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

A report by Small World Consulting Ltd

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Executive summary

Background

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

Together, the UK's 14 National Parks (NPs), The Norfolk and Suffolk Broads, 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 South Downs National Park, is one of a series of methodologically compatible reports produced for each UK National Park and Welsh AONB, with the Cotswolds AONB and Cannock Chase AONB also joining. They are designed to provide a robust and consistent evidence basis for climate action, matched to the unique characteristics and circumstances of each protected landscape, as we enter an era in which climate mitigation and sustainable land management become ever more central to all our lives, our work and to all policy decisions.

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

Consumption-based emissions reporting differs from more traditional production-based reporting, such as that used by the UK in setting its 2050 net zero target. A production-based assessment would cover all the emissions that are directly produced within the boundary of the landscape whether by people or businesses or from land, 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.

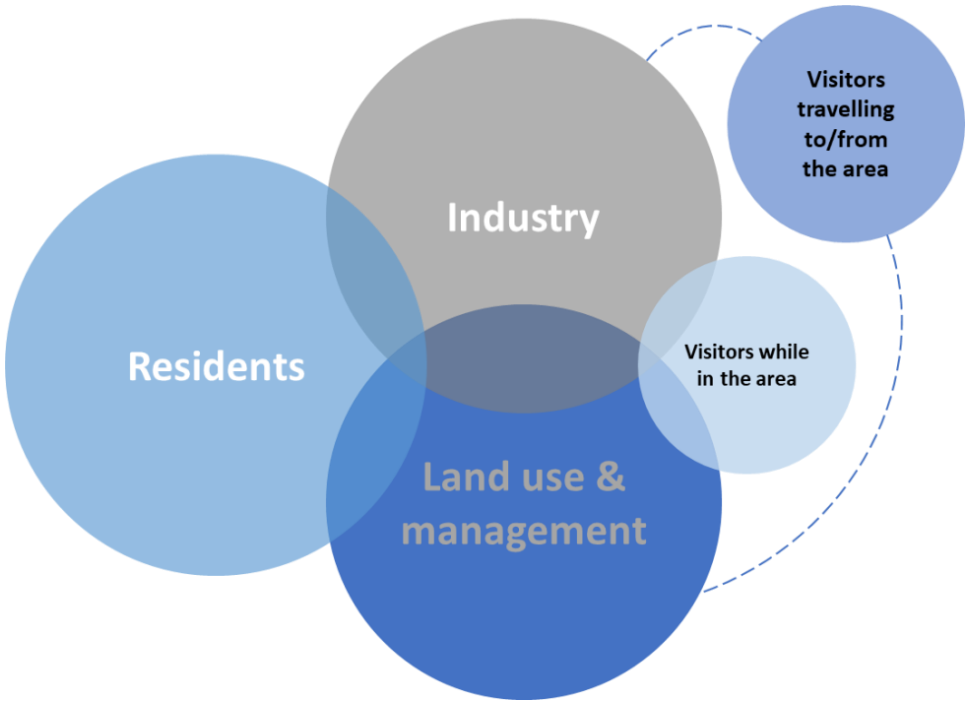


Figure 1: Boundaries of the greenhouse gas footprint assessment

One feature of consumption-based reporting is that it does not include emissions from industry (except where an industry's goods and services are consumed by residents and visitors). 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.

This report also 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 by residents, visitors and industry
- Food and drink consumed by residents and visitors

- Other goods purchased by residents and visitors
- Visitor travel to and from the National Park or AONB
- Land use non-CO_2 component (including emissions from livestock and fertilisers)
- Land use CO_2 component (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.

Results

South Downs National Park	
Annual emissions from residents	**2,185,545 tCO_2e** (15.5 tCO_2e per person per year)
Annual emissions from visitors while in the National Park	**287,108 tCO_2e** (14.1 $kgCO_2e$ per visitor-day)
Annual emissions from visitors travelling to/from the National Park	**460,814 tCO2e** (24.3 $kgCO_2e$ per visit)
Annual industry emissions	**1,415,499 tCO_2e**

Key highlights

The South Downs National Park has the largest residential population among all the National Parks in the UK. Its average residents' household spending excluding public services is 11.1% above the UK average. This is slightly below the estimated average household spending across all UK National Parks (12.9% above the UK average). Demographic data points towards a mix of working age population and retired population.

In a given year, the footprint of the residents in the South Downs National Park is estimated to be 25.6% higher than the UK average. Several fossil fuel-based sources of greenhouse gas emissions are particularly high: residents' emissions from flying are estimated to be nearly three times higher than for an average UK resident, while emissions from driving and other transport are around 26% and 21% above the UK average, respectively. Household electricity emissions are around 27% higher than for an average UK resident, and household fuel emissions (excluding driving) are estimated to be around 11% above the UK average. It must be noted that our estimates for emissions from household fuel and electricity use do not include renewable energy solutions such as solar panels and heat pumps, nor do they factor in the uptake of electric vehicles. As of 2019, the share of these technologies across households was comparatively low and no suitable data with sufficient geographical detail was available. The footprint from household fuel use (excluding driving) is particularly uncertain since there is insufficient data for residual fuel use (oil, coal, biomass).

The footprint of visitors while travelling to and from South Downs is around 60% higher than their footprint while in the National Park. The largest component of the footprint of the South Downs visitors while in the National Park is food and drink (62%), followed by driving (14%). Estimated average one-way mileage travelled on land to get to South Downs (40 miles) and proportion of visitors staying overnight (3.6%) are some of the lowest among all National Parks and AONBs on the programme. South Downs visitors' footprint while travelling to and from the National Park is dominated by driving (43%) and flying (41%).

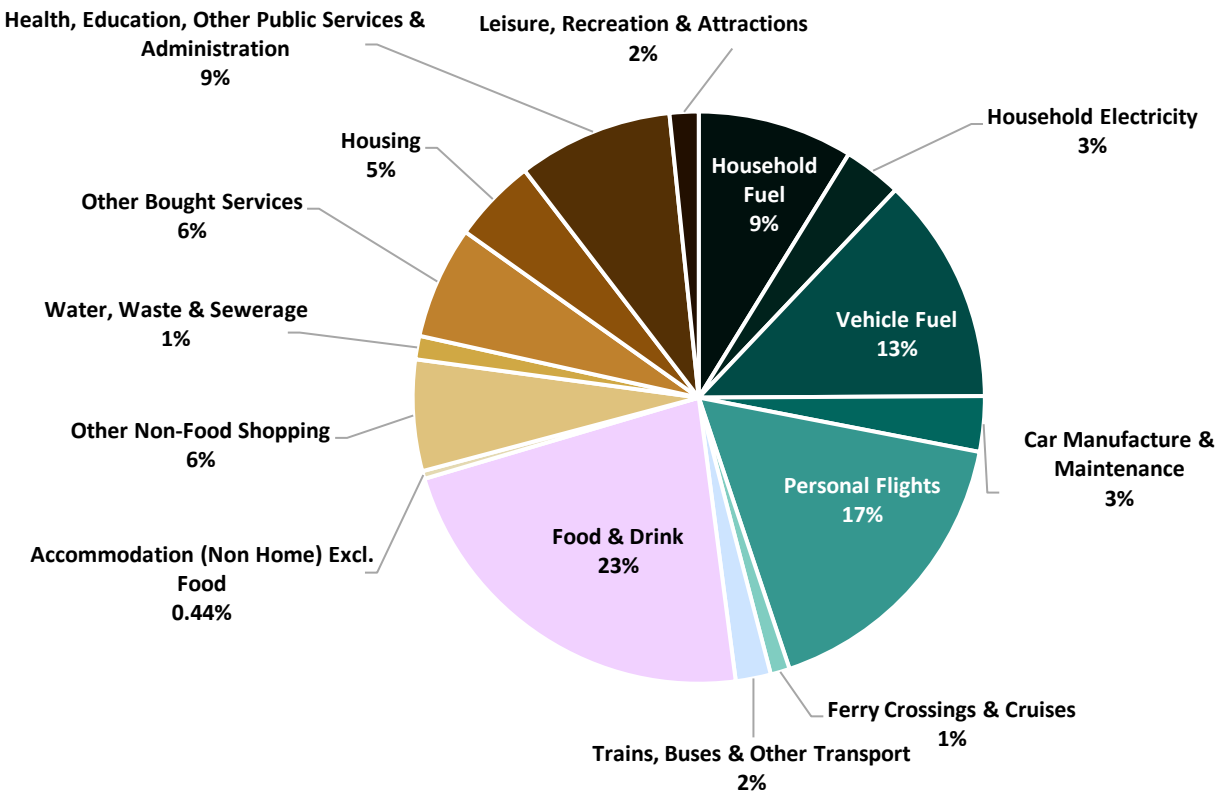
Production businesses (all types of manufacturing) account for 41% of the footprint of industries in the National Park, with agriculture and fishing accounting for 13%, and construction contributing 9%. In addition to these sectors, professional services, accommodation and food services, education and health have considerably higher per-resident footprints compared to UK averages.

South Downs is estimated to have a considerable traffic footprint from the major roads (most notably M3, A26, A27, A31 and A32), which amounts to around 28% compared to the total footprint of the residents. Through traffic is estimated to account for account for around 75% of the emissions from the major roads.

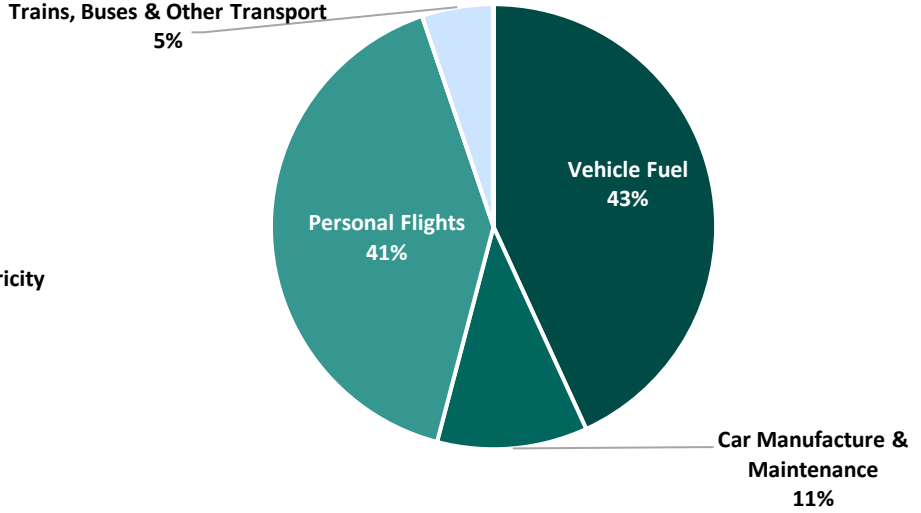
Targets recommendation

A minimum Paris-aligned target trajectory has been constructed for each of the six elements of the targets, as illustrated in Figure 6. When combined, they result in a net zero date of 2045 for the South Downs National Park. 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: 2,185,545 tCO_2e



Visitors while travelling to & from the National Park: 460,814 tCO_2e



Visitors while in the National Park: 287,108 tCO_2e

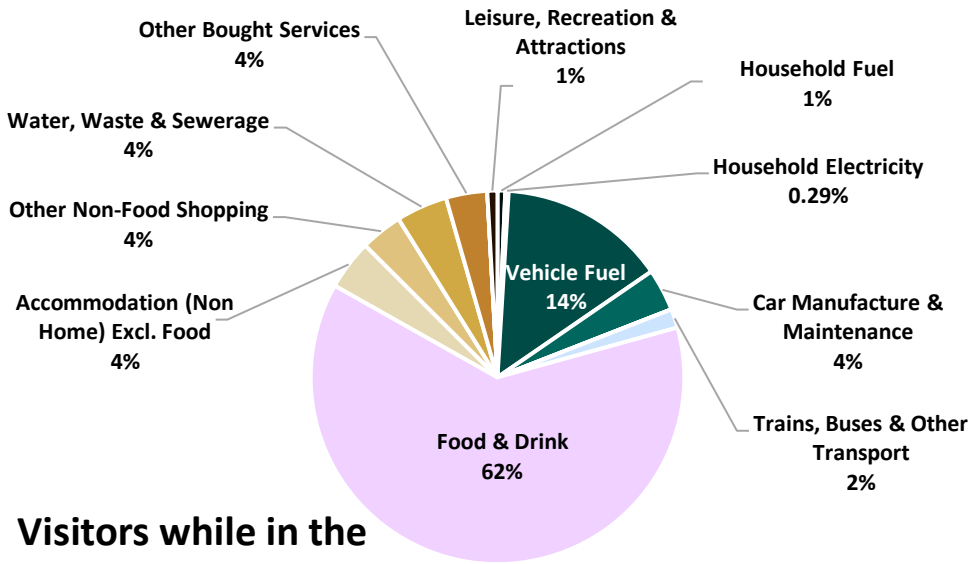


Figure 2: (left) Residents' GHG emissions in the South Downs National Park, by percentage

Figure 3: (top right) Visitors' GHG emissions on the way to and from the South Downs National Park, by percentage

Figure 4: (bottom right) Visitors' GHG emissions while in the South Downs National Park, by percentage

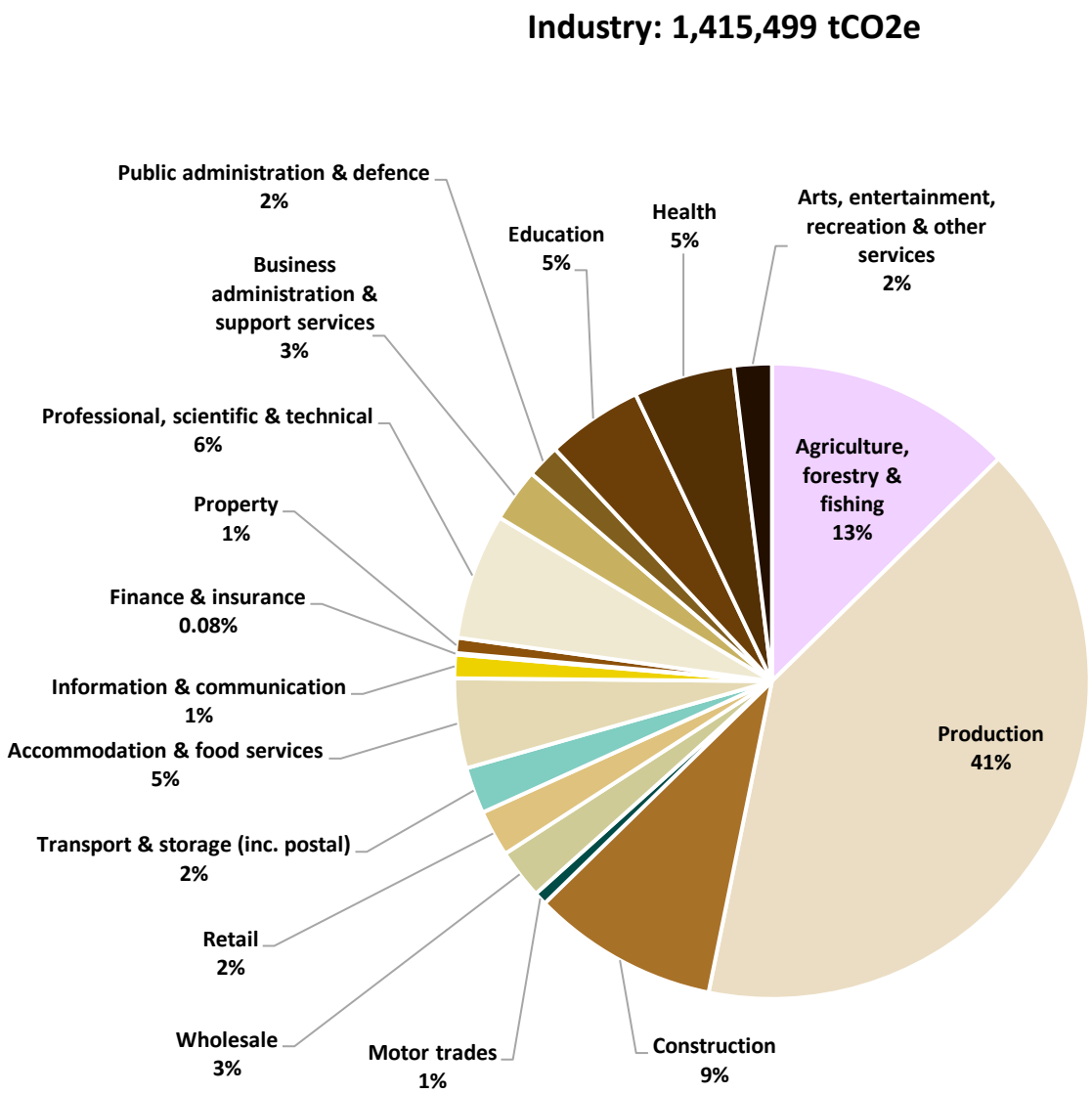


Figure 5: An estimate of emissions from industries within the National Park and their supply chains (scopes 1, 2 and upstream scope 3)

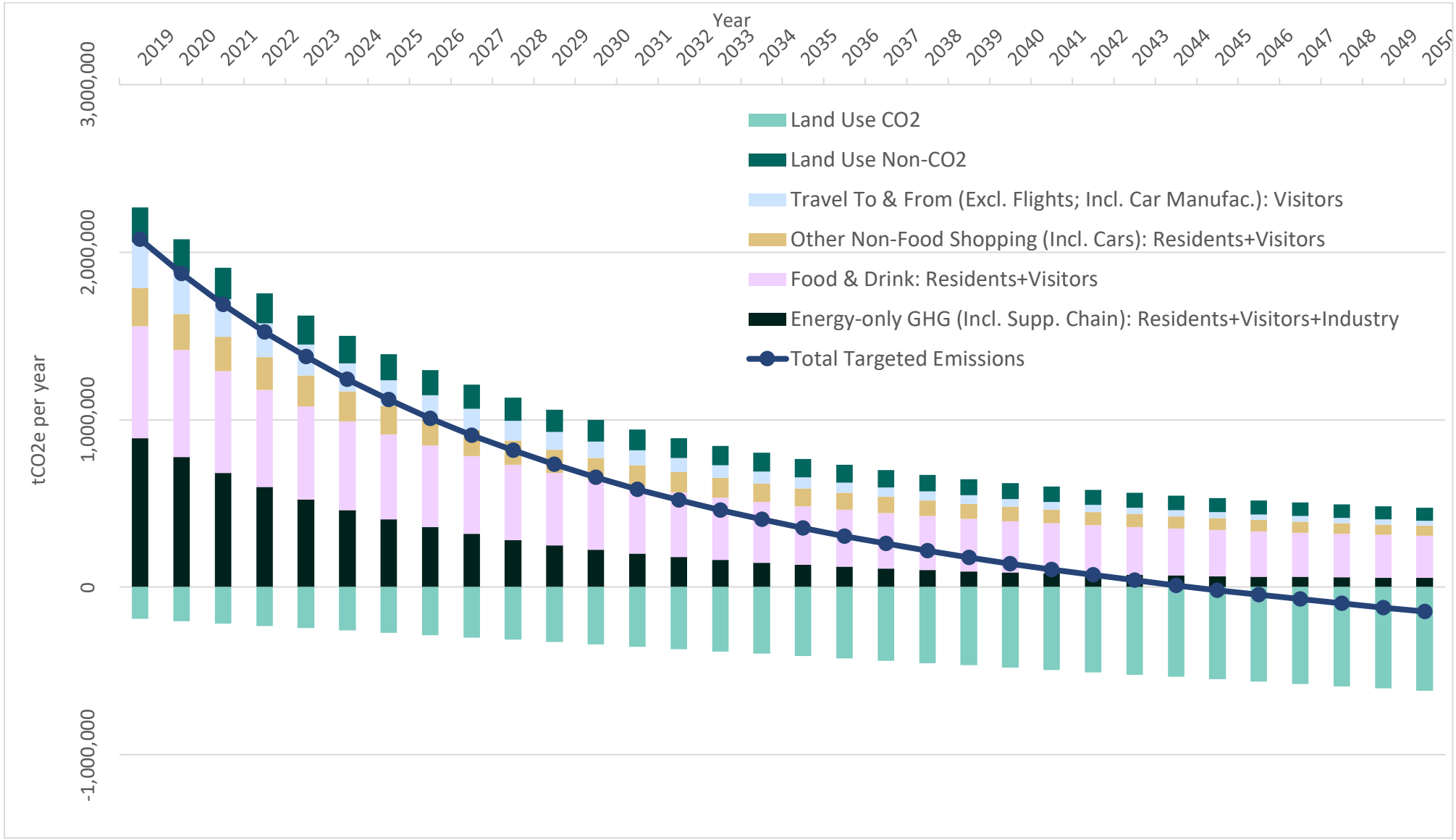


Figure 6: Recommended target pathways resulting in net zero emissions for the South Downs National Park by 2045

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, the Broads Authority, 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 the South Downs National Park, is one of a series of methodologically compatible reports produced for each UK National Park, the Broads, each Welsh AONB, as well as the Cotswolds and Cannock Chase AONBs in England. The baseline year for the assessment is 2019, the most recent pre-COVID year. The report also includes recommendations for 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, achieving these targets would mean South Downs reaching consumption-based net zero emissions in 2045 and acting as a net carbon sink afterwards, subject to the targets being fulfilled and to the considerable uncertainties remaining in the data.

Together, the UK's 14 National Parks, the Broads 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.

Almost every action connected with people living, working and spending time in the protected landscapes gives rise to greenhouse gas emissions, which lie within the influence and therefore management responsibilities of the National Park Authorities, the Broads Authority or Local Authorities for the AONB. While the need to transition from fossil fuels to renewable energy is the single greatest challenge in responding to the climate emergency, for the protected landscapes in particular, land management is also a critical element of dealing with both the climate and biodiversity crises.

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

peatland and woodland coverage, in their amount and types of agricultural land, and in the population densities of residents and visitors.

The main body of this report is designed for a broad audience, including some who may be less familiar with carbon analysis, but who have an active interest in the findings. This includes National Park 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

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.

2.1. Climate change policy

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 more ambitious target of the Paris Agreement by the parties to the UN Framework Convention on Climate Change (UNFCCC); it is also understood to be a "safer" warming limit both for societies and ecosystems globally. In 2019, the UK Government agreed to a legally binding target of net zero greenhouse gas emissions by 2050.

Subsequently, the IPCC published its Sixth Assessment Report (AR6) in stages, with the final volume released in March 2022. Compiled by the world's leading 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.

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[2]. Notably, it affirms that the increase of carbon dioxide, methane, and nitrous oxide in the Earth's atmosphere through the industrial era, i.e. since the late 19th century, is the result of human activities. What is clear in the report is that our chance of limiting the increase in global mean temperature to 1.5°C above pre-industrial levels now appears small. Keeping warming below the "safer" 1.5°C limit will likely require the most ambitious actions – i.e. those at the top end of known technical feasibility – to reduce emissions and also upscale efforts on carbon sequestration.

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

[2] IPCC (2021) Climate Change 2021: The Physical Science Basis https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

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 2035 relative to 1990, which is a 63% reduction from 2019 levels[3]. Further detail relating to this is provided in Section 2.4 of this report, outlining associated real-world change towards decarbonisation.

Ahead of COP26, in October 2021, the UK Government published its Net Zero Strategy: Build Back Greener[4]. 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)[5]. The NDCs pledged at COP26 are estimated to represent a trajectory towards a temperature *rise* of 2.4°C (relative to pre-industrial levels) by the end of the century, whereas the existing Net Zero pledges, if fully implemented, would limit global warming to 1.8°C.[6]

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 of air pollution

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

[3] 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.
[4] HM Government (2021), "Net Zero Strategy: Build Back Greener" https://www.gov.uk/government/publications/net-zero-strategy.
[5] COP26, "The Glasgow Climate Pact," p.8 https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf.
[6] https://climateactiontracker.org/global/temperatures/.

NHS has identified that more than 2,000 GP practices and 200 hospitals are in localities affected by 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).

2.3. Climate-driven impacts in the UK

The impact of climate change on our natural world is evidenced by higher temperatures, changing rainfall patterns, changes in ecosystems, sea level rise, increasing frequency and intensity of storm surges, retreating glaciers, and melting sea ice and ice sheets. In the UK we are seeing significant changes in the winter and summer rainfall patterns. The UK Met Office's latest report states that "Winters in the UK, for the most recent decade (2009-2018), have been on average 5% wetter than 1981-2010 and 12% wetter than 1961-1990", and that "Summers in the UK have also been wetter, by 11% and 13% respectively"[7]. 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)[8].

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:

- 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.

[7] 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

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

- UK industry captures its remaining carbon emissions and stores them safely (and permanently).
- By 2035 the UK's electricity production is zero carbon.
- Low-carbon hydrogen is scaled up as a fuel for shipping, transport and industry, and for some buildings it replaces natural gas for heating (demand for natural gas is set to double/treble by 2050).
- UK wastes fewer resources and reduces its reliance on high-carbon goods.
- UK has a national programme to improve insulation of existing buildings[9].
- Fewer miles travelled by car and air.
- Diets change, reducing consumption of high-carbon meat and dairy products[10] by 20% by 2030.
- Agriculture and the use of farmland are transformed, while maintaining the same levels of food per head produced today.
- By 2035, 460,000 hectares of new mixed woodland are planted to remove CO2 from the atmosphere and deliver wider environmental benefits.
- By 2035, 260,000 hectares of current farmland are dedicated to producing energy crops.
- Woodland coverage of the UK's land surface rises from 13% today to 15% by 2035 and 18% by 2050.
- Peatlands are widely restored and managed sustainably.

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"[11].

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

2.5. Policy implications for local planning authorities

South Downs National Park Authority is the Local Planning Authority for the National Park, handling a significant number of planning applications and managing development across the National Park. The size of both the National Park's area and of its residential population mean that South Downs

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

[10] 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.

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

makes far more planning decisions than any other National Park Authority, and the number of applications it receives is comparable to that of a large UK city.

Planning is one tool the Authority can use to address GHG emissions, specifically through decarbonisation of the built sector. Policies within the Local Plan and guidance in a Sustainable Construction Supplementary Planning Document (SPD) are pushing the construction sector to consider the embodied GHG emissions in the materials used, achieve dramatic improvements in energy efficiency, and install low/zero-carbon energy technologies in new builds. Planning policies also encourage the uptake of low/zero-carbon transport in new developments. Although new-builds emit relatively small quantities of GHGs compared to existing buildings, savings achieved in new-build stock will minimise the need for expensive future retrofitting. They will also demonstrate the potential of – and stimulate the market for – building techniques and products that are more sustainable.

Planning can also provide information on which types of renewable energy technology that 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 is also scope for planning to increase urban green space, through new green infrastructure, tree planting and habitat creation. Local Plan policies on Ecosystem Services and Biodiversity Net Gain are delivering biodiversity and climate change adaptation benefits through development. The Local Plan also makes provision for non-motorised transport routes, protecting disused railway lines which offer excellent opportunities for active travel. This is important as another journey option for leisure and commuting within the National Park, and for the many day visitors from the surrounding urban centres.

3. South Downs National Park: demographic profile and key statistics

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

3.1. People and key characteristics

The South Downs National Park has by far the largest residential population of all UK National Parks; the latest partnership management plan suggests a population of 117,000. For the purposes of this carbon footprint assessment, population estimates from mid-2019 were used, and we included all postcodes that have at least 30% of their area within the National Park boundary, which gives a total of around 140,000 residents. A further 2 million people live within 5 km of the National Park in neighbouring towns and cities including Chichester, Winchester, Worthing, Brighton & Hove, Eastbourne and Alton[12]. This results in a comparatively large urban element in the National Park make-up, as well as a relatively large number of day visitors from the nearby urban centres. 43% of

[12] South Downs National Park (2020-2025), "Partnership Management Plan," p.5.

the National Park's residents are believed to commute to work destinations outside the Park[13], and London is just over an hour away by train.

When considering partnership-working on decarbonisation agendas, there are 15 local authorities represented within the National Park including East Sussex County Council, West Sussex County Council and Hampshire County Council. The SDNP (2018) "Economic profile" report suggests the population within the Park is growing, although at a slower rate than the comparator areas. It is also ageing, with a notable drop in numbers in the 25-44 age band and an increase in over-65s. The National Park's resident population is forecast to increase by nearly 8%, or more than 9,000 people, by 2033[14]. Therefore, consumption is likely to increase, impacting future GHG emissions.

The SDNP (2018) report shows low levels of deprivation, and suggests that the National Park's residents' wages are higher than all the comparator areas apart from Enterprise M3. Full-time wages earned by females are 19% lower than those of males, but a similar gap is seen in most of the comparator areas, apart from Solent Local Enterprise Partnership (LEP). Workplace wages in the National Park are lower than residents' wages, as in the other areas, indicating that those with higher-level skills tend to commute to where there are higher-value jobs. These behaviour patterns are also showing up in our data analysis in the context of fuel usage. The occupational profile suggests the following make-up: Managers/Directors 25.2%, Professionals 14.3%, Associate Professional & Technology 18%, Admin and Secretarial 10.7%, Skilled Trades 11.8%, Caring and Leisure services 14.6% and Elementary 7.7%. These are important factors when considering the potential opportunities to change behaviour in spending habits, as too are the 8,000 businesses registered in the Park. Further detail pertaining to the Park's key consumption characteristics can be found in Appendix 10.1.

3.2. Geography and landscape

In terms of its landscape, the South Downs National Park is the third largest in England, spanning 1,627 km^2 (162,700 ha). South Downs is one of England's most valued lowland landscapes, a large part of which is privately owned farmland; approximately 3,000 people are employed in the Park's agricultural industry. In terms of habitat characteristics as reflected in the Partnership Management Plan, the National Park consists of over 70% farmland (47% arable land, 20% other farmland and 33% permanent pasture), while 23% is woodland, nearly half of which (45%) is ancient woodland[15]. Chalk grassland (4%) areas feature local heritage landscape figures such as the Long Man of Wilmington[16]. Less than 1% of lowland heath remains, with sites recently restored as part of the Heathland United initiative, which has seen the return of rare sand lizards and natterjack toads[17]. These special managed landscapes arose from lowland mixed farming and forestry systems. It is therefore important to reflect on this when considering land use and land use change, given that the wholesale abandonment of farming may be undesirable not only culturally and economically, but also ecologically.

[13] South Downs National Park Authority (2018), "The Economy of the South Downs National Park," p. 3.
[14] South Downs National Park Authority (2018), "The Economy of the South Downs National Park," p. 18, 39, 49, 55, 56.
[15] South Downs National Park (2020-2025), "Partnership Management Plan," p.6.
[16] South Downs National Park (2020-2025), "Partnership Management Plan," p.8.
[17] National Trust (2021) Saving our heathlands in the South Downs https://www.nationaltrust.org.uk/black-down/features/saving-our-heathlands-in-the-south-downs

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[18]. 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, South Downs residents spend around 11% more than other UK residents (Table 1), excluding public services. This is slightly below the average across all National Parks. The consumption data points to a mix between working-age and retired populations, unlike most other National Parks which tend to have predominantly older and, in many cases, more affluent residents. A detailed summary of the key statistics and spending habits for South Downs residents is provided in Appendix 10.1.

Table 1: Relative difference in consumer spending per capita (excluding public services) between South Downs National Park and the UK average.

Consumer Expenditure Category	**South Downs National Park vs. UK Consumer Spending (Excl. Public Services)**	**All National Parks vs. UK average**
Food & non-alcoholic drinks	8.1%	10.2%
Alcoholic drinks, tobacco & narcotics	10.8%	14.6%
Clothing & footwear	8.3%	9.2%
Housing, fuel & power	-8.6%	-8.3%
Household goods & services	17.1%	16.7%
Health	24.0%	41.9%
Transport	21.0%	29.8%
Communication	3.5%	4.7%
Recreation & culture	21.2%	22.1%
Education	-19.5%	-39.8%
Restaurants & hotels	7.8%	3.1%
Miscellaneous goods & services	8.7%	7.8%
Other expenditure items	17.9%	23.1%
Total	**11.1%**	**12.9%**

[18] Catapult Energy Systems (June 2021), "Net Zero Societal Change Analysis: Summary report," p. 11.

4. GHG reporting conventions and methods

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

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

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

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

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

As a separate and overlapping analysis, we also include a simple assessment of emissions from industry within each protected landscape and associated supply chains (Scopes 1, 2 and upstream Scope 3). We provide this to give some sense of the relative scale of industry emissions compared to those linked to visitors and residents. However, important caveats apply to this assessment. Firstly, it is not possible to eliminate the double counting of emissions, occurring when industries within the area sell to each other or to residents and visitors. Secondly, this crude estimate for industry has been made by applying generic, UK-wide emissions factors for each industry sector to local revenue data from businesses registered in the area. This may in some cases misrepresent actual industry-related activities within the landscape boundary. Figure 7 illustrates the relationship between the main components of our central assessment and the industry emissions.

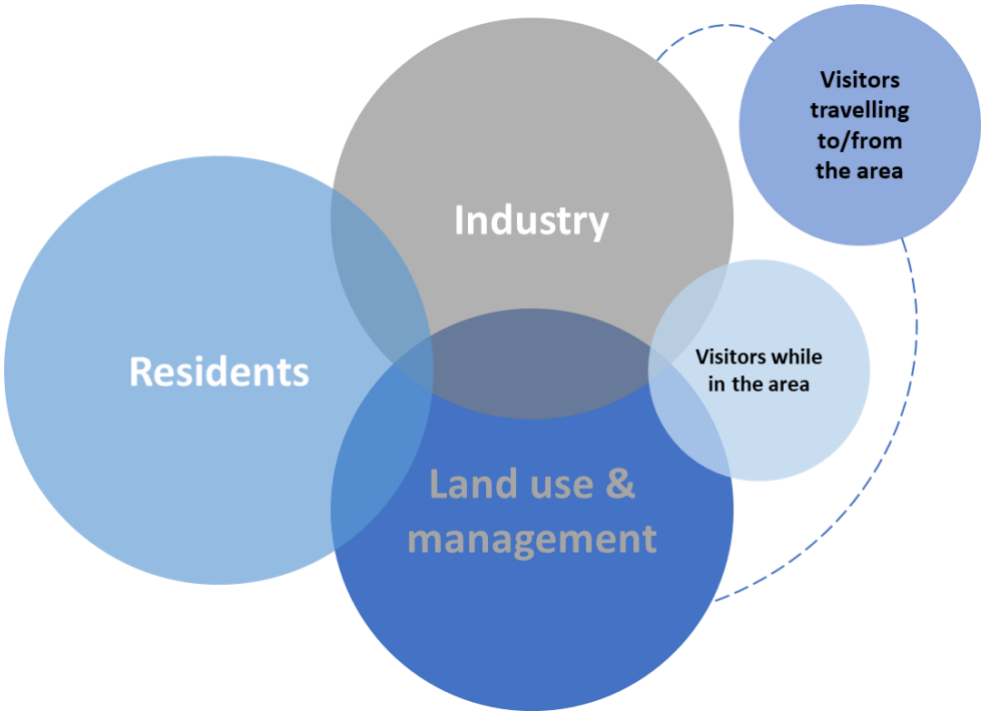


Figure 7: Boundaries of carbon footprint assessment (Repeat of Figure 1)

This report also 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 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 (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-CO_2 component (including emissions from livestock and fertilisers)
- Land use CO_2 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[19]. Scope 3 can be split into two parts: upstream and downstream. Our assessment of Industry

[19] 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.

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

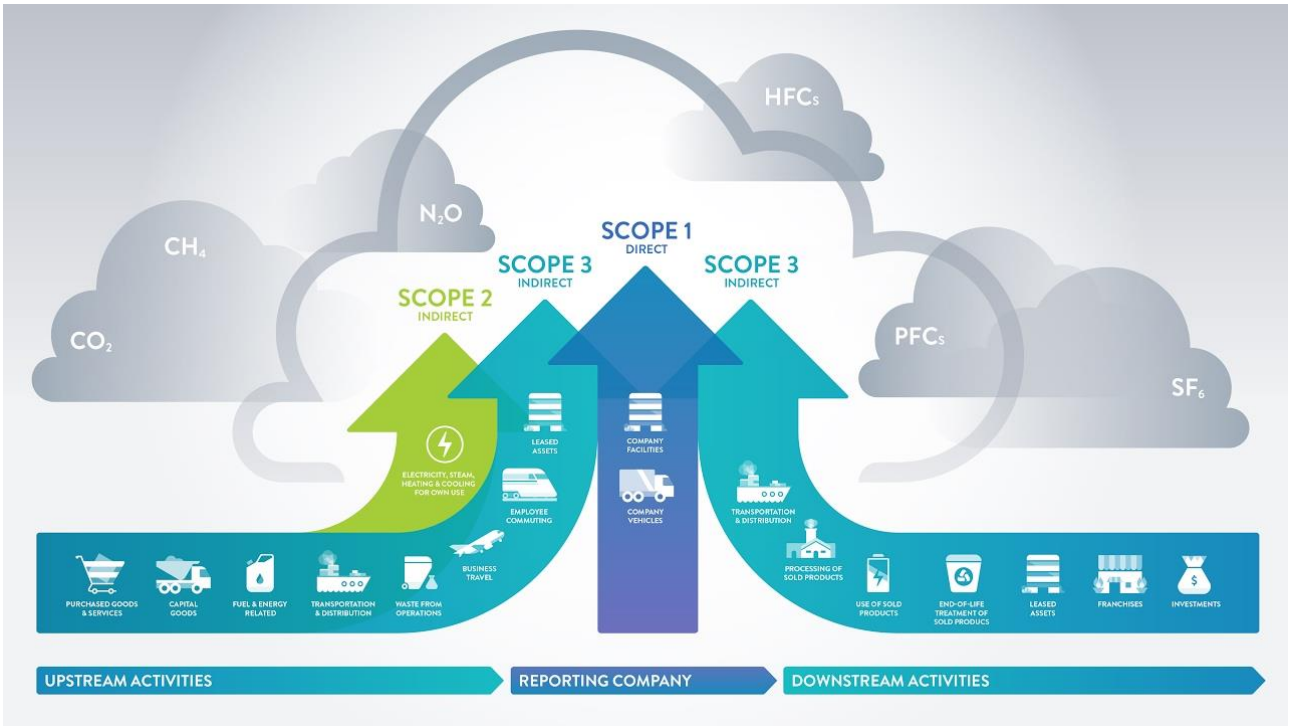


Figure 8: Types of greenhouse gas emissions used for carbon accounting

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

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

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 10.2 and 10.3.

5. South Downs: Consumption-based GHG emissions

5.1. Results overview

Here, we outline our analysis of the carbon footprint of South Downs residents and visitors' 2019 GHG emissions (Figure 9). Residents' emissions were estimated at 2.186 million tCO_2e (Figure 10) and visitors' emissions, while travelling to and from and while in the park combined, were estimated at 0.748 million tCO_2e (Figure 11 and Figure 12). The resident population stands at 140,881 people, compared to over 19 million day-visitors per year. A full breakdown of these figures is provided in Appendix 10.4 and 10.5. This data shows that the South Downs has the largest residential and visitor populations among all National Parks. South Downs residents are also comparatively more affluent, as the demographic profile in Section 3.3 suggests. Annual final consumption per year for residents (including public services) is over 4.6 billion pounds.

To give an indication of the scale of the South Downs National Park's emissions, you would need to plant over 7,900 Premier League football pitches with broadleaf trees, leaving them to grow for over 100 years, to mitigate the resident and visitors combined 2019 GHG emissions. This shows the need to prioritise GHG emissions *reductions* to limit global warming, rather than just mitigating these 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[21]. We shall use these four key categories to comment on the results, and to suggest where the local councils and partners could target initiatives aimed at behaviour change.

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

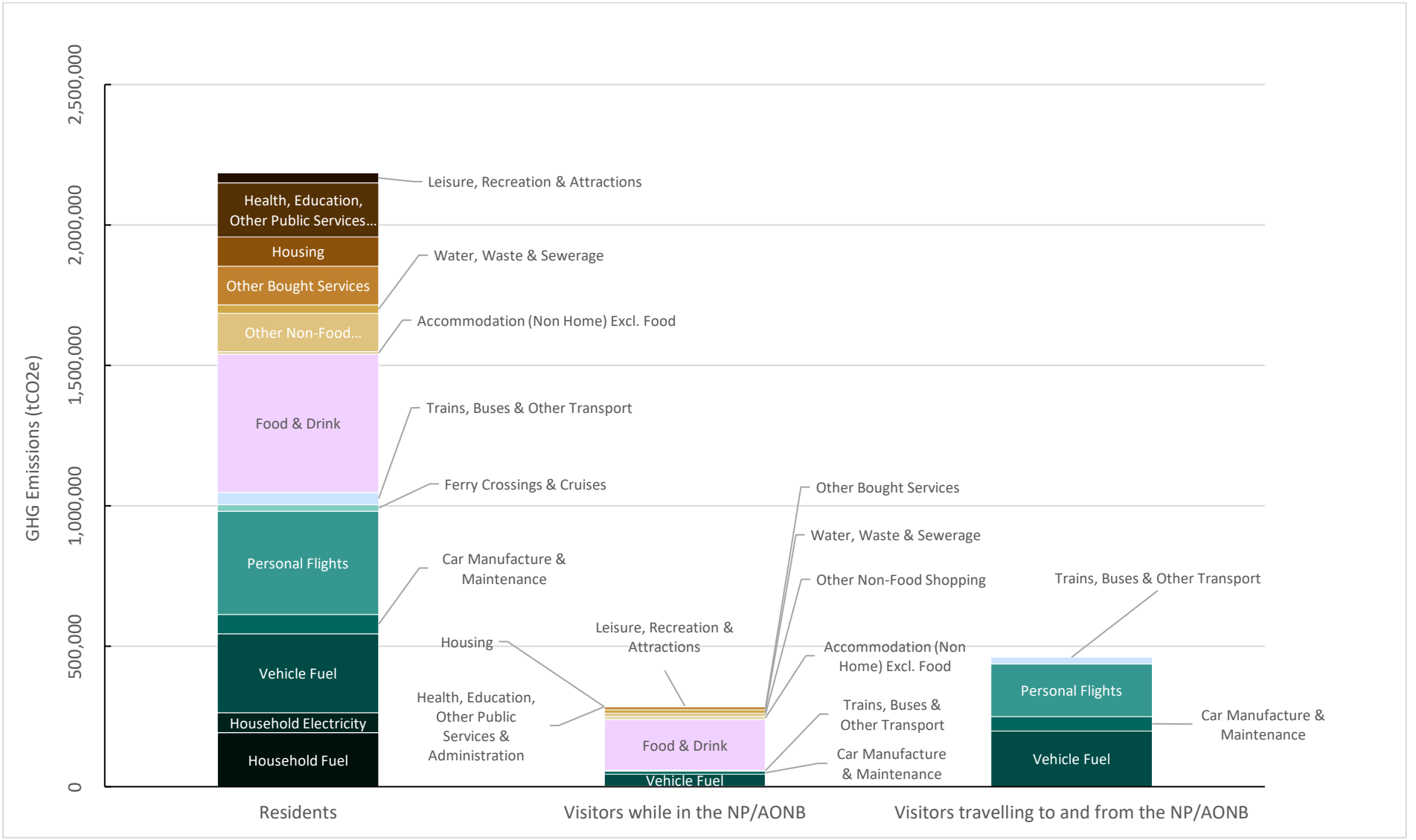
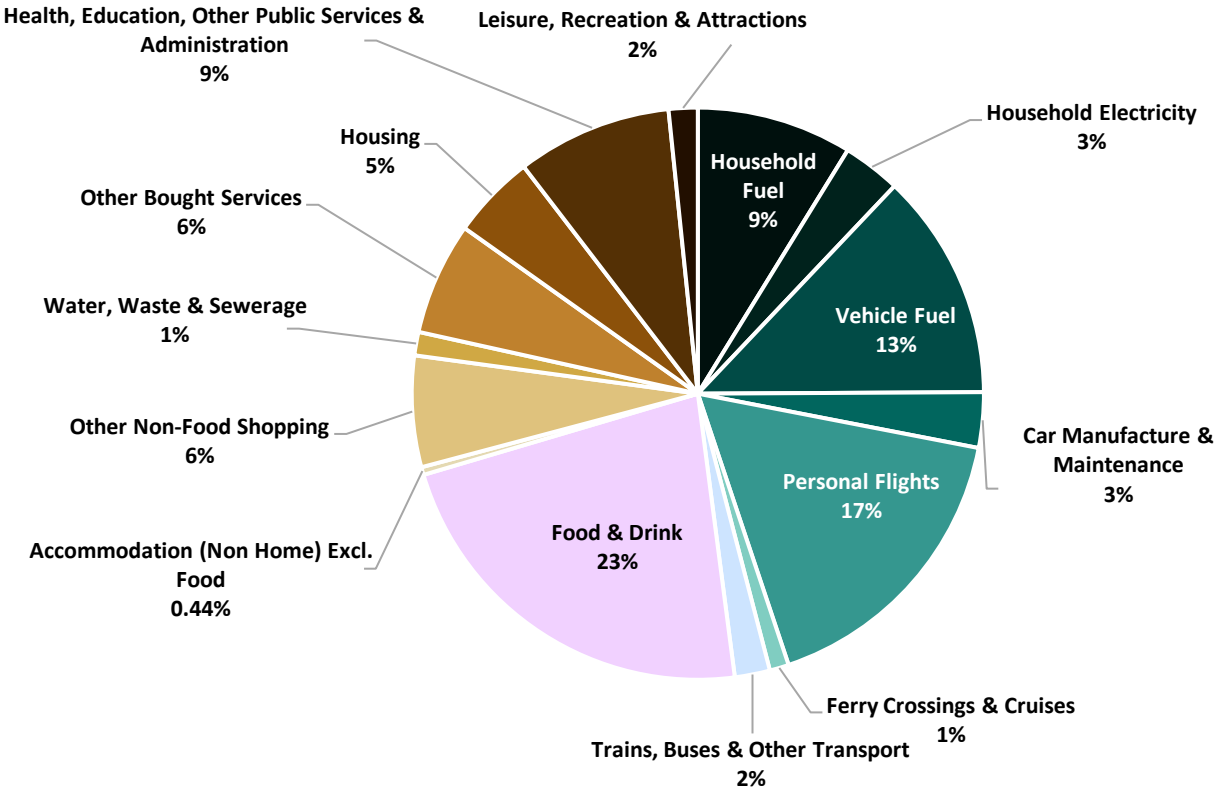
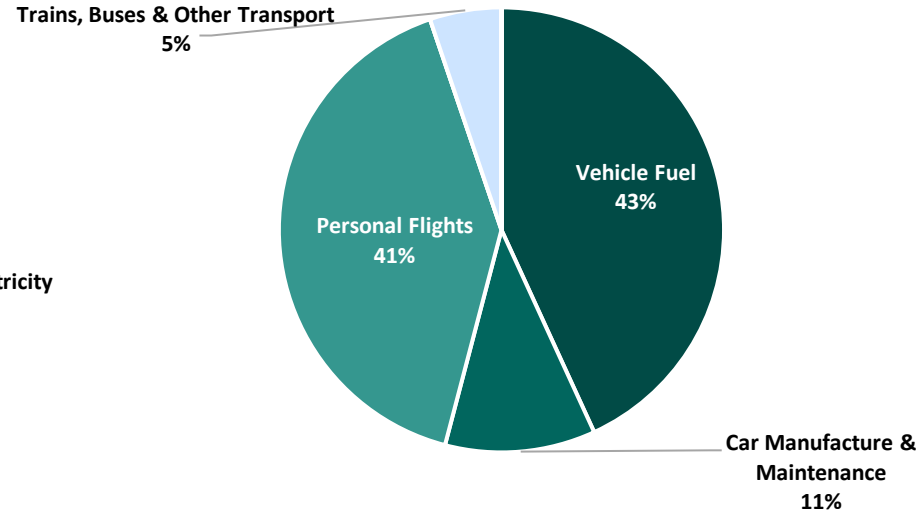


Figure 9: A consumption-based assessment of emissions relating to residents, visitors, and visitor travel to and from the South Downs National Park.

Residents: 2,185,545 tCO_2e



Visitors while travelling to & from the National Park: 460,814 tCO_2e



Visitors while in the National Park: 287,108 tCO_2e

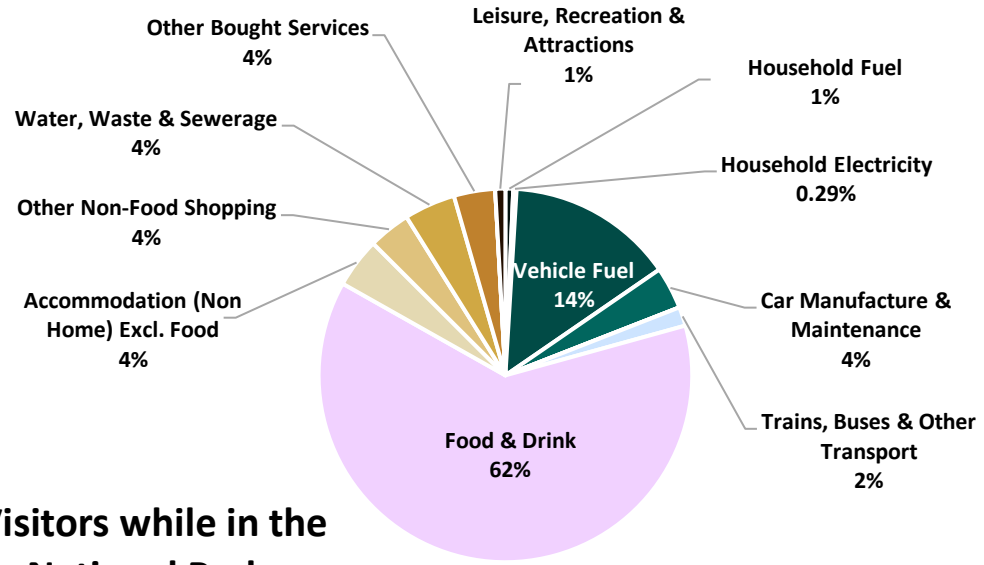


Figure 10: (left) Residents' GHG emissions in the South Downs National Park, by percentage

Figure 11: (top right) Visitors' GHG emissions on the way to and from the South Downs National Park, by percentage

Figure 12: (bottom right) Visitors' GHG emissions while in the South Downs National Park, by percentage

5.2. Residents' and visitors' GHG footprint components

South Downs residents' emissions totalled 2.186 million tCO_2e in 2019, with the greatest emissions categories being Food & Drink (22%), Personal Flights (17%) and Vehicle Fuel (13%).

South Downs visitors' emissions totalled 0.748 million tCO_2e in 2019, comprised of 460,814 tCO_2e from travelling to and from the area, and 287,108 tCO_2e while in the are. Visitor travel to and from the National Park indicates GHG emissions are dominated by Vehicle Fuel (43%) and Personal Flights (41%), with only 5% related to the remainder of public transport. Of the footprint of visitors while in the National Park, Food & Drink consumed represents 62%, while Vehicle Fuel used within the area equates to 14%.

5.2.1. Food

When considering behaviour change around food at its simplest level, we look at the sustainable choices available to us when we buy food and drinks from shops, and when we "eat out". The carbon footprint from food and drink in the South Downs National Park is considerable: for residents it is 491,434 tCO_2e (23% of the residents' total), and for visitors 179,343 tCO_2e (62% of the visitors' total); see Appendices 10.4 and 10.5. "Buy local, eat local" has become a common aspiration among the more environmentally aware, along with eating seasonal fruit and vegetables, and varying traditional eating patterns to include more plant-based protein and meal choices (a "flexitarian" diet). It is also possible to use carbon intensity as the basis for choosing which meat to consume, with beef having the highest intensity, then in descending order: lamb, pork and chicken. As well as alleviating the burden on the environment, these kinds of dietary choices can also help individuals live healthier lifestyles. This is because red meat (beef, lamb, pork) as a source of protein and fat is typically a moderately-to-high calorie density food, and therefore needs to be consumed in moderation for a balanced healthy diet. Lean protein sources like turkey and chicken, on the other hand, have a low-calorie density. The amount of calories people eat and drink has a direct impact on weight, with obesity being a key risk factor for long term conditions in later life; see section 5.2.4.

Eliminating food waste can reduce an individual's food footprint by a further 12%, as well as saving them money. Forgoing fruit and veg grown in hot-houses or air-freighted to the UK in favour of local, seasonal varieties could deliver a 5% reduction in the total food footprint[22]. Ship-transported and frozen produce are also good low-carbon alternatives, as the emissions per item are far lower than for air-freighted goods [23].

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 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.

[22] 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.
[23] Berners-Lee, M. (2010) "How Bad Are Bananas – The Carbon Footprint of Everything," p. 26-29.

Based on the 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[24]. 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[25].

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"[26].

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"[27], 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, regarding how to transition given the implications for livestock and food production in the UK. The National Farmers' Union (NFU) is aware of these and has set the goal of reaching net zero greenhouse gas (GHG) emissions across the whole of agriculture in England and Wales by 2040[28]. Achieving this would require considerable reductions of emissions from livestock, and reduced use of synthetic fertilisers, while actively pursuing efforts to sequester carbon by creating woodland, restoring peatland within agricultural land, and implementing regenerative farming practices[29].

5.2.2. Homes and accommodation away from home

Homes and accommodation away from home and responsible for 377,488 tCO_2e (17%) of the residents' footprint, and 15,146 tCO_2e of the visitors' footprint (5% of their footprint while in the area). We considered the following components: household fuel (191,998 tCO_2e; 9% of the residents' total footprint), housing (104,039 tCO_2e; 5%), household electricity (71,825 tCO_2e; 3%) and accommodation away from home (9,627 tCO_2e; 0.4%), see Appendix 10.4. The single biggest intervention the public can readily make is changing their energy supplier (switching to one that is divesting from fossil fuels) and actively sourcing a supply derived from genuinely renewable energy, e.g. solar, wind, tidal and/or hydro-electric power. The public generally lack knowledge about where their household energy comes from, with many consumers not being able to distinguish between:

[24] National Food Strategy Independent Review, The Plan Chapter 16: The Recommendations.
[25] National Food Strategy Independent Review, The Plan p.147.
[26] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section, p.21.
[27] Department of Health (2012) Policy Paper. "Long-term conditions compendium of Information: 3rd edition."
[28] National Farmers Union (2021), "Achieving Net Zero, Farming's 2040 goal."
[29] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section.

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 majority of South Downs visitors’ footprints: 517,494 tCO_2e (69%), including the entire footprint of traveling to-and-from the National Park, and 20% of emissions while in the Park. The majority of this travel footprint is from car fuel (240,362 tCO_2e; 32% of the visitors’ total), personal flights (187,593 tCO_2e; 25%), car manufacture and maintenance (8%) and a small amount from trains, buses and other transport (4%).

Travel accounts for 36% of the residents’ GHG footprint. In considering residents’ travel we looked at personal flights (367,503 tCO_2e; 17% of the residents’ footprint), vehicle fuel (280,717 tCO_2e; 13%), car manufacture and maintenance (68,411 tCO_2e; 3%), trains, buses and other transport (43,440 tCO_2e; 2%), and ferry crossings and cruises (23,724 tCO_2e; 1%).

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

In terms of vehicle fuel use, variations in residents’ annual mileage, and in vehicle size (both residents and visitors) make a big difference to carbon footprints. If someone drives 10,000 miles in a year, 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[30]. 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[31]. The Committee on Climate Change (CCC) has recommended that 60% of all new cars and vans sold should be electric by 2030, and the Government recently announced a ban on selling new petrol, diesel or hybrid cars in the UK from 2030[32]. As South Downs has a more affluent demographic profile on average, the typically cost-prohibitive entry into owning an electric car is more likely to be within reach for some residents in the area. Aside from switching to an electric car, there are other choices that everyone can make to reduce vehicle emissions:

- The average person walks 210 miles per year[33]. 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.
- 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.

It is not possible to identify from this assessment whether visitors are using their own vehicles or hire cars, but where hire cars are used it may be beneficial for the National Park to work with local providers to fast-track electrification of vehicles. In either case, increasing the availability of electric car charging points could encourage visitors to travel by electric vehicle.

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

[30] Like all other road vehicles, electric cars emit particulates from tyres and breaks. Compared to tailpipe exhaust, these emissions mostly impact air quality rather than on climate. A bigger average weight of electric cars relative to conventional cars, driven by the battery, leads to marginally higher emissions from tyres. On the contrary, regenerative breaking into the battery means electric cars have lower emissions from breaks compared to conventional cars.

[31] https://www.ft.com/content/d57efdf6-ffad-11e9-be59-e49b2a136b8d https://www.ft.com/content/d57efdf6-ffad-11e9-be59-e49b2a136b8d.

[32] https://www.bbc.co.uk/news/science-environment-51366123549814 25

[33] Department of Transport (2019)), “National Travel Survey (England): 2018”.

5.2.4. Everything else

The remainder of the residents' footprint consisted of: public services including health and education (191,734 tCO_2e; 9% of the residents' footprint), other bought services (138,990 tCO_2e; 6%), other non-food shopping (137,340 tCO_2e; 6%), leisure, recreation and attraction (35,806 tCO_2e; 2%), and waste, water and sewage (28,956 tCO_2e; 1%). For visitors, the remainder of emissions come from water, waste and sewerage (12,743 tCO_2e; 4% of the footprint while in the Park), other non-food shopping (10,432 tCO_2e; 4%), other bought services (10,260 tCO_2e; 4%), and leisure, recreation and attraction (2,503 tCO_2e; 1%).

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

We suggest that the role played by the National Parks in enabling the public to access green/blue space – known to support mental and physical well-being – should not be underestimated. Recent research by White *et al.* (2019) identified that the amount of recreational time individuals need to spend in natural environments in order to gain self-reported health and well-being benefits is at least 120 minutes per week[34]. 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[35].

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

Threshold ≥ 120mins green space exposure per week = health and wellbeing 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.

[34] 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.

[35] 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.

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

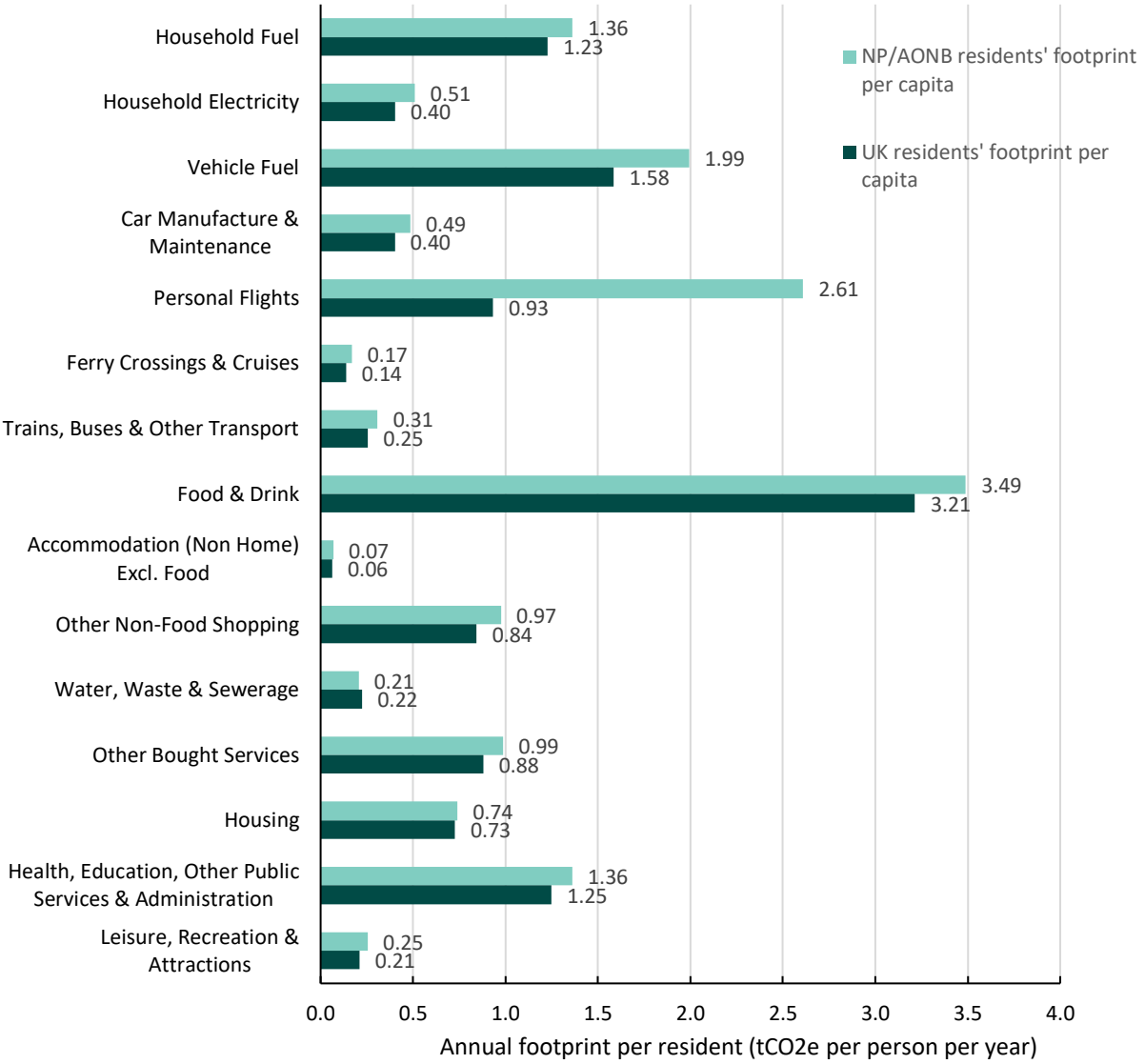


Figure 13: Residents' GHG footprints compared between the South Downs National Park average and the UK national average, by category

5.3. Industry assessment

This section presents the GHG emissions from industry but first outlines the scope of the industry assessment given that two approaches were used, as explained in 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 10.6.1 to 10.6.3). Please note that the reported turnover data does not necessarily reflect on the actual geographical distribution of locations where business revenue is being generated.

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

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

5.3.2. Industry sector analysis

The ONS UK Standard Industrial Classification (SIC) Hierarchy is used in formulating data analysis by the UK government to assess economic activity[36]. For transparency we include the IDBR broad industry group structure and see how this compares with the SIC (2007); see Appendix 10.6.1. When interpreting the results 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 in the South Downs National Park, which total 1,415,499 tCO_2e. Figure 14 highlights production as the largest source of GHG emissions (574,022 tCO_2e; 41%), followed by agriculture, forestry and fishing (179,027 tCO_2e; 13%), and construction (134,243 tCO_2e; 9%). See Appendix 0 for further details. Industry-related flights are estimated to account for 127,784 tCO_2e of the total footprint but are not separately categorised. Each of the main contributing categories are discussed below.

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

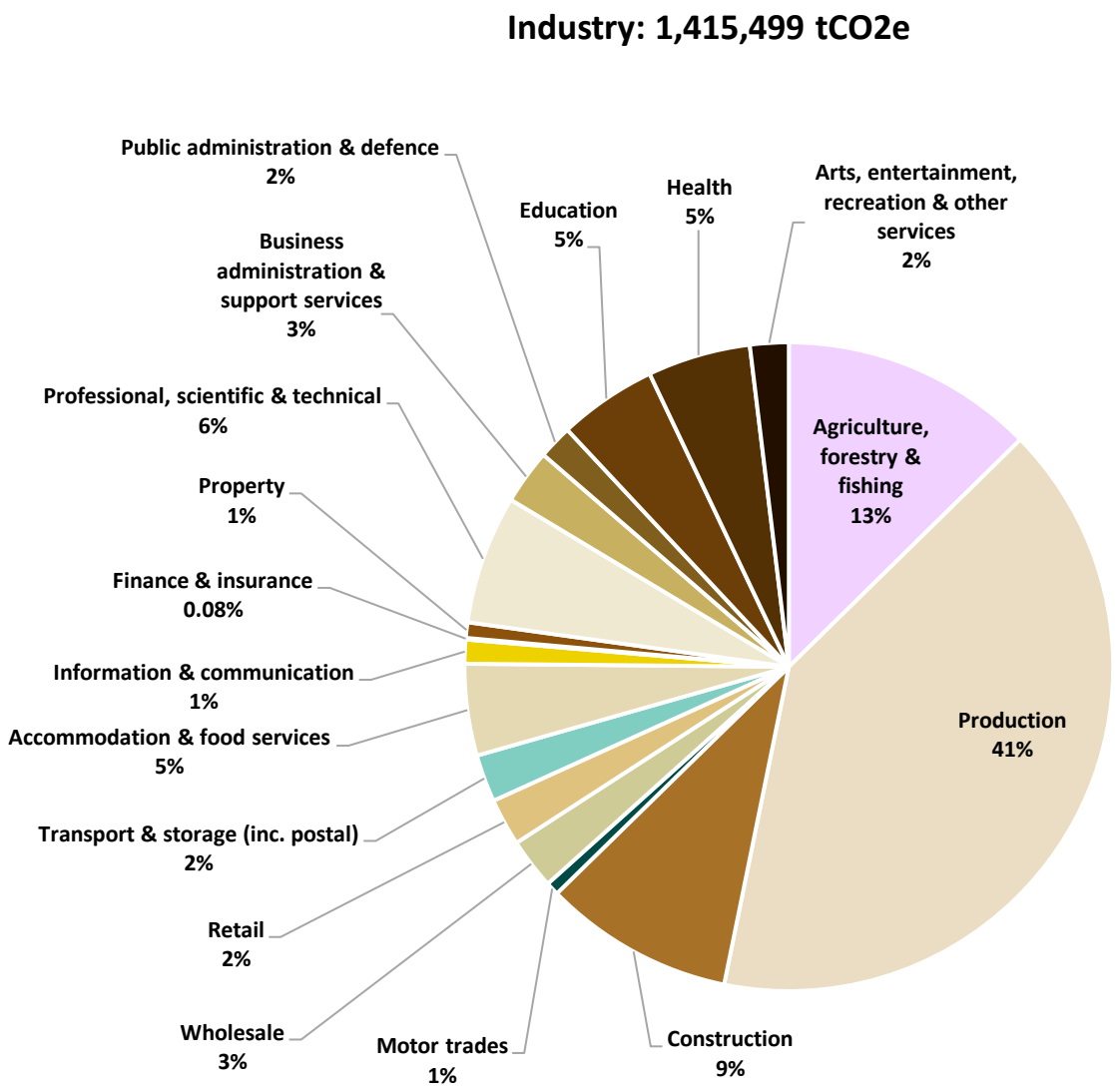


Figure 14: An estimate of emissions from industries within the National Park and their supply chains (scopes 1, 2 and upstream scope 3)

Production

Production (referring to manufacturing industries) plays an important role in the National Park. The SDNP (2018) "Economic profile" report suggests "manufacturing production makes up 5% of the business base and over 8% when engineering activities are included. Together, manufacturing and engineering account for over 5,000 jobs". However, it is this manufacturing base which is responsible for the greatest volume of emissions. We suggest manufacturing as a sector is the top industry where Local Enterprise Partnerships may wish to focus efforts to encourage companies to undertake assessment of their Scope 1, 2 and 3 GHG emissions and to develop credible roadmaps to reduce them.

Agriculture

The second top industry for GHG emissions is agriculture, forestry and fishing (179,027 tCO_2e; 13%). 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). More generally, the Sixth Carbon Budget (2020)

"Agriculture and land use, land use change and forestry" report suggests multiple opportunities for reducing emissions, as follows.

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

The Sixth Carbon Budget also discusses reducing 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.

Other opportunities relate to improving productivity and efficiency, with a headroom to increase average crop yields from around 8 t/ha at present to around 11 t/ha. However, climate change is likely to pose additional risks to yields. The report suggests land management measures such as increasing soil quality, smaller tillage, nutrition and pesticide management, and opportunity mapping. Innovations in breeding are also discussed along with increasing stocking density. Another key suggestion is increasing paddock grazing to 80%, which improves the quality of grass and enhances sequestration of carbon in the soil. 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.

Construction

We estimate that construction is the third largest GHG-emitting industry in the South Downs. The Sixth Carbon budget (2020) "Manufacturing and construction sector" report showed that GHG emissions from this sector contributed 12% of the total production-based UK GHG emissions in 2019. Opportunities for interventions to reduce construction-related emissions include:

- Resource efficiency: reducing the flow of materials through the economy, and using products more efficiently (and for longer), can reduce manufacturing emissions as part of a shift towards a more circular economy.
- Material substitution: manufacturing emissions can be reduced by switching from high-embodied-carbon materials to low-embodied-carbon materials. Measures include using wood in construction and using alternatives to clinker (e.g. fly ash) in cement.
- Energy efficiency*:* using energy more efficiently reduces operating costs while cutting emissions. The energy efficiency measures that we include are "low-regret" actions that often reduce fuel costs significantly. Measures include process and equipment upgrades, installing/improving heat recovery systems, and clustering/networking with other sites and businesses to efficiently utilise waste heat and other by-products.

- Fuel switching in manufacturing*:* hydrogen, electricity and bioenergy can all be used to meet demands for heat, motion and electricity, thus removing the need for fossil fuels and reducing GHG emissions.
- Carbon Capture and Storage (CCS): CCS can be used to capture CO_2 produced by larger industrial point-sources and transport it to a CO_2 storage site, thereby reducing emissions to the atmosphere[37].

IDBR and GVA based emissions comparison

We undertook a comparison between IDBR data and GVA data, as we know that economic reporting often uses GVA as the primary measure upon which many LEPs base their workforce planning; see Appendix 10.6.3. When the GVA dataset is compared to IDBR, this indicates a potential under-reporting of GVA based emissions from agriculture, production, construction, wholesale, transport and storage, accommodation and food services, information and communication, property, professional, scientific and technical, business administration, and arts, entertainment and recreation (Figure 15).The National Park may wish to discuss this with Local Enterprise Partnerships in the area.

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

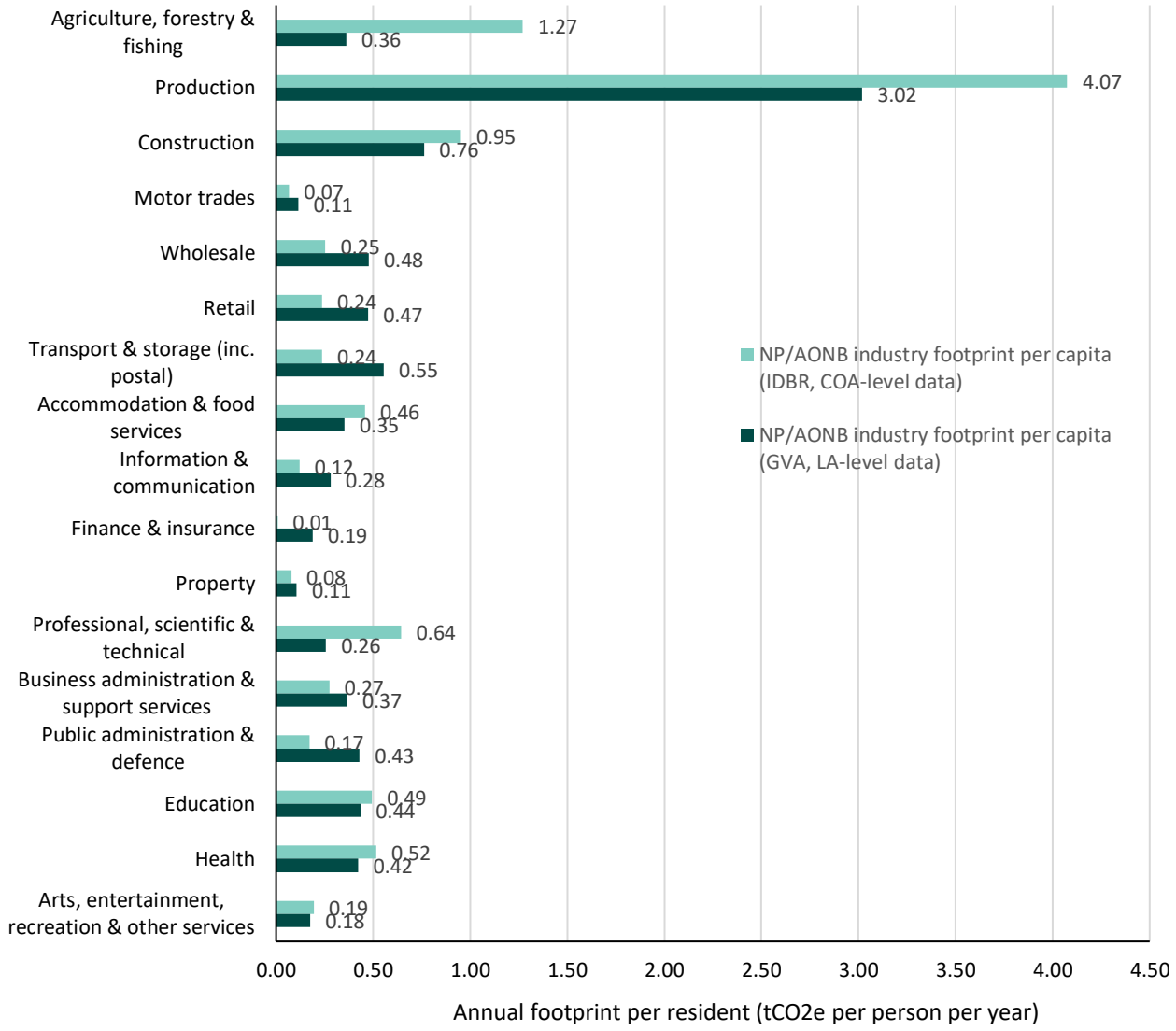


Figure 15: South Downs National Park Industry Footprint Estimates: IDBR vs GVA

5.3.3. Energy-only industry analysis

This analysis is a subset of the industry carbon footprint estimate. Energy is estimated to make up 21% of emissions from industry (294,837 tCO_2e). Table 2 shows the breakdown of industry emissions from electricity and fuels.

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

Industry Electricity	103,432 tCO_2e per year
Industry Fuels Excl. Road	155,851 tCO_2e per year
Industry Road Fuels	35,554 CO_2e per year
Total	**294,837 tCO_2e per year**

5.3.4. Large emitters analysis

As a further component of the industry GHG footprint analysis, the BEIS Pollution Inventory (2018) enables us to identify specific large emitters within each UK National Park (see Appendix 10.6.4). These are:

- Viridor Waste Management Ltd (Horton Landfill): 16.9 $ktCO_2$ (Scope 1)
- Veolia ES South Downs Ltd (Newhaven EfW Plant): 201.611 $ktCO_2$ (Scope 1)

The total volume of carbon dioxide relating to large emitters is **218,511 tCO_2.** This amounts to around 15% compared to the estimated total industry emissions in South Downs. We note that the estimated total IDBR-based industry footprint for South Downs (1,415,499 tCO_2e) excludes the COA regions hosting these two sites, as well as all large emitters in the vicinity of the National Park's boundary. Furthermore, unlike the reported emissions from the Viridor and Veolia sites, our total industry footprint estimate includes Scope 2 and 3 emissions. The two footprints should therefore be treated separately. The National Park may choose to engage with these companies, either directly or through the relevant Local Authorities, to promote carbon assessment of Scope 1, 2, and 3 GHG emissions, as well as carbon reduction planning with a view to a net zero target[38].

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

5.3.5. Comparison of annual industry footprint with UK averages

It may be helpful for the National Park to compare itself with the UK national average for each industry category. This helps to identify patterns and pinpoint where it would be beneficial to focus partnership-working with Local Authorities. The results (Figure 16) show higher-than-national averages for Agriculture, Forestry and Fishing, Production, Construction, Accommodation and Food Services, Professional, Scientific and Technical, Education, Health, and Arts, Entertainment and Recreation.

As background to influencing change, the UK Government enacted legislation on the 1st of October 2013 making it mandatory for the UK's largest quoted companies to report their GHG emissions (Statutory Instrument (SI) 2013/1970:5). In 2018, this SI 2013 was amended to include "emissions, energy consumption and energy efficiency action by quoted companies" (SI 2018/1155, Part 6) to reflect the true impact of their operations[39]. This was extended to all large companies, including the public sector. Due to this legislation, one should expect all large organisations to be in the process of assessing their full GHG emissions and preparing carbon reduction plans aimed at reaching net zero. However, large businesses fall under the new statutory reporting requirements and are new to carbon accounting may find the process challenging, so joined-up approaches may be helpful, particularly in the public sector.

[38] UK local authority and regional carbon dioxide emissions national statistics: 2005-2019

[39] 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.

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

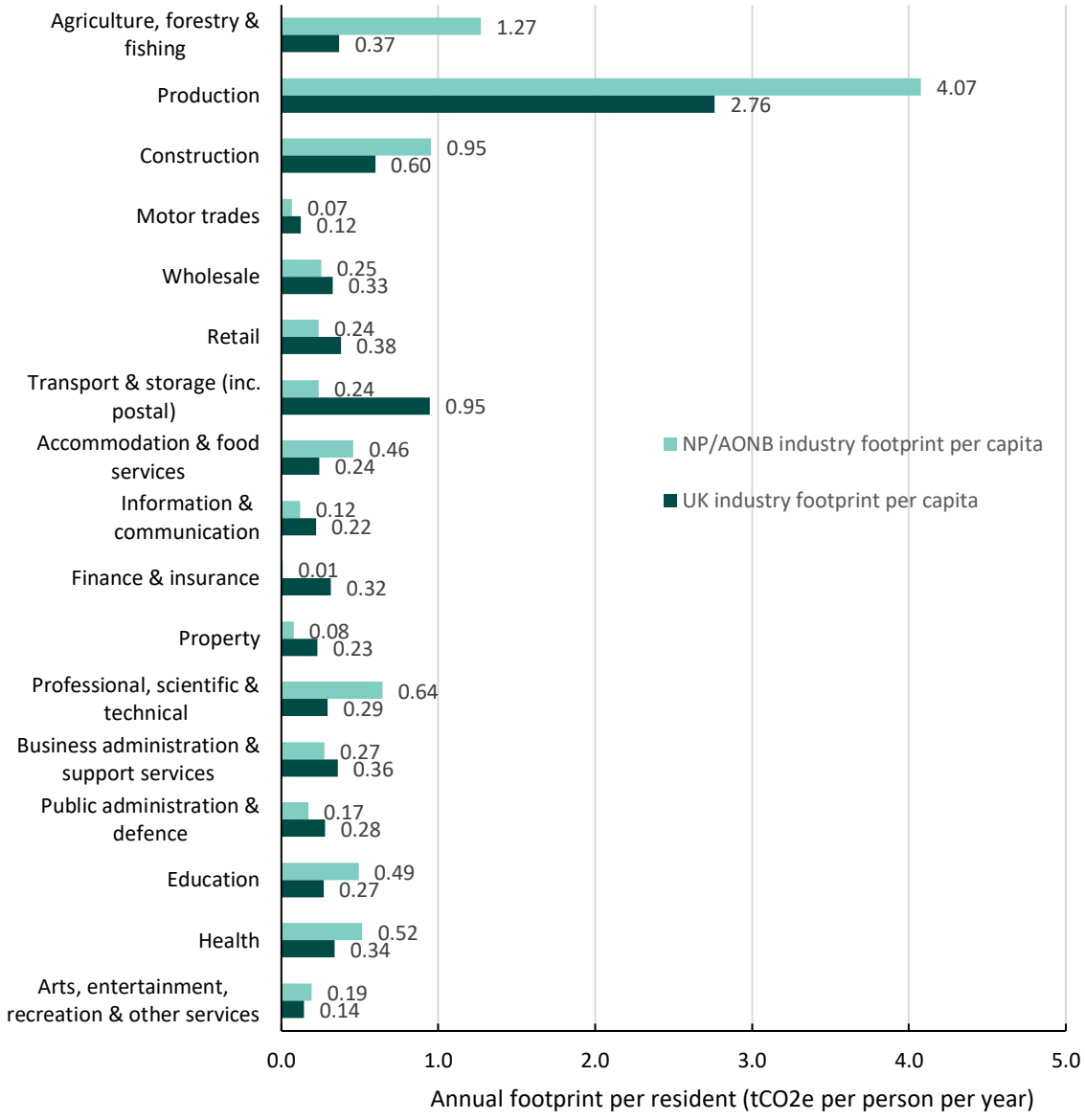


Figure 16: South Downs National Park industry GHG emissions compared with UK national average by sector

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

The analysis of the impact of through traffic has been included at the request of several National Park Authorities and Local Authorities for AONBs (see Appendix 10.7). Through traffic refers to vehicles passing through the National Park or AONB without visiting, regardless of their origin and destination. Its footprint is estimated by comparing total traffic point counts with pump-level fuel

sales within each National Park or AONB, along with assumptions about commuting in 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 South Downs National Park, estimated total through traffic emissions from cars, buses, motorbikes, vans and lorries are **457,115 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 the South Downs National Park are the M3, A26, A27, A31, A32, A23, A24, A272, A280, A283, A3. The estimated footprint of these roads within the National Park's geographical boundary is 606,626 tCO_2e per year across all vehicle types. This amounts to around 28% compared to the total footprint of the residents.

5.5. Land use emissions

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

Table 3: Land use GHG emissions – South Downs National Park

Land use CO_2	-189,642 tCO_2e per year
Land use non-CO_2	207,304 tCO_2e per year
Total: Land use	**17,663 tCO_2e per year**

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

There are no Government datasets for land use GHG emissions currently available for AONBs. As a result, we had to reconstruct them using the IDBR industry data for agriculture (for "land use non-CO_2"), and the habitat and peat data provided by each AONB (for "land use CO_2"; see Appendix 10.8.8).

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[40]. 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 10 in Appendix 10.8.7 (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[41]
- Climate Change Committee (2020) – Land Use: Policies for a Net Zero UK
- Climate Change Committee (2020) – The Sixth Carbon Budget: Agriculture and land use, land use change and forestry
- England Peatland Action Plan (2021).

Given that only 13% of England's peatlands are estimated to be in a near natural state at present, the Peatland Action Plan explicitly states that: "We will support National Parks and Areas of Outstanding Natural Beauty teams to deliver significant amounts of peatland restoration over the next 10 years[42]." The next section reflects upon 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

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

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

Please note that the land use GHG estimates for National Parks are published by BEIS, and given the existing levels of uncertainty they are expected to change in the future. Any changes introduced to the figures may impact on the proposed glide paths to net zero for all the UK National Parks and AONBs to varying degrees. It is expected that the BEIS land use data will be refined in subsequent years, and retrospectively applied to the entire published time series. Baseline year data will therefore be impacted in future years. Sections 5.6.1 to 5.6.4 discuss the importance of woodland, peatlands, and agricultural landscapes when developing subsequent strategies to implement land use targets that support climate adaptation and mitigation.

5.6.1. Trees, woodlands and forestry

The target of 500 ha of new woodland per year proposed in Section 6 is based on apportioning UK-wide woodland targets from The Sixth Carbon Budget and has been developed in discussion with the National Park officers. Our approach for apportioning the woodland target, which has been applied to all National Parks and AONBs participating in this programme, safeguards existing woodland (leaving aside the issue of replacing conifers with native broadleaf/mixed species) and protected habitats such as lowland heathland, while also reflecting on the agricultural make-up of the area. However, it is recognised that this the apportioned target does not replace discussions by the relevant Local Authorities, their members, partners and stakeholders in developing real-world operational strategies for land use change implementation, particularly in relation to developing a Tree, Forestry and Woodland Strategy.

There are multiple issues for stakeholders to consider including the complexities associated with the “right tree, right place” principle. Key to changing hearts and minds about the volume of tree coverage is the public perception of natural beauty within protected landscapes and how much change is acceptable within historic landscapes. For instance, woodland design may benefit from emulating “natural” patterns and forms rather than linear boundaries, unless there is a historic precedent[43]. There are also practical considerations in the choice of tree species to foster long-term resilience to average the anticipated temperature increases, increased average rainfall, more frequent flood events, and more severe drought periods driven by climate change. The Met Office have recorded a 1.21°C increase in average monthly maximum temperatures over the last 60 years or so for the weather station in Martyr Worthy[44]. Natural England published another helpful report, worthy of review, examining the relative sensitivity of habitats to climate change[45].

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

[43] Forestry Commission (2017), “The UK Forestry Standard: The governments approach to sustainable forestry.”
[44] https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/u134xcy4j
[45] Climate Change Adaptation Manual Evidence to support nature conservation in a changing climate

is the Forest of Bowland Area of Outstanding Natural Beauty (2021) "Trees, Woodland and Forestry Strategy".

5.6.2. Local authority opportunities

There are other opportunities to establish trees, some of them particularly town-friendly; for example, working with local authority partners to plant micro-forests, shrubs and hedgerows in urban settings such as parks and schools, and on public highways, e.g. roundabouts. These natural barriers can also offer some protection against air pollution if the correct species are chosen. Public highways can provide excellent spaces for pollinator patches, and the costs paid by local authorities to maintain these stretches can be reduced by changing grass-cutting regimes, as discussed in the Lancaster City Council (2021) Grassland Management Strategy[46]; see Box 1.

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

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

Source: Extracts from LCC (2021) Grassland Management Strategy

5.6.3. Peatlands and wetlands

Peatlands are globally important in tackling climate change; they cover only 3% of the global land surface, yet hold nearly 30% of the world's soil carbon[47]. In the UK, peat soils account for nearly 33% of land cover[48]. 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.

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[49].

There are three broad types of peatland in the UK:

[46] Lancaster City Council (2021), "Grassland Management Strategy"; https://www.lancaster.gov.uk/news/2021/feb/implementation-of-new-grassland-management-strategy.

[47] IUCN National Committee United Kingdom (2021) "About Peatlands"; https://www.iucn-uk-peatlandprogramme.org/about-peatlands.

[48] IUCN National Committee United Kingdom (2018) "UK Peatland Strategy 2018-2040", p. 25.

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

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

Peat restoration involves raising the water table nearer to the surface and re-establishing peat-forming fen or bog vegetation. Peatlands damaged by drainage and other human activities can rapidly lose their stored carbon, predominantly in the form of carbon dioxide (CO_2) release to the atmosphere. It's worth stating that peatlands are complex; they both emit and capture CO_2, and the balance between these processes depends on the peatland's condition. Peatlands may also be either sources or sinks of methane, and sources of nitrous oxide. However, the evidence suggests that, overall, peatland restoration delivers greenhouse gas benefits by protecting stored carbon and drastically reducing the amount of carbon dioxide emitted, even after factoring in the initial increase in methane emissions following re-wetting[50].

Building on the successes to date, it would be useful to continues assessing the soil depths throughout the landscape, which could present opportunities to employ citizen science. New 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 responsible for the delivery of Water Resources West Regional Plan and Water Resources Management Plans.

5.6.4. Agricultural landscape and food production

In considering land use and land use change potential, it is also important to understand the nature of the land in the protected landscape and how it contributes to UK food security. The UK is a net importer of food (Figure 17). Only 55% of food consumed in the UK (by economic value) is of UK origin, with 26% imported from Europe[51].

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.

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

[51] 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.

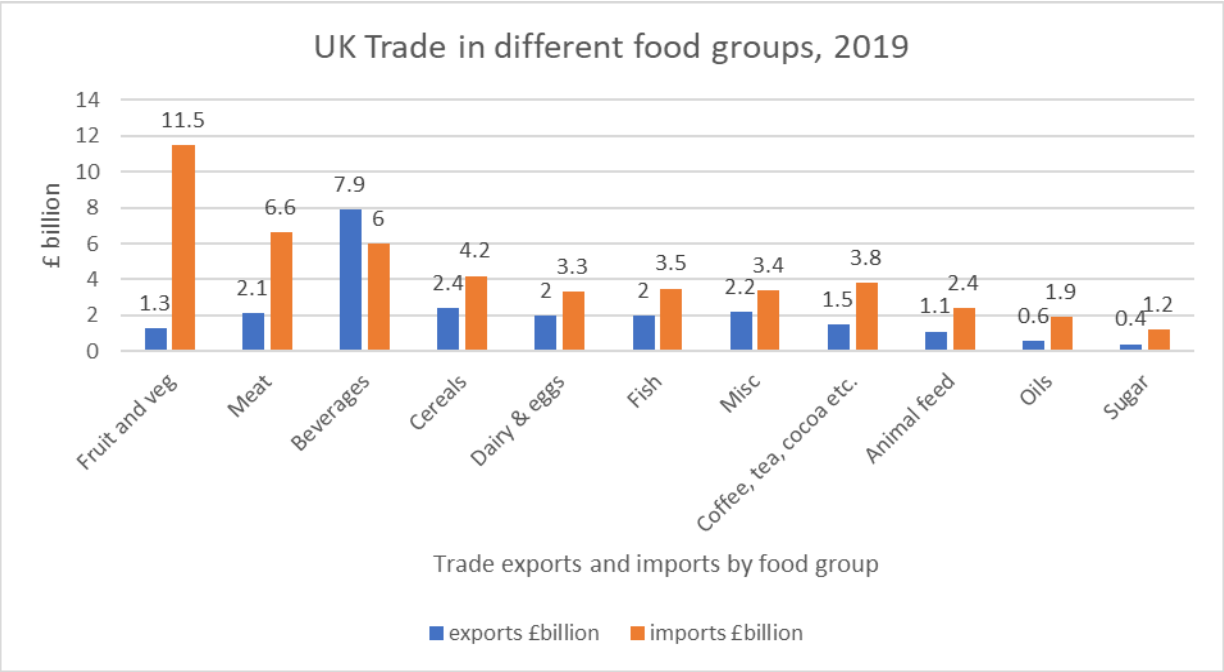


Figure 17: UK trade in different food groups, 2019

The South Downs National Park is an important food producer. A DEFRA (2017) survey of its farmland found the following make-up of agricultural holdings by type: lowland grazing livestock 36.1%, cereals 23.9%, general cropping 17.2%, mixed cropping 10.6%, horticulture 5.5%, dairy 3.2%, poultry 1.6%, pigs 1.1% and other 0.9%[52]. The landscape predominantly consists of Grade 3 agricultural land, with some Grade 4 land and non-agricultural land (largely forested) and spots of Grade 5 agricultural land[53]. The National Park's internal GIS analysis suggests an average of 43,399 hectares of agricultural land between 2015 and 2020. Grasslands cover roughly 65,000 ha.

RPA Crop Map (2019) indicates production of a wide range of crops including Beet, Clover, Lucerne, Maize, Mixed Crop-Group 1, Perennial Crops and Isolated Trees, Potato, Spring Barley, Spring Field Beans, Spring Linseed, Spring Oats, Spring Oilseed, Spring Peas, Spring Wheat, Winter Barley, Winter Field Beans, Winter Oats, Winter Oilseed, Winter Rye, Winter Triticale and Winter Wheat.

The opportunities presented are therefore different from the majority of the UK's National Parks, which have far less high-grade agricultural land. The South Downs landscape could present significant opportunities for agroforestry, hedgerow-planting on the margins of pasture and cropland, introducing legume species for grasslands and using cover cropping for arable land. There are also opportunities to plant native broadleaf woodland.

RPA Crop Map (2019) suggests that woodland habitats in the broadest sense – i.e. trees, scrub, short woody plants and hedgerows – occupy 50,500 hectares of the National Park, while according to Land Cover Map (CEH, 2015), typical broadleaf woodland occupies 30,000 ha, with coniferous woodland exceeding 5,000 ha. These estimates imply that around a quarter of the National Park

[52] "The Economy of the South Downs National Park."
[53] DEFRA MAGIC (https://magic.defra.gov.uk).

area is covered in woodland, which far exceeds the UK average. The total area of woodland coverage in the UK (as at 31 March 2021) is estimated to be 3.23 million hectares, represents 13% of the total land area in the UK (10% in England, 15% in Wales, 19% in Scotland[54]).

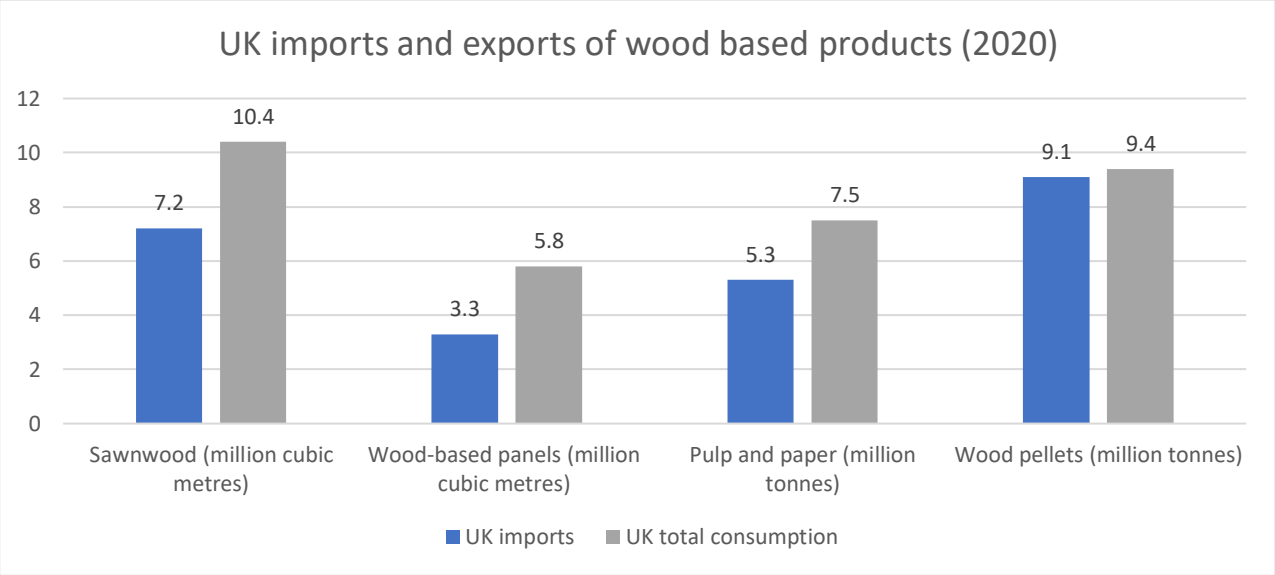
Specifically missing from RPA Crop Map as a category is viticulture (grapevine production). A consultancy, "Vinescapes", found that only 0.4% of South Downs agricultural land was used for viticulture, although the National Park reportedly hosts 51 vineyards and 11 wineries, an industry which could increase with the impact of climate change[55].

A key aim of the Partnership Management Plan is therefore "to build consensus among land managers about how to use agriculture, forestry and rewilding approaches together to rebuild our natural capital alongside, not instead of, producing food"[56].

UK Timber production context

The UK is heavily reliant on imported timber; timber products worth £7.5 billion entered the UK in 2020, compared to exports of £1.5 billion. The UK mostly uses timber in sawmills, for making wood-based panels, and increasingly for wood fuels (although this remains a small proportion of the total). In 2020 the UK softwood industry harvested around 10 million green tonnes, and the hardwood industry 0.8 million green tonnes[57]. 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[58].

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



[54] Forest Research (2021), "Resources: Woodland Statistics" https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/woodland-statistics/.

[55] "Sky News Climate change could make South Downs ripe for wine-making boom," Amar Mehta, News Reporter 21/06/2021.

[56] South Downs National Park (2020-2025), "Partnership Management Plan," p.16.

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

[58] 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/.

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"[59]. 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[60]. This is in contrast to carbon credits (for carbon sequestration) sold on the UK open market at £10-25 per tCO2e[61] (Forest Research states 1.25 to 1.43 cubic metres per tonne for roundwood).

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

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

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

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

This section outlines the aspiration for the South Downs National Park to set a challenging glide path to reach a consumption-based Net Zero by 2045, and beyond this date, to become a carbon sink as one of the 'lungs' of the South of England contributing to the UK's Net Zero target. It also outlines the planning assumptions used.

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

(i) Cover everything of significance within the influence of policy-makers;
(ii) Keep the target simple enough to describe;
(iii) Avoid double-counting;
(iv) 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. The six target categories are summarised below, with further supporting data in Appendix Section 10.8.4.

- **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 10.8); 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 South Downs National Park is estimated at 2,076,667 tCO_2e per year.

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

- Residents' travel by air, ferries, trains, buses and other transport (excl. cars). Local public transport will be counted through the energy GHG emissions linked to local industry (Target Category 1 above), and travel outside of the National Park is beyond the scope of influence by local authorities
- Residents' holiday accommodation outside the National Park
- Residents' housing (construction and maintenance)
- Residents' health, education and other public services
- Residents' and visitors' other bought services (e.g. financial, telecoms, travel agents, hairdressers)
- Residents' and visitors' art, sport and other leisure activities
- Residents' and visitors' water, waste and sewerage
- 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 4, and represent the minimum that can be considered to be Paris-aligned. For some of the 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 recommendation. Some or all will require appropriate support from government in order to be feasible, and part of the role of each Local Authority may be to push for the necessary support.

Table 4. Decarbonisation targets for the selected components of carbon footprint. For further details, see Appendix 10.8.4

Category	New Model for All National Parks and AONBs (2021) – used in this report	Achievable ceiling
1. Energy only GHG emissions (incl. supply chains) by residents, visitors and industry	**13.4 %** (specific to South Downs National Park) reduction per year	**5%** of present-day emissions
2. Food consumed by residents and visitors	**5%** reduction per year	**30%** of present-day emissions
3. Other goods purchased by residents and visitors	**5%** reduction per year	**10%** of present-day emissions
4. Visitor travel to and from the National Park or AONB	**10%** reduction per year	**7.5%** of present-day emissions
5 & 6. Land use (non-CO_2 and CO_2)	We have split land use emissions and targets into non-CO_2 and CO_2 components. See Appendix 10.8.8 for further details	**30%** of present-day emissions for the non-CO_2 component only; Achievable ceiling is not applicable for the CO_2 component in the current assessment

The six elements outlined above can be combined into an overall decarbonisation pathway, which in the case of the South Downs National Park results in a net zero date of 2045. 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 the land use CO_2 component, has been based on exponential decay (emissions decreasing by the same proportion each year) towards residual unavoidable emissions in the long run. The proposed reductions are broadly aligned with the Paris Agreement and with the UK's 2050 net zero policy.

The land use CO_2 component has been assumed to change linearly with time, which is characteristic of gradual uptake of a number of measures to manage land sustainably, increase its carbon uptake (and/or reduce CO_2 emissions through restoring peatland), and enhance biodiversity. The rate of change has been drawn from the Sixth Carbon Budget and apportioned to the South Downs National Park according to its land characteristics (see Appendix Section 10.8.8).

The 6th Carbon Budget apportionment methodology for South Downs results in the annual target for land use change summarised in Table 5, alongside the associated carbon sequestration flux increases each year. When measured in hectares per year converted, the cover cropping target comes on top at 1,167 ha/y., followed by legume creation at 1159 ha/yr., and new native broadleaf/mixed woodland at 500 ha/yr. Other measures are comparatively small, and we assume no conifer plantations in South Downs in order to prioritise native broadleaf species, while there is no peatland to restore. When converted to changes in carbon sequestration fluxes, the broadleaf/mixed woodland creation (-9,228 tCO_2e per year added each year) provides over 3.5

times higher contribution compared to the second-largest contribution from legumes (Table 5). This clearly illustrates the priorities for land use measures in order to achieve Net Zero.

We emphasise that priority must be given to managing agricultural land sustainably, both to enhance soil carbon sequestration, and to achieve co-benefits such as biodiversity gains and flood risk mitigation[62]. 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[63]. Typical sequestration values associated with regenerative agricultural practices (such as agroforestry, hedging, and growing legume-rich grasses and cover crops) are estimated to be between 1 and 3 tCO_2e per year per hectare in the first couple of decades. This is only a small fraction (a fifth to a tenth) of the carbon sequestration benefits typically achieved by creating new woodland on similar timescales, which – due to its natural simplicity and its age-old familiarity – is always going to be the main source of carbon sequestration, and 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 5: South Downs National Park: Apportioned 6th Carbon Budget targets for land use change and the associated additions to annual carbon sequestration fluxes.

Proposed Land Use Targets	**Value**	**Units**
New Native Broadleaf / Mixed Woodland	500.0	ha per year
New Productive Coniferous Woodland	0.0	ha per year
Restored Peatland	0.0	ha per year
Agroforestry (improved grassland & cropland)	299.1	ha per year
New Hedgerows (improved grassland & cropland)	17.1	ha per year
Legumes (improved grassland)	1159.0	ha per year
Cover Cropping (cropland)	1167.3	ha per year
Associated Carbon Sequestration	**Value**	**Units**
New Native Broadleaf / Mixed Woodland	-9,228	tCO_2e per year per year
New Productive Coniferous Woodland	0	tCO_2e per year per year
Restored Peatland	0	tCO_2e per year per year
Agroforestry (improved grassland & cropland)	-702	tCO_2e per year per year
New Hedgerows (improved grassland & cropland)	-182.1	tCO_2e per year per year
Legumes (improved grassland)	-2,380	tCO_2e per year per year
Cover Cropping (cropland)	-1,369.6	tCO_2e per year per year

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

[63] 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.

Based on the target-setting assumptions outlined in Table 5 and in Appendix 10.8.8, the South Downs National Park will achieve a total cumulative reduction in the net annual GHG emissions of 2,221,975 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.

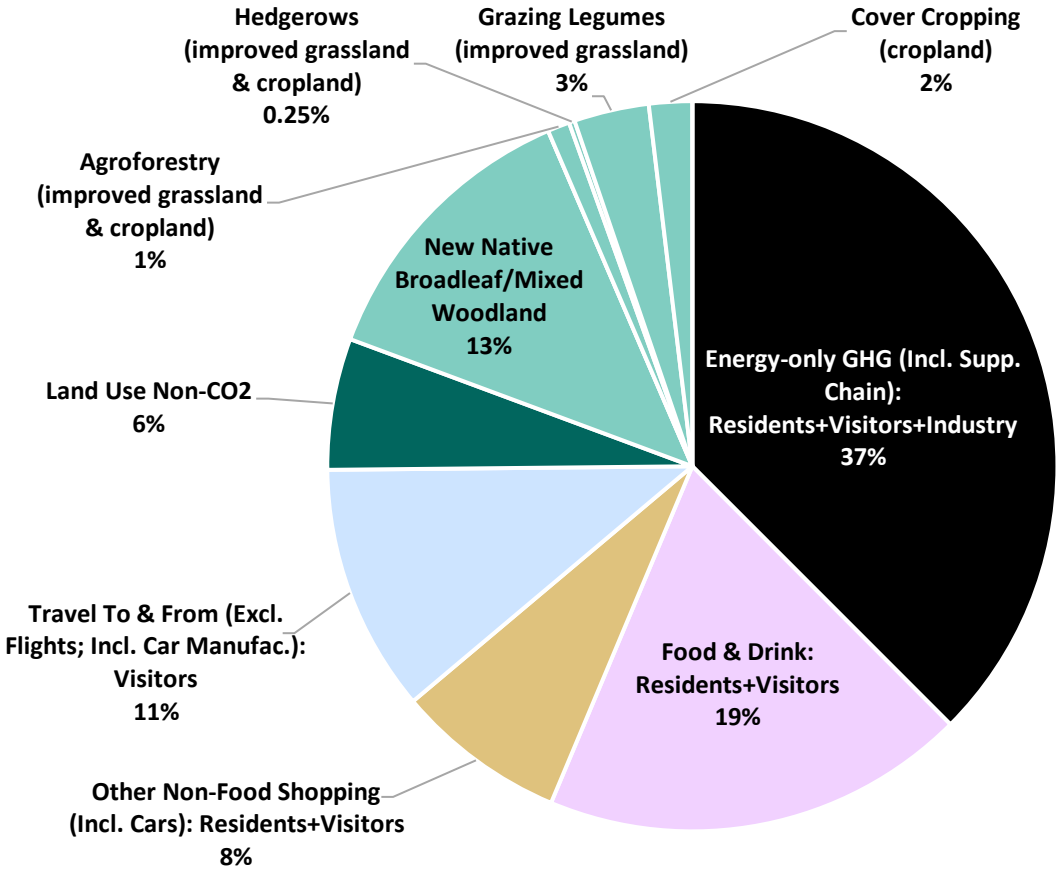


Figure 19. Percentage breakdown of the projected cumulative reduction in net annual GHG emissions for South Downs between the base year (2019) and 2050 according to the individual emitting categories and carbon sequestration measures considered in this assessment.

The assumptions above imply that South Downs would achieve Net Zero emissions in 2045 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 6 for the target figures). It also assumes the recommended decarbonisation and carbon sequestration efforts, including land use change, ratchet up to the required levels immediately in the base year of the assessment. In reality, the high levels of ambition for different sectors explored in this report are likely going take several years to achieve, given that post-COVID emissions have largely rebounded, and that decarbonisation trends to date have been relatively small in magnitude compared to what we know is required for keeping global warming below the safer 1.5°C limit from the Paris Agreement. These factors are expected to push the projected net zero year back by several years. The stated net zero date on its own should therefore not be taken as the main level of ambition to decarbonise for a given landscape.

An alternative target trajectory for South Downs using all consumption and landscape-based emissions as the baseline is given in Figure 21. The resulting 2019 baseline is considerably higher for South Downs, leading to a delay (until 2052) in reaching Net Zero compared to the default pathway (Figure 21).

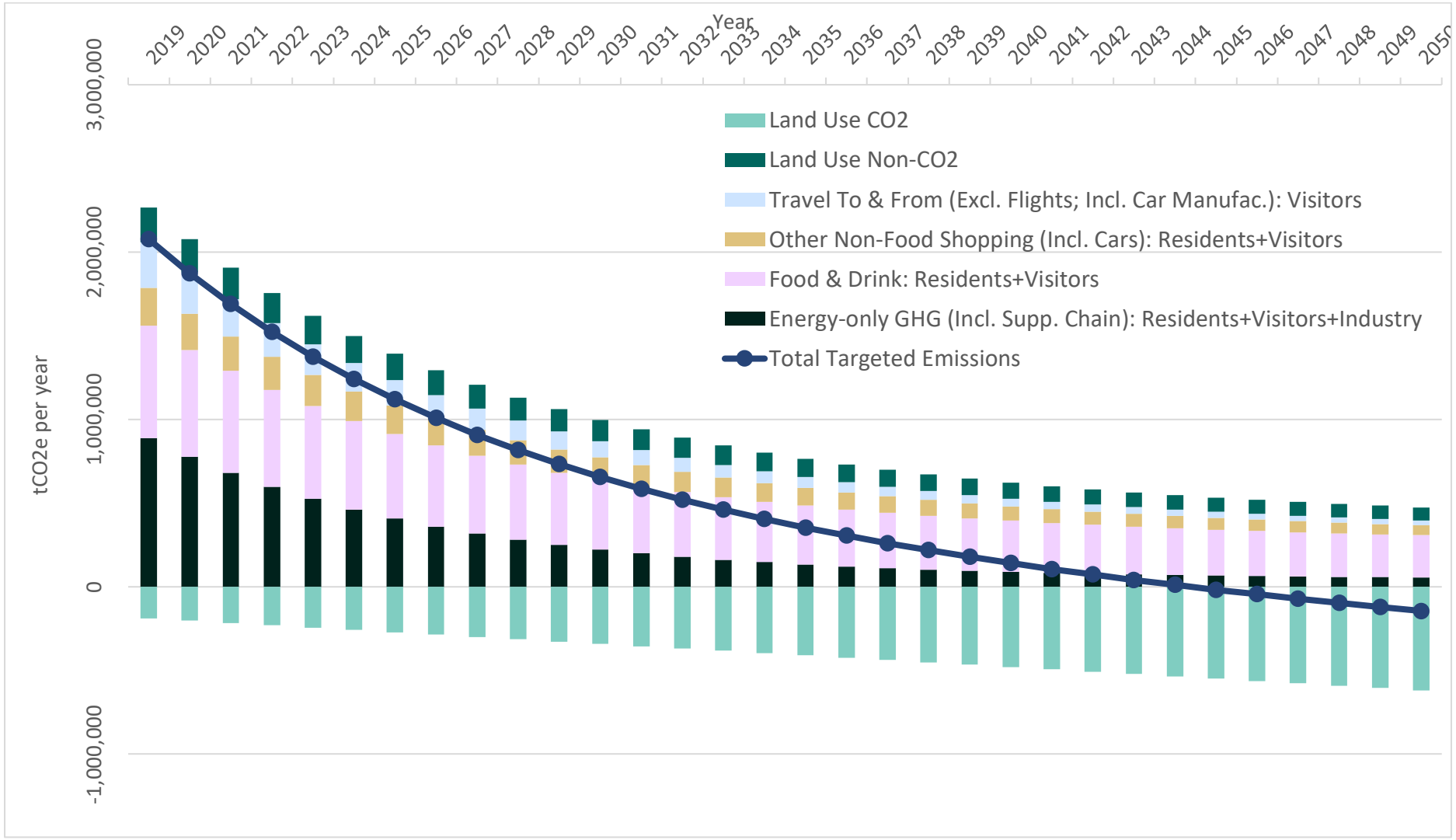


Figure 20. South Downs National Park: Pathway to Net Zero (Repeat of Figure 6)

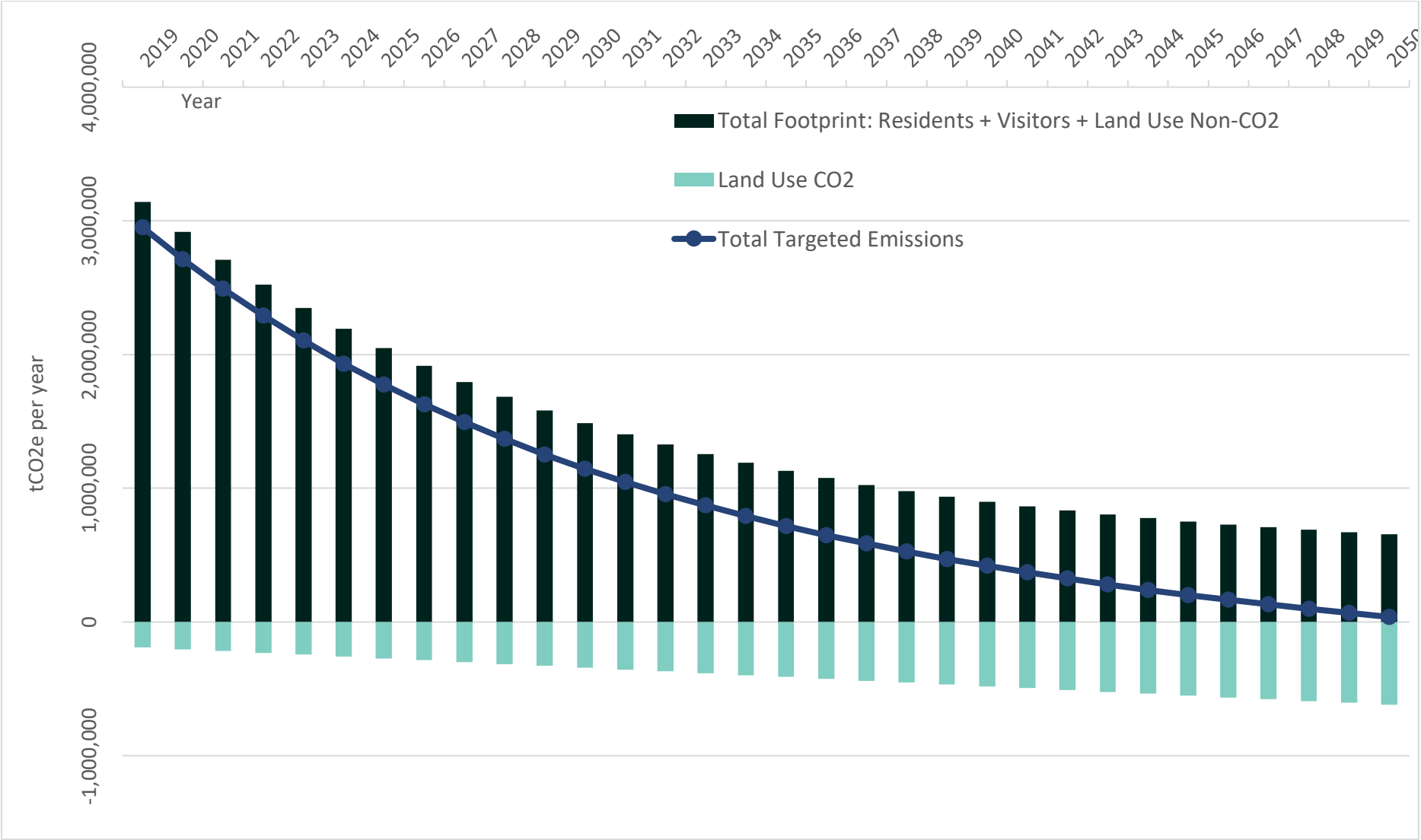


Figure 21. South Downs National Park: Alternative Pathway to Net Zero

7. Conclusions and recommendations

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

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

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

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

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,
- Reduce the need for future expensive retrofitting before 2040, even though it is crucial to pursue retrofitting to improve insulation and switch to renewable heating for existing housing stock,
- 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, South Downs would achieve net zero GHG emissions in 2045. It would subsequently reach negative emissions of approximately -145,307 tCO2e per year by 2050, with annual carbon sequestration in the park scaling up to around -619,344 tCO2e per year, and residual emissions dropping roughly to 474,037 tCO2e across the shortlisted policy priority areas (23% of the present-day carbon footprint baseline).

Although designed as the minimum to attain Paris-aligned targets, the trajectory for each is steep and challenging. This reflects the severity of the climate emergency in which the world now finds itself. The South Downs net zero date of 2045 should not be interpreted to mean that the target

recommendation is stronger than the UK's 2050 net zero target, but rather as a reflection of the Park's proportionately greater capacity for carbon sequestration compared to the UK as a whole.

In meeting the targets, some help from outside the National Park can be expected, thanks to anticipated changes in the UK and global economy. For example, the electricity grid is endeavouring 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 also be expected to come from government policies, and where this is not sufficient, part of the role of the South Downs National Park will be to push for the support needed to ensure that the National Park attains the recommended targets. This will require active engagement with all stakeholders, drawing on existing relationships and nurturing future ones, including partnership programmes with local organisations, with neighbouring Unitary Authorities, with the UK Government, and with the general public. It is through collaborative creative thinking, taken forward in sustained joint efforts by all stakeholders, that the exciting and realistic vision outlined in this report – of how a low-carbon future could work for everyone in the South Downs – 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 South Downs, dominated by broadleaf woodland creation, grassland improvement and cover cropping, must be ambitious enough and sustained for long enough for the sequestration flux to scale up sufficiently year on year, in line with the suggested land use CO_2 pathway. Establishing irreversible carbon sinks (with biodiversity co-benefits) relies on the availability of suitable incentives enabling land managers to implement land use changes such as woodland creation, peatland restoration (where applicable) and regenerative farming, in line with current recommendations by the UK Government.[64]

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.

[64] UK Sixth Carbon Budget: "Agriculture, Forestry and Other Land Use" section.

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

Environmental Land Management Schemes (ELMS)

Three new schemes were piloted during 2021, and launched in 2022, to reward environmental land management: the Sustainable Farming Incentive, Local Nature Recovery, and Landscape Recovery[65]. Through these schemes, according to current public communications, farmers and other land managers may enter into agreements to be paid for delivering the following: clean and plentiful water, clean air, thriving plants and wildlife, protection from environmental hazards, mitigation of and adaptation to climate change, beauty, heritage, and engagement with environmental law.

Woodland grants and incentives[66]

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

Peatland restoration

- Peatland Code
- Nature for Climate Peatland Grant Scheme

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

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

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

8. Acronyms

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Turnover: A synonym to business revenue.

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

10. Appendices

10.1. Appendix: National Park key statistics

Table 6: Key statistics for South Downs National Park

Output Variable	Value	Unit	Source		Output Variable	Value	Unit	Source
Land Area	**165,268**	ha	Official Figures / CEH LCM					
Resident Population	**140,881**	persons	ONS Mid-2019 LSOA Population; ONSPD 2019; BEIS 2019 Postcode Electricity Meters; Custom Postcodes		Average Visitors Per Day	**55,801**	persons	STEAM 2019
Resident Population Density	**0.85**	persons per ha	Based on the Above		Visitor Population Density	**0.34**	persons per ha	Based on the Above
Annual Final Consumption (Households + Public Services)	**32,639**	£ per person per year	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes		Annual Visitors Spend	**276,673,259**	£ per year	STEAM 2019
Annual Household Fuel per Resident	**6,246**	kWh per person per year	BEIS 2019 Postcode Gas; BEIS 2018 Residual Fuels; ONSPD 2019; Custom Postcodes		Annual Visitors All Types	**18,964,324**	persons per year	STEAM 2019
Annual Household Electricity per Resident	**1,504**	kWh per person per year	BEIS 2019 Postcode Electricity; ONSPD 2019; Custom Postcodes		Percentage of Visitors Staying Overnight	**3.6%**	percentage	STEAM 2019
Annual Vehicle Fuel per Resident	**5,333**	kWh per person per year	BEIS 2018 Road Fuels; ONSPD 2019; Custom Postcodes		Average Duration of Stay for Overnight Visitors	**3.1**	days	STEAM 2019
Annual Personal Flights per Resident, Economy Class	**2.07**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate		Average Visitor Party Size	**2.5**	persons	Visitor Survey
Annual Personal Flights per Resident, Business Class	**0.014**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate		Average Visitor One-Way Road/Train/Boat Mileage Travelled	**40**	miles	Visitor Survey
Average Resident One-Way Mileage per Flight, Economy Class	**1,771**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes		Estimated Fraction of Trips by Car	**74.3%**	percentage	Visitor Survey
Average Resident One-Way Mileage per Flight, Business Class	**4,038**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes		Estimated Fraction of Trips Involving Flights	**6.7%**	percentage	Visitor Survey
Annual Business Turnover, COA-based	**9,600,269,000**	£ per year	IDBR 2019; ONSPD 2019; Custom Postcodes		Average Visitor One-Way Mileage per Flight, Economy Class	**2,110**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Percentage of Suppressed Turnover Output, COA-based	**0.00%**	percentage	IDBR 2019; ONSPD 2019; Custom Postcodes		Average Visitor One-Way Mileage per Flight, Business Class	**1,376**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes

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

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

10.3. Appendix: Carbon footprint definitions and data sources

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

10.4. Appendix: Residents GHG emissions

SMALL WORLD CONSULTING

Residents GHG emissions: South Downs National Park

Consumer Expenditure Categories Summary	ALL Scopes	Units
Household Fuel	191,998	tCO2e per year
Household Electricity	71,825	tCO2e per year
Vehicle Fuel	280,717	tCO2e per year
Car Manufacture & Maintenance	68,411	tCO2e per year
Personal Flights	367,503	tCO2e per year
Ferry Crossings & Cruises	23,724	tCO2e per year
Trains, Buses & Other Transport	43,440	tCO2e per year
Food & Drink	491,434	tCO2e per year
Accommodation (Non Home) Excl. Food	9,627	tCO2e per year
Other Non-Food Shopping	137,340	tCO2e per year
Water, Waste & Sewerage	28,956	tCO2e per year
Other Bought Services	138,990	tCO2e per year
Housing	104,039	tCO2e per year
Health, Education, Other Public Services & Administration	191,734	tCO2e per year
Leisure, Recreation & Attractions	35,806	tCO2e per year
Total	**2,185,545**	**tCO2e per year**

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

10.5. Appendix: Visitors GHG emissions

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Visitors GHG emissions: South Downs 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 could be marginally different to the sum of individual components due to rounding

Consumer Expenditure Categories Summary	In NP	To & From NP	Units
Household Fuel	1,934	0	tCO2e per year
Household Electricity	832	0	tCO2e per year
Vehicle Fuel	41,482	198,880	tCO2e per year
Car Manufacture & Maintenance	10,502	50,353	tCO2e per year
Personal Flights	0	187,593	tCO2e per year
Ferry Crossings & Cruises	0	0	tCO2e per year
Trains, Buses & Other Transport	4,696	23,988	tCO2e per year
Food & Drink	179,343	0	tCO2e per year
Accommodation (Non Home) Excl. Food	12,381	0	tCO2e per year
Other Non-Food Shopping	10,432	0	tCO2e per year
Water, Waste & Sewerage	12,743	0	tCO2e per year
Other Bought Services	10,260	0	tCO2e per year
Housing	0	0	tCO2e per year
Health, Education, Other Public Services & Administration	0	0	tCO2e per year
Leisure, Recreation & Attractions	2,503	0	tCO2e per year
Total	**287,108**	**460,814**	**tCO2e per year**

10.6. Appendix. Industry footprint estimates

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

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

IDBR

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

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

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

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

Source: IDBR Meta Data

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

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Industry GHG emissions (IDBR-based): South Downs National Park

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

Industry Categories Summary (IDBR sectors)	**ALL Scopes**	**Units**
Agriculture, forestry & fishing	179,027	tCO2e per year
Production	574,022	tCO2e per year
Construction	134,243	tCO2e per year
Motor trades	9,265	tCO2e per year
Wholesale	35,771	tCO2e per year
Retail	33,380	tCO2e per year
Transport & storage (inc. postal)	33,416	tCO2e per year
Accommodation & food services	64,598	tCO2e per year
Information & communication	16,894	tCO2e per year
Finance & insurance	1,120	tCO2e per year
Property	10,959	tCO2e per year
Professional, scientific & technical	90,779	tCO2e per year
Business administration & support services	38,609	tCO2e per year
Public administration & defence	24,054	tCO2e per year
Education	69,400	tCO2e per year
Health	72,682	tCO2e per year
Arts, entertainment, recreation & other services	27,278	tCO2e per year
Total	**1,415,499**	**tCO2e per year**
ENERGY-ONLY INDUSTRY (subset of INDUSTRY) -- South Downs National Park		
Industry Road Fuels	103,432	tCO2e per year
Industry Fuels Excl. Road	155,851	tCO2e per year
Industry Electricity	35,554	tCO2e per year
Total	**294,837**	**tCO2e per year**
LARGE EMITTERS (Scope 1) -- South Downs National Park		
Large Emitters	**218,511**	**tCO2e per year**
INDUSTRY-RELATED FLIGHTS (subset of INDUSTRY) -- South Downs National Park		
Industry-related flights	**127,784**	**tCO2e per year**
Land Use -- South Downs National Park		
Land Use CO2	**-189,642**	**tCO2e per year**
Land Use Non-CO2	**207,304**	**tCO2e per year**

10.6.3. Appendix: IDBR vs GVA industry footprint estimates

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IDBR vs GVA Industry Footprint Estimates: South Downs National Park

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

Industry Categories Summary (IDBR sectors)	NP/AONB industry footprint per capita (IDBR, COA-level data)	NP/AONB industry footprint per capita (GVA, LA-level data)	Units
Agriculture, forestry & fishing	1.27	0.36	tCO2e/person/year
Production	4.07	3.02	tCO2e/person/year
Construction	0.95	0.76	tCO2e/person/year
Motor trades	0.07	0.11	tCO2e/person/year
Wholesale	0.25	0.48	tCO2e/person/year
Retail	0.24	0.47	tCO2e/person/year
Transport & storage (inc. postal)	0.24	0.55	tCO2e/person/year
Accommodation & food services	0.46	0.35	tCO2e/person/year
Information & communication	0.12	0.28	tCO2e/person/year
Finance & insurance	0.01	0.19	tCO2e/person/year
Property	0.08	0.11	tCO2e/person/year
Professional, scientific & technical	0.64	0.26	tCO2e/person/year
Business administration & support services	0.27	0.37	tCO2e/person/year
Public administration & defence	0.17	0.43	tCO2e/person/year
Education	0.49	0.44	tCO2e/person/year
Health	0.52	0.42	tCO2e/person/year
Arts, entertainment, recreation & other services	0.19	0.18	tCO2e/person/year
Total	**10.05**	**8.78**	**tCO2e/person/year**

10.6.4. 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 Norfolk and Suffolk Broads	Broadland	British Sugar Plc	Cantley	NR133ST	120.77
Peak District National Park Borders	Derbyshire Dales	HJ Enthoven & Sons Ltd	Darley Dale	DE42LP	25.8
Peak District National Park	Derbyshire Dales	Tarmac Ltd	Ballidon Quarry	DE61QX	0.002702
Peak District National Park	High Peak	Hope Construction Materials Ltd	Hope Works	S336RP	1,048.88
South Downs National Park	Horsham	Viridor Waste Management Ltd	Horton Landfill	BN59XH	16.9
South Downs National Park	Lewes	Veolia ES South Downs Ltd	Newhaven EfW Plant	BN90HE	201.6
New Forest National Park	New Forest	Cleansing Service Group Ltd	Poundbottom Landfill	SP52PU	13.4
North York Moors National Park	Redcar and Cleveland	Cleveland Potash Ltd	Saltburn-By-The-Sea	TS134UZ	13.7
New Forest National Park	Wiltshire	Renewable Power Systems Ltd	Poundbottom Landfill Site	SP52PU	3.8

10.7. Appendix: Emissions from major roads

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Emissions from major roads: South Downs National Park

- *This analysis of the impact of transit traffic has been included at the request of several NPs*
- *(*) The Larger and Smaller subsets of selected A roads include elements of transit traffic as well as traffic from residents, visitors and industry.*
- *(**) 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*

SELECTED A ROADS - SMALLER SUBSET * -- South Downs National Park		
Road Names, Smaller Subset	M3 A26 A27 A31 A32	
Cars, Buses & Motorbikes	162,411	tCO2e per year
Vans & Lorries	86,498	tCO2e per year
Total	**248,909**	**tCO2e per year**
SELECTED A ROADS - LARGER SUBSET * -- South Downs National Park		
Road Names, Larger Subset	Smaller Set + A23 A24 A272 A280 A283 A3	
Cars, Buses & Motorbikes	406,574	tCO2e per year
Vans & Lorries	200,052	tCO2e per year
Total	**606,626**	**tCO2e per year**
THROUGH TRAFFIC ** -- South Downs National Park		
Cars, Buses & Motorbikes	284,492	tCO2e per year
Vans & Lorries	172,623	tCO2e per year
Total	**457,115**	**tCO2e per year**

10.8. Appendix: Methodology

10.8.1. Appendix: History of model development

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

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

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

10.8.2. Appendix: Model development for 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 the datasets used in the carbon footprint model is provided in Appendix 10.2.

10.8.3. Appendix: Outline of emissions estimation methodology

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

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

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

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

- For visitors, the same EEIO model was used to estimate emissions from consumption other than road fuel. We used data from multiple visitor surveys and tourism modelling to derive

estimates of visitor numbers and visitor spending, which we combined with emission factors from the EEIO model.

- Emissions relating to land-based visitor travel to and from the National Park and within the National Park were derived using visitor surveys, and comparisons with resident road travel emissions.

- Emissions related to through traffic, which by definition occur within the boundary of the National Park or AONB, are estimated by comparing total traffic point counts with pump-level fuel sales within the National Park or AONB, along with assumptions about commuting in out of the area.

- Civil Aviation Authority survey data was used to estimate the emissions associated with flights taken by residents and visitors. The emission factors used take account of flight distances and flight class, and include a markup factor for high-altitude climate effects.

- A very rough estimate of industry emissions (including their supply chains), which overlaps with resident and visitor emissions, was included for added perspective. The estimate was derived from Inter-Departmental Business Registry (IDBR) turnover data for businesses registered in an area that was mapped as closely as possible to the National Park, combined with industry-specific emission factors that were drawn from the EEIO model. Separately, energy-related emissions from industry were calculated from consumption data and energy-related emission factors that included supply chain components.

- We adopted land use emissions estimates published by BEIS for all National Parks (both for the CO_2 and non-CO_2 components). For AONBs, the CO_2 component of land-based emissions and carbon sequestration was estimated separately using bespoke land use datasets provided by the AONBs following a common methodology developed as part of this programme, together with the BEIS and Natural England habitat-specific emission factors. The Non-CO_2 component of land-based emissions for AONBs (including emissions from livestock and fertiliser use) was approximated using footprint estimates for the industry sector "agriculture, forestry and fishing" derived from the IDBR data.

The data sources used are listed in Appendix 10.2.

10.8.4. Appendix: Target setting rationale

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

For energy-related emissions we drew on modelling by the Tyndall Centre for Energy and Climate Change Research for setting local authority targets. For food-related emissions we examined recommendations from the National Food Strategy and other sources. For goods other than food, the target reflects the relative difficulty of reducing emissions from global supply chains, compared

to UK energy-related emissions. For visitor travel the target reflects both possible changes in future travel habits and the likely decarbonisation of land transport. The land use targets reflect the feasibility assessment in line with the Sixth Carbon Budget's 2050 net zero pathway for the UK.

Table 6 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 6: High level comparison between Cumbria and new National Park target setting methodology and assumptions used.

Category	Previous Model for Cumbria (2020)	New Model for All National Parks (2021) – used in this report	Asymptote (Achievable ceiling)
Energy only emissions by residents, visitors and industry	13% per year reduction in energy-related CO_2 (as prescribed by the Tyndall Carbon Budget)Tool[67]). Includes Scope 1 and 2 carbon dioxide emissions only (excluding motorways).	**13.4 %** (specific to South Downs National Park) per year reduction in energy-related CO_2 as prescribed by the Tyndall Carbon Budget Tool, and extended to other GHGs. Includes Scope 1, 2 and 3 GHG energy emissions expressed at tCO_2e for residents, visitors and industry.	**5%** of present-day emissions. This is our expert judgement for embedded emission across various forms of renewable energy, for example assuming little or no CCS
Food consumed by residents and visitors	5% reduction per year	**5%** reduction per year. This assumes 3% per year from dietary change (National Food Strategy: 30% in 10 years), 1% per year from waste reduction and 1% per year from other changes incl. technology.	**30%** of present-day emissions. This is based on the 6th Carbon Budget (AFOLU section), stating that UK agriculture emissions are set to halve from 54 $MtCO_2e$ today to 27 $MtCO_2e$ in 2050 under the Net Zero pathway. Some further savings may come from widespread adoption of vertical farming, which is why we opted for the more ambitious 30% ceiling.
Other goods purchased by residents and visitors	5% reduction per year	**5%** reductions per year. Includes cars. This assumes that sectors such as cement and steel, which feed into complex supply chains (incl. making cars), will take time to	**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

[67] 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/

		decarbonise globally and won't reach zero emissions in large exporters like China by 2050.	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%** 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 model of transport from cars.	**7.5%** of present-day emissions. This is our expert judgement for embedded emission across various forms of renewable energy, and from the sectors (via supply chains) such as cement and steel that will take time to decarbonise globally (affecting car manufacturing, buildings, etc).
Land Use	Expert judgement based on discussions with stakeholders involved	We have split land use into Land Use Non-CO_2 and Land Use CO_2. See Table 7 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 10.8.8. Table 7 below provides a brief overview.

Table 7. 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 12. 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 South Downs, the proposed land use measures are estimated to add -13,861 tCO_2e/year to the total carbon sequestration flux in the landscape each year (i.e. an extra 13,861 tCO_2e removed per year in each of the subsequent years).

10.8.5. 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[68]. 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 8 and Table 9. The report states that emissions from the AFOLU sector "have declined by 16% since 1990. This is mainly due to successive reform of the Common Agricultural Policy (CAP) in the 1990s and early 2000s, which reduced livestock numbers, coupled with changes in farming practices due to EU environmental legislation to address non-GHG pollutants (e.g., Nitrates Directives). There has been little change in emissions since 2008".

Table 8: 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 $MtCO_2e$

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

Carbon dioxide (CO2) from fossil fuel use	11%	6.0 $MtCO_2$
Total	**100%**	**54.6 $MtCO_2e$**
Data Source: The Sixth Carbon Budget: Agriculture and land use, land use change and forestry, p.6		

Table 9: Baseline for Agriculture emissions (2018) using Global Warming Potential of AR5 for methane

	Percentage of UK emissions	**Quantity of CO_2 equiv.t**
Agriculture Breakdown		*SWC planning assumptions*
Methane from livestock (Enteric fermentation digestion process of ruminant livestock)	53%	28.9 $MtCO_2e$
Agricultural soils	21%	11.5 $MtCO_2e$
Waste and manure management	16%	8.7 $MtCO_2e$
Stationary machinery	8%	4.4 $MtCO_2e$
Other	2%	1.1 $MtCO_2e$
Total	**100%**	**54.6 $MtCO_2e$**
Data Source: The Sixth Carbon Budget Agriculture and land use, land use change and forestry p.6 Figure M.7.1		

10.8.6. 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[69]. The six land classes are:

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

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

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

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

In 2017 the Centre for Ecology and Hydrology proposed changes to the methodology for reporting emissions from peatlands[70]. 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[71].

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 10). 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

[70] 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.
[71] Ricardo Energy & Environment UK NIR 2020 (Issue 1) UK GHG Inventory 1990-2019 Annex p. 854

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.

Table 10. Extract from Ricardo Energy & Environment UK NIR 2020 (Issue 1) UK GHG Inventory 1990-2019 Annex p. 858

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

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

[a] Tier 1 default EF (IPCC 2014)
[b] Tier 2 EF (updated literature analysis in 2019 incorporating data from Evans et al. 2017)
[c] Tier 3 Forest Research CARBINE model implied EF for 1990 to 2019. The decreasing trend is due to an increase in age of forests on organic soils due to decreasing afforestation on organic soils.

10.8.8. 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)[72] according to present-day land use distribution in each National Park or AONB. It is worth noting that all land use datasets have considerable uncertainties. We adopted the CEH Land Cover Map classification for land use assessments across all National Parks and AONBs on the current programme.

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

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

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

The degraded peatland classification follows the methodology adopted by BEIS for annual LULUCF GHG inventories[73], which is based on the assessment by Evans *et al.* (2017).

For the South Downs National Park, the current land use distribution is illustrated in Table 11. It is based on the 2015 CEH Land Cover Map. 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 12.

At roughly 165,000 ha, South Downs accounts for around 0.7% of UK's total land area, but its share of UK's broadleaf woodland is 4.5 times higher than its land share. The National Park may be in a

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

position to further expand the existing woodland cover, giving preference to native broadleaf trees that have multiple co-benefits rather that to productive coniferous woodland.

The South Downs share of improved grassland and cropland is marginally higher than the UK averages, with good potential to apply restorative agricultural practices as part of the 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 11. South Downs: Key land use types by area (present-day), including underlying peat areas the estimated percentage of peat in healthy condition (by area)

Land Cover (Habitat) Type	**Habitat Area (ha)**	**Peat Area (ha)**	**Estimated % of Peat Area in Healthy Condition**
Broadleaved woodland	29,988.7	0.0	NA
Coniferous woodland	4,795.2	0.0	NA
Arable and horticulture	59,485.4	0.0	NA
Improved grassland	59,060.5	0.0	NA
Neutral grassland	363.2	0.0	NA
Calcareous grassland	4,795.2	0.0	NA
Acid grassland	10.1	0.0	NA
Fen, marsh, swamp	11.7	11.7	100%
Heather	598.9	0.0	NA
Heather grassland	53.9	0.0	NA
Bog	0.0	0.0	NA
Saltmarsh	107.2	0.0	NA
Urban	364.6	0.0	NA
Suburban	4,745.2	0.0	NA
Total	**164,379.6**	**11.7**	**NA**

Table 12. South Downs: Areas of the main land cover (habitat) types compared with the relevant UK totals

Land Cover Type	**Current UK Area (ha)**	**Current NP Area (ha)**	**NP Area as % of UK Area**
Broadleaf Woodland	1,572,900	29,989	1.895%
Coniferous Woodland	1,637,100	4,795	0.291%
Improved Grassland (mineral soils only)	6,161,798	59,060	0.958%
Cropland (mineral soils only)	5,788,356	59,485	1.028%
Degraded Peatland (all types)	2,909,940	0	0.000%
Total Woodland Area (Broadleaf + Coniferous)	3,210,000	34,784	1.084%

Total Agricultural Area (Improv. Grassland + Cropland)	11,950,154	118,546	0.992%
Total Area of Selected Land Cover Types (above)	18,070,094	153,330	0.884%
Total Area (incl. urban, rough grassland, water, rock, etc)	24,249,500	165,268	0.682%

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

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

Each of these measures is described in the subsections below.

Woodland creation

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

As a starting point, we apportion UK-wide woodland creation target based on the current woodland coverage in each National Park and AONB as a percentage of the UK coverage (see Table 12 above), which simply mirrors the approach for apportioning other land use and management options considered here (e.g. peatland restoration and a better agricultural management). However, the fact that creating new woodland requires a fundamental change to land use rather than management changes on existing land, the woodland target has to be set differently, by considering total areas of suitable habitats within each landscape. We refer to this assessment as a high-level woodland opportunity mapping, which is a first step in setting a practical woodland target, to be followed by a field-level multi-benefit opportunity mapping.

As a default rule, we safeguard habitats such as existing woodland, calcareous grassland, lowland heathland, fen and bog from the opportunity mapping for new woodland. On the other hand, habitats such as neutral grassland, acid grassland and upland heathland, part of which are commonly referred to as “moorland”, are prime candidates for woodland opportunity mapping, subject to field-level ecological and economic considerations. We note that large areas of the acid grassland and upland heathland habitats contain both deep and shallow peat, typically classified as modified bog dominated by heather/grass, either drained or undrained. 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 South Downs in Table 13. For most protected landscapes, the ambition is around two times the minimum target based on suitable areas. This reflects on unique opportunities that Protected Landscapes have in terms of attracting both public and private grants to expand the woodland cover, and the central role they ought to play for meeting ambitious nature recovery goals across the UK. The proposed higher ambition approach is supported by field-level woodland opportunity mapping performed by several landscapes (e.g. Cotswolds, Northumberland). Based these principles, the custom woodland target for South Downs is 500 ha/yr.

Table 13. Three ways of setting new woodland targets in South Downs.

Woodland target apportioned by woodland land cover area in the National Park or AONB	538	ha/yr
Minimum woodland target apportioned by suitable habitat areas in the National Park or AONB	255	ha/yr
Custom woodland target in the National Park or AONB	500	ha/yr

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

In this assessment, we propose to use the 100%-0% woodland cover split in favour of native woodland for the South Downs National Park, to benefit from the broader environmental and social benefits of native woodland.

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[74]. 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

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

from the WCC) representative estimates of soil carbon sequestration for woodland, from a recent literature review by Bossio *et al.* (2020)[75].

Peatland restoration

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

The UK-wide peatland restoration target is apportioned to each National Park or AONB according to its total estimated area of peatland. Each National Park's and AONB's target is further broken down into sub-targets for individual peatland areas with distinct types of modification and/or degradation, following the peatland conventions adopted in the BEIS LULUCF GHG inventory (Section 10.8.7). The sub-targets are based on the estimated current surface areas of the relevant types of degraded peatland (Table 11).

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

As with the peatland classification, our peatland emissions factors follow the BEIS methodology (Section 10.8.7). 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.

Peatland targets are irrelevant in the case of the South Downs National Park since the 12 ha of lowland fens within its boundary have been restored in recent years and are deemed to be in a near-natural condition.

Agroforestry uptake

According to the Sixth Carbon Budget, 10% of UK farmland area may need to be converted to agroforestry systems by 2050 in line with the recommended Net Zero pathway. We apply this target to improved grassland and cropland systems only. Agroforestry is assumed to be current practice

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

on 1% of UK farmland; we do not have definitive figures at this stage. Agroforestry is different from present-day farm woodland, which is estimated to cover 5% of the total farmland area in the UK.

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

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

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

Hedgerows expansion

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

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

Grazing legumes for improved grassland

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

Based on the assumptions above, the recommended increase in land dedicated to UK-wide grazing legumes is just over 120,000 ha/year between now and 2050, which applies to improved grassland areas only. This target is apportioned to each National Park or AONB according to the size of existing

areas of improved grassland in the landscape, and is adjusted according to the projected decrease in the total area of UK agricultural land by 2050 (the same as for agroforestry and hedgerows).

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

Cover cropping for cropland

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

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

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

Summary: Land use targets and carbon sequestration fluxes for South Downs

Table 14 summarises the proposed land use change and management targets for the South Downs National Park, which follow the principles outlined above.

Table 14. Land use targets and the associated additional carbon sequestration fluxes per year (emissions reduction for peat) for South Downs.

Land Use / Management Category	**Land Use Change Target (ha/yr)**	**Change in Carbon Flux (tCO_2e/yr/yr)**
New Native Broadleaf/Mixed Woodland	500	-9,228
New Productive Coniferous Woodland	0	0
Agroforestry (improved grassland & cropland)	299	-702
Hedgerows (improved grassland & cropland)	17	-182
Grazing Legumes (improved grassland)	1,159	-2,380
Cover Cropping (cropland)	1,167	-1,370
Restored Eroding Modified Bog (bare peat), Drained	0	0
Restored Eroding Modified Bog (bare peat), Undrained	0	0
Restored Modified Bog (heather/grass dominated), Drained	0	0
Restored Modified Bog (heather/grass dominated), Undrained	0	0
Restored Cropland Peat, Drained	0	0
Restored Intensive Grassland Peat, Drained	0	0
Restored Extensive Grassland Peat, Drained	0	0

Restored Forested Peat, Drained	0	0
Total	**3,142**	**-13,861**