SMALL WORLD CONSULTING

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

A report by Small World Consulting Ltd

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Contents

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Executive summary

Background

As the world wakes up to the climate and wider environmental emergency, rapid reduction in 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 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 and planning authority while simultaneously creating better places for people to live, work and visit.

This report

This report, for the Brecon Beacons National Park, is one of a series of methodologically compatible reports produced for each UK National Park, each Welsh AONB, and the Cotswolds and Cannock Chase AONBs in England. 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 Park (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, 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. 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.

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.

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). 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 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.

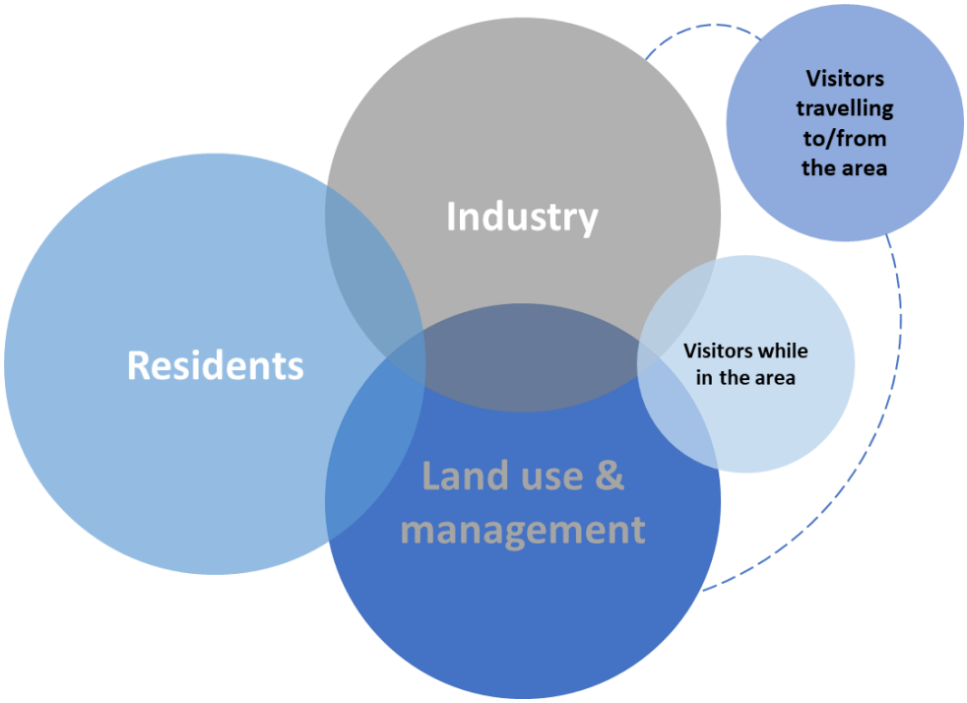


Figure 1: Boundaries of the greenhouse gas footprint assessment

This report also includes a scenario for Paris-aligned greenhouse gas emission targets across six key areas. These 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 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 target areas is slightly different from that of the overall emissions assessment. The six target 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
- Land use non-CO_2 component (including emissions from livestock and fertilisers)
- Land use CO_2 component (including both emissions and sequestration)

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. However, given current constraints on data availability, these estimates are sufficiently robust to provide an evidence basis for carbon management and target setting. The estimate of industry-related emissions is particularly crude, being based on comparatively simple revenue data and generic UK-wide emission factors. As more granular spatially explicit data becomes available for various components of the assessment, it would be possible to update and improve the methodology accordingly to reduce the uncertainties in subsequent assessments. This has been done for over 10 years through the pilot work with the Lake District National Park, which provided a platform for the current programme.

Results

Brecon Beacons National Park **(**Figure 2 **–** Figure 5**)**	
Annual emissions from residents	**561,000 tCO_2e** (14.9 tCO_2e per person per year)
Annual emissions from visitors while in the National Park	**100,772 tCO_2e** (17.8 kg CO_2e per visitor-day)
Annual emissions from visitors travelling to/from the National Park	**163,590 tCO_2e** (38.0 kg CO_2e per visit)
Annual industry emissions	**369,934 tCO_2e**

Key highlights

According to the UK-wide postcode-level demographic data from the 2011 population census (the most recent census available), the Brecon Beacons' resident population is one of the least affluent among the UK's National Parks. Nevertheless, its average residents' consumer spending is estimated to be 8.7% above the UK average (excl. public services). The data points to an ageing population, with health expenditure being particularly high. Despite this, the total environmental footprint of Brecon Beacons residents is more than double the footprint of the annual visitors to the Park (factoring in travel to and from the area).

In a given year, the residents' footprint per capita is estimated to be around 21% higher than the UK average. Several fossil fuel-based sources of greenhouse gas emissions are particularly high for residents: compared to the UK average, emissions from flying are estimated to be 72% higher, transport emissions (excl. driving) and driving emissions are around 21% and 28% higher,

respectively, household electricity footprint is around 20% higher, and the estimated household fuel emissions (excl. vehicle fuel) are estimated to be 51% above the UK average. We note that the latter estimate has a comparatively high uncertainty since more properties are off the gas grid in the National Park compared to the overlapping unitary local authorities, and because there is insufficient data for residual fuel use (oil, coal, biomass) and renewable energy solutions (solar panels, heat pumps). As of 2019, the share of the renewable technologies across households was comparatively low and no suitable data with sufficient geographical detail was available.

The footprint of visitors relating to their travel to and from the Brecon Beacons is over 60% higher than the footprint associated with their activities in the National Park. The visitors' footprint while they are in the National Park is dominated by food and drink, followed by driving and accommodation. Compared to most other National Parks, a smaller proportion of visitors (10%) stay overnight. The visitors' footprint while travelling to and from the Brecon Beacons is dominated by vehicle fuel use, followed by flying, with only 2% being from trains, buses and other transport.

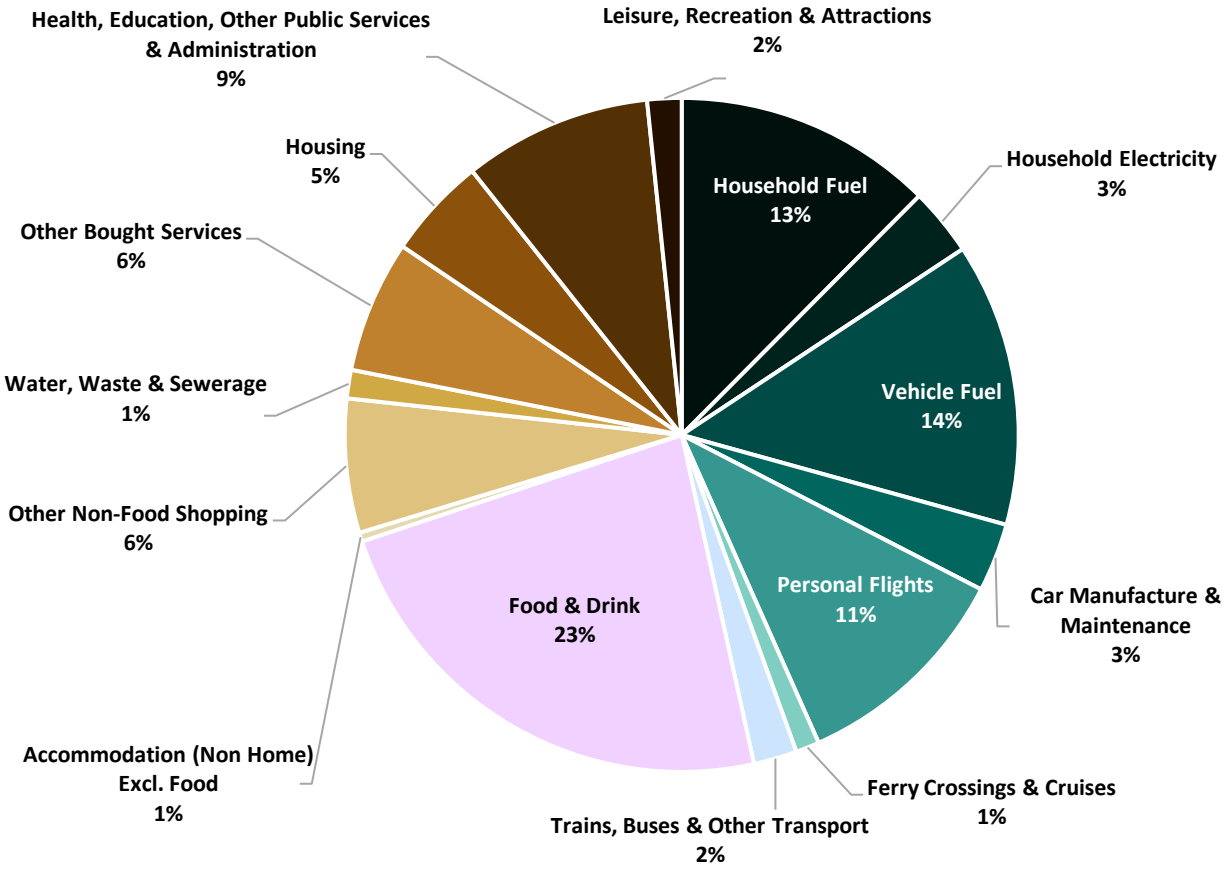
The footprint associated with industry in the Brecon Beacons National Park is dominated by production (28%), agriculture and forestry (21%), health (20%), and construction (11%). Per resident, the footprints linked to agriculture and forestry, health, construction, and business administration and support services are higher than the UK averages.

Given its location and connectivity to sizeable population centres in Wales and England, the Brecon Beacons National Park is estimated to have a considerable traffic footprint from the major A-roads (based on traffic counts on A40, A470, A465 and A479), which amounts to around 22% compared to the total footprint of the residents. Emissions from through traffic (passing through the Brecon Beacons on the way somewhere else, and therefore excluding traffic from residents, visitors and industry) are estimated to account for around 78% of the total vehicle footprint from the major A roads.

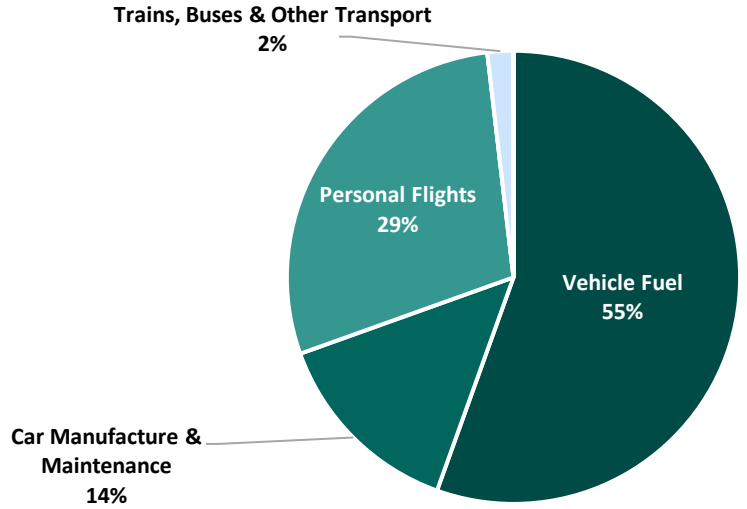
Targets scenario

A minimum Paris-aligned target trajectory has been constructed for each of the six main elements of the emissions, as illustrated in Figure 6. When combined, they result in a net zero date of 2035 for the Brecon Beacons National Park. The rationale behind selecting the six emissions categories and excluding other sources of emissions is provided in Section 6, together with an alternative pathway associated with the full consumption-based footprint. We note that the net zero date reflects the unique characteristics of the landscape, including the land use 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 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.

Residents: 561,000 tCO_2e



Visitor travel to & from the National Park: 163,590 tCO_2e



Visitors while in the National Park: 100,722 tCO_2e

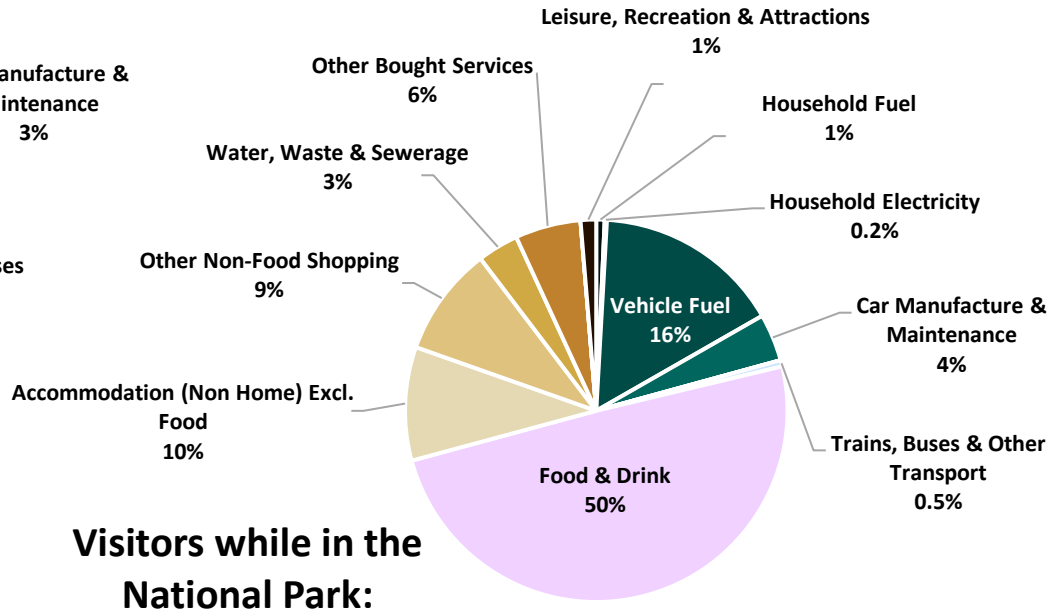


Figure 2: (left) Residents' GHG emissions in Brecon Beacons National Park, by percentage

Figure 3: (top right) Visitors' GHG emissions from travel to and from Brecon Beacons National Park, by percentage

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

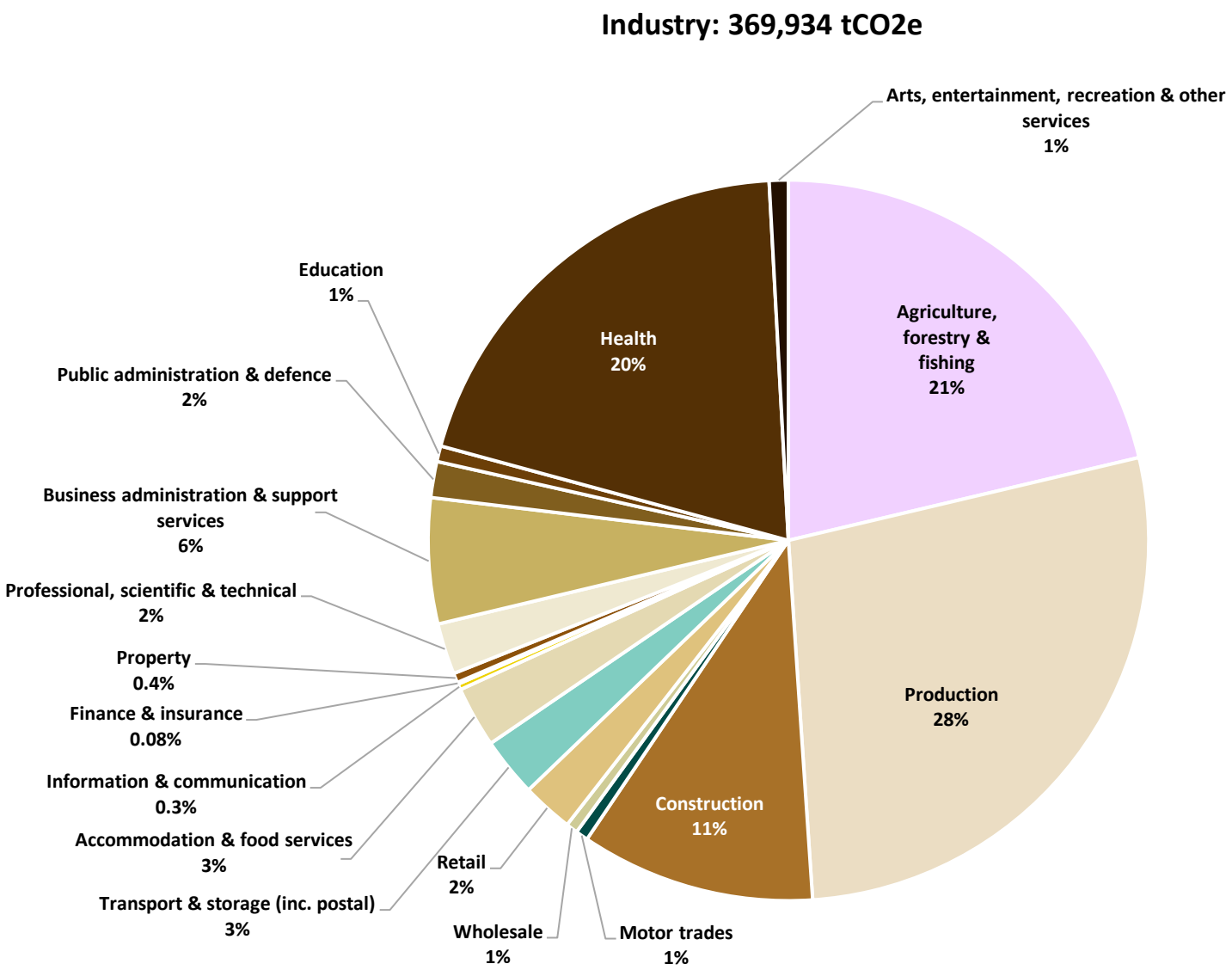


Figure 5: A estimate of emissions from industries within the Park and their supply chains (scopes 1, 2 and upstream scope 3)

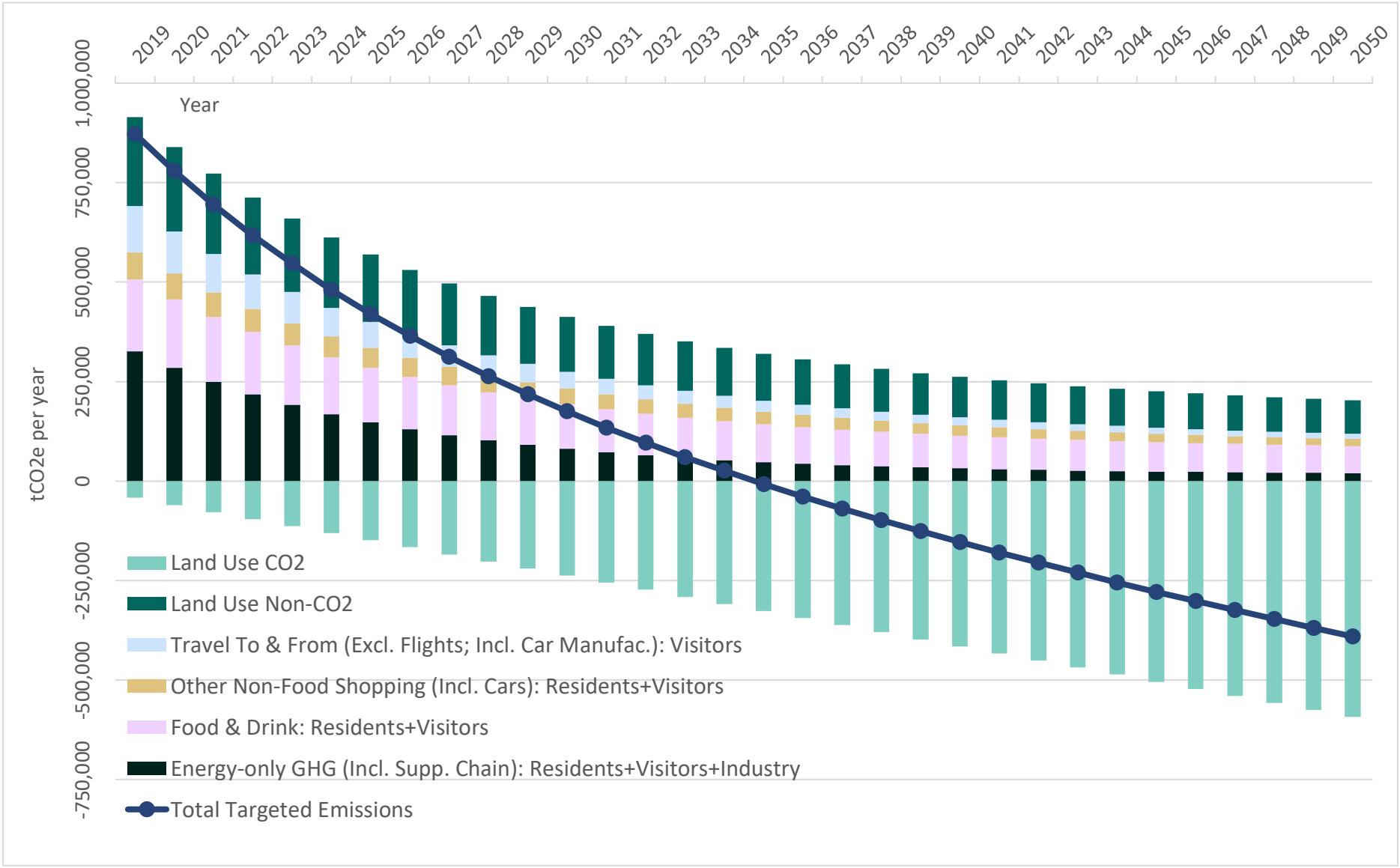


Figure 6: Recommended target pathways leading to net zero emissions for the Brecon Beacons National Park by 2035

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 greenhouse gas emissions attributable to residents and visitors, including travel to and from the landscape.

This report, for Brecon Beacons National Park, is one of a series of methodologically compatible reports carried out 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; post-COVID changes to business activities and lifestyles, including travel patterns, and their effect on the footprint estimates, will have to be explored in a follow up assessment once the relevant 2022 data becomes available. The report also includes recommendations for Paris-aligned targets on GHG emissions reduction across six key areas, as well as for carbon sequestration through land-based climate mitigation measures. Together with the estimated 2019 GHG baseline, these targets result in a net zero date of 2032, subject to the targets being fulfilled and to the considerable uncertainties remaining in the data.

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.

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 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 may wish to respond to in delivering its statutory duties. With the Brecon Beacons being a Welsh National Park, these drivers do not only include UK laws but those of the devolved Welsh Parliament. We consider both levels of policy ambition where the UK -wide and Welsh legal frameworks have differences; see Appendix 10.1.

Climate change driven by anthropogenic GHG emissions, plus the wider ecological crisis, are some 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[1]. 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 most ambitious target of the Paris Agreement signed in 2015 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.

The Welsh Government has its own specific emissions reduction legislation set out in The Environment (Wales) Act 2016, updated in 2021 with a legal commitment to reaching Net Zero by 2050, in line with the UK target. This target covers the Welsh National Parks, and the Welsh Government recognises the National Parks as a public sector opportunity for leadership on decarbonisation and carbon sequestration, playing an important role in enabling the country to reach its net zero goals.

The IPCC published its Sixth Assessment Report (AR6) in stages, with the final volume released in March 2022. Compiled by the world's leading 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. As part of the publication, in February 2022 the IPCC issued a global call to action to "at least halve emissions by 2030"[2].

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[3]. 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

[1] IPCC (2018) Special Report: "Global Warming of 1.5°C Summary for Policymakers." https://www.ipcc.ch/sr15/chapter/spm/.
[2] IPCC (April 4 2022) "The evidence is clear: the time for action is now. We can halve emissions by 2030."
[3] IPCC (2021) Climate Change 2021: The Physical Science Basis https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

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, including Scotland and Wales. 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 2032 relative to 1990, which is a 63% reduction from 2019 levels[4]. Further detail relating to this is provided in Section 2.4 of this report, outlining associated real-world change towards decarbonisation. The Welsh Government's own legally binding path to Net Zero sets goals of a 63% reduction by 2030, an 89% reduction by 2040 (relative to 1990 or 1995 depending on the greenhouse gas) and Net Zero by 2050[5]. These targets are production-based, which means they refer to the territorial emissions within Wales rather than consumption-based emissions associated with the lifestyles and supply chains assessed in this report (see Section 4 for an overview of methodological assumptions). The Brecon Beacons and most other National Parks and AONBs on the current programme tend to have less emissions per unit area and more opportunities to sequester carbon through nature-based climate solutions. As a result, their recommended consumption-based net zero targets are often several years earlier than the production-based targets for the UK and devolved administrations, even though consumption-based assessments generally result in a higher per-capita footprint.

The devolved nations (Wales, Northern Ireland and Scotland) were the source of 22% of UK total emissions in 2019 and share responsibility for the actions required for their own decarbonisation with the UK Government. This is due to the mix of devolved and reserved (UK Central Government) powers that cover the key areas relevant for decarbonisation (Table 1). An advice report for Wales assessed whether required emissions abatement was covered by devolved or reserved powers and found that nearly 40% of the abatement required in Wales by 2050 is under the devolved power of the Welsh Parliament. The remaining 60%, including electricity supply, will be under the power of the central UK Government policy[6].

Table 1: Policy areas relevant to decarbonisation and the extent of their devolution to the Welsh Government. Reproduced from CCC (2020) Advice Report: The path to a Net Zero Wales

Balance of devolved and reserved powers in Wales for different sectors		
"Mostly" devolved	**"Partially" devolved**	**"Mostly" reserved**

[4] 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.
[5] Welsh Government (2021) Climate change targets and carbon budgets https://gov.wales/climate-change-targets-and-carbon-budgets
[6] CCC (2020) Advice Report: The path to a Net Zero Wales

• Agriculture • Land use, land-use change and forestry • Waste management • Fluorinated-gases (F-gases) e.g. HFS's used in fridges	• Buildings • Surface transport	• Electricity supply • Fuel supply • Manufacturing & construction • Aviation • Shipping • Bioenergy with Carbon Capture and Storage for power generation (BECCS)

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 between 2.4°C and 2.7°C (relative to pre-industrial levels) by the end of the century, whereas the existing Net Zero pledges, if fully implemented, are expected to limit global warming to 1.8°C.[9,10]

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 or Local Authorities for AONBs will need to be familiar with as they fulfil their statutory planning authority obligations, 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,
- The principle that environmental damage should, as a priority, be rectified at source,
- The "polluter pays" principle.

2.2. Health impacts

In addition to the impact of climate change on the environment, greenhouse gas emissions 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. Poor air quality can have a disproportionate impact on the health and wellbeing 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

[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/.
[10] Some estimates suggest the NDCs could lead to an even higher warming of 2.7°C by 2100 compared to the 2.4°C calculated by the Climate Action Tracker; see, for example, https://unfccc.int/news/full-ndc-synthesis-report-some-progress-but-still-a-big-concern. Making more precise projections on such long timescales is challenging given the uncertainties in the climate system.

toxic air. In the UK, 5.4 million people are currently receiving treatment for asthma: 1.1 million children (1 in 11) and 4.3 million adults (1 in 12). Every day, three families are devastated by the death of a loved one due to an asthma attack, and tragically, two thirds of these deaths are preventable (Asthma UK, 2020).

Some cities in Wales suffer from especially bad particulate matter (PM2.5) and nitrous oxide ($NO_{2)}$ pollution levels above EU legal limits, with the South Wales built up area ranking second worst in the UK behind Greater London. World Health Organisation (WHO) recommended levels for particulate matter (PM2.5) were also exceeded in Chepstow, Cardiff, Swansea and Port Talbot in 2020[11].

2.3. Climate adaptation and mitigation

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"[12]. 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 summer as hot as 2018, which is projected to become 50% more likely with future warming.

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.

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:

[11] https://www.iqair.com/uk/wales

[12] 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

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

- By the early 2030s, all new cars and vans, and all domestic and non-domestic replacement boilers are low-carbon – largely electric.
- By 2040 all new trucks 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 2032 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 2032, 460,000 hectares of new mixed woodland are planted to remove CO_2 from the atmosphere and deliver wider environmental benefits.
- By 2032, 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 2032 and 18% by 2050.
- Peatlands are widely restored and managed sustainably.

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"[16].

The key challenge for Local Authorities and National Park Authorities will be translating the targets and initiatives to their geographical areas.

2.5. Policy implications for local planning authorities

[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] Climate Change Committee (2020), "The Sixth Carbon Budget: The UK's Path to Net Zero," p.30.

Two Acts of Parliament are particularly relevant to Welsh National Park Authorities, namely the Planning (Wales) Act 2015[17], which provides the legislative framework for the operation of the planning system, and the Well-being of Future Generations (Wales) Act 2015[18], which sets a legally binding common purpose for development and use of land. Developments are now required to contribute to seven well-being goals to improve the economic, health, social, environmental and cultural well-being of Wales. The white paper "Future Wales – the National Plan 2040" was subsequently published in 2021 as the national framework, setting the direction for development in Wales. The key development priorities include "sustaining and developing a vibrant economy, achieving decarbonisation and climate resilience, developing strong ecosystems, and improving the health and well-being of our communities"[19]. This framework seeks to ensure the production of a Strategic Development Plan at a regional planning level together with Local Well-being Plans and Local Development Plans, which the Welsh National Park Authorities already factor into their partnership planning.

These legal and policy frameworks also require a Habitats Regulations Assessment whenever a plan or project has the potential to impact on a site within the National Site Network (formerly known as Natura 2000 sites, prior to the amendments made to the Habitats Regulations by the Conservation of Habitats and Species (Amendment) (EU Exit) Regulations 2019). There is scope for planning to increase green space, through new green infrastructure, tree planting and habitat creation. Policies on Ecosystem Services and Biodiversity Net Gain have the potential to deliver biodiversity and climate change adaptation benefits through development. The State of Natural Resources Report in Wales (SoNaRR) provides an ideal partnership opportunity for coordinated planning[20].

Planning is one of the tools the Authority can use to address GHG emissions, specifically through decarbonising the built sector. Sustainability, climate change, design and placemaking are significant Government policy areas, as statutory requirements[21]. Policies within the Local Development Plan and guidance in a Sustainable Construction Supplementary Planning Document (SPD) are pushing the construction sector to consider embodied GHG emissions in materials used, as well as dramatically improving energy efficiency and low / zero carbon energy supply for new build. Planning policies also encourage the uptake of low /zero carbon transport in new development. Although the scale of GHG emissions from new build is relatively small compared to those of existing buildings, savings made in new build stock will minimise the need for future expensive retrofitting and demonstrate to and stimulate the market for more sustainable building techniques and products.

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. There may be significant potential for hydro-electric power generation in the Park, given the mountainous terrain and the numerous rivers, lakes and reservoirs. Community renewable schemes have already been demonstrated e.g. Talybont on Usk Energy Ltd's 36kW hydro scheme and several solar PV arrays, together estimated

[17] https://www.legislation.gov.uk/anaw/2015/4/contents/enacted.

[18] https://www.futuregenerations.wales/about-us/future-generations-act/.

[19] Gov.Wales (2021) Future Wales – the National Plan 2040 p.6.

[20] Cymru Wales (2020) State of Natural Resources Report (SoNaRR) https://naturalresources.wales/sonarr2020?lang=en

[21] Loch Lomond & the Trossachs National Park (2017) Local Development Plan 2017-2021 p.21

to produce 17% of the community's electricity[22]. The National Park Authority has already supported two further community-scale small hydro systems through its Sustainable Development Fund[23]. It may also be possible to generate local renewable energy from the wind. Potential hydro-electric or wind power developments within protected landscapes remain subject to careful consideration, and consultation with statutory agencies and the public.

Outside the National Park Authority's control (although there may be potential to influence future direction), the UK and Welsh governments are likely to face a crowd-funded legal challenge calling for a judicial review over the decision in 2016 to grant a licence extension for the Aberpergwm drift coalmine. This licence allowed for the extraction, over the next twenty years, of up to 40 million tonnes of coal for use in the steel production industry, which according to the Global Energy Monitoring research group would emit an estimated 100m tonnes of carbon dioxide[24]. While the coalmine is located just outside the boundaries of the Brecon Beacons, the emissions associated with its operations and transportation could affect the Brecon Beacons NP's footprint in future years if the mine's supply chains and distribution lines overlap with the National Park.

[22] https://talybontenergy.co.uk/.
[23] "A Management Plan for the Brecon Beacons National Park (2015-2020)," p.52.
[24] https://www.theguardian.com/environment/2022/feb/09/grant-coal-mining-licence-aberpergwm-south-wales-court-challenge.

3. Brecon Beacons National Park: demographic profile and key statistics

The National Park is already working in partnership with a range of stakeholders and citizens, with a strong strategic steer and support from the Welsh government to facilitate evidence-based decision making. It is pleasing to see, in the latest draft of the NP's management plan, a clear approach to defining what success looks like, using the "Doughnut" model devised by Professor Kate Raworth. This shows the extent to which the National Park is meeting its strategic ambitions for cross-cutting themes, i.e. the factors that contribute to social prosperity, in combination with improving ecological and planetary health[25]. This is a potential exemplar for other National Parks.

In section 3.1 – 3.2 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 the projects by the programme partners.

3.1. People and key characteristics

The Brecon Beacons' resident population of 33,999 makes it the sixth largest of all the UK's National Parks[26]. Above it in terms of population are the South Downs (118,351), followed by the Lake District (40,028), the Peak District (36,878), the New Forest (35,459), and then Dartmoor (34,787). For the purposes of this GHG assessment, population estimates from mid-2019 were used, including residents in all postcodes that have at least 30% of their area within the National Park boundary, which gives a total of around 37,681 people residing in the Park.

Three of Wales' largest cities – Cardiff, Newport and Swansea – are within 20 miles of the National Park. Therefore, around half of Wales' population live within easy travelling distance, together with the English cities of Bristol and Gloucester, both less than an hour's drive away. The National Park attracts over 3.9 million annual day visitors. The bulk of the Park's population live in the town of Brecon (approx. 10,000) with the remainder living in the smaller towns of Hay-on-Wye, Crickhowell and Talgarth, plus villages and rural areas.

When considering partnership-working on decarbonisation agendas, there are nine unitary authorities that geographically overlap with the National Park[27]. Powys County Council, Carmarthenshire County Council and Monmouthshire County Council have a substantial overlap with the National Park, while Rhondda Cynon Taff Council, Merthyr Tydfil County Borough Council,

[25] Brecon Beacons National Park (2022), "Future Beacons: The Management Plan for the Brecon Beacons National Park 2022-2027", Consultation Draft p.28.
[26] ONS (2021) National Park population estimates (Experimental Statistics), Mid-2020:SAP23DT9 edition https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/nationalparkmidyearpopulationestimatesexperimental.
[27] https://www.beacons-npa.gov.uk/wp-content/uploads/basic-facts-about-the-brecon-beacons-national-park.pdf .

Blaenau Gwent County Borough Council, Torfaen County Borough Council, Neath Port Talbot Council, and Caerphilly County Borough Council have smaller geographical overlaps.[28].

While the average affluence of Brecon Beacons NP residents is higher than the UK average, there are pockets of deprivation. Several areas of the Park in Brecon town, and north of Merthyr Tydfil, fall into the "most deprived 20-30%" category of the Welsh Index of Multiple Deprivation, and areas bordering the Park in Ystradgynlais and Merthyr Tydfil are in the "most deprived 10%" category[29]. The majority of rural areas are in the least deprived 50% category. However, one issue of notable concern post-COVID is an increase in food poverty, with Brecon food bank reporting a 405% increase in terms of food weight distributed, compared with 2019[30]. The need for affordable housing is also a key issue in this National Park and others, with house prices exceeding average available incomes.

Statistics describing the projected population changes in Wales (2018-2028) predict growth of 3.5% in the Park's resident population by 2028, bucking the general trend within UK National Parks[31]. These projections also show an increase (+3%) in the number of children aged 0-15 years, unique among the Welsh National Parks. The working population is expected to decrease slightly (-2%), while the number of people of retirement age increases significantly: 65-74s up by 16% and a 35% increase in the number of people aged 75 or over, meaning that the overall population is ageing. Across the Welsh National Parks the average age is 50, which is 11 years older than the Welsh national average. The Brecon Beacons NP will face the same challenges as the rest of Wales in supporting a growing retiree population, juxtaposed with a shrinking working population. Interestingly, this National Park showed the greatest increase of all Welsh or English Parks in the number of residents aged 15-29, between the 2001 and 2011 census years[32]. Perhaps these younger people are now starting families of their own, as suggested by the increase in the population of children aged 0-15. Having young families in the National Park often – naturally and positively – supports vibrant living communities for the future.

The age profile suggests that the NHS and Local Authorities may need to plan for higher consumption of health and social care services in future years, and suitable housing to accommodate older people; this may also be an emerging issue for the National Park as a Planning Authority. Likewise, strategies for workforce planning and housing may benefit from further efforts to render the idea of living in the National Park more attractive to working-age people, encouraging migration into the area. This is already on the National Park's radar, since its Local Development Plan seeks to develop the Park whilst ensuring its special characteristics are retained. Under the Plan, sustainability considerations underpin all development projects e.g. encouraging development on brownfield sites and on locations close to facilities and services, to minimise travel requirements; encouraging sustainable building design and community-scale renewable energy[33]. It is recognised

[28] Brecon Beacons National Park Landscape Character Assessment (2012), Chapter 3: Background https://www.beacons-npa.gov.uk/planning/draft-strategy-and-policy/landscape-character-assessment/.
[29] Welsh Index of Multiple Deprivation Results Report (2019) https://gov.wales/sites/default/files/statistics-and-research/2019-11/welsh-index-multiple-deprivation-2019-results-report-024.pdf.
[30] Brecon Beacons National Park (2022), "Future Beacons: The Management Plan for the Brecon Beacons National Park 2022-2027", Consultation Draft p.36.
[31] National Park population projections for Wales: 2018-based https://gov.wales/sites/default/files/statistics-and-research/2021-05/subnational-population-projections-national-parks-2018-based-983.pdf.
[32] "A Management Plan for the Brecon Beacons National Park (2015-2020)," p.10.
[33] Brecon Beacons National Park Authority, "Local Development Plan 2007-2022."

that increased availability of affordable, good-quality housing and secure, well-paid jobs is needed in order to retain the working population in the National Park.

These are all important factors when considering the potential opportunities to change behaviour in spending habits. Further detail pertaining to the Park's key consumption characteristics can be found in Appendix 10.2.

3.2. Landscape

In terms of its landscape, the Brecon Beacons National Park is the ninth largest in the UK, spanning 1,344 square kilometres (134,400 ha) in the heart of South Wales, with the Park forming the northern boundary of the Cardiff Capital Region. The Brecon Beacons offers a diverse landscape, where sweeping uplands contrast with green valleys, dramatic waterfalls, ancient woodland, archaeological sites, caves, forests and reservoirs[34]. Examples being the iconic peaks (or "Beacons") of Pen y Fan and Corn Du, the Usk and Wye lowland river valleys, and woodland such as Glasfynydd Forest. Peat bog is thought to cover around 16,000 hectares of the Park. The majority of the National Park's land (approximately 65%) is in private ownership. The Brecon Beacons is unique among British National Parks in that a significant amount of land is owned by the National Park Authority (approximately 15%, or 200 square kilometres), much of which is managed as common land, continuing the tradition of common land sheep farming practices. Also, a high proportion (20%) is owned by other public or non-governmental organisations[35]. The National Trust is a significant landowner, of an area that includes Wales' highest mountain.

Large swathes of the Park are classed as Grades 4 and 5 Agricultural Land, indicating their low potential as productive land for farming. The Park's more productive land is mostly confined to the Usk Valley; hence the majority of the NP's agriculture is pastoral grazing of sheep. The Brecon Beacons' special landscapes include 85 Sites of Special Scientific Interest (SSSIs), 10 Special Areas of Conservation (SACs), 6 National Nature Reserves (NNRs) and 70% of Wales' limestone pavement. These landscapes support a diversity of wildlife and a wealth of semi-natural habitats, including Western Europe's largest breeding population of the Lesser Horseshoe Bat[36], several endemic species of Hawkweed plants, and populations of Red Grouse and Golden Plover, rarely seen in the south of the UK.

The location of the Park, upstream of Wales' most densely populated areas, means it also plays an important role in both water supply and flood risk management for South Wales. There are twenty-three water sources that directly provide 36% of Cardiff's drinking water, and other land in the Park encompasses more than half the watershed of the River Usk, which provides a further 50% of Cardiff's water[37]. Recent trends of reduced rainfall in the summer and more frequent, heavy rainfall in the winter have led to landslides, polluting water sources. The two largest rivers within the river basin catchment are the Usk and the Wye. These have recently attracted public attention due to

[34] Brecon Beacons National Park (2015), "A Management Plan for the Brecon Beacons National Park 2015-2020," p.7.
[35] Brecon Beacons National Park (2015), "A Management Plan for the Brecon Beacons National Park 2015-2020," p.7.
[36] "A Management Plan for the Brecon Beacons National Park (2015-2020)," p.26.
[37] "A Management Plan for the Brecon Beacons National Park (2015-2020)," p.11.

their pollution levels, which consistently exceed target thresholds[38]. Assessed levels of phosphates in the Usk have led to compliance concerns, and have resulted in algal blooms which are damaging to the rest of the river ecosystem.

Today, the Natural Park plays a key role as an enabler for climate change adaptation and mitigation, not only for local communities, but for Wales as a country. Some of the key ecological challenges identified within the latest management plan are water quality (including impacts of soil erosion), invasive species, the importance of land conservation for habitats such as hedgerows, riverbanks, roadsides and urban trees, while also maintaining sites of special scientific interest in favourable condition, and air pollution. The National Park seeks to restore eroded and drained peatland to boost landscape resilience. All strategies for climate change adaptation and mitigation, including flood risk management, also benefit from developing a landscape rich in trees, woods and hedgerows. This would be nurtured through improved woodland management, restored ancient woodlands, and planting more trees in order to deliver the many social and ecological benefits they bring[39].

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[40]. 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. 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.

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 is higher than the UK average, even though the Parks tend to have pockets of deprivation. On average, Brecon Beacons residents spend around 8.7% more than other UK residents (Table 2), excluding public services. This is the lowest value across all National Parks in the UK. Some noteworthy spending patterns, compared to UK averages, are high spending on healthcare (+36.3%) and low spending on education (-43.1%). This pattern is similar to other National Parks and probably goes hand in hand with an ageing resident population. A detailed summary of the key statistics and spending habits for Brecon Beacons residents is provided in Appendix 0.

[38] https://cdn.cyfoethnaturiol.cymru/media/693025/compliance-assessment-of-welsh-sacs-against-phosphorus-targets-final-v10.pdf?mode=pad&rnd=132557227300000000.
[39] Brecon Beacons National Park (2022), "Future Beacons: The Management Plan for the Brecon Beacons National Park 2022-2027", Consultation Draft p.50.
[40] Catapult Energy Systems (June 2021), "Net Zero Societal Change Analysis: Summary report," p. 11.

Table 2: Relative difference in consumer spending per capita (excluding public services) between Brecon Beacons National Park and the UK average, and the relative difference between all 15 UK NPs averaged and the UK average.

Consumer Expenditure Category	**Brecon Beacons NP vs. UK average**	**All NPs vs. UK average**
Food & non-alcoholic drinks	7.6%	10.2%
Alcoholic drinks, tobacco & narcotics	10.1%	14.6%
Clothing & footwear	6.7%	9.2%
Housing, fuel & power	-9.6%[41]	-8.3%
Household goods & services	12.8%	16.6%
Health	36.3%	41.9%
Transport	21.7%	29.7%
Communication	3.9%	4.7%
Recreation & culture	16.8%	22.1%
Education	-43.1%	-39.8%
Restaurants & hotels	1.3%	3.1%
Miscellaneous goods & services	4.9%	7.8%
Other expenditure items	16.1%	23.1%
Total	**8.7%**	**12.9%**

[41] The lower-than-average figure in this expenditure category is due to higher ownership percentages among the disproportionately older and rural population. This is despite a separate fuel use dataset suggesting that there is more household fuel use per capita in the National Park compared to the UK average, likely due to bigger, older and less well-insulated houses.

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 Park, along with a section introducing the methodology. The assessment covers all greenhouse gases in the "basket of six"(see below), 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.

By taking a consumption-based approach, we include embodied, indirect emissions in everything that residents and visitors buy and do while in the National Park, as well as the footprint of travelling to and from the Park. This amounts to a full footprint associated with the residents' and visitors' lifestyles. The consumption-based approach to carbon accounting is different to the production-based approach currently adopted by the UK and the Welsh Governments, which tracks only territorial emissions occurring within a specified geographical region such as a Unitary Local Authority or a National Park (see Appendix 10.11 for further information on the Welsh climate policy framework).

More specifically, the following sources of emissions are within the scope of this consumption-based assessment:

- all residents' personal travel and visitor travel to, from and around the Park;
- fuel and electricity consumed in homes and places to stay;
- emissions from food, 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 predominantly 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 the Park, 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 double-counting of emissions, occurring when industries within the Park sell to each other or to residents and visitors. Secondly, this crude estimate for industry has been made by applying generic, UK-wide emission factors for each industry sector to local revenue data from businesses registered in the Brecon Beacons National Park. This may in some cases misrepresent actual industry-related activities within the Park boundary.

Figure 7 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 10.3 and 10.9. 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. We keep to the principle of counting everything once and once only and without truncation error[42]. 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.

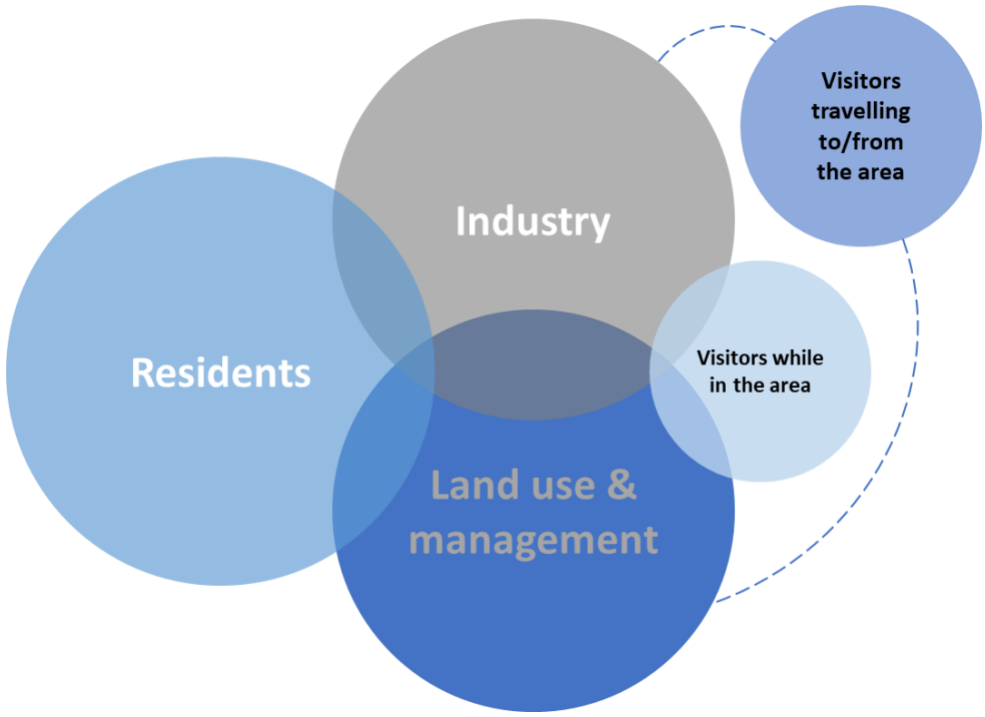


Figure 7: Boundaries of carbon footprint assessment (repeat of Figure 1)

Our approach to carbon accounting aligns with the Greenhouse Gas Protocol's (GHGP) Corporate Accounting and Reporting Standard, a globally recognised standard for organisational carbon footprint estimates. We extend this approach to landscapes by tracking full lifestyle-related emissions of the residents and visitors, in addition to emissions from land use and from other business activities in the area. While we emphasise that all supply chain and lifestyle-related assessments contain a degree of uncertainty, we have confidence that this work identifies in broad terms the most and least significant components of the GHG footprint of the National Park or AONB

[42] Truncation error occurs when an LCA only considers a finite number of supply chain levels due to the underlying complexities and data limitation, instead of including supply chains in their entirety, as is done in the input-output model. The truncation affects the accuracy of the embedded carbon footprint estimates of all goods and services, which are central to the consumption-based assessment in this report.

to facilitate successful carbon management to limit global warming to 1.5°C in line with the Paris Agreement.

More specifically, the report includes a recommendation for Paris-aligned greenhouse gas targets across six key areas. These six areas have been selected in order to find a best-fit between the competing desires to cover everything of significance within the influence of policy makers, to keep the boundary simple to describe, to avoid double counting, and to make use of any readily available data for tracking progress. As a result, the scope for the target areas is slightly different from that of the overall emissions assessment. The six target areas are:

- Energy-only emissions (incl. 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-CO2 component (including emissions from livestock and fertilisers)
- Land use CO2 component (including both emissions and sequestration)

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[43]. 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 8). 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.

In the report, we measure greenhouse gas emissions in tonnes of carbon dioxide equivalent (tCO_2e)[44]. 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.

[43] 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.

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

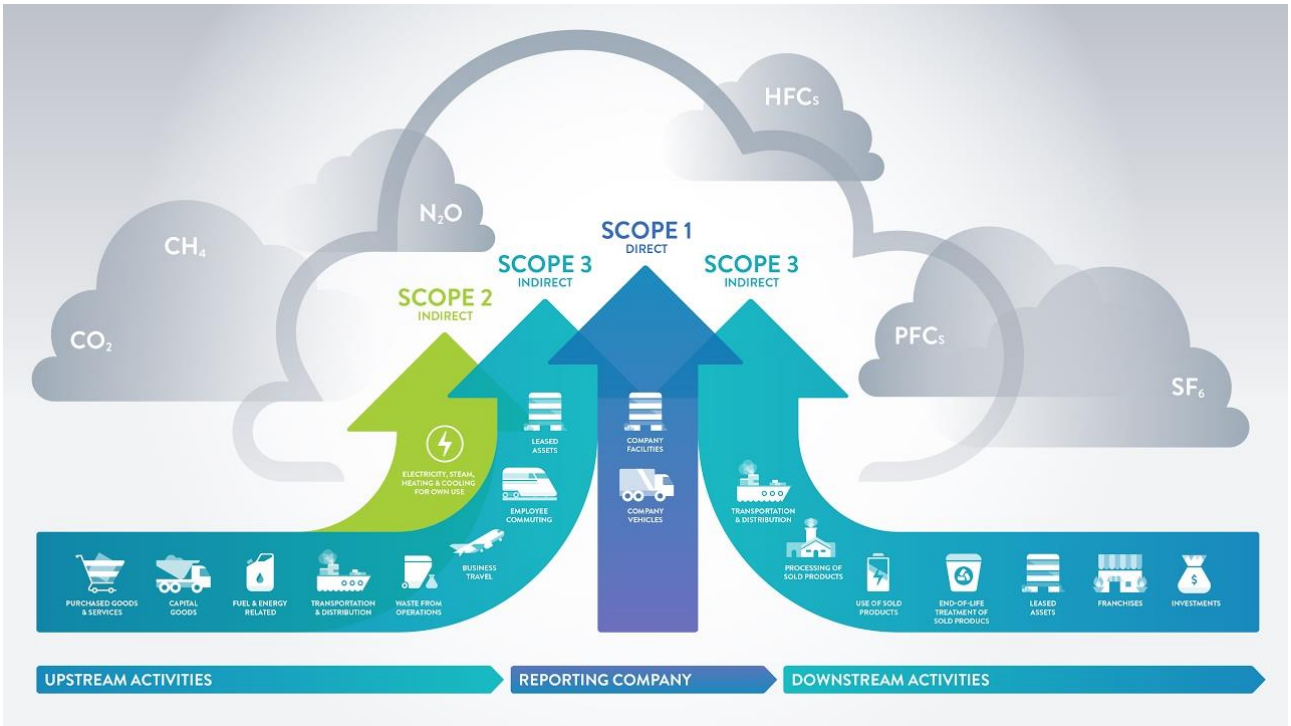


Figure 8: Types of greenhouse gas emissions used for carbon accounting. Source: Greenhouse Gas Protocol.

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 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 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 outlined in Appendices 10.3 and 10.4.

5. Brecon Beacons National Park: Consumption-based GHG emissions

5.1. Results overview

Here, we outline our analysis of the carbon footprint of Brecon Beacons residents' and visitors' GHG emissions for 2019 (Figure 9). The relevant data and methodological details are summarised in Section 4, with further information provided in the Appendix.

Residents' emissions were estimated at 0.561 million tCO_2e (Figure 10), and visitors' emissions – from time spent in the Park and during travel to and from – were estimated at 0.264 million tCO_2e (Figure 11 and Figure 12). The resident population stands at 37,681, compared to over 4.3 million visitors per year (both single-day and overnight). A full breakdown of these figures is provided in Appendices 10.5 and 10.6. The final annual consumption for residents (including public services) is over £1.2 billion.

To indicate the scale of the annual GHG emissions from Brecon Beacons National Park, you would need to plant over 2,200 Premier League football pitches with broadleaf trees, and let them grow for over 100 years, to mitigate the combined GHG emissions of the Park's 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 more 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[45]. We shall use these four categories to comment on the results, and to suggest where the National Park Authority and partners could target initiatives aimed at behaviour change.

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

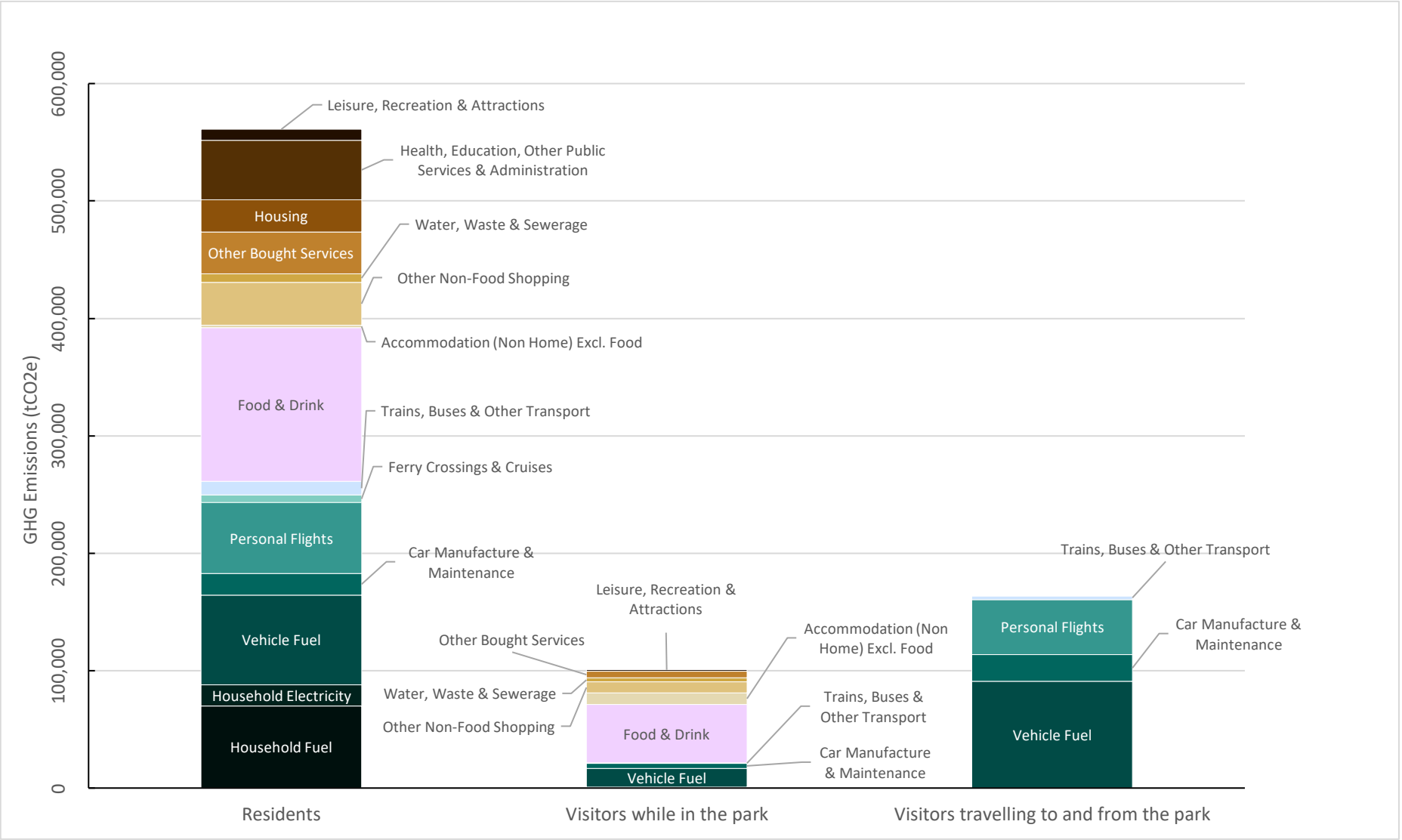
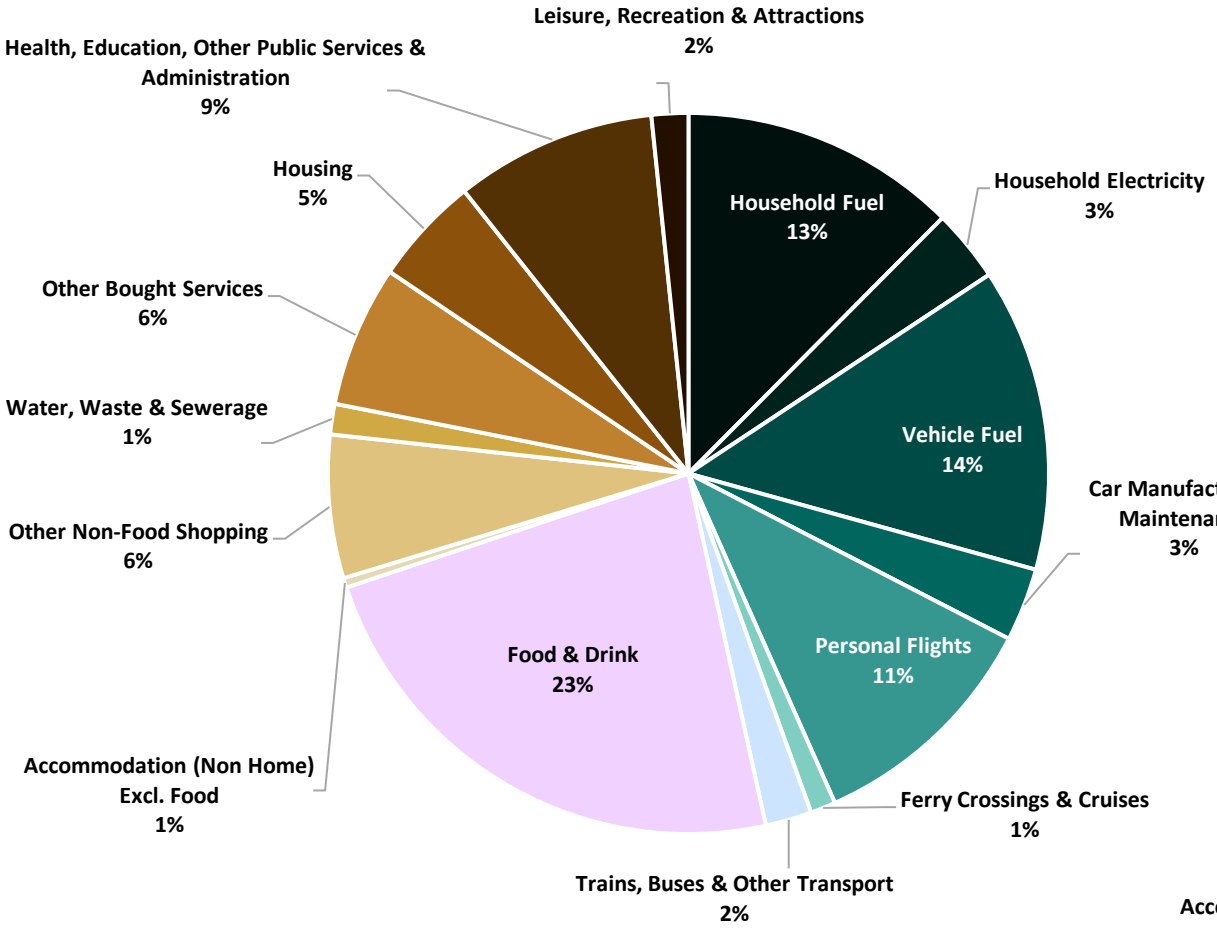
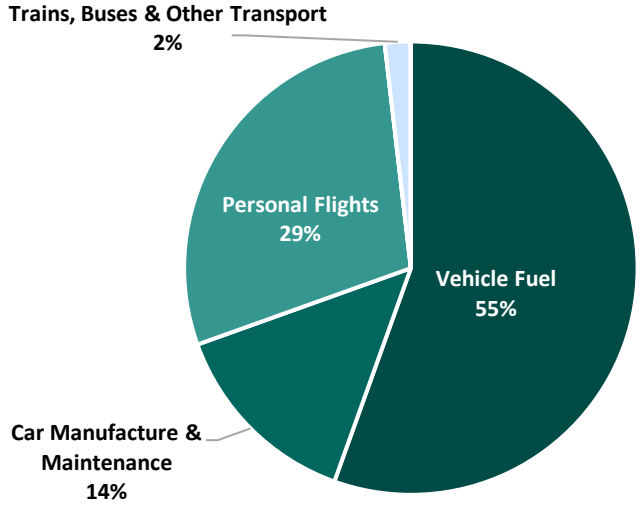


Figure 9: A consumption-based assessment of emissions associated with residents, visitors, and visitor travel to and from the Brecon Beacons National Park

Residents: 561,000 tCO_2e



Visitor travel to and from the National Park: 163,590 tCO_2e



Visitors while in the National Park: 100,722 tCO_2e

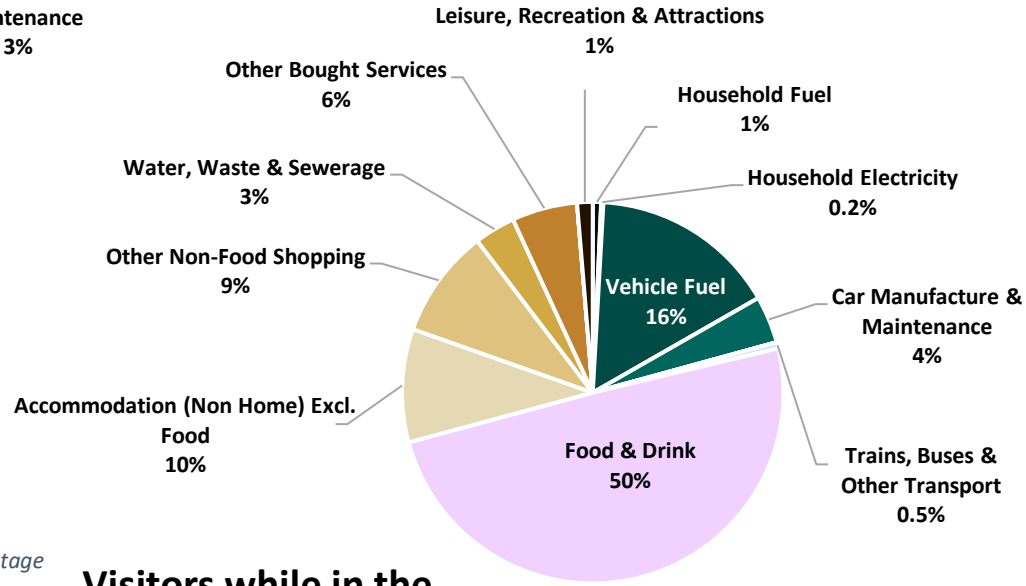


Figure 10 (left): Residents' GHG emissions in Brecon Beacons National Park, by percentage (repeat of Figure 2).

Figure 11 (top right): Visitors' GHG emissions on the way to and from Brecon Beacons National Park, by percentage (repeat of Figure 3).

Figure 12 (bottom right): Visitors' GHG emissions while in Brecon Beacons National Park (repeat of Figure 4).

5.2. Residents' and visitors' GHG footprint components

Brecon Beacons residents' emissions totalled 0.561 million tCO_2e in 2019, with the highest emissions arising from the Food and Drink (23%), Vehicle Fuel (14%) and Household Fuel (12%) categories.

GHG emissions produced by visitors to the Brecon Beacons NP totalled 0.264 million tCO_2e in 2019, comprised of 163,590 tCO_2e linked to travel to and from the Park, and 100,722 tCO_2e produced while in the Park. The chart presenting visitor travel to and from the National Park indicates that GHG emissions are dominated by Vehicle Fuel (55%) and Personal Flights (29%), with only 2% arising from other public transport. Of the footprint of visitors while in the Park, 50% is linked to Food and Drink, while Vehicle Fuel accounts for 16%.

5.2.1. Food

When considering behaviour change around food at its simplest level, we consider 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 Brecon Beacons is considerable: for residents it is 130,828 tCO_2e (23% of the residents' total), and for visitors 49,886 tCO_2e (50% of the visitors' total); see Appendix sections 10.5 and 10.6.

Plant-based sources of calories, protein and other nutrients for human consumption have significantly fewer GHG emissions and a much lower land use footprint than animal-sourced equivalents when compared on a like-for-like basis[46,47]. Therefore, reducing the amount of meat and dairy products consumed in the National Park will be an important component of reducing the overall carbon footprint. It is also possible to use carbon intensity as the basis for choosing which meat to consume, with beef having the highest intensity, followed by 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 meat protein sources like turkey and chicken, on the other hand, have a low calorie density. Plant based protein, such as lentils and tofu, has lower calory intensity than meat. The number of calories people consume through eating and drinking 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[48]. Ship-transported and frozen produce are also good low-carbon alternatives, as the emissions per item are far lower than for air-freighted goods [49].

[46] Poore, J., & Nemecek, T. (2018). Reducing food's environmental impacts through producers and consumers. *Science*, 360(6392), 987-992.

[47] See https://www.theccc.org.uk/wp-content/uploads/2020/12/Sector-summary-Agriculture-land-use-land-use-change-forestry.pdf, page 19.

[48] 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.

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

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, with a formal response to be released in a white paper expected imminently[50]. 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[51]. Wales has had its own National Food Strategy dating back to 2010, which has less of a focus on sustainability than the recent English independent review. An updated "Food (Wales) Bill" is currently being prepared for presentation to the Welsh Parliament, which will likely address the issue[52].

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"[53].

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 the Department of Health: "people with long-term conditions account for about 50% of all GP appointments, 64% of all outpatient appointments and over 70% of all inpatient bed days"[54], and treatment and care for people with long-term conditions is estimated to absorb around £7 in every £10 of total health and social care expenditure (Department of Health, 2012).

These discussions present significant challenges for the agriculture industry in 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[55]. Achieving this would require considerable reductions in emissions from livestock and reductions in synthetic fertiliser use while actively pursuing efforts to sequester carbon through creating woodland, restoring peatland within agricultural land, and implementing regenerative farming practices[56]. It is also important for the UK to aspire towards greater self-sufficiency in food, which would involve reducing high-carbon agricultural imports from overseas (including animal feeds) and increasing domestic production sustainably and in line with broader climate and biodiversity objectives (see Section 5.6.4 for further details).

In farming communities particularly, food production and consumption seem to be one of the hottest and most polarising topics, particularly given the potential impact on farming livelihoods

[50] "National Food Strategy Independent Review, The Plan," Chapter 16: The Recommendations.
[51] "National Food Strategy Independent Review, The Plan," p. 147.
[52] Welsh Parliament (2021), "Proposals to introduce a Food (Wales) Bill wins Senedd support."
[53] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section, p.21.
[54] Department of Health (2012) Policy Paper. "Long-term conditions compendium of Information: 3rd edition."
[55] National Farmers Union (2021), "Achieving Net Zero Farming's 2040 goal."
[56] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry section."

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 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 net gain and produce food, while also facing the challenge of an ageing workforce and workers opting to leave the industry.

5.2.2. Homes and accommodation away from home

The "Home and accommodation" category accounts for 117,799 tCO_2e (21%) of the footprint of Brecon Beacons NP residents, and 10,570 tCO_2e of visitors' footprint (10% of their in-the-Park footprint). We considered the following components: household fuel 69,846 tCO_2e (12% of residents' total footprint); housing 27,299 tCO_2e (5%); household electricity 18,237 tCO_2e (3%) and accommodation away from home 2,418 tCO_2e (0.4%); see Appendix 10.5. 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 undertaking the necessary due diligence 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 or other funding.

5.2.3. Travel

Travel is responsible for the lion's share (70%) of the footprint of Brecon Beacons visitors: 184,113 tCO_2e, largely made up of travel to and from the Park, with 20% from visitors' emissions while in the Park. The majority of this travel footprint comes from fuel burned in private vehicles, 106,714 tCO_2e (40% of the visitors' total); personal flights 46,825 tCO_2e (18%); vehicle manufacture and maintenance (10%) and a small amount from the use of trains, buses and other transport (1%).

Travel accounts for 31% of the residents' GHG footprint. In considering residents' travel we looked at personal flights 60,353 tCO_2e (11%); vehicle fuel 76,305 tCO_2e (14%); vehicle manufacture and maintenance 18,399 tCO_2e (3%); trains, buses and other transport 11,683 tCO_2e (2%) and ferry crossings and cruises 6,363 tCO_2e (1%); see Appendix 10.5.

One of the biggest positive impacts could be achieved through public messaging on reducing flying, particularly "casual flying" for short trips where other transport opportunities are feasible by train, bus and/or boat. All 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. Mass public transport offers the added advantage of reducing pressure on the Park's vehicle parking infrastructure.

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, the associated emissions are around 4.5 tCO_2e if their vehicle is a small petrol run-around, 5.6 tCO_2e for a medium family-size car and 8.3 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 in an average petrol car would produce 0.11 tCO_2e of emissions, including the embodied emissions of the vehicle and its 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 slightly lower than for petrol, at 0.10 tCO_2e, 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[57]. 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.

In the UK in 2019, 10% of all new cars and vans purchased were electric[58]. 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 2035[59]. As the Brecon Beacons National Park has a relatively affluent demographic profile (although less affluent than most National Parks), the typically cost-prohibitive entry into owning an electric car is more likely to be within reach for some Park residents. Aside from switching to an EV, there are other choices that everyone can make to reduce vehicle emissions:

- The average person walks 210 miles per year[60]. Walking an additional 2.5 miles per week for local journeys, e.g. visits to local shops or the school run, could save 1.3 tCO_2e in a year and bring co-benefits for health.

[57] 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.
[58] https://www.ft.com/content/d57efdf6-ffad-11e9-be59-e49b2a136b8d.
[59] https://www.bbc.co.uk/news/science-environment-51366123.
[60] Department of Transport (2019), "National Travel Survey (England): 2018."

- Emissions would be reduced if more people travelled more often by bicycle, perhaps on an electric bike which uses just 5% of the energy per mile of an electric car.
- 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 would 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.
- If affordable, replacing a large car with an electric hybrid car would save 4.49 tCO_2e a year. Switching to a fully electric car would provide further footprint reductions.

The 2016/17 Brecon Beacons Visitor Survey showed that 4% of visitors travel by hire car. It may be beneficial for the National Park Authority to work with partners and local providers to fast-track the electrification of hire vehicles. In addition, increasing the availability of electric car charging points could encourage visitors to travel by electric vehicle.

5.2.4. Everything else

The remainder of the residents' footprint consisted of: public services including health and education, 50,684 tCO_2e (9% of residents' footprint); other bought services, 35,646 tCO_2e (6%); other non-food shopping, 36,054 tCO_2e (6%); leisure, recreation and attractions, 9,227 tCO_2e (2%) and waste, water and sewerage, 7,659 tCO_2e (1%). The remainder of the visitors' emissions arose from: water, waste and sewerage, 3,506 tCO_2e (3% of their footprint while in the Park); other non-food shopping, 9,321 tCO_2e (9%); other bought services, 5,590 tCO_2e (6%) and leisure, recreation and attractions, 1,326 tCO_2e (1%).

The biggest single factor in the "everything else" category is health and education. As discussed in Section 5.2.1 food, 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[61]. 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[62].

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

[61] 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.

[62] 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.

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

Results suggest it does not matter how "threshold" achieved per week.

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 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 and carbon benefits are considered when undertaking option appraisals.

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

Figure 13 compares the average per capita footprint of the Brecon Beacons residents' footprint with the UK national average.

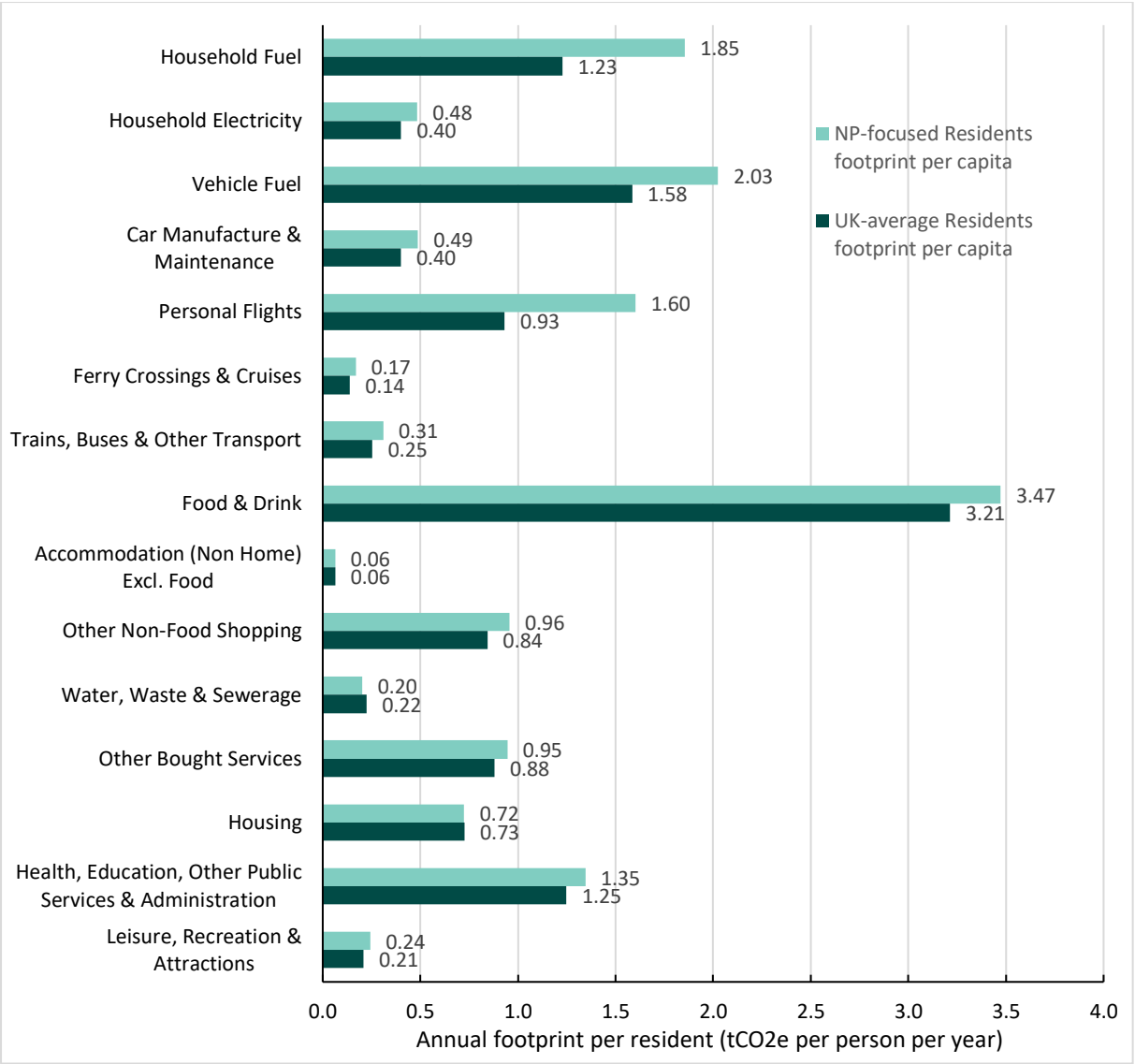


Figure 13: Residents' GHG footprints: Brecon Beacons National Park average compared to the UK national average

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 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 Gross Value Added (GVA) data since it is more geographically specific (see Appendices 10.7.1 to 10.7.3). Please note that the reported turnover data does not necessarily reflect 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 National Park boundary, leading to marginal overestimates of the total turnover and the resulting industry footprint within the National Park. 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.

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[63]. For transparency we include the IDBR broad industry group structure and see how this compares with the SIC (2007); see Appendix 10.7.1. 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 531,587 tCO_2e.

Figure 14 highlights Production as the largest source of GHG emissions (238,013 tCO_2e; 45%); followed by Health (87,594 tCO_2e; 16%) and Agriculture, forestry and fishing (79,231 tCO_2e; 15%), see Appendix 0. Industry-related flights account for 6,579 tCO_2e of the total footprint but are not categorised separately. Each of the main contributing categories are discussed in turn below.

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

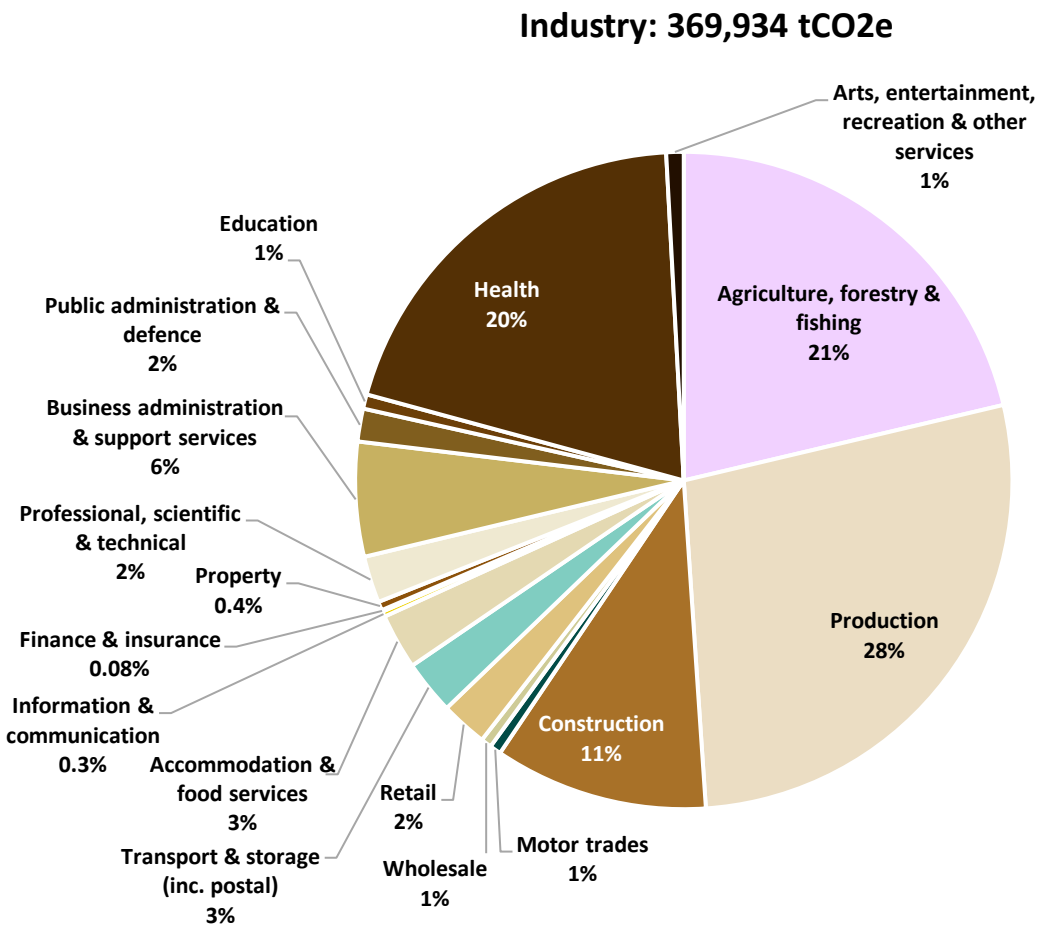


Figure 14: Brecon Beacons NP consumption-based GHG emissions for industry, by percentage (repeat of Figure 5)

Production

Production (referring to manufacturing industries) makes up the largest proportion of the industry footprint in the Brecon Beacons (102,179 tCO_2e; 28% of total industry-related emissions). We calculate that the greatest contributor to this production footprint is from the manufacturing of basic materials (32,711 tCO_2e). We suggest that manufacturing is the industrial sector where it could be most beneficial for Local Enterprise Partnerships to focus their efforts in encouraging companies to have their Scope 1, 2 and 3 GHG emissions assessed, and that carbon reduction planning to decarbonise these industries should be made the priority.

One area that may see a rise in GHG emissions over the coming years is the mining sector. While many of the coal mines that formerly operated in or near the National Park have now closed, the recent decision to extend the licence of the Aberpergwm drift coalmine on the edge of the Brecon Beacons allows up to 40 million tonnes of coal to be extracted over the next 20 years. As mentioned previously in section 2.5, the coalmine is located just outside the boundaries of the Brecon Beacons NP, but the emissions associated with its operations and transportation could still affect the Brecon Beacons' footprint in future years if the mine's supply chains and distribution lines overlap with the National Park.

Agriculture

The second-largest industry in terms of GHG emissions is agriculture, forestry and fishing (78,815 tCO_2e; 21% of total industry-related emissions). The issues pertaining to this industry are discussed in detail under Sections 3.2 (Agricultural landscape), 5.2.1 (Food) and 5.2.4 (Everything else). Agricultural land makes up the largest land area within the Brecon Beacons, with a significant amount of land grazed by livestock.[64] The rearing of livestock, especially ruminants such as cows and sheep, are probably the main drivers of the Park's agriculture footprint. We therefore suggest that farmers not already implementing sustainable farming practices consider doing so, to reduce this footprint.

Members of the Park's agricultural industries may wish to read and reflect on the Sixth Carbon Budget (2020) "Agriculture and land use, land use change and forestry" report, which 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 methane losses, 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.

The Sixth Carbon Budget also discusses reducing numbers of cattle, sheep, pigs and poultry through technological and dietary changes, leading to smaller overall areas grassland and cropland, as well as shifting to new hydrogen technology. JCB, for example, have developed a prototype hydrogen tractor, so there may be benefits in the LEP collaborating with manufacturers who may be able to assist 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 a second largest food exporter globally despite the comparatively small land area. 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 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. The report suggests that only 50% of the grass produced 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.

[64] https://www.beacons-npa.gov.uk/environment/farming-in-the-brecon-beacons/farming-and-national-park-purposes/.

Health

Health (referring to health and social work activities) is the industry with the second-highest GHG emissions in the Brecon Beacons (73,704 tCO_2e; 20% of total industry-related emissions). This is probably due to the number of hospitals and healthcare centres located within the Brecon Beacons National Park or bordering it. These include three located in Brecon: the Powys Healthcare NHS trust, Brecon War Memorial General Hospital and Health Visitor Brecon, plus the Nevill Hall Hospital in Abergavenny. We suggest that the best way for Brecon Beacons NP to reduce its healthcare footprint is for it to continue working with public health bodies and the NHS to promote healthy lifestyle opportunities within the National Park and partnering local authorities. This is with the aspiration of mitigating the development of long-term conditions in the current working-age population, and reducing future demand for healthcare services. The current 65+ age bracket, whose need for health and social care services is likely to rise in future years, may benefit from increased use of digital healthcare and telehealth technologies, to help them manage long-term conditions at home with primary care support. Indeed, all three National Parks in Wales already have policies in place to promote Health and Well-being, and Brecon Beacons NP has previously spearheaded the National Park Champions project to encourage socially excluded communities to visit the National Park and feel the benefits to their health and well-being.[65] Running similar projects in the future, using an evidence-based approach to promote healthy lifestyles within the Park, is likely the most effective way for the Brecon Beacons NP to reduce its health industry footprint.

Construction

We estimate that construction is the fourth-largest GHG-emitting industry in the Brecon Beacons NP (38,907 tCO_2e; 11%). This is slightly lower than for the UK as a whole; the Sixth Carbon budget (2020) data on manufacturing and construction showed that this sector contributed 12% of the total GHG emissions for the whole UK. However, emissions associated with this area may rise in the coming years due to increased creation of infrastructure to deliver renewable energy,[66] as well as the construction of more affordable housing in areas such as Brecon, Dyffryn and Quarter Bach.[67]

Opportunities for interventions 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.

[65] National Park Wales: "Together for Health and Well-being."

[66] Community Renewable Energy Scenarios. "Detailed Methodology and Guidance for Interpretation," November 2020.

[67] Brecon Beacons Affordable Housing Strategy, June 2018.

- 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[68].

IDBR and GVA based emissions comparison

We also undertook a comparison between IDBR data and GVA data, as we know that economic reporting often uses GVA as the primary measure on which many LEPs base their workforce planning; see Appendix 10.7.13. The GVA dataset is available for unitary local authorities and does not represent the sectoral breakdown of industries within the National Park boundary. In contrast, the IDBR data is available for COA geographies that are much more closely aligned to the National Park boundary. A comparison between the GVA dataset and the IDBR indicates potential under-reporting of the GVA-based emissions arising from several sectors, including agriculture, construction, business administration, and health (Figure 15). The National Park may wish to discuss this with local LEPs.

5.3.3. Energy-only industry analysis

This analysis is a subset of the carbon footprint estimate for industry in the NP. Energy makes up 39% of emissions from industry (144,078 tCO_2e). Table 3 shows the breakdown of emissions from electricity and fuels.

Table 3: Energy-only industry (subset of industry) – Brecon Beacons National Park (figures are in tCO_2e)

Industry Electricity	52,899
Industry Fuels excl. Road	79,708
Industry Road Fuels	11,471
Total	**144,078**

5.3.4. Large emitters analysis

As a further subset analysis of the industry analysis, the BEIS Pollution Inventory (2018) enables us to identify specific large emitters within each UK National Park (see Appendix 10.7.4). The total volume of carbon dioxide produced by large emitters in the Brecon Beacons NP is zero tCO_2e. 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 the assessment of Scope 1, 2, and 3 GHG emissions, and carbon reduction planning with a view to net zero[69]. Please note that the quoted zero volume refers to carbon dioxide emissions only and is limited to Scope 1.

We also identify where the sector-level IDBR data for the given NP/AONB, obtained using COA geographies, 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 approximated using LSOA-based and UK-based business turnover datasets (also made available to us by the ONS). In the case of the Brecon

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

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

Beacons, a total of 44.22% of the estimated business turnover has been suppressed in the COA-based dataset. This is likely to include the military operations within the Park, such as the Infantry Battle School in Brecon.

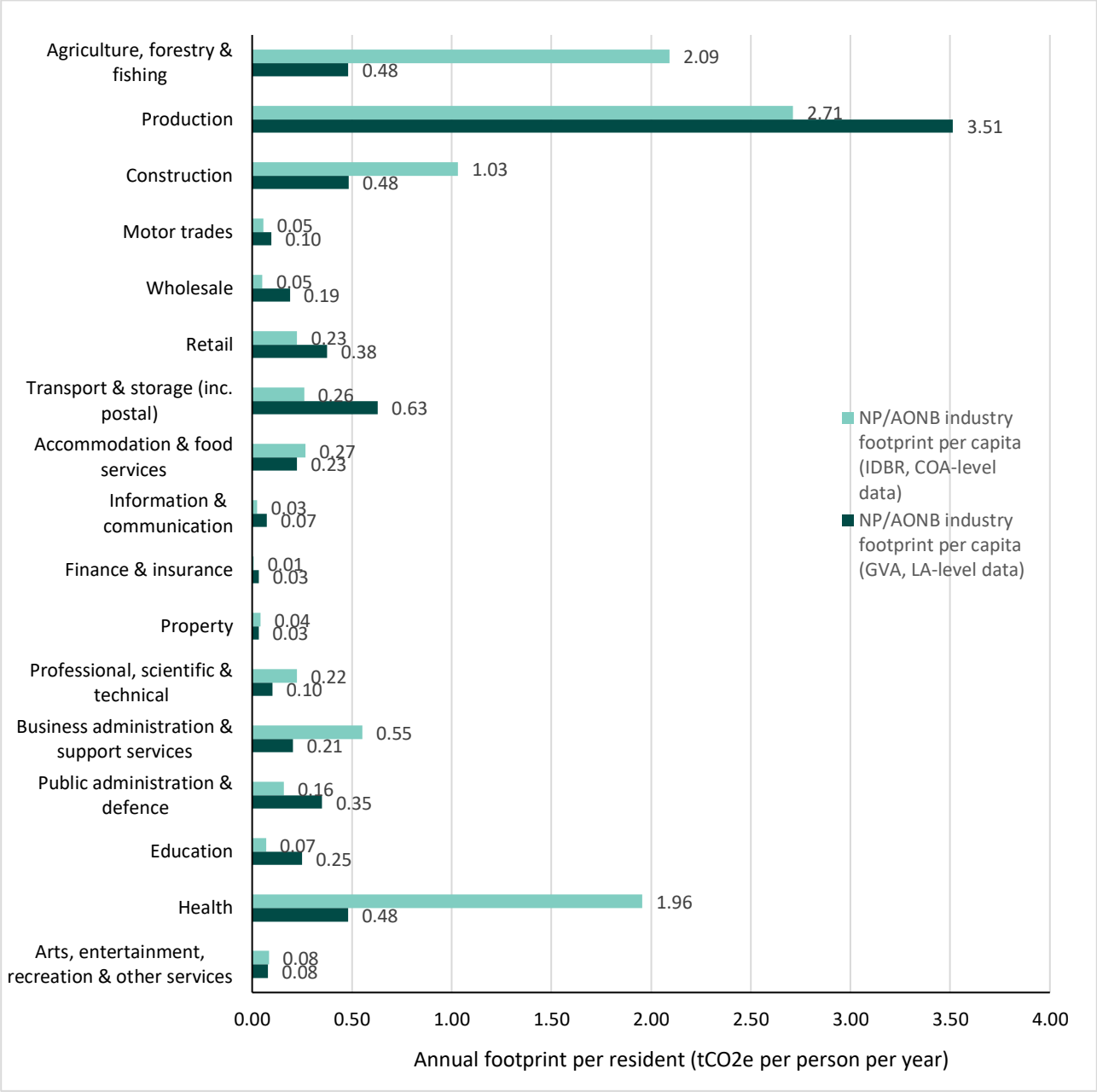
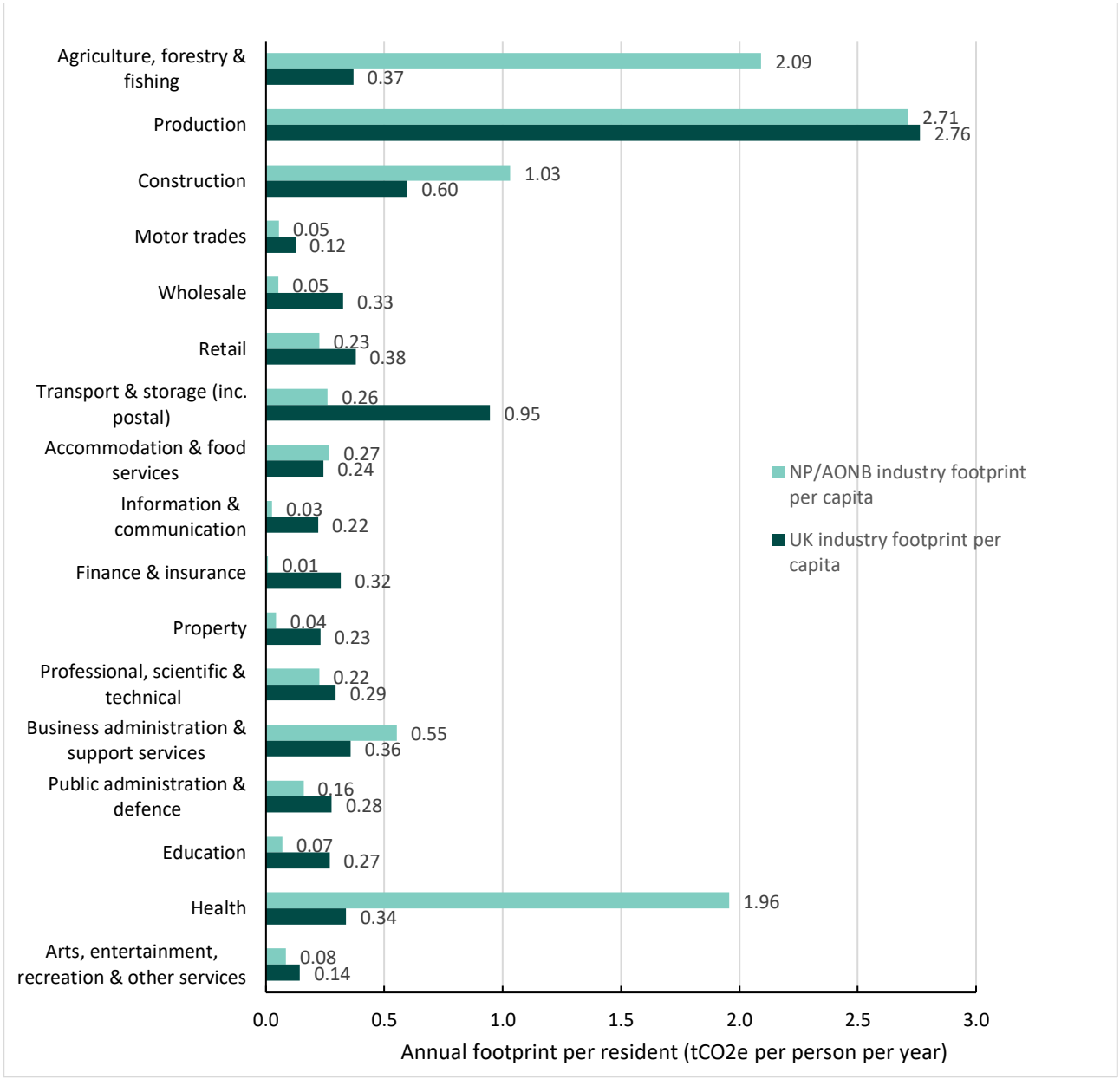


Figure 15: Brecon Beacons National Park industry footprint estimates: IDBR vs. GVA

5.3.5. Comparison of annual industry footprint with UK averages

It may be helpful for the National Park to compare its industry-related emissions 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 16) show higher-than-national-average figures for: Agriculture, Forestry & Fishing; Construction; Accommodation & Food Services; Business Administration & Support Services; and Health.

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 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[70]. 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 organisations new to carbon accounting may be finding it a challenge to work through the process and the recent legislative changes, so joined-up approaches may be helpful, particularly in the public sector.



[70] 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 16: Brecon Beacons National Park industry GHG emissions compared with UK national average, by sector

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 recognise that capacity and capability often pose challenges to medium and small enterprises that have more limited resources.

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

This analysis of the impact of transit traffic has been included at the request of several National Park Authorities (see Appendix 10.8). 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 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 the Brecon Beacons, estimated total through traffic emissions from cars, buses, motorbikes, vans and lorries are **94,489 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 Brecon Beacons are the A40, A465, A470 and A479 (Appendix 10.8). The estimated footprint of these roads within the Park geographical boundary is 121,005 tCO_2e per year across all vehicle types. This amounts to around 22% 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 4). 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. 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 4: Land use GHG emissions – Brecon Beacons National Park

Land use CO_2	-42,190 tCO_2e per year
Land use non-CO_2	223,413 tCO_2e per year
Total: Land use	**181,224 tCO_2e per year**

Land use GHG emissions data 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[71]. 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 11 in Appendix 10.9.8 (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 (England only)[72]
- 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
- National Peatland Action Programme (Wales), 2020-2025

In total, peatland covers more than 4% of Wales' land surface (approximately 85,000 ha), and no more than 10% of the near-natural and modified peatland is in a "favourable condition". The Wales National Peatland Action Programme has the long-term goals of (i) ensuring that "all peatlands with

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

semi-natural vegetation are subject to favourable management/restoration (a minimum estimated area of 30,000 ha)", and (ii) restoring "a minimum of 25% (~5,000 ha) of the most modified areas of peatland" [73]. In the 2020-25 plan, the stated aim is to restore 600-800 ha per year. We estimate that peatland covers 4.5% of the total land surface in the Brecon Beacons NP, which is a small proportion but restoring peatland can still make a considerable contribution to reducing land-based emissions in the National Park. The National Park Management Plan refers to the Brecon Beacons having the largest concentration of eroding peat bog in Wales, and emphasises the importance of reversing this erosion.

The next section reflects on this guidance in terms of target-setting.

5.6. Factors for consideration in land use target-setting

To increase reliability of the land use data, the National Park Authority has undertaken its own GIS assessment of its key habitat types by area, as described in Section 3.2, which provides baseline area data for the target-setting discussed in Section 6. 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, where applicable (both of which improve grassland and cropland), and also where applicable, 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, given existing levels of uncertainty it is expected that these may alter in the future. Any changes introduced to the figures may impact on the proposed glide paths to net zero for all the UK National Parks 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 -5.6.4 discuss the importance of woodland, peatlands, and agricultural landscapes when developing subsequent strategies for the implementation of LULUCF targets in supporting climate adaptation and mitigation.

5.6.1. Trees, woodland and forestry

The notional woodland target of 800 ha per year proposed in Section 6 was derived using the high-level land use opportunity mapping procedure developed for all National Parks and AONBs as part of this programme (Appendix 10.9.9). We recognise that the target does not replace robust discussion by the National Park Authority, its partners and other stakeholders in developing real-world operational strategies for land use change implementation, particularly in relation to implementing its current 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[74]. There are also practical considerations in the choice of tree species to foster long-term

[73] Natural Resources Wales (2020), "National Peatland Action Programme, 2020-2025."
[74]Forestry Commission (2017), "The UK Forestry Standard: The governments approach to sustainable forestry."

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 0.97°C increase in average monthly maximum temperatures over the last 60 years or so, for the weather station at Capel Curig[75]. Natural England (2020) has published another helpful report, worthy of review, examining the relative sensitivity of habitats to climate change[76].

Any new woodland planning requires multi-benefit opportunity mapping to identify the optimum strategic placement and economic considerations for farmers (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, along with sustainable woodland management. A good 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". It is noted that the Welsh Government has produced a Woodlands for Wales Strategy[77], which sets out the strategic direction for forestry across Wales and discusses many of the issues raised in this section.

We note that the Brecon Beacons National Park has recently (2021) produced several Forest Resource Plans which discuss many of the challenges and opportunities that go hand in hand with having forests in the Park, including improving water quality in the central reservoirs of the Park which are important sources of drinking water for South Wales[78].

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[79]; see Box 1.

[75] Met Office (2022) UK climate averages: Capel Curig Climate, period 1961-1990.
[76] Climate Change Adaptation Manual, "Evidence to support nature conservation in a changing climate."
[77] "Woodlands for Wales." The Welsh Government's strategy for Woodlands and Trees (2018).
[78] Brecon Beacons (Central) National Park Forest Resource Plan https://naturalresources.wales/about-us/strategies-and-plans/forest-resource-plans/brecon-beacons-central-forest-resource-plan/?lang=en.
[79] Lancaster City Council (2021), "Grassland Management Strategy"; https://www.lancaster.gov.uk/news/2021/feb/implementation-of-new-grassland-management-strategy.

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[80]. In the UK, peat soils account for nearly 33% of land cover[81]. 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 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.

There are three broad peatland types in the UK:

- Blanket bog (globally rare and typically found in uplands)
- Raised bog (mainly found in lowlands)
- Fens (fed by both surface and groundwater)

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[82].

In Wales, peatlands cover more than 4% of the land area (approximately 85,000 ha), and no more than 10% of the near-natural and modified peatland is in a "favourable condition". Wales' National Peatland Action Programme has the long-term goals of (i) ensuring that "all peatlands with semi-natural vegetation are subject to favourable management/restoration (a minimum estimated area of 30,000 ha)", and (ii) restoring "a minimum of 25% (~c. 5,000 ha) of the most modified areas of peatland"[83]. In the 2020-25 plan, the stated aim is to restore 600-800 ha per year.

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

[80] IUCN National Committee United Kingdom (2021) "About Peatlands"; https://www.iucn-uk-peatlandprogramme.org/about-peatlands.
[81] IUCN National Committee United Kingdom (2018) "UK Peatland Strategy 2018-2040", p. 25.
[82] IUCN National Committee United Kingdom Peatland Programme (2021) "Peatland Damage"; https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-damage.
[83] Natural Resources Wales (2020) National Peatland Action Programme, 2020-2025

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[84].

It is suggested that an important action for all National Parks with peatland habitats is the assessment of the condition, including area, and habitat type to enable priorities for peat restoration to be identified. It would also be beneficial to assess soil depth, and this could present opportunities to employ citizen science. Hydrology assessments may also be beneficial where appropriate, i.e. where assessment identifies the need for water management, to boost the water levels in the peat soils. Work in partnership with water utility companies is therefore 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 East Regional Plan and Water Resources Management Plans.

We use the Unified Peatland Map of Wales to estimate the peatland extent in the National Park, in line with all Welsh designated landscapes on the current programme. According to the Unified Peatland Map, peatland accounts for 6,347 ha (4.5%) of the Brecon Beacons' land area, even though there remains a considerable uncertainty, with an alternative estimate by ADAS being over twice higher[85]. Regardless of the estimate used, restoring peatland is an important action for the National Park, and the Brecon Beacons team is already undertaking peatland restoration as part of the Peatlands and Uplands Project[86]. Assessment of peat restoration opportunities should shed light on the peatland condition, including the habitat types and the associated areas featuring peat soils, which will enable priorities for restoration to be identified. It would also be useful to assess the soil depth, which could present opportunities to employ citizen science. Hydrology assessments may also be beneficial where appropriate, i.e. where assessment identifies the need for water management, to boost the water levels in the peat soils. Work in partnership with water utility companies is therefore 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.

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

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

[85] The 2015 study "Mapping and assessing the status of upland peat bodies, Brecon Beacons National Park" carried out by ADAS lists a much higher figure of around 16,000 ha. Reconciling this estimate with that of the Unified Peatland Map of Wales can only be achieved through ground-truthing, which is ongoing at the time of writing. For further details, see https://www.beacons-npa.gov.uk/environment/peatlands-and-uplands/.

[86] https://www.beacons-npa.gov.uk/environment/peatlands-and-uplands/.

importer of food (Figure 17). Only 55% of food consumed in the UK (by economic value) is of UK origin, with 26% imported from Europe[87].

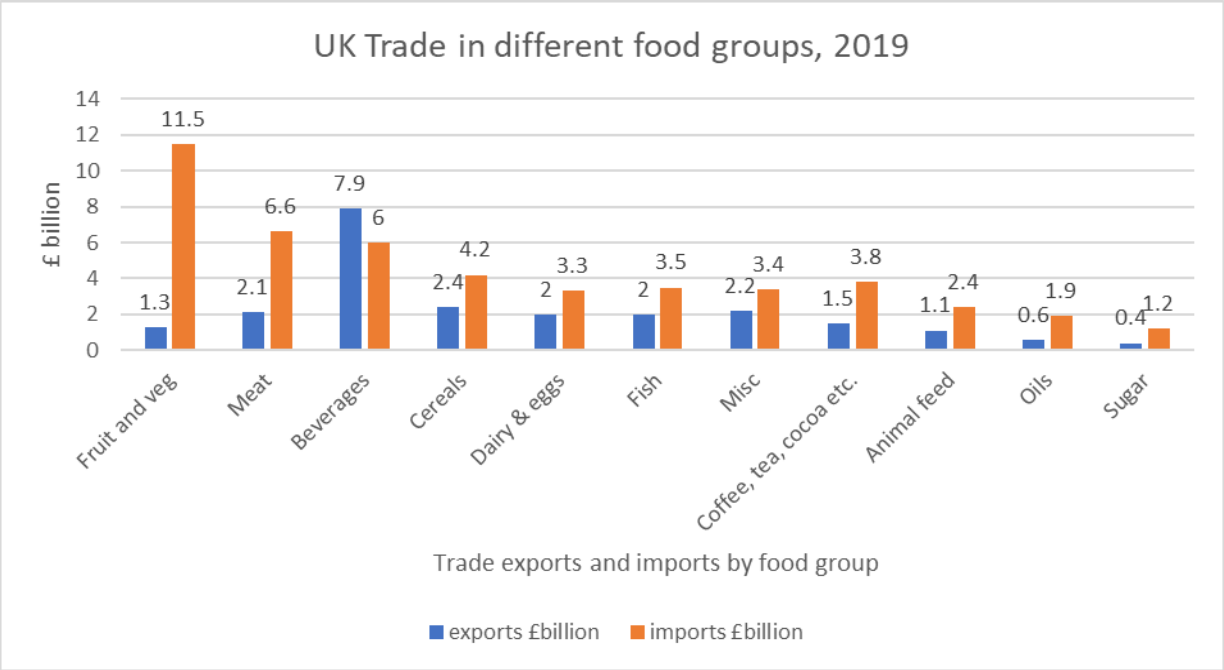


Figure 17: UK trade in different food groups, 2019

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 17.

At the time of the 2011 census, employment in farming represented 5.9% of total employment in the Brecon Beacons.[88]

5.6.5. UK Timber production context

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 industry 0.8 million green tonnes[89].

[87] 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.
[88] "A Management Plan for the Brecon Beacons National Park (2015-2020)," p.50.
[89] Forest Research (2021) "UK Wood Production and Trade: 2020 Provisional Figures."

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[90].

Figure 18 illustrates timber production and trade in the UK, as reported by Forest Research.

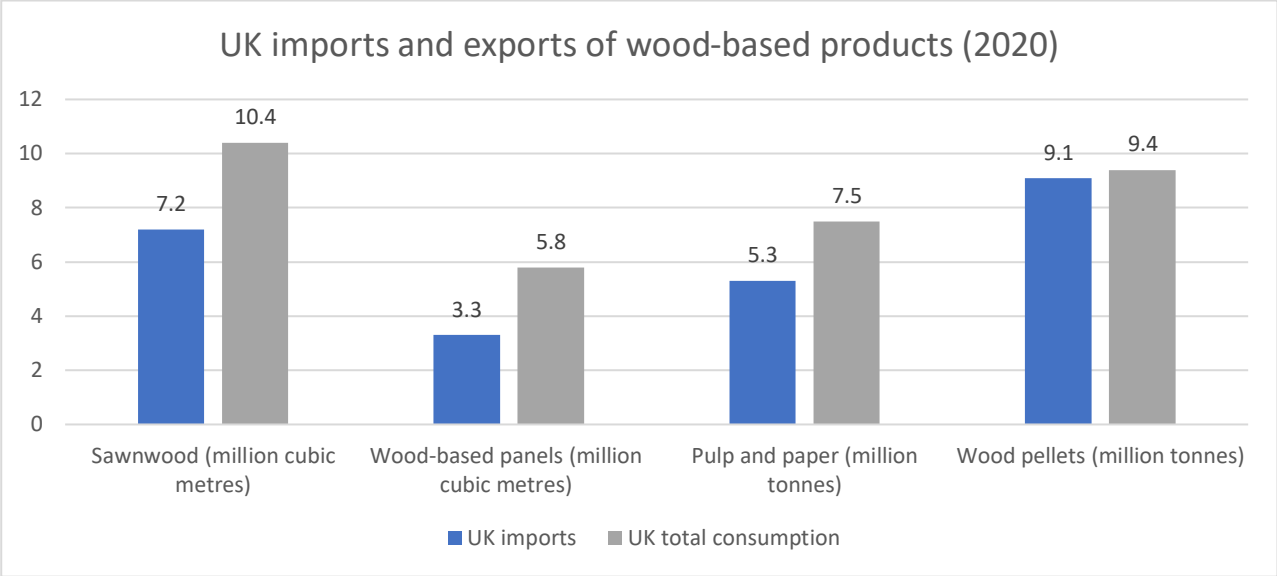


Figure 18: Self-generated from Forest Research (2021) UK Wood Production and Trade: provisional figures, 2020 release

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"[91]. 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[92]. This is in contrast to carbon credits (for carbon sequestration) sold on the UK open market at £10-25 per tCO_2e[93] (Forest Research states 1.25 to 1.43 cubic metres per tonne for roundwood).

[90] 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/.

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

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

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

Wales produces less timber than Scotland and England, but timber is still a notable industry, employing around 10,000 people and generating close to 1% of Welsh Gross Value Added[94].

[94] https://naturalresources.wales/about-us/what-we-do/forestry/forestry-sector/forestry-statistics-forecasts-and-surveys/?lang=en

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

This section outlines the aspiration for the Brecon Beacons National Park in setting a challenging glide path to Net Zero by 2032 and beyond, to become a carbon sink as one of the "lungs" of Wales contributing to the UK's Net Zero target. It also outlines the planning assumptions used. For the treatment of targets such as energy we have taken a pro-rata approach for all National Parks based on a percentage of GHG emissions. However, land use requires a bespoke approach of proportioning UK targets to known key habitats within the National Park and uses area assumptions.

Six 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 target categories is slightly different from that of the overall emissions assessment in Section 5 and contains elements of both the consumption-based and production-based footprint estimates (Section 4; Appendix 10.11). The six target categories are summarised below, with further supporting data in Appendix Section 10.9.4.

- **Target Category 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.
- **Target Category 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.
- **Target Category 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.
- **Target Category 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 10.9); visitor aviation emissions are still an important consideration for policymakers.
- **Target Category 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.

- **Target Category 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.

Across these six categories, the 2019 carbon baseline for Brecon Beacons National Park is estimated at 872,364 tCO_2e per year.

Following the principles outlined above, some components of the wider carbon footprint of Brecon Beacons National Park, presented in previous sections, have been excluded from the 2019 consumption-based 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 are summarised in Table 5, and represent the minimum that can be considered to be Paris-aligned, with the caveat that the chosen emissions baseline is predominantly consumption-based with some production-based features (Section 4). If only production-based footprint estimates were used, as currently is the case for multiple local authorities across the UK, the minimum Paris-aligned targets would tend to be lower. For target 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 recommendations. Some or 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 10.9.4

Category	New Model for All National Parks (2021) – used in this report	Achievable ceiling
1. Energy-only GHG emissions (incl. supply chains) by residents, visitors and industry	**13.5%** (specific to Brecon Beacons 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	**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 LULUCF Non-CO_2 and LULUCF CO_2 components. See Appendix 10.9.9 for further details	**30%** of present-day emissions for LULUCF Non-CO_2 only; Achievable ceiling is not applicable for LULUCF CO_2 in the current assessment due to the unique role of this category as a net carbon sink

The six elements outlined above can be combined into an overall decarbonisation pathway, which in the case of the Brecon Beacons National Park results in a net zero date of 2035. Note that targets 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 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 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 a 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. The rate of change has been drawn from the Sixth Carbon Budget, apportioned to the Brecon Beacons National Park according to its land characteristics (see Appendix Section 10.9.9).

When the Sixth Carbon Budget's apportionment methodology is applied to the Brecon Beacons National Park, this results in the annual land use change targets summarised in Table 6, along with the associated carbon sequestration flux increases each year. When measured in hectares per year converted, the legumes (improved grassland) target comes on top at around 790 ha/yr., followed by new broadleaf/mixed woodland at 640 ha/yr., new productive coniferous woodland at 160 ha/yr., and restored peatland at 115 ha/yr. When converted to changes in carbon sequestration fluxes, the new native broadleaf/mixed woodland (-11,812 tCO_2e per year added each year) provides around 3.3 times more sequestration compared to the second-largest contribution from new productive coniferous woodland, and around 7.3 times more sequestration compared to the third-largest contribution from legumes (improved grassland) (Table 6).

We emphasise that priority must also 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[95]. 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 erosion[96]. Typical sequestration values associated with regenerative agricultural practices (such as agroforestry, hedging, and growing legume-rich grasses and cover crops, where applicable) 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 delivers 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) programmes.

Table 6: Brecon Beacons National Park: Apportioned Sixth Carbon Budget targets for land use change and the associated additions to annual carbon sequestration fluxes. Derived from the National Park-specific habitat and peatland data. Note that the peatland restoration estimates are based on the Unified Peatland Map of Wales, which are understood to be on a conservative side subject to a further ground-truthing.

Proposed Land Use Targets	**Value**	**Units**
New Native Broadleaf / Mixed Woodland	640.0	ha per year
New Productive Coniferous Woodland	160.0	ha per year
Restored Peatland	115.1	ha per year
Agroforestry (improved grassland & cropland)	104.9	ha per year
New Hedgerows (improved grassland & cropland)	6.0	ha per year
Legumes (improved grassland)	789.8	ha per year
Cover Cropping (cropland)	26.2	ha per year

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

[96] 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.

Associated Carbon Sequestration	Value	Units
New Native Broadleaf / Mixed Woodland	-11,812	tCO_2e per year per year
New Productive Coniferous Woodland	-3,539	tCO_2e per year per year
Restored Peatland	-460	tCO_2e per year per year
Agroforestry (improved grassland & cropland)	-246	tCO_2e per year per year
New Hedgerows (improved grassland & cropland)	-63.9	tCO_2e per year per year
Legumes (improved grassland)	-1,622	tCO_2e per year per year
Cover Cropping (cropland)	-30.7	tCO_2e per year per year

Based on the target-setting assumptions outlined in Table 6 and in Appendix 10.9.9, the Brecon Beacons National Park will achieve a total cumulative reduction in the net annual GHG emissions of 1,263,122 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 19.

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 19.

The assumptions above imply that the Brecon Beacons would achieve Net Zero emissions in 2035 and will act as a net carbon sink in subsequent years (Figure 20). 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 10.9.5 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.

An alternative target trajectory for the Brecon Beacons using all consumption and landscape-based emissions as the baseline is given in Figure 21. The resulting 2019 baseline is higher, which delays the net zero date until 2037.

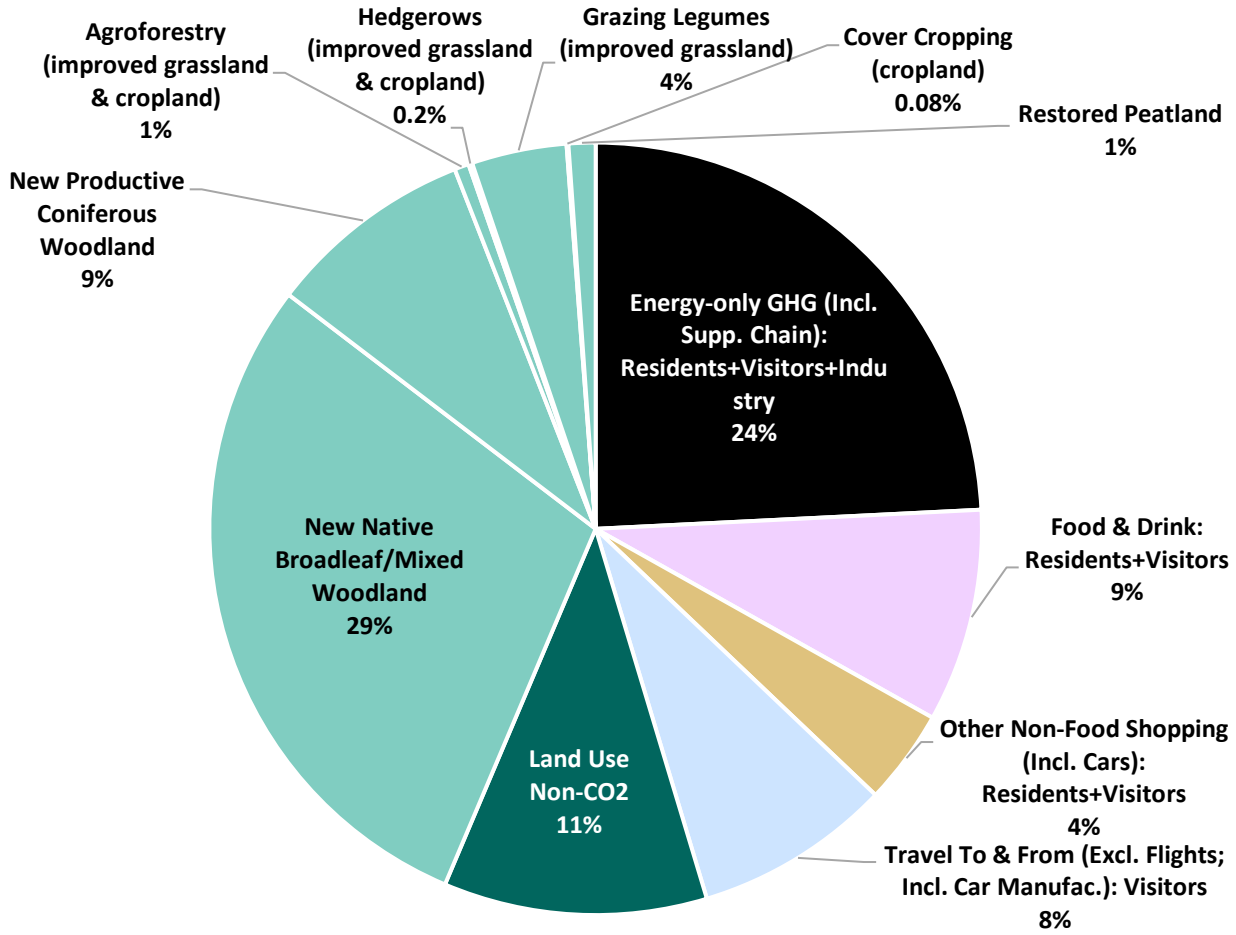


Figure 19. Percentage breakdown of the projected cumulative reduction in net annual GHG emissions for the Brecon Beacons between the base year (2019) and 2050 according to the individual emitting categories and carbon sequestration measures considered in this assessment. Note that the peatland restoration estimates are based on the Unified Peatland Map of Wales, which are understood to be on a conservative side subject to a further ground-truthing.

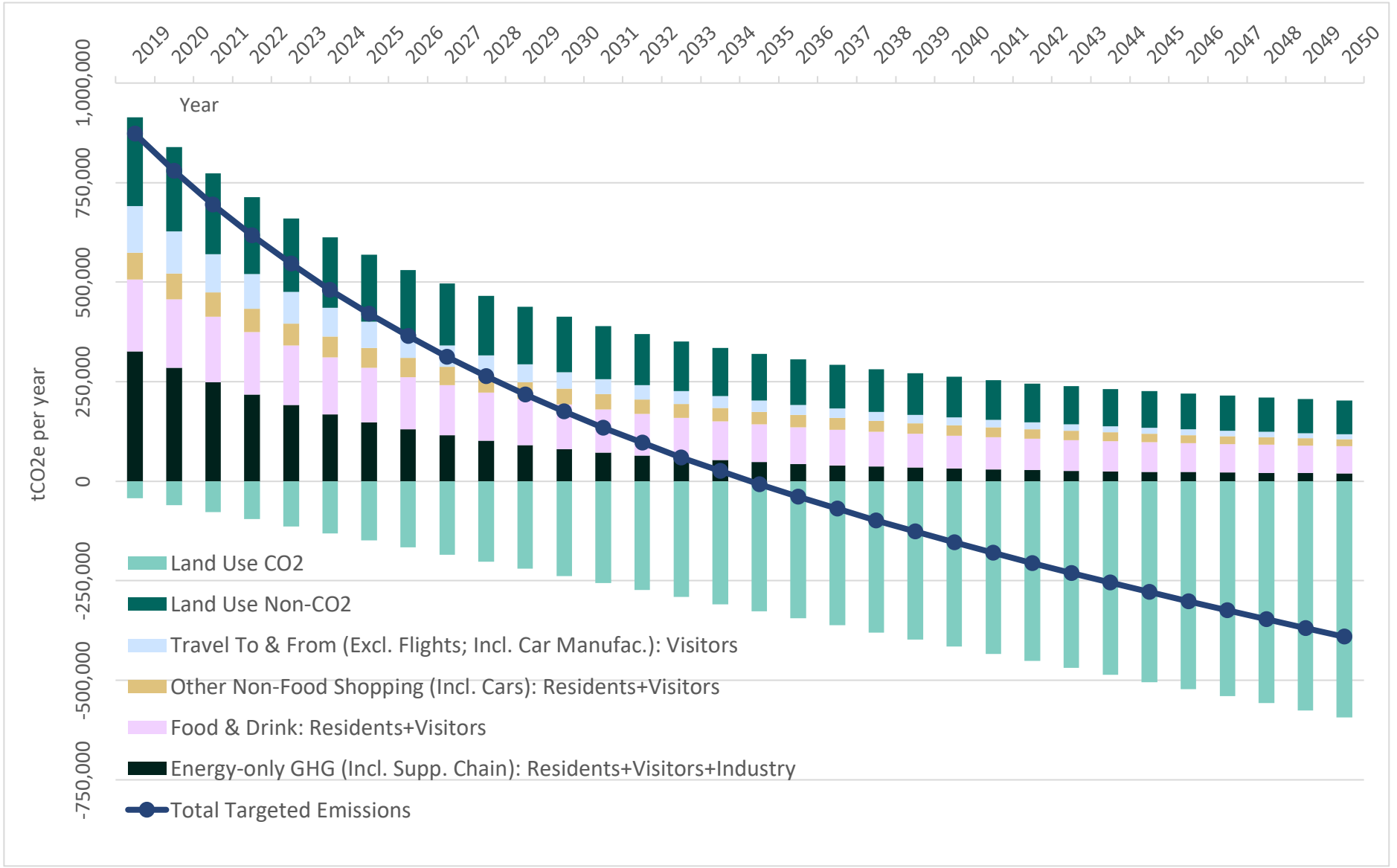


Figure 20. Brecon Beacons National Park: Pathway to Net Zero (repeat of Figure 6)

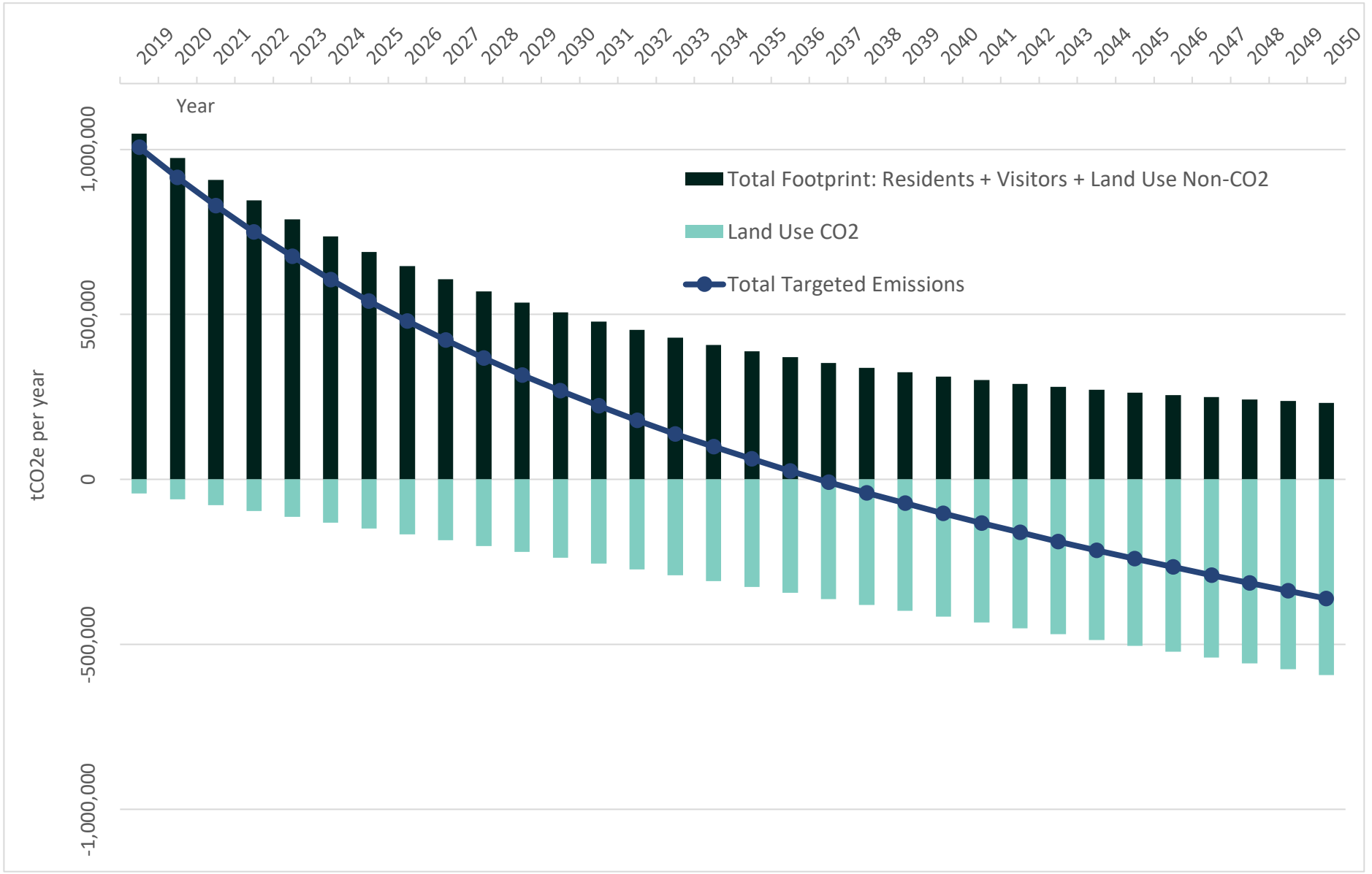


Figure 21. The Brecon Beacons National Park: Alternative pathway to Net Zero (based on full consumption and land use footprint in the area)

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 Brecon Beacons National Park entails strong and decisive action in many areas: construction, direct home energy; food production and diets; travel and transport; business energy use; 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 Park.

The National Park Authority's 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.

Although it is accepted that new-builds present limited opportunities to reduce GHG emissions compared to tackling emissions from residents and existing buildings, these opportunities are still important, as they:

- Aggregate to the existing stock every year,
- Minimise the need for future expensive retrofitting before 2040,
- Demonstrate (more easily) that zero-carbon construction and operation of buildings is technically possible,
- Help stimulate and grow the market for building techniques and products that are more sustainable (also relevant for retrofitting existing buildings), bringing their cost down,
- Encourage existing building owners and occupants to upgrade their properties.

If all the targets proposed in this report were met, the Brecon Beacons would achieve net zero GHG emissions in 2035. It would subsequently reach negative emissions of approximately -390,758 tCO_2e per year by 2050, with carbon sequestration in the Park scaling up to around -593,157 tCO_2e per year, and annual residual emissions dropping to roughly 202,400 tCO_2e across the shortlisted policy priority areas (23% of the present-day carbon footprint baseline).

Although designed to be the minimum 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 Brecon Beacons National Park's net zero goal of 2035 should not be interpreted to mean that the target recommendation is stronger than the UK / Welsh net zero targets of 2050 and 2045, but rather as a reflection of the Park's proportionately

lower territorial emissions per unit area and a greater capacity for carbon sequestration compared to the UK and to Wales as a whole. In our framework, after reaching consumption-based net zero emissions, a landscape may serve to sequester additional carbon to compensate for residual emissions by actors located elsewhere, provided they follow the SBTi net zero standards by eliminating at least 90% of their current Scope 1, 2 and 3 footprint through science-based targets[97].

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 degree of help can be expected to come from government policies, and where this is not sufficient, part of the role of the Brecon Beacons National Park Authority and its partners will be to push for the support needed to ensure that the 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 Welsh and UK Governments, 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 the Brecon Beacons – 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 the Brecon Beacons NP, dominated by New Native Broadleaf/Mixed Woodland and New Productive Coniferous Woodland, 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 CO_2 pathway for land use. However, the goal of 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 and regenerative farming, in line with current recommendations by the UK Government.[98]

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. The Welsh National Parks may also be challenged with

[97] https://sciencebasedtargets.org/net-zero.
[98] UK Sixth Carbon Budget: "Agriculture, Forestry and Other Land Use" section.

mediating a pragmatic solution with stakeholders and special interest groups to the competing land pressures for UK food production, UK timber production, peatland restoration, biodiversity net gain, and the need to grow and support local "living" communities.

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.

Woodland grants and incentives

- Glastir woodland creation grants[99]
- Woodland Carbon Code

Peatland restoration

- Natural Resources Wales capital development grants of £10,000-£30,000 for peatland restoration
- Peatland Code

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.

[99] https://gov.wales/glastir-woodland-creation

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
SPD	Sustainable Construction Supplementary Planning Document
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
I 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: Comparison of Welsh Policy with UK/England policy

UK or England Policy / Targets	Reserved matters or devolved	Equivalent Welsh Policy / Targets	Level of Aspiration	Welsh Policy Link	Notes
Net Zero by 2050	Reserved matters	Net Zero by 2050	Equivalent	https://gov.wales/climate-change-targets-and-carbon-budgets	The UK target applies to Wales, but Wales has its own sub-targets, including interim targets of 63% reduction by 2030 and 89% by 2040 - very similar aspiration to UK interim target of 78% by 2035.
Climate Change Act (2019 amendment)	Reserved matters	Environmental (Wales) Act 2016	Equivalent	https://www.legislation.gov.uk/anaw/2016/3/contents/enacted	The UK Climate Change Act applies to Wales, with some separate provisions for Welsh Ministers. Wales specific emissions targets and reporting requirements are in the Environment (Wales) Act 2016.
Environment Act 2021	Partially devolved	Environmental (Wales) Act 2016		https://www.legislation.gov.uk/anaw/2016/3/contents/enacted	A large amount, but not all, of the policy in the Environment Act 2021 applies to Wales.
HM Government (2021) Net Zero Strategy: Build Back Greener	Reserved matters	Prosperity for All: A Low Carbon Wales (2019)	Slightly lower	https://gov.wales/low-carbon-delivery-plan	Current document only targeting 80% emissions reduction by 2050. Welsh document states updates will follow every 5 years. Contains slightly less detail of implementation than the 2021 Net Zero Strategy.
The Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013	Reserved matters	N/A	N/A	N/A	This is the mandatory reporting of GHG emissions requirement for large UK companies.
The 25 Year Environmental Plan (2018)	Devolved	Environmental (Wales) Act 2016	Not Comparable	https://www.legislation.gov.uk/anaw/2016/3/contents/enacted	The English document is a forward looking overview plan. Wales does not have a comparable '25 year plan', instead having the more detailed Environment Act, and its Nature recovery action plan.
CCC (2020): Land Use: Policies for a Net Zero UK	Reserved matters	The future of land management in Wales (2017)	Lower	https://senedd.wales/laid%20documents/cr-ld10995/cr-ld10995-e.pdf	Both documents are recommendations rather than policy. The CCC advice and targets cover the entire UK. The Welsh document is the advice of the Welsh Climate Change, Environment and Rural Affairs Committee, and has a less clear focus on sustainability, tree planting, and red meat reduction.

CCC (2020): The Sixth Carbon Budget Agriculture and land use, land use change and forestry	Reserved matters	N/A	N/A	N/A	CCC advice and targets cover the entire UK. The Sixth Carbon Budget was made law in the UK by The Carbon Budget Order 2021.
England Peatland Action Plan (2021)	Devolved	National Peatland Action Programme (Wales), 2020-2025	Slightly lower	https://cdn.cyfoethnaturiol.cymru/media/692545/national-peatlands-action-programme.pdf	Wales aims to restore 0.66-0.7% of its deep peat annually (600-800ha per year), with no mention of shallow peat or protection from burning. The English target is for 35,000ha over 5 years (1% of deep peat) and protection of 142,000ha from managed burning.
National Food Strategy Independent Review: The Plan (2021)	Devolved	Food for Wales, Food from Wales 2010 2020	Lower	https://gov.wales/sites/default/files/publications/2018-05/food-strategy-for-wales-2010-to-2020.pdf	The Welsh document has a lower priority on the sustainability of food production and consumption, with less discussion of the high emissions of ruminant animals and products. An updated "Food (Wales) Bill" is currently being prepared.
National Farmers Union (2021) Achieving Net Zero Farming's 2040 goal.	Separate Organisations	NFU Cymru Net Zero goal for 2040	Equivalent	https://www.nfu-cymru.org.uk/archive?treeid=145025#:~:text=NFU%20Cymru%20and%20the%20NFU,of%20net%20zero%20by%202050.	The 2040 date for all GHGs is in line with the English NFU.

10.2. Appendix: National Park key statistics

Output Variable	Value	Unit	Source		Output Variable	Value	Unit	Source
Land Area	**142,039**	ha	Official Figures / CEH LCM					
Resident Population	**37,681**	persons	ONS Mid-2019 LSOA Population; ONSPD 2019; BEIS 2019 Postcode Electricity Meters; Custom Postcodes		Average Visitors Per Day	**15,521**	persons	STEAM 2019
Resident Population Density	**0.27**	persons per ha	Based on the Above		Visitor Population Density	**0.11**	persons per ha	Based on the Above
Annual Final Consumption (Households + Public Services)	**31,951**	£ per person per year	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes		Annual Visitors Spend	**200,401,007**	£ per year	STEAM 2019
Annual Household Fuel per Resident	**7,831**	kWh per person per year	BEIS 2019 Postcode Gas; BEIS 2018 Residual Fuels; ONSPD 2019; Custom Postcodes		Annual Visitors All Types	**4,306,236**	persons per year	STEAM 2019
Annual Household Electricity per Resident	**1,428**	kWh per person per year	BEIS 2019 Postcode Electricity; ONSPD 2019; Custom Postcodes		Percentage of Visitors Staying Overnight	**10.2%**	percentage	STEAM 2019
Annual Vehicle Fuel per Resident	**5,918**	kWh per person per year	BEIS 2018 Road Fuels; ONSPD 2019; Custom Postcodes		Average Duration of Stay for Overnight Visitors	**4.1**	days	STEAM 2019
Annual Personal Flights per Resident, Economy Class	**1.25**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate		Average Visitor Party Size	**3.2**	persons	Visitor Survey
Annual Personal Flights per Resident, Business Class	**0.006**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate		Average Visitor One-Way Road/Train/Boat Mileage Travelled	**92**	miles	Visitor Survey
Average Resident One-Way Mileage per Flight, Economy Class	**1,793**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes		Estimated Fraction of Trips by Car	**81.2%**	percentage	Visitor Survey
Average Resident One-Way Mileage per Flight, Business Class	**6,743**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes		Estimated Fraction of Trips Involving Flights	**5.0%**	percentage	Visitor Survey
Annual Business Turnover, COA-based	**2,635,597,000**	£ per year	IDBR 2019; ONSPD 2019; Custom Postcodes		Average Visitor One-Way Mileage per Flight, Economy Class	**3,072**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Percentage of Suppressed Turnover Output, COA-based	**44.22%**	percentage	IDBR 2019; ONSPD 2019; Custom Postcodes		Average Visitor One-Way Mileage per Flight, Business Class	**3,422**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes

10.3. 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

10.4. 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

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Residents' GHG emissions: Brecon Beacons National Park

Consumer Expenditure Categories Summary	ALL Scopes	Units
Household Fuel	69,846	tCO_2e per year
Household Electricity	18,237	tCO_2e per year
Vehicle Fuel	76,305	tCO_2e per year
Car Manufacture & Maintenance	18,399	tCO_2e per year
Personal Flights	60,353	tCO_2e per year
Ferry Crossings & Cruises	6,363	tCO_2e per year
Trains, Buses & Other Transport	11,683	tCO_2e per year
Food & Drink	130,828	tCO_2e per year
Accommodation (Non-Home) Excl. Food	2,418	tCO_2e per year
Other Non-Food Shopping	36,054	tCO_2e per year
Water, Waste & Sewerage	7,659	tCO_2e per year
Other Bought Services	35,646	tCO_2e per year
Housing	27,299	tCO_2e per year
Health, Education, Other Public Services & Administration	50,684	tCO_2e per year
Leisure, Recreation & Attractions	9,227	tCO_2e per year
Total	**561,000**	**tCO_2e per year**

NOTE: The total may differ slightly from the sum of individual components due to rounding

10.6. Appendix: Visitors' GHG emissions

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Visitors' GHG emissions: Brecon Beacons National Park

- *"Household Fuel" & "Household Electricity" apply to visitors staying with friends and relatives*
- *"Accommodation" includes electricity, gas and other fuels used by hotels and B&Bs*

NOTE: The total may differ slightly from the sum of individual components due to rounding

Consumer Expenditure Categories Summary	**In NP**	**To & From NP**	**Units**
Household Fuel	714	0	tCO_2e per year
Household Electricity	186	0	tCO_2e per year
Vehicle Fuel	15,953	90,761	tCO_2e per year
Car Manufacture & Maintenance	4,039	22,979	tCO_2e per year
Personal Flights	0	46,825	tCO_2e per year
Ferry Crossings & Cruises	0	0	tCO_2e per year
Trains, Buses & Other Transport	532	3,025	tCO_2e per year
Food & Drink	49,886	0	tCO_2e per year
Accommodation (Non-Home) Excl. Food	9,670	0	tCO_2e per year
Other Non-Food Shopping	9,321	0	tCO_2e per year
Water, Waste & Sewerage	3,506	0	tCO_2e per year
Other Bought Services	5,590	0	tCO_2e per year
Housing	0	0	tCO_2e per year
Health, Education, Other Public Services & Administration	0	0	tCO_2e per year
Leisure, Recreation & Attractions	1,326	0	tCO_2e per year
Total	**100,722**	**163,590**	**tCO_2e per year**

10.7. Appendix. Industry footprint estimates

10.7.1. 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 conditioning 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 Metadata

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

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Industry GHG emissions (IDBR-based): Brecon Beacons National Park

** Large emitters report Scope 1 only; depending on the underlying IDBR data quality, they may not be fully included in the industry figures*

*** For information*

NOTE: The total may differ slightly from the sum of individual components due to rounding

Industry Categories Summary (IDBR sectors)	ALL Scopes	Units
Agriculture, forestry & fishing	78,815	tCO2e per year
Production	102,179	tCO2e per year
Construction	38,907	tCO2e per year
Motor trades	2,070	tCO2e per year
Wholesale	1,948	tCO2e per year
Retail	8,497	tCO2e per year
Transport & storage (inc. postal)	9,812	tCO2e per year
Accommodation & food services	10,098	tCO2e per year
Information & communication	960	tCO2e per year
Finance & insurance	296	tCO2e per year
Property	1,594	tCO2e per year
Professional, scientific & technical	8,473	tCO2e per year
Business administration & support services	20,833	tCO2e per year
Public administration & defence	5,979	tCO2e per year
Education	2,608	tCO2e per year
Health	73,704	tCO2e per year
Arts, entertainment, recreation & other services	3,161	tCO2e per year
Total	**369,934**	**tCO2e per year**
ENERGY-ONLY INDUSTRY (subset of INDUSTR– -- Brecon Beacons National Park		
Industry Road Fuels	52,899	tCO2e per year
Industry Fuels Excl. Road	79,708	tCO2e per year
Industry Electricity	11,471	tCO2e per year
Total		
LARGE EMITTERS (Scope 1) * -- Brecon Beacons National Park		
Large Emitters	**-**	**tCO2e per year**
INDUSTRY-RELATED FLIGHTS (subset of INDUSTRY) ** -- Brecon Beacons National Park		
Industry-related flights	**6,579**	**tCO2e per year**
Land use -- Brecon Beacons National Park		
Land Use CO2	**- 42,190**	**tCO2e per year**
Land Use Non-CO2	**223,413**	**tCO2e per year**

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IDBR vs. GVA Industry Footprint Estimates: Brecon Beacons National Park

Industry Categories Summary (IDBR sectors)	NP OA-based IDBR Industry Footprint (per resident)	NP LA-based GVA Industry Footprint (per resident)	Units
Agriculture, forestry & fishing	2.09	0.48	tCO_2e/person/year
Production	2.71	3.51	tCO_2e/person/year
Construction	1.03	0.48	tCO_2e/person/year
Motor trades	0.05	0.10	tCO_2e/person/year
Wholesale	0.05	0.19	tCO_2e/person/year
Retail	0.23	0.38	tCO_2e/person/year
Transport & storage (inc. postal)	0.26	0.63	tCO_2e/person/year
Accommodation & food services	0.27	0.23	tCO_2e/person/year
Information & communication	0.03	0.07	tCO_2e/person/year
Finance & insurance	0.01	0.03	tCO_2e/person/year
Property	0.04	0.03	tCO_2e/person/year
Professional, scientific & technical	0.22	0.10	tCO_2e/person/year
Business administration & support services	0.55	0.21	tCO_2e/person/year
Public administration & defence	0.16	0.35	tCO_2e/person/year
Education	0.07	0.25	tCO_2e/person/year
Health	1.96	0.48	tCO_2e/person/year
Arts, entertainment, recreation & other services	0.08	0.08	tCO_2e/person/year
Total	**9.82**	**7.60**	**tCO_2e/person/year**

NOTE: The total may differ slightly from the sum of the individual components due to rounding

10.7.4. Appendix: Pollution inventory for large emitters

Pollution Inventory: Large Emitters, All National Parks (2018 data)					
National Park	**LAD14NM**	**Operator**	**Site**	**Postcode**	**CO_2 emissions (kt)**
The Broads National Park	Broadland	British Sugar Plc	Cantley	NR13 3ST	120.77
Peak District National Park Borders	Derbyshire Dales	HJ Enthoven & Sons Ltd	Darley Dale	DE4 2LP	25.8
Peak District National Park	Derbyshire Dales	Tarmac Ltd	Ballidon Quarry	DE6 1QX	0.002702
Peak District National Park	High Peak	Hope Construction Materials Ltd	Hope Works	S33 6RP	1,048.88
South Downs National Park	Horsham	Viridor Waste Management Ltd	Horton Landfill	BN5 9XH	16.9
South Downs National Park	Lewes	Veolia ES South Downs Ltd	Newhaven EfW Plant	BN9 0HE	201.6
New Forest National Park	New Forest	Cleansing Service Group Ltd	Pound Bottom Landfill	SP5 2PU	13.4
North York Moors National Park	Redcar and Cleveland	Cleveland Potash Ltd	Saltburn-by-the-Sea	TS13 4UZ	13.7
New Forest National Park	Wiltshire	Renewable Power Systems Ltd	Pound Bottom Landfill	SP5 2PU	3.8

10.8. Appendix: Emissions from major roads

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Emissions from major roads: Brecon Beacons National Park

- *(*) Through-Traffic refers to vehicles passing through the NP without visiting. It is not included in the residents', visitors' or industry footprints. It is estimated by comparing total traffic point counts with pump-level fuel sales within each NP*
- *(**) The Larger and Smaller subsets of selected A-roads include elements of through-traffic as well as traffic from residents, visitors and industry.*

SELECTED A-ROADS – SMALLER SUBSET ** – Brecon Beacons National Park		
Road Names, Smaller Subset	A40 + A470	
Cars, Buses & Motorbikes	41,939	tCO_2e per year
Vans & Lorries	26,035	tCO_2e per year
Total	**67,974**	**tCO2e per year**
SELECTED A-ROADS – LARGER SUBSET ** – Brecon Beacons National Park		
Road Names, Larger Subset	A40 + A470 + A465 + A479	
Cars, Buses & Motorbikes	74,164	tCO_2e per year
Vans & Lorries	46,841	tCO_2e per year
Total	**121,005**	**tCO2e per year**
THROUGH-TRAFFIC * – Brecon Beacons National Park		
Cars, Buses & Motorbikes	58,051	tCO_2e per year
Vans & Lorries	36,438	tCO_2e per year
Total	**94,489**	**tCO_2e per year**

10.9. Appendix: Methodology

10.9.1. 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.

10.9.2. Appendix: Model development for the National Park 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 datasets used in the carbon footprint model is provided in Appendix 10.3.

10.9.3. 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 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 10.3.

10.9.4. Appendix: Assumptions for visitors’ surveys

Modes of transport

The 2016-17 Brecon Beacons Visitors Survey provided data for travel *within* the Park, but not to/from the Park. The assumption was made that travel to and from the Park followed the same distribution. The Brecon Beacons data had a shared category for cars/vans, so to approximate the split of private cars to motorhomes/vans, Cairngorms visitors survey data was used, with it being one of the few National Parks to provide this breakdown.

Inferring visitors' Flights Share

No data was provided on the number of overseas visitors arriving by plane. The mode of transport within the Park data showed 4% of visitors travelling by hire car, and 1% by private bus tour. These visitors were assumed to have flown to the UK, hence their requirement for a hire car / tour vehicle. Data was provided giving the proportion of overseas visitors, and the majority of their countries of origin. Any visitors from outside Europe were assumed to fly, and visitors from within Europe were allocated the remainder of the calculated flight share, with those left over assumed to have travelled by land to the UK.

10.9.5. Appendix: Target-setting rationale

Each component of the overall emissions reduction target has been judged to represent a "maximum effort" technically possible, subject to the uncertainties involved. At the same time, this high level of ambition likely represents an absolute 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, given the limited progress in reducing global emissions to date and the small carbon budget remaining within the 1.5°C target[100]. 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 7 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 7: High-level comparison between target-setting methodology and assumptions used for Cumbria (old) and National Park (new)

Category[101]	Previous model for Cumbria (2020)	New model for all National Parks (2021) – used in this report	Asymptote (Achievable ceiling)
Energy-only emissions	13% per year reduction in energy-	**13.5%** (specific to Brecon Beacons National Park) per year	**5%** of present-day emissions. This is our expert

[100] https://www.ipcc.ch/assessment-report/ar6/.

[101] The targets for the six broad categories of emissions shortlisted here are generally aligned with the more granular decarbonisation roadmaps for individual industry sectors and households proposed by the Sixth Carbon Budget (Section 2.4), as well as by the National Food Strategy (for food-related emissions).

by residents, visitors and industry	related CO_2 (as prescribed by the Tyndall Carbon Budget Tool[102]). Includes Scope 1 and 2 carbon dioxide emissions only (excl. 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 energy-related GHG emissions expressed as 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% of emissions reduction per year from dietary changes (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), which states 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, including purchases of 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 sectors (via supply chains) such as cement and steel that will take time to decarbonise globally (affecting car manufacturing, buildings, etc.).

[102] 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/

Land Use	Expert judgement based on discussions with stakeholders involved	We have split land use into Land Use Non-CO_2 and Land Use CO_2. See Table 8 for further details.	**30%** of present-day emissions for Land Use Non-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 Appendix 10.9.9. Table 8 below provides a brief overview.

Table 8. 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 13. 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 Brecon Beacons, the proposed land use measures are estimated to add 17,773 tCO_2e/year to the total carbon sequestration flux in the landscape each year (i.e. an extra 17,773 tCO_2e removed per year in each of the subsequent years).

10.9.6. 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[103]. 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 9 and Table 10.

Table 9: 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 (CO_2) from fossil fuel use	11%	6.0 $MtCO_2e$
Total	**100%**	**54.6 $MtCO_2e$**
Data Source: The Sixth Carbon Budget: Agriculture and land use, land use change and forestry, p.6		

"Emissions 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: Baseline for Agriculture emissions (2018) using Global Warming Potential of AR5 for methane

	Percentage of UK agriculture emissions	**Quantity of CO_2 equiv.t**
Agriculture breakdown		*SWC planning assumptions*
Methane from livestock (from 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 $MtCO_2e$

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

Other	2%	1.1 $MtCO_2e$
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		

10.9.7. 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[104]. 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 wetlands • 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 for the pool of harvested wood products, category (4G) to describe the carbon pool in harvested wood products.

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

10.9.8. Appendix: Changes in methodology for quantifying GHG emissions from peatland

In 2017 the Centre for Ecology and Hydrology proposed changes to the methodology for reporting emissions from peatlands[105]. 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[106].

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 11). 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.

[105] 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.
[106] Ricardo Energy & Environment UK NIR 2020 (Issue 1), "UK GHG Inventory 1990-2019," Annex p. 854.

Table 11. 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.

10.9.9. 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)[107] according to present-day land use distribution in each National Park. 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 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[108], which is based on the assessment by Evans *et al.* (2017)[109].

For the Brecon Beacons National Park, the current land use distribution is illustrated in Table 12. It is based on the 2019 CEH Land Cover Map and the Unified Peatland Map of Wales. 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 13.

[107] UK's Sixth Carbon Budget: "Agriculture and land use, land use change and forestry" (AFOLU) report. Climate Change Committee, 2020.
[108] Ricardo Energy & Environment, UK NIR 2020 (Issue 1) "UK GHG Inventory 1990-2019," Annex p. 854.
[109] 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.

At roughly 142,039 ha, Brecon Beacons accounts for around 0.6% of the UK's total land area, while the National Park's current share of tree cover is 30% 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/mixed 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.

We use the Unified Peatland Map of Wales to estimate the peatland extent in the National Park, in line with all Welsh designated landscapes on the current programme. According to the Unified Peatland Map, peatland accounts for 6,347 ha (4.5%) of the Brecon Beacons' land area, which is roughly 60% lower than the UK average per unit area. However, there remains a considerable uncertainty regarding the peatland extent in the Park, with an alternative estimate by ADAS suggesting nearly 16,000 ha[110]. Reconciling these estimates can only be achieved through ground-truthing, which is ongoing at the time of writing. Regardless of the estimate, restoring peatland can make a meaningful contribution to reducing land-based emissions in the National Park, even though it still needs to be a priority.

The Brecon Beacons improved grassland and cropland areas are estimated to be 12% higher and 96% 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 12. Brecon Beacons: Key land use types by area (present-day), including underlying peat areas and the estimated percentage of peat in a healthy condition (by area). The peatland extent estimates are based on the Unified Peatland Map of Wales, which are understood to be on a conservative side subject to a further ground-truthing

Land Cover (Habitat) Type	**Habitat Area (ha)**	**Peat Area (ha)**	**Estimated % of Peat Area in Healthy Condition**
Broadleaved woodland	12,711.0	19.0	25%
Coniferous woodland	11,863.0	112.0	0%
Arable and horticulture	1,333.0	0.0	NA
Improved grassland	40,278.0	31.0	0%
Neutral grassland	0.0	0.0	NA
Calcareous grassland	2.0	0.0	NA
Acid grassland	62,666.0	4,577.0	25%
Fen, marsh, swamp	0.0	0.0	NA
Heather	2,153.0	88.0	25%
Heather grassland	7,313.0	1,373.0	25%
Bog	703.0	146.0	25%
Saltmarsh	0.0	0.0	NA
Urban	30.0	0.0	NA
Suburban	1,911.0	1.0	0%
Total	**140,963.0**	**6,347.0**	**NA**

[110] ADAS (2015) "Mapping and assessing the status of upland peat bodies, Brecon Beacons National Park".

Table 13. Brecon Beacons: Areas of the main land cover (habitat) types compared with the relevant UK totals. The peatland extent estimates are based on the Unified Peatland Map of Wales, which are understood to be on a conservative side subject to a further ground-truthing

Land Cover Type	Current UK Area (ha)	Current NP Area (ha)	NP Area as % of UK Area
Broadleaf woodland	1,572,900	**12,692**	**0.802%**
Coniferous woodland	1,637,100	**11,751**	**0.713%**
Improved grassland (mineral soils only)	6,161,798	**40,247**	**0.653%**
Cropland (mineral soils only)	5,788,356	**1,333**	**0.023%**
Degraded Peatland (all types)	2,182,455	**4,796**	**0.220%**
Total woodland area (Broadleaf + Coniferous)	3,210,000	**24,443**	**0.761%**
Total Agricultural Area (improved Grassland + Cropland)	11,950,154	**41,580**	**0.348%**
Total Area of Selected Land Cover Types (above)	18,070,094	**70,819**	**0.408%**
Total Area (incl. urban, rough grassland, water, rock, etc.)	24,249,500	**142,039**	**0.586%**

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 (where applicable)
- Peatland restoration (across all degraded types, where applicable)
- Agroforestry (for improved grassland and cropland, where applicable)
- Hedgerows (for improved grassland and cropland, where applicable)
- Introducing legume grass species (for improved grassland, where applicable)
- Introducing cover crops (for cropland, where applicable)

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 13 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, peatland, calcareous grassland, lowland heathland, 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 (for example, excluding ecologically important breeding ground for rare species). We note that relatively large areas of the acid grassland and upland heathland habitats tend to contain both deep and shallow peat, typically classified as modified bog dominated by heather/grass, either drained or undrained. 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 Brecon Beacons in Table 14. 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 on these principles, the custom woodland target for Brecon Beacons is 800 ha/yr., which includes an empirical 18% cap on the total area of new woodland that could be created within a given landscape over a 30-year period[111].

Table 14. Three ways of setting new woodland targets in Brecon Beacons NP.

Total Woodland Target Apportioned by Wood. LC Area in NP	**378**	ha/yr.
Total Woodland Target Apportioned by NP Area	**623**	ha/yr.
Total Custom Woodland Target in NP	**800**	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

[111] The 18% cap was applied to a small number of National Parks and AONBs on the programme that produced the highest woodland targets, given the landscapes' respective areas, following the high-level opportunity mapping procedure. The magnitude of the cap is driven by the overall long-term ambition for the share of UK's land containing woodland, as outlined in the Sixth Carbon Budget.

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.

In this assessment, we propose to use the 80%-20% woodland cover split for the Brecon Beacons National Park, to balance the broader environmental and social benefits of native woodland with the economic importance of productive coniferous woodland, when also managed for biodiversity.

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[112]. 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)[113].

Peatland restoration (where applicable)

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 (where applicable). 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 10.9.8). The sub-targets are based on the estimated current areas of the relevant degraded peatland types (Table 12).

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

[112] UK's Sixth Carbon Budget, AFOLU report, page 27.
[113] Bossio, D. A., et al. (2020). "The role of soil carbon in natural climate solutions." Nature Sustainability, 3(5), 391-398.

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.

As with the peatland classification, our peatland emissions factors follow the BEIS methodology (Section 10.9.8). 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 (where applicable)

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 (where applicable). 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.

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 (where applicable), 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 (where applicable)

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 (where applicable). 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 (where applicable)

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 (where applicable). 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 Brecon Beacons National Park

Table 15 summarises the proposed land use change and management targets for the Brecon Beacons NP, which follow the principles outlined above.

Table 15. Land use targets and the associated additional carbon sequestration fluxes per year (emissions reduction for peat) for the Brecon Beacons National Park. Note that the peatland restoration estimates are based on the Unified Peatland Map of Wales, which are understood to be on a conservative side subject to a further ground-truthing.

Land Use / Management Category	Land Use Change Target (ha/yr)	Change in Carbon Flux ($tCO_2e/yr/yr$)
New Native Broadleaf/Mixed Woodland	**640**	**-11,812**
New Productive Coniferous Woodland	**160**	**-3,539**
Agroforestry (improved grassland & cropland)	**105**	**-246**
Hedgerows (improved grassland & cropland)	**6**	**-64**
Grazing Legumes (improved grassland)	**790**	**-1,622**
Cover Cropping (cropland)	**26**	**-31**
Restored Eroding Modified Bog (bare peat), Drained	**5**	**-64**
Restored Eroding Modified Bog (bare peat), Undrained	**0**	**0**
Restored Modified Bog (heather/grass-dominated), Drained	**105**	**-374**
Restored Modified Bog (heather/grass-dominated), Undrained	**1**	**-3**
Restored Cropland Peat, Drained	**0**	**0**
Restored Intensive Grassland Peat, Drained	**0**	**0**
Restored Extensive Grassland Peat, Drained	**1**	**-10**
Restored Forested Peat, Drained	**3**	**-10**
Total	**1,842**	**-17,773**

10.10. Appendix: Additional considerations regarding woodland targets[114]

In comparison to the notional woodland target of 800 ha per year proposed for the Brecon Beacons National Park in this assessment, recent progress has been slow under the Glastir woodland creation schemes for the past 10 years.

Achieving any woodland target will rely on the effectiveness of the delivery mechanisms available, including the funding, volume of the personnel to deliver, and strength of relationship building with farmers and other landowners. In the current policy and market context, the actual amount of new woodland planted will be based on the following contributions:

- Woodland grants under the Sustainable Farming Scheme
- Proposed new small woodland creation grant scheme by the Welsh Government
- Private initiatives
- Natural regeneration through reduction in agricultural activity, including reducing grazing pressure
- Direct project intervention, e.g. Nature Recovery Action Plans (Actions 3.1, 3.2), small grants by the Welsh Government, and new Sustainable Management Scheme proposal

The high-level land use opportunity methodology developed in this assessment (Appendix 10.9.9), including the notional woodland target, does not account for the Woodland Opportunity

[114] This section was written jointly with Paul Sinnadurai, Senior Ecologist (Climate Adaptation), Brecon Beacons National Park Authority.

Mapping[115] and Working With Natural Processes mapping[116] by the Welsh Government and the Natural Resources Wales, nor does it include the Ecological Network and Resilience mapping by the Brecon Beacons Natural Park. Being based on the available habitat and peatland maps in England, Scotland and Wales, the methodology was designed to be generic for all UK's National Parks and AONBs on the programme. As is stated in the relevant sections in the report (5.6.1, 10.9.9), it provides a consistent framework for all the landscapes on the programme, but requires a field-level opportunity mapping to account for the ecological, economic and social constraints.

It is worth noting the Glastir woodland creation grant exclude semi-natural habitats such as heather moorland, species-rich neutral grassland and upland acid grassland, focusing mainly on improved pasture. In contrast, the methodology introduced here assumes that 50% of upland heathland and neutral grassland, and 75% of upland acid grassland can be **considered** for woodland opportunity mapping. The latter means that, in reality, relatively small fractions of the mapped 50% or 75% of the corresponding habitat areas will be forested in the long run. At the same time, we limit the woodland opportunity mapping to only 25% of the improved grassland and arable habitats, which means that even smaller fractions of these areas are likely to be forested in the long run. The rationale behind this approach is to ensure the most productive agricultural land remains in food production, especially where it is possible to grow crops, in order to achieve a greater food security (Section 5.6.4), while recognising that a bigger share of semi-natural areas with rough grazing may need to be transformed into woodland habitats to meet the joint climate and biodiversity objectives.

While considering semi-natural habitats for woodland projects, it is important to take into account the following:

- Species-rich neutral grassland is a habitat of principal importance to Wales (Section 7 Environment (Wales) Act), supporting a range of species of principal importance. Neutral grassland, even where it is improved pasture, might prove to be vital for the Important Curlew Areas, for example. On the other hand, we do need to see a recovery of floodplain wood pasture and parkland, and riparian treescapes;
- Upland acid grasslands can be important locations for species of principal importance to Wales, including species protected under the Habitats Regulations, and regionally and nationally rare waxcap fungi. They might also be important wintering grounds for upland birds, as well as spring ground-nesting birds;
- Upland heathland is a habitat of principal importance to Wales, supporting a range of species of principal importance. Most areas of this habitat in the Brecon Beacons National Park are also designated as SSSIs;
- Upland acid grassland and heathland are at significant risk of arson-related wildfire each late winter/early spring. This risk would apply to any new woodland plantations within these habitats.

Targeting rough grazing areas, improved pastures and arable land for woodland creation projects might be feasible where tree planting and, importantly, natural regeneration, are presented in tandem with other measures, for example restoration of wetlands (reversing land drainage),

[115] https://datamap.gov.wales/maps/woodland-opportunity-map-2021/view#/
[116] https://lle.gov.wales/catalogue/item/WWNPRiparianWoodlandPotentialWales/?lang=en

nutrient stripping, and other complementary habitat improvements. Promoting green jobs, collaborations and co-operative ventures that might emerge where, for example, neighbouring farms work together to achieve benefits at scale, is also going to be crucial. Making the Payment for Ecosystem Services scheme and other natural capital accounting schemes work locally, rather than relying on external corporate offsets (which carry a higher risk of "greenwashing"), might help support the emergence of *local* public benefit supply chains, where farmers and other landowners can see the local beneficiaries of the nature recovery projects.

10.11. Appendix: Welsh climate policy framework[117]

In its recent remit letter to the Welsh National Parks, the Welsh Government has asked the Parks to "*become exemplars in responding to the climate and nature emergency. You are uniquely placed to engage with the communities within your boundaries to develop solutions which deliver benefits for people and the environment".* We interpret "exemplary" to mean maximising the efforts towards or beyond the fair share of actions to keep global temperature rise below 1.5°C in line with the science and equity principles of the Paris Agreement. We also think that accounting for and reducing embedded GHG emissions (the approach taken in this assessment) has to be part of the efforts to mitigate climate change by wealthier countries, given that they are responsible for the biggest share of global GHG emission to date, and are in the position to play a leadership role in transitioning to a low-carbon economy.

Both the UK and the Welsh Governments currently set targets only for territorial emissions occurring within their geographical boundaries, which is referred to as the production-based approach and is different from the consumption-based approach adopted here, with the latter accounting for embedded emissions of goods, services and, in a broader sense, of people's lifestyles (Section 4). Inevitably, the targeted categories of emissions and the associated levels of ambitions are going to be different and cannot be mapped onto one another easily.

The Welsh Government's engagement approach to addressing climate emergency focuses on the territorial (production-based) emissions from following eight sectors within the local authorities and for Wales as a whole:[118]

- Agriculture
- Land Use Land Use Change and Forestry
- Transport
- Electricity and Heat Generation
- Industry and Business
- Waste
- Residential Housing
- Public Sector

In contrast, our assessment considers embedded emissions of food and other goods and services consumed within a given region, most of which are imported from other parts of the UK and from abroad (Sections 5 and 6). Our emissions reduction targets contain elements of both the

[117] This section was written jointly with Liz Hutchins, Senior Policy Advisor, Brecon Beacons National Park Authority.
[118] https://gov.wales/sites/default/files/publications/2022-08/engagement-approach-around-climate-change-2022-26.pdf.

consumption-based and production-based footprint estimates, as described in detail in Section 6. Together with the unique characteristics of the National Park, including its land use, these methodological choices imply that the decarbonisation pathway proposed in this assessment is different to the 2050 production-based target for the whole of Wales.

There is currently a gap in the Welsh Government's "Working Together to Reach Net Zero" framework for climate action[119] because it doesn't systematically address area-based emissions reduction planning by the unitary local authorities and National Parks. Therefore, there is an opportunity for the Brecon Beacons National Park and other designated landscapes and unitary authorities in Wales to innovate best practice in this space. This could be achieved by working with partners from the global "Race to Zero" coalition[120], to which Wales is a formal member, and by adopting the carbon accounting and emission reduction recommendations proposed in this report.

[119] https://gov.wales/sites/default/files/publications/2022-04/working-together-to-reach-net-zero-all-wales-plan-april-22-update.pdf.
[120] https://unfccc.int/climate-action/race-to-zero-campaign.