sugar and/or salt[50].

The Sixth Carbon budget (2021) supplementary "Agriculture and land use" report references "modelling by Oxford University of Public Health's Eatwell Guide, the Government's official guide to achieving a healthy and balanced diet", which provides some even more challenging proposals. It suggests "an average reduction in the consumption of meat by around 89% for beef, 66% for pork and 63% for lamb, and a 20% reduction in dairy products"[51].

The health improvements that accompany a more sustainable diet are highly relevant when considering the public health agenda and the public purse. Diet-related health issues are long-term conditions that place a considerable load on the NHS. Being overweight is associated with many of the most common long-term health risks, i.e. coronary heart disease, hypertension (high blood pressure), liver disease, osteoarthritis, stroke, type 2 diabetes and cancer. According to data from Public Health England, obesity is estimated to cost the wider society around £27 billion per year, while treating overweight- and obesity-related conditions was costing the NHS over £6 billion in the financial year 2014-2015[52].

These discussions present significant challenges for the agriculture industry, regarding how to transition given the implications for livestock and food production in the UK. The National Farmers' Union (NFU) is aware of these and has set the goal of reaching net zero greenhouse gas (GHG) emissions across the whole of agriculture in England and Wales by 2040[53]. Achieving this would require considerable reductions of emissions from livestock, and reduced use of synthetic fertilisers, while actively pursuing efforts to sequester carbon by creating woodland, restoring peatland within agricultural land, and implementing regenerative farming practices[54].

5.2.2. Homes and accommodation away from home

The "Home and accommodation" category is estimated to account for 98,992 tCO_2e (17%) of the footprint of Dartmoor residents, and 5,347 tCO_2e of the visitors' footprint (9% of their footprint while in the Park). We considered the following components: household fuel (51,503; 9% of residents' total footprint), housing (27,634 tCO_2e; 5%), household electricity (17,375 tCO_2e; 3%),

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[49] National Food Strategy Independent Review, The Plan Chapter 16: The Recommendations; https://www.gov.uk/government/publications/government-food-strategy.
[50] National Food Strategy Independent Review, The Plan p.147.
[51] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section, p.21.
[52] https://www.gov.uk/government/publications/health-matters-obesity-and-the-food-environment/health-matters-obesity-and-the-food-environment--2.
[53] National Farmers Union (2021), "Achieving Net Zero, Farming's 2040 goal."
[54] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section.

and accommodation away from home (2,480 tCO_2e; 0.4%); see Appendix 10.4 for further details. The single biggest intervention the public can readily make is changing their energy supplier (switching to one that is divesting from fossil fuels) and actively sourcing a supply derived from genuinely renewable energy, e.g. solar, wind, tidal and/or hydro-electric power. The public generally lack knowledge about where their household energy comes from, with many consumers not being able to distinguish between:

a) "green tariffs" backed only by cheap Renewable Energy Guarantees Origin (REGO), which have little impact on encouraging further expansion of renewable electricity generation, and
b) suppliers that are more genuinely investing in renewable electricity, and offering tariffs wholly backed by Power Purchase Agreements (PPAs).

Further improvements can be made by reducing energy use within homes. Options vary from lowering the thermostat temperature, to improving home insulation, to replacing oil or gas boilers with alternatives such as an electric heat pump. Moving off-gas-grid properties from oil heating to a heat pump has the potential to reduce emissions significantly, while offering householders a more convenient system. Increased electricity demand in rural areas can be met by local renewable energy production and/or improved grid connections, which are particularly relevant if the locals will be using electric heat pumps and electric vehicles. We recognise that affordability is always a factor, and depends on individuals' financial means; however, a variety of home energy efficiency measures can be installed at different levels of cost, often met in part by access to Government grants (means-tested) or other funding.

5.2.3. Travel

Travel is estimated to be responsible for the biggest share of the total footprint of Dartmoor visitors (110,417 tCO_2e, 69%), including the entire footprint of travelling to and from the Park and 19% of the visitors' emissions while in the Park. The majority of this travel footprint comes from fuel burned in private vehicles, (71,678 tCO_2e; 45% of visitors' total), personal flights (15,995 tCO_2e; 10%), vehicle manufacture and maintenance (11%), as well as comparatively small amount from the use of trains, buses and other transport (3%).

Travel accounts for 34% of the residents' GHG footprint. In considering residents' travel we looked at personal flights (80,610 tCO_2e; 14% of residents' footprint), vehicle fuel (78,483 tCO_2e; 14%), vehicle manufacture and maintenance (18,924 tCO_2e; 3%), trains, buses and other transport (12,017 tCO_2e; 2%) and ferry crossings and cruises (6,547 tCO_2e; 1%). See Appendix 10.4 for further details.

Car travel is one of the largest contributors to the overall consumption-based footprint of the Dartmoor National Park, amounting to 26% of the combined footprint of the residents and visitors (this includes embedded emissions of manufacturing and maintaining cars).

All National Park users – whether visitors travelling to and from, or residents travelling locally – could benefit from work undertaken with local authorities to promote the use of public transport. This could explore mechanisms to help fast-track electrification of public-use vehicles such as buses, taxis and hire vehicles, and to influence Government to support the transition from diesel-powered to electric trains.

In terms of vehicle fuel use, variations in residents' annual mileage, and in vehicle size (both residents and visitors) make a big difference to carbon footprints. If someone drives 10,000 miles in a year, we estimate that the associated GHG emissions, including the embedded footprint of producing and distributing the fuel, as well as of manufacturing and maintaining the vehicle, are around 4.1 tCO_2e for a small petrol run-around, 5.1 tCO_2e for a medium family-size car and 7.6 tCO_2e for a large car. It is also worth noting that while car travel can have a high footprint if the driver travels alone, it becomes a far lower-carbon option per person when a car is full, e.g. transporting a family of 4 or 5.

The vehicle type also affects the GHG impact. A trip from Manchester to London (around 200 miles) in an average petrol car would produce 0.10 tCO_2e of emissions, including the embodied emissions of the vehicle itself and of the fuel. For the same journey an ordinary hybrid vehicle produces 0.08 tCO_2e, and for a plug-in electric hybrid car the figure is 0.07 tCO_2e. The average diesel car's greenhouse gas emissions are almost the same as for a comparable petrol car, but bear in mind that while diesel vehicles produce less CO_2e per mile and deliver better fuel economy than petrol vehicles, they may perform less well in terms of soot and nitrogen oxide production. Exhaust fumes are a key contributor to air pollution, so the cleanest choice is an electric car, which would also produce the lowest emissions: 0.04 tCO_2e[55]. We note that the latter estimate accounts for the current average carbon intensity of the UK electricity grid and the embedded carbon footprint of manufacturing the battery (largest embedded footprint of manufacturing electric vehicles), both of which are expected to come down as electricity generation and other related industries decarbonise[56].

In the UK in 2019, 10% of all new cars and vans purchased were electric[57]. The Committee on Climate Change (CCC) has recommended that 60% of all new cars and vans sold should be electric by 2030, and the Government recently announced a ban on selling new petrol, diesel or hybrid cars in the UK from 2030[58]. As Dartmoor has a more affluent demographic profile on average, the typically cost-prohibitive entry into owning an electric car is more likely to be within reach for some residents in the area. Aside from switching to an electric car, there are other choices that everyone can make to reduce vehicle emissions:

- The average person walks 210 miles per year[59]. Walking an additional 2.5 miles per week for local journeys, e.g. visits to local shops or the school run, could save 70 kg CO_2e in a year and bring co-benefits for health.

[55] Like all other road vehicles, electric cars emit particulates from tyres and brakes. Compared to tailpipe exhaust, emissions from electric vehicles mostly impact air quality rather than the climate. Since electric cars tend to be heavier on average than conventional cars, due to the battery, their emissions from tyres are marginally higher. Conversely, thanks to regenerative braking into the battery, electric cars' emissions associated with braking are lower than for conventional cars.
[56] The estimates for the embedded footprint of electric cars provided here are based on generic car manufacturing and maintenance emission factors per pound spend when buying a new vehicle. This is an approximate methodology which accounts for the larger embedded footprint of electric cars through their higher market prices compared to conventional cars. A more precise set of estimates based on life cycle analysis could be found in the ICCT briefings (see, for example, https://theicct.org/publication/effects-of-battery-manufacturing-on-electric-vehicle-life-cycle-greenhouse-gas-emissions/). However, these estimates still have limited information on the variations in the manufacturing footprint of electric cars between different countries of origin.
[57] https://www.ft.com/content/d57efdf6-ffad-11e9-be59-e49b2a136b8d.
[58] https://www.bbc.co.uk/news/science-environment-5136612354981425
[59] Department of Transport (2019), "National Travel Survey (England): 2018".

- Travelling by push bike is around ten times less carbon intensive than driving a medium-sized petrol car, and electric bikes are even less carbon intensive[60]. Cycling 10 miles a week instead of driving could therefore save around 0.25 tCO_2e per year.
- On average, travelling by train, bus or tram is nearly seven times less carbon intensive than driving a medium-sized petrol car. Taking public transport for 10 miles a week instead of driving could therefore save around 0.23 tCO_2e per year.
- Driving outside the rush hour avoids prolonged time at low vehicle speeds: an average car crawling five miles each way emits 22 $kgCO_2e$ a day, which over a year could equal 4.8 tCO_2e.
- When replacing an ageing medium family-size car, downsizing to a small petrol car would save 1.1 tCO_2e a year.
- When replacing an ageing large car, downsizing to a medium family-size petrol car would save 2.7 tCO_2e a year.
- The embodied emissions of a new car are substantial, with an average-sized petrol car having a carbon footprint of around 8 tCO_2e, and even a small car having a footprint of around 4 tCO_2e[61]. So, if you do need to buy a car, second hand saves the embodied emissions.
- If affordable, replacing a medium-sized petrol car with an electric car would save 2.2 tCO_2e a year. If you replaced a large car with a medium electric car the savings would be 5.5 tCO_2e a year.

It is not possible to identify from this assessment whether visitors are using their own vehicles or hire cars, but where hire cars are used it may be beneficial for the National Park to work with local providers to fast-track electrification of vehicles. In either case, increasing the availability of electric car charging points could encourage visitors to travel by electric vehicle. Of particular importance in the National Park's historic towns and villages, where the road network was not designed around the car and many houses do not have on-site parking, is working towards an effective on-street charging solution and funding roll-out of this. Another challenge is to ensure sufficient electricity grid capacity, particularly in the more remote and rural areas of the Dartmoor.

The other main contributor to the travel footprint is flying. One approach that could have the single biggest impact in reducing this travel footprint could be to step up messaging that encourages the public to fly less, and suggest in particular that they reduce "casual flying" for short-haul trips where other means of transport are feasible, e.g. travel by train, bus and/or boat.

5.2.4. Everything else

The remainder of the residents' footprint estimates consisted of: public services including health and education (53,188 tCO_2e; 9% of residents' footprint), other bought services (36,559 tCO_2e; 6%), other non-food shopping (37,210 tCO_2e; 7%), leisure, recreation and attractions (9,548 tCO_2e; 2%), and waste, water and sewerage (7,572 tCO_2e; 1%). The remainder of the visitors' emissions arose from: other non-food shopping (7,317 tCO_2e; 12%% of footprint while in the Park), other bought

[60] Electric bikes are estimated to be less carbon intensive than push bikes because electricity is more efficient at powering the bike compared to the food required to power a person over the same distance. The battery is also very small, so the additional embodied emissions compared to a push bike don't outweigh the efficiency improvements. How Bad Are Bananas (2020) Berners-Lee, M. pp28-29, 32-33.

[61] How Bad Are Bananas? (2020). Berners-Lee, M. pp 145-148.

services (2,904 tCO_2e; 5%), water, waste and sewerage (2,127 tCO_2e; 4%), and leisure, recreation and attractions (766 tCO_2e; 1%).

The biggest single factor in the "everything else" category is health and education. As discussed in Section 5.2.1, there can be a causal relationship between food, obesity and long-term health conditions. The public health "prevention" (of illness) agenda is therefore also important in helping National Parks and Local Authorities to decarbonise, as well as benefiting health and well-being.

We suggest that the role played by the National Parks in enabling the public to access green/blue space – known to support mental and physical well-being – should not be underestimated. Recent research by White *et al.* (2019) identified that the amount of recreational time individuals need to spend in natural environments in order to gain self-reported health and well-being benefits is at least 120 minutes per week[62]. White *et al.* (2010) also suggest that green space combined with aquatic blue space (water) offers enhanced perceived benefits, which can be incorporated into landscape design and opportunities for improving public accessibility[63].

Summary of key findings of exposure to green space to gain health and well-being benefits (White et al. 2010 and 2019)

Threshold ≥ 120 mins of green space exposure per week = health and well-being benefits.

Results suggest benefits can be achieved through a number of smaller visits.

E.g.

4 x 30 mins = 120 mins
6 x 20 mins = 120 mins

Psycho-physiological benefits gained from sitting passively in natural settings.

Scenes with water are associated with greater positive affect and higher perceived restorativeness than those without water.

The next biggest factors to consider in the "Everything else" category are other bought services and other non-food shopping. Simply put, the choices we make around which goods and services we purchase count towards our carbon footprint, due to the amount of fossil fuels used in production, or the air/road miles associated with those products and services. Making different choices when procuring goods and services can make a notable difference in reducing the resulting carbon costs.

Encouraging a circular economy within the National Park and its neighbouring Local Authorities may help reduce the emissions associated with goods and services. A circular economy is a model of production and consumption that involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible, rather than throwing them away and buying new.

In terms of waste, water, and sewerage, the National Park Authority is well-placed to support partners in strategic planning to deliver multi-environmental benefits, especially given the new

[62] White *et. al.* (2019), "Spending at least 120 minutes a week in nature is associated with good health and well-being." *Scientific Reports*. 9:7730 https://doi.org/10.1038/s41598-019-44097-3.
[63] White, M.P., Smith, A., Humphryes, K., Pahl, S., Snelling, D. and Depledge, M. (2010) "Blue space: the importance of water for preference, affect and restorativeness ratings of natural and built scenes." *Journal of Environmental Psychology* 30, 482–493.

Environment Act (2021) and the role the National Park Authority plays in processing and scrutinising planning applications. It is important to consider opportunities for:

- Mitigating the impact of air pollution
- Supporting healthy river basin catchments
- Supporting and restoring nature
- Protecting endangered species and fragile habitats
- Highlighting and improving the relationship between people and the landscape

Another issue to bear in mind: interventions to “slow the flow” in flood risk areas. When choices are made around nature-based solutions in upstream areas, or civil engineering solutions downstream which are likely to use cement in their construction, we suggest that both cost, carbon and broader environmental benefits are considered when undertaking option appraisals.

5.2.5. Comparison of residents’ GHG emissions with UK national average by category

Figure 14 compares the average per capita footprint of Dartmoor residents’ footprint with the UK national average.

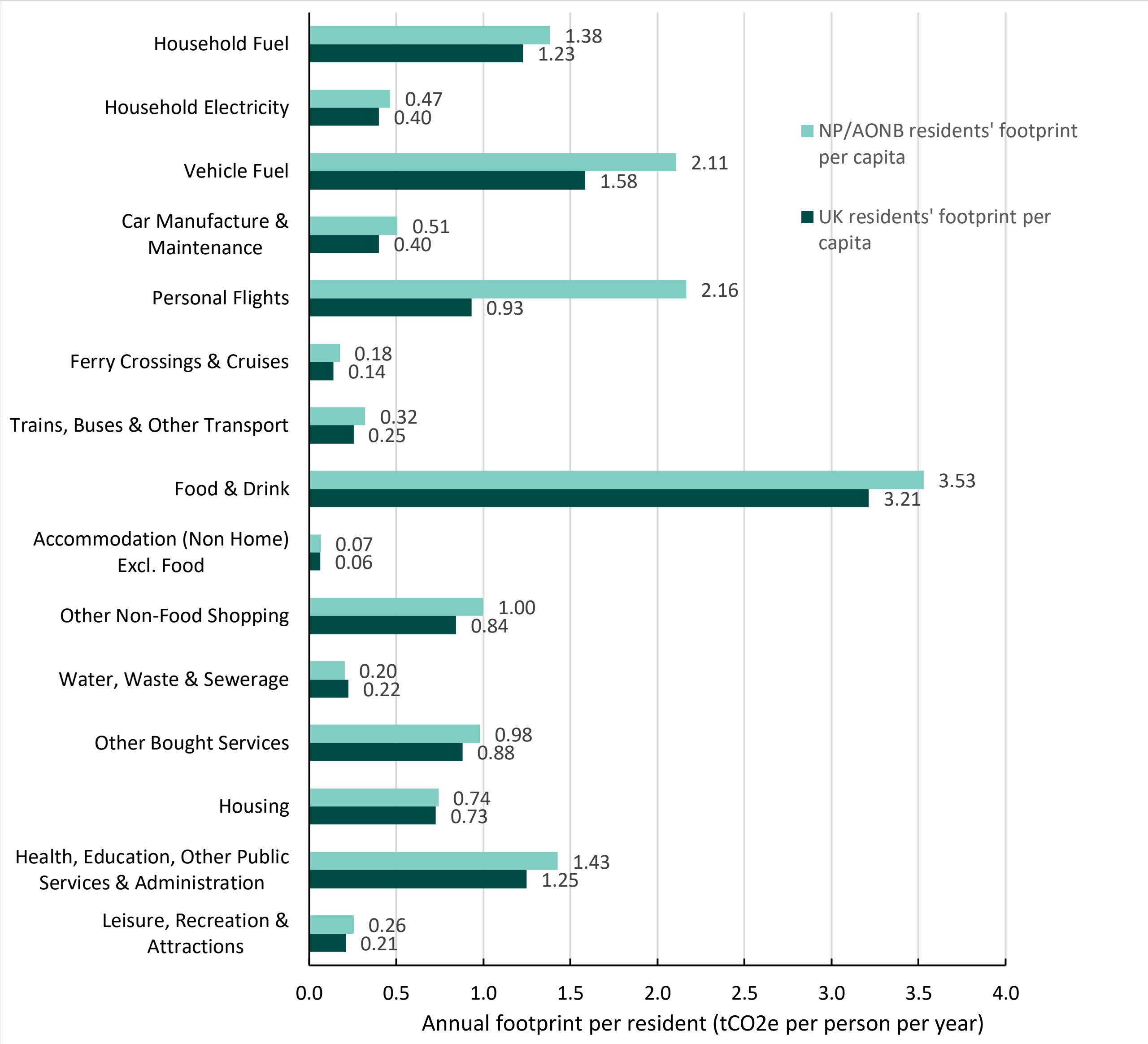

Figure 14: Residents' GHG footprints compared between the Dartmoor National Park average and the UK national average, by category

5.3. Industry assessment

This section presents the GHG emissions from industry but first outlines the scope of the industry assessment given that two approaches were used, as explained in Section 5.3.1.

5.3.1. Scope of industry assessment

Aside from the footprint of residents and visitors, we also include, for perspective, a rough assessment of the footprint of industries and their supply chains. We use data from the Office for National Statistics' Inter-Departmental Business Register (IDBR) for business turnovers in Census Output Areas (COA). This is used rather than Local Authority-level Gross Value Added (GVA) data since it is more geographically specific (see Appendices 10.6.1 to 10.6.3). Please note that the reported turnover data does not necessarily reflect on the actual geographical distribution of locations where business revenue is being generated.

Because of confidentiality constraints regarding the ONS IDBR data, we also had to include all COA geographies overlapping with the landscape's boundary, leading to marginal overestimates of the total turnover and the resulting industry footprint within the landscape. The industry footprint assessment is comparatively crude since COA-level business turnover data has only fifteen broad sectors, and the footprint calculation is based on the associated industry-specific carbon intensity averages for the UK. The use of UK-average carbon intensities could have a particular effect on the footprints for agriculture and forestry, because these sectors are known to have unique features across most National Parks and AONBs.

Please also note that this assessment overlaps with our more detailed analysis of resident and visitor emissions, since it is not feasible to eliminate double-counting arising from sales by local businesses to residents and visitors.

5.3.2. Industry sector analysis

The ONS UK Standard Industrial Classification (SIC) Hierarchy is used in formulating data analysis by the UK government to assess economic activity[64]. For transparency we include the IDBR broad industry group structure and see how this compares with the SIC (2007); see Appendix 10.6.1. When interpreting the results, please note that the IDBR production category includes mining, quarrying and utilities (Division 05/09, 35/39); added together with manufacturing (Division 10/33). Similarly, the SIC (2007) code arts, entertainment and recreation is aggregated to include: Other service activities; activities of households as employers; undifferentiated goods-and-services-producing activities for own use; and activities of extraterritorial organisations and bodies, Division 90/99 respectively.

Please note also that the IDBR national dataset suppresses data under seven categories, so an incomplete picture may apply to:

023: Gathering of wild-growing non-wood products.
071: Mining of iron ores.
072: Mining of non-ferrous metal ores.
531: Postal activities under universal service obligation
642: Activities of holding companies
653: Pension funding
843: Compulsory social security activities

We now consider the results for industry-related GHG emissions which total 207,523 tCO_2e. Figure 15 highlights production as the largest source of GHG emissions (72,614 tCO_2e; 35%); followed by agriculture, forestry and fishing (58,985 tCO_2e; 28%) and construction (23,752 tCO_2e; 11%), see Appendix 10.6.2. Industry-related flights account for 11,287 tCO_2e of the total footprint but are not separately categorised. Each of the main contributing categories are discussed in turn below.

[64] https://onsdigital.github.io/dp-classification-tools/standard-industrial-classification/ONS_SIC_hierarchy_view.html.

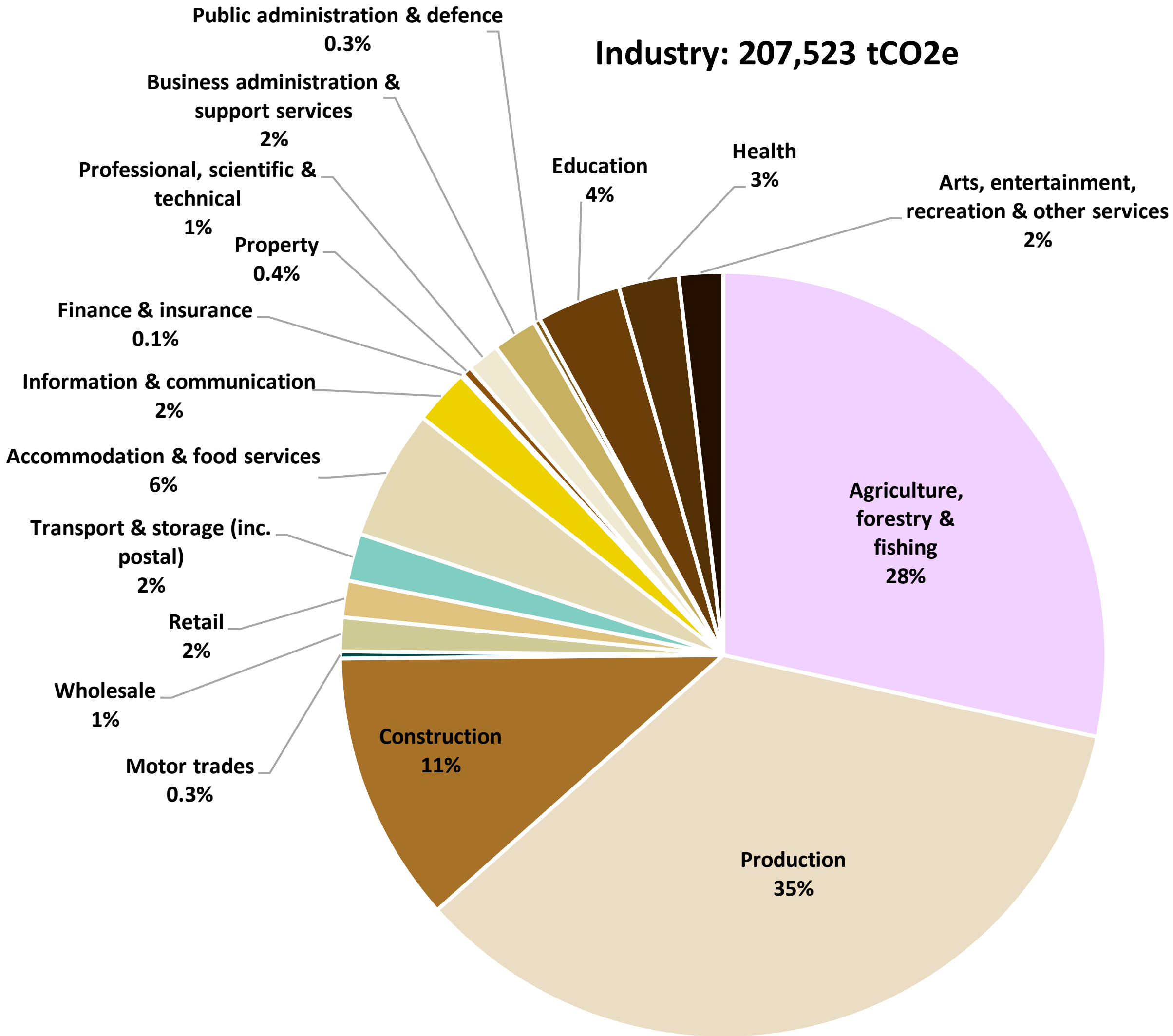

Figure 15: An estimate of emissions from industries within the National Park and their supply chains (scopes 1, 2 and upstream scope 3) (repeat of Figure 5)

Production

Production (referring to manufacturing industries) plays an important role in the National Park (72,614 tCO_2e; 35% of the estimated total industry footprint in the region). It must be noted that there are inevitable overlaps between the National Park and the nearby regions when it comes to industry data since it is being soused from the course COA geographies instead of the postcodes. While these overlaps cannot be eliminated until a more spatially granular data becomes available, we suggest that manufacturing as a sector should be one of the top industries to decarbonise in the wider area. This is where Local Enterprise Partnerships may wish to focus efforts by encouraging companies to undertake assessment of their Scope 1, 2 and 3 GHG emissions and to develop credible roadmaps to reduce them.

Agriculture

The second top industry for GHG emissions is agriculture, forestry and fishing (58,985 tCO_2e; 28%). The issues pertaining to this industry are discussed in detail under 3.2 (Agricultural landscape), 5.2.1 (Food) and 5.2.4 (Everything else). The Sixth Carbon Budget (2020) "Agriculture and land use, land use change and forestry" report suggests multiple opportunities for reducing emissions, as follows.

The initial focus relates to low-carbon farming practices, including livestock measures such as selective breeding, increased milking frequency, changes to livestock diet to decrease enteric methane emissions, and improved livestock health. The second focus is on soil improvement, achieved through the use of legumes, cover crops and grass leys. The third focus is on waste and manure, including the use of anaerobic digestion and covering slurry tanks.

The Sixth Carbon Budget also discusses reducing the numbers of cattle, sheep, pigs and poultry reared, and making technological (e.g. hydrogen technology) and dietary changes which lead to smaller overall areas of grassland and cropland used to support pastoral farming. JCB, for example, have developed a prototype hydrogen tractor, and there may be benefits in the local enterprise partnership (LEP) collaborating with manufacturers who can facilitate, and even accelerate, such a transition. Moving some production to greenhouses and vertical urban farms, collectively referred to as indoor horticulture, is also likely going to be required to make the UK self-sufficient in terms of food while enabling large-scale nature recovery programmes. Such technologies have been piloted successfully by other countries including the Netherlands, which has become the second-largest food exporter globally despite its comparatively small land area[65]. Changes to a more plant-based diet will go hand in hand with the recommended scaling-up of indoor horticulture. In terms of innovations, options such as lab-grown meat and insects as new sources of protein should also be on the table.

Other opportunities relate to improving productivity and efficiency, with a headroom to increase average crop yields from around 8 t/ha at present to around 11 t/ha. However, climate change is likely to pose additional risks to yields. The report suggests land management measures such as increasing soil quality, smaller tillage, nutrition and pesticide management, and opportunity mapping. Innovations in breeding are also discussed along with increasing stocking density. Another key suggestion is increasing paddock grazing to 80%, which improves the quality of grass and enhances sequestration of carbon in the soil, provided it is well managed and doesn't lead to over-grazing and soil compaction. The report suggests that only 50% of grass produced in paddocks is actually eaten.

Another clear and significant intervention that would reduce requirements from agriculture, alongside improved productivity and dietary changes, would be measures to reduce food waste, amid data showing that 3.6-13.6 million tonnes of UK food is wasted per year.

Construction

We estimate that construction is the third-largest GHG-emitting industry in the Dartmoor National Park (at 11% of the total). The Sixth Carbon budget (2020) "Manufacturing and construction sector" report showed that GHG emissions from this sector contributed 12% of the total production-based

[65] FAOSTAT, "Trade of Agricultural Commodities 2000-2020", https://www.fao.org/3/cb9928en/cb9928en.pdf.

UK GHG emissions in 2019. Opportunities for interventions to reduce construction-related emissions include:

- Resource efficiency: reducing the flow of materials through the economy, and using products more efficiently (and for longer), can reduce manufacturing emissions as part of a shift towards a more circular economy.
- Material substitution: manufacturing emissions can be reduced by switching from high-embodied-carbon materials to low-embodied-carbon materials. Measures include using wood in construction and using alternatives to clinker (e.g. fly ash) in cement.
- Energy efficiency*:* using energy more efficiently reduces operating costs while cutting emissions. The energy efficiency measures that we include are "low-regret" actions that often reduce fuel costs significantly. Measures include process and equipment upgrades, installing/improving heat recovery systems, and clustering/networking with other sites and businesses to efficiently utilise waste heat and other by-products.
- Fuel switching in manufacturing*:* hydrogen, electricity and bioenergy can all be used to meet demands for heat, motion and electricity, thus removing the need for fossil fuels and reducing GHG emissions.
- Carbon Capture and Storage (CCS): CCS can be used to capture CO_2 produced by larger industrial point-sources and transport it to a CO_2 storage site, thereby reducing emissions to the atmosphere[66].

IDBR and GVA-based emissions comparison

We undertook a comparison between the inter-departmental business registry (IDBR) data and gross value added (GVA) data, as we know that economic reporting often uses GVA as the primary measure upon which many local enterprise partnership (LEPs) base their workforce planning, see Appendix 10.6.1. The GVA dataset is only available for the neighbouring unitary local authorities. Therefore, when it is projected from the local authorities on the National Park and compared to the more geographically-aligned IDBR data, this indicates a potential under-reporting of GVA-based emissions from agriculture and information and communication, and a potential over-reporting for the remainder of industries, including production, construction and transport and storage (Figure 16). The National Park may wish to discuss this with LEPs in the area.

[66] The Sixth Carbon Budget (2020), "Manufacturing and construction" section, p. 6-11.

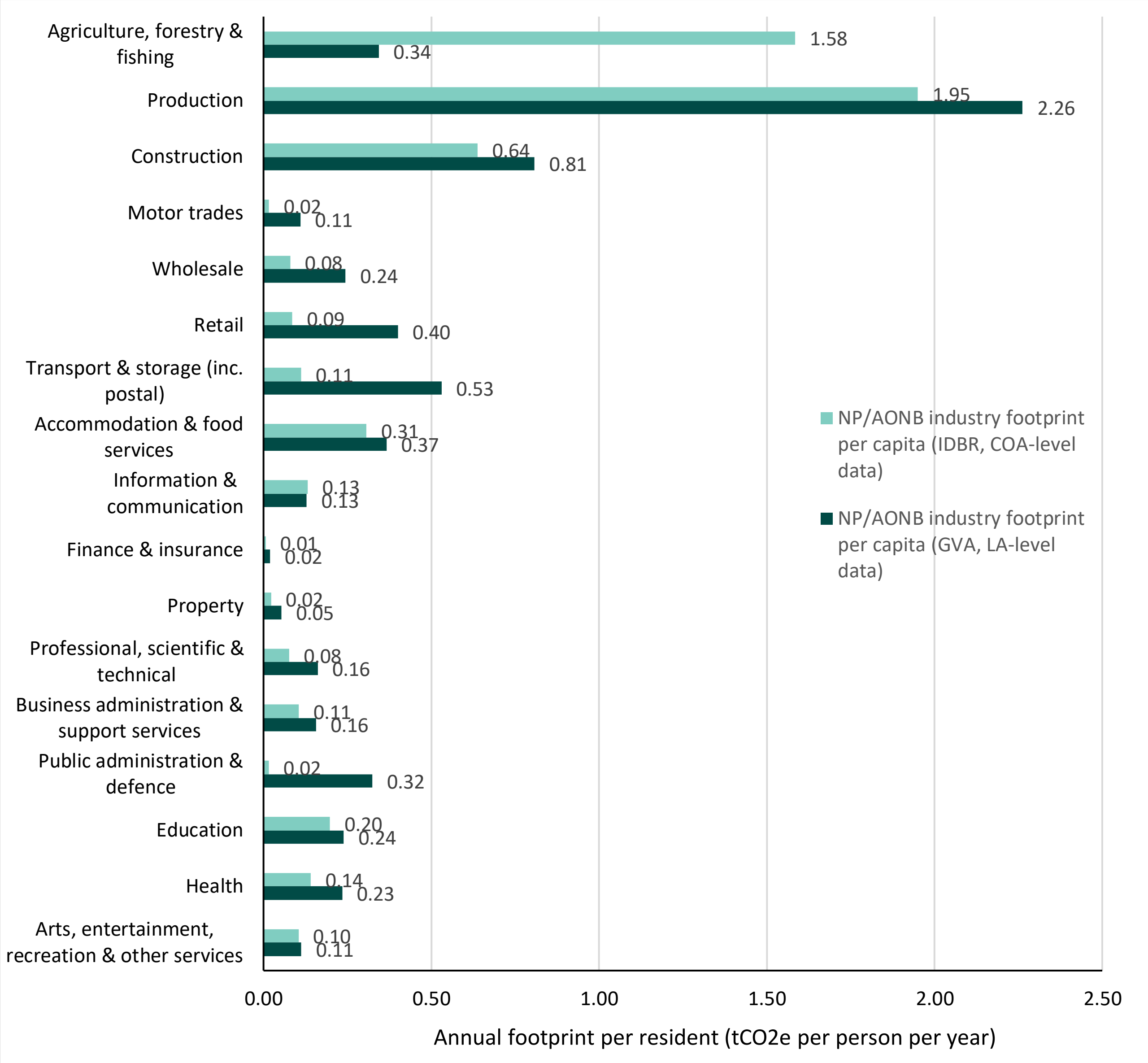

Figure 16: The Dartmoor National Park industry footprint estimates: IDBR vs. GVA, by sector

5.3.3. Energy-only industry analysis

This analysis is a subset of the industry carbon footprint estimate. Energy is estimated to make up 50% of emissions from industry (102,806 tCO_2e). Table 2 shows the breakdown of industry emissions from electricity and fuels in the Dartmoor National Park.

Table 2: Energy-only industry (subset of industry) – Dartmoor National Park

Industry Electricity	37,257	tCO_2e
Industry Fuels Excl. Road	56,139	tCO_2e
Industry Road Fuels	9,411	tCO_2e
Total	**102,806**	**tCO_2e**

5.3.4. Large emitters analysis

As a further component of the industry GHG footprint analysis, the BEIS Pollution Inventory (2018) enables us to identify specific large emitters within each UK National Park (see Appendix 10.6.4). For the Dartmoor National Park, there are no large emitters within the Park area. If at a future date large emitters emerge within the Park it may be possible to engage with them either directly or through the relevant Local Authorities. The aspiration is to promote carbon assessment of Scope 1, 2, and 3 GHG emissions, and carbon reduction planning with a view to net zero[67].

We also identify where IDBR data has been suppressed by the ONS's own software, which means a null value is returned for confidentiality reasons. Where this poses an issue for the reliability and validity of the results, these issues are discussed, and the missing data is approximated using LSOA-based and UK-based business turnover datasets (also made available to us by the ONS). In the case of the Dartmoor National Park, none of the IDBR data was found to be suppressed[68].

5.3.5. Comparison of annual industry footprint with UK averages

It may be helpful for the National Park to compare itself with the UK national average for each industry category. This helps to identify patterns and pinpoint where it would be beneficial to focus partnership-working with Local Authorities. The results (Figure 17) show higher-than-national averages for: agriculture, forestry and fishing, construction, and accommodation and food services.

As background to influencing change, the UK Government enacted legislation on the 1st of October 2013 making it mandatory for the UK's largest quoted companies to report their GHG emissions (Statutory Instrument (SI) 2013/1970:5). In 2018, this SI 2013 was amended to include "emissions, energy consumption and energy efficiency action by quoted companies" (SI 2018/1155, Part 6) to reflect the true impact of their operations[69]. This was extended to all large companies, including the public sector. Due to this legislation, one should expect all large organisations to be in the process of assessing their full GHG emissions and preparing carbon reduction plans aimed at reaching net zero. However, large businesses that fall under the new statutory reporting requirements and are new to carbon accounting may find the process challenging and would need specialist help to prepare the GHG emission reports.

Some organisations are attempting to encourage a sector-wide approach, e.g. the National Farmers Union and water utility companies. It is recognised that there is much goodwill in industry, with many leaders and individuals in organisations concerned about the climate emergency and striving to make their business more sustainable. However, we also recognise that capacity and capability often pose challenges to medium and small enterprises that have more limited resources.

[67] UK local authority and regional carbon dioxide emissions national statistics: 2005-2018.

[68] We note that business activities and emissions associated with the Okehampton military training camp are likely to be consolidated with other facilities around the country in the MoD reporting, which does not disclose information on individual military facilities.

[69] The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013 (SI 2013/1970) (Strategic Report Regulations 2013), enacted from 1st October 2013 to the present.

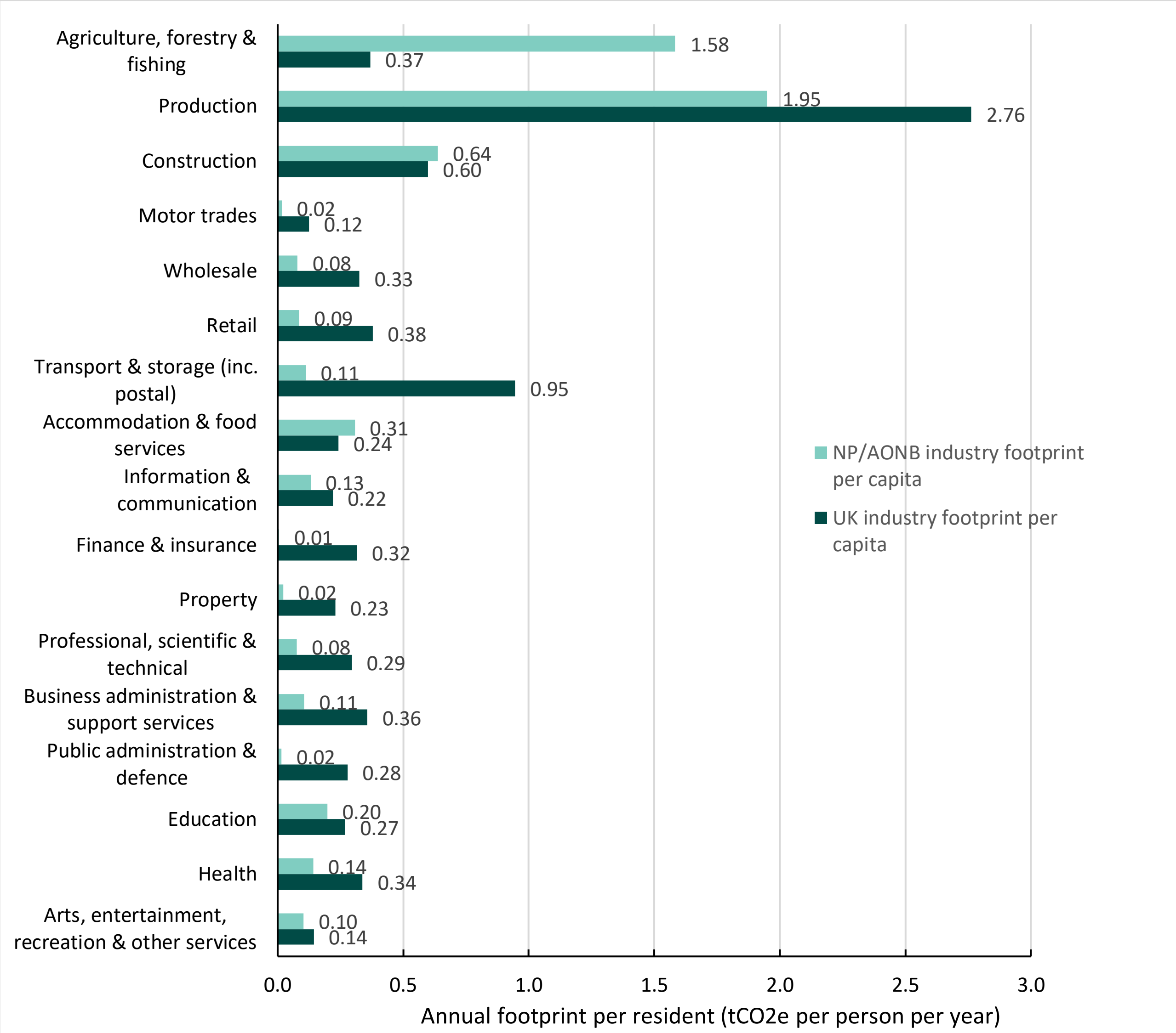

Figure 17: The Dartmoor National Park industry GHG emissions compared with UK national average, by sector

5.4. Analysis of emissions from through-traffic and major roads

The analysis of the impact of through-traffic has been included at the request of several National Park Authorities and Local Authorities for AONBs (see Appendix 10.7). Through-traffic refers to vehicles passing through the National Park or AONB without visiting, regardless of their origin and destination. Its footprint is estimated by comparing total traffic point counts with pump-level fuel sales within each National Park or AONB, along with assumptions about commuting in and out of the area. The estimate represents the emissions from through-traffic that occur within the geographical boundary of the National Park or AONB, unlike the total driving footprints of the residents and visitors that mostly occur outside of the boundary. The purpose of reporting the through-traffic emissions is to show how much of the geographical footprint due to road traffic within the National Park or AONB boundary is not related to living in or visiting the area, which could be used to support new road electrification infrastructure as well as public transport.

For Dartmoor National Park, estimated total through-traffic emissions from cars, buses, motorbikes, vans and lorries are **23,824 tCO_2e.** This data is **not included** in the residents', visitors' or industry footprints.

We also report emissions from smaller and larger subsets of selected A-roads, which carry elements of through-traffic as well as traffic from residents, visitors and industry. The selected roads assessed for Dartmoor are the A386, A385 and A382 (Appendix 10.7). The estimated footprint of these roads within the Dartmoor geographical boundary is 49,853 tCO_2e per year across all vehicle types. This amounts to around 9% compared to the total footprint of the residents.

5.5. Land use emissions

The land use sector differs from other sectors in the Greenhouse Gas Inventory in that it contains both sources and sinks of greenhouse gases. The sources, or emissions to the atmosphere, are given as positive values; the sinks, or removals from the atmosphere, are given as negative values (see Table 3). Our definition of the land use sector includes emissions from livestock (mostly methane), synthetic fertiliser use (mostly N_2O), degrading mineral and organic soils (peat) (mostly CO_2), and lost biomass (CO_2), as well as carbon sequestration in soils and biomass through woodland creation, peatland restoration and regenerative agriculture practices (Table 4). The net land use GHG flux is therefore split into CO_2 and non-CO_2 components. Our land use sector overlaps with the "land use, land use change and forestry" (LULUCF) sector for national GHG reporting in line with the IPCC guidelines. However, LULUCF excludes emissions from livestock and fertiliser use, which are reported separately as part of the "agriculture" sector; the latter is different from our IDBR "agriculture, forestry and fishing" industry sector.

Table 3: Land use GHG emissions for the Dartmoor National Park, based on a blend between the 2019 and 2017 land use data releases for the National Parks published by BEIS

Land use CO_2 (inc. biomass and carbon sequestration)	-52,129	tCO_2e per year
Land use non-CO_2 (inc. livestock and fertiliser)	159,193	tCO_2e per year
Total: Land use	**107,064**	**tCO_2e per year**

Table 4. Breakdown of the land use emissions into sources separately for each GHG for the Dartmoor National Park, based on the 2019 land use data for the National Parks published by BEIS

GHG type	**CO_2 (tCO_2e per year)**	**CH_4 (tCO_2e per year)**	**N_2O (tCO_2e per year)**
Agriculture Livestock	0	103,415	18,112
Agriculture Soils	547	0	19,978
Net Emissions: Forest land	-84,192	56	748
Net Emissions: Cropland	20,348	30	1,023
Net Emissions: Grassland	882	14,323	591
Net Emissions: Wetlands	-8,365	22,434	200
Net Emissions: Settlements	17,520	87	1,301
Net Emissions: Harvested Wood Products	0	0	0
Net Emissions: Indirect N_2O	0	0	562

Land use GHG emissions data for all National Parks is prepared by the Department for Business, Energy and Industrial Strategy (BEIS) through three subcontractors – Ricardo Energy & Environment, Centre for Ecology and Hydrology, and Forest Research – in accordance with the requirements to report UK Greenhouse Gas Emissions for the United Nations Framework Convention on Climate Change (UNFCCC). There is a risk that future improvements to the methodology for reporting land use GHG emissions might shift the sector from a net sink to a net source of emissions, as indicated within the Sixth Carbon Budget (2020).

Although the latest BEIS land use emissions estimates (2019) are more accurate than in previous years, they remain subject to considerable uncertainty. This is due to an evolving methodology and a process to refine the measurement of emission factors for UK peatlands, attempting to take into account transitions from heavily modified peatlands (forested land, cropland, grassland, peat extraction, eroding bog) and semi-natural peatlands (heather-dominated and grass-dominated bogs). Peatlands in their semi-natural state may be near-natural, modified, or rewetted. The estimates for CO_2 emissions in the form of dissolved organic carbon (DOC) use Tier 1 emission factors, and therefore are the least robust of all (IPCC 2014). Tier 2 emission factors for the UK-relevant peat condition categories were subsequently developed by Evans *et al.* (2017), providing estimates for "particulate organic carbon" (POC) emissions, as well as direct CO_2 emissions. The Tier 2 estimations add more granularity and are country-specific, being tested for robustness using at least four different study locations considered reliable enough to replace Tier 1 values. The CARBINE Tier 3 carbon accounting model developed by Forest Research was employed to derive the emission factor for forested peatland between 1990 and 2019, and was tested using field data[70]. For the full set of assumptions made in order to estimate peatland emissions in the National Parks using the latest (2019) land use emissions data released by BEIS, please see Table 12 in Appendix 10.8.8 (Table A.3.4.28 in the BEIS methodology annex).

In relation to the "family" of National Parks and AONBs, it is worth noting four key reports which outline implementation of land use policy, namely:

- The 25-Year Environment Plan[71]
- Climate Change Committee (2020) – Land Use: Policies for a Net Zero UK
- Climate Change Committee (2020) – The Sixth Carbon Budget: Agriculture and land use, land use change and forestry
- England Peatland Action Plan (2021).

Given that only 13% of England's peatlands are estimated to be in a near-natural state at present, the Peatland Action Plan explicitly states that: "We will support National Parks and Areas of Outstanding Natural Beauty teams to deliver significant amounts of peatland restoration over the next 10 years[72]." The next section reflects upon this guidance in terms of target-setting.

5.6. Factors for consideration in land use target-setting

The National Park Authority has also undertaken its own GIS assessment of its key habitat types by area, as described in Appendix 10.8.10. The results of this analysis are not used for estimating land

[70] Ricardo Energy & Environment, UK NIR 2020 (Issue 1): "UK GHG Inventory 1990-2019," Annex p. 854.
[71] HM Government (2018), "A Green Future: Our 25-Year Plan to Improve the Environment."
[72] UK Government (2021), "England Peat Action Plan", p. 12.

use emission in the base year, which are quoted directly from the BEIS dataset, but instead provide baseline area data for the land use target-setting discussed in Section 6. This analysis involved mapping between the bespoke SWEEP dataset for habitats and peat in the Dartmoor National Park and a more generic set of habitat classes used by the Centre for Ecology and Hydrology, which are the default in our analysis for all National Parks and AONBs on the current programme. The mapping introduced a different kind of uncertainty to the results for the land use targets (Appendix 10.8.10), and this would need to be addressed in subsequent assessments.

Reflecting upon the Sixth Carbon Budget (2021) we identify hectares-per-year targets for creating native broadleaf/mixed woodland, planting new productive coniferous woodland, restoring peatland, adopting agroforestry practices and increasing the extent of hedgerows (both of which improve grassland and cropland), adding legume species to improved grassland, and adopting winter cover cropping for cropland.

Please note that the land use GHG estimates for National Parks are published by BEIS, and given the existing levels of uncertainty they are expected to change in the future. Any changes introduced to the figures may impact on the proposed pathways to net zero for all the UK National Parks and AONBs to varying degrees. It is expected that the BEIS land use data will be refined in subsequent years, and retrospectively applied to the entire published time series. Baseline year data will therefore be impacted in future years. Sections 5.6.1 to 5.6.5 discuss the importance of woodland, peatlands, and agricultural landscapes when developing subsequent strategies to implement land use targets that support climate adaptation and mitigation.

5.6.1. Trees, woodlands and forestry

The notional target of 350 ha/yr of new woodland per year proposed in Section 6 is based on apportioning UK-wide woodland targets from The Sixth Carbon Budget, which is described in detail in Appendix 10.8.9. Our approach for apportioning the woodland target, which has been applied to all National Parks and AONBs participating in this programme, safeguards existing woodland (leaving aside the issue of replacing conifers with native broadleaf/mixed species) and protected habitats such as lowland heathland, while also reflecting on the agricultural make-up of the area. However, it is recognised that this the apportioned target does not replace discussions by the relevant Local Authorities, their members, partners and stakeholders in developing real-world operational strategies for land use change implementation, particularly in relation to developing a Tree, Forestry and Woodland Strategy.

There are multiple issues for stakeholders to consider including the complexities associated with the "right tree, right place" principle. Key to changing hearts and minds about the volume of tree coverage is the public perception of natural beauty within protected landscapes and how much change is acceptable within historic landscapes. For instance, woodland design may benefit from emulating "natural" patterns and forms rather than linear boundaries, unless there is a historic precedent[73]. There are also practical considerations in the choice of tree species to foster long-term resilience to the anticipated average temperature increases, increased average rainfall, more frequent flood events, and more severe drought periods driven by climate change. The Met Office has recorded a 0.93°C increase in average monthly maximum temperatures over the last 60 years

[73]Forestry Commission (2017), "The UK Forestry Standard: The government's approach to sustainable forestry."

or so, for the weather station at Yarner Wood[74]. Natural England published another helpful report, worthy of review, examining the relative sensitivity of habitats to climate change[75].

Any new woodland planning requires multi-benefit opportunity mapping to identify the optimum strategic placement and economic considerations for farmers and landowners (e.g. “a wood that pays is a wood that stays”). Another key factor to consider is the UK’s demand for productive woodland to supply the construction and biomass industries, as well as sustainable woodland management. An example case study of where a local partnership has followed this approach to produce a woodland strategy is the Forest of Bowland Area of Outstanding Natural Beauty (2021) “Trees, Woodland and Forestry Strategy”.

5.6.2. Local authority opportunities

There are other opportunities to establish trees, some of them particularly town-friendly; for example, working with local authority partners to plant micro-forests, shrubs and hedgerows in urban settings such as parks and schools, and on public highways, e.g. roundabouts. These natural barriers can also offer some protection against air pollution if the correct species are chosen. Public highways can provide excellent spaces for pollinator patches, and the costs paid by local authorities to maintain these stretches can be reduced by changing grass-cutting regimes, as discussed in the Lancaster City Council (2021) Grassland Management Strategy[76]; see Box 1.

Box 1: Sharing the learning example case study: Lancaster City Council Pollinator Patches

“Since the 1930s, England has lost 97% of its grasslands, with more than 500 species having disappeared, and more could yet follow, including hedgehogs and house sparrows. Lancaster City Council has developed several different cutting palettes specific to different grassed areas across the district, based on advice from experts in the field including Natural England, Butterfly Conservation, Lune Valley Pollinators, landscape architects and ecologists. The nine cutting palettes are public open space, managed long meadow, desirelines, meadow edges, verges, amenity prestige, informal sports, and two types of wildflower meadows (introductory mix and perennial mix).”

Source: Extracts from LCC (2021) Grassland Management Strategy

5.6.3. Peatlands and wetlands

Peatlands are globally important in tackling climate change; they cover only 3% of the global land surface, yet hold nearly 30% of the world’s soil carbon[77]. In the UK, peat soils account for nearly 33% of land cover[78]. According to the UK Peatland Strategy (2018) peatlands form the UK’s largest expanse of semi-natural habitat occupying 10% of the UK’s land area and are extremely important

74 https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gbvrg6vzc.
75 Climate Change Adaptation Manual, “Evidence to support nature conservation in a changing climate.”
76 Lancaster City Council (2021), “Grassland Management Strategy”; https://www.lancaster.gov.uk/news/2021/feb/implementation-of-new-grassland-management-strategy.
77 IUCN National Committee United Kingdom (2021) “About Peatlands”; https://www.iucn-uk-peatlandprogramme.org/about-peatlands.
78 IUCN National Committee United Kingdom (2018) “UK Peatland Strategy 2018-2040”, p. 25.

habitats. They are our largest terrestrial carbon store, a haven for rare wildlife, and natural providers of water regulation, with 13% of the world's blanket bog formed in the UK.

Both the UK Peatland Strategy (2018-2040) and the Sixth Carbon Budget (2020) recommend that Peatlands are widely restored to their natural state and managed sustainably. It is estimated that eighty percent of peatlands in the UK have been modified as a result of past and present management[79].

There are four broad types of peatland in the UK[80]:

- Blanket bog (globally rare and typically found in uplands, fed by rainwater)
- Raised bog (mainly found in lowlands, peatland raised above surrounding landscape and fed by rainwater)
- Fens (fed by groundwater)
- Mire (fed by rainfall and surface water)

Peatland areas in the Dartmoor National Park largely consist of blanket bog, with small areas of raised bog and valley mire.

Peat restoration involves raising the water table nearer to the surface and re-establishing peat-forming fen or bog vegetation. Peatlands damaged by drainage and other human activities can rapidly lose their stored carbon, predominantly in the form of carbon dioxide (CO_2) release to the atmosphere. It's worth stating that peatlands are complex; they both emit and capture CO_2, and the balance between these processes depends on the peatland's condition. Peatlands may also be either sources or sinks of methane, and sources of nitrous oxide. However, the evidence suggests that, overall, peatland restoration delivers greenhouse gas benefits by protecting stored carbon and drastically reducing the amount of carbon dioxide emitted, even after factoring in the initial increase in methane emissions following re-wetting[81].

We estimate that peatland accounts for 33% of Dartmoor's land area. Restoring peatland is therefore of large significance for the National Park. Dartmoor is already working as part of the South West Peatland Partnership to assess and restore peatland across the moors of the South West[82]. The University of Exeter has undertaken a peatland mapping project, and this assessment goes a significant way to understanding current peatland condition, including the habitat types and the associated areas featuring peat soils, which will enable priorities for restoration to be identified[83]. Since hydrology assessments are key for restoring peat soils, furthering work already undertaken in partnership with water utility companies is also recommended, given their responsibility for ensuring water quality and sustainability as part of the Water Framework Directive Regulations. Water utility companies are also responsible for delivering the Water Resources Regional Plan and Water Resources Management Plan.

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[79] IUCN National Committee United Kingdom Peatland Programme (2021) "Peatland Damage"; https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-damage.

[80] https://peatlands.org/peatlands/types-of-peatlands/

[81] "Carbon storage and sequestration by habitat: a review of the evidence (second edition)." Natural England Research Report NERR094.

[82] https://www.dartmoor.gov.uk/wildlife-and-heritage/our-conservation-work/the-south-west-peatland-project

[83] https://www.exeter.ac.uk/research/creww/research/casestudies/miresproject/

5.6.4. Agricultural landscape and food production

In considering land use and land use change potential, it is also important to understand the nature of the land in the protected landscape and how it contributes to UK food security. The UK is a net importer of food (Figure 18). Only 55% of food consumed in the UK (by economic value) is of UK origin, with 26% imported from Europe[84].

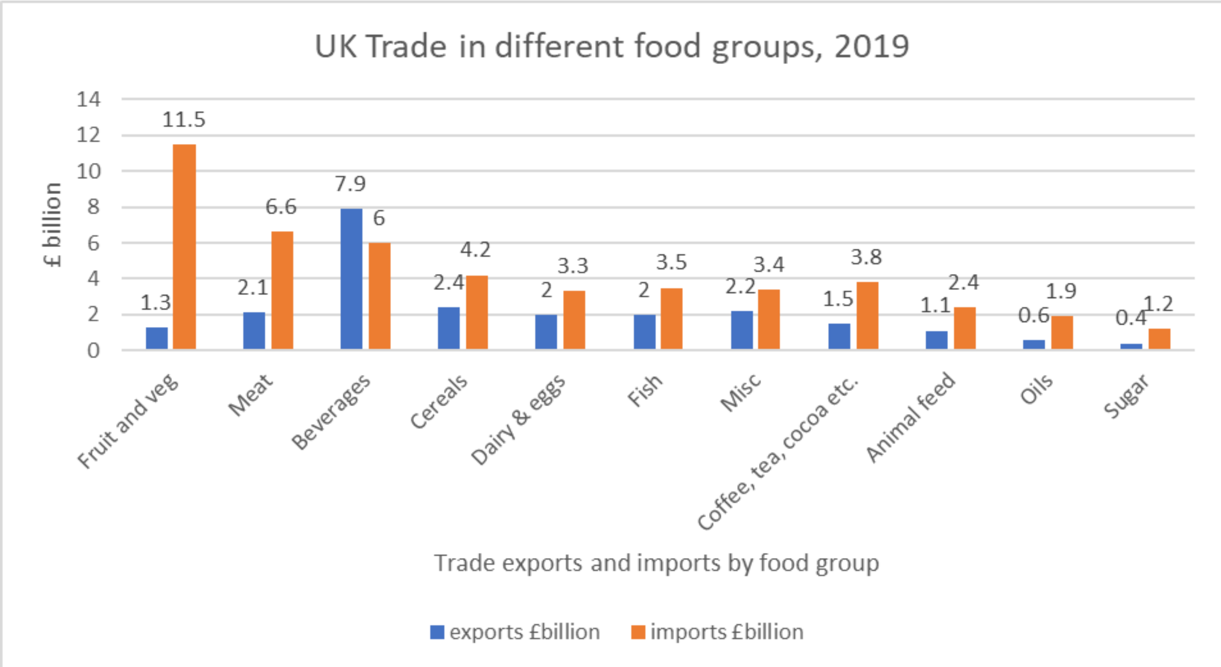

Figure 18: UK trade in different food groups, 2019

The Agricultural Land Classification System (England and Wales) identifies six grades of land. Grades 1, 2 and subgrade 3a are considered the "best and most versatile" land category in the current planning system. This land is deemed to be the most flexible and productive, and the best to deliver future crops for food and non-food uses (such as biomass, fibres and pharmaceuticals). Subgrade 3b is deemed only moderate-quality agricultural land, with substantial limitations that affect the choice of crop, level of yield, and/or timing and type of cultivation/harvesting. Grades 4 and 5 both designate poor-quality agricultural lands. Along with level 3b they offer, in general terms, the greatest opportunities for land use change. Such change could be marginal or could raise possibilities for larger projects such as woodland creation, peatland restoration and grassland improvement. However, we suggest reviewing all opportunity mapping in the context of regional food production and security, given that the UK is a net importer of food; see Figure 18.

5.6.5. UK Timber production context

The UK is heavily reliant on imported timber; timber products worth £7.5 billion entered the UK in 2020, compared to exports of £1.5 billion. The UK mostly uses timber in sawmills, for making wood-based panels, and increasingly for wood fuels (although this remains a small proportion of the total). In 2020 the UK softwood industry harvested around 10 million green tonnes, and the hardwood

[84] GOV. UK (2021) "National statistics: Food Statistics in your pocket: Global and UK supply"; https://www.gov.uk/government/statistics/food-statistics-pocketbook/food-statistics-in-your-pocket-global-and-uk-supply.

industry 0.8 million green tonnes[85]. This only satisfies around a fifth of current UK demand; the rest is met by imports from Sweden, Norway, the USA and other countries. This makes the UK the world's second-largest importer of wood, which poses a risk to the security of supply for construction and manufacturing[86].

Figure 19 illustrates timber production and trade in the UK, as reported by Forest Research.

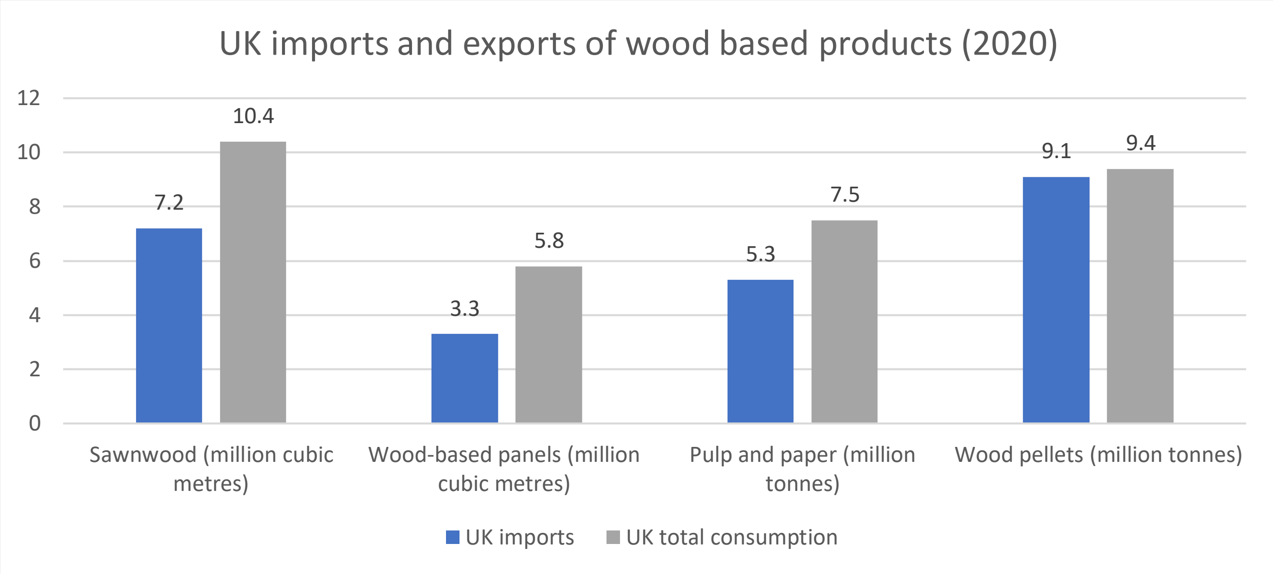

Figure 19: Self-generated from Forest Research (2021) UK Wood Production and Trade: provisional figures 2020 release

Demand for wood from UK forests continues at unprecedented levels, but the market remains constrained by a lack of supply. There is rising demand for wood, but limited availability due to long rotation periods, diversification into tangible assets, and increasing recognition of the environmental benefits of woodlands. There may also be new opportunities for monetisation, such as woodland carbon code credits. Capital values are therefore rising, although there is concern within the industry as to whether this trend is sustainable. The value of growth for the UK forestry market in 2018 showed a 19% drop in supply; however, the overall market value went up by nearly 6%, meaning a 30% increase in the average value per gross hectare, although this value varies according to region. In contrast, Savills (2019) states that in the north of Scotland prices are relatively low and static, indicative of "the geography and productive capacity of the woodland resource, with large areas of low-quality softwood, remote from timber markets and often challenging to harvest"[87]. In terms of the timber marketplace, the best softwood parcels traded at higher prices of £79 per cubic metre in 2021 (Softwood Sawlog) compared to small roundwood sales of almost £38 per cubic metre[88]. This is in contrast to carbon credits (for carbon sequestration) sold on the UK open market at £10-25 per tCO_2e[89] (Forest Research states 1.25 to 1.43 cubic metres per tonne for roundwood).

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[85] Forest Research (2021) "UK Wood Production and Trade: 2020 Provisional Figures."

[86] Tilhill (2022) "Confederation of Forest Industries Warns More Tree Planting is Urgently Needed to Avoid UK Facing Crisis in Wood Supply", https://www.tilhill.com/resource-hub/our-news/confederation-of-forest-industries-warns-more-tree-planting-is-urgently-needed-to-avoid-uk-facing-crisis-in-wood-supply/.

[87] Savills (2019) "The Forestry Market: UK Rural – March 2019," p.3.

[88] Forest Research (2021) Timber Price Indices https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/timber-statistics/timber-price-indices/.

[89] Strutt & Parker (2021) Rural Hub: "5 ways to generate income from carbon farming."

6. A vision for a low-carbon National Park: GHG targets

This section outlines the aspiration for the Dartmoor National Park in setting a challenging pathway to reach a consumption-based Net Zero by 2037, and beyond this date to become a carbon sink as one of the “lungs” of the South West contributing to the UK’s Net Zero target. It also outlines the planning assumptions used.

To deal with certain priority areas such as energy, we have taken a pro-rata approach for all National Parks based on a percentage of GHG emissions. However, the land use sector requires a bespoke approach of setting UK targets in proportion to known key habitats within the Dartmoor National Park boundary, and uses area assumptions.

Six priority areas, also referred to as “target categories of emissions”, were selected for the original Lake District National Park assessment and have been chosen in order to find a best fit between the competing desires to:

1. Cover everything of significance within the influence of policy-makers;
2. Keep the target simple enough to describe;
3. Avoid double-counting;
4. Make use of any readily available data for tracking progress.

As a result, the scope for the priority areas is slightly different from that of the overall emissions assessment in Section 5. The six priority areas are summarised below, with further supporting data in Appendix Section 10.8.5.

- **Priority Area 1: Energy-only greenhouse gas emissions.** This includes emissions relating to energy use within the National Park by residents, visitors and industry. It includes emissions from roads, except those from (estimated) through-traffic that does not stop in the National Park. This target has been chosen because relatively high-quality data is regularly published by BEIS, and because it covers a significant proportion of the total emissions. Furthermore, its selection allows us to draw on a robust tool developed by the Tyndall Centre for Climate Change to help local authorities establish Paris-aligned trajectories for energy-only emissions reduction in local areas.
- **Priority Area 2: Food and drink consumed by residents and visitors.** This includes food and drink at the point of purchase in shops as well as from hospitality businesses. A food and drink target is important because when measured on a consumption basis, this category represents roughly a quarter of UK residents’ emissions.
- **Priority Area 3: Other goods purchased by residents and visitors while in the area.** This includes all purchases of tangible non-food and drink items such as clothing, electronic equipment, furniture, soft furnishings and cars. This target is important because it brings two particular elements into the landscape’s carbon management agenda: sustainable consumption of non-edible products, and circular economy principles into the National Park’s carbon management agenda.
- **Priority Area 4: Visitor travel to and from the area.** We include here only travel within the UK, not visitor travel to the UK. International travel is omitted purely due to the practical

difficulty of tracking change (as described in Appendix 10.8); visitor aviation emissions are still an important consideration for policymakers.

- **Priority Area 5: Land use non-CO_2 component.** This includes all net non-CO_2 emissions from land within the National Park or AONB, and most notably includes enteric emissions from ruminants, and emissions from manure and fertilizer use. A comparatively small contribution to the non-CO_2 land use emissions comes from a range of ecosystems, in both near-natural and modified states, for example from peatlands releasing methane.
- **Priority Area 6: Land use CO_2 component.** This most notably includes emissions from degrading peat and carbon sequestration by woodland, farm trees, hedges and soils (including healthy peat) in the National Park or AONB. It is the only emissions category that stands to become negative, relative to present-day values, through land use and management targets. This involves reducing peatland emissions through restoration projects, and also sequestering carbon by creating new woodlands, switching to agroforestry systems, extending hedgerows and adopting better practices for managing agricultural soils. Therefore, the CO_2 land use component could well enable "net zero" and "net negative" emissions in any of the National Parks or AONBs.

Across these six priority areas, the 2019 carbon baseline for the Dartmoor National Park is estimated at 677,355 tCO_2e per year (Figure 20).

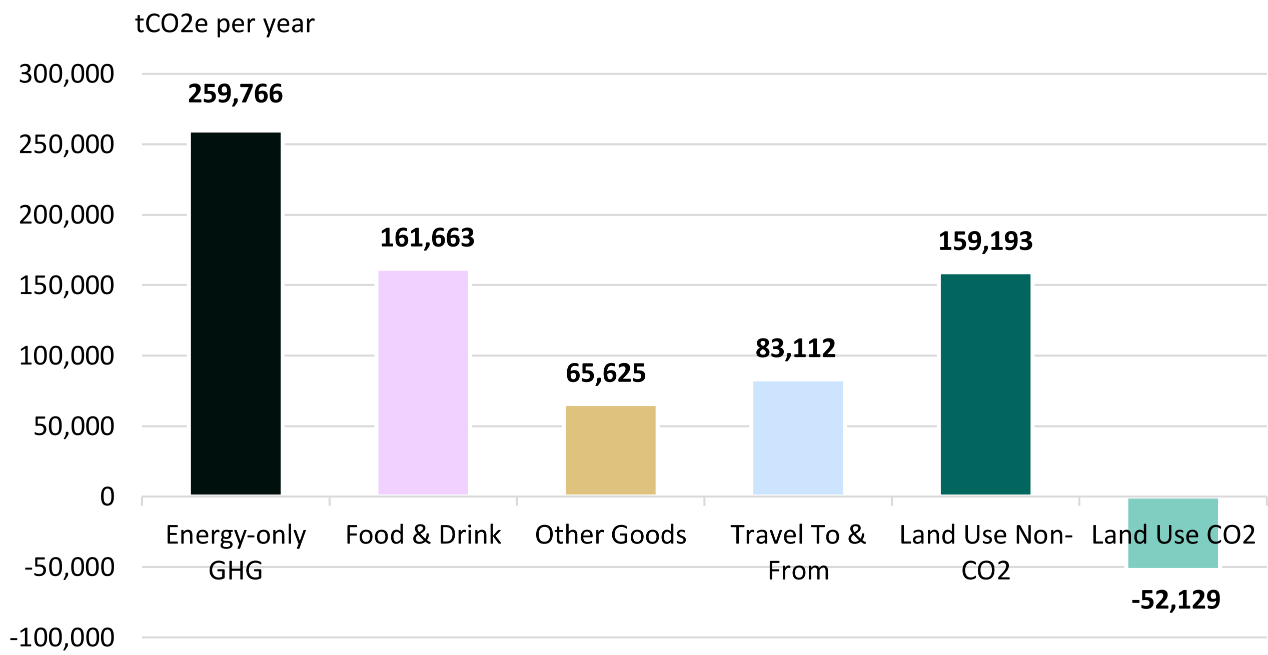

Figure 20. GHG emissions baseline for the Dartmoor National Park represented using six priority areas introduced in the text

Following the principles outlined above, some components of the wider carbon footprint of Dartmoor National Park presented in the previous sections have been excluded from the 2019 carbon baseline and the associated emissions reduction targets. These excluded components are:

- Residents' travel by air, ferries, trains, buses and other transport (excl. cars). Local public transport will be counted through the energy GHG emissions linked to local industry (Target

Category 1 above), and resident's travel outside of National Park is beyond the scope of influence by local authorities

- Residents' holiday accommodation outside the National Park
- Residents' housing (construction and maintenance). Local construction companies' energy use will be counted through the energy GHG emissions linked to local industry (Target Category 1 above)
- Residents' health, education and other public services. Local providers' energy use will be counted through the energy GHG emissions linked to local industry (Target Category 1 above)
- Residents' and visitors' other bought services (e.g. financial, telecoms, travel agents, hairdressers). Local providers' energy use will be counted through the energy GHG emissions linked to local industry (Target Category 1 above)
- Residents' and visitors' art, sport and other leisure activities. Local providers' energy use will be counted through the energy GHG emissions linked to local industry (Target Category 1 above)
- Residents' and visitors' water, waste and sewerage. Local providers' energy use will be counted through the energy GHG emissions linked to local industry (Target Category 1 above)

Industries' supply chains (both within and outside the National Park)

Our expectation is that these footprint components will be tackled, where appropriate, by the other local authorities, the UK Government, international climate agreements, and the local, national and international industries responsible for the respective types of emissions.

Our recommended target trajectories for the six priority areas are summarised in Table 5, and represent the minimum that can be considered to be aligned with the Paris Agreement pledge to keep global temperature rise below 1.5°C above pre-industrial conditions. For some of the priority areas where primary data is lacking, an element of expert judgement has been applied to determine what is required. The targets have been set to fit with the best available science and the latest policy recommendation. All will require appropriate support from government in order to be feasible, and part of the role of each National Park Authority may be to push for the necessary support.

Table 5. Decarbonisation targets for the selected components of carbon footprint. For further details, see Appendix 10.8.5

Priority area (target category)	New Model for All National Parks and AONBs (2021) – used in this report	Achievable ceiling
1. Energy only GHG emissions (incl. supply chains) by residents, visitors and industry	**14.3 %** (specific to Dartmoor National Park) reduction per year	**5%** of present-day emissions
2. Food consumed by residents and visitors	**5%** reduction per year	**30%** of present-day emissions
3. Other goods purchased by residents and visitors	**5%** reduction per year	**10%** of present-day emissions
4. Visitor travel to and from the National Park or AONB	**10%** reduction per year	**7.5%** of present-day emissions
5 & 6. Land use (non-CO_2 and CO_2)	We have split land use emissions and targets into non-CO_2 and CO_2	**30%** of present-day emissions for the non-CO_2 component only;

	components. See Appendix 10.8.9 for further details	Achievable ceiling is not applicable for the CO_2 component in the current assessment

The six elements outlined above can be combined into an overall decarbonisation pathway, which in the case of Dartmoor National Park results in a net zero date of 2037. Note that targets for the priority areas 1 to 4 should be adjusted in proportion to any significant changes in resident and visitor numbers in the National Park.

Each trajectory, apart from that for the land use CO_2 component, has been based on exponential decay (emissions decreasing by the same proportion each year) towards residual unavoidable emissions in the long run. The proposed reductions are broadly aligned with the Paris Agreement and with the UK's 2050 net zero policy.

The land use CO_2 component has been assumed to change linearly with time, which is characteristic of gradual uptake of a number of measures to manage land sustainably, increase its carbon uptake (and/or reduce CO_2 emissions through restoring peatland), and enhance biodiversity. As a default for all National Parks and AONBs on the programme, the rate of change has been drawn from the Sixth Carbon Budget and apportioned to the Dartmoor National Park according to its land characteristics (see Appendix Section 10.8.9). The associated scenario is presented in Section 6.1. We also consider the National Park's own woodland expansion and peatland restoration targets included in the National Park's Partnership Plan[90], which are introduced in a separate Section 6.2.

6.1. Scenario based on land use targets apportioned from the Sixth Carbon Budget

When the Sixth Carbon Budget's apportionment methodology is applied to the Dartmoor National Park, it produces the annual target for land use change summarised in Table 6, plus the associated annual increases in carbon sequestration flux. When measured in hectares per year converted, the restored peatland target comes on top at 737 ha/yr., followed by legumes in improved grassland at 426 ha/yr. and new native broadleaf / mixed woodland at 280 ha/yr. Other measures are comparatively small, and we assume a smaller area of productive (commercial) conifer plantation creation in Dartmoor in order to prioritise native broadleaf species. When converted to changes in carbon sequestration fluxes, the native broadleaf / mixed creation (-5,167.7 tCO_2e per year added each year) provides nearly two times more net emissions reduction benefits compared to the second-largest contribution from restored peatland, and over three times more benefit compared to the third-largest contribution from new productive coniferous woodland (Table 6). This clearly illustrates the priorities for land use measures in order to achieve Net Zero.

We emphasise that priority must be given to managing agricultural land sustainably, both to enhance soil carbon sequestration, and to achieve co-benefits such as biodiversity gains and flood risk mitigation[91]. However, global evidence shows that soil carbon sequestration is a slow process, and requires the necessary management practices to be maintained indefinitely. Also, despite one's best efforts, carbon sequestration in soils tends to reach saturation over time (years/decades), and it is vulnerable to climate change as predicted increases in flood events are likely to increase soil

[90] https://www.yourdartmoor.org.
[91] Bossio, D. A., *et al.* (2020). "The role of soil carbon in natural climate solutions." *Nature Sustainability*, 3(5), 391-398.

erosion[92]. Typical sequestration values associated with regenerative agricultural practices (such as agroforestry, hedging, and growing legume-rich grasses and cover crops) are estimated to be between 1 and 3 tCO_2e per year per hectare in the first couple of decades. This is only a small fraction (a fifth to a tenth) of the carbon sequestration benefits typically achieved by creating new woodland on similar timescales, which – due to its natural simplicity and its age-old familiarity – is always going to be the main source of carbon sequestration, and can deliver wider co-benefits such as biodiversity gains. Healthy soils alone cannot reverse the negative effects associated with centuries-long conversion of natural landscapes to pasture and cropland, nor can they offset the broad-ranging emissions associated with our economic activities. It is therefore imperative that regenerative agricultural practices aimed at enhancing soil carbon stocks go hand in hand with ambitious woodland creation (and where applicable, peatland restoration and other habitat creation and restoration) programmes.

Table 6: The Dartmoor National Park: Apportioned Sixth Carbon Budget targets for land use change and the associated additions to annual carbon sequestration fluxes. These targets need to be maintained until 2050 under the proposed pathway. Further details are provided in Appendix 10.8.9

Proposed Land Use Targets	**Value**	**Units**
New Native Broadleaf / Mixed Woodland	280.0	ha per year
New Productive Coniferous Woodland	70.0	ha per year
Restored Peatland	736.9	ha per year
Agroforestry (improved grassland & cropland)	58.6	ha per year
New Hedgerows (improved grassland & cropland)	3.4	ha per year
Legumes (improved grassland)	426.3	ha per year
Cover Cropping (cropland)	29.6	ha per year
Associated Carbon Sequestration	**Value**	**Units**
New Native Broadleaf / Mixed Woodland	-5,168	tCO_2e per year per year
New Productive Coniferous Woodland	-1,548	tCO_2e per year per year
Restored Peatland	-2,719	tCO_2e per year per year
Agroforestry (improved grassland & cropland)	-138	tCO_2e per year per year
New Hedgerows (improved grassland & cropland)	-35.7	tCO_2e per year per year
Legumes (improved grassland)	-875	tCO_2e per year per year
Cover Cropping (cropland)	-34.8	tCO_2e per year per year

Based on the target-setting assumptions outlined in Table 6 and in Appendix 10.8.9, Dartmoor National Park will achieve a total cumulative reduction in the net annual GHG emissions of 952,920 tCO_2e per year between the base year (2019) and 2050. The net estimate includes both reductions in emissions and carbon sequestration, depending on the contributing footprint category. Percentage breakdown of the projected total cumulative reduction in the net annual GHG emissions by individual footprint categories and land-based measures is provided in Figure 21.

[92] Frank, D., *et al.* (2015). "Effects of climate extremes on the terrestrial carbon cycle: concepts, processes and potential future impacts." *Global Change Biology*, 21(8), 2861-2880.

Under the assumptions above, the Dartmoor National Park would achieve Net Zero emissions in 2037 and will act as a net carbon sink in subsequent years (Figure 22). We note that the net zero date reflects the unique characteristics of the area, including the quantity and type of land, the number of residents and visitors and their consumption patterns, and the level and type of industrial activity (see Section 6 for the target figures). It also assumes the recommended decarbonisation and carbon sequestration efforts, including land use change, ratchet up to the required levels immediately in the base year of the assessment. In reality, the high levels of ambition for different sectors explored in this report are likely going take several years to achieve, given that post-COVID emissions have largely rebounded, and that decarbonisation trends to date have been relatively small in magnitude compared to what we know is required for keeping global warming below the safer 1.5°C limit from the Paris Agreement. These factors are expected to push the projected net zero year back by several years. The stated net zero date on its own should therefore not be taken as the main level of ambition to decarbonise for a given landscape.

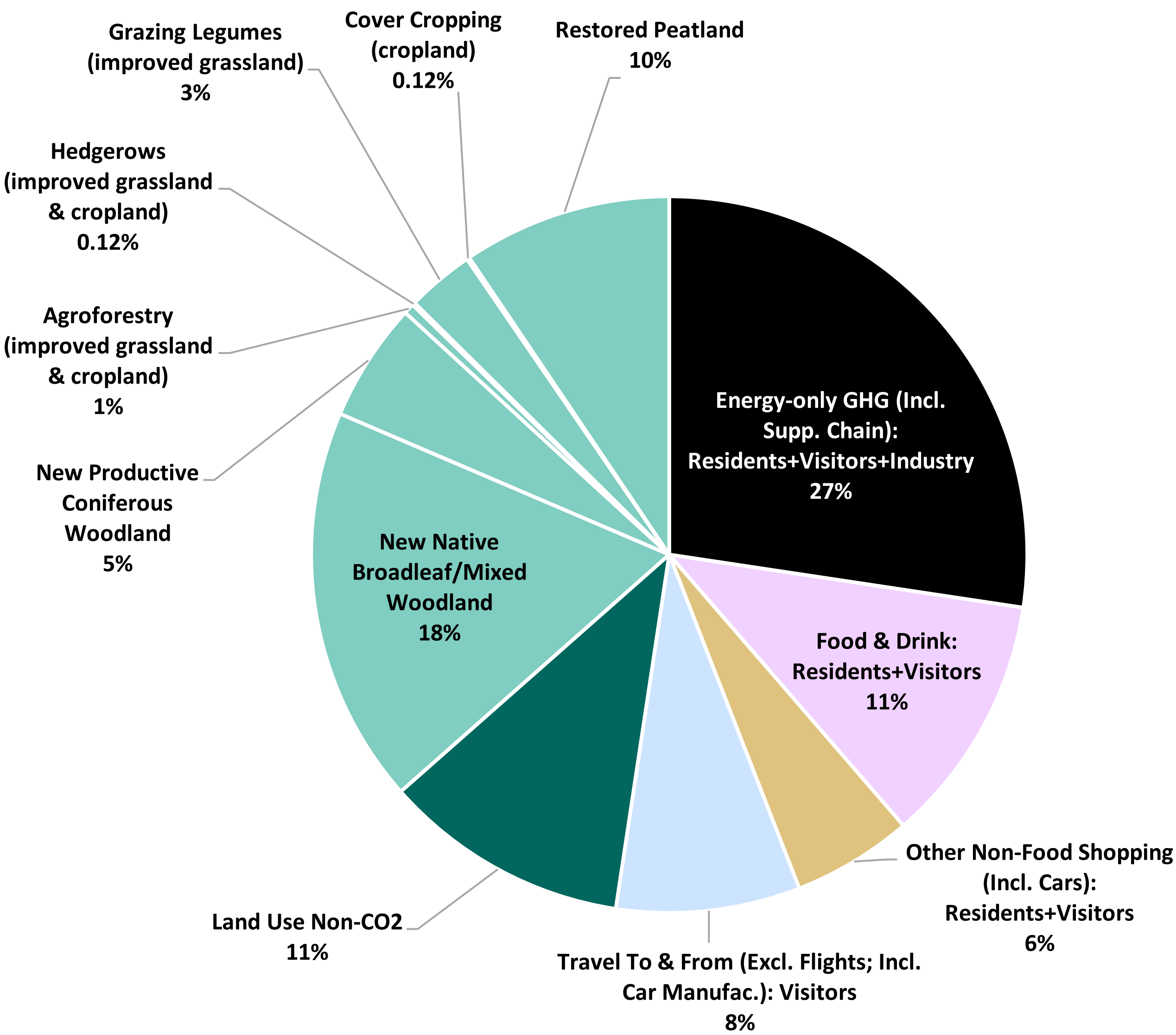

Figure 21. Percentage breakdown of the projected cumulative reduction in net annual GHG emissions for the Dartmoor National Park between the base year (2019) and 2050 according to the individual emitting categories and carbon sequestration measures considered in this assessment

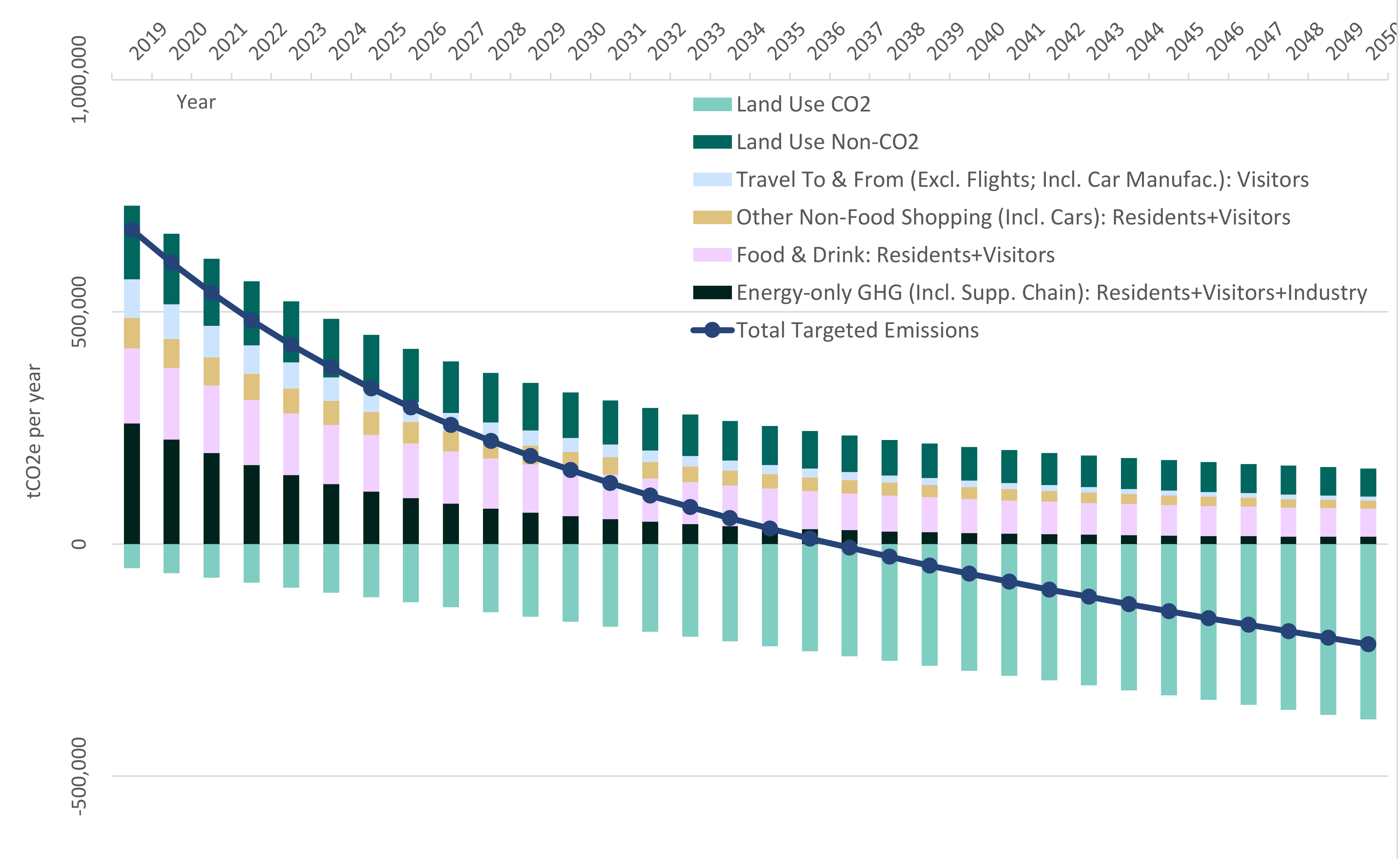

Figure 22. Dartmoor National Park: Pathway to Net Zero (repeat of Figure 6)

6.2. Scenario based on land use targets from the Partnership Plan

The 2021-2026 Dartmoor National Park Partnership Plan[93] includes woodland and peatland targets that differ from those based on the Sixth Carbon Budget (Section 6.1). The targets are summarised in Table 7.

Table 7. Woodland and peatland targets from the 2021-2026 Management Plan, which are used for the alternative scenario explored in this section

	Horizon year	Cumulative target (ha)	Equivalent annual target (ha/yr) assumed to remain in place until 2050
Woodland expansion	2045	2,000	80
Peatland restoration	2026	1,000	200

In this section, we consider an exploratory scenario, which assumes that annual targets for woodland expansion (80 ha/yr.) and peatland restoration (200 ha/yr.) inferred from the Management Plan persist between the base year of the assessment (2019) and 2050. Such a scenario could be considered as a lower-end alternative to the default scenario presented in Section 6.1, with the latter based on the woodland and peatland targets of 350 and 737 ha/yr., respectively. In the alternative scenario, all the other land-based measures and decarbonisation efforts not involving land follow the default assumptions made in Section 6.1.

Based on the adjusted target-setting assumptions outlined in Table 7, the Dartmoor National Park could see a total cumulative reduction in the net annual GHG emissions of 671,293 tCO_2e per year between the base year (2019) and 2050. Recall that the default scenario resulted in the reduction of 952,920 tCO_2e per year during the same period. As before, the net estimate includes both reductions in emissions and increases in carbon sequestration, depending on the contributing footprint category. Percentage breakdown of the projected total cumulative reduction in the net annual GHG emissions by individual footprint categories and land-based measures is provided in Figure 23.

The adjusted land use targets imply that the Dartmoor National Park would reach Net Zero emissions in 2051 (Figure 24). As with the default scenario, the actual net zero date is likely to be delayed by several years given the comparatively limited progress in reducing emissions and scaling up land-based measures in the UK to date, which means it could take some time to reach the recommended levels of ambition.

93 https://www.yourdartmoor.org.

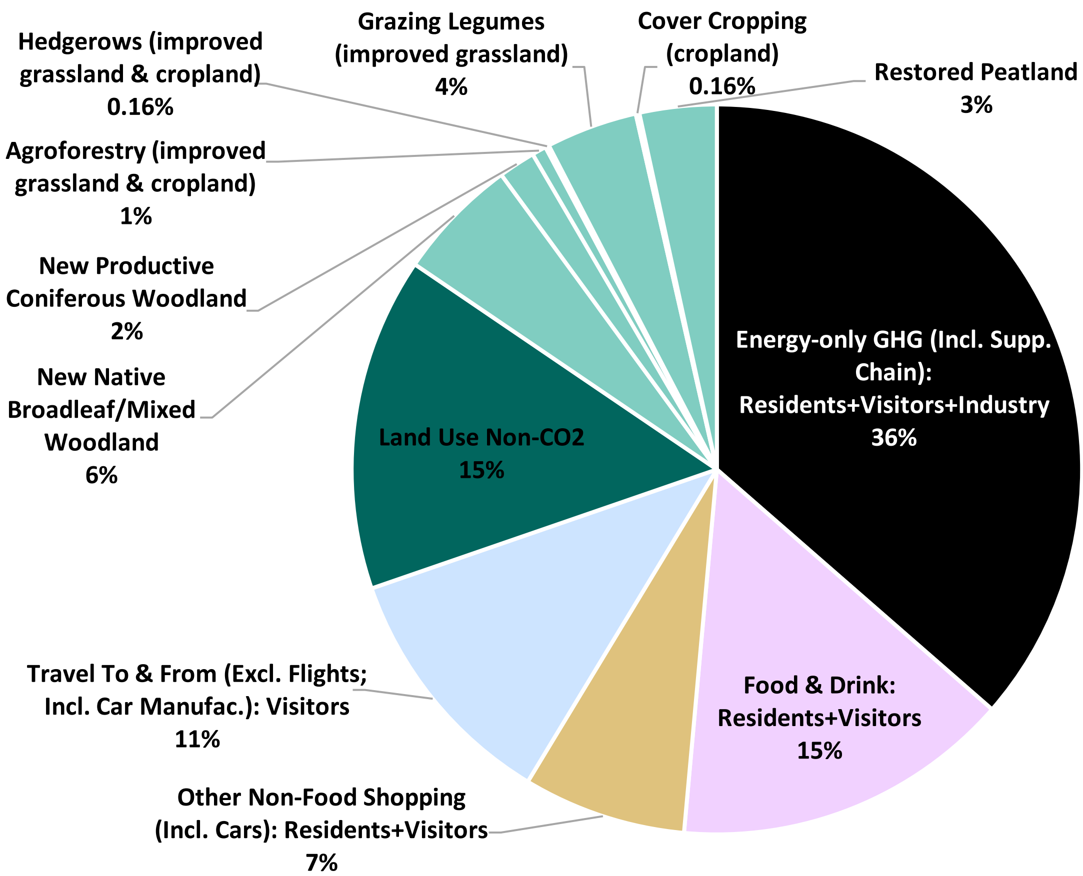

Figure 23. Alternative percentage breakdown of the projected cumulative reduction in net annual GHG emissions for the Dartmoor National Park between the base year (2019) and 2050, using the woodland and peatland targets from the current Management Plan

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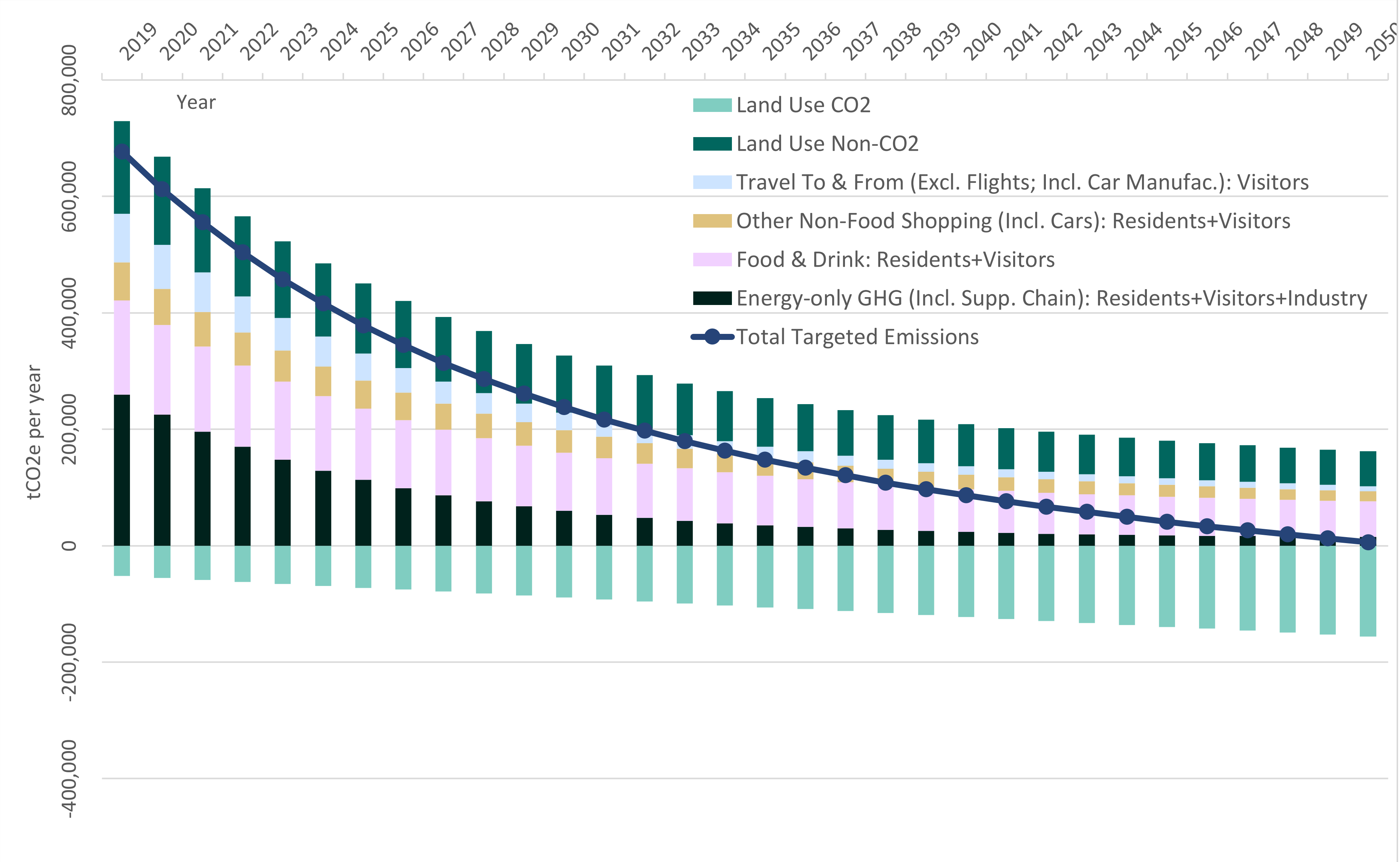

Figure 24. Dartmoor National Park: Alternative pathway to Net Zero based on the woodland and peatland targets from the current Management Plan

7. Conclusions and recommendations

The emissions assessment in this report is designed to bring every relevant area of carbon management into perspective for policymakers. A transition to a low-carbon future for the Dartmoor National Park entails strong action in many areas: construction, home energy, food production and diets, travel and transport, business energy use, the nature of tourism and the visitor experience, the circularisation of the material economy (including repair, maintenance, renting and reselling of consumer goods), and significant changes in land management.

The challenge is to find a coherent way of bringing these policy areas together, one that adds up to more than the sum of its parts and delivers an enhanced experience of living, working and spending time in the National Park.

The Local Authorities' planning powers are a tool that can provide substantial leverage in:

- Preparing the construction sector for zero-carbon building (embodied GHG emissions);
- Ensuring that new buildings are energy-efficient and supplied with low/zero-carbon energy (operational energy / GHG emissions);
- Encouraging low/zero-carbon transport in new developments (cycling, electric vehicles, etc.);
- Implementing Ecosystems Services-oriented policies and Biodiversity Net Gain initiatives in new-builds;
- Encouraging refurbishment of existing buildings to ensure they are energy-efficient and supplied with low/zero-carbon energy.

If all the targets proposed in this report were met, the Dartmoor National Park would achieve net zero GHG emissions in 2037. It would subsequently reach negative emissions of approximately -275,565 tCO2e per year by 2050, with annual carbon sequestration in the park scaling up to around -437,692 tCO2e per year, and residual emissions dropping roughly to 162,128 tCO2e across the shortlisted policy priority areas (24% of the present-day carbon footprint baseline).

Although designed as the minimum to attain Paris-aligned targets, the trajectories for each of the six components of the target are steep and challenging. This reflects the severity of the climate emergency in which the world now finds itself. The Dartmoor net zero date of 2037 should not be interpreted to mean that the target recommendation is stronger than the UK's 2050 net zero target, but rather as a reflection of the National Park's proportionately greater capacity for carbon sequestration compared to the UK as a whole.

In meeting the targets, some help from outside the National Park can be expected, thanks to anticipated changes in the UK and global economy. For example, the electricity grid is expected to decarbonise, and the use of electric vehicles will be more widespread, meaning less fossil fuel powering all forms of road transport. On top of this, the public may become increasingly carbon-conscious and choose more sustainable options, for example insulating their homes, installing renewable heating systems and solar panels, and opting for less carbon-intensive diets. Last but not least, businesses would also want to play an active role in the transition to low carbon by cutting their direct emissions, while simultaneously opting for suppliers that provide products and services with lower embedded carbon, thus accelerating the transition across the whole value chain.

A considerable degree of help can also be expected to come from government policies, and where this is not sufficient, part of the role of the Dartmoor National Park will be to push for the support needed to ensure the National Park attains the recommended targets. This will require active engagement with all stakeholders, drawing on existing relationships and nurturing future ones, including partnership programmes with local organisations, with neighbouring Unitary Authorities, with the UK Government, and with the general public. It is through collaborative creative thinking, taken forward in sustained joint efforts by all stakeholders, that the exciting and realistic vision outlined in this report – of how a low-carbon future could work for everyone in Dartmoor – will become a reality.

Land management is central to all National Parks and deserves a separate discussion. The wide-ranging land use measures proposed for Dartmoor, dominated by new native broadleaf / mixed woodland and restored peatland, must be ambitious enough and sustained for long enough, for the sequestration flux to scale up sufficiently year on year, in line with the suggested land use CO_2 pathway. Establishing irreversible carbon sinks (with biodiversity co-benefits) relies on the availability of suitable incentives enabling land managers to implement land use changes such as woodland creation, peatland restoration (where applicable) and regenerative farming, in line with current recommendations by the UK Government.[94]

It must be noted that the Dartmoor National Park Authority (DNPA) does not currently have the statutory powers, duties, structure or resources to deliver the land use targets in this report directly. The DNPA can use its soft powers working with stakeholders and partners to encourage and, in some areas, incentivise action. However, at present there is no guarantee and little confidence that the right structures are in place to deliver these ambitious targets.

Furthermore, public perceptions of how a protected natural landscape should look may also need to evolve, in order for people to continue visiting the National Park and finding it beautiful after changes in land use. Most UK National Parks and AONBs have considerable areas of low-grade grassland and moorland, which create the landscapes familiar to many in the UK and abroad. However, centuries ago the majority of the UK was covered in woodland, compared to just 12% today, and relatively large swathes of land may need to be returned to this forested state in the coming years and decades, in line with climate goals. Visitors and residents' perception of natural beauty in these protected landscapes may therefore need to shift towards greater appreciation of more widespread woodland coverage, alongside protected and restored peatland areas, applying the "right tree, right place" principle.

To assist with the transition towards the required land use and management options, there are a range of new funding opportunities which may be available to landowners, tenant farmers or public sector partners, depending on each set of grant conditions. These options are listed below.

Environmental Land Management Schemes (ELMS)

[94] UK 6th Carbon Budget; Agriculture, Forestry and Other Land Use section

Three new schemes were piloted during 2021, and launched in 2022, to reward environmental land management: the Sustainable Farming Incentive, Local Nature Recovery, and Landscape Recovery[95]. Through these schemes, according to current public communications, farmers and other land managers may enter into agreements to be paid for delivering the following: clean and plentiful water, clean air, thriving plants and wildlife, protection from environmental hazards, mitigation of and adaptation to climate change, beauty, heritage, and engagement with environmental law.

Woodland grants and incentives[96]

- Forestry Commission Local Authority Treescapes Fund
- Forestry Commission Urban Tree Challenge Fund
- Woodland Creation Planning Grant
- HS2 Woodland Fund (land must be within a 25-mile zone of phase one of the HS2 route from London to the West Midlands)
- England Woodland Creation Offer (new grant scheme for farmers and landowners to encourage investment in woodland creation)
- Woodland Carbon Code or Scottish Forestry Grant Scheme
- Woodland Carbon Guarantee
- Countryside Stewardship grants
- Woodland Creation and Maintenance part of Countryside Stewardship
- Woodland Tree Health part of Countryside Stewardship
- Woodland Improvement (WD2 and capital items) part of Countryside Stewardship

Peatland restoration

- Peatland Code
- Nature for Climate Peatland Grant Scheme

As a response to the climate and ecological emergency, we hope that the National Park Authority members and partners welcome this greenhouse gas emissions assessment, its findings and recommendations to help the partnership support decarbonisation and plan actions for change.

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95 https://www.gov.uk/government/publications/environmental-land-management-schemes-overview/environmental-land-management-scheme-overview.

96 https://www.gov.uk/government/publications/woodland-grants-and-incentives-overview-table/woodland-grants-and-incentives-overview-table.

8. Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
BEIS	UK Government Department for Business, Energy and Industrial Strategy
CH_4	Methane
CO_2	Carbon Dioxide
COA	Census Output Areas
DACCS	Direct Air Capture with Carbon Storage
DEFRA	Department for Environment, Food and Rural Affairs
DOC	Dissolved organic carbon
EV	Electric vehicle
GIS	Geographic Information System
GDPR	General Data Protection Regulations
GWP	Global warming potential
GVA	Gross Value Added
Ha	Hectares
HFCs	Hydrofluorocarbons
IDBR	Office for National Statistics' Inter-Departmental Business Register
LEP	Local Enterprise Partnership
LULUCF	Land Use, Land Use Change and Forestry
NAEI	National Atmospheric Emissions inventory
NFU	National Farmers' Union
N_2O	Nitrous Oxide
ONS IDBR	Office of National Statistics' Inter-Departmental Business Register
PFCs	Perfluorocarbons
POC	Particulate organic carbon
SF_4	Sulphur Hexafluoride

9. Glossary

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects (IPCC AR5 Glossary Annex 11)

Air pollution: Degradation of air quality with negative effects on human health or the natural or built environment due to the introduction, by natural processes or human activity, into the atmosphere of substances (gases, aerosols) which have a direct (primary pollutants) or indirect (secondary pollutants) harmful effect (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Anaerobic digestion: Anaerobic digestion (AD) is a natural process in which plant and animal materials are converted into useful products by micro-organisms in the absence of air. The process releases biogas (mainly a mixture of around 60% methane and 40% carbon dioxide), which can be used directly to provide heat, power or transport fuel. Biogas can also be purified by removal of the carbon dioxide to produce biomethane, which can be fed directly into the public natural gas grid in the same way as natural gas or used as a vehicle fuel. The types of materials suitable for AD include food waste, slurry and manure, crops and crop residues (DEFRA, GOV.UK, published 9th December 2021).

Anthropogenic emissions: Emissions of greenhouse gases, greenhouse gas precursors and aerosols caused by human activities. These activities include the burning of fossil fuels, deforestation, land use changes, livestock production, fertilization, waste management, and industrial processes (IPCC AR5 Glossary Annex 11).

Anxiety: A feeling of stress, panic or fear that can affect your everyday life physically and psychologically (NHS, 2021).

Asthma: A common lung condition that causes occasional breathing difficulties. It affects people of all ages and often starts in childhood, although it can also develop for the first time in adults. There's currently no cure, but there are simple treatments that can help keep the symptoms under control (NHS, 2021).

BEIS pollution inventory: The UK Government (department for Business, Energy and Industrial Strategy (BEIS)) produces an annual greenhouse gas inventory for local authorities and large industrial sites that act as point-sources of emissions, which forms a consistent time series of UK greenhouse gas emissions from 1990 onwards (www.gov.uk, 2021).

Biodiversity: Biological diversity means the variability among living organisms from all sources, including *inter alia*: terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN, 1992).

Biodiversity net gain: Biodiversity net gain (BNG) is an approach to development, and/or land management, that aims to leave the natural environment in a measurably better state than it was beforehand (Local Government Association, 2022).

Carbon capture and storage: The process of capturing and storing carbon dioxide (CO_2) before it is released into the atmosphere (Grantham Research Institute on Climate Change and the Environment, 2018).

Carbon intensity: The amount of emissions of carbon dioxide (CO_2) released per unit of another variable such as gross domestic product (GDP), output energy use or transport (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Carbon flux: A carbon flux is the amount of carbon exchanged between Earth's carbon pools, i.e. the oceans, atmosphere, land and living things, during a specified time period (e.g. a day or a year).

CARBINE model: A modelling tool used to estimate the carbon stocks of stands and forests (in living and dead biomass and soil), and any associated harvested wood products. It is also used to estimate the greenhouse gas emissions avoided through the use of wood products that displace fossil fuels and fossil-fuel intensive materials (Forest Research, 2021).

Catapult (energy systems): Energy Systems Catapult was set up to accelerate the transformation of the UK's energy system and ensure that UK businesses and consumers capture the opportunities of clean growth. The Catapult is an independent, not-for-profit centre of excellence that bridges the gap between industry, government, academia and research. The Catapult takes a whole-systems view of the energy sector, helping it identify and address innovation priorities and market barriers in order to decarbonise the energy system at the lowest cost (Catapult Energy Systems, 2021).

Consumption-based footprint assessment: This means assessing the greenhouse gas "footprint" of residents, visitors and industry in a given landscape, including the entire lifestyles of residents, visitors' travel to and from the area, and supply chains of industry. Put differently, consumption-based footprint assessment includes everything that residents and visitors buy and do while in the landscape, as well and their travel to and from the area. Consumption-based reporting attributes the emissions from product and service supply chains to the landscape, regardless of where emissions are physically released during production (Small World Consulting, 2022).

Coronary heart disease (CHD): A major cause of death in the UK and worldwide. CHD is sometimes called ischaemic heart disease or coronary artery disease, and describes what happens when blood supply to the heart is blocked or interrupted by a build-up of fatty substances in the coronary arteries.

Census output areas (COAs): The 2001 Census Output Areas are designed specifically for statistical purposes. They are based on data from the 2001 Census and were built from postcode units. Output Areas are used not only for Census output but also as the basis of Super Output Areas, which have been introduced as stable and consistently sized areas for Neighbourhood Statistics. (ONS, 2022).

Climate action: Actions taken to pursue the goal of positive change for the climate.

Cumbria's Zero Carbon Programme: The Zero Carbon Cumbria Partnership is working towards the shared aim of making Cumbria the first carbon-neutral county in the UK, by 2037. It is funded by a

£2.5 million grant from the National Lottery Climate Action Fund (Cumbria Action for Sustainability, 2022).

Decarbonisation: The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their consumption of carbon (IPCC AR5 Glossary Annex 11).

Direct emissions: Scope 1 (direct emissions from owned or controlled sources) includes company facilities and vehicles (Greenhouse Gas Protocol (2013), Technical Guidance for Calculating Scope 3 Emissions, Version 1.0).

Ecosystem services: Ecological processes or functions that have monetary or non-monetary value to individuals or wider society. These are frequently classified as (1) supporting services such as biological productivity or *biodiversity* maintenance, (2) provisioning services such as food or fibre, (3) regulating services such as climate regulation or *carbon sequestration*, and (4) cultural services such as tourism or spiritual and aesthetic appreciation (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Electric vehicle: A car, a van, a bus or a lorry that uses electric motor and battery storage as sole means of propulsion and energy. Electric vehicles do not generate direct emissions apart from those associated with tyres and brake pads.

Electric heat pump: An air-, ground-, or water-source heat pump is an electric heating system that absorbs internal heat energy from the air, earth or water outside, to provide domestic space heating and hot water. To transfer the heat energy from the colder outdoors to the warmer indoors, a heat pump uses a relatively small amount of electricity (around 30% of the total heat transferred). The heat pump works in reverse of an air conditioning system and is sometimes combined with the latter.

Embodied emissions: This term (also referred to as "embedded carbon") describes the set of greenhouse gas emissions attributed to the whole production process of a product, up to the point of usage.

Environmental land management: An approach providing the means to store carbon, reduce the risks from a changing climate such as more frequent and severe flooding or crop failures, and restore wildlife and habitats, while maintaining a thriving agricultural and forestry sector, growing high-quality food and timber, and supporting human health and well-being.

Extraction-based emissions: These are the emissions produced by burning any fossil fuels that are extracted from the ground within a given landscape, wherever they are burned. This type of emissions reporting is important for understanding the climate change implications of decisions relating to any fossil fuel extraction in the landscape (Small World Consulting, 2021).

Flexitarian diet: A flexitarian or semi-vegetarian diet (SVD) is one that is primarily vegetarian with the occasional inclusion of meat or fish (Derbyshire E.J., "Flexitarian Diets and Health: A Review of the Evidence-Based Literature." *Front Nutr.* 2017; 3:55. Published 6th Jan, 2017. Doi:10.3389/ fnut.2016.00055)

Fossil fuels: A fossil fuel is a hydrocarbon-containing material formed underground over tens of millions of years from the remains of dead plants and animals that humans extract and burn to release energy for use. The main fossil fuels are coal, petroleum and natural gas, which humans extract through mining and drilling.

Greenhouse gas (GHG): Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and clouds. This property causes the greenhouse effect. Water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary greenhouse gases in the Earth's atmosphere. Moreover, there are a number of entirely human-made greenhouse gases in the atmosphere, such as halocarbons and other chlorine- and bromine-containing substances, dealt with under the Montreal Protocol. Beside CO_2, N_2O, and CH_4, the Kyoto Protocol deals with the greenhouse gases sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) (IPCC AR5 Glossary Annex 11).

Greenhouse gas protocol: The GHG Protocol establishes comprehensive global standardised frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions. The standards are designed to provide a framework for businesses, governments, and other entities to measure and report their greenhouse gas emissions in ways that support their missions and goals (ghgprotocol.org, 2022).

GHG reporting: The quality of greenhouse gas (GHG) inventories relies on the integrity of the methodologies used, the completeness of reporting, and the procedures for compilation of data. To this end, the Conference of the Parties (COP) has developed standardised requirements for reporting national inventories. The UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention (Annex I Parties) require each Annex I Party, by 15th April each year, to provide its annual GHG inventory covering emissions and removals of direct GHGs (carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3)) from five sectors (energy; industrial processes and product use; agriculture; land use, land-use change and forestry (LULUCF); and waste), and for all years from the base year (or period) to two years before the inventory is due (United Nations Framework Convention on Climate Change, 2022).

Hybrid car: A car that combines a conventional combustion engine with an electric motor and battery storage.

Hypertension: High blood pressure.

Indirect emissions: Indirect emissions may be classified as Scope 2 and 3 emissions. Scope 2 are indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 3 includes all other indirect emissions that occur in a company's value chain. The 15 categories in scope 3 are intended to provide companies with a systematic framework to measure, manage and reduce emissions across a corporate value chain. The categories are designed to be mutually exclusive, to avoid a company double-counting emissions among categories (Greenhouse Gas Protocol (2013), Technical Guidance for Calculating Scope 3 Emissions, Version 1.0 p.6).

Land cover map: The UK Centre for Ecology and Hydrology (UKCEH) uses satellite imagery and machine learning algorithms to classify land cover according to one of 21 distinct habitats. The first national Land Cover Map of Great Britain was produced in 1990. Since 2016, Land Cover Maps and land cover change data have been produced on yearly basis. The UKCEH land cover (habitat) classes are based on the UK Biodiversity Action Plan (BAP) Broad Habitats (Jackson, 2000). They describe the physical material occupying the surface of the United Kingdom, providing an uninterrupted national dataset of land cover classes from grassland, woodland and fresh water to urban and suburban built-up areas (CEH, 2022).

Natural capital: That part of nature which directly or indirectly provides value to people, including ecosystems, species, freshwater, soils, minerals, the air and oceans, as well as natural processes and functions (Natural Capital Committee, 2019).

Net Zero: Net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic greenhouse gas removals over a specified period. Where multiple greenhouse gases are involved, the quantification of net zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential and others, as well as the chosen time horizon). See also "Net zero CO_2 emissions", "Negative emissions" and "Net negative emissions" (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Osteoarthritis: A condition that causes joints to become painful and stiff, and may impact movement. Almost any joint can be affected by osteoarthritis, but the condition most often causes problems in the knees, hips and small joints of the hands (NHS, 2021).

Point sources: Point source pollution comes mostly from spills, leaks and discharges at a single point or over a small area. It's often easy to identify because it results from mainly isolated events or activities with a clear link to a polluter (Environment Agency, 2022).

Partnership management plan: Every National Park and AONB has a Partnership Management Plan, which is among its most important documents. This Plan sets out how a range of organisations will work together to achieve shared objectives for the future management of the National Park or AONB. Each Management Plan will look 5-10 years ahead (National Parks England, 2022; https://landscapesforlife.org.uk).

Pollinator patches: A pollinator patch is a bed of annual flowers which may be native, non-native or a mixture of both. To be a successful pollinator patch, the ground needs to be meticulously prepared, which involves digging the site over and removing all existing vegetation, especially grasses, docks and nettles. Seed is sown in the spring (Lune Valley Beekeepers, 2022).

Production-based emissions: These are the net emissions that are physically released in a given landscape (most notably by burning coal, oil and gas), those arising from the production of electricity used in the area (wherever that power is generated), and direct emissions associated with land use within the landscape (parts of agriculture excluding fuel use and supply chains, peatland degradation, etc.) (Small World Consulting, 2022).

Paris Agreement: The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in December 2015 in Paris, France, at the 21st session of the Conference of the Parties (COP) to the UNFCCC. The agreement, adopted by 196 Parties to the UNFCCC, entered into force on 4th November 2016, and as of May 2018 had 195 Signatories and was ratified by 177 Parties. One of the goals of the Paris Agreement is "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels", recognising that this would significantly reduce the risks and impacts of climate change. The temperature targets require reducing net anthropogenic greenhouse gas emissions through a range of measures collectively referred to as climate mitigation. Additionally, the Agreement aims to strengthen the ability of countries to deal with the impacts of climate change through climate adaptation measures. The Paris Agreement became fully effective in 2020. See also United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and Nationally Determined Contributions (NDCs). (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Paris-aligned greenhouse gas targets: Greenhouse gas emission reduction targets (and/or carbon sequestration targets) that are aligned with the Paris Agreement targets on warming.

Post-traumatic stress disorder (PTSD): Post-traumatic stress disorder (PTSD) is an anxiety disorder caused by very stressful, frightening or distressing events. People experiencing PTSD often relive the traumatic event through nightmares and flashbacks, and may experience feelings of isolation, irritability and guilt. Problems sleeping, insomnia, and concentration difficulties are often associated with PTSD. These symptoms are often severe and persistent enough to have a significant impact on the person's day-to-day life (NHS, 2022).

Precautionary principle: As referred to within the Environment Bill 2021, the precautionary principle states that where there are threats of serious or irreversible environmental damage, a lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (GOV.UK, 2021). This appears to have been adopted from the United Nations General Assembly (1992) definition.

Public health prevention: This is split into three categories:

Primary prevention: Taking action to reduce the incidence of disease and health problems within the population, either through universal measures that reduce lifestyle risks and their causes or by targeting high-risk groups.

Secondary prevention: Systematically detecting the early stages of disease and intervening before full symptoms develop – for example, prescribing statins to reduce cholesterol, and taking measures to reduce high blood pressure.

Tertiary prevention: Softening the impact of an ongoing illness or injury that has lasting effects. This is done by helping people manage long-term, often complex health problems and injuries (e.g.

chronic diseases, permanent impairments) in order to improve as much as possible their ability to function, their quality of life and their life expectancy (Local Government Association, 2022).

Quoted (listed) company: Under the Companies Act 2006, a "quoted company" means a company whose equity share capital:

(a) has been included in the official list in accordance with the provisions of Part 6 of the Financial Services and Markets Act 2000 (c. 8), or
(b) is officially listed in a European Economic Area (EEA) State, or
(c) is admitted to dealing on either the New York Stock Exchange or the exchange known as Nasdaq.

In paragraph (a) "the official list" has the meaning given by section 103(1) of the Financial Services and Markets Act 2000 (Legislation.gov.uk, 2006).

Railway electrification: The process of transition from diesel-powered locomotives (trains) to electric railways using either electric locomotives (hauling passengers or freight in separate cars), electric multiple units (passenger cars with their own motors) or both. Electricity is typically generated in large and relatively efficient generating stations, transmitted to the railway network, and distributed to the trains via overhead power lines.

Resilience: The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure while also maintaining the capacity for adaptation, learning and transformation. This definition builds on the definition used by the Arctic Council (2013) (IPCC, 2018: Annex 1: Glossary [Matthews, J.B.R. (ed)]).

Revenue: In accounting, revenue is the total amount of income generated by the sale of goods and services related to the primary operations of the business. Commercial revenue may also be referred to as sales or as turnover.

Rewilding (landscape recovery): There are varying definitions for rewilding, from popularised terms to more science-based definitions. In the public perception the practice of "rewilding" has emerged as a method for returning native flora and fauna to landscapes humans have altered. However, due to differing definitions and interpretations, the practice of rewilding has been both promoted and criticised in recent years. Benefits of rewilding include flexibility to react to environmental change and the promotion of opportunities for society to reconnect with nature. Criticisms include the lack of a clear conceptualization of rewilding, insufficient knowledge about possible outcomes, and the perception that rewilding excludes people and agriculture from landscapes. This particularly relates to the re-introduction of natural predators such as wolves and lynx where there may be human-wildlife conflicts, specifically where communities' livelihoods and food production are impacted.

(Summarised from Alice Di Sacco, Kate A. Hardwick, *et al.* "Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits," *Global Change Biology*, 27, 7, (1328-1348), (2021). https://doi.org/10.1111/gcb.15498)

Riparian woodland: Woodlands on the banks of natural bodies of water, such as lakes and rivers.

SIC codes (industry sectors): Information about activities of businesses and industry in the UK – including data on the production and trade of goods and services, sales by retailers, characteristics of businesses, the construction and manufacturing sectors, and international trade – is collected by the Office of National Statistics. “Standard industrial classification of economic activities” (SIC) codes are used to classify and report industrial activity in specific sectors (ONS, 2022).

Supply chain: The suppliers used by a company or organisation to produce and distribute products, goods and services.

Sustainable land management: A knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising demands for food and fibre while sustaining ecosystem services and livelihoods. Sustainable land management is necessary in order to satisfy the requirements of a growing population while avoiding irreversible damage to ecosystems that support our livelihoods. Improper land management can lead to land degradation and a significant reduction in the productive and service functions (biodiversity niches, hydrology, carbon sequestration) of watersheds and landscapes (The World Bank).

Slurry: Manure is organic matter that is used as organic fertilizer in agriculture. Most animal manure consists of faeces. Common forms of animal manure include farmyard manure or farm slurry (liquid manure).

Statutory instrument: Statutory instruments are the most common form of secondary (or delegated) legislation in the UK. The power to make a statutory instrument is set out in an Act of Parliament and nearly always conferred on a Minister of the Crown. The Minister is then able to make law on the matters identified in the Act, using the parliamentary procedure set out in the Act. Statutory instruments may follow affirmative or negative procedure, or have no procedure at all; the decision on which to use is fixed by the Act (UK Parliament, 2022).

Toxic air: This refers to pollutants in the air at high enough concentrations to cause or contribute to an increase in mortality or an increase in serious illness, or pose a present or potential future hazard to human health.

Turnover: A synonym to business revenue.

Zero-carbon energy supply: Zero carbon means that no carbon emissions are being produced from a product or service (for example, a wind farm generating electricity, or a battery deploying electricity) (National Grid, 2022).

10. Appendices

10.1. Appendix: National Park key statistics

Output Variable	Value	Unit	Source	Output Variable	Value	Unit	Source
Land Area	**95,300**	ha	Official Figures / CEH LCM				
Resident Population	**37,237**	persons	ONS Mid-2019 LSOA Population; ONSPD 2019; BEIS 2019 Postcode Electricity Meters; Custom Postcodes	Average Visitors Per Day	**9,413**	persons	STEAM 2019
Resident Population Density	**0.39**	persons per ha	Based on the Above	Visitor Population Density	**0.10**	persons per ha	Based on the Above
Annual Final Consumption (Households + Public Services)	**33,130**	£ per person per year	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes	Annual Visitors Spend	**108,700,990**	£ per year	STEAM 2019
Annual Household Fuel per Resident	**6,340**	kWh per person per year	BEIS 2019 Postcode Gas; BEIS 2018 Residual Fuels; ONSPD 2019; Custom Postcodes	Annual Visitors All Types	**2,578,730**	persons per year	STEAM 2019
Annual Household Electricity per Resident	**1,377**	kWh per person per year	BEIS 2019 Postcode Electricity; ONSPD 2019; Custom Postcodes	Percentage of Visitors Staying Overnight	**11.7%**	percentage	STEAM 2019
Annual Vehicle Fuel per Resident	**6,500**	kWh per person per year	BEIS 2018 Road Fuels; ONSPD 2019; Custom Postcodes	Average Duration of Stay for Overnight Visitors	**3.9**	days	STEAM 2019
Annual Personal Flights per Resident, Economy Class	**1.08**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate	Average Visitor Party Size	**3.1**	persons	Visitor Survey
Annual Personal Flights per Resident, Business Class	**0.002**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate	Average Visitor One-Way Road/Train/Boat Mileage Travelled	**108**	miles	Visitor Survey
Average Resident One-Way Mileage per Flight, Economy Class	**2,983**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes	Estimated Fraction of Trips by Car	**80.4%**	percentage	Visitor Survey
Average Resident One-Way Mileage per Flight, Business Class	**609**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes	Estimated Fraction of Trips Involving Flights	**4.9%**	percentage	Visitor Survey
Annual Business Turnover, COA-based	**1,117,076,000**	£ per year	IDBR 2019; ONSPD 2019; Custom Postcodes	Average Visitor One-Way Mileage per Flight, Economy Class	**1,898**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Percentage of Suppressed Turnover Output, COA-based	**0.00%**	percentage	IDBR 2019; ONSPD 2019; Custom Postcodes	Average Visitor One-Way Mileage per Flight, Business Class	**0**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes

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10.2. Appendix: Summary datasets used for carbon footprint and confidence levels

Summary of Datasets					Level of granularity of data								Confidence Levels: High/Medium/Low	
Dataset	Data Year	Industry sector base	Fuel type base	Land Use base	Demographic base	Geographical pinpoints	Postcodes	COA	LSOA	MSOA	LA (Local Authority District)	NP / AONB	Original Dataset	Implement. in SWC Tool
SWC EEIO Emissions Factors for Industries	2019	■											High	Medium
SWC-BEIS Emissions Factors for Fuels	2019		■										High	High
ONS Postcode Directory	2019				■	■	■	■	■	■	■	■	High	High
Custom Postcode Boundary	2019 or later						■					▒	High	High
BEIS Domestic Electricity	2019		■				■						High	High
BEIS Domestic Gas	2019		■				■						High	High
ONS Population Demographics (2011 Census)	2011				■		■						High	High
ONS Population Numbers (mid-year)	2019								■				High	High
BEIS Non-Domestic Electricity	2019		■							■			High	Medium
BEIS Non-Domestic Gas	2019		■							■			High	Medium
BEIS Residual Fuels	2018		■								■		Medium	Medium
BEIS Road Fuels	2018		■								■		Medium	Medium
Custom DfT Traffic Points	2019					■					■	▒	Medium	High
ONS Gross Value Added (GVA)	2019	■									■		Medium	Low
IDBR Data for Business Turnover	2019	■						■	■				High	Medium
NAEI Data for Large Emitters	2018						■						High	High
BEIS CO2 Emissions	2018										■		High	Medium
BEIS Non-CO2 Emissions	2018										■		High	Medium
BEIS-DEFRA Land Use GHG Emissions for NPs (CO2 & Non-CO2)	2019 & 2017											■	Medium	High
ONS Atmospheric Emissions Inventory	2019	■											High	High
STEAM Tourism Dataset	2019	■										▒	Medium	Medium
Civil Aviation Authority	2019										■		Medium	Medium
Custom Visitor Surveys (where available)	2019 or earlier	■										▒	Medium	Medium
ONS Household Expenditure A52 (by demographics)	2018				■								Low	Medium
Custom Habitat and Peatland Maps	2019 or earlier			▒								▒	High TBC	Medium
6th Carbon Budget, Tyndall Carbon Budget Tool, National Food Strategy, etc	2019-2021	■	■	■									Medium	Medium

10.3. Appendix: Carbon footprint definitions and data sources

Consumption-based Footprint Category	Contributing Factors	Source
Household Fuel	Gas and other fuels consumed in homes	BEIS 2019 Postcode Gas; BEIS 2018 Residual Fuels; ONSPD 2019; Custom Postcodes; SWC 2019 Emission Factors. In addition for Visitors: STEAM 2019
Household Electricity	Electricity consumed in homes	BEIS 2019 Postcode Electricity; ONSPD 2019; Custom Postcodes; SWC 2019 Emission Factors. In addition for Visitors: STEAM 2019
Vehicle Fuel	Petrol and diesel use by private cars, taxis, motorhomes/campervans and motorbikes	BEIS 2018 Road Fuels; ONSPD 2019; Custom Postcodes; SWC 2019 Emission Factors;. In addition for Visitors: Visitors Survey, STEAM 2019
Car Manufacture & Maintenance	Footprint associated with making & maintaining private vehicles	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO* UK Consumption; SWC 2019 EEIO Emissions Factors
Personal Flights	Flights for purposes other than business	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes. In addition for Visitors: Visitors Survey, STEAM 2019
Ferry Crossings & Cruises	Residents: ferries, boats and cruises; Visitors (where applicable): boats (in NP) and ferries (to & from NP)	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: Visitors Survey, STEAM 2019; Custom Datasets (where applicable)
Trains, Buses & Other Transport	Trains (excl. freight), buses, coaches, etc.	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: Visitors Survey, STEAM 2019
Food & Drink	Entire food & drink consumption, including from shops, restaurants, take-aways, pubs, hotels and B&Bs	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Accommodation (Non Home) Excl. Food	Includes accommodation energy use and supply chains (excl. food) Residents: holiday accommodation; Visitors: accommod. while in NP	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Other Non-Food Shopping	All other shopping	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Water, Waste & Sewerage	Water, waste and sewerage	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Other Bought Services	Includes financial services, telecoms, letting agents (for residents only), travel agents, etc.	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Housing	Everything connected with building, buying and maintaining private properties (for residents only)	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Health, Education, Other Public Services & Administration	Includes hospitals, schools, police, firefighting, bin collection, etc.	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019
Leisure, Recreation & Attractions	Arts & entertainment, sports facilities, libraries, museums, etc.	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes; SWC 2019 EEIO UK Consumption; SWC 2019 EEIO Emissions Factors. In addition for Visitors: STEAM 2019

10.4. Appendix: Residents GHG emissions

Residents GHG emissions: Dartmoor National Park

Consumer Expenditure Categories Summary	ALL Scopes	Units
Household Fuel	51,503	tCO2e per year
Household Electricity	17,375	tCO2e per year
Vehicle Fuel	78,483	tCO2e per year
Car Manufacture & Maintenance	18,924	tCO2e per year
Personal Flights	80,610	tCO2e per year
Ferry Crossings & Cruises	6,547	tCO2e per year
Trains, Buses & Other Transport	12,017	tCO2e per year
Food & Drink	131,409	tCO2e per year
Accommodation (Non Home) Excl. Food	2,480	tCO2e per year
Other Non-Food Shopping	37,210	tCO2e per year
Water, Waste & Sewerage	7,572	tCO2e per year
Other Bought Services	36,559	tCO2e per year
Housing	27,634	tCO2e per year
Health, Education, Other Public Services & Administration	53,188	tCO2e per year
Leisure, Recreation & Attractions	9,548	tCO2e per year
Total	**571,061**	**tCO2e per year**

NOTE: The total could be marginally different to the sum of individual components due to rounding

10.5. Appendix: Visitors GHG emissions

Visitors GHG emissions: Dartmoor National Park

Consumer Expenditure Categories Summary	In NP	To & From NP	Units
Household Fuel	401	0	tCO2e per year
Household Electricity	186	0	tCO2e per year
Vehicle Fuel	8,586	63,092	tCO2e per year
Car Manufacture & Maintenance	2,174	15,974	tCO2e per year
Personal Flights	0	15,995	tCO2e per year
Ferry Crossings & Cruises	0	0	tCO2e per year
Trains, Buses & Other Transport	551	4,046	tCO2e per year
Food & Drink	30,253	0	tCO2e per year
Accommodation (Non Home) Excl. Food	4,760	0	tCO2e per year
Other Non-Food Shopping	7,317	0	tCO2e per year
Water, Waste & Sewerage	2,127	0	tCO2e per year
Other Bought Services	2,904	0	tCO2e per year
Housing	0	0	tCO2e per year
Health, Education, Other Public Services & Administration	0	0	tCO2e per year
Leisure, Recreation & Attractions	766	0	tCO2e per year
Total	**60,023**	**99,107**	**tCO2e per year**

NOTE: The total could be marginally different to the sum of individual components due to rounding

10.6. Appendix. Industry footprint estimates

10.6.1. Appendix: SIC Codes (2007) summary and IDBR description

SIC (2007)	The SIC hierarchy High-Level Summary
Section A	Agriculture, Forestry and fishing
Section B	Mining and quarrying
Section C	Manufacturing
Section D	Electricity, gas, steam and air condition supply
Section E	Water supply; sewerage, waste management and remediation activities
Section F	Construction
Section G	Wholesale and retail trade, repair of motor vehicles
Section H	Transportation and storage
Section I	Accommodation and food services
Section J	Information and communication
Section K	Financial and insurance activities
Section L	Real estate activities
Section M	Professional, scientific and technical activities
Section N	Administrative and support service activities
Section O	Public administration and defence; compulsory social security
Section P	Education
Section Q	Human health and social work activities
Section R	Arts, entertainment, and recreation
Section S	Other service activities
Section T	Activities of households as employers; undifferentiated goods-and services-producing activities for own use
Section U	Activities of extraterritorial organisations and bodies

IDBR

This dataset uses the 2007 revision to the Standard Industrial Classification (UK SIC 2007) in place of the 2003 revision Standard Industrial Classification (UK SIC 2003). The UK SIC 2007 is a major revision of UK SIC 2003 with changes at all levels of the SIC. Further details on Standard Industrial Classification can be found on the ONS website:

http://www.ons.gov.uk/ons/guide-method/classifications/current-standard-classifications/index.html

The broad industry group structure has been defined under UK SIC 2007 and is listed below:

Description	UK SIC 2007 Section	Division
Agriculture, forestry & fishing	A	01/03
Production	B, C, D and E	05/39
Mining, quarrying & utilities	*B, D and E*	*05/09, 35/39*
Manufacturing	*C*	*10/33*
Construction	F	41/43
Wholesale and retail; repair of motor vehicles	G	45/47
Motor trades	*G*	*45*
Wholesale	*G*	*46*
Retail	*G*	*47*
Transport & storage (inc postal)	H	49/53
Accommodation & food services	I	55/56
Information & communication	J	58/63
Finance & insurance	K	64/66
Property	L	68
Professional, scientific & technical	M	69/75
Business administration and support services	N	77/82
Public administration & defence	O	84
Education	P	85
Health	Q	86/88
Arts, entertainment, recreation and other services	R, S, T and U	90/99

Source: IDBR Meta Data

Source: SIC (2007) https://onsdigital.github.io/dp-classification-tools/standard-industrial-classification/ONS_SIC_hierarchy_view.html

10.6.2. Appendix: IDBR industry footprint

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Industry GHG emissions (IDBR-based): Dartmoor National Park

Industry Categories Summary (IDBR sectors)	ALL Scopes	Units
Agriculture, forestry & fishing	58,985	tCO2e per year
Production	72,614	tCO2e per year
Construction	23,752	tCO2e per year
Motor trades	619	tCO2e per year
Wholesale	2,965	tCO2e per year
Retail	3,189	tCO2e per year
Transport & storage (inc. postal)	4,162	tCO2e per year
Accommodation & food services	11,429	tCO2e per year
Information & communication	4,894	tCO2e per year
Finance & insurance	230	tCO2e per year
Property	830	tCO2e per year
Professional, scientific & technical	2,845	tCO2e per year
Business administration & support services	3,924	tCO2e per year
Public administration & defence	585	tCO2e per year
Education	7,375	tCO2e per year
Health	5,248	tCO2e per year
Arts, entertainment, recreation & other services	3,877	tCO2e per year
Total	**207,523**	**tCO2e per year**
ENERGY-ONLY INDUSTRY (subset of INDUSTRY) -- Dartmoor National Park		
Industry Road Fuels	37,257	tCO2e per year
Industry Fuels Excl. Road	56,139	tCO2e per year
Industry Electricity	9,411	tCO2e per year
Total	**102,806**	**tCO2e per year**
LARGE EMITTERS (Scope 1) * -- Dartmoor National Park		
Large Emitters	**-**	**tCO2e per year**
INDUSTRY-RELATED FLIGHTS (subset of INDUSTRY) ** -- Dartmoor National Park		
Industry-related flights	**11,287**	**tCO2e per year**
LULUCF -- Dartmoor National Park		
Land Use CO2	**-52,129**	**tCO2e per year**
Land Use Non-CO2	**159,193**	**tCO2e per year**

NOTE: The total could be marginally different to the sum of individual components due to rounding

10.6.3. Appendix: IDBR vs. GVA industry footprint estimates

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IDBR vs. GVA Industry Footprint Estimates: Dartmoor National Park

Industry Categories Summary (IDBR sectors)	NP/AONB industry footprint per capita (IDBR, COA-level data)	NP/AONB industry footprint per capita (GVA, LA-level data)	Units
Agriculture, forestry & fishing	1.58	0.34	tCO_2e/person/year
Production	1.95	2.26	tCO_2e/person/year
Construction	0.64	0.81	tCO_2e/person/year
Motor trades	0.02	0.11	tCO_2e/person/year
Wholesale	0.08	0.24	tCO_2e/person/year
Retail	0.09	0.40	tCO_2e/person/year
Transport & storage (inc. postal)	0.11	0.53	tCO_2e/person/year
Accommodation & food services	0.31	0.37	tCO_2e/person/year
Information & communication	0.13	0.13	tCO_2e/person/year
Finance & insurance	0.01	0.02	tCO_2e/person/year
Property	0.02	0.05	tCO_2e/person/year
Professional, scientific & technical	0.08	0.16	tCO_2e/person/year
Business administration & support services	0.11	0.16	tCO_2e/person/year
Public administration & defence	0.02	0.32	tCO_2e/person/year
Education	0.20	0.24	tCO_2e/person/year
Health	0.14	0.23	tCO_2e/person/year
Arts, entertainment, recreation & other services	0.10	0.11	tCO_2e/person/year
Total	**5.57**	**6.50**	**tCO_2e/person/year**

NOTE: The total could be marginally different to the sum of individual components due to rounding

10.6.4. Appendix: Pollution inventory for large emitters

Pollution Inventory: Large Emitters (2018 data) Within Adopted Postcode Boundaries for National Parks (2018 data)					
National Park	**LAD14NM**	**Operator**	**Site**	**Postcode**	**CO_2 emissions (kt)**
The Broads	Broadland	British Sugar Plc	Cantley	NR133ST	120.672408
Peak District National Park	Derbyshire Dales	HJ Enthoven & Sons Ltd	Darley Dale	DE42LP	25.8
Peak District National Park	Derbyshire Dales	Tarmac Ltd	Ballidon Quarry	DE61QX	0.002702
Peak District National Park	High Peak	Hope Construction Materials Ltd	Hope Works	S336RP	1048.8045
South Downs National Park	Horsham	Viridor Waste Management Ltd	Horton Landfill	BN59XH	16.9
South Downs National Park	Lewes	Veolia ES South Downs Ltd	Newhaven EfW Plant	BN90HE	201.611
North York Moors National Park	Redcar and Cleveland	Cleveland Potash Ltd	Saltburn-By-The-Sea	TS134UZ	13.73193
New Forest National Park	Wiltshire	Renewable Power Systems Ltd	Poundbottom Landfill Site	SP52PU	3.82

10.7. Appendix: Emissions from major roads

SMALL WORLD CONSULTING

Emissions from major roads: Dartmoor National Park

SELECTED A-ROADS – SMALLER SUBSET – Dartmoor National Park		
Road Names, Smaller Subset	A386	
Cars, Buses & Motorbikes	27,252	tCO_2e per year
Vans & Lorries	10,844	tCO_2e per year
Total	**38,096**	**tCO_2e per year**
SELECTED A-ROADS – LARGER SUBSET – Dartmoor National Park		
Road Names, Larger Subset	Smaller Set + A385 A382	
Cars, Buses & Motorbikes	34,809	tCO_2e per year
Vans & Lorries	15,044	tCO_2e per year
Total	**49,853**	**tCO_2e per year**
THROUGH-TRAFFIC – Dartmoor National Park		
Cars, Buses & Motorbikes	10,880	tCO_2e per year
Vans & Lorries	12,944	tCO_2e per year
Total	**23,824**	**tCO_2e per year**

NOTE: The total could be marginally different to the sum of individual components due to rounding

10.8. Appendix: Methodology

10.8.1. Appendix: History of model development

In 2010, Small World Consulting (SWC) carried out a first consumption-based greenhouse gas assessment for the Lake District National Park (LDNP). This project adopted a consumption-based assessment approach alongside more traditional production-based metrics.

This opened up policy areas such as food, shopping, business supply chains, and travel by both residents and visitors to and from the Park. The study led to a carbon budget being set each year, with a target to reduce annual emissions by 1% per year compared to business as usual (therefore 6% by 2016). Each year actions taken to cut emissions were collated from members of the Park's strategic partnership, and assessed in terms of their contribution to the target. Overall, after seven years, these emission reduction actions are thought to have accumulated to around 3% reduction in annual emissions, compared to business as usual.

Seven years after the baseline study for the LDNP, a lot had changed, including: reporting methods, underlying model data, the numbers and behaviours of residents and visitors, and the climate change agenda. SWC therefore refreshed the LDNP carbon assessment in 2017 and again in 2020, extending the latter to the whole of Cumbria. Through this work, a Zero Carbon Cumbria Partnership was formed in 2021, financed by a successful bid for National Lottery funding. Subsequently, SWC was commissioned in 2021 to undertake a similar consumption-based carbon footprint assessment for all the UK National Parks, plus several AONBs.

10.8.2. Appendix: Model development for the National Park and AONB family

Our development of a carbon footprint model for the National Parks and AONBs has been and remains an iterative process, with insights obtained from each tranche to date (namely 1, 2, 3 and 4) serving to improve various parts of the model.

Tranche 5 (April-July 2022) is considered the point by which all major updates of the model were completed. Subsequent updates, which will be applied to all National Parks and AONBs on the current programme, are possible but less likely at this stage.

The datasets and methodologies used in the May 2022 version of the footprint model are considerably more complex than in the LDNP and Cumbria assessments, but the model is robust and could easily be updated when new post-COVID data becomes available.

The main methodological challenge arises from the need to map data between various geographies: postcode, COA, LSOA, MSOA, LA, and National Park boundaries. This has been dealt with by constructing appropriate masks with mapping weights, as well as performing custom GIS analysis.

Another key addition is that of the traffic points data, which can be used to assess through-traffic in each National Park or AONB and estimate footprints linked to the motorways, the main A-roads and the largest B-roads within its boundaries.

Another noticeable change in methodology concerns industry footprint estimates. An initial analysis was conducted using GVA datasets from Local Authorities; however, when this was applied across the National Parks and AONBs, it became apparent that a better geographical representation of industry sectors within each landscape was required.

As a result, additional licences were purchased for ONS IDBR datasets, for COA-level industry turnover, in order to estimate the relevant footprint. By necessity, the turnover estimates include all COA geographies overlapping with the National Park or AONB boundary, leading to marginal overestimates. The COAs within and on the boundary that are known to contain large point-source emitters were excluded from the turnover figures.

The emissions estimates for the agriculture and forestry sector, derived using IDBR data, reflect local enterprise turnovers; however, they rely on the UK-average carbon intensities of these sectors, which may not reflect the unique farming and forestry characteristics within each landscape.

Another key footprint category updated recently is land use emissions based on the latest version of the Department of Business, Energy and Industrial Strategy (BEIS) land use CO_2 data for National Parks for 2019. The 2019 BEIS land use CO_2 dataset includes, for the first time, emissions from different types of peatland and varying levels of peat degradation. We also employ peat emission factors from this dataset, alongside afforestation and peatland restoration targets from the Sixth Carbon Budget, as part of our net zero pathway recommendations for each National Park and AONB.

A summary of the datasets used in the carbon footprint model is provided in Appendix 10.2.

10.8.3. Appendix: Outline of emissions estimation methodology

This section provides a brief outline. A more detailed methodology document will be produced separately by the end of 2022.

- Household energy-related emissions were derived from consumption data available at postcode and local authority levels. The energy-related emissions factors used included supply chain components.

- Local authority level fuel use data was employed as the starting point for estimating residents' road fuel emissions. Road traffic counts data was used to estimate emissions from through-traffic and emissions from selected major roads. The emissions factors used for all transport take account of direct vehicle emissions, energy supply chain emissions and the emissions embodied in the production and maintenance of vehicles and transport infrastructure.

- Emissions from UK residents, other than those relating to household energy and vehicle use, were derived using a well-established environmentally extended input output model (EEIO) developed by Small World Consulting. Residents' emissions per capita were adjusted from the UK averages provided by the EEIO model, using demographic data for the National Park or AONB at the postcode level, together with survey data on national household expenditure.

- For visitors, the same EEIO model was used to estimate emissions from consumption other than road fuel. We used data from multiple visitor surveys and tourism modelling to derive estimates of visitor numbers and visitor spending, which we combined with emission factors from the EEIO model.

- Emissions relating to land-based visitor travel to and from the National Park and within the National Park were derived using visitor surveys, and comparisons with resident road travel emissions.
- Emissions related to through-traffic, which by definition occur within the boundary of the National Park or AONB, are estimated by comparing total traffic point counts with pump-level fuel sales within the National Park or AONB, along with assumptions about commuting in out of the area.
- Civil Aviation Authority survey data was used to estimate the emissions associated with flights taken by residents and visitors. The emission factors used take account of flight distances and flight class, and include a markup factor for high-altitude climate effects.
- A very rough estimate of industry emissions (including their supply chains), which overlaps with resident and visitor emissions, was included for added perspective. The estimate was derived from Inter-Departmental Business Registry (IDBR) turnover data for businesses registered in an area that was mapped as closely as possible to the National Park, combined with industry-specific emission factors that were drawn from the EEIO model. Separately, energy-related emissions from industry were calculated from consumption data and energy-related emission factors that included supply chain components.
- We adopted baseline land use emissions estimates published by BEIS for all National Parks (both for the CO_2 and non-CO_2 components). For AONBs, the CO_2 component of land-based emissions and carbon sequestration was estimated separately using bespoke land use datasets provided by the AONBs following a common methodology developed as part of this programme, together with the BEIS and Natural England habitat-specific emission factors. The Non-CO_2 component of land-based emissions for AONBs (including emissions from livestock and fertiliser use) was approximated using footprint estimates for the industry sector "agriculture, forestry and fishing" derived from the IDBR data.

The data sources used are listed in Appendix 10.2.

10.8.4. Appendix: Assumptions for visitors' surveys

Visitor party size

Data was provided in the Dartmoor 2020 visitors' survey on the number of visitors per party, with a breakdown of whether the party consisted of 1,2,3,4 or more than 5 individuals. For the more than 5 individuals category, a party size of 6 was assumed, given that this is used to calculate the number of people per car, and very few cars have more than 6 or 7 seats.

Modes of transport

No data was provided in visitors' surveys on the modes of transport used to travel to/from or within the Park. Data from the Exmoor visitors' survey was used, given that this is the closest National Park, with similar travel links to the rest of the UK.

Inferring flights share

No data on flights was provided, but data on the number of visitors travelling from Europe or outside of Europe was given in the 2016 Dartmoor visitors' survey. Given this, the inferred flight share was assumed to be the Non-European overseas visitor percentage (1%) plus 60% of the European visitors (0.6*6%) based on the Cairngorms National Park data, summing to 4.9%. The remainder of the European visitors are assumed to arrive in the UK by land transport.

Inferring distance travelled to the National Park on land

For European visitors, countries of origin were taken from the 2016 visitors' survey, given that the 2020 survey was skewed by the COVID-19 pandemic. For visitors from the UK, the 2020 visitors' survey data file contained the first half of the postcode of residence for each respondent (known as postcode districts). Distances were calculated by finding the driving distance from each postcode district (e.g. CB1) to Haytor. The most frequent postcode areas in the survey are EX, PL and TQ.

10.8.5. Appendix: Target-setting rationale

Each component of the overall emissions reduction target has been judged to be the minimum required in order to align with the IPCC's recommendations for limiting global temperature change to 1.5°C compared to pre-industrial conditions. The components' feasibility may depend on appropriate government and private sector support, for which the Park should advocate as part of its climate response. The steepness of the proposed emissions reduction trajectories reflects decades of global inaction, and illustrates the scale and urgency of the challenge we now face.

For energy-related emissions we drew on modelling by the Tyndall Centre for Energy and Climate Change Research for setting local authority targets. For food-related emissions we examined recommendations from the National Food Strategy and other sources. For goods other than food, the target reflects the relative difficulty of reducing emissions from global supply chains, compared to UK energy-related emissions. For visitor travel the target reflects both possible changes in future travel habits and the likely decarbonisation of land transport. The land use targets reflect the feasibility assessment in line with the Sixth Carbon Budget's 2050 net zero pathway for the UK.

Table 8 outlines the methodology used in this report (New Model for All National Parks 2022) and how it compares with an earlier iteration (Cumbria 2020). Methodological differences arose from new learning and knowledge transfer incorporated in the planning assumptions for National Park target-setting. In setting targets, we have made a pragmatic assumption that we may reach percentage ceilings in the emissions reductions that can be achieved for some sectors, as it may not be entirely possible to achieve real zero emissions in these sectors given that there will always be residual emissions.

Table 8: High level comparison between Cumbria and new National Park target-setting methodology and assumptions used.

Priority area	Previous Model for Cumbria (2020)	New Model for All National Parks (2021) – used in this report	Achievable ceiling
Energy-only emissions	13% per year reduction in energy-related CO_2	**14.3%** (specific to Dartmoor National Park) per year	**5%** of present-day emissions. This is our expert

by residents, visitors and industry	(as prescribed by the Tyndall Carbon Budget Tool[97]). Includes Scope 1 and 2 carbon dioxide emissions only (excluding motorways).	reduction in energy-related CO_2 as prescribed by the Tyndall Carbon Budget Tool, and extended to other GHGs. Includes Scope 1, 2 and 3 GHG energy emissions expressed at tCO_2e for residents, visitors and industry.	judgement for embedded emissions across various forms of renewable energy, for example assuming little or no CCS.
Food consumed by residents and visitors	5% reduction per year	**5%** reduction per year. This assumes 3% per year from dietary change (National Food Strategy: 30% in 10 years), 1% per year from waste reduction and 1% per year from other changes incl. technology.	**30%** of present-day emissions. This is based on the Sixth Carbon Budget (AFOLU section), stating that UK agriculture emissions are set to halve from 54 $MtCO_2e$ today to 27 $MtCO_2e$ in 2050 under the Net Zero pathway. Some further savings may come from widespread adoption of vertical farming, which is why we opted for the more ambitious 30% ceiling.
Other goods purchased by residents and visitors	5% reduction per year	**5%** reduction per year. Includes cars. This assumes that sectors such as cement and steel, which feed into complex supply chains (incl. making cars), will take time to decarbonise globally and won't reach zero emissions in large exporters like China by 2050.	**10%** of present-day emissions. The is our expert judgement for residual emissions from sectors such as cement and steel that will take time to decarbonise globally and won't reach zero emissions in large exporters like China by 2050.
Visitor travel to and from the National Park	Visitor travel to and from Cumbria (excluding international travel)	**10%** reduction per year. Excludes flights but includes car manufacturing. This assumes a 4% per year increase in duration of stay (roughly doubling after 20 years), a 4% per year reduction in the footprint of transport (roughly halving emissions from cars in 20 years, leaving predominantly the embedded car manufacturing footprint), and a 2% per year shift in the mode of transport from cars.	**7.5%** of present-day emissions. This is our expert judgement for embedded emissions across various forms of renewable energy, and from the sectors (via supply chains) such as cement and steel that will take time to decarbonise globally (affecting car manufacturing, buildings, etc.).
Land Use	Expert judgement based on discussions	We have split land use into Land Use Non-CO_2 and Land	**30%** of present-day emissions for Land Use Non-

97 A budget tool for energy only CO2 for local authorities, based on IPCC recommendations for "well below 2 degrees and in pursuit of 1.5 degrees," developed by the Tyndall Centre and available at: https://carbonbudget.manchester.ac.uk/reports/

	with stakeholders involved	Use CO_2. See Table 9 for further details.	CO_2 only, which follows the arguments for the Food & Drink category. Land Use CO_2: Achievable ceiling is not applicable in this assessment due to 2050 being a comparatively short horizon in terms of land-based carbon sequestration measures

A detailed breakdown of how the land use targets are derived, and the relevant planning assumptions, can be found in 10.8.9. Table 9 below provides a brief overview.

Table 9. Land Use target assumptions for National Parks.

Land Use Non-CO_2	The Non-CO_2 component includes methane and N_2O emissions from livestock and fertilizer use within the National Park, which must be reduced in line with broader targets for the Food & Drink category. We therefore assume a 5% per year reduction for this component. Inevitably, there will be a small amount of double-counting, linked to residents and visitors consuming locally produced food in the area.
Land Use CO_2	The CO_2 component includes emissions from degraded peatland and other types of soil, as well as carbon sequestration through woodland creation, peatland restoration and regenerative agricultural practices. This component changes linearly with time as the land use change measures are extended to bigger land areas, and becomes negative when the carbon sink quantities exceed carbon emissions from land. The assumed year-on-year changes to land use are based on apportionment of the Sixth Carbon Budget targets according to present-day land use in each National Park; see Table 14. The resulting rates of land conversion (e.g. afforestation or peatland restoration) and/or application of new management practices (e.g. cover cropping or grazing legumes) are then combined with the per-hectare carbon sequestration fluxes associated with these land use changes (established from field studies and desk-based research). In Dartmoor, the proposed land use measures are estimated to add -10,519 tCO_2e/year to the total carbon sequestration flux in the landscape each year (i.e. an extra 10,519 tCO_2e removed per year in each of the subsequent years).

10.8.6. Appendix: Assumptions for Land Use sector

The Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC 2006, IPCC 2014) describes a uniform structure for reporting emissions and removals of greenhouse gases. The Department for Business, Energy and Industrial Strategy (BEIS) contracts a company, Ricardo Energy & Environment, to compile an annual Inventory of UK

Greenhouse Gas Emissions for the United Nations Framework Convention on Climate Change (UNFCCC). Ricardo subcontracts two further entities – the UK Centre for Ecology and Hydrology, and Forest Research – to prepare the data relating to Land Use, Land-Use Change and Forestry (LULUCF) in the UK.

The LULUCF sector differs from other sectors in the Greenhouse Gas Inventory in that it contains both sources and sinks of greenhouse gases[98]. The sources, or emissions to the atmosphere, are given as positive values; the sinks, or removals from the atmosphere, are given as negative values.

To provide context, an analysis was undertaken to understand and extract the key facts, logic and rationale applied to changes in either reporting or target-setting, as outlined in the Sixth Carbon Budget report on agriculture, forestry and other land use (AFOLU); see Table 10 and Table 11. The report states that emissions from the AFOLU sector "have declined by 16% since 1990. This is mainly due to successive reform of the Common Agricultural Policy (CAP) in the 1990s and early 2000s, which reduced livestock numbers, coupled with changes in farming practices due to EU environmental legislation to address non-GHG pollutants (e.g., Nitrates Directives). There has been little change in emissions since 2008".

Table 10: UK baseline for Agriculture emissions (2018) using Global Warming Potential of IPCC AR5 for methane

	Percentage of UK emissions	**Quantity of CO_2 equiv.t**
Summary for Agriculture	**10%**	**54.6 $MtCO_2e$**
Breakdown		*SWC planning assumptions*
Methane (CH_4) from livestock	63%	34.4 $MtCO_2e$
Nitrous oxide (N_2O) mostly from soil	26%	14.2 $MtCO_2e$
Carbon dioxide (CO2) from fossil fuel use	11%	6.0 $MtCO_2$
Total	**100%**	**54.6 $MtCO_2e$**
Data Source: The Sixth Carbon Budget: Agriculture and land use, land use change and forestry, p.6		

Table 11: Baseline for Agriculture emissions (2018) using Global Warming Potential of AR5 for methane

	Percentage of UK emissions	**Quantity of CO_2 equiv.t**
Agriculture Breakdown		*SWC planning assumptions*
Methane from livestock (Enteric fermentation digestion process of ruminant livestock)	53%	28.9 $MtCO_2e$
Agricultural soils	21%	11.5 $MtCO_2e$
Waste and manure management	16%	8.7 $MtCO_2e$
Stationary machinery	8%	4.4 $MtCO_2e$
Other	2%	1.1 $MtCO_2e$

[98] DEFRA (2021), "UK Local and Regional Carbon Dioxide Emissions Estimates for 2005-2019," Technical Report p.62.

Total	100%	54.6 $MtCO_2e$
Data Source: The Sixth Carbon Budget Agriculture and land use, land use change and forestry p.6 Figure M.7.1		

10.8.7. Appendix: Land class categories for reporting nationally

For reporting purposes all land in the country must be identified as having remained in one of six classes since a previous survey, or as having changed to a different (identified) class in that period[99]. The six land classes are:

Land use category	Sub-category
4A: Forest Land	• Forest land remaining forest land • Biomass burning • Land converted to forest land • Drainage of organic soils • Direct N_2O emissions from N mineralisation/mobilisation
4B: Cropland	• Biomass burning • Cropland remaining cropland • Land converted to cropland • Direct N_2O emissions from N mineralisation/mobilisation
4C: Grassland	• Biomass burning • Grassland remaining grassland • Land converted to grassland • Drainage of organic soils • Direct N_2O emissions from N mineralisation/mobilisation
4D: Wetlands	• Wetlands remaining • Drainage of organic soils • Land converted to wetland
4E: Settlements	• Settlements remaining settlements • Biomass burning • Land converted to settlements • Drainage of organic soils • Direct N_2O emissions from N mineralisation/mobilisation
4F: Other land	• Harvest wood • Indirect N_2O emissions

There is a seventh category (4G) for the pool of harvested wood products.

[99] BEIS, CEH, Forest Research (2020) "National Atmospheric Emissions Inventory: Projections of Emissions and Removals from LULUCF Sector to 2050", p. 3

10.8.8. Appendix: Changes in methodology for quantifying peatland GHG emissions

In 2017 the Centre for Ecology and Hydrology proposed changes to the methodology for reporting emissions from peatlands[100]. Emissions from the drainage and rewetting of peatlands were included for the first time in the 1990-2019 LULUCF inventory (Brown *et al.* 2021). These emissions are reported under all LULUCF land use categories and are **not** specifically identified separately. In summary, the following principles are applied:

- Emissions from drained and rewetted organic soils are allocated to UK local authorities using peat condition mapping outputs from Evans *et al.* (2017).
- The majority of the peatland area, reported in the Grassland category, includes semi-natural bog categories, extensive and intensive grassland, and rewetted bog or fen from semi-natural bog and intensive and extensive grassland.
- Emissions from active extraction of peat (on site, and off-site for horticultural peat), as well as from organic soils affected by historical peat extraction, are reported under Wetlands.
- Naturally occurring GHG emissions and/or removals from pristine areas of bog and fen, rewetted bog or fen, and from peat extraction, are now included in LULUCF reporting under Wetlands.
- Emissions of CO_2 from drained organic soils in Forest, Cropland and Settlement areas are reported in those respective categories.
- The "Other land" category predominantly comprises bare rock and scree, with no emissions or removals reported.

These recommendations were further refined for the current UK GHG Inventory 1990-2019[101].

Although the latest (BEIS) LULUCF estimations (2019) are more accurate than previous years, they remain subject to considerable uncertainty. This is due to an evolving methodology and a process to refine the measurement of emission factors for UK peatlands, attempting to take into account transitions from heavily modified peatlands (forested land, cropland, grassland, peat extraction, eroding bog) and semi-natural peatlands (heather-dominated and grass-dominated bogs). Peatlands in their semi-natural state may be near-natural, modified, or rewetted (Table 12). The estimates for CO_2 emissions in the form of dissolved organic carbon (DOC) use Tier 1 emission factors, and therefore are the least robust of all (IPCC 2014). Tier 2 emission factors for the UK-relevant peat condition categories were subsequently developed by Evans *et al.* (2017), providing estimates for "particulate organic carbon" (POC) emissions, as well as direct CO_2 emissions. The Tier 2 estimations add more granularity and are country-specific, being tested for robustness using at least four different study locations considered reliable enough to replace Tier 1 values. The CARBINE Tier 3 carbon accounting model developed by Forest Research was employed to derive the emission factor for forested peatland between 1990 and 2019, and was tested using field data.

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[100] Centre for Ecology and Hydrology (2017) "Implementation of an Emissions Inventory for UK Peatlands: A report to the Department for Business, Energy, and Industrial Strategy," Issue Number 1.
[101] Ricardo Energy & Environment UK NIR 2020 (Issue 1), UK GHG Inventory 1990-2019, Annex p. 854.

Table 12. Extract from Ricardo Energy & Environment UK NIR 2020 (Issue 1) UK GHG Inventory 1990-2019 Annex p. 858

Table A 3.4.28 Emission factors for peat condition types updated from Evans et al (2017). All fluxes are shown in $tCO_2e\ ha^{-1}\ yr^{-1}$. Note that a positive EF indicates net GHG emission, and a negative EF indicates net GHG removal.

Peat Condition	Drainage status	Direct CO_2	CO_2 from DOC	CO_2 from POC	Direct CH_4	CH_4 from Ditches	Direct N_2O	Total
Forest	Drained	2.52 to -1.79[c]	1.14[a]	0.3[b]	0.06[a]	0.14[a]	1.31[a]	**5.46 to 1.15**
Cropland	Drained	28.60[b]	1.14[a]	0.3[b]	0.02[b]	1.46[a]	6.09[a]	**37.61**
Eroding Modified Bog (bare peat)	Drained	6.18[b]	1.14[a]	5.0[b]	0.14[a]	0.68[a]	0.14[a]	**13.28**
	Undrained	6.18[b]	0.69[a]	5.0[b]	0.15[a]	0[a]	0.14[a]	**12.17**
Modified Bog (semi-natural Heather + Grass dominated)	Drained	0.13[b]	1.14[a]	0.3[b]	1.26[b]	0.66[a]	0.06[b]	**3.54**
	Undrained	0.13[b]	0.69[a]	0.1[b]	1.33[b]	0[a]	0.06[b]	**2.31**
Extensive Grassland (combined bog/fen)	Drained	6.96[b]	1.14[a]	0.3[b]	1.96[b]	0.66[a]	2.01[a]	**13.03**
Intensive Grassland	Drained	21.31[b]	1.14[a]	0.3[b]	0.68[b]	1.46[a]	2.67[b]	**27.54**
Rewetted Bog	Rewetted	-0.69[b]	0.88[a]	0.1[b]	3.59[b]	0.0[a]	0.04[b]	**3.91**
Rewetted Fen	Rewetted	4.27[b]	0.88[a]	0.1[b]	2.81[b]	0.0[a]	0[a]	**8.05**
Rewetted Modified (Semi-natural) Bog	Rewetted	-3.54[b]	0.69[a]	0[b]	2.83[b]	0[a]	0[a]	**-0.02**
Near Natural Bog	Undrained	-3.54[b]	0.69[a]	0[b]	2.83[b]	0[a]	0[a]	**-0.02**
Near Natural Fen	Undrained	-5.41[b]	0.69[a]	0[b]	3.79[b]	0[a]	0[a]	**-0.93**
Extracted Domestic	Drained	10.27[a]	1.14[a]	1.01[b]	0.14[a]	0.68[a]	0.14[a]	**13.37**
Extracted Industrial	Drained	6.18[b]	1.14[a]	5.0[b]	0.14[a]	0.68[a]	0.14[a]	**13.28**
Settlement	Drained	0.07[b]	0.57[a]	0.15[b]	0.63[b]	0.16[a]	0.03[b]	**1.61**

[a] Tier 1 default EF (IPCC 2014)

[b] Tier 2 EF (updated literature analysis in 2019 incorporating data from Evans et al. 2017)

[c] Tier 3 Forest Research CARBINE model implied EF for 1990 to 2019. The decreasing trend is due to an increase in age of forests on organic soils due to decreasing afforestation on organic soils.

10.8.9. Appendix: Target-setting methodology for land use change

The land use change and management targets in each National Park or AONB, which include woodland creation, peatland restoration and several regenerative agriculture measures, are derived by apportioning land-based carbon sequestration measures from the UK's Sixth Carbon Budget (2020)[102] according to present-day land use distribution in each National Park or AONB. It is worth noting that all land use datasets have considerable uncertainties. We adopted the CEH Land Cover Map classification for land use assessments across all National Parks and AONBs on the current programme.

In the case of woodland creation, a more ambitious target has been introduced for each protected landscape through a high-level opportunity mapping and conversations with the National Park and AONB teams on the ground, with a preference (in most cases) for native broadleaf or mixed species in order to achieve broader environmental benefits across protected landscapes, such as those in National Parks and AONBs.

Our land use change and management options focus on either creating, enhancing or restoring (as applicable) four common land use types (habitats) on mineral soils, and eight types of degrading peatland habitats:

- Broadleaf woodland on mineral soil
- Coniferous woodland on mineral soil
- Improved grassland on mineral soil
- Cropland on mineral soil
- Eroding modified bog (bare peat), drained
- Eroding modified bog (bare peat), undrained
- Modified bog (heather/grass-dominated), drained
- Modified bog (heather/grass-dominated), undrained
- Cropland on peat soil, drained
- Intensive grassland on peat soil, drained
- Extensive grassland (on bog/fen), drained
- Forest on peat soil, drained.

The degraded peatland classification follows the methodology adopted by BEIS for annual LULUCF GHG inventories[103], which is based on the assessment by Evans *et al.* (2017)[104].

For the Dartmoor National Park, the current land use distribution is illustrated in Table 13. It is based on the 2020 SWEEP habitat classification dataset and University of Exeter peatland dataset[105], mapped on the CEH Land Cover Map habitats. The methodology is described in Appendix 10.8.10.

[102] UK's Sixth Carbon Budget: "Agriculture and land use, land use change and forestry" (AFOLU) report. Climate Change Committee, 2020.
[103] Ricardo Energy & Environment, UK NIR 2020 (Issue 1) "UK GHG Inventory 1990-2019," Annex p. 854 .
[104] Centre for Ecology and Hydrology (2017) "Implementation of an Emissions Inventory for UK Peatlands: A report to the Department for Business, Energy, and Industrial Strategy," Issue 1.
[105] South West Partnership for Environmental and Economic Prosperity (2019) Habitat Classification Tool; https://sweep.ac.uk/portfolios/habitat-mapping/.

The UK-wide areas of the selected land use (habitat) types and the corresponding percentages accounted for by the National Park are shown for context in Table 14.

At roughly 95,300 ha, Dartmoor accounts for around 0.4% of the UK's total land area, while the National Parks current share of tree cover (excluding trees on peat) is 18% higher than the UK average. There may be an opportunity to further expand the existing woodland area. We propose the majority of tree planting to be native broadleaf trees, recognising that a native permanent woodland also has multiple co-benefits in addition to carbon sequestration, that cannot be matched by productive coniferous forestry.

The estimated occurrence of degraded peatland in Dartmoor is nearly 4 times higher than the UK average per unit area. Restoring peatland can therefore make a considerable contribution to reducing land-based emissions in the National Park.

The Dartmoor improved grassland and cropland areas are estimated to be 10% lower and 15 lower than the respective UK averages. There is potential to apply restorative agricultural practices as part of proposed UK-wide measures to manage land more sustainably, which are outlined in the Sixth Carbon Budget. However, some of the least productive and lowest grade farmland would need to be taken off agricultural production to enable new woodland plantations.

Table 13. Dartmoor National Park: Key land use types by area (present-day), including underlying peat areas and the estimated percentage of peat in a healthy condition (by area)

Land Cover (Habitat) Type	Habitat Area (ha)	Peat Area (ha)	Estimated % of Peat Area in Healthy Condition
Broadleaved woodland	13,339.9	473.9	0%
Coniferous woodland	2,967.6	924.2	0%
Arable and horticulture	1,556.7	46.8	0%
Improved grassland	22,650.8	925.6	0%
Neutral grassland	0.0	0.0	NA
Calcareous grassland	0.0	0.0	NA
Acid grassland	37,413.6	18,933.6	0%
Fen, marsh, swamp	1,525.0	997.6	23%
Heather	10,333.6	6,915.0	0%
Heather grassland	1,528.5	623.5	0%
Bog	1,571.6	1,332.7	23%
Saltmarsh	0.0	0.0	NA
Urban	0.0	0.0	NA
Suburban	1,475.4	63.4	0%
Total	**94,362.6**	**31,236.4**	**NA**

Table 14. Dartmoor National Park: Areas of the main land cover (habitat) types compared with the relevant UK totals

Land Cover Type	Current UK Area (ha)	Current NP Area (ha)	NP Area as % of UK Area

Broadleaf Woodland (mineral soil only)	**1,572,900**	**12,866**	**0.813%**
Coniferous Woodland (mineral soil only)	**1,637,100**	**2,043**	**0.124%**
Improved Grassland (mineral soils only)	**6,161,798**	**21,725**	**0.353%**
Cropland (mineral soils only)	**5,788,356**	**1,510**	**0.026%**
Degraded Peatland (all types)	**2,182,455**	**30,703**	**1.407%**
Total Woodland Area (Broadleaf + Coniferous)	**3,210,000**	**14,909**	**0.464%**
Total Agricultural Area (Improv. Grassland + Cropland)	**11,950,154**	**23,235**	**0.194%**
Total Area of Selected Land Cover Types (above)	**17,342,609**	**68,847**	**0.397%**
Total Area (incl. urban, rough grassland, water, rock, etc)	**24,249,500**	**95,300**	**0.393%**

We consider the following seven options for land use change and management that will enable carbon sequestration (or emissions reduction in the case of degraded peatland) and create wider environmental benefits (biodiversity gains, flood mitigation, air quality improvements, gains in recreational value, etc.), in alignment with the Sixth Carbon Budget:

- New native broadleaf/mixed woodland
- New productive coniferous woodland
- Peatland restoration (across all degraded types)
- Agroforestry (for improved grassland and cropland)
- Hedgerows (for improved grassland and cropland)
- Introducing legume grass species (for improved grassland)
- Introducing cover crops (for cropland)

Each of these measures is described in the subsections below.

Woodland creation

Our chosen UK-wide woodland creation target form the Sixth Carbon Budget is 50,000 ha per yr, representing medium to high levels of ambition as part of the proposed Net Zero scenario for 2050.

As a starting point, we apportion UK-wide woodland creation target based on the current woodland coverage in each National Park and AONB as a percentage of the UK coverage (see Table 14 above), which simply mirrors the approach for apportioning other land use and management options considered here (e.g. peatland restoration and a better agricultural management). However, the fact that creating new woodland requires a fundamental change to land use rather than management changes on existing land, the woodland target has to be set differently, by considering total areas of suitable habitats within each landscape. We refer to this assessment as a high-level woodland opportunity mapping, which is a first step in setting a practical woodland target, to be followed by a field-level multi-benefit opportunity mapping.

As a default rule, we safeguard habitats such as existing woodland, calcareous grassland, lowland heathland, purple moor grassland and rush pasture, fen, and bog from the opportunity mapping for new woodland. On the other hand, habitats such as neutral grassland, acid grassland and upland heathland, part of which are commonly referred to as "moorland", are prime candidates for woodland opportunity mapping, subject to field-level ecological and economic considerations. We note that large areas of the acid grassland and upland heathland habitats contain both deep and shallow peat, typically classified as modified bog dominated by heather/grass, either drained or undrained[106]. We exclude these areas from woodland opportunity mapping, and apply restoration targets to these types of peatland, in addition to degraded areas of peatland classified as blanket bog, peat under agricultural soils or forested peat. For arable land and improved grassland, only a relatively small fraction of the area (25%) is considered for woodland opportunity mapping, for example by creating mosaic habitats with new woodland on field margins freed by reducing livestock numbers and adopting higher-yielding crop varieties.

Our approach for apportioning the UK woodland target to each protected landscape through a high-level opportunity mapping procedure has been applied to all National Parks and AONBs participating in this programme. As a default for this assessment, we assign a custom woodland creation target that exceeds the area-based target described above, which is illustrated for the Dartmoor National Park in Table 15. For most protected landscapes, the ambition is around two times the minimum target based on suitable areas. This reflects on unique opportunities that Protected Landscapes have in terms of attracting both public and private grants to expand the woodland cover, and the central role they ought to play for meeting ambitious nature recovery goals across the UK. The proposed higher ambition approach is supported by field-level woodland opportunity mapping performed by several landscapes (e.g. Cotswolds, Northumberland). Based these principles, the custom woodland target for Dartmoor is 350 ha/yr.

Table 15. Three ways of setting new woodland targets in Dartmoor National Park.

Woodland target apportioned by woodland land cover area in the National Park or AONB	**231**	ha/yr
Minimum woodland target apportioned by suitable habitat areas in the National Park or AONB	**178**	ha/yr
Custom woodland target in the National Park or AONB	**350**	ha/yr

The combined woodland target is then divided between native broadleaf/mixed woodland and productive coniferous woodland. As a default position, we opted to use a 100%-0% split in favour of native broadleaf/mixed woodland for lowland landscapes and/or those landscapes that advocate for forestry areas to be predominantly outside of their borders, for example in the sphere of influence of the neighbouring Local Authority Districts. For some upland landscapes, 80%-20% or 70%-30% in favour of the native woodland could be considered. A 50%-50% split may be applicable in exceptional circumstances such as strategic importance of forestry in certain protected areas.

[106] More research is needed to determine whether restoring degraded shallow peat is worthwhile compared to woodland creation, especially where the shallow peat is in small patches in otherwise un-biodiverse acid grassland/bracken.

In this assessment, we propose to use the 80%-20% woodland cover split in favour of native woodland for the Dartmoor National Park, to benefit from the broader environmental and social benefits of native woodland, while also reflecting on the importance of productive forestry to the UK economy.

Our estimates regarding carbon sequestration in woodland biomass employ yield class (YC) 8 for native broadleaf/mixed woodland and YC 18 for productive conifer trees, as per the Sixth Carbon Budget's recommendations[107]. We use 30-year average sequestration fluxes for trees from these yield classes (inferred from the Woodland Carbon Code, WCC), to match the timescales of the Net Zero target of 2050. Different trees planted in the years ahead will be between 0 and 30 years old by 2050, which is why we adopt the 30-year average sequestration flux value in our calculations. Another simplification is that no time lag in carbon sequestration in trees is considered, with the S-shaped curve representing the actual cumulative carbon uptake in trees replaced by a linear function from the moment of planting. We also add to the biomass carbon sequestration (inferred from the WCC) representative estimates of soil carbon sequestration for woodland, from a recent literature review by Bossio *et al.* (2020)[108].

Peatland restoration

Our adopted UK-wide peatland restoration target follows the recommendation in the Sixth Carbon Budget that 79% of UK's peatland areas will need to be restored by 2050, which would be a big improvement on the current estimate that only 25% of UK's peatlands are in a healthy condition. This results in a combined annual target of just under 52,400 ha/year of peatland to restore across the UK between now and 2050.

The UK-wide peatland restoration target is apportioned to each National Park or AONB according to its total estimated area of peatland. Each National Park's and AONB's target is further broken down into sub-targets for individual peatland areas with distinct types of modification and/or degradation, following the peatland conventions adopted in the BEIS LULUCF GHG inventory (Section 10.8.8). The sub-targets are based on the estimated current surface areas of the relevant types of degraded peatland (Table 13).

Unless bespoke information on peatland degradation levels has been provided by an individual National Park or AONB, we assume that the UK-average estimate of 25% of peatland being in a near-natural or restored condition applies to all peatland areas in each landscape. The remaining peatland areas in each landscape (75%) are assumed to be in various states of degradation. For blanket bog habitats, the most common modification is peat dominated by heather/grass and drained, alongside comparatively small areas of eroding bare peat. For heathland habitats, the peat is commonly dominated by heather/grass and may be either drained or undrained. In some National Parks and AONBs, there are also organic soils under agricultural and forested areas, which have their unique types of peatland degradation and associated carbon fluxes.

[107] UK's Sixth Carbon Budget, AFOLU report, page 27.

[108] Bossio, D. A., et al. (2020). "The role of soil carbon in natural climate solutions.." Nature Sustainability, 3(5), 391-398.

As with the peatland classification, our peatland emissions factors follow the BEIS methodology (Section 10.8.8). Restoring a certain amount of peatland means reducing emissions relative to the present-day baseline in line with the adopted peat classifications and emission factors. Because of the considerable uncertainties associated with reversing degradation of peatland so that it becomes a net carbon sink, our analysis focuses on reducing emissions from degraded peat through restoration and excludes subsequent sequestration benefits associated with a healthy restored peatland.

Agroforestry uptake

According to the Sixth Carbon Budget, 10% of UK farmland area may need to be converted to agroforestry systems by 2050 in line with the recommended Net Zero pathway. We apply this target to improved grassland and cropland systems only. Agroforestry is assumed to be current practice on 1% of UK farmland; we do not have definitive figures at this stage. Agroforestry is different from present-day farm woodland, which is estimated to cover 5% of the total farmland area in the UK.

Based on the assumptions above, the recommended increase in land managed along agroforestry principles across the UK is just over 30,000 ha/year between now and 2050, which applies to improved grassland and cropland areas. This target is apportioned to each National Park or AONB according to the size of existing areas of improved grassland and cropland within the landscape.

When recommending conversion of land to agroforestry for each National Park of AONB, we take an average of the UK agricultural land area at present and that projected for 2050, in line with the Net Zero pathway from the Sixth Carbon Budget. Under this pathway, the UK's total agricultural land area will be reduced by 3.8 million ha in favour of new woodland, restored peatland and other land uses. The reduction will be compensated by agricultural productivity increases, dietary shifts, and possibly also by moves to alternative production systems such as vertical farming.

Our agroforestry-related carbon sequestration estimates are based on the figures from Bossio *et al.* (2020) for the two most common agroforestry types – alleys and windbreaks – and account for the low tree-planting densities associated with these farming systems. The estimates include both biomass gains and soil carbon sequestration.

Hedgerows expansion

The Sixth Carbon Budget assumes a 40% increase in the area covered by hedgerows across the UK by 2050, amounting to 1,725 ha/year of new hedgerows planted across the UK between now and 2050 (based on estimated present-day coverage). This target is apportioned to each National Park or AONB according to its share of improved grassland and cropland, and is adjusted according to the projected decrease in the total area of the UK's agricultural land by 2050 (the same as for agroforestry). New hedgerows could be created by dividing larger fields, and on field margins, as part of a transition to smaller-scale and less intensive farming systems.

Our estimates of hedgerow carbon sequestration are based on trees with yield class (YC) 4. As is the case for new woodland creation, we use a 30-year average carbon sequestration flux for trees from this yield class (inferred from the Woodland Carbon Code, WCC) to match the timescales of the Net Zero target of 2050. We do not add soil carbon sequestration to hedgerow carbon flux estimates.

Grazing legumes for improved grassland

According to the Sixth Carbon Budget, 75% of UK grazed grassland area may need to be converted to less intensive systems by 2050, with legume species replacing synthetic fertilisers as natural nitrogen fixers. We apply the grazing legumes target to improved grassland only. Grassland with legume species is assumed to account for 5% of the current improved grassland area; we do not have definitive figures at this stage.

Based on the assumptions above, the recommended increase in land dedicated to UK-wide grazing legumes is just over 120,000 ha/year between now and 2050, which applies to improved grassland areas only. This target is apportioned to each National Park or AONB according to the size of existing areas of improved grassland in the landscape, and is adjusted according to the projected decrease in the total area of UK agricultural land by 2050 (the same as for agroforestry and hedgerows).

The carbon sequestration benefit of introducing grazing legume grassland species follows the figures from Bossio *et al.* (2020).

Cover cropping for cropland

According to the Sixth Carbon Budget, it may be necessary to adopt winter cover cropping on 75% of the UK's cropland area by 2050, with cover crops preventing soil erosion, improving landscapes' flood resilience and enhancing carbon sequestration. Winter cover crops are assumed to account for 5% of the current cropland area; we do not have definitive figures at this stage.

Based on the assumptions above, the recommended increase in land dedicated to cover crops across the UK is just under 114,000 ha/year between now and 2050, which applies to cropland areas only. This target is apportioned to each National Park or AONB according to the size of existing areas of cropland in the landscape, and adjusted in line with the projected decrease in the UK's total agricultural land area by 2050 (the same as for agroforestry, hedgerows and grazing legumes).

The carbon sequestration benefit of introducing cover crops follows the figures from Bossio *et al.* (2020).

Summary: Land use targets and carbon sequestration fluxes for the Dartmoor National Park

Table 16 summarises the proposed land use change and management targets for the Dartmoor National Park, which follow the principles outlined above.

Table 16. Land use targets and the associated additional carbon sequestration fluxes per year (emissions reduction for peat) for Dartmoor National Park.

Land Use / Management Category	**Land Use Change Target (ha/yr)**	**Change in Carbon Flux ($tCO_2e/yr/yr$)**
New Native Broadleaf/Mixed Woodland	**280**	**-5,168**
New Productive Coniferous Woodland	**70**	**-1,548**

Agroforestry (improved grassland & cropland)	**59**	**-138**
Hedgerows (improved grassland & cropland)	**3**	**-36**
Grazing Legumes (improved grassland)	**426**	**-875**
Cover Cropping (cropland)	**30**	**-35**
Restored Eroding Modified Bog (bare peat), Drained	**18**	**-241**
Restored Eroding Modified Bog (bare peat), Undrained	**18**	**-224**
Restored Modified Bog (heather/grass dominated), Drained	**2**	**-5**
Restored Modified Bog (heather/grass dominated), Undrained	**642**	**-1,483**
Restored Cropland Peat, Drained	**1**	**-42**
Restored Intensive Grassland Peat, Drained	**22**	**-612**
Restored Extensive Grassland Peat, Drained	**0**	**0**
Restored Forested Peat, Drained	**34**	**-111**
Total	**1,605**	**-10,519**

10.8.10. Appendix: Land use data limitations[109]

The land use figures in Table 13 are based on the 2020 SWEEP habitat classification data, retrofitted to the CEH habitat classification (Table 17). Peatland/peaty soil presence is identified by the University of Exeter study. Estimated present-day land use emissions associated with peatland and mineral soil habitats on the Dartmoor are summarised in Table 18.

The resulting data product has several limitations:

- **Habitat classifications:** The transition of habitat classifications from SWEEP to CEH is very rough, the classifications are fundamentally different, and the CEH categories do not summarise the SWEEP categories well in carbon terms. Purple moor grass is one of the examples where mapping between the SWEEP and CEH categories is challenging. However, we believe the proposed approach is good enough for our high-level opportunity mapping for land use. It is not possible to go into more landscape-specific details as part of the current programme, and the framework applied to all landscapes is sufficient given the inherent uncertainties in the data. We advocate for a field-level land use opportunity mapping to follow from our high-level assessment, and such a mapping could be carried out in the future using the more nuanced and landscape-specific SWEEP classification
- **Peatland extent:** The University of Exeter study of peatland extent is based on a constrained study area focussing on the north and south moor areas of Dartmoor. It does not consider peatland areas lying outside of these regions, which are significant. Because of this, there is an inherent under-reporting of habitats lying on peatland or peaty soils. This issue is common for nearly all landscapes across the country, who had to rely on the incomplete Natural England peatland map and the equivalent datasets in Scotland and Wales. Even the Yorkshire Dales National Park, which has got a very detailed peatland data from the Yorkshire Peat Partnership, has had to make assumptions and extrapolations regarding the extend and condition of peat within each habitat. The desire to improve the data should

[109] This section was written by Alex Gandy, Dartmoor National Park Authority, and edited by Dmitry Yumashev.

hopefully facilitate further work in Dartmoor in partnership with the University of Exeter and other organisations. Natural England have themselves acknowledged the shortcomings of their peatland data and are looking to produce a new version of the dataset in 2024. In theory, this update should include bottom-up data from individual National Parks and AONBs

- **Modified bog drained/undrained:** There currently is no data on the drainage status of the modified bog dominated by grass or heather in Dartmoor, so the entire areas were assumed to be undrained. There is a difference in the flux depending on the drainage status, according to the BEIS emissions factors based on the Evans et al (2017) UK peatland inventory report. For example, modified bog dominated by grass/heather emits ~3.6 $tCO_2e/ha/yr$ if drained and ~2.3 $tCO_2e/ha/yr$ if undrained, according to these assessments. Most landscapes introduced an approximate split between the drained and undrained classes based on the amount of work their peat partnership teams have done on restoring peat over the years. In the absence of a more detailed data, the assumptions made are well within the overall uncertainty

The University of Exeter data also includes a layer for drains. With addition work to establish buffers based on available research on the areas of peat affected by a drain, it ought to be possible to utilise this data layer to estimate the area of drained peatland for Dartmoor. Furthermore, it should be possible to use the University of Exeter layers showing bare peat and erosion features to estimate the area of actively eroding peat in the National Park.

Table 17. Mapping between 2020 SWEEP habitat and peat data, and the CEH Land Cover Map habitat classes.

UoE SWEEP Habitat Data (SENTINEL II)	DNP Total Ha	CEH Landcover Categories	DNP Total Ha	No peat Ha	<40cm peat Ha	>40cm peat Ha
Other broadleaved, mixed and yew woodland	12,078	Broadleaved woodland	13,340	12,866	361	113
Upland oakwood	1,262					
Coniferous woodland	2,969	Coniferous woodland	2,968	2,043	598	326
Cropland	1,557	Arable and horticulture	1,557	1,510	33	13
Modified grassland	22,651	Improved grassland	22,651	21,725	564	362
		Neutral grassland	0	0	0	0
		Calcareous grassland	0	0	0	0
Upland hay meadows	841	Acid grassland	37,414	18,480	8,637	10,297
Lowland meadows	2,082					
Upland acid grassland	17,041					
Lowland acid grassland	2,595					
Bracken	6,508					
Gorse scrub	1,164					

Acid grass over degraded blanket bog	7,183					
Flushes, fens, marsh and swamp	1,525	Fen, marsh and swamp	1,525	527	422	576
Upland Heathland	4,957	Heather	10,334	3,419	2,726	4,189
Lowland Heathland	1,114					
Heathland over degraded blanket bog	4,262					
Purple moor grass and rush pastures	1,528	Heather grassland	1,528	905	305	319
Blanket bog (H7130)	679	Bog	1,572	239	202	1,131
Unvegetated degraded blanket bog	893					
Inland rock	749	Inland rock	749	536	106	107
Rivers and lakes	411	Freshwater	411	328	34	49
		Saltwater	0	0	0	0
		Supra-littoral rock	0	0	0	0
		Supra-littoral sediment	0	0	0	0
		Littoral rock	0	0	0	0
		Littoral sediment	0	0	0	0
		Saltmarsh	0	0	0	0
		Urban	0	0	0	0
Urban	1,475	Suburban	1,475	1,412	49	14
Total	**95,522**	**Total**	**95,522**	**63,991**	**14,036**	**17,496**

Table 18. Estimated present-day land use emissions associated with peatland and mineral soil habitats on the Dartmoor

Degraded Peatland	**Area (ha)**	**Carbon Flux ($tCO_2e/ha/yr$)**	**Total Carbon Flux (tCO_2e/yr)**
Eroding modified bog (bare peat), drained	757	13.3	10,053
Eroding modified bog (bare peat), undrained	769	12.2	9,353
Modified bog (heather/grass dominated), drained	63	3.6	225
Modified bog (heather/grass dominated), undrained	26,743	2.3	61,776
Cropland on peat soil, drained	47	37.6	1,759
Intensive grassland on peat soil, drained	926	27.6	25,509
Extensive grassland (on bog/fen), drained	0	13.0	0
Forest on peat soil, drained	1,398	3.3	4,635
Degraded Peatland Total	**30,703**	**3.7**	**113,309**

Near-Natural Peatland	Area (ha)	Carbon Flux (tCO2e/ha/yr)	Total Carbon Flux (tCO2e/yr)
Near-natutal bog on peat soils	305	0.0	-6
Near-natural fen on peat soils	228	-0.9	-212
Near-Natural Peatland Total	**534**	**-0.4**	**-219**
Habitats on Mineral Soils	**Area (ha)**	**Carbon Flux (tCO2e/ha/yr)**	**Total Carbon Flux (tCO2e/yr)**
Broadleaved woodland on mineral soil	12,866	-10.8	-138,309
Coniferous woodland on mineral soil	2,043	-14.5	-29,681
Arable and horticulture on mineral soil	1,510	0.3	438
Improved grassland on mineral soil	21,725	-0.4	-7,821
Neutral grassland on mineral soil	0	0.0	0
Calcareous grassland on mineral soil	0	0.0	0
Acid grassland on mineral soil	18,480	0.0	0
Fen, marsh, swamp on mineral soil	527	0.0	0
Heather on mineral soil	3,419	0.1	191
Heather grassland on mineral soil	905	0.1	51
Bog on mineral soil	239	0.0	0
Saltmarsh on mineral soil	0	-5.2	0
Urban on mineral soil	0	0.0	0
Suburban on mineral soil	1,412	0.0	0
Habitats on Mineral Soils Total	**63,126**	**-2.8**	**-175,131**
	Area (ha)	**Carbon Flux (tCO2e/ha/yr)**	**Total Carbon Flux (tCO2e/yr)**
Habitats on Mineral and Peat Soils: Grand Total	**94,363**	**-0.7**	**-62,041**