Land Use Emissions Baselines and Targets for UK National Parks – A Synthesis Report

Small World Consulting

July 2024

Small World Consulting Ltd
Lancaster Environment Centre
Gordon Manley Building
Lancaster University, Lancaster LA1 4YQ
info@sw-consulting.co.uk
01524 510272
www.sw-consulting.co.uk

SMALL WORLD CONSULTING

SMALL WORLD CONSULTING

Contents

SMALL WORLD CONSULTING

Document control

Small World Consulting Ltd, +44 (0) 1524 510272, www.sw-consulting.co.uk

Landscape Carbon Tracker development by: Dr Dmitry Yumashev (Principal Consultant), Prof Mike Berners-Lee (Director), Lorraine Ritchen-Stones MBA MSc (Associate Consultant), Dr Tom Higgs (Consultant), and Morgan Neilson (Research Assistant), supported by representatives from UK National Parks, National Landscapes, and Local Authority districts and counties

Technical support: Matt Bond MRes (Consultant), Dr Tom Davies (Consultant), Dr Hannah Wright (Consultant)

GIS analysis (land use opportunity mapping): Duncan Hornby, GeoData

Additional GIS support: GIS officers from National Park Authorities

Peatland data analysis for Yorkshire: Aaron de Raat, Yorkshire Peat Partnership

Peatland data analysis for the Broads: Andrea Kelly, the Broads Authority

Results exported from: SWC's Python Landscape Carbon Tracker, version from 10 June 2024 with minor update on 28 June 2024

Report prepared by: Dmitry Yumashev, Mike Berners-Lee, Tom Higgs, Morgan Neilson

Report contributions: Charlie Westney, Lorraine Ritchen-Stones, Hannah Wright, Tom Davies, Matt Bond

Results quality-checked by: Dmitry Yumashev

Proofreading: Jennifer Lyon

Title: Land Use Emissions Baselines and Targets for UK National Parks – A Synthesis Report

Report version: 9

Status: Final version with revised 2022 GHG baselines, updated targets and forewords

Dated: 25 July 2024

Approved by: Dmitry Yumashev, Mike Berners-Lee

Acknowledgements

The work has been funded through a grant agreement with DEFRA and was also supported by the Esmee Fairbairn Foundation. We are grateful to the National Parks Partnership for helping us to secure this funding, as well as to the National Parks England for providing additional support. Special thanks go to Chris Fairbrother (South Downs), Liz Hutchins (Bannau Brycheiniog) and Richard Leafe (Lake District) for their support.

Foreword by Mike-Berners Lee: Founder and Director of Small World Consulting

As the world wakes up to the climate and wider environmental emergency, the fundamental importance of sustainable land management is becoming increasingly recognised.

In the UK, the 15 National Parks account for around 10% of the country's land area, and other designated landscapes make up a further 8%. These designated landscapes are mission-critical in enabling the UK to reach important climate and biodiversity goals and in strengthening food security in a future increasingly destabilised by climate impacts.

Scaled-up action across the designated landscapes is essential in order for the UK to meet its climate obligations via three approaches: protecting large existing natural carbon stores such as in peatlands and forests; scaling up carbon sequestration, i.e. drawing down excess carbon from the atmosphere; and decarbonisation, by cutting avoidable carbon emissions from buildings, transport, food, consumables and degraded land.

Small World Consulting has been working with the Lake District National Park since 2010 and with all 15 of the UK's National Parks since 2021, providing them with industry-leading evidence and analysis of their current greenhouse gas emissions, and developing decarbonisation and nature recovery pathways, based on the latest scientific research. Our work has helped National Park Authorities to understand the type and scale of changes necessary to respond to the climate and ecological emergencies, which must be achieved while improving food security and the economic resilience of local communities.

This high-level Synthesis Report draws together our greenhouse gas assessments from across all 15 UK National Parks. It has a particular focus on land-based climate mitigation opportunities. It also includes a new post-COVID baseline year and an improved methodology.

National Park Authorities now have the evidence they need to understand the scale and pace of action the science shows is required, and which is achievable while enhancing livelihoods, provided there is appropriate support. The exciting and creative challenge for National Park Authorities is to be lead enablers of a fair transition to net zero emissions which also improves food security, restores depleted nature, and strengthens local economies and communities.

Mike Berners-Lee, Founder and Director of Small World Consulting

Foreword by Richard Leafe: CEO, Lake District National Park Authority

National Parks were established as part of the post-World War II nation-building project that created the NHS and the welfare state. The vision was of beautiful places protected for the nation, where working people could relax and connect with nature. That was a very different time, before the perils of the climate and nature emergencies unfolded. But it was a time of resolve to build a better future for everyone, and that is what the National Park Authorities are working together to achieve now.

The climate and nature emergencies are acute. The rapidly heating global climate is already having an impact on people and nature globally and in the UK's National Parks. The extreme heat and desiccation of our landscapes, followed by months and months of rain, is pushing natural ecological cycles off-kilter, impeding farmers in their efforts to produce food, and visibly re-shaping landscapes through erosion. These are the natural ecosystems and food supplies that everyone relies on – this is not just a threat to National Parks.

The National Park Authorities are taking an evidence-based approach in our response to this complex crisis. We are working to understand the impacts of climate change on people and nature – now, and projected into the future. We want to better understand the importance of protecting the huge, precious carbon stores in our landscapes – peat bogs, trees and soils. And we want to understand the greenhouse gas emissions attributable to our landscapes – both as a result of activities by people who live and work here, and by visitors.

This high-level Synthesis Report is the culmination of months of work between UK National Parks and Small World Consulting. This work helps us to understand the carbon footprints of our landscapes and the priorities for action, particularly in relation to land-based mitigation such as improving soil health, restoring peatland, and increasing tree cover in a way that is ecologically sensitive, strengthens resilience in food growing, and protects downstream communities from flooding.

Our designated landscapes can seem timeless, but they are constantly evolving and now is no different. The numbers in this report are challenging – big changes are needed in a short space of time. Our response is not to duck the change needed but to work alongside farmers, residents and visitors to ensure their voices are heard in shaping the path to a fairer, greener net zero future.

The UK National Park Authorities are uniquely placed to catalyse, enable and support this change. But we can't do it alone. We need others to step up to this challenge with us in a spirit of shared learning, partnership and determination – the UK and devolved Governments, other parts of the public sector, businesses, farmers, residents and visitors. We hope this report will be a useful contribution to inform the work of those partnerships.

We are grateful to the Esmee Fairbairn Foundation and DEFRA for financially supporting this important research.

Richard Leafe, CEO of the Lake District National Park Authority, and Lead CEO of the UK National Parks Climate Change Group

Executive summary

About this report

This is a high-level synthesis and an update of the 15 technical GHG assessment reports produced in 2021-22, one for each of the 15 National Parks[1], with a particular focus on land-based climate mitigation opportunities. It includes a new post-COVID baseline year and an improved methodology.

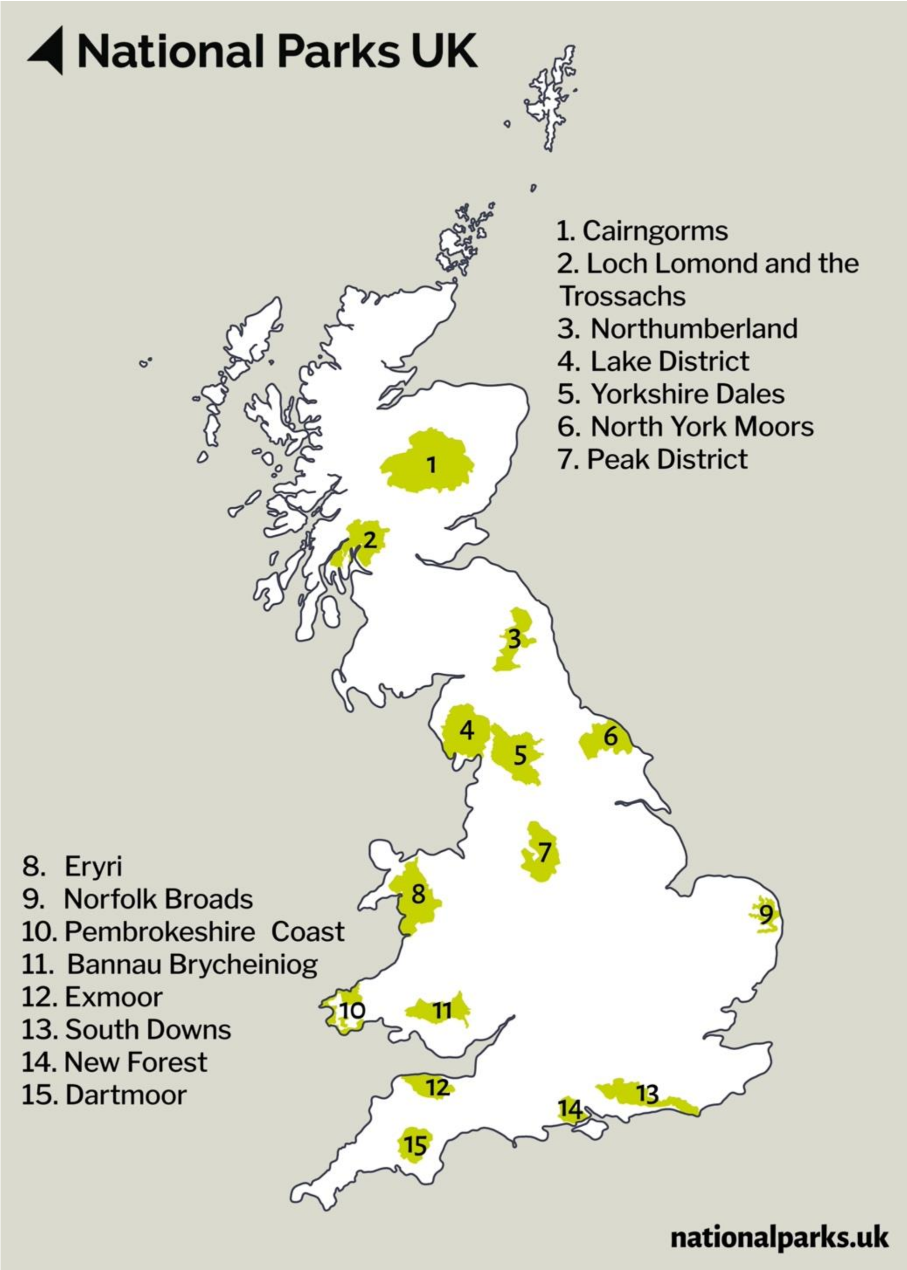

Figure 1. UK's National Parks. Source: www.nationalparks.uk.

[1] The assessment also covered all Welsh National Landscapes, as well as the Cotswolds and Cannock Chase National Landscapes in England.

The report is designed to provide evidence to inform strategic leadership by National Park Authorities in response to the climate emergency.

Climate action in National Parks is an essential part of the UK's path to net zero. Together, the UK's 15 National Parks are home to around 0.5 million residents, attract approximately 100 million visitors per year, and account for around 10% of the UK's land area, totalling over 2.3 million hectares (Figure 1). They host vitally important carbon stores, which need to be protected, most importantly through restoring degraded peatland. Our work shows that these designated landscapes also have the capacity to sequester considerable amounts of additional carbon through improving soil health and increasing tree cover. Furthermore, they are an integral part of rural Britain and could be exemplars in transitioning to more sustainable farming practices, decarbonising rural energy and transport, and helping promote more sustainable food and consumer goods.

UK National Park Authorities have a clear responsibility to be part of UK-wide climate efforts. The UK Government is a signatory of the Paris Climate Agreement which aims to limit global temperature rise to 1.5 degrees relative to pre-industrial conditions. All UK public sector organisations and their partners have an important role to play in this global endeavour.

Key shifts needed to reach net zero

There are considerable differences between the National Parks in terms of overall land area, types and extents of habitats, resident population sizes and demographics, numbers and types of visitors and businesses, agriculture, road traffic, and public transport. All these factors affect present-day greenhouse gas emissions as well as opportunities and priorities to reduce them, alongside increasing land-based (and, where applicable, marine) carbon sequestration.

Despite the unique sets of circumstances in each National Park, there are common factors and themes, creating an important opportunity for the landscapes to address the climate and ecological challenges collectively. These themes include:

- Cutting energy-related emissions from buildings, traffic and industries;
- Reducing the carbon and ecological footprints of locally consumed food;
- Strengthening the resilience of farms faced with climate impacts and improving food security;
- Reducing the carbon and ecological footprint of local agriculture;
- Restoring or recreating at scale semi-natural habitats, including woodlands, peatlands and wildflower meadows where appropriate;
- Reducing the carbon footprint of visitors travelling to and enjoying the National Parks;
- Educating the public on the role they can play in reducing their environmental footprint.

This report points to a range of case studies illustrating how these shifts are bringing benefits to people and nature in the National Parks. These landscapes play an important role in rural policy development, both for the UK as a whole and in the devolved nations. They are ideally placed to pilot innovative rural solutions addressing the climate and ecological crises, by working with local farmers, residents, visitors and public-sector partners.

Consumption-based analysis and science-based targets

Small World Consulting has used a consumption-based methodology which tracks the embodied carbon footprint of goods and services purchased, in addition to emissions from the consumption of fossil fuels and electricity, and from land use.

This approach is important because it reflects the full climate impact of everyone who lives in, works in and visits National Parks, including goods and services procured from elsewhere as well as visitors' approach travel. It is complemented by setting science-based targets to reduce emissions and scale up carbon sequestration, consistent with keeping global warming below the "safer" 1.5°C limit in the Paris Agreement. This evidence is intended to inform National Parks Authorities and their partners on the policies, projects and initiatives that address the full range of greenhouse gas emissions.

The difference between consumption-based and the more commonly measured "territorial" emissions produced directly within a geographical area is often considerable. According to our in-house Environmentally Extended Input-Output (EEIO) model, UK-wide consumption-based emissions in 2022 were around 871 $MtCO_2e$ (approximately 12.9 tCO_2e per person). This is roughly double the figure of 399 $MtCO_2e$ for the UK's 2021 territorial emissions reported by UK GHG Inventory[2], which covers only those emissions directly produced within the UK's borders.

Across the priority areas shortlisted as part of this consumption-based GHG assessment, which are complemented by agriculture and land use within the National Parks, the collective total (net) GHG emissions baseline for the 15 National Parks is estimated to be around **11.5 million tCO_2e per year**, as at 2022 (Figure 2)[3]. If the recommended decarbonisation and land use change targets were adopted for all the landscapes with immediate effect and carried forward, their collective total (net) GHG emissions should reach net zero in the late-2030s. The National Parks would subsequently become net carbon sinks as sequestration starts to outweigh the residual emissions, eventually reaching a net negative value of roughly **–3.5 million tCO_2e per year** by 2050 (Figure 2 and Figure 3).

We applied equally ambitious and science-based targets aligned with the global 1.5°C target to each National Park. However, due to their different characteristics, the resulting overall trajectories and net zero dates differ for each landscape. It is important to be clear, therefore,

[2] Source: https://www.gov.uk/government/statistics/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics-2005-to-2021. The corresponding 2022 figures are not yet available at the time of writing.
[3] In comparison, UK healthcare emissions (including supply chains) were estimated to be around 22.6 million tCO_2e per year in 2019.

that the net zero date for each of the National Parks is not a measure of its level of ambition but a reflection of its characteristics.

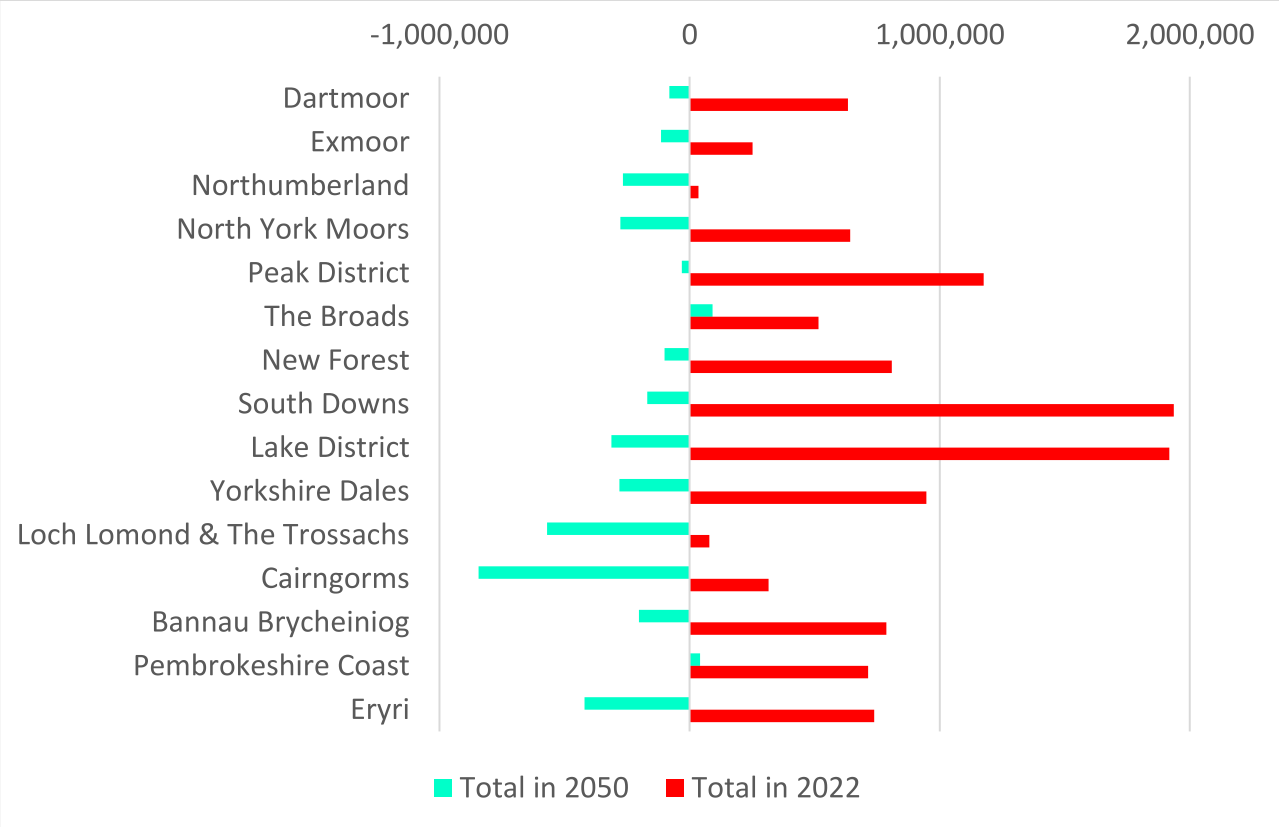

Figure 2. Estimated net GHG emissions in 2022 (baseline year) and projected net GHG emissions in 2050 for the UK's National Parks. Units: tCO_2e per year.

Of the projected approximate **15 million tCO_2e per year** reduction in net annual emissions between 2022 and 2050 for all the National Parks combined, 63% comes from reducing human activity emissions excluding agriculture and other land use, which roughly makes these landscapes net zero collectively. The remaining 37% comes from decarbonising agriculture and, most importantly, from reducing emissions and scaling up carbon sequestration through land use change. As demonstrated in Figure 3, by 2050 UK National Parks are projected to become a large landscape-scale carbon sink under the proposed targets. This is their "superpower".

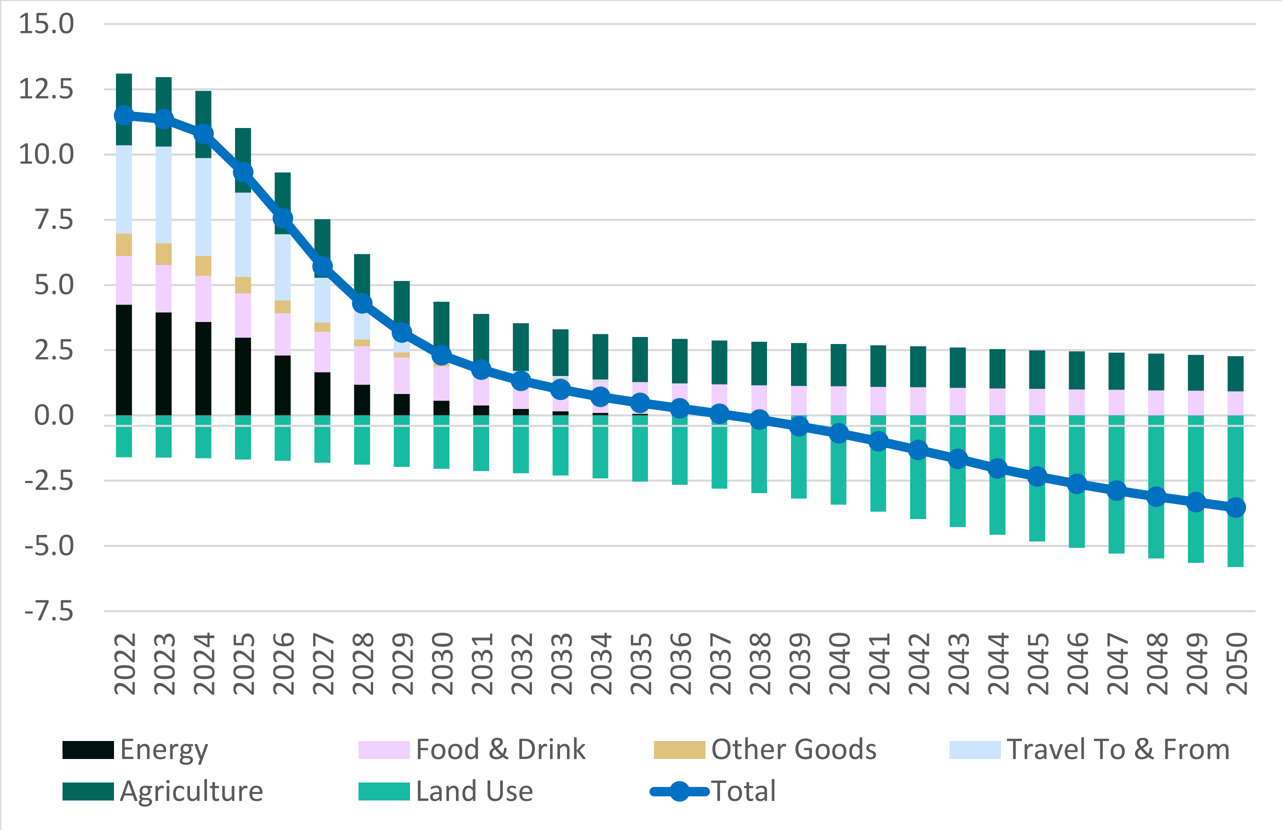

Figure 3. GHG pathways for all the National Parks combined, derived from their 2022 GHG baselines and the recommended targets for each of the six priority areas shortlisted as part of this assessment. Units: MtCO₂e per year.

The scale of the transition

Because of their unique characteristics, the National Parks could become path-setters for the whole rural economy across the UK if they were to pursue the recommended targets. By leading the transition jointly with other designated and non-designated rural landscapes, UK National Parks could play a vital role as net carbon sinks that will negate residual emissions from UK cities, hard-to-decarbonise industries, and global supply chains, helping the whole country to meet its climate goals by 2050.

A transition in line with the science-based targets would involve the following changes collectively across the 15 National Parks between 2023 and 2050 – with different opportunities and challenges in each:

- Creating 7,800 ha per year of new mosaic woodland for 28 years (9% of total land area of the National Parks);
- Restoring over 6,000 ha per year of deep peat for 28 years (7% of total land area of the National Parks);

- Rolling out over 8,000 ha per year various regenerative agriculture measures[4] for 28 years (10% of total land area of the National Parks);
- Reducing emissions from energy (buildings, transport, industrial processes) to less than 1% of the 2022 levels by 2050;
- Reducing emissions from visitors travelling to and from the National Parks to less than 1% of the 2022 levels by 2050;
- Reducing emissions from food (both produced locally, and elsewhere in the UK and abroad) to around 50% of the 2022 levels by 2050.

We recognise that the land use targets set out in this report require further ground-truthing and refinement for each National Park. Decisions on each piece of land are complex and specific to the unique circumstances of the UK's diverse land characteristics. They need to meet the three core objectives of food production, climate mitigation and adaptation, and biodiversity enhancement, while enabling thriving livelihoods and communities[5].

A positive future for the National Parks

While the challenges ahead are considerable, and tackling them requires strong national and international policies, the associated opportunities are both wide-ranging and exciting. By working together to respond to the recommendations of this assessment, the National Parks and their partners could become global leaders in an evidence-based low-carbon transition which also strengthens food security, nature recovery and rural communities. In doing so, they could inspire decision-makers in other parts of the UK, as well as in many landscapes and countries abroad, to pursue similarly ambitious policies, and commit to the investments and lifestyle changes that are understood to be essential for building a sustainable world for future generations.

[4] These include species-rich grassland, cover crops, agroforestry and hedgerows.

[5] See our recent paper on UK farming and land use for an in-depth discussion of these objectives: https://www.sw-consulting.co.uk/food-and-land/uk-farming-land-use.

SMALL WORLD CONSULTING

Introduction

Consumption-based GHG assessment for designated landscapes

Climate change driven by anthropogenic greenhouse gas (GHG) emissions, together with the wider ecological crisis, are among the biggest challenges facing humanity today. Only a joined-up response to tackling them is likely to improve both situations.

Since 2010, Small World Consulting has carried out a series of assessments, commonly referred to as “consumption-based”, of GHG emissions for the Lake District National Park, resulting in a set of science-based recommendations for transitioning to a low-carbon economy.

The Lake District work was extended to the whole of Cumbria in 2020, leading to a successful multi-million-pound (GBP) funding bid to establish the Zero Carbon Cumbria Partnership (ZCCP)[6]. ZCCP is aimed at delivering the recommended reductions in GHG emissions, which are consistent with keeping global warming below the “safer” 1.5°C limit in the Paris Agreement.

Building on the Lake District and Cumbria work, consumption-based GHG assessments were subsequently carried out for each UK National Park and each Welsh National Landscape, as well as the Cotswolds and Cannock Chase National Landscapes in England. This programme, which ran in 2021 and 2022, culminated in a series of technical GHG assessment reports for each landscape, alongside several presentations to board members. The recommendations of the reports have since started to form an integral part of the new partnership plans and the associated stakeholder engagement across the country.

This report is a high-level synthesis of the technical GHG assessment reports produced for each National Park, with a particular focus on land-based climate mitigation opportunities. It also includes a comprehensive update to the GHG assessment carried out earlier in 2024, which made use of the more recent post-COVID data and improved methodologies. The synthesis report is designed to provide a robust and consistent evidence basis for climate action, commensurate with the unique characteristics and circumstances of the National Parks, as we enter an era in which climate change mitigation and sustainable land management become ever more central to all our lives, our work and to all policy decisions.

Consumption-based emissions reporting differs from more traditional “production-based” (territorial) 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

[6] https://zerocarboncumbria.co.uk.

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 (Figure 4).

By contrast, 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 ("upstream activities" in Figure 4). In doing so, it better reflects the full climate impact of people's lifestyles, bringing into focus for policymakers parts of our true climate footprint that a production-based assessment overlooks. This is particularly relevant for geographic areas such as the UK and its local authorities, including the National Parks, that are major net importers of goods. By pursuing the consumption-based approach to GHG accounting, policymakers, businesses and citizens can take more ambitious steps to reduce emissions and become leaders in responding to the climate and wider environmental emergency.

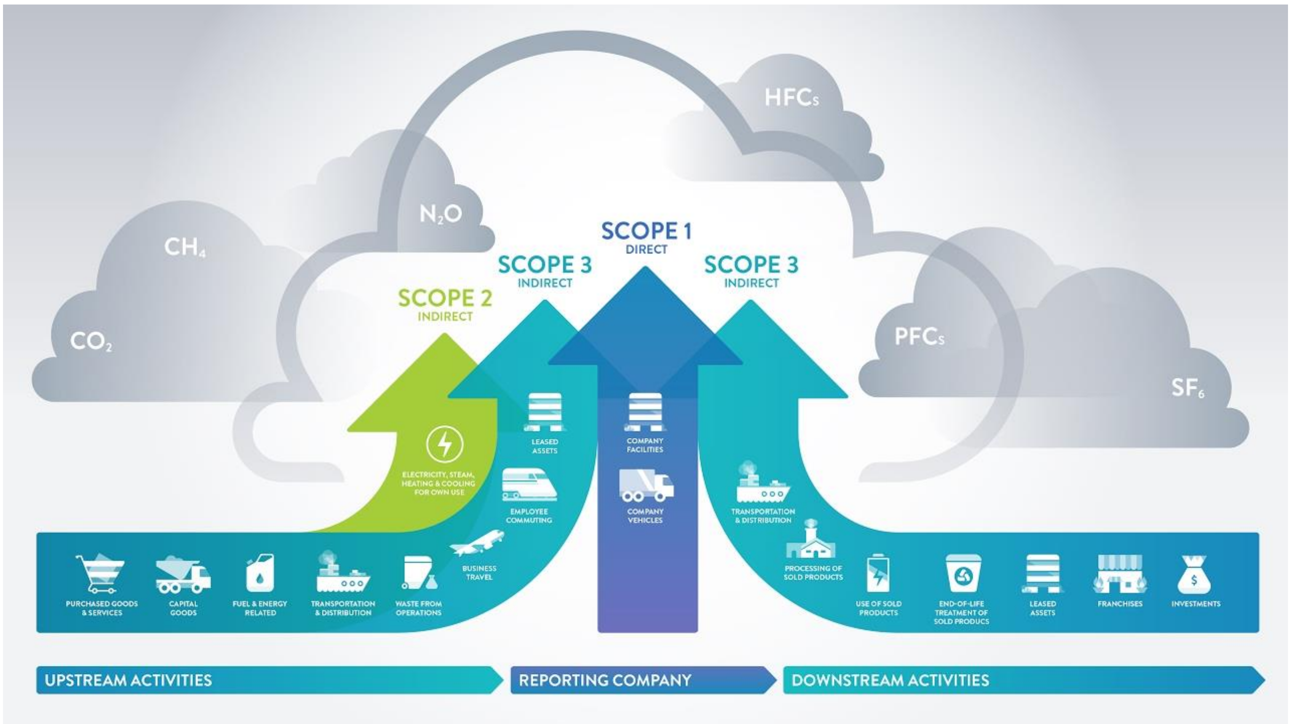

Figure 4: Types of greenhouse gas emissions used for GHG accounting. Source: Greenhouse Gas Protocol.

Throughout the report, we consider both CO_2 and non-CO_2 emissions, which are combined into a single tCO_2e figure using the widely adopted GWP100 accounting metric. The issues associated with applying the alternative GWP* metric (for methane emissions) to the results that are based either on the GWP100 metric, or on treating CO_2 and methane emissions separately, are described in our recent briefing paper "GWP*: Applications & Misapplications"[7]. The results for the National Parks presented in this assessment are based largely on separate targets for CO_2 and methane, and essentially do not require a GWP metric.

[7] https://www.sw-consulting.co.uk/gwpstar.

Six priority areas to reduce emissions for designated landscapes

In order to define methodologically consistent and manageable GHG baselines for the National Parks, and to propose science-based targets for emission reduction and land use change, consistent with action toward or beyond a fair share of effort to stay within the 1.5°C limit in the Paris Agreement, we introduce the following **six priority areas** (which could also be referred to as "assessment boundaries"):

- Energy-related emissions by residents, visitors and industry (building heating, electricity, road fuels and public transport, fuel use by agricultural machinery; excluding flights)[8];
- Food and drink consumed by residents and visitors (purchased in shops and eating out);
- Other goods purchased by residents and visitors (including cars);
- Visitor travel to and from the National Park (excluding flights);
- Agriculture (emissions from livestock and fertilisers; excluding agricultural machinery and buildings);
- Land use (emissions from and/or carbon sequestration in soils and biomass across all habitats)[9,10].

Accounting for emissions from land use and management is especially important for the National Parks. These landscapes are mostly rural, with comparatively small populations and large swathes of land under various forms of intensive agricultural management, plus more extensive agricultural and non-agricultural habitats such as woodlands, wildflower meadows, heathlands and peatlands.

Land-based emissions originate predominantly from livestock ruminants (mostly methane), synthetic fertiliser use (mostly nitrous oxide), and degradation of 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 both consumption-based and land-based emissions, and scaling up land-based carbon sequestration efforts, is going to be crucial for addressing the joint climate and ecological emergencies both in the designated landscapes and across the whole of the UK.

---

[8] Flights are excluded, since their decarbonisation requires global cooperation between governments and the aviation and tourism industries, which is deemed to be beyond the sphere of influence of the National Parks and their partnerships.
[9] This sector is commonly referred to as land use, land use change and forestry (LULUCF).
[10] Our assessment does not consider possible future marine carbon sequestration, which is often referred to as "blue carbon". This type of carbon sequestration may allow the National Parks with coastal areas to accelerate their climate mitigation efforts and achieve an earlier net zero date.

UK National Parks: Key Characteristics

There are considerable differences between the National Parks in terms of overall land area, types and extents of habitats, resident population sizes and demographics, numbers and types of visitors and businesses, agriculture, road traffic, and public transport. All these factors affect present-day GHG emissions as well as opportunities and priorities to reduce them, alongside increasing land-based (and, where applicable, marine) carbon sequestration.

Land use

The National Parks are predominantly rural areas with high proportions of agricultural land. However, they differ considerably in terms of their overall areas (Table 1) and percentage shares of the key habitats (Figure 5). All these factors determine their current land-based emissions, as well as the potential for land use change to aid carbon sequestration and enhance biodiversity.

Table 1. Surface areas of the National Parks. The colour scale illustrates the magnitudes, ranging from the smallest (green) to the largest (red).

National Park	Land area (ha)
Dartmoor	95,300
Exmoor	69,400
Northumberland	104,800
North York Moors	143,400
Peak District	143,700
The Broads	30,300
New Forest	57,000
South Downs	165,268
Lake District	236,258
Yorkshire Dales	217,900
Loch Lomond & The Trossachs	186,500
Cairngorms	452,800
Bannau Brycheiniog[11]	142,039
Pembrokeshire Coast	62,100
Eryri	217,600
All National Parks	**2,324,365**

Cairngorms is by far the largest National Park, nearly twice the size of the second largest (Lake District) and just over two times bigger than the third and fourth largest landscapes (Yorkshire Dales and Eryri[12]). The smallest National Park, The Broads, is roughly half the size of the second

[11] Bannau Brycheiniog is known as Brecon Beacons in English.
[12] Eryri is known as Snowdonia in English.

and third smallest landscapes (New Forest and Pembrokeshire Coast), and around 15 times smaller than Cairngorms.

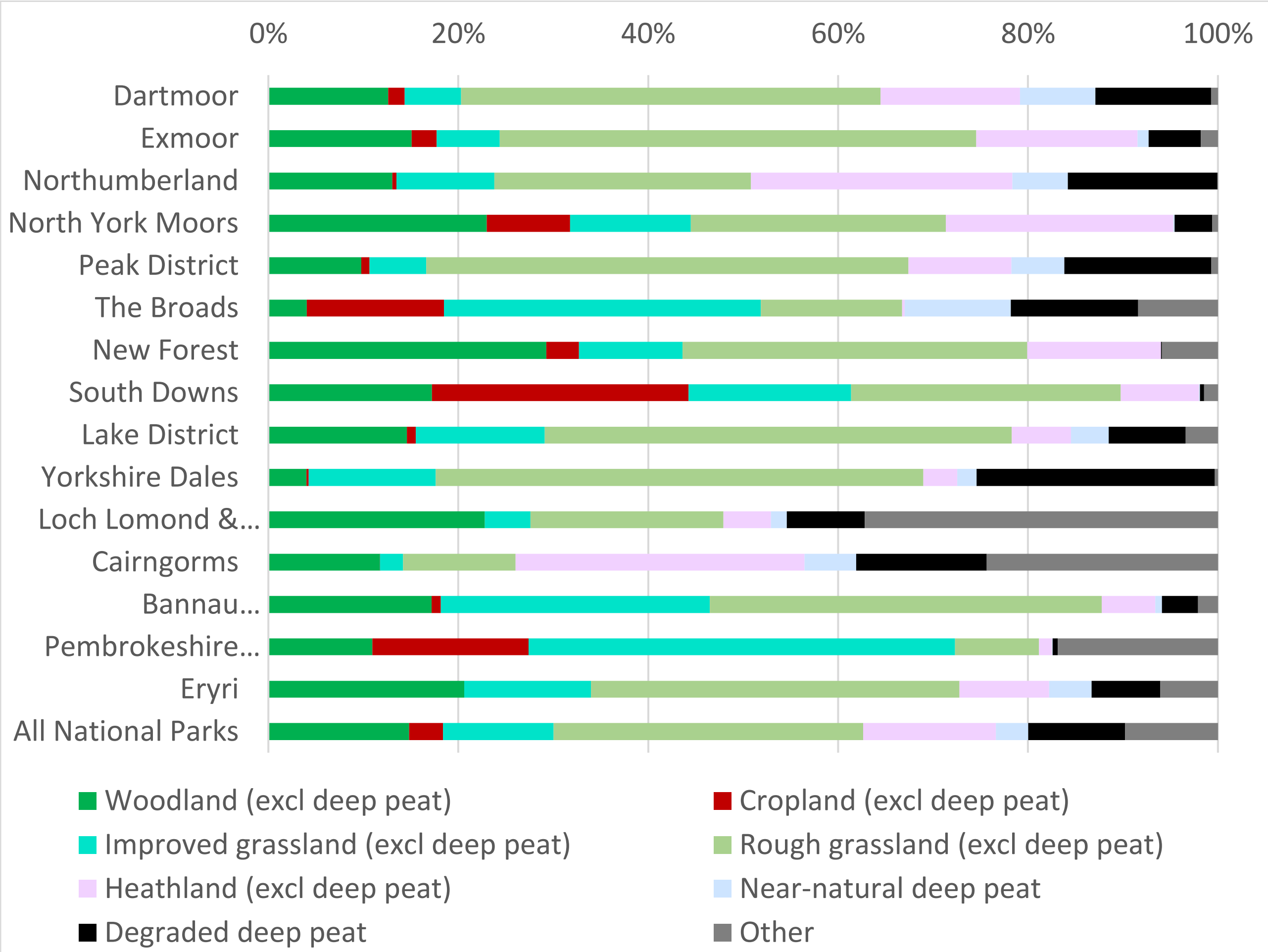

Figure 5. Estimated percentage shares of the key habitats in the National Parks in 2022. The category "Other" includes coastal, urban and suburban areas, as well as inland water bodies and rock.

In terms of agricultural make-up, Yorkshire Dales, Peak District, Exmoor and the Lake District are estimated to have the largest shares of rough grazing (around 50% of their total areas, excluding modified deep peat), while Pembrokeshire Coast, The Broads, and Bannau Brycheiniog have the largest shares of improved grassland (45% of the total area in Pembrokeshire Coast)[13]. Arable land (also referred to as cropland) occurs in the predominantly lowland landscapes such as South Downs (36% of the total area), Pembrokeshire Coast and The Broads.

[13] Note that grasslands common to The Broads sit somewhere between the CEH definitions of "improved" and "neutral" grasslands (the latter is part of the "rough grassland" category in Figure 5). The habitat classification and the underpinning remote sensing data used here are aimed at providing a common framework for all National Parks, but limitations of this approach mean that it can miss certain unique ecological characteristics of each landscape, as is the case for The Broads.

In terms of non-agricultural habitats, the New Forest has by far the largest share of existing woodland cover on non-peat soils (29% of the total area), followed by Loch Lomond & The Trossachs (23%), North York Moors (23%) and Eryri (21%; this is still well above the current UK average), while The Broads (4%), Yorkshire Dales (4%) and Peak District (10%) have the lowest proportion of woodland cover on non-peat soils. Cairngorms, Northumberland and North York Moors have the highest proportions of heathland, while Loch Lomond & The Trossachs has the largest share of inland freshwater (included in the “Other” category in Figure 5).

Deep peat[14] in various forms of modification and degradation is most common in Yorkshire Dales (25% of the total land area), Northumberland (16%, which includes forested peat), followed by Peak District (15%), Cairngorms (14%) and The Broads (13%)[15]. Near-natural and/or restored deep peat is most common in The Broads (11%) and Dartmoor (8%). Most of the peatland across the UK is understood to be in various forms of degradation (around 80% of the peatland area on average), which is due to a number of factors including drainage, active erosion, grass- and heather- dominated modifications, impacts of herbivores (including over-grazing), and non-native forestation. Degraded peat acts as a source of GHG emissions. These emissions could be mitigated through peatland restoration.

Residents and visitors

A key part of assessing the consumption-based GHG emissions and decarbonisation options for landscapes such as the National Parks is to understand the sizes and behaviours of their resident and visitor populations.

Figure 6 shows estimated average numbers of residents and visitors in the National Parks on a given day in 2022, excluding weekly and seasonal variations. South Downs has by far the largest resident population, while the Lake District has the largest numbers of visitors. Notably, average daily visitor numbers exceed the resident populations in Northumberland, the Lake District and Eryri.

Table 2 summarises, with reference to residents of the National Parks in 2022, estimated average final consumption per person (both household spending and public services), average energy consumption per person (including gas, oil and other fuels for heating, vehicle fuels, and electricity), and average number of annual flights per person (irrespective of miles flown). The final consumption levels (£ per person) reflect the demographics, including average affluence levels across each landscape. The estimates suggest that the Yorkshire Dales residents are the most affluent, while Northumberland residents are the least affluent.

---

[14] Deep peat is defined as being more than 40 cm deep in England and Wales, and greater than 50 cm deep in Scotland.

[15] For the area of peatland in Bannau Brycheiniog, we use a conservative estimate of around 6,350 ha from the Unified Peatland Map of Wales (deep peat only). There remains considerable uncertainty regarding the peatland’s extent in Bannau, with an alternative estimate by ADAS suggesting nearly 16,000 ha (some of which may include shallow peat). These estimates can only be reconciled through ground-truthing, which is ongoing at the time of writing.

The energy consumption figures reflect multiple factors such as size and energy performance of properties, usage of gas or oil for heating, number of cars per household, and uptake of renewable energy and mobility solutions such as rooftop solar panels, heat pumps and electric vehicles. The Lake District is estimated to have by far the highest energy consumption per resident, which is largely due to its comparatively inefficient housing and high-carbon heating systems; meanwhile, the comparatively low energy use in Northumberland is linked to many properties being off-grid and relying on biomass energy.

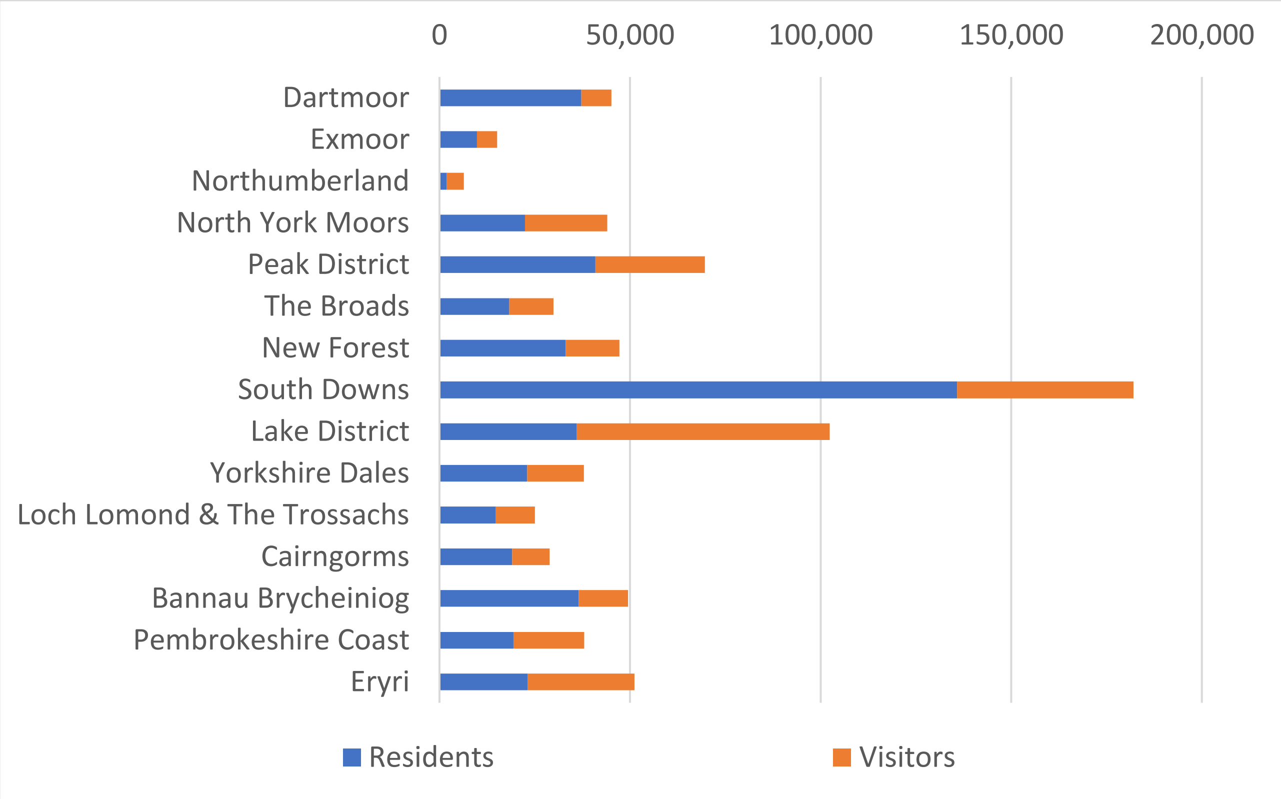

Figure 6. Estimated average resident and visitor numbers for the UK National Parks on a given day in 2022 (excluding weekly and seasonal variations).

Finally, the number of annual flights taken by an average resident partly correlates with the affluence levels in each landscape, even though other factors are at play such as proximity to airports. South Downs has the highest number of flights per resident.

Table 2. Estimated average final consumption per person (including public services), average energy consumption per person (gas and other fuels for heating, vehicle fuels, electricity), and average annual flights per person, for residents of the National Parks in 2022. The colour scale from green (lowest value) to red (highest value) is applied separately to each column.

National Park	Annual Final Consumption (£ per resident)	Annual Energy Consumption (kWh/resident)	Annual Flights (per resident)
Dartmoor	£34,786	13,363	1.59
Exmoor	£35,744	14,109	1.41

Northumberland	£28,286	12,440	1.29
North York Moors	£35,990	15,470	1.44
Peak District	£34,936	15,413	1.47
The Broads	£35,000	15,738	1.51
New Forest	£35,485	15,445	1.50
South Downs	£33,608	14,098	1.66
Lake District	£34,492	20,211	1.49
Yorkshire Dales	£36,141	17,676	1.41
Loch Lomond & The Trossachs	£33,998	15,276	1.60
Cairngorms	£34,280	16,065	1.62
Bannau Brycheiniog	£34,035	14,264	1.64
Pembrokeshire Coast	£35,651	16,736	1.51
Eryri	£34,245	16,071	1.53

Table 3 summarises estimated average one-way distances travelled by visitors, percentage of visitors staying overnight, and average durations of stay for overnight visitors in the National Parks in 2022. Cairngorms is estimated to have the largest travel distances primarily due to its remoteness, which is also the key factor behind relatively long travel distances for the likes of Pembrokeshire Coast, Loch Lomond & The Trossachs, and Exmoor. Visits to Eryri and the Lake District, on the other hand, entail longer travel distances mostly due to their global profiles and the resulting high numbers of international visitors coming from London, while landscapes such as the New Forest and South Downs tend to attract more local visitors with much shorter distances travelled. Around 60% of all visitors to Pembrokeshire Coast stay overnight, contrasting with predominantly single-day visitors in South Downs and Northumberland. Finally, Eryri and The Broads have the longest estimated average durations of stay.

Table 3. Estimated average one-way visitor distances travelled, % of overnight visitors, and average durations of stay for overnight visitors in the National Parks in 2022. The colour scale from green (lowest value) to red (highest value) is applied separately to each column.

National Park	Average One-Way Distance Travelled (miles)	% of Visitors Staying Overnight	Average Duration of Overnight Stay (days)
Dartmoor	108	12%	3.9
Exmoor	143	21%	3.8
Northumberland	62	4%	5.0
North York Moors	104	8%	4.6
Peak District	73	8%	4.5
The Broads	104	14%	5.3
New Forest	33	15%	4.4
South Downs	40	4%	3.1
Lake District	174	18%	3.7
Yorkshire Dales	106	13%	3.4
Loch Lomond & The Trossachs	170	31%	3.1

Cairngorms	279	48%	3.2
Bannau Brycheiniog	92	10%	4.1
Pembrokeshire Coast	174	58%	5.1
Eryri	206	35%	5.6

Businesses and industries

For perspective, it is also useful to be aware of the nature and scale of all businesses and industries in the National Parks.

Tracking business activities in a given area is often challenging, due to the common disconnect between the locations where businesses operate and where they are registered. Some of the most accurate business figures come from the Inter-Departmental Business Registry (IDBR) turnover data, which is based on VAT returns. Figure 7 and Figure 8 summarise the IDBR data approximating business turnovers in each of the National Parks, including a percentage breakdown of the turnovers into broad industry-sector groups.

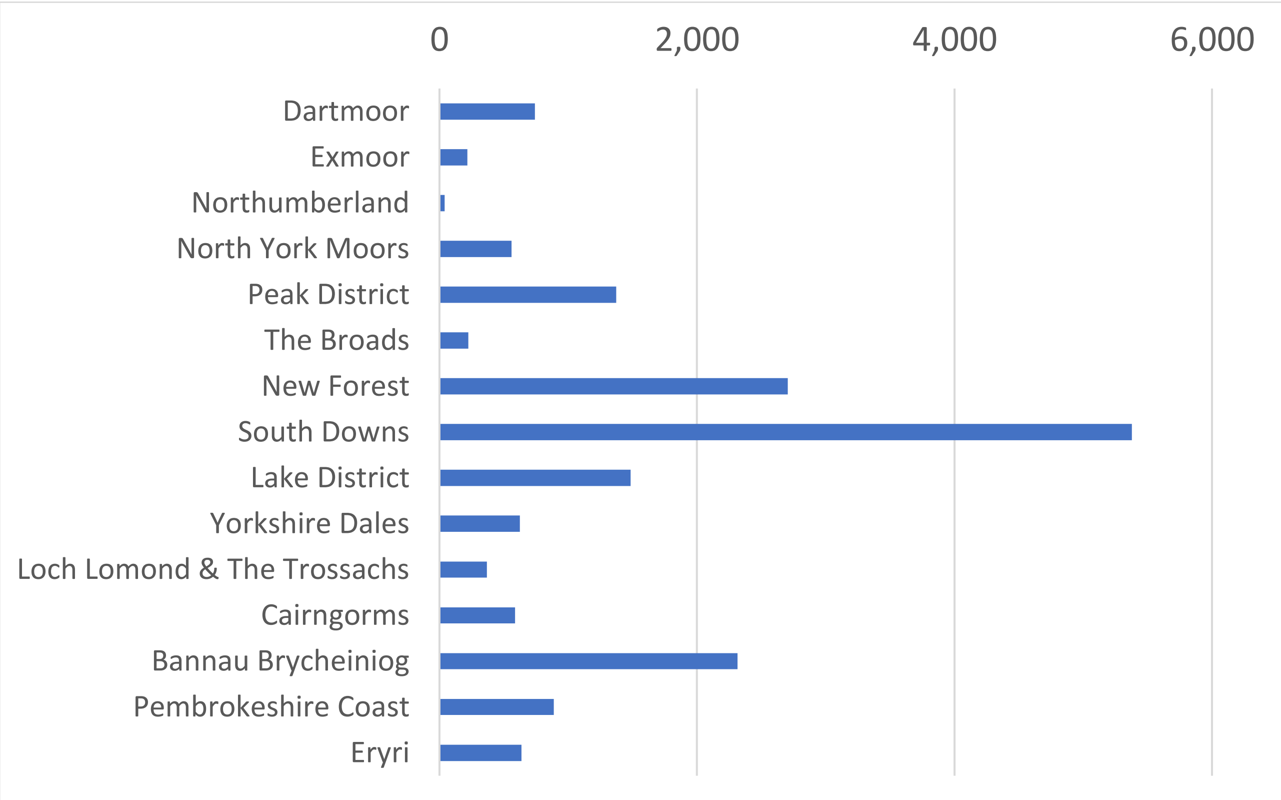

Figure 7. Estimated business turnover for the National Parks in 2022. Units: £ million per year. Source: Inter-Departmental Business Registry (IDBR) data for the Census Output Areas (COAs) overlapping with the landscapes, excluding large industrial sites (both inside and immediately outside the landscape).

With some exceptions, the National Parks' businesses show fairly predictable turnover sizes and patterns that align with the sizes and characteristics of the resident and visitor populations, as well as with the land use patterns described in the previous sections. The combined agriculture, forestry and fishing sector is well represented everywhere, particularly in Northumberland, Yorkshire Dales and Exmoor. Accommodation and food service businesses are more common in the landscapes with a large proportion of overnight stays (Loch Lomond & The Trossachs, Lake District), as well as where visitor numbers are close to or exceed the resident population (Lake District, Eryri, Pembrokeshire Coast). The broad production sector, which includes manufacturing, extraction and utilities, also has a fairly good business presence in most of the landscapes. Likewise, construction and retail also tend to be well represented in most areas.

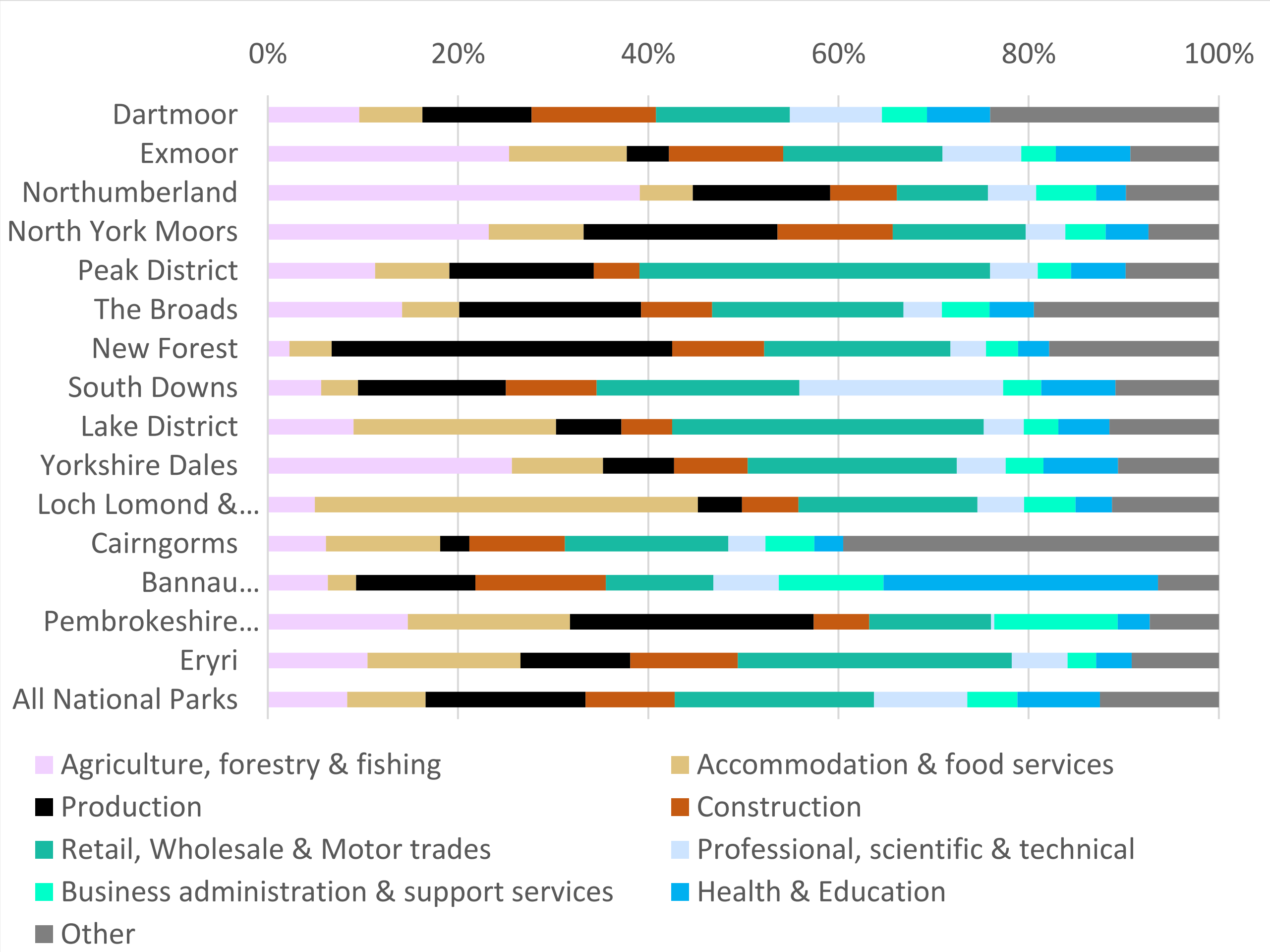

Figure 8. Percentage breakdowns of the IDBR business and industry turnovers into broad sector groups in the National Parks in 2022. The category "Other" includes transport & storage, information & communication, finance & insurance, property, public administration & defence, education, and finally arts, entertainment, recreation & other services.

It is worth noting that the relative magnitudes of business turnovers across different industry sectors do not necessarily correlate with the associated GHG emissions. This is because different industry sectors have very different GHG intensities (emissions per £ of turnover) both in their operations and in their supply chains. Furthermore, there are often considerable variations in the make-ups of the businesses in each broad sector from one location to another, which makes it problematic to use UK-wide GHG intensities for estimating industry-related footprints in a given local area.

UK National Parks: Land Use GHG Baselines and Targets

Agriculture and land use GHG baselines

The broad agriculture and land use sector differs from other sectors in that it contains both sources and sinks of GHGs. The sources, or emissions to the atmosphere, are given as positive values; the sinks, or removals from the atmosphere, are given as negative values. Our definition of the agriculture sector includes emissions from livestock (mostly methane) and synthetic fertiliser use (mostly N_2O). Our definition of the land use sector included emissions from degrading mineral and organic (peat) soils (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. Distinguishing between agriculture and land use makes it possible to focus on policies for individual GHGs and the associated industry sectors (e.g. forestry, livestock farming, etc.) without having to deal with the issue of choosing a GWP metric for methane emissions.

Our broad land use sector overlaps with both the “land use, land use change and forestry” (LULUCF) and “agriculture” sectors in the UK’s national GHG inventory[16] compiled in line with the IPCC guidelines. By definition, LULUCF excludes emissions from livestock and fertiliser use, which are reported as part of the “agriculture” sector.

In this assessment, the net agriculture and land use emissions baselines for the National Parks in 2022 are derived from the LULUCF and “agriculture” sector emissions estimates prepared for the National Parks by the Department for Energy Security and Net Zero (DESNZ) as part of the UK’s regional GHG inventories[17]. They are summarised for each National Park in Figure 9. We use the 2023 update of the 2021 “agriculture” and LULUCF emissions by DESNZ, which resulted in considerably lower land use emissions for most National Parks (see Appendix 0 for further details). The DESNZ estimates for 2022 are not yet available at the time of writing.

According to Figure 9, land-based carbon sequestration is stronger than land use GHG emissions across most National Parks, resulting in net-negative land use fluxes. The exceptions are The Broads, Yorkshire Dales and Pembrokeshire Coast, which either have some of the largest areas of intensively managed agricultural land, very little woodland, sizeable areas of degraded peatland, or several of these features at the same time. The highest agricultural emissions (from livestock and fertilisers), on the other hand, are in the Yorkshire Dales, the Lake District and Peak District. These landscapes have large areas of both intensively managed grassland and rough grassland.

[16] https://www.gov.uk/government/collections/uk-greenhouse-gas-emissions-statistics.

[17] https://www.gov.uk/government/statistics/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics-2005-to-2021.

Using the 2023 update of the DESNZ GHG inventory, estimated agriculture and land use totals across all the National Parks in 2022 are, respectively, 2.8 million tCO_2e per year and −1.6 million tCO_2e per year (the latter implying net sequestration). In comparison, the 2022 total for all the National Parks across the six priority areas defined in this assessment is 11.5 million tCO_2e per year (Appendix 0).

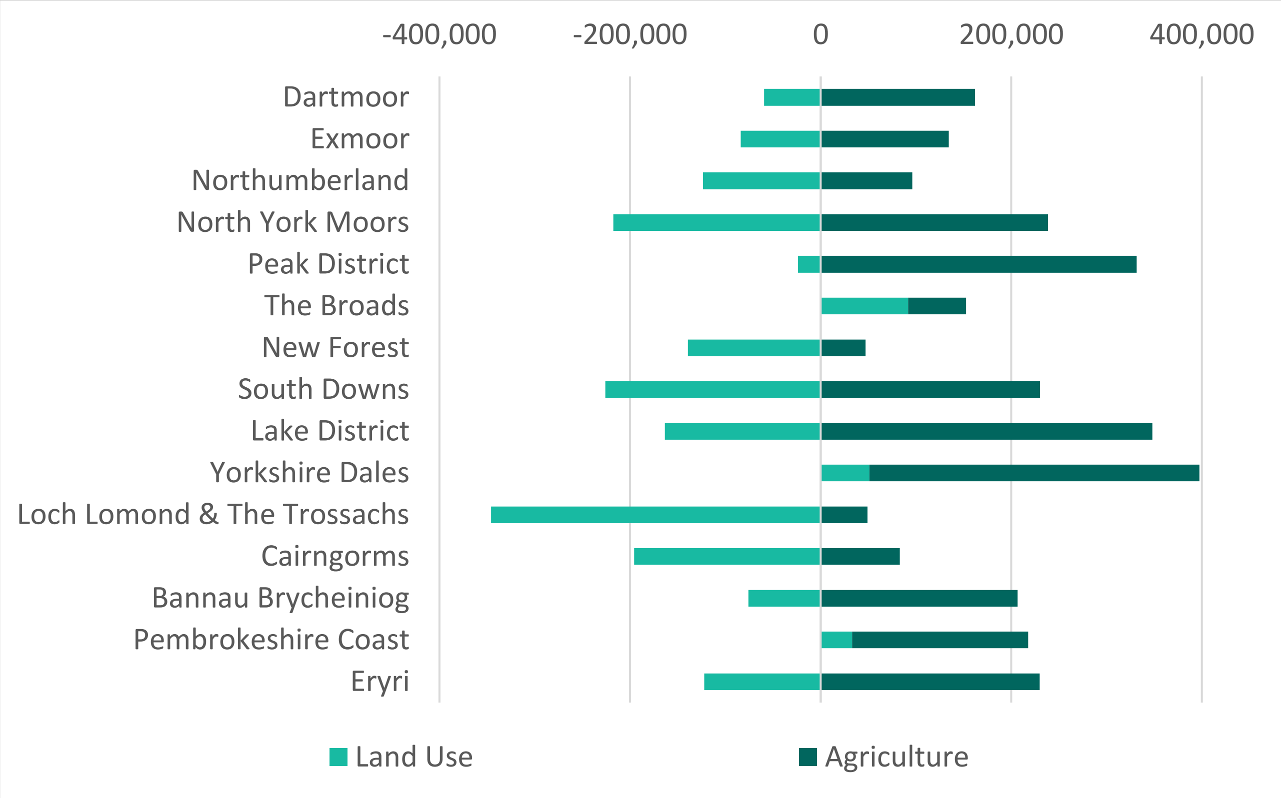

Figure 9. Estimated land-based emissions for the National Parks in 2022 derived from the 2023 update of UK GHG inventory. Units: tCO_{2e} per year. Negative values imply net carbon sequestration.

Land use opportunity mapping based on habitats and peat

We consider the following 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 such as biodiversity gains, flood mitigation, air quality improvements, and gains in recreational value, in alignment with the Sixth Carbon Budget:

- Woodland creation
  - New native broadleaf/mixed woodland
  - New productive coniferous woodland
- Peatland restoration (across all degraded types; deep peat only)
- Regenerative agriculture
  - Agroforestry
  - Hedgerows

- Introducing species-rich grasslands with legume species
- Introducing cover crops.

The targets for each of these options are derived by apportioning UK-wide land-based carbon sequestration measures from the UK's Sixth Carbon Budget (2020)[18] according to present-day land use distribution in each National Park (Section 0). These distributions are based on the Living England Habitat Probability Map, CEH Land Cover Map, UK GHG Inventory Peat Map, NatureScot Soils and Peat Map, and the Unified Peatland Map of Wales, as well as several other datasets (Appendix 0). The degraded peatland classification follows the methodology adopted by the UK Government for annual LULUCF GHG inventories[19], which is based on the assessment by Evans *et al.* (2017)[20].

In the case of woodland creation, we developed a new opportunity mapping procedure which accounts for a wide range of suitability factors and constraints. This is illustrated for the Lake District in Figure 10; further details are provided in Appendix 0. The procedure assigns a score between 0 (unsuitable) and 1 (most suitable) to each 10m land parcel in England, allowing one to apportion England-wide targets for new woodland from the Sixth Carbon Budget to any landscape within the country. For Scotland and Wales, we used a comparable habitat-level procedure in which each habitat has its average woodland suitability score.

The apportioned woodland targets for each National Park are then increased by 50% to mitigate the UK's comparatively large consumption-based footprint generated overseas (estimated to be roughly equal to UK territorial emissions; see Section 0), which is not included in the Sixth Carbon Budget targets. The proposed higher-ambition approach is supported by field-level woodland opportunity mapping performed by several landscapes (e.g. Cotswolds[21], Northumberland[22]). It also reflects the National Parks' unique opportunities to attract both public and private grants to expand the woodland cover, and the central role these landscapes ought to play for meeting ambitious nature recovery goals across the UK.

The recommended uptake of deep peatland restoration measures is based on the assessment of deep peat coverage and condition in each National Park, as is illustrated for the Yorkshire Dales in Table 4, including an assessment of the types of peat degradation in line with the Evans *et al.* (2017) methodology (see Appendix 0 for further details). We do not consider shallow peat in this report since the feasibility of its restoration across the country remains uncertain. In setting the level of ambition, we follow the UK-wide target from the Sixth Carbon Budget which aims for 80% of peatland to be in a healthy condition by 2050, and apply it to deep peat areas only.

---

[18] UK's Sixth Carbon Budget: "Agriculture and land use, land use change and forestry" (AFOLU) report. Climate Change Committee, 2020.
[19] Ricardo Energy & Environment, UK NIR 2020 (Issue 1) "UK GHG Inventory 1990-2019," Annex p.854.
[20] https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1904111135_UK_peatland_GHG_emissions.pdf.
[21] https://www.arcgis.com/apps/dashboards/3652fdb534cf47e58b7262cdb2345366.
[22] https://storymaps.arcgis.com/stories/e06f03103c364e17b895c6e133e7b03c.

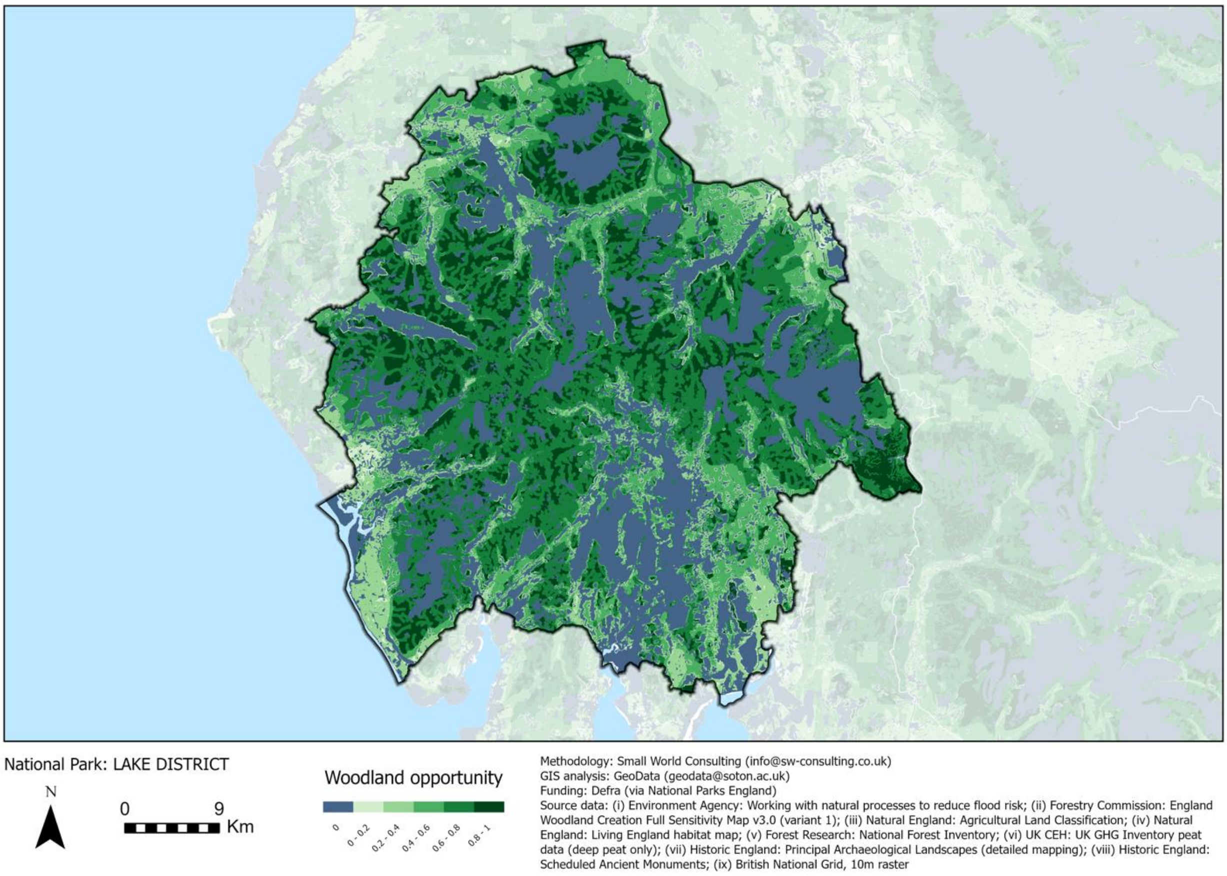

Figure 10. Normalised woodland opportunity scores based on the new opportunity mapping procedure by Small World Consulting. Coverage: Lake District National Park.

Table 4. Yorkshire Dales National Park: Key land use types by area (present-day), including underlying deep peat areas and the estimated percentage of peat in a healthy condition (by area) provided by the Yorkshire Peat Partnership. The colour scales for habitat and peat areas range from green (lowest value) to red (highest value) and are applied separately to each column. The colour scale for "% of deep peat in healthy condition" range from red (lowest value) to green (highest value).

CEH Land Cover Type	Habitat Area (ha)	Deep Peat Area (ha)	Estimated % of Deep Peat Area in Healthy Condition
Broadleaved woodland	4,043	3	0%
Coniferous woodland	4,112	1,193	3%
Arable and horticulture	20	0	NA
Improved grassland	51,755	54	7%
Neutral grassland	0	0	NA
Calcareous grassland	19,047	519	20%
Acid grassland	77,135	12,807	10%
Fen, marsh, swamp	0	0	NA
Heather	4,795	3,063	3%
Heather grassland	8,091	1,828	12%
Bog	45,722	39,586	7%

Saltmarsh	0	0	NA
Urban	104	0	NA
Suburban	698	0	0%
Total	**215,521**	**59,053**	**7.4%**

The recommended regenerative agriculture targets are based on apportioning the relevant UK-wide targets from the Sixth Carbon Budget according to the extent of arable, improved grassland and other grassland habitats in each National Park (Appendix 0)[23]. By design, the proposed uptake levels of regenerative agriculture measures double-count some parts of these habitats within a given landscape, for example when agroforestry and species-rich grassland systems are rolled out in the same area.

Appendix 0 provides more information on the adopted approach to setting land use targets for the National Parks.

Land use targets for UK National Parks

As described in the previous section, land use change targets require a separate assessment based on the characteristics of the habitats in each landscape. Consequently, this report recommends annual and the associated cumulative targets for new woodland, restored peatland and regenerative agriculture for each National Park between 2023[24] and 2050 (horizon year), which are summarised in Figure 11 and Table 5.

Cairngorms has the highest annual targets for new woodland and restored peatland (both of the order of 1,500 ha per year) due to its size and the types of habitats within. The next highest woodland creation targets are for Eryri, the Lake District and Yorkshire Dales, while the next biggest deep peatland restoration targets are for the Yorkshire Dales (on par with Cairngorms) and Peak District (nearly three times lower than for Cairngorms). South Downs has the highest capacity for the selected regenerative agriculture measures (over 1,600 ha per year, combined across all measures).

[23] In the case of The Broads, since grasslands common to this National Park sit somewhere between the CEH definitions of "improved" and "neutral" grasslands that are used to set regenerative agriculture targets, its proposed share of these targets is likely to have a considerable degree of uncertainty.
[24] We assume that all measures start in 2023, the year after the baseline year 2022.

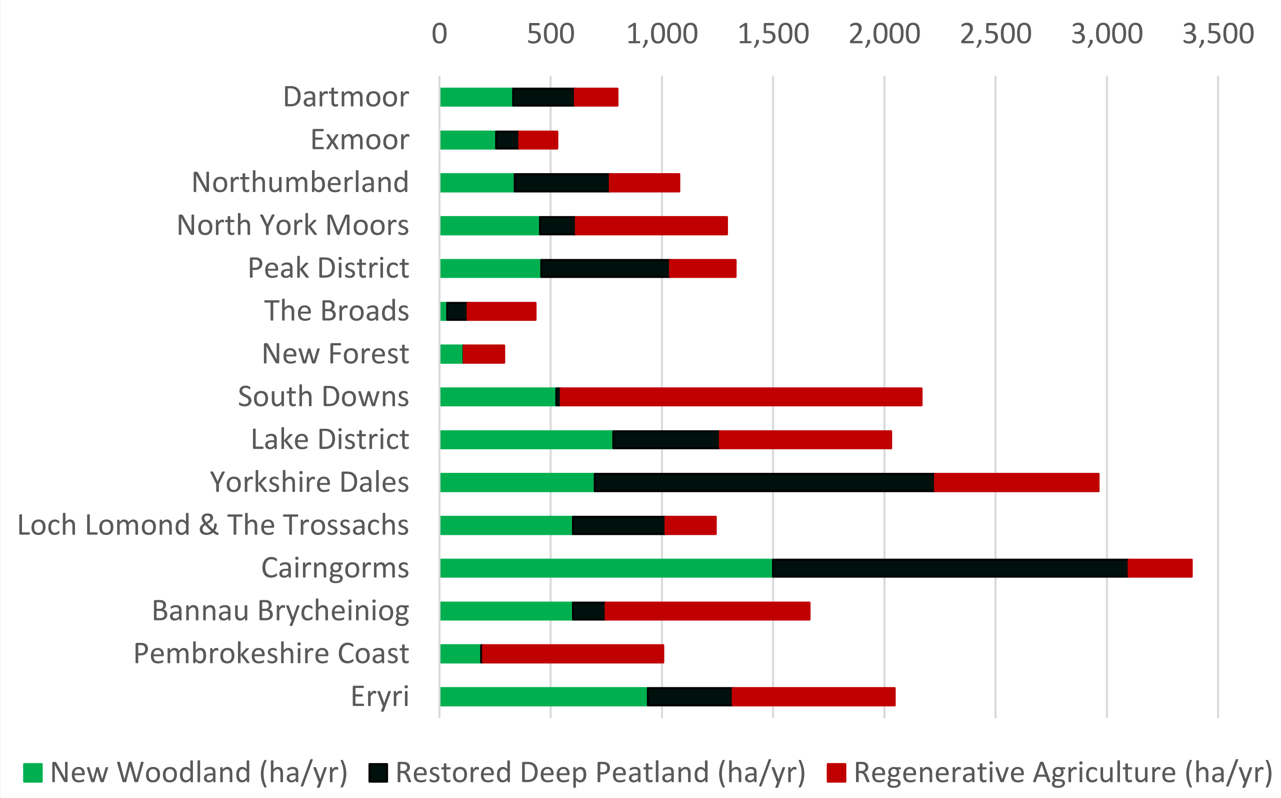

Figure 11. Recommended annual targets for new woodland, restored deep peatland and regenerative agriculture for the National Parks ***between 2023 and 2050****. Units: ha per year. Note that the regenerative agriculture targets double-count some parts of cropland and improved grassland within a given landscape, for example when agroforestry and species-rich grassland systems are rolled out in the same area.*

Table 5. Recommended annual targets for new woodland, restored deep peatland and regenerative agriculture for the National Parks ***between 2023 and 2050****. Units: ha per year. The colour scale from green (lowest value) to red (highest value) is applied separately to each column.*

National Park	New Woodland (ha/yr)	Restored Deep Peatland (ha/yr)	Regenerative Agriculture (ha/yr)
Dartmoor	332	278	191
Exmoor	255	103	172
Northumberland	338	427	313
North York Moors	452	161	679
Peak District	458	578	296
The Broads	35	92	305
New Forest	107	1	183
South Downs	525	20	1,622
Lake District	781	480	770
Yorkshire Dales	698	1,530	735
Loch Lomond & The Trossachs	600	416	226
Cairngorms	1,500	1,598	283

Bannau Brycheiniog	600	147	916
Pembrokeshire Coast	188	9	810
Eryri	938	381	729
All National Parks	**7,805**	**6,223**	**8,228**

The relevant cumulative area figures for new woodland, restored peatland and regenerative agriculture recommended for each National Park between 2023 and 2050, and described as percentages of their total areas, are summarised in Figure 12 and Table 6.

Eryri, Bannau Brycheiniog and Exmoor are estimated to have the highest capacities for creating new woodland relative to the total areas of the landscapes, while The Broads and New Forest have the lowest relative capacities. Most of the new plantations are assumed to be permanent native broadleaf or mixed woodlands, which serve joint climate and ecological objectives, although predominantly upland landscapes receive a 20% share of the new plantations allocated to productive forestry (50% in Scotland).

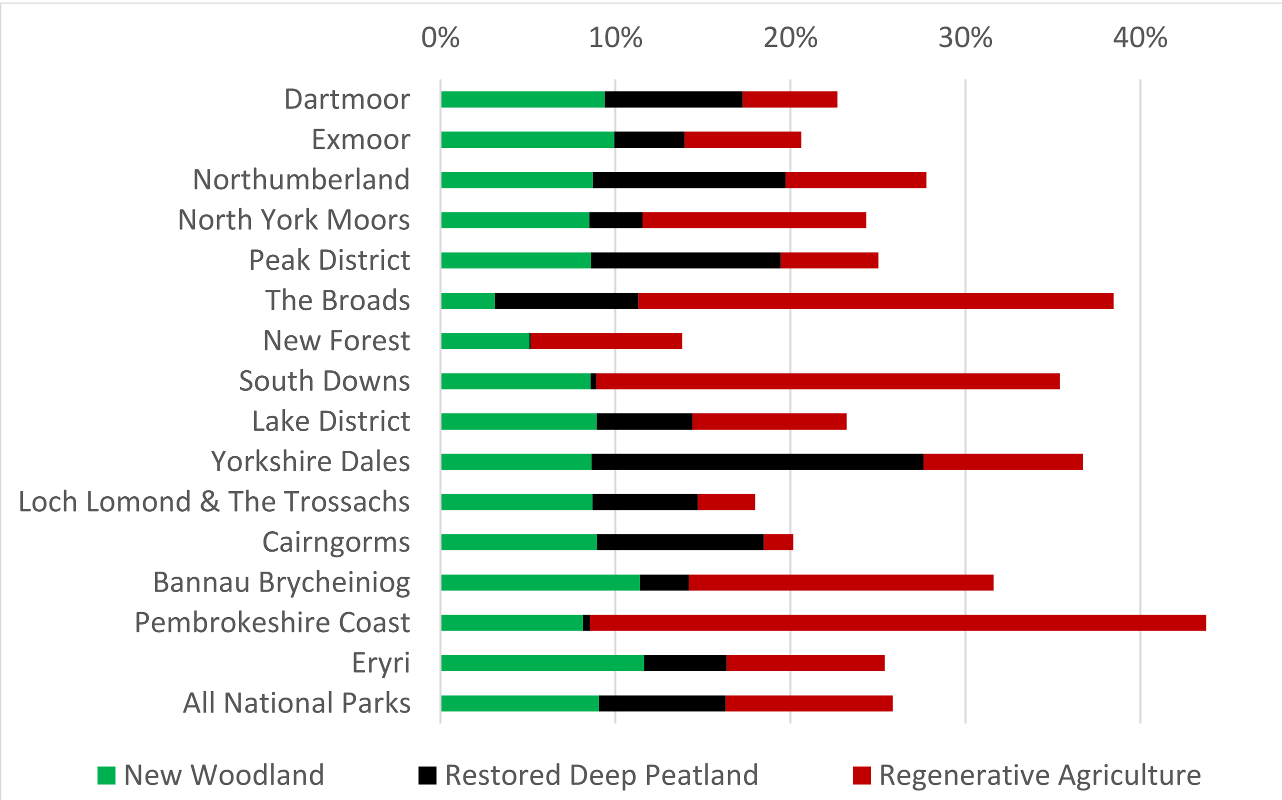

*Figure 12. Recommended cumulative areas of new woodland, restored deep peatland and regenerative agriculture for the National Parks **between 2023 and 2050**, expressed as percentages of the landscapes' areas. Note that the regenerative agriculture targets double-count some parts of cropland and improved grassland within a given landscape, for example when agroforestry and species-rich grassland systems are rolled out in the same area.*

Yorkshire Dales, Northumberland, and Peak District are estimated to have the highest capacities for restoring deep peatland relative to the total areas of the landscapes. The restoration capacities follow the estimated occurrences of degraded deep peat (with a conservative estimate used for Bannau Brycheiniog, as explained in section 0). This includes areas of deep peat degraded in different ways, including eroding peat, modified grass-dominated peat, forested peat and so on. The proposed peatland restoration target for each landscape is split between these areas according to their relative prevalence.

Pembrokeshire Coast, The Broads and South Downs are estimated to have the highest capacities for adopting selected regenerative agriculture practices relative to the total areas of the landscapes. As mentioned before, in some cases multiple regenerative practices could be applied to the same parts of land, and the total targets presented here count such parts of land more than once.

*Table 6. Recommended cumulative areas of new woodland, restored deep peatland and regenerative agriculture for the National Parks **between 2023 and 2050**, expressed as percentages of the landscapes' areas. The colour scale from green (lowest value) to red (highest value) is applied separately to each column.*

National Park	New Woodland	Restored Deep Peatland	Regenerative Agriculture
Dartmoor	9%	8%	5%
Exmoor	10%	4%	7%
Northumberland	9%	11%	8%
North York Moors	9%	3%	13%
Peak District	9%	11%	6%
The Broads	3%	8%	27%
New Forest	5%	0%	9%
South Downs	9%	0%	26%
Lake District	9%	5%	9%
Yorkshire Dales	9%	19%	9%
Loch Lomond & The Trossachs	9%	6%	3%
Cairngorms	9%	10%	2%
Bannau Brycheiniog	11%	3%	17%
Pembrokeshire Coast	8%	0%	35%
Eryri	12%	5%	9%
All National Parks	**9%**	**7%**	**10%**

Projected changes in land-based emissions and sequestration

The land use change targets introduced in the previous section, in conjunction with proposed long-term reductions to agricultural emissions (Appendix 0), are projected to reduce net annual land-based GHG emissions across all the National Parks combined by around **5.6 million tCO_2e/yr** between 2022 and 2050. This includes both the agriculture and land use components introduced in Section 0, and factors in both reductions in emissions and increases in carbon sequestration.

The breakdown of these changes for each land use measure in each National Park is provided in Figure 13. The shape of the distribution across the National Parks very broadly follows the underpinning annual land use targets in Figure 11, but with higher contributions per hectare of intervention from new woodland (−13.1 $tCO_2e/ha/yr$) compared to restored deep peatland (−5.2 $tCO_2e/ha/yr$), and higher contributions per hectare of intervention from restored peatland, on average, compared to regenerative agriculture (−2.6 $tCO_2e/ha/yr$). The split between new permanent broadleaf/mixed woodland (planted for climate and ecological purposes) and productive coniferous woodland (planted primarily for timber) is assumed to be 100%-0% for the lowland landscapes (e.g. South Downs), 80%-20% for most upland landscapes (e.g. Lake District), and 50%-50% for the two Scottish National Parks, Cairngorms and Loch Lomond & The Trossachs, due to their unique circumstances.

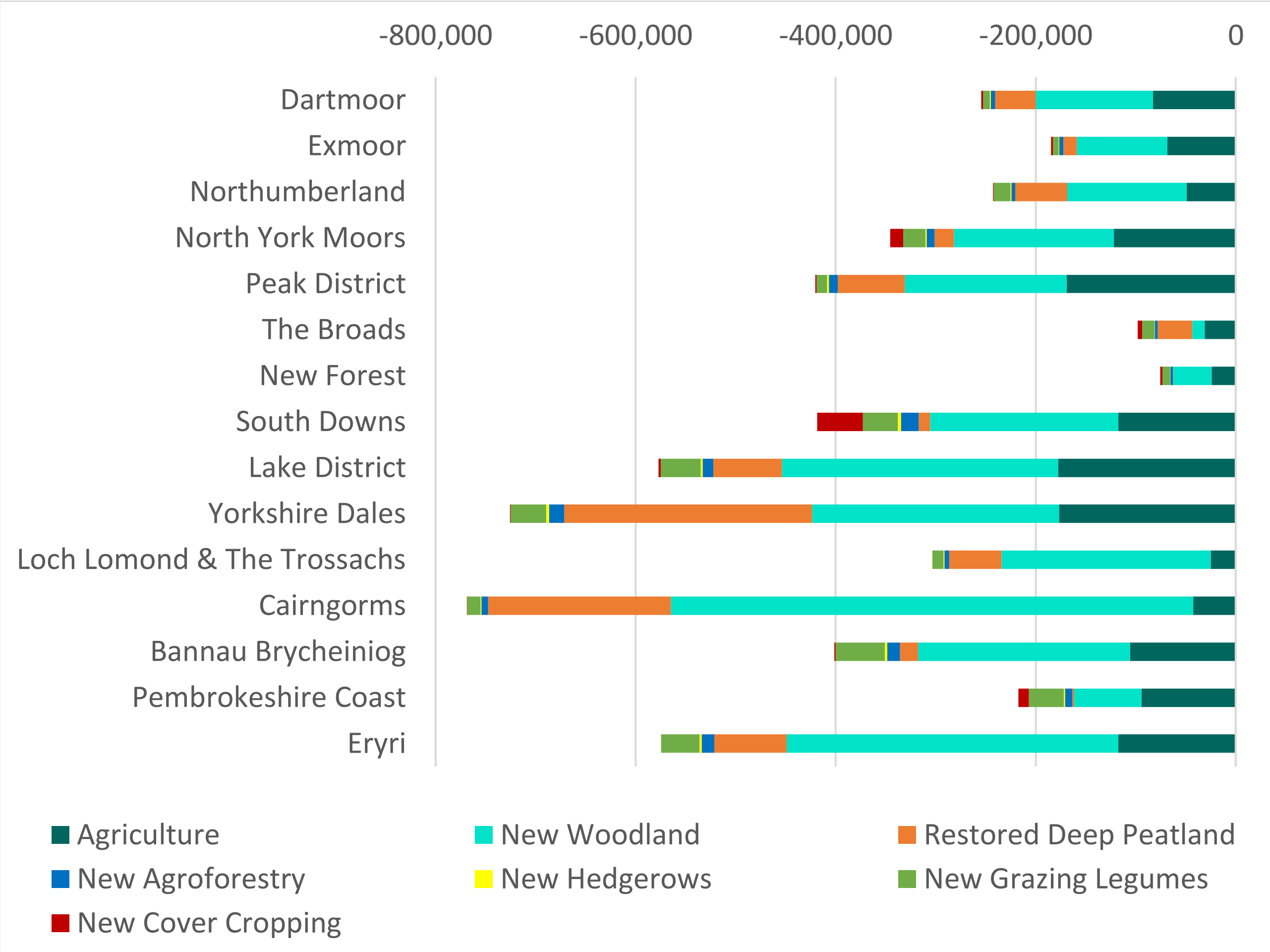

*Figure 13. Projected changes in net annual land-based GHG emissions for the National Parks **between 2022 and 2050** as a result of implementing the recommended land use change targets. Units: tCO_2e per year (difference between the 2022 and 2050 emissions).*

Figure 13 shows that, in absolute terms, the highest carbon sequestration from creating new woodlands is projected to be achieved in the Cairngorms, Eryri and the Lake District. The biggest potential for emission reductions through deep peatland restoration lies in the Yorkshire Dales and Cairngorms. South Downs could achieve the highest carbon sequestration through regenerative agriculture measures, while the Lake District, Yorkshire Dales and Peak District are set to deliver the biggest reductions in emissions from livestock and fertilisers.

The underpinning parameterisations for land-based emission reductions and carbon sequestration – that were used to convert the land use targets in Figure 11 to reductions in net GHG emissions in Figure 13 – are described in Appendix 0. We are aware that the effectiveness of some of the regenerative agriculture measures for carbon sequestration is still being actively researched, particularly for permanent grassland systems, and the relevant parameterisations may need to be revised if new scientific consensus emerges. However, the assessment in the current from is sufficiently robust for practical decision-making in the next few years. There is high confidence that all of the proposed measures will deliver significant climate mitigation benefits, alongside other benefits such as increased biodiversity, flood risk mitigation and recreational value.

GHG reductions for all priority areas, and caveats related to projected net zero years

For perspective, we need to compare the projected land-based emission reductions and carbon sequestration described in the previous section against the projected reductions in emissions across other priority areas for the National Parks, such as energy use, food and visitor travel (Appendix 0). This is illustrated in Figure 14. All the measures other than those related to land use change are projected to deliver another reduction of around **9.4 million tCO_2e/yr** in annual GHG emissions across all the National Parks between 2022 and 2050 (compared with 5.6 million tCO_2e/yr for land-based reductions).

Figure 14 shows that, in absolute terms, the biggest reductions in energy-related emissions are projected to be achieved in South Downs, followed by New Forest and Lake District. By far the largest reductions in emissions associated with consumption of food and other goods will be in the South Downs, reflective of the large resident population and high number of visitors; the Lake District and Peak District come distant second and third across these two footprint categories. The Lake District will see the biggest reductions in emissions from visitor travel to and from the landscape, with South Downs and North York Moors coming distant second and third. When all the six priority areas are added together (including land use), the Lake District, and South Downs are set to deliver the largest reductions in net annual GHG emissions between 2022 and 2050, each in excess of 2 million tCO_2e/yr. Peak District, Yorkshire Dales, Cairngorms and Eryri are set to deliver net GHG reductions in excess of 1 million tCO_2e/yr.

The combined total net annual GHG emissions across all the National Parks, based on the six priority areas identified in this assessment, are projected to drop from around **11.5 million tCO_2e/yr** in 2022 to **-3.5 million tCO_2e/yr** in 2050, a reduction of approximately **15 million tCO_2e/yr** over the 28-year period. In the process, all but two National Parks are projected to change from net GHG emitters in 2022 to net GHG sinks in 2050, which is illustrated in Figure

15. National Parks such as Cairngorms, Loch Lomond & The Trossachs and Northumberland will see the biggest net negative emissions in 2050 (by magnitude) compared to the scale of their present-day emissions. The likes of Peak District and South Downs, on the other hand, will see the smallest net negative emissions in 2050 (by magnitude) compared to their present-day emissions. In the process, all the National Parks except for The Broads and Pembrokeshire Coast are set to reach net zero GHG emissions at some point between the late-2020s and 2050, assuming the recommended targets were implemented in 2023 and will persist until 2050. The Broads and Pembrokeshire Coast are the only exceptions, owing to their comparatively large share of productive agricultural land and limited opportunities to implement land-based measures to sequester carbon (especially in the case of The Broads).

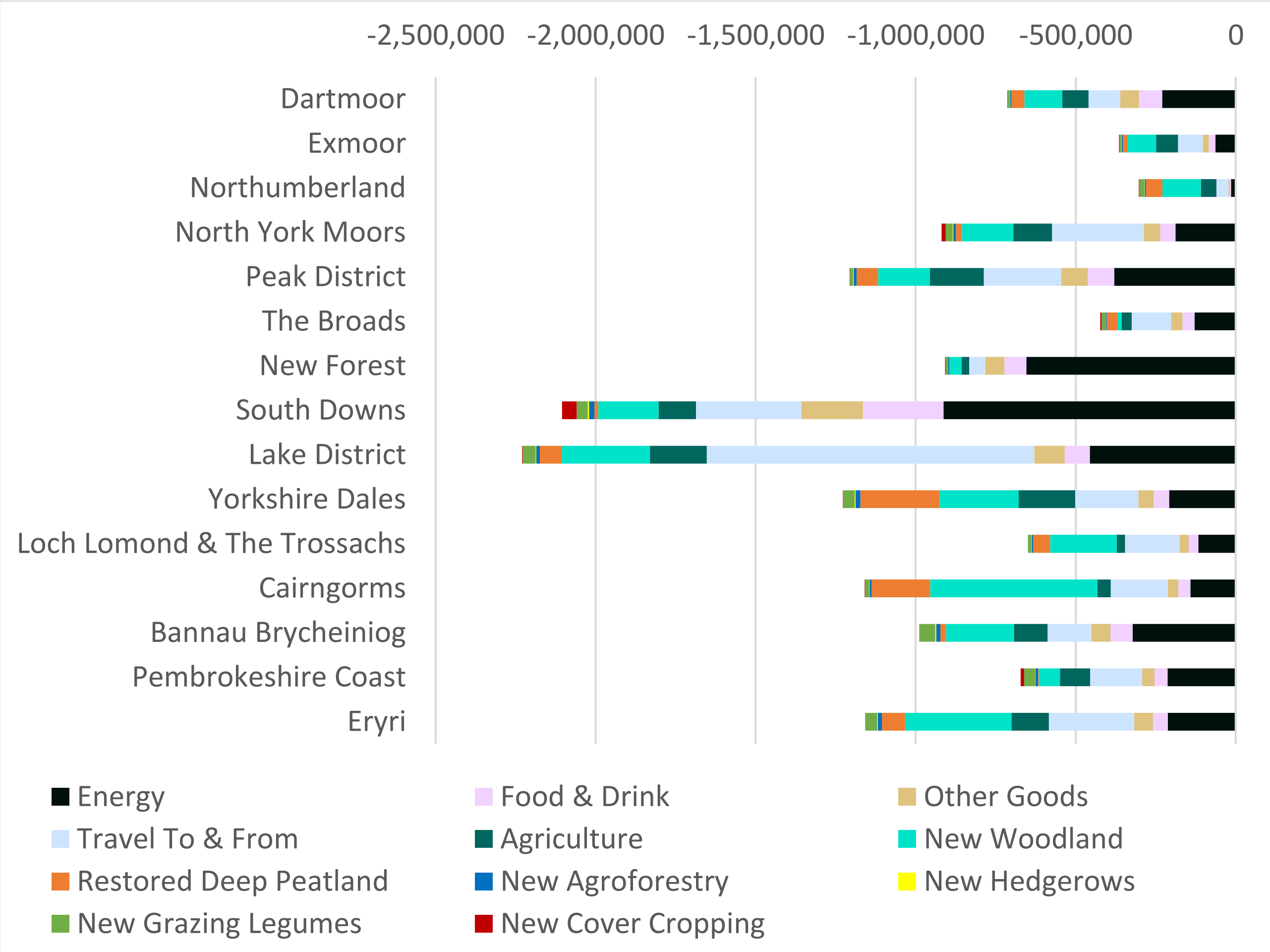

*Figure 14. Projected changes in net annual GHG emissions **across all six priority areas** for the National Parks **between 2022 and 2050** as a result of implementing the recommended targets. Units: tCO_2e per year (difference between the 2022 and 2050 emissions).*

It is important to remember that the projected net zero year and net emissions in 2050 (Figure 15) reflect the individual characteristics of the National Parks rather than differences in recommended levels of ambition. All the targets proposed for each National Park in this assessment are consistent with keeping global warming below the “safer” 1.5°C limit in the

Paris Agreement. However, the scale of present-day emissions in each of the six priority areas and the capacity to tackle them vary considerably between the National Parks.

Combined, the 15 National Parks are projected to become a large landscape-scale carbon sink in the 2040s under the proposed targets (Figure 16).

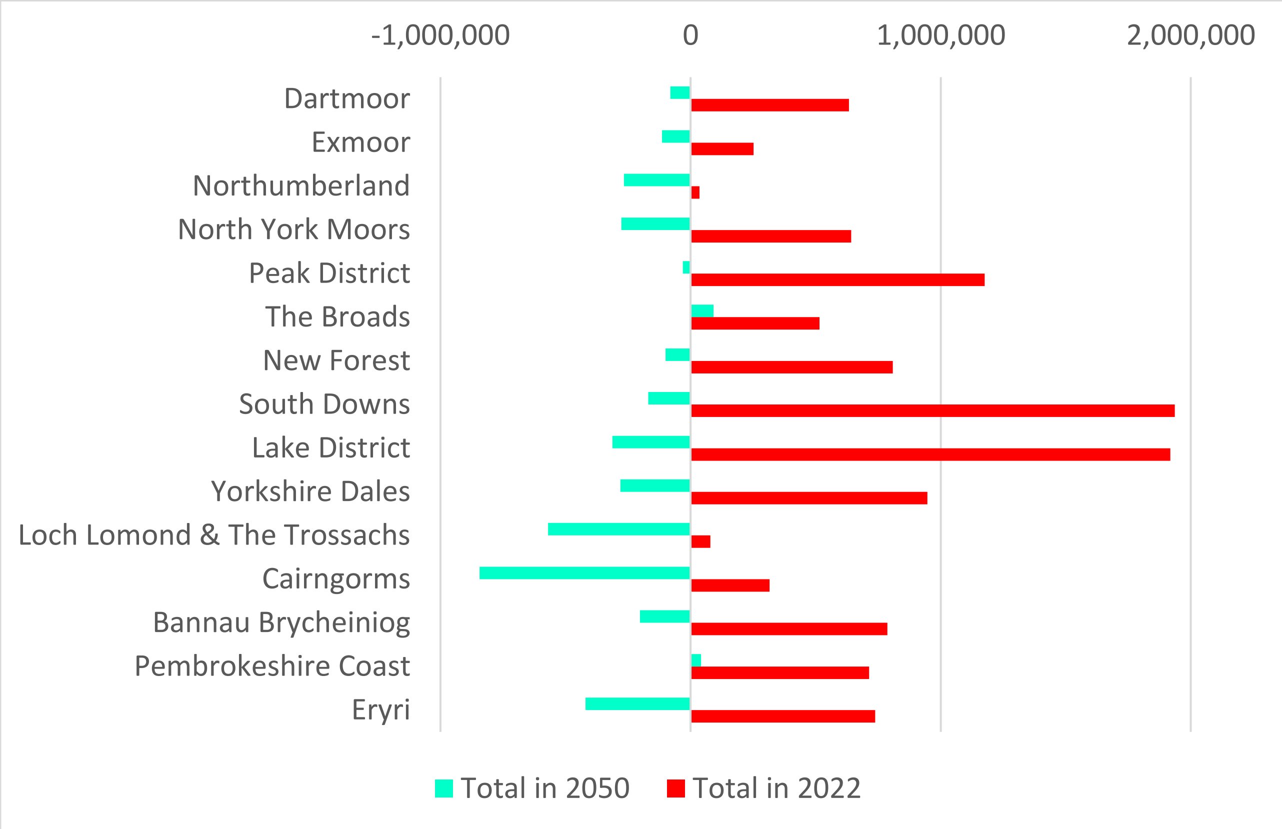

Figure 15. (Repeat of Figure 2) Estimated net GHG emissions in 2022 (baseline year) and projected net GHG emissions in 2050 for the UK's National Parks. Units: tCO_2e per year.

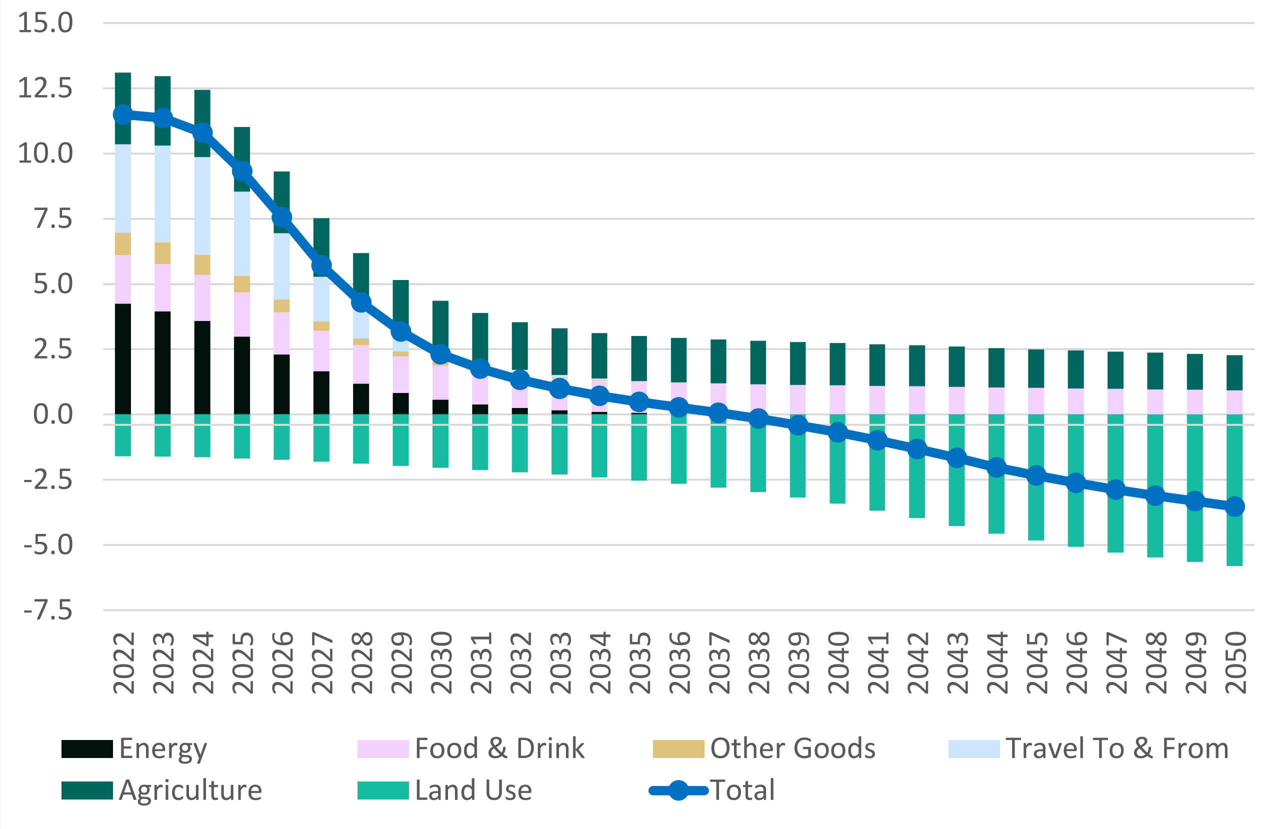

Figure 16. (Repeat of Figure 3) GHG pathways for all the National Parks combined, derived from their 2022 GHG baselines and the recommended targets for each of the six priority areas shortlisted as part of this assessment. Units: $MtCO_2e$ per year.

A Vision for UK National Parks and Other Designated Landscapes

Balancing food, climate and biodiversity goals

Our recent paper "*UK Farming and Land Use: Addressing the Climate and Ecological Emergencies while Supporting Farmers*" brings the latest scientific evidence to the contentious and emotive debate around what truly sustainable farming and land use in the UK and globally should look like[25]. This section provides a brief overview of some of the key findings from this paper and discusses them in context of the UK's National Parks.

A sustainable food system needs to achieve multiple objectives simultaneously. Although our work has focused on climate mitigation, we do not intend that this goal is pursued in isolation or even prioritised at the expense of other essential objectives. Specifically, at the same time as meeting science-aligned GHG emission reduction targets, a sustainable land and food system also needs to meet several other criteria:

- Rebuild the biodiversity that is currently in rapid decline;
- Provide a healthy and secure food supply to all;
- Halt and reverse soil degradation;
- Remove any reliance on fossil fuel inputs;
- Enable quality livelihoods and vibrant communities;
- Contribute to flood resilience.

The challenge, globally, nationally, and within each of the National Parks, is for every piece of land to optimise its contribution to this wider public agenda, according to its unique qualities and circumstances.

Fortunately, many of the key actions for reducing GHG emissions also align with these other objectives. Most notably, there is a very large double impact of moving towards a more plant-based diet: the GHG emissions from livestock farming decrease, and the freed-up land can then be used, for example, to sequester carbon, improve biodiversity and/or better retain flood water.[26]

A look at the global perspective is useful before turning more specifically to the UK's National Parks. Figure 17 and Figure 18 track the world's calories and protein on their journey from human-digestible crops to human mouths, while Figure 19 shows the corresponding land use demands. The most important features to note are:

---

[25] https://www.sw-consulting.co.uk/food-and-land/uk-farming-land-use.

[26] Sun, Zhongxiao *et al.* "Dietary Change in High-Income Nations Alone Can Lead to Substantial Double Climate Dividend". *Nature Food* 3, no. 1 (10 January 2022): 29–37. https://doi.org/10.1038/s43016-021-00431-5.

- 50% of all global habitable land is currently farmed, and 77% of this farmed land is used to support livestock, which only produces 18% of human supply of calories and 37% of human supply of protein (Figure 19).
- At the global level we produce around two and a half times the calories (Figure 17) and four times the protein (Figure 18) in crops alone compared to what is required for a healthy diet for all.
- Despite losses through the system, there would still be a small surplus in supply if the food were optimally distributed.
- The greatest loss of nutrition occurs when around 1,700 kilocalories per person per day are fed to animals, along with roughly 3,800 kilocalories produced per person per day in grass pasture and stover (which we can't digest, but some of which is grown on land that could be used for crops and some on land that could be used for nature recovery). In return, humans obtain just under 600 kilocalories per person per day from animal products, but this figure also includes wild caught fish which do not benefit at all from animal feed. Reducing the proportion of meat and dairy would be transformative in taking pressure off the food system, and enabling a secure food supply with lower GHG emissions and more opportunities for nature recovery.
- There are various other losses throughout the system, including during harvesting, storage, transport, distribution, processing and consumer waste. Although not as significant as the losses from feeding human digestible feed to animals,[27] these are still cumulatively very high and it will clearly be beneficial to minimise all of them. (Note also that in the UK, the proportion of consumer waste is several times higher than the global average).
- The situation for protein is similar to that for calories, although animals are marginally more efficient at producing protein (nearly 30% conversion rate compared to 10% for energy), and the global net excess consumption of protein is far higher, at nearly double the requirements for a healthy diet.
- Looking at the global average obscures the very great inequities present, with wealthier people often eating and wasting far more than necessary, and with a higher proportion of more polluting and impactful foods, while the poorest still starve. Note that these wide inequalities exist between different countries as well as within countries.

[27] Shepon et al (2018). "The Opportunity Cost of Animal-Based Diets Exceeds All Food Losses." DOI: https://doi.org/10.1073/pnas.1713820115.

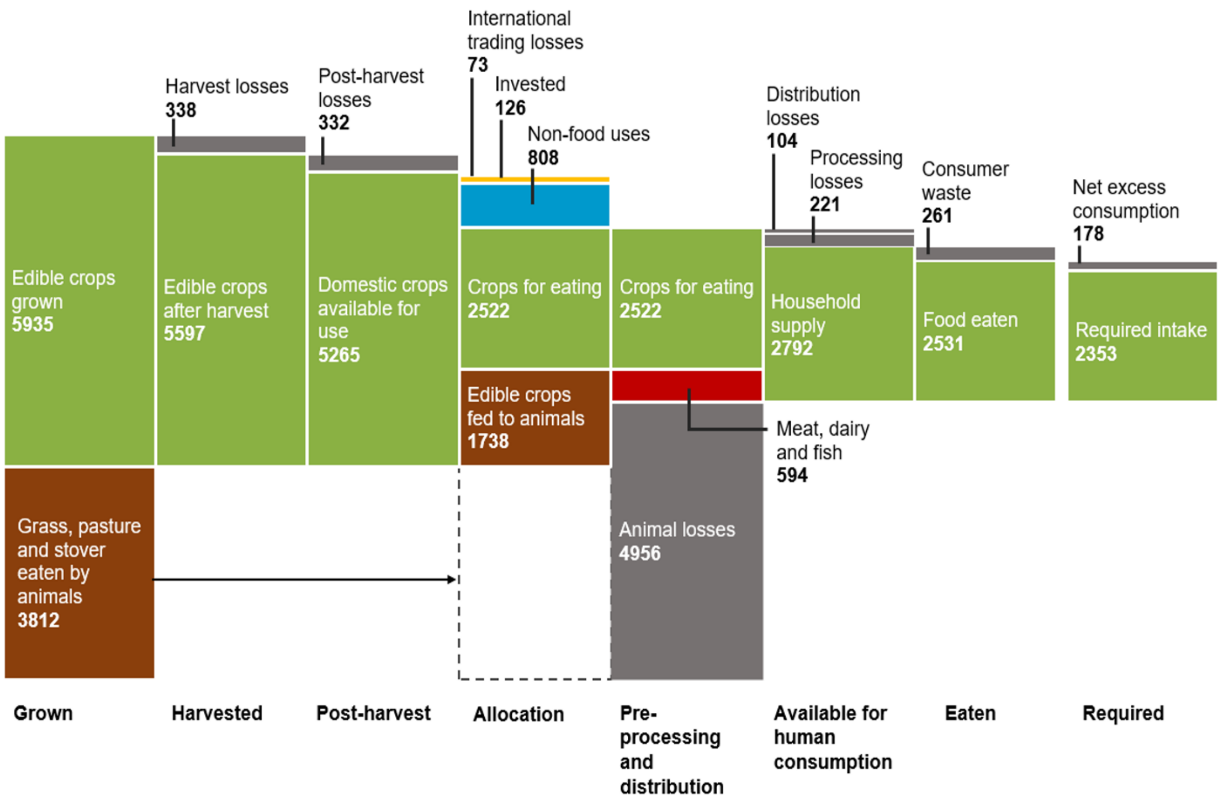

Figure 17: The journey of energy (in kcals per person per day) through the global food system, from cultivation to consumption. Animal losses make up a significant source of total losses, and although the grass, pasture and stover calories are not directly human-edible, they are often grown on land which could be used for edible crops or returned to natural habitats. Source: Berners-Lee et al (2018). "Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation." DOI: https://doi.org/10.1525/elementa.310.

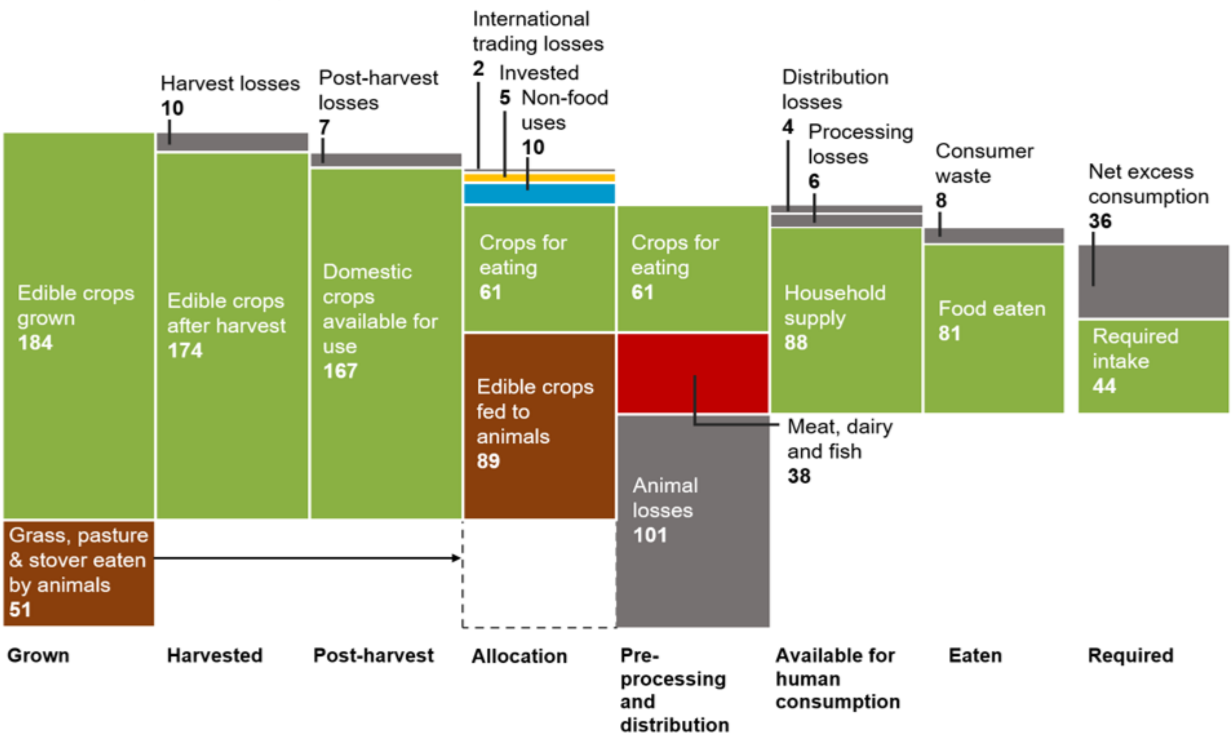

Figure 18: The global flow of protein (in grams per person per day), from cultivation to consumption. Although animal losses are less severe than for calories, they are still large, and the ratio of excess consumption to required consumption is also

higher. Source: Berners-Lee et al (2018). "Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation." DOI: https://doi.org/10.1525/elementa.310.

From a health perspective, whereas meat and dairy once were sources of multiple essential nutrients in otherwise limited diets for many, the UK now has ready access to a very wide range of plant foods, including ample supplies of all the human-essential nutrients without resorting to the levels of meat and dairy that are currently consumed.[28] Conversely, much of the world's and the UK's meat and dairy production system can be argued to be increasing human health risks such as antibiotic resistance and the migration of disease from animals to humans. The shift to ultra-processed foods also threatens biodiversity,[29] as well as myriad other harms such as concentrating money and power into fewer hands, eroding local traditions and culture, introducing new energy needs for bulk transport and processing, as well as the adverse health effects.

The inherent efficiency of a more plant-based food system over one that is high in meat and dairy also brings net economic benefits[30]. However, the way the economic benefits are distributed may be determined by the balance of power between farmers, processors, distributors and consumers, and by the relevant government subsidies and taxes.

Implementing the required changes to land use in order to meet climate and biodiversity targets is complicated by the influence of farming to earn an income under a subsidy regime. Small farmers trying to stay afloat and corporations seeking maximised monetary returns will take the most economic path, often without regard for the long-term or dispersed negative impacts. Without climate-positive subsidies or support, many food producers will find their hands tied by their economic situation. Perverse monetary incentives can then lead to perverse outcomes, such as allocating human-edible crops to non-food uses while food insecurities grow. The switch from the decades-long influence of the EU's agricultural policies to domestically set policies stands to bring either significant potential for improvement or risks of further regression.[31] Figure 20 shows how policies addressing edible crop use can affect food security in the future.

[28] Dimbleby, H. (2021) "National Food Strategy: The Plan." https://www.nationalfoodstrategy.org.

[29] Leite F.H.M., Khandpur N., Andrade G.C., et al. "Ultra-processed foods should be central to global food systems dialogue and action on biodiversity." *BMJ Global Health* 2022;7:e008269. doi:10.1136/bmjgh-2021-008269.

[30] Schepers J., Annemans L. "The potential health and economic effects of plant-based food patterns in Belgium and the United Kingdom." *Nutrition* 2018 Apr;48:24-32. doi: 10.1016/j.nut.2017.11.028. Epub 2017 Dec 15. PMID: 29469016.

[31] The Royal Society: "Multifunctional landscapes: Informing a long-term vision for managing the UK's land", January 2023.

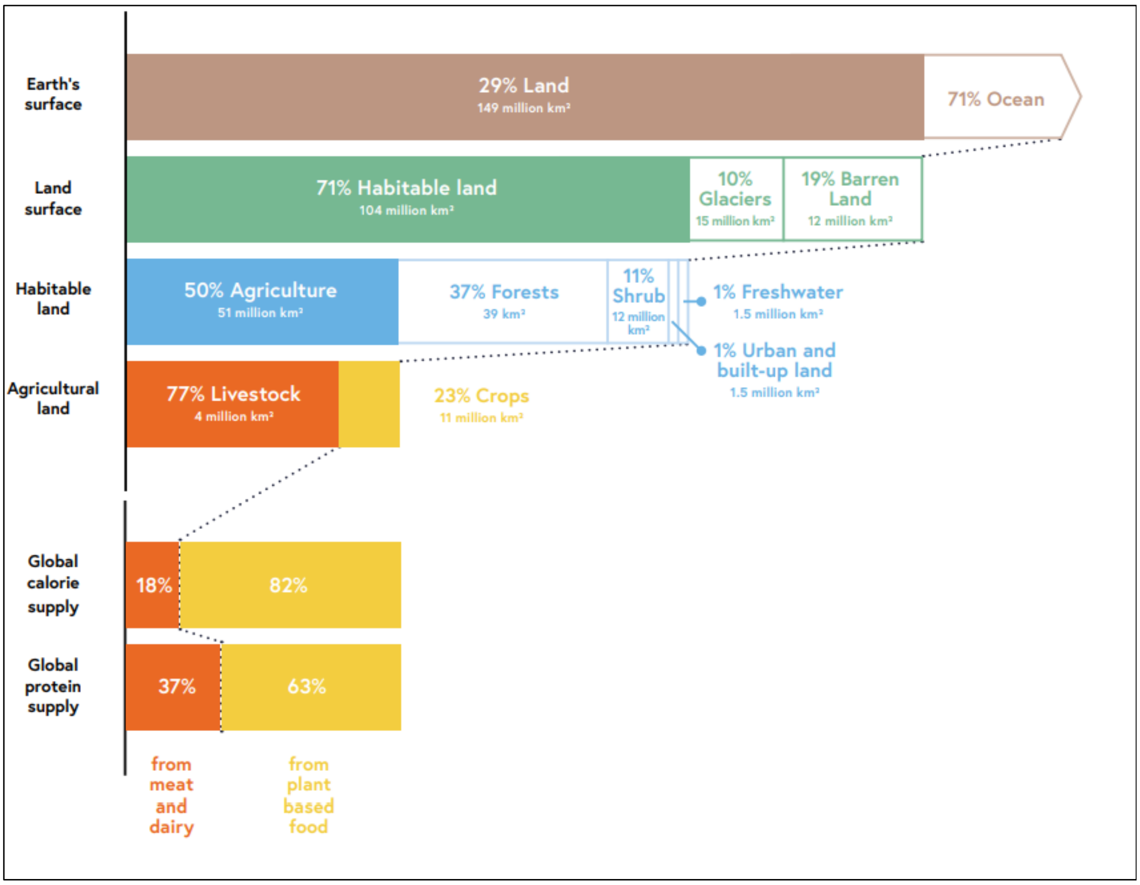

Figure 19: An overview of global land use, as well as the calorie and protein conversions from land use area into food supply. Source: The National Food Strategy report (2021); https://www.nationalfoodstrategy.org/.

Figure 21 illustrates that reducing meat and dairy production and consumption not only enables food security and biodiversity, but also brings very large reductions in GHG emissions. In the UK, a weekly food basket per person with average levels of meat and dairy consumption, coupled with typical high levels of waste and air freight, has a GHG footprint of 88 kgCO_2e. In contrast, a vegan shopping basket with no waste and no air freight produces 17 kgCO_2e.

How these overall perspectives apply to each piece of land within each National Park is more difficult to generalise, but most land falls into one of the following categories, as described in Sections 0 and 0:

- Land that is unsuitable for crops and, without subsidies, uneconomic for animal food production, and is therefore best suited to nature recovery, possibly entailing a low density of animal farming and low food production.
- Animal farmland that cannot be used for crops but is sufficiently productive to justify continued animal farming, with an emphasis on regenerative techniques, including minimising the following: feed, fertiliser use and herbicide/pesticide applications.
- Land that has been assumed to be unsuitable for crops but could once again become arable by deploying modern understandings and techniques, perhaps including animals in one phase of a crop rotation.

- Arable land that can continue as such while optimising yields, supporting nature recovery and improving soil health through emerging agroecology techniques for minimising expensive farm inputs, maximising soil cover and minimising tillage.

Making and implementing the best choices will require a great deal of work at every skill level, as well as substantial change to farming practices. This ought to be an overall opportunity for enhancing both livelihoods and communities in the National Parks, although realising this may be dependent on the right government support and incentives, and appropriate private-sector funding vetted from greenwashing and land-grabbing[32], as well as openness to change within farming communities.

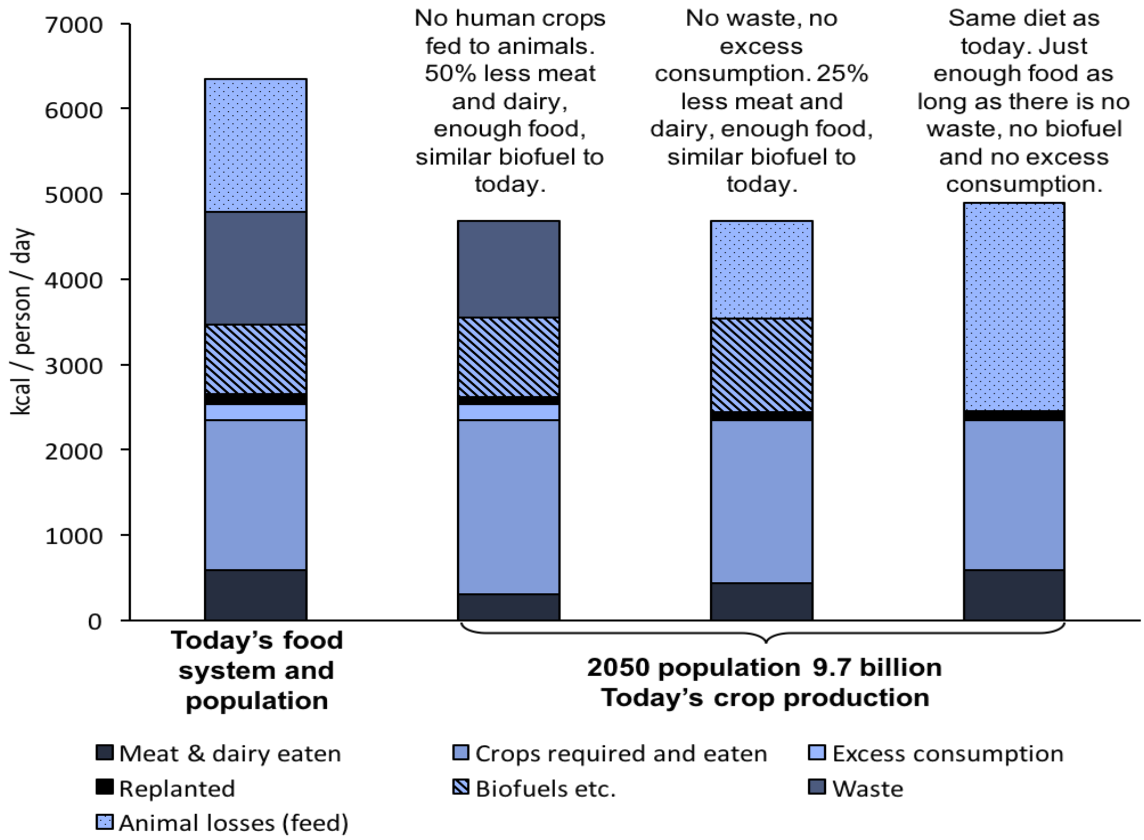

Figure 20: Scenarios exploring how to feed a larger 2050 population with the same global food production as today. Using human-edible crops for non-food uses such as biofuel production, feeding human-edible crops to animals, and other wastes limit the ability to absorb population growth. On the other hand, with positive global diet shifts today's production is already adequate. Source: Berners-Lee et al (2018). "Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation." DOI: https://doi.org/10.1525/elementa.310.

[32] See, for example, https://revere.eco/faqs/.

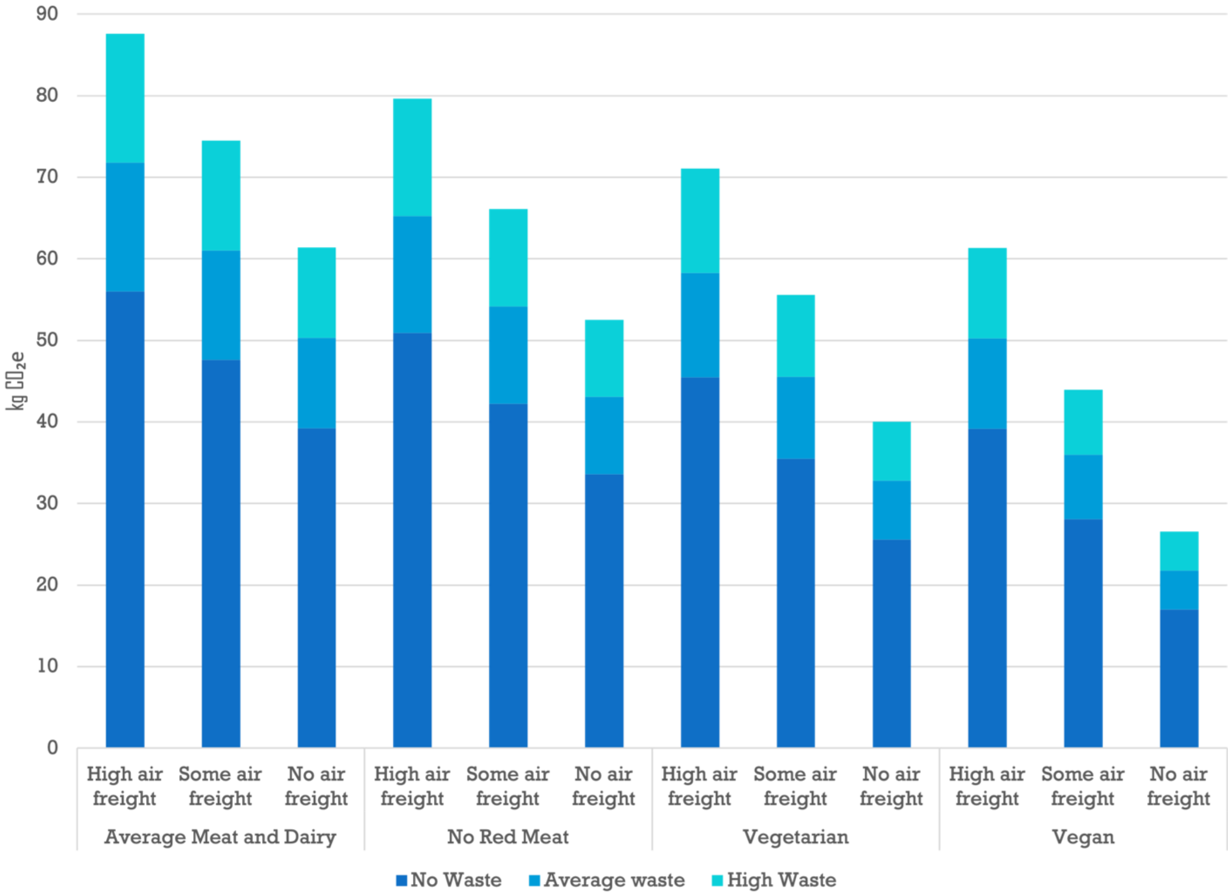

Figure 21. A range of GHG footprints associated with a weekly shopping basket in the UK, depending on proportions of meat and dairy, air freight and waste. Units: kgCO_2e per person per week using GWP100 to convert non-CO_2 emissions to CO_2e.

Summing up, key recommendations to decarbonise food consumption and production are:

- Raise awareness of climate and ecological impacts associated with current food systems and diets;
- Choose low-carbon food options, including plant-based meals (action by consumers);
- Make low-carbon food options, including plant-based meals, seem easy, attractive and normal (action by catering businesses and shops);
- Promote seasonal produce;
- Promote local produce;
- Work with local, regional, national and international farmers, food manufacturers, retailers and governments to meet these challenges.

Key recommendations for land use change aligned with proposed food system changes:

- Restore or recreate semi-natural habitats, including woodlands, peatlands and wildflower meadows where appropriate;
- Adopt broad regenerative agriculture practices, including species-rich extensive grasslands, cover crops, agroforestry and hedgerows where appropriate.

Land use & food system changes in the context of UK climate commitments

To meet UK targets for reducing GHG emissions, while also considering the land use opportunity cost of animal production, the Climate Change Committee called for a 20% reduction in meat and dairy consumption by 2030[33]. The National Food Strategy report subsequently recommended reducing meat consumption 30% by 2030[28], while promoting other dietary changes for health reasons:

- 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.

The scientific evidence is clear that to meet the joint climate, biodiversity and food security goals, crops suitable for human consumption should not be fed to farm animals due to the inherent inefficiency of conversion to human nutrition (Section 0)[34,35,36,37]. Ruminant livestock production (e.g. cattle and sheep) has gained particular attention in the UK as the largest source of on-farm methane emissions from enteric fermentation among farm animals (per unit of feed intake)[38]. Monogastric animals such as pigs and poultry have considerably lower on-farm emissions than ruminants[39]. However, feed supply chains for animals could also have large footprints, particularly for feed originating from deforested areas[40], so local grass-fed ruminants may have a lower total GHG footprint compared to chickens fed on soybeans imported from the Amazon, for example. Intensive pig and poultry production systems can also have negative impacts on soil, water, and air quality, and on animal welfare, with large operations requiring permits from the relevant Government agencies[41].

Appropriately located and managed livestock farming, which follows what is commonly referred to as "extensive" or "regenerative" practices, still has an important role to play in

---

[33] Climate Change Committee (2020), "The Sixth Carbon Budget: The UK's path to Net Zero."
[34] Alexander, P., *et al.* (2017), "Losses, inefficiencies and waste in the global food system." *Agricultural Systems*, 153, 190–200.
[35] Alon Shepon, A., *et al. (*2018), "The opportunity cost of animal-based diets exceeds all food losses." *PNAS*, 115:15, 3804–3809.
[36] Xu, X., *et al.* (2021), "Global greenhouse gas emissions from animal-based foods are twice those of plant-based foods." *Nature Food*, 2, 724–732.
[37] Berners-Lee, M., *et al.* (2018), "Current global food production is sufficient to meet human nutritional needs in 2050 provided there is radical societal adaptation." *Elementa: Science of the Anthropocene*, 6: 52.
[38] DEFRA, UK Government Official Statistics (2021), "Agri-Climate Report". Agri-climate report 2021 - GOV.UK (www.gov.uk).
[39] Climate Change Committee (2020), "Land use: Policies for a Net Zero UK", https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/.
[40] Revoredo-Giha, C., & Costa-Font, M. (2021), "How to delink the UK's soybean imports and livestock supply chains from deforestation in the Amazon". LSE Business Review.
[41] See, for example, the following regulations by Natural Resources Wales: https://naturalresources.wales/media/1227/rgn-2-appendix-3-understanding-the-meaning-of-regulated-facility-interpretation-of-intensive-farming-installations.pdf.

providing some human nutrition, alongside delivering biodiversity benefits and wider ecosystem services[42]. However, as described in Section 0, plant-based protein and calories tend to have significantly lower GHG and land use footprints than animal-based protein and calories[43]. While appropriate ruminant grazing practices can maintain or enhance soil carbon stocks and have biodiversity co-benefits, overgrazing can cause soil degradation and carbon loss, coupled with negative biodiversity impacts. Therefore, the carbon sequestration and wider ecosystem benefits are location-specific and depend on the livestock density and grazing practices[8]. And despite the possible environmental benefits, livestock farming systems still have substantially higher land use requirements compared to the equivalent plant-based protein sources of human nutrition, which is the case both in the UK[44] and globally[43].

In view of the above, it is clear that without appropriate siting and management, the well-known carbon sequestration and biodiversity benefits of regenerative ruminant grazing systems could simply be negated by the climate impacts associated with methane emissions from the livestock, coupled with the lost opportunity to create more species-rich and climate-resilient habitats.

All these considerations have direct implications for nature recovery and landscape enhancement programmes across the UK, as well as for ensuring that the UK becomes less reliant on food imports. Embarking on ambitious programmes to restore or recreate semi-natural habitats, including woodlands, peatlands and wildflower meadows where appropriate, is going to be essential for addressing the joint climate and ecological emergencies. The National Parks are well placed to become leaders in delivering the required changes.

Beyond dietary changes, forgoing fruit and vegetables grown in hot-houses or air-freighted to the UK in favour of local, seasonal varieties could deliver an estimated 5% reduction in the total food footprint[45]. Ship-transported and frozen produce are also good low-carbon alternatives, as the emissions per item are far lower than for air-freighted goods[46].

Local businesses such as grocery stores and restaurants can directly contribute to achieving the required food system and dietary transitions, including by offering and promoting more plant-based options alongside locally sourced, extensively farmed animal products. For public-sector bodies, procurement is a much bigger lever than promotion. This could help drive

[42] Burgess, P.J., *et al.* (2019), "Regenerative Agriculture: Identifying the Impact; Enabling the Potential". Report for SYSTEMIQ, 17 May 2019. Bedfordshire, UK: Cranfield University.
[43] Poore, J., & Nemecek, T. (2018), "Reducing food's environmental impacts through producers and consumers." *Science*, Vol 360, Issue 6392, pp. 987-992. https://www.science.org/doi/10.1126/science.aaq0216.
[44] Leinonena, I., *et al.* (2020), "Regional land use efficiency and nutritional quality of protein production." *Global Food Security*, 26, 2211-9124.
[45] Hoolohan, C., *et al.* (2013), "Mitigating the greenhouse gas emissions embodied in food through realistic consumer choices." *Energy Policy* Vol. 63, p. 1065.
[46] Berners-Lee, M. (2010), "How Bad Are Bananas – The Carbon Footprint of Everything," p.26-29.

the required changes through public-sector procurement requirements, such as those stipulated by the Wellbeing of Future Generations Act in Wales[47].

As well as affecting consumers, these aspirations also present significant challenges for the agriculture industry, particularly given the implications for livestock farming in the UK. The National Farmers Union (NFU) is aware of these challenges and has set the goal of reaching net zero greenhouse gas (GHG) emissions across the whole of agriculture in England and Wales by 2040[48]. 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[49].

Farming and land use: core principles for sustainable livelihoods and practices[50]

For millennia farmers have played a critical role in managing land to meet essential human needs and feed a growing population. In the UK, for example, they have kept the nation fed through wars and responded to various crises, both economic and health-related (e.g. foot and mouth disease). In recent decades, they have been incentivised or even mandated into particular practices through EU and UK government regulation and subsidies as well as market pressures including the intensification of arable and livestock systems, removal of hedgerows, and adoption of technology for yield increases (e.g. fertiliser and pesticides). We now understand that many of these intensification practices do not best serve either people or planet.

In the 21st century, we have an even bigger ask of farmers: to feed us better than ever AND simultaneously look after nature and climate. A modern sustainable food and land system needs to optimise for multiple objectives, including:

- Food production ensuring food security and improved nutrition
- Climate change mitigation and adaptation
- Nature recovery including enhancing biodiversity
- Farmers' and food growers' livelihoods

How best to meet these joint objectives is complex. It requires changes in farming practices in response to evolving and complex science. High-quality decision-making is essential, and with

[47] https://www.gov.wales/procurement-policy-statement-html#:~:text=The%20Welsh%20public%20sector%20will%20follow%2010%20principles,social%20and%20economic%20value%20outcomes%20from%20public%20spend.
[48] National Farmers Union (2021), "Achieving Net Zero, Farming's 2040 goal."
[49] The Sixth Carbon Budget, "Agriculture and land use, land use change and forestry" section.
[50] This section was written jointly with Henry Russell (Russell Regen). See our recent paper "UK Farming and Land Use: Addressing the Climate and Ecological Emergencies while Supporting Farmers" for further details. https://www.sw-consulting.co.uk/food-and-land/uk-farming-land-use.

that in mind, **we propose some core principles**, listed below, for how the debate could be conducted by multi-party stakeholders.

In the end, a truly sustainable food system will require coordination between farming, government, general public, NGOs, and non-farming businesses. Where there is misalignment, an important next step will be to lobby, advocate, and influence while being pragmatic about what is possible in the meantime. For example, in the absence of sufficient and coherent government support, it may be impractical for all farms to adopt optimal sustainable practices. It is worth mentioning that although "top-down" government policymaking is important, there is also a collective "bottom-up" requirement for organisations (farming and non-farming) and individual citizens to do everything they can to respond to the climate and ecological emergencies through their respective activities (e.g. choices made around purchases and travel).

Our suggested core principles for decision-making regarding land are as follows:

Principle 1. In all decision-making that responds to the 21st century challenges and pressures for land we will positively engage with the farming community to seek their views on how any land-use changes will affect their farming businesses and livelihoods, and ensure they are active participants in the discussion. Only a "Just Transition" ensuring that nobody is left behind is acceptable. Over the years, farmers' share of the final sale price of food has eroded because of globalised and extensive food supply chains, leading to an over-reliance on government subsidies. As part of the Just Transition, we aim for farms to become more financially self-sufficient (i.e. minimised input costs), get paid a fair price for their produce, and, where relevant, be adequately supported with government and private sector funding for any mandated land-use changes (e.g. woodland creation or peatland restoration).

Principle 2. All parties agree to honour the highest quality evidence, including the best available science. We recognise that some emerging and largely qualitative evidence from farmers may provide compelling cases for adopting specific practices, both from the point of view of carbon, biodiversity and other joint goals outlined in this document. However, any quantifications put forward should undergo a rigorous scientific process. The key criteria to use when determining what scientific evidence to trust should include:

a) The scientific credentials of the source
b) Independent peer review by the academic community
c) Understanding of any partisan loyalties to particular interest groups, including funding and affiliation
d) Whether or not the source considers global systemic challenges and constraints associated with land use and food systems (e.g. climate change, biodiversity loss, availability of land)

Principle 3. In looking for solutions that honour the best available science, all interests are taken into account in a proportionate way. This implies that a diverse range of views and options will be sought to ensure balanced decisions are reached. Where the interests of different groups seem to compete, we try to find a solution that meets the needs of all parties such as through various facilitation approaches, even if one cannot initially be imagined at the outset. We understand that taking a proportionate account of the interests of all parties could be difficult to define precisely, but it is a step forward to operate from this principle.

Principle 4. We will be careful not to bend the scientific evidence in order to protect any one group. Instead, we will find other ways of looking after their legitimate interests, in negotiation with those of other interest groups, and honouring the best available science.

Principle 5. We will make every effort to be transparent about motives. In other words, we will not advocate courses of action for reasons other than those that we state.

Principle 6. We recognise that the UK's land is mosaic of different habitats and management practices, and therefore any solutions conceived at national level should be adapted to the local context. This process should consider the local climate, soil type, natural seed bank and previous land use, among other factors.

Climate adaptation planning and links with land use change[51]

General points

The climate risks to the UK are varied and depend on humanity's actions in the next few years. As climate change begins to affect us more noticeably, we have already experienced increased rainfall intensity, more flooding, hotter summers and more wildfires. Some of these effects are exacerbated by poor land use systems which can be improved, while others will require adaptation. Fortunately, changing land use patterns in order to reduce GHG emissions and improve biodiversity often coincides with actions which mitigate adverse impacts. For example, woodland creation and peatland restoration measures are known to improve water retention in soils across river catchments and therefore reduce flood risks downstream[52,53].

If climate change continues unabated, food and land systems in the UK will have to deal with increasing fragility and more frequent, intense shocks. Incorporating as much resilience as possible into the system will be key, with a lot of that resilience coming from increased biodiversity, healthier soils and more resilient ecosystems in general.

Various effects will interact to cause competing increasing and decreasing land use pressures, with human decisions having a large influence as always:

[51] This section was written jointly with Chris Fairbrother (South Downs).
[52] https://www.gov.uk/government/publications/national-flood-resilience-review.
[53] Hewett, C. J., *et al.* (2020), "Catchment systems engineering: An holistic approach to catchment management." *Wiley Interdisciplinary Reviews*: Water, 7(3), e1417.

- A gradual shift towards more plant-based diets will decrease land use pressure both in the UK and globally (see Section 0);
- Pressure on UK land will increase if we move to a more self-sufficient food production system, since the UK is currently a major net food importer;[54]
- Some land will have to change use from agricultural monoculture or urban paving to rewilded or restored peatland, marshes, bogs and woodland in order to buffer the impacts of heavier rainfall, storm surges, and other climate impacts;
- The switch to organic farming away from fossil fuel inputs may require a larger land footprint for the same yield;
- More land may need to be brought into more productive use in order to increase resilience against climate effects such as increased aridity in the South East, higher sea levels, less dependable weather/seasons, and lower nutritional value of crops;[55]
- It is possible that meeting climate targets for transport emissions and energy use will free up significant areas of land which could be freed from pavements.

Role of National Park Authorities (NPAs) in adaptation planning

The adaptation responses mentioned above must be informed by the best possible evidence and realistically plan for the long term. NPAs therefore need to ensure they have a full understanding of the risks posed by climate change within their area. The NPAs have been involved with adaptation reporting before, and the majority have produced risk assessments and action plans that set out how they were meeting these challenges.

Adaptation plans broadly follow a methodology that:

- Identifies the key assets and features of their National Park; and assesses their vulnerability to climate change;
- Considers sectoral impacts such as on farming and forestry, on rural economy, and on the resilience of local communities;
- Assesses the level of risks and/or opportunity based on their likelihood and impact;
- Sets out a plan of action to address these risks and impacts over the short, medium and long term;
- Develops policies and programmes that help to deliver adaptation responses at scale.

The Secretary of State for Environment, Food and Rural Affairs has asked the NPAs to participate in a fourth round of adaptation reporting (ARP4) by November 2024. This time the NPAs are being asked to consider how they might best integrate this process with the 5-yearly review of their statutory Management Plans. There is potential for this approach to better co-

[54] https://www.gov.uk/government/statistics/united-kingdom-food-security-report-2021/united-kingdom-food-security-report-2021-theme-2-uk-food-supply-sources#united-kingdom-food-security-report-2021-theme2-indicator-2-1-3.

[55] Ritchie, P. D. L., *et al.* (2020), "Shifts in National Land Use and Food Production in Great Britain after a Climate Tipping Point". *Nature Food* 1, no. 1 (13 January 2020): 76–83. https://doi.org/10.1038/s43016-019-0011-3.

ordinate efforts and use the NPAs' convening power to deliver shared actions on Climate Change through their local partnerships.

UK winter floods of 2015-2016, adaptation spending and insurance

The winter floods of 2015-2016 caused widespread disruption and hundreds of millions of pounds' worth of damage across northern England and other areas of the UK. Triggered by what meteorologists called a "truly exceptional" period of cyclonic weather patterns in November and December 2015, which was driven by climate change and enhanced by a strong global El Niño event, the floods included the extreme rainfalls of Storm Desmond and on Boxing Day, and led to a complete re-thinking of the country's flood risk management and resilience strategies. This includes the Government's National Flood Resilience Review of 2016, which introduced a stress-testing approach using a rare but plausible Desmond+ event, a recommendation to more than double annual spending on flooding and coastal change infrastructure as part of the long-term investment scenarios published in 2019, increased efforts to find suitable natural flood risk management schemes in upper catchments involving woodland creation and peatland restoration[52], and creation of the Cumbria Strategic Flood Partnership which brings together local, regional and national stakeholders involved in flood risk management.

According to estimates by the Environment Agency, for every £1 spent on protecting communities from floods, around £9 in property damages and wider impacts is avoided. And a recent study by the Flood-Re reinsurance scheme, in partnership with Risk Management Solutions (RMS), found that the financial impact of Storm Desmond in Cumbria could have been £2.8bn instead of £0.6bn had there not been flood defences in place. The Flood-Re scheme, which became operational in 2016 shortly after the floods, is set to terminate in 2039, by which point it is expected to reshape both public and private investments and insurance policies aimed at managing flood risks and building resilient communities. This includes whole-catchment approaches to flood mitigation, involving woodland creation[56] and peatland restoration programmes.

Monitoring future progress against the targets

Monitoring is essential to gauge progress in reducing GHG emissions against the set targets, although measuring specific elements of the progress can be difficult. This is especially relevant for the areas where responses and feedbacks can occur on slower timescales, such as land use change. As such, choosing the correct metrics is important. For example, while an overall goal may be a decrease in global land-based GHG emissions and an increase in carbon sequestration, attributing any measured progress in this to local actions is challenging, so proxy measures such as hectares of restored peatland and new woodland must be used instead.

---

[56] See, for example, https://www.forestresearch.gov.uk/publications/designing-and-managing-forests-and-woodlands-to-reduce-flood-risk/.

When considering more holistic positive outcomes, it may be necessary to move away from traditional performance metrics. For example, measuring food yield per hectare tells us simply how much food is produced, but doesn't tell us how much damage was done to produce it. The measurement obscures the effects such as the GHG emissions from manufacturing the fertiliser, or the biodiversity loss from nutrient runoff. It is therefore important to consider other metrics such as biodiversity indices, in addition to GHG emissions and food calories and protein produced from a hectare of land.

Providing national and global leadership in land use

General points

A transition to a low-carbon future for the National Parks entails strong action in many areas: home energy use, food production and diets, travel and transport, business energy use, construction, 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 use and management. The vision presented in this report aims to bring every relevant area of carbon and land management into perspective for policymakers, businesses and citizens.

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.

While the proposed targets for each of the six priority areas, including for land use, are designed as the minimum consistent with keeping global warming below the 1.5°C limit in the Paris Agreement, they represent steep and challenging changes in the current trajectory. This reflects the severity of the climate emergency in which the world now finds itself.

To help meet the proposed targets, some help from outside the designated landscapes would 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 become 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 low-carbon transition by cutting their direct emissions, while simultaneously opting for suppliers that provide products and services with lower embedded carbon, thus accelerating the transition across the whole value chain.

A degree of help can be expected to come from government policies, and where this is not sufficient, part of the role of the designated landscapes and their partners will be to push for the support needed to ensure that they can aim for 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 local authorities, with the UK Government and devolved administrations, and with the general public. It is through collaborative creative thinking, taken forward in a sustained joint effort 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 National Parks – will become a reality.

Land management is central to all National Parks (and also to National Landscapes) and deserves a separate discussion. The wide-ranging land use measures proposed for the National Parks, dominated by new woodland, restored peatland and regenerative agriculture, must be sufficiently ambitious and enduring to achieve the projected net reductions in GHG emissions. However, the goal of establishing irreversible carbon sinks, accompanied by biodiversity co-benefits, relies on the availability of suitable incentives enabling land managers to implement the required land use changes[57].

Last but not least, public perceptions of how a designated landscape should look may also need to evolve, in order for people to continue visiting a place and finding it beautiful after changes in land use. Most UK National Parks and National Landscapes have considerable areas of low-grade grassland and moorland, which create the landscapes familiar to many in the UK and abroad. However, centuries and millennia ago the UK was significantly more wooded across its landscapes compared to its present-day tree cover of just 12%, and large swathes of the land within the National Parks and National Landscapes may need to be returned to this forested state in the coming years and decades to meet the climate and biodiversity goals. Visitors' and residents' perceptions of natural beauty in the designated 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.

Over time, those using the National Parks and National Landscapes may notice changes to the special characteristics that contribute to these landscapes' natural beauty, and reductions in the areas of moorland and uphill grazing. The local authorities, the UK Government, and devolved administrations would need to work with a wide range of stakeholders and special interest groups to find a pragmatic solution to the competing land pressures from UK food production, UK timber production, climate mitigation and adaptation needs, peatland restoration goals, biodiversity net gain goals, and the need to nurture local "living" communities.

While the challenges ahead are considerable, and tackling them requires strong national and international policies, the associated opportunities are both wide-ranging and exciting. By working together to respond to the recommendations of this assessment, the National Parks, National Landscapes and their partners could become global leaders in addressing the joint

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

climate and ecological crises. In doing so, they could inspire decision-makers in other parts of the UK, as well as in many landscapes and countries abroad, to pursue similarly ambitious policies, and commit to the investments and lifestyle changes that are understood to be essential for building a sustainable world for future generations.

National Parks' statutory Management Plans

Each National Park has a statutory Management Plan, which must be reviewed every five years. Being area-based and partnership driven, these plans are a key mechanism for delivering the statutory objectives of designated landscapes.

Climate mitigation is already becoming central to the latest editions of Management Plans by multiple NPAs[58], in part thanks to the assessments carried out by SWC during 2021-22, which form the basis of this synthesis report.

According to the UK Government's third National Adaptation Programme (NAP3), "climate change adaptation should be considered in each phase of delivering on the ambitions set out in Management Plans and as such, includes forest and woodland management and tree planting. (...) The role of trees and woodlands in developing resilient landscapes should also be considered, including their role in natural flood management, protecting freshwater ecosystems from the effects of climate change by providing riparian shade, and reducing the urban heat island in built-up areas."

Making climate mitigation and adaptation targets, and the associated goals for nature and society, central to statutory Management Plans will provide a powerful tool for the NPAs to deliver the required change both at pace and at scale.

National Parks and Race to Zero campaign

One important example of national and global leadership is an ongoing application by the National Parks to join the Race to Zero campaign run by the UNFCCC[59]. At the time of writing, Race to Zero represents a coalition of over 11,000 non-state members, including over 8,300 companies, around 600 financial institutions, 52 regions, over 1,100 cities and over 1,100 educational institutions, 65 healthcare institutions, and 29 other organisations.

Each Race to Zero member commits to five "starting line" actions:

1. **Pledge**: to maximise effort toward or beyond a fair share of the 50% global GHG reduction needed by 2030, and to reach net zero by 2050 at the latest.

---

[58] See, for example, https://www.lochlomond-trossachs.org/park-authority/get-involved/consultations/draft-national-park-partnership-plan-2024-29/.

[59] https://unfccc.int/climate-action/race-to-zero-campaign#Minimum-criteria-required-for-participation-in-the-Race-to-Zero-campaign.

2. **Plan**: within 12 months develop an evidence-based emissions reduction plan in line with the pledge.
3. **Proceed**: take immediate action towards meeting the pledge.
4. **Publish**: commit to report data and actions in relation to meeting the pledge, publicly and at least annually – feeding into the UNFCCC Global Climate Action Portal.
5. **Persuade**: align advocacy activities with net zero by proactively supporting climate policies consistent with Race to Zero.

The application by the National Parks to join Race to Zero has been approved earlier in 2024. It is closely linked with the GHG emissions and land use assessments for the National Parks carried out by Small World Consulting during 2021-22, with subsequent methodological and data improvements, which are summarised in this report.

UK National Parks are set to be the first national parks in the world to join Race to Zero. The UN Climate Champions that lead the Race to Zero campaign, together with supporting global organisations such as Climate Disclosure Project (CDP), are particularly keen to support UK National Parks because they understand the critical role of protected landscapes in the global effort to tackle climate change, and they want others to follow this lead.

Example Climate Mitigation and Nature Recovery Projects

Below is a relatively small selection of the projects already being undertaken across multiple National Parks, aimed at climate mitigation and nature recovery.

Priority area	National Park	Project name	Description
Regenerative agriculture	Lake District	Gowbarrow Hall Farm	Farming system converted to regenerative practices, with stocking densities close to conservation grazing while maintaining seasonal food production.
	Broads	FibreBroads project	A pilot wetland agriculture project to produce fibre crops while managing a higher water table in the peat (paludiculture), engage with farmers about how to change water tables, and investigate markets for fibre products
	Bannau Brycheiniog	Our Food 1200	An initiative to secure 1,200 acres of land in 3-10 acre plots across Bannau Brycheiniog and the county of Powys for modern, regenerative fruit and vegetable farming for local markets.
	South Downs	Iford Biodiversity Project	A leading landscape restoration project in the area, creating new habitat across 1,200 ha of farmland in South Downs. By 2025, it will have created and restored habitat and created space for nature, allowing diversity of species to expand over the whole estate, while still retaining food production over the most fertile land.
Woodland creation	English and Scottish National Parks	Revere Partnership	An innovative programme aimed at providing private-sector funding to support famers who embark on woodland creation and peatland restoration projects
	Northumberland	Great Northumberland Forest	A plan to plant millions of trees
	Lake District	Woodland Futures Cumbria	Providing graduate employment advice, guidance and funding through woodland projects
	Exmoor	Bye Wood	Getting volunteers and schools involved in seed collection and tree

Priority area	National Park	Project name	Description
			planting, and installing sustainably designed tree guards
	Bannau Brycheiniog	Stump Up for Trees	A community initiative aiming to plant a million trees in Bannau Brycheiniog National Park. It is supporting large-scale hedgerow restoration and new woodland creation in partnership with the National Park Authority
Peatland restoration	English and Scottish National Parks	Revere Partnership	An innovative programme aimed at providing private-sector funding to support famers who embark on woodland creation and peatland restoration projects
	North York Moors	Moor to Restore	Over the past two years, North York Moors National Park Authority, Yorkshire Peat Partnership and individual estates have surveyed 9,410 ha of moorland and peat bogs to establish where deep peat is found in the National Park. From these sites, 1,100 ha of moorland and former forestry sites will be put forward for restoration by March 2025
	Northumberland	Northumberland Peat Partnership	The partnership works to draw down finance to survey, manage and restore damaged peatlands in Northumberland in conjunction with our partners and landowners working in the North of England.
	Exmoor and Dartmoor	Southwest Peatland Partnership	Working to restore large areas of degrading peatland across Cornwall, Dartmoor and Exmoor before 2025
	Bannau Brycheiniog	Bannau Brycheiniog Peatland Recovery Project	Restoring upland peatland habitats (up to 10% of the National Park's area), protecting the large carbon stores in their soils, regenerating habitats for nature, and improving water quality downstream.
Transport and travel for residents and visitors	Lake District	Wasdale shuttlebus	Sustainable travel
	Lake District	West Windermere Way	Accessible active travel route with quantified carbon footprint of construction and modelling of future avoided carbon emissions

Priority area	National Park	Project name	Description
	Lake District	Keswick to Threlkeld trail	Accessible active travel route with quantified carbon footprint of construction and modelling of future avoided carbon emissions
	Northumberland	The Hadrian's Wall bus	
Energy generation and energy efficiency	Exmoor	Pinkery visitor centre biomass boiler	Electricity from sustainably sourced wood chips and pellets
	North York Moors	Decarbonised visitor centres	
	Northumberland	Community Action Northumberland off-grid taskforce	
	Northumberland	Low Bleakhope Farm	Supplying off-grid properties using solar PV, wind turbine and hydro
	Northumberland	Kielder hydro	England's largest hydroelectric power station, Northumbria Water
	Exmoor	EV charging across Exmoor NP	
	Bannau Brycheiniog	Electric vehicle fleet and renewably powered buildings	All of Bannau Brycheiniog National Park Authority's car fleet is electric, and all of the buildings owned by the organisation are powered by renewable energy. The National Park Authority has installed public EV charging points at its visitor centres, making these rural locations more accessible for greener travel
	Bannau Brycheiniog	Sustainable community buildings initiative	The Bannau Brycheiniog Sustainable Development Fund has supported communities across the National Park to install energy-efficiency measures and renewable energy infrastructure in halls and community centres
	South Downs	Super Homes	A project run by local charity Petersfield Climate Action Network (PeCAN) is giving homeowners the opportunity to have an assessment on their home to help reduce their carbon footprint as well as their household bills, while maintaining a warm and comfortable home

Priority area	National Park	Project name	Description
Nature recovery and carbon sequestr. win-wins	North York Moors	Revitalise landscape partnership	Nature restoration programme focusing on water and riparian habitats, which also includes veteran trees, new woodland and hedgerows
	Northumberland	Hadrian's Wall recovering nature project	
	Bannau Brycheiniog	The Penpont Project	Launched in 2019 on the 2,000-acre Penpont estate in Bannau Brycheiniog National Park, the Penpont Project is an intergenerational nature recovery project bringing together young people, farmers, foresters, landowners, artists and ecologists to revive biodiversity and Welsh cultural heritage, and to connect local people with nature, with all the benefits this brings. The project includes restoring hedgerows, increasing tree cover and habitat availability, and adopting regenerative agricultural and conservation practices to regenerate land and waterscapes, provide habitats for struggling species, increase carbon sequestration, and provide communities with a range of benefits
	Exmoor	Temperate rainforest in the National Nature Reserves of Tarr Steps, Hawkcombe and Horner Wood	

Appendices

Climate science and policy context

This section summarises key drivers for change that the National Parks may wish to respond to in delivering their statutory duties.

A 2018 report by the Intergovernmental Panel on Climate Change (IPCC) outlined the need to reduce global GHG emissions by 45% (from 2010 levels) by 2030, and achieve net zero emissions by 2050[60]. It stated that these reductions are necessary in order to limit the increase in global mean temperature to 1.5°C relative to pre-industrial levels, which is the more ambitious target of the Paris Agreement by the parties to the UN Framework Convention on Climate Change (UNFCCC), and is understood to be a "safer" warming limit for societies and ecosystems globally. In 2019, the UK Government agreed to a legally binding target of net zero territorial GHG emissions by 2050.

The IPCC subsequently published its Sixth Assessment Report (AR6) in stages, with the final synthesis report released in March 2023[61]. 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 to inform global climate negotiations, national policies, business planning and individual actions.

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[62]. Notably, it is unequivocal that the observed warming trends and increases in extreme weather events across the world have resulted from, and continue to be driven by, the steady increases in atmospheric concentrations of carbon dioxide, methane, nitrous oxide and other GHGs, generated by human activity and industry since the late 19th century. The report also makes clear that our chance of limiting the increase in global mean temperature to 1.5°C above pre-industrial levels now appears small. Keeping the warming below the "safer" 1.5°C limit will likely require the most ambitious actions thought to be technically possible, supported by adequate policies, funding mechanisms and lifestyle changes.

The UK's Climate Change Committee (CCC) advises the whole of the UK, as well as the devolved administrations, on emissions reduction targets. Its Sixth Carbon Budget (2020)

---

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

[61] https://www.ipcc.ch/report/sixth-assessment-report-cycle/.

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

recommends that the UK achieves a 78% reduction in its territorial GHG emissions by 2035 relative to 1990, which is a 63% reduction from 2019 levels[63].

Ahead of COP26, in October 2021, the UK Government published its Net Zero Strategy: Build Back Greener[64]. This publication outlines the Government's strategy to reduce emissions across the key sectors, including power, fuel supply and hydrogen, industry, heat and buildings, transport, waste, and greenhouse gas removals. It also considers supporting a wider low-carbon transition across the economy.

COP26 concluded with the agreement of the Glasgow Climate Pact, with 153 countries putting forward new emission reduction targets for 2030 ("Nationally Determined Contributions", NDCs)[65]. 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.[66]

During COP26, the UK's Environment Act 2021 received Royal Assent, becoming law on the 9th November 2021 as an Act of Parliament. The broad aims of the 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 designated landscapes will need to be familiar with as they fulfil their statutory 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.

Protected Landscapes Targets and Outcomes Framework

In January 2024, DEFRA published the policy paper "Protected Landscapes Targets and Outcomes Framework"[67]. It proposes 10 targets aimed at meeting joined objectives of climate mitigation and nature recovery:

---

[63] Climate Change Committee (2020): "The Sixth Carbon Budget: The UK's Path to Net Zero," p.13.
[64] HM Government (2021), "Net Zero Strategy: Build Back Greener," https://www.gov.uk/government/publications/net-zero-strategy.
[65] COP26, "The Glasgow Climate Pact," p.8 https://ukcop26.org/wp-content/uploads/2021/11/COP26-Presidency-Outcomes-The-Climate-Pact.pdf.
[66] https://climateactiontracker.org/global/temperatures/.
[67] https://www.gov.uk/government/publications/protected-landscapes-targets-and-outcomes-framework/protected-landscapes-targets-and-outcomes-framework.

- Target 1: Restore or create more than 250,000 ha of a range of wildlife-rich habitats within Protected Landscapes (PLs) outside protected sites by 2042 (2022 baseline);
- Target 2: Bring 80% of SSSIs within PLs into favourable condition by 2042 (Natural England is assessing all SSSIs, with a target completion date of 2028 – 20% done so far);
- Target 3: 60% of SSSIs within PLs assessed as having "actions on track" to achieve favourable condition by 31st January 2028;
- Target 4: Continue favourable management of all existing priority habitat already in favourable condition, outside of SSSIs (from 2022 baseline) and increasing to include all newly restored or created habitat through agri-environment schemes by 2042;
- Target 5: Ensure that at least 65% to 80% of land managers adopt nature-friendly farming on at least 10% to 15% of their land by 2030;
- Target 6: Reduce net greenhouse gas emissions in PLs to net zero by 2050 relative to 1990 level (area of the PL, not the PL Authority itself);
- Target 7: Restore approximately 130,000 ha of peat in PLs by 2050;
- Target 8: Increase tree canopy and woodland cover (combined) by 3% of total land area in PLs by 2050 (from 2022 baseline);
- Target 9: Improve and promote accessibility to and engagement with PLs for all, using metrics based on those in the "Access for All" programme;
- Target 10: Decrease the number of nationally designated heritage assets at risk in PLs (includes heritage assets at risk and condition of scheduled monuments).

The paper sets out an 18-month consultation process with Natural England about what each Protected Landscape will contribute towards these targets.

Although the targets above represent the right direction of travel, they are considerably less ambitious than the land-use targets for National Parks put forward in this assessment (Section 0). One of the key underlying reasons is that the DEFRA targets are more aligned with the Sixth Carbon Budget and therefore focus on UK territorial emissions, whereas we are considering the UK's consumption-based emissions (Section 0), which are roughly double the territorial emissions (Section 0). These differences need to be highlighted during the 18-month consultation process, to ensure that climate mitigation commitments by National Parks and other landscapes are more in line with the actual climate footprint of the UK and its regions.

Methodology underpinning landscape GHG footprint estimates

This section provides a brief outline of the methodology underpinning the GHG footprint results presented in this synthesis report, as well as in the technical reports for the individual landscapes from our 2021-22 programme.

- Emissions figures for household energy 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 count 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 (EEIO) model 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 National Landscape 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, and also within, the National Park or National Landscape were derived using visitor surveys, and comparisons with road travel emissions by residents.
- Emissions related to through-traffic, which by definition occur within the boundary of the National Park or National Landscape, are estimated by comparing total traffic point counts with pump-level fuel sales within the National Park or National Landscape, along with assumptions about commuting into and out of the area. Note: Through-traffic emissions are excluded from the consumption-based priority areas that were introduced in order to define the GHG baseline and set proposed decarbonisation targets for each landscape.
- We used peer-reviewed studies to estimate the emissions associated with flights taken by residents and visitors depending on their income levels. The emission factors used take account of flight distances and include a markup factor for high-altitude climate effects. Note: Emissions from flights are excluded from the consumption-based priority areas that were introduced to define the GHG baseline and set proposed decarbonisation targets for each landscape.
- A very rough estimate of industry emissions (including their supply chains), which overlaps with resident and visitor emissions, was included in the technical reports 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 bottom-up energy consumption data and energy-related emission factors that included supply chain components. Note: The full industry footprint estimates are excluded from the consumption-based priority areas, while the energy-related industry footprint estimates are included.

- We used land-based emissions estimates published for all National Parks by DESNZ (formerly BEIS) to define the respective GHG baselines both for the agriculture and land use components.

The data sources used in the assessment, including their geographical and sectoral resolution as well as the associated confidence levels, are summarised in Figure 22.

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)	NP / AONB	Original Dataset	Implement. in SWC Tool
SWC EEIO Emissions Factors for Industries	2022	■											High	Medium
SWC-BEIS Emissions Factors for Fuels	2022		■										High	High
ONS Postcode Directory	2022				■	■	■	■	■	■	■	■	High	High
Custom Postcode Boundary	2019 or later						■					custom	High	High
DESNZ Domestic Electricity	2022		■				■						High	High
DESNZ Domestic Gas	2022		■				■						High	High
ONS Population Demographics (2021 Census)	2021				■		■						High	High
ONS Population Numbers (mid-year)	2022								■				High	High
DESNZ Non-Domestic Electricity	2022		■							■			High	Medium
DESNZ Non-Domestic Gas	2022		■							■			High	Medium
DESNZ Residual Fuels	2019		■								■		Medium	Medium
DESNZ Road Fuels	2019		■								■		Medium	Medium
Custom DfT Traffic Points	2019					■					■	custom	Medium	High
ONS Gross Value Added (GVA)	2022	■									■		Medium	Low
IDBR Data for Business Turnover	2022	■						■	■				High	Medium
NAEI Data for Large Emitters	2019						■						High	High
DESNZ GHG Emissions for LAs	2021										■		High	Medium
DESNZ GHG Emissions for NPs	2021											■	High	Medium
ONS Atmospheric Emissions Inventory	2022	■											High	High
STEAM Tourism Dataset	2019	■										custom	Medium	Medium
Custom Visitor Survey	2019 or earlier	■										custom	Medium	Medium
Destination Research Visitor Economy Recovery Assessment	2022	■									■		Medium	High
ONS Household Expenditure A52 (by demographics)	2019				■								Low	Medium
Custom Habitat and Peatland Maps	2022 or earlier			custom								custom	Medium	Medium
National Habitat and Peatland Maps	2022 or earlier			■							■	■	Medium	Medium
Sixth Carbon Budget, Tyndall Carbon Budget Tool, National Food Strategy, etc	2019-2021	■	■	■									Medium	Medium

Figure 22. Datasets used in the GHG assessment for the designated landscapes.

Detailed methodology underpinning land use targets

UK-wide land use targets

We use the Balanced pathway from the Sixth Carbon budget to derive UK-wide targets for each of the land measures introduced above. These are apportioned to England, Scotland and Wales on a simple area basis (Table 7). These targets are then apportioned to each National Park using the new opportunity mapping procedures defined in the sections below.

Table 7. Land use targets for the UK and devolved nations inferred from the Sixth Carbon Budget. The values have been rounded to the nearest 10 ha. Note that the peatland targets are defined in relative terms here and are applied to deep peat only.

	UK target (ha/yr)	England target (ha/yr)	Scotland target (ha/yr)	Wales target (ha/yr)

SMALL WORLD CONSULTING

New Woodland	50,000	26,750	16,140	4,270
Restored Peatland	80% of deep peat restored by 2050			
Agroforestry	30,150	16,130	9,730	2,580
Hedgerows	1,730	920	560	150
Legumes	120,900	64,670	39,030	10,340
Cover Crops	113,600	60,770	36,680	9,700

Woodland opportunity mapping and targets

The fact that creating new woodland requires a fundamental change to land use, rather than management changes on existing land, means that the proposed woodland target has to be set by considering total areas of suitable habitats within each landscape.

As part of a 2024 programme for protected landscapes funded by DEFRA, Small World Consulting carried out a woodland opportunity mapping exercise for 10m land parcels across the whole of England using the following datasets that define woodland opportunities and constraints:

- Environment Agency: Working with natural processes to reduce flood risk;
- Forestry Commission: England Woodland Creation Full Sensitivity Map v3.0, variant 1;
- Natural England: Agricultural Land Classification;
- Natural England: Living England habitat probability map;
- Forest Research: National Forest Inventory;
- UK CEH: UK GHG Inventory peat data; "deep peat" layer only;
- Historic England: Principal Archaeological Landscapes; set of layers "Detailed Mapping" (excluding "ridge & furrow alignment" and "ridge & furrow area" layers);
- Historic England: Scheduled Ancient Monuments;
- British National Grid, 10m raster.

The mapping procedure involved introducing England-wide statistical regressions between the various datasets above to derive a harmonized set of woodland opportunity scores, which are presented for selected National Parks in Figure 23 and for the whole of England in Figure 24. The score of 0 means that a given 10m pixel is not suitable for tree planting, while the score of 1 (or 100%) means the highest relative suitability compared to all other 10m pixels across England. Full methodological details are expected to be published later in 2024 following a peer-review by Natural England.

To derive apportioned target for each National Park (or for any other area within England), one has to tally all the 10m pixel woodland opportunity scores within this area, divide this by the corresponding England-wide tally of the scores, and multiply the resulting fraction by the England-wide woodland target (26,750 ha/yr; Table 7). The apportioned woodland targets for each National Park are then increased by 50% to mitigate the UK's comparatively large consumption-based footprint generated overseas (estimated to be roughly equal to UK territorial emissions; see Section 0), which is not included in the Sixth Carbon Budget targets.

Because of differences in the available land use data between devolved nations, our detailed spatial opportunity mapping for woodland has not yet been extended to Scotland and Wales. Therefore, in this report we have applied a simpler methodology to the Scottish and Welsh National Parks which focuses on broad types of habitats within each landscape and assigns relative woodland opportunity scores to each habitat. Although this procedure is less accurate than the one developed for England, it produces comparable results.

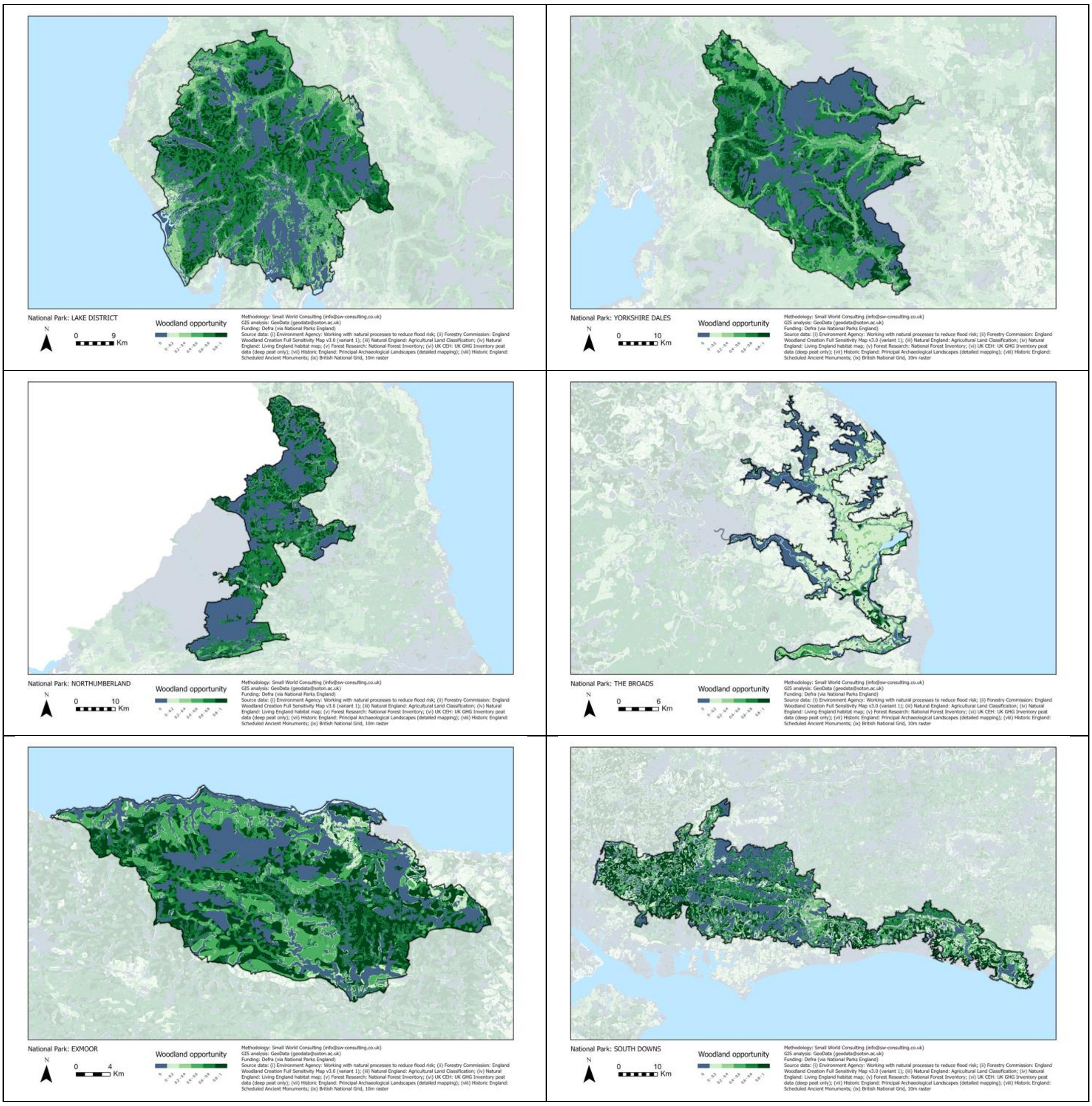

Figure 23. Normalised woodland opportunity scores for selected National Parks in England based on the new opportunity mapping procedure by Small World Consulting. Note: the scale varies between the plots.

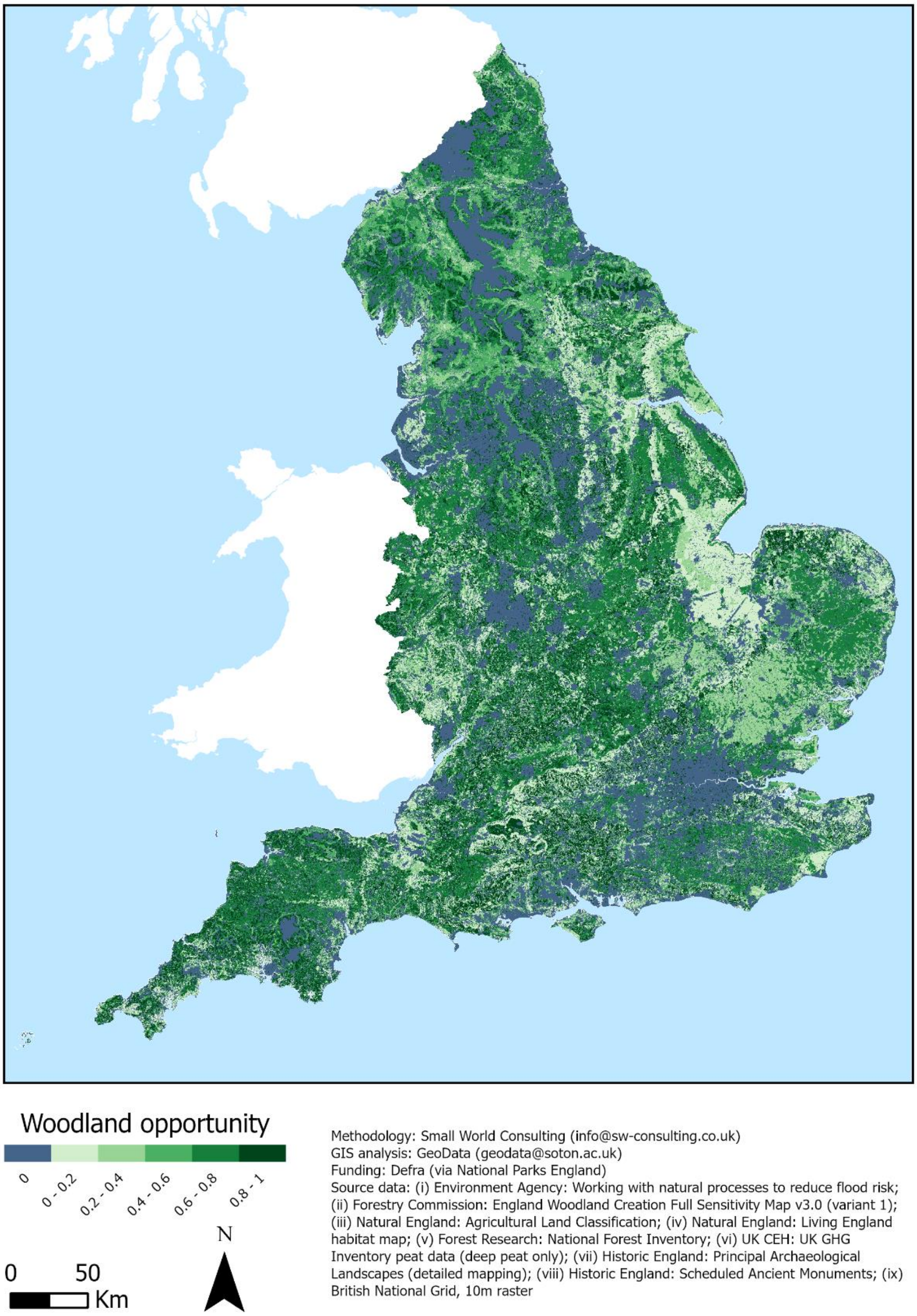

Figure 24. Normalised woodland opportunity scores based on the new opportunity mapping procedure by Small World Consulting. Coverage: England.

The assumed mix of tree species for new woodland in each National Park is summarised in Table 8. The corresponding species definitions, spacings and yield classes are given in Table

9. The associated tree biomass carbon sequestration curves are taken from the Woodland Carbon Code database, resulting in combined sequestration profiles like the one shown in Figure 25. These profiles are scaled up using estimates of soil carbon sequestration for woodlands from a recent literature review by Bossio *et al.* (2020)[68], which amount to 9% of the biomass carbon on average.

Table 8. Assumed mix of tree species used in the assessment for new woodland in each National Park.

National Park	Woodland Target (ha/yr)	SAB share	SP share	DF share	SS share	NS share
Dartmoor	**332**	80%	5%	5%	5%	5%
Exmoor	**255**	80%	5%	5%	5%	5%
Northumberland	**338**	80%	5%	5%	5%	5%
North York Moors	**452**	80%	5%	5%	5%	5%
Peak District	**458**	80%	5%	5%	5%	5%
The Broads	**35**	100%	0%	0%	0%	0%
New Forest	**107**	100%	0%	0%	0%	0%
South Downs	**525**	100%	0%	0%	0%	0%
Lake District	**781**	80%	5%	5%	5%	5%
Yorkshire Dales	**698**	80%	5%	5%	5%	5%
Loch Lomond & The Tro.	**600**	50%	25%	0%	25%	0%
Cairngorms	**1,500**	50%	25%	0%	25%	0%
Bannau Brycheiniog	**600**	80%	5%	5%	5%	5%
Pembrokeshire Coast	**188**	100%	0%	0%	0%	0%
Eryri	**938**	80%	5%	5%	5%	5%

Table 9. Tree species, spacings and yield classes used in the assessment.

Species	Description	Spacing	Yield Class
SAB	Sycamore, Ash, Birch	2.5	6
SP	Scots Pine	2	14
DF	Douglas Fir	1.7	16
NS	Norway Spruce	1.5	16
SS	Sitka Spruce	2	16

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

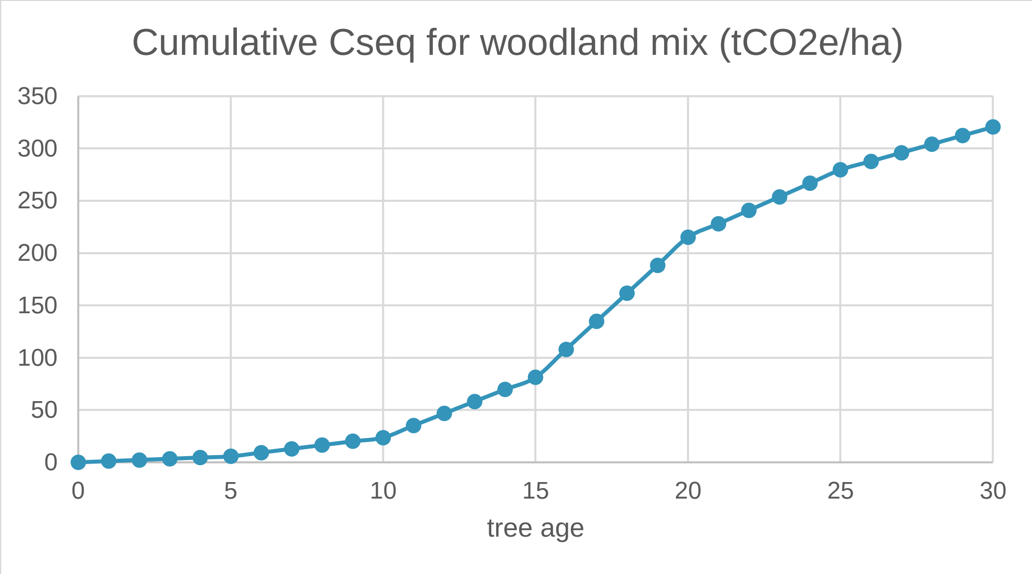

Figure 25. Combined cumulative woodland biomass carbon sequestration profile for the most used mix of species in Table 8 (80-5-5-5-5). Source: Woodland Carbon Code.

Peatland opportunity mapping and targets

Our assessment of peatland degradation types, and the relevant emissions factors, follow the methodology adopted in the UK's LULUCF GHG inventory, drawing on the work by Evans *et al*. (2017)[69] (Table 10). 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, and due to comparatively low values (in absolute terms) of carbon sequestration fluxes in healthy peat compared to emissions from degrading peat, our analysis focuses on reducing emissions from degraded peat through restoration and excludes subsequent sequestration benefits associated with a healthy restored peatland.

Table 10. Natural England and UK GHG inventory emission factors (EFs); habitats on degraded peat soils. Units: tCO_2e per ha per year.

Peat Condition & Drainage Status	Total EF
Eroding modified bog (bare peat), Drained	13.28
Eroding modified bog (bare peat), Undrained	12.16
Modified bog (heather/grass dominated), Drained	3.55
Modified bog (heather/grass dominated), Undrained	2.31
Cropland peat, Drained	37.61
Intensive grassland peat, Drained	27.56
Extensive grassland peat, Drained	13.03
Forested peat, Drained	3.315
Domestic Extraction	13.37

[69] Centre for Ecology and Hydrology (2017), "Implementation of an Emissions Inventory for UK Peatlands: A report to the Department for Business, Energy, and Industrial Strategy," Issue 1.

Industrial Extraction	13.28
Settlement	1.61

The recommended uptake of peatland restoration measures is based on the assessment of deep (>40 cm) peatland coverage and condition across the UK by the Centre for Ecology and Hydrology (CEH), which is part of the UK's GHG Inventory[70]. Yorkshire Dales and North York Moors supplied custom results based on the Yorkshire Peat Partnership's (YPP) peat depth and vegetation survey data. The Broads also supplied a custom in-house peat data. The results for Yorkshire Dales are illustrated in Table 11, complementing the deep peat hectarages and degradation percentages given in Table 4. We do not consider shallow (<40 cm) peat in this report.

Table 11. Yorkshire Dales National Park: Assessment of degraded deep peat types (columns) within each habitat (rows). The values in each row add up to 100% and are based on the data provided by the Yorkshire Peat Partnership. Note: Habitats such as "Arable & Horticulture", "Saltmarsh" and "Urban" are either not present in the Yorkshire Dales or do not contain any deep peat; their likely peat degradation types have been assigned below for completeness.

	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
Broadleaved woodland	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%
Coniferous woodland	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%
Arable and horticulture	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Improved grassland	2.0%	2.0%	4.2%	57.5%	0.0%	0.0%	34.3%	0.0%
Neutral grassland	0.0%	0.0%	0.0%	50.0%	0.0%	0.0%	50.0%	0.0%
Calcareous grassland	0.1%	0.3%	7.3%	84.2%	0.0%	0.0%	8.2%	0.0%
Acid grassland	0.1%	0.1%	28.2%	52.7%	0.0%	0.0%	18.9%	0.0%
Fen, marsh, swamp	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%
Heather	0.1%	0.2%	23.6%	75.3%	0.0%	0.0%	0.7%	0.0%
Heather grassland	0.0%	0.1%	28.4%	66.7%	0.0%	0.0%	4.9%	0.0%
Bog	0.4%	0.2%	50.4%	43.5%	0.0%	0.0%	5.5%	0.0%
Saltmarsh	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
Urban	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Suburban	0.0%	0.0%	50.0%	50.0%	0.0%	0.0%	0.0%	0.0%

For each National Park, we require 80% of its estimated deep peat area to be restored by 2050 in line with the adopted UK-wide targets (Table 7).

[70] https://www.gov.uk/government/collections/uk-greenhouse-gas-emissions-statistics.

Regenerative agriculture opportunity mapping and targets

The recommended regenerative agriculture targets are based on apportioning the relevant UK-wide targets from the Sixth Carbon Budget (Table 7) according to the extent of the habitats within each National Park that are deemed to be suitable for each regenerative agriculture measure. The assumed relative suitability scores are summarised in Table 12.

Table 12. Assumed relative suitability of regenerative agriculture measures for different habitats (excluding peat soils).

CEH LCM habitat (subset)	Agroforestry	Hedgerows	Legumes	Cover Crops
Broadleaved Woodland	0%	0%	0%	0%
Coniferous Woodland	0%	0%	0%	0%
Arable and Horticulture	100%	100%	0%	100%
Improved Grassland	100%	100%	100%	0%
Neutral Grassland	50%	50%	50%	0%
Calcareous Grassland	50%	50%	0%	0%
Acid Grassland	50%	50%	0%	0%
Fen, Marsh and Swamp	0%	0%	0%	0%
Heather	0%	0%	0%	0%
Heather Grassland	0%	0%	0%	0%
Bog	0%	0%	0%	0%
Saltmarsh	0%	0%	0%	0%
Urban	0%	0%	0%	0%
Suburban	0%	0%	0%	0%

The effects of agroforestry and hedgerows are modelled using representative broadleaf tree carbon sequestration profiles from Woodland Carbon Code, while additional soil carbon sequestration due to legumes and cover crops is estimated using our in-house model (Figure 26), together with estimates from Bossio *et al.* (2020). The adopted settings for regenerative agriculture are summarised in Table 13.

Table 13. Adopted regenerative agriculture carbon sequestration parameters, including emission factors (EFs) from Bossio et al. (2020).

Measure	Model	Tree Species	Tree Yield Class	Tree Spacing (m)	Soil share of total C	Bossio EF (tCO_2e / ha / yr)	Bossio EF reference period (yr)
Agroforestry	Tree S-shaped	SAB	6	2.5	NA	-2.35	30
Hedgerows	Tree S-shaped	SAB	4	1.5	9%	NA	NA
Legumes	Soil exponential	NA	NA	NA	100%	-2.05	30
Cover Crops	Soil exponential	NA	NA	NA	100%	-1.17	50

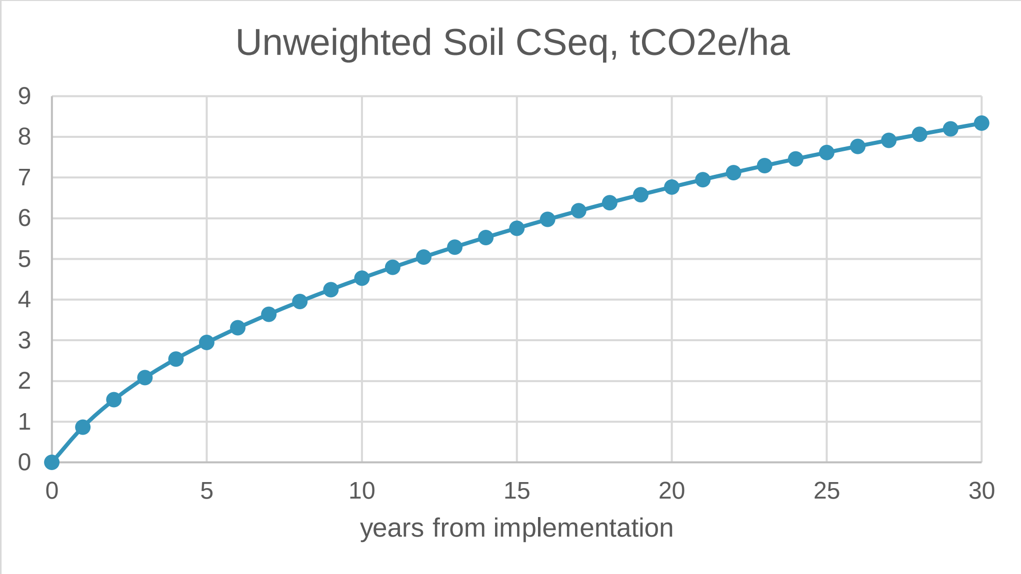

Figure 26. Cumulative soil carbon sequestration (topsoil and subsoil combined) driven by an increase of 1 tCO_2e/ha/yr in carbon transfer from plants following adoption of a regenerative practice. This curve is scaled according to the estimates for carbon uptake from legumes and cover crops from Bossio et al. (2020). Source: Small World Consulting soil carbon model derived from the N14CP model (Yumashev et al., 2022).[71]

2023 update to the LULUCF emissions inventory for National Parks

Various parts of the DESNZ national and regional GHG inventories related to the land use emissions baselines in Figure 9 are updated each year by Ricardo Energy & Environment, Centre for Ecology and Hydrology, and Forest Research. The underpinning LULUCF methodology has undergone considerable improvements since 2020, starting with revisions to peat emissions following the work of Evans *et al.* (2017), which were incorporated in the 2022 Small World Consulting reports for all the National Parks. Most recently, the 2023 release of the LULUCF figures has included considerable improvements in the historical land use change data. Using 2019 as the base year for comparing the two data releases, the 2023 update by DESNZ resulted in significant reductions in the GHG baselines for all but two National Parks (Figure 27). The two outliers, Northumberland and Pembrokeshire Coast, are characterised, respectively, by large areas of forested peatland and intensively managed grassland, which are likely to be the main reasons behind the increase in the LULUCF baselines following the latest revision. Despite the outliers, the total LULUCF flux across all the National Parks in 2019 has been revised downward by just over 1 million tCO_2e. The revision has been incorporated in this synthesis report, including the 2021 baseline land use emissions estimates in Figure 9.

[71] Yumashev, D., *et al.* (2022). "Terrestrial carbon sequestration under future climate, nutrient and land use change and management scenarios: a national-scale UK case study." Environmental Research Letters, 17(11), 114054.

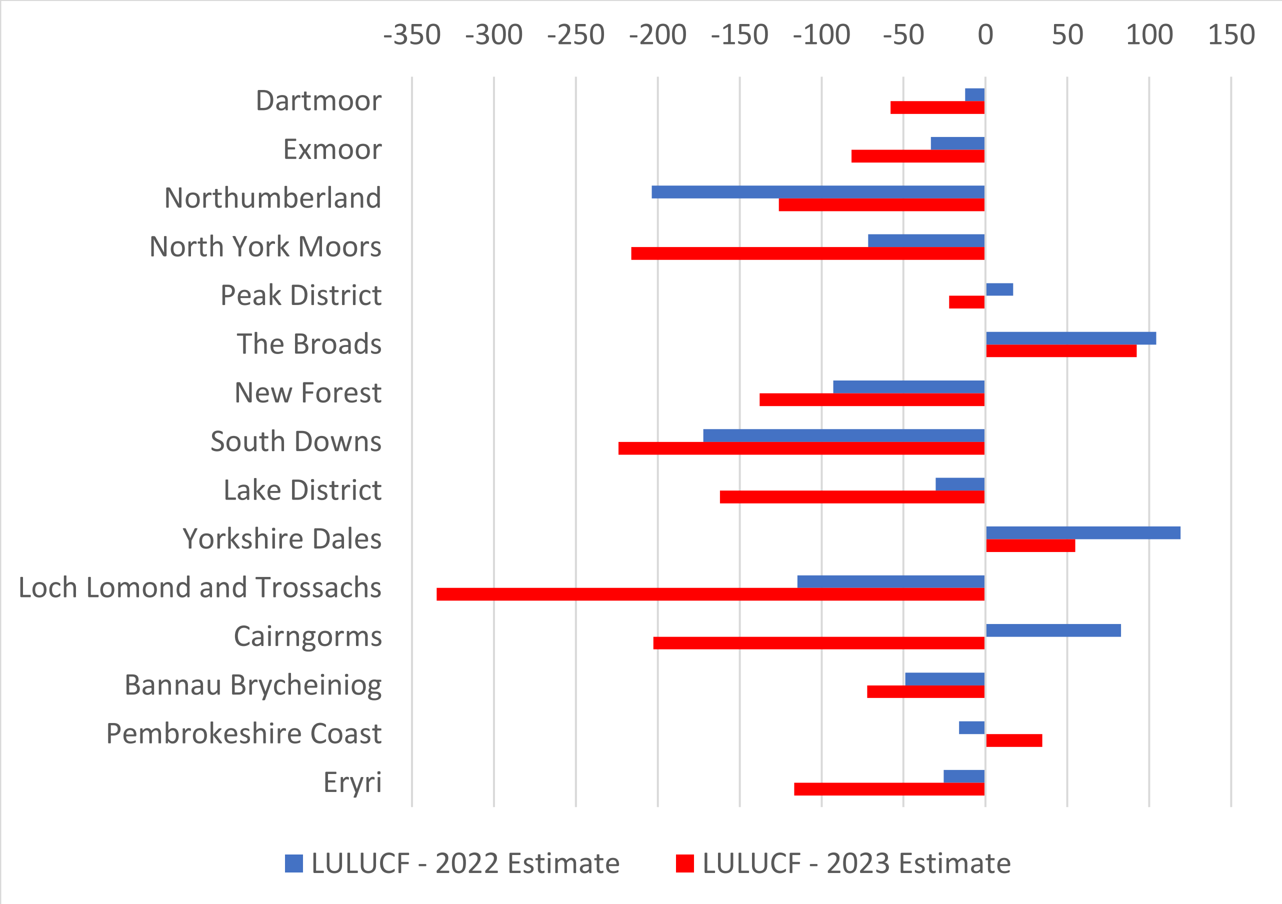

Figure 27. 2019 LULUCF GHG estimates by DESNZ for National Parks: 2023 revisions compared to the earlier 2022 data release. Units: ktCO₂e per year.

GHG baselines for the six priority areas for National Parks

The GHG assessment for the National Parks presented in this report focuses on the following **six priority areas**:

- Energy-related emissions by residents, visitors and industry (building heating, electricity, road fuels and public transport; excluding flights);
- Food and drink consumed by residents and visitors (purchased in shops and eating out);
- Other goods purchased by residents and visitors (including cars);
- Visitor travel to and from the National Park or National Landscape (excluding flights);
- Agriculture (mostly emissions from livestock and fertilisers);
- Land use (emissions from and/or carbon sequestration in soils and biomass across all habitats).

Across these priority areas, the collective total (net) GHG emissions baseline for the National Parks is estimated to be around **11.5 million tCO_2e per year**, as at 2022. The GHG baselines for the individual landscapes are summarised in Table 14. Their absolute magnitudes reflect the sizes and characteristics of the resident and visitor populations, make-ups of the businesses and industries, and types of land use and management.

Table 14. 2022 GHG baselines for the National Parks based on the six priority areas introduced in the text.

National Park	GHG Baselines, tCO_2e/yr
Dartmoor	633,439
Exmoor	251,345
Northumberland	36,164
North York Moors	642,291
Peak District	1,176,251
The Broads	515,238
New Forest	808,104
South Downs	1,935,932
Lake District	1,917,671
Yorkshire Dales	947,217
Loch Lomond & The Trossachs	79,082
Cairngorms	315,495
Bannau Brycheiniog	787,138
Pembrokeshire Coast	713,611
Eryri	738,675
All National Parks	**11,497,653**

The breakdowns of the 2022 emissions for each National Park, across the six priority areas introduced above, are shown in Figure 28. These breakdowns illustrate the key differences between the landscapes in terms of the factors underpinning the emissions and carbon sequestration, and in terms of the overall magnitudes of the effects. For example, South Downs and New Forest currently have the highest energy-related footprint, while the Lake District has by far the highest emissions associated with visitor travel to and from the landscape (all in absolute terms). Loch Lomond & The Trossachs, South Downs, North York Moors and Cairngorms currently have the biggest net levels of carbon sequestration.

For all the National Parks combined (Figure 29), energy-related emissions dominate, followed by emissions associated with visitor travel to and from the landscape (excluding flights), agricultural emissions, and emissions linked to the food and drink consumed by residents and visitors.

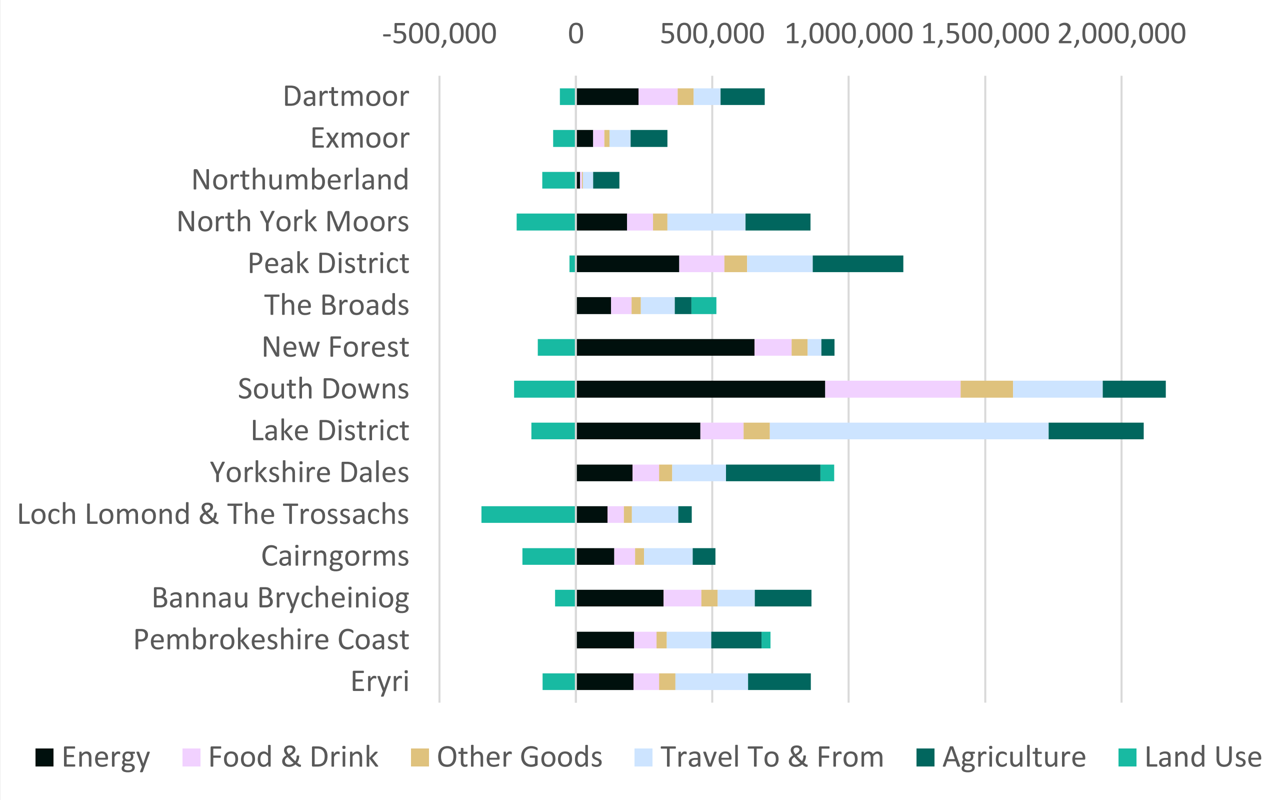

Figure 28. Breakdown of the estimated emissions for each National Park in 2022 across the six priority areas. Units: tCO_2e per year.

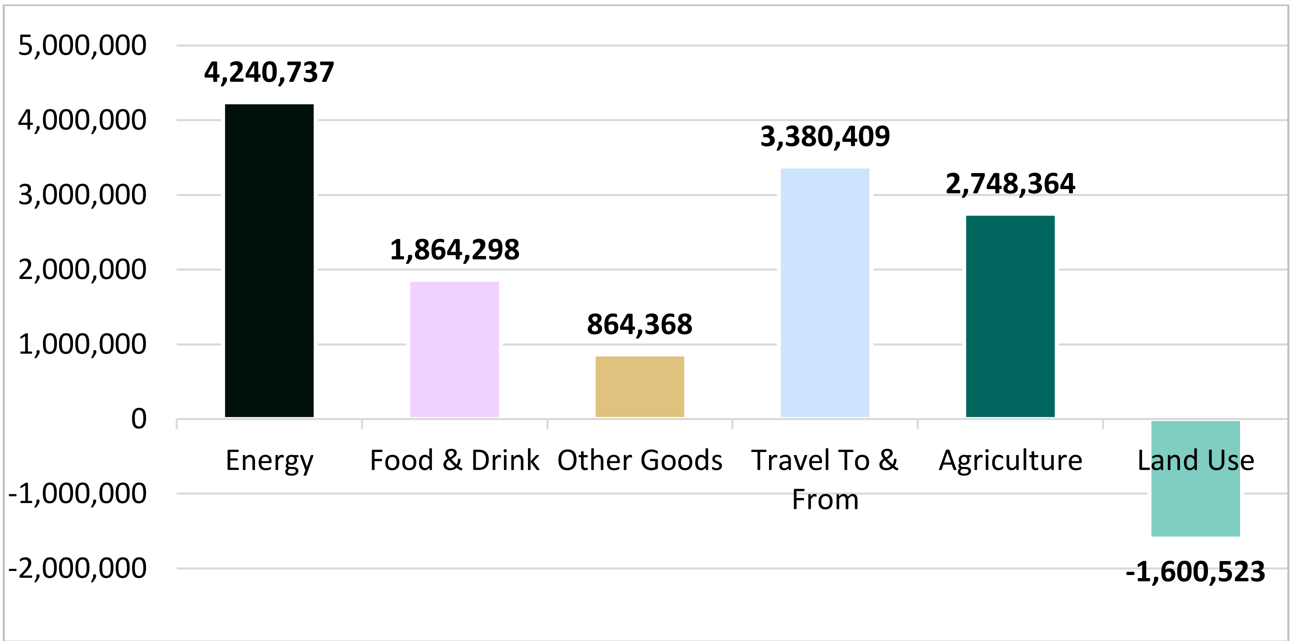

Figure 29. Breakdown of the estimated combined total (net) emissions for the National Parks in 2022 across the six priority areas. Units: tCO_2e per year.

We also provide breakdowns of the 2022 emissions for each National Park, calculated across the six priority areas introduced above, into the Scope 1, 2 and 3 components defined by the GHG Protocol[72] (Figure 30). The three Scopes include:

- Scope 1: Direct emissions from combustion of fossil fuels by residents, visitors (while in the National Park), and industry, as well as agricultural emissions (livestock, fertiliser), emissions from degrading soils (mineral and peat), and carbon sequestration in healthy soils and biomass (trees, hedges);
- Scope 2: Indirect emissions from electricity (and steam, if applicable) consumed by residents, visitors (while in the National Park), and industry;
- Scope 3: Well-to-tank emissions associated with fossil fuels, supply chain emissions associated with electricity generation, embedded emissions in food and other goods consumed by residents and visitors (while in the National Park), and emissions associated with visitor travel to and from the National Park (excluding flights).

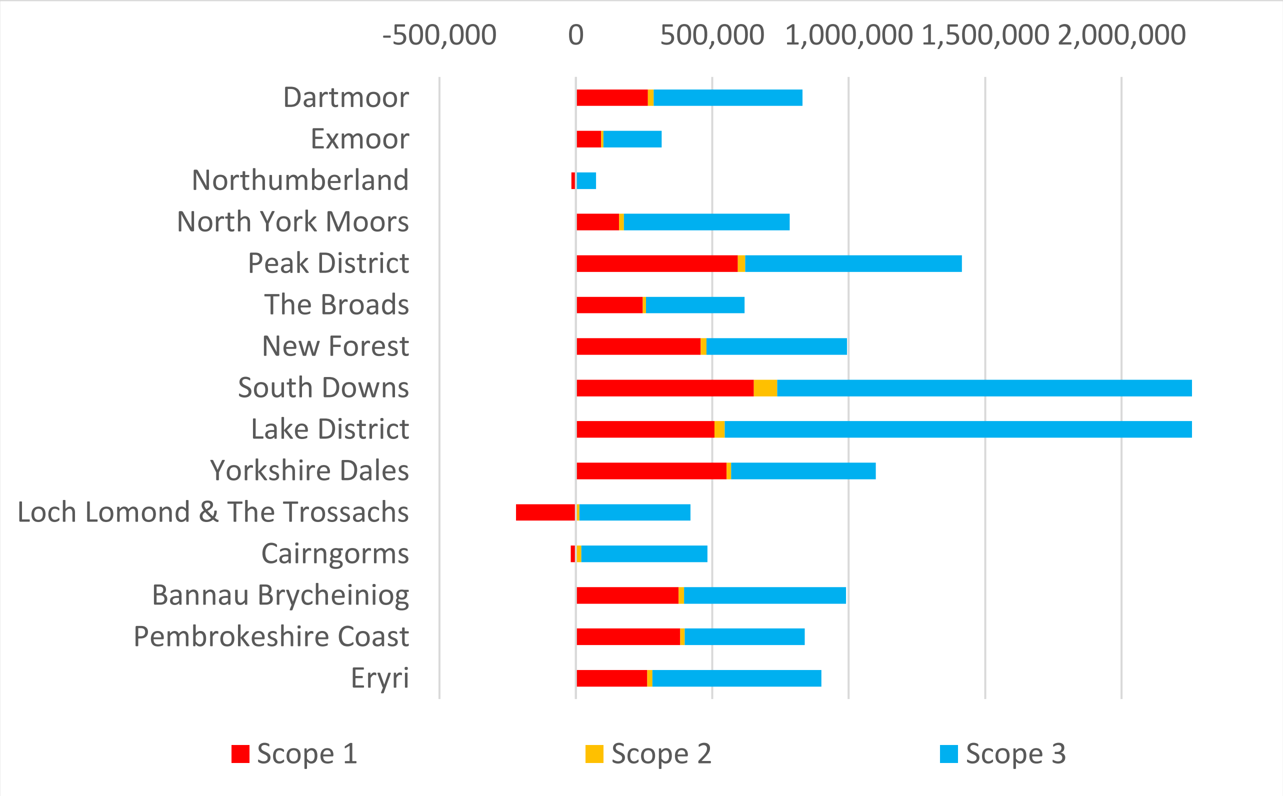

Figure 30. Breakdown of the estimated emissions for each National Park in 2022 (calculated across the six priority areas) into Scope 1, 2 and (upstream) Scope 3 components. Units: tCO_2e per year.

Scope 3 emissions dominate the GHG baselines in most National Parks, particularly in the Lake District and South Downs. This is largely due to emissions associated with visitor travel to and from the landscapes, in addition to well-to-tank fossil fuel emissions, and footprints of

[72] https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf.

consumed food and other consumer goods. Negative Scope 1 emissions seen in Loch Lomond & The Trossachs, Cairngorms and Northumberland are largely due to carbon sequestration in existing woodlands, which compensates for emissions from degrading peat, agricultural emissions, and direct emissions associated with fossil fuels consumed within these landscapes.

Decarbonisation targets for the six priority areas

Having defined the GHG baselines for each National Park, we set the recommended targets for each of the six priority areas. The targets are derived from the following science-based assessments:

- UNFCCC Paris Agreement (namely keeping global warming below 1.5°C);
- IPCC's Sixth Assessment Report;
- Tyndall Carbon Budget Tool;
- UK's Sixth Carbon Budget;
- UK's National Food Strategy.

Due to the considerable complexities and uncertainties involved, applying these assessments to the six priority areas requires elements of expert judgement. The proposed pathways are summarised in Table 15 and follow three distinct approaches:

- For the **energy**, **visitor travel** and **other goods** priority areas, which are dominated by CO_2 emissions, the pathways follow the Sixth Carbon Budget with additional ratcheting-up to make them fit within the estimated remaining 1.5°C carbon budgets.
- For the consumed **food and drink** as well as local **agriculture** priority areas, which are dominated by methane emissions and therefore have long-term annual targets rather than cumulative carbon budgets, we use global agriculture pathway from the IPCC's Sixth Assessment Report consistent with the 1.5°C target. This pathway was derived for individual GHGs and does not rely on a particular GWP metric. We further scale it to account for higher current per-capita food footprint in the UK compared to global average.
- The **land use** change targets and the associated net emission reduction pathways are more nuanced and are described in detail in Section 0.

All the pathways also include a 5-year ratcheting-up period between 2023 and 2028 to allow the National Park Authority teams and their partners time to collectively adopt the required targets, and to secure the necessary funds to implement them. We assume that during this period, the efforts for each priority area will gradually scale up from their current levels to the recommended levels. The resulting decarbonisation pathways for all the National Parks combined are shown in Figure 16.

Table 15. Proposed emission reduction (or carbon sequestration) targets for each of the six priority areas that define GHG baselines in the National Parks.

Priority area	Proposed decarbonisation pathways
Energy-related emissions by residents, visitors and industry (building heating, electricity, road fuels and public transport; excluding flights)	We used the Sixth Carbon Budget pathways for decarbonising electricity, electrifying transport, decarbonising building heading, and mitigating fugitive emissions from remaining fossil fuel extraction. We applied additional ratcheting-up to ensure the remaining cumulative emissions between 2023 and 2050 stay within the 1.5°C budget in line with the Tyndall assessment.
Food and drink consumed by residents and visitors (purchased in shops and eating out)	We used global pathway for Agriculture from the IPCC's Sixth Assessment Report consistent with the 1.5°C target. We further scaled it to account for higher current per-capita food emissions in the UK (estimated at 3.2 tCO_2e per person per year[73]) compared to global average (approximately 2.3 tCO_2e per person per year[74]), so that by 2050 both the UK's and global per-capita food emissions reach the IPCC target of around 1.5 tCO_2e per person per year.
Other goods purchased by residents and visitors (including cars)	We used the Sixth Carbon Budget pathway for decarbonising manufacturing and construction. We applied additional ratcheting-up to ensure the remaining cumulative emissions between 2023 and 2050 stay within the 1.5°C budget in line with the Tyndall assessment.
Visitor travel to and from the National Park or National Landscape	We used the Sixth Carbon Budget pathways for decarbonising electricity and electrifying transport. We applied additional ratcheting-up to ensure the remaining cumulative emissions between 2023 and 2050 stay within the 1.5°C budget in line with the Tyndall assessment.
Agriculture (mostly emissions from livestock and fertilisers)	Same as for the food and drink priority area (above).
Land use (woodland creation, peatland restoration and regenerative agriculture)	**New woodland** (carbon sequestration): new opportunity mapping to apportion UK-wide target from the Sixth Carbon Budget based either on spatially explicit data with 10m resolution (England) or on aggregate habitat areas (Scotland and Wales). **Restored peatland** (emission reduction): apportioning of UK-wide target from the Sixth Carbon Budget based on peat areas and condition. **Regenerative agriculture** (carbon sequestration): apportioning of UK-wide targets from the Sixth Carbon Budget based on arable and grassland habitat areas.

[73] https://www.sciencedirect.com/science/article/abs/pii/S0301421513009701.
[74] https://www.nature.com/articles/s43016-021-00225-9.

	We applied additional 50% ratcheting-up to the woodland targets to compensate for the UK's consumption-based footprint, which currently is approximately twice higher that the country's territorial emissions.

Key practical recommendations for individual priority areas (other than land use and agriculture)

This section provides an overview of the key actions that need to be taken to address the main sources of emissions in the designated landscapes other than food consumption, agriculture and land use change, which are already covered in Sections 0 and 0.

The key actions can be broken down into the following four broad themes:

Theme 1: Transport;
Theme 2: Buildings and energy;
Theme 3: Goods, services and waste;
Theme 4: Food consumption, agriculture and land use change (already covered in Sections 0 and 0).

Across these themes, which are closely linked with the GHG footprint priority areas introduced in Appendix 0, the most critical actions in order to deliver deep emission reductions are:

- Electrifying road and rail transport;
- Switching from gas and oil boilers to heat pumps, and insulating buildings;
- Reducing and ultimately eliminating waste of all kinds by moving to a circular economy;
- Growing and consuming a more sustainable food basket, including plant-based options, and embarking on ambitious landscape enhancement programmes (Sections 0 and 0).

The sub-sections below describe each of the themes other than food consumption, agriculture and land use change in more detail, including a broader UK-wide narrative underpinning the recommended actions.

Even though the primary responsibility for transport and waste sits with local authorities, while consumption of energy, food, other goods and services is mostly within the remit of national policy, the National Parks could play an important role in making the case to local authorities, as well as to the UK Government and devolved governments, for the changes needed. They could also engage local communities, businesses and other organisations to inspire and galvanise behaviour change. Furthermore, the National Parks have an important place-shaping role through their planning powers. All the designated landscapes are going be instrumental in delivering wide-ranging landscape recovery and enhancement programmes, including woodland creation and peatland restoration, together with moving to more sustainable agricultural practices.

Transport

Key recommendations

Key recommendations to decarbonise the sector:

- Switch to electric (and, where applicable, green hydrogen) cars, buses, trains, vans and lorries;
- Work with regional and national governments and with industry associations to invest in large-scale electric vehicle charging infrastructure;
- Reduce annual car mileages;
- Reduce the number of cars per household;
- Reduce car sizes;
- Promote public transport;
- Promote cycling and walking.

General points

Promoting the use of public transport delivers benefits for visitors, residents and businesses alike, from the point of view of cutting GHG emissions, improving air quality, and reducing congestion. It is therefore important for local authorities to explore mechanisms to help fast-track electrification of public-use vehicles such as buses, taxis and hire vehicles, and to influence the UK Government to support the transition from diesel-powered trains to electric trains.

In terms of vehicle fuel use, variations both in annual mileage and in vehicle size make a big difference to carbon footprints. If someone drives the UK average of 7,600 miles in a year, the associated emissions are around 3 tCO_2e if their vehicle is a small petrol run-around, 4 tCO_2e for a medium family-size car, and 6 tCO_2e for a large car. It is also worth noting that while car travel can have a high footprint if the driver travels alone, it becomes a far lower-carbon option per person if the driver can share the journey with passengers.

The vehicle type also affects the GHG footprint. A road trip from Manchester to London (around 200 miles) in an average petrol car would produce 0.10 tCO_2e of emissions, including the embodied emissions of the vehicle and its fuel. For the same journey an ordinary hybrid vehicle produces 0.07 tCO_2e. The average diesel car's footprint from the same journey is almost exactly the same as for the average petrol car, at 0.10 tCO_2e, but diesel vehicles are likely to perform less well in that they produce more soot and nitrogen oxides. Exhaust fumes are a key contributor to air pollution, so the cleanest choice is an electric car, which would also produce the lowest emissions for the illustrative journey: 0.04 tCO_2e. 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 (which dominates the 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. The Climate Change Committee (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. However, it is also important to reduce car usage wherever possible, as electric cars still have high embodied emissions and still have a footprint from the electricity they consume. We therefore list the following choices that everyone can make to reduce vehicle emissions:

- The average person walks 210 miles per year. Walking an additional 2.5 miles per week for local journeys, e.g. visits to local shops or the school run, could save 70 kg CO_2e in a year and bring co-benefits for health.
- Travelling by bicycle is around ten times less carbon-intensive than driving a medium-sized petrol car, and electric bikes are even less carbon-intensive. Cycling 10 miles a week instead of driving could therefore save around 0.25 tCO_2e per year.
- On average, travelling by train, bus or tram is nearly seven times less carbon-intensive than driving a medium-sized petrol car. Taking public transport for 10 miles a week instead of driving could therefore save around 0.23 tCO_2e per year.
- Driving outside the rush hour avoids prolonged time at low vehicle speeds: an average car crawling five miles each way emits 22 $kgCO_2e$ a day, which over a year could equal 4.8 tCO_2e.
- When replacing an ageing medium family-size car, downsizing to a small petrol car would save around 1 tCO_2e a year.
- When replacing an ageing large car, downsizing to a medium family-size petrol car would save around 3 tCO_2e a year.
- The embodied emissions of a new car are substantial, with an average-sized petrol car having a carbon footprint of around 8 tCO_2e, and even a small car having a footprint of around 4 tCO_2e. Therefore, if one needs to buy a car, a second-hand option is likely to save the embodied emissions (even though its maintenance will produce higher emissions compared to a new car).
- If affordable, replacing a medium-sized petrol car with an electric car would save around 2 tCO_2e a year. Replacing a large car with a medium electric car would save around 5 tCO_2e a year.

It is not always possible to identify whether visitors are using their own vehicles or hire cars, but where hire cars are used, it may be beneficial for local authorities to work with 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.

Buildings and energy

Key recommendations

Key recommendations to decarbonise buildings and energy (excl. transport):

- Replace gas and oil boilers with air-source and ground-source heat pumps;
- Reduce energy demand by carrying out deep retrofit of domestic & commercial properties (aiming to upgrade as many as possible to EPC ratings of A or B);
- Ensure high EPC ratings and heat pump installations for all new-build properties;
- Switch to certified renewable electricity providers;
- Work with regional and national governments and with industry associations to invest in large-scale renewable electricity generation infrastructure.

General points

The building sector is an area in which local authorities can have significant impact in reducing emissions. In order to meet the UK-wide and local net zero pledges, there needs to be a significant ramp-up in heating efficiency, insulation, and low-carbon heating and electricity in both new and existing buildings. According to the Sixth Carbon Budget, possible ways to achieve this include:

- Constructing all new-builds to the highest possible efficiency standard (EPC rating of at least C);
- Retrofitting all existing homes to the highest possible efficiency standard (EPC rating of at least C) by means of loft and cavity wall insulation;
- A complete phase-out of any coal or oil heating systems by 2028;
- A complete phase-out of gas heating by 2033, with all homes heated with heat pumps (main technology), hydrogen boilers or low-carbon district heating;
- Generating at least 87% of electricity from renewable or low-carbon sources by 2030.

The main priorities are to switch from fossil fuels and reduce energy use within existing buildings. Energy-saving options vary from lowering the thermostat temperature, to improving home insulation, to replacing gas and oil boilers with electric heat pumps. Converting both off-gas-grid and gas-grid properties to use a heat pump system will reduce emissions significantly, while also offering householders and businesses a more convenient system. Increased electricity demand in rural areas can be met by local renewable energy production and improved electricity grid connections, which would be both relevant and timely as the locals will be switching to electric heat pumps and electric vehicles. We recognise that affordability is always a factor. 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.

Furthermore, most of the recommended measures are expected to deliver sizeable long-term savings in energy use and cost.

Low-carbon construction techniques will also be needed to ensure that the embodied emissions involved in constructing new buildings are as low as possible. Measures could include substituting standard materials with low-carbon alternatives, for example using steel produced using hydrogen power in place of steel produced using coal, or substituting ordinary Portland cement with lower-carbon alternative cements. Other measures include improving resource efficiency and using machinery powered by renewable energy as opposed to fossil fuels.

In addition to improving insulation and switching to heat pumps, individual households and businesses can readily reduce emissions arising from their electricity use by changing their energy supplier to one that is divesting from fossil fuels and actively procuring electricity from a genuinely renewable source, e.g. solar, wind, tidal or hydroelectric power. The public and businesses generally lack knowledge about where their energy comes from, with many consumers not being able to distinguish between:

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

Currently, the only UK suppliers who provide 100% renewable energy from PPAs are Ecotricity, 100Green and Good Energy[75]. Other suppliers such as Octopus Energy also invest in renewable electricity generation. We have ranked all the current UK electricity suppliers according to their renewable generation credentials, presented in the table below.

Ranking of supplier	Suppliers list
1) Only supplied by 100% renewable energy via PPAs	Ecotricity, 100Green and Good Energy
2) 100% renewable or low-carbon energy with some PPAs/investment in renewables	E.ON, Octopus Energy and all suppliers owned by Octopus Energy (Ebico, London Power, M&S Energy, Qwest Energy), Shell Energy and So Energy
3) 100% renewable only via REGO certificates	Outfox the Market
4) Not 100% renewable energy	Boost, British Gas, E, EDF Energy, E.ON Next, Energy SW, Fairer Power, Glide, Lumo,

[75] https://www.which.co.uk/reviews/energy-companies/article/green-energy-suppliers/differences-between-green-energy-suppliers-aN19W0B8B2Mc.

	OVO Energy, Sainsbury's Energy, Scottish Power, SSE, Utilita, Utility Warehouse

Goods, services and waste

Key recommendations

Key recommendations to decarbonise consumer goods (excl. food), services and waste:

- Make carbon-cautious consumer choices (action by the public);
- Procure low-carbon goods and services (action by businesses and public-sector bodies);
- Reduce waste and promote/facilitate recycling, guided by principles of Circular Economy (CE) and using policies such as Extended Producer Responsibility (EPR);
- Eliminate as much food waste as possible.

General points

Consumers can influence the embedded footprint of goods and services by making carbon-conscious choices. The choices we, as individuals, make around which goods and services we purchase count towards our carbon footprint, due to the amount of fossil fuels used in production (both goods and services), and/or the quantity of air/road/sea miles required for transportation (goods only). The same logic applies to businesses when they procure goods and services through their supply chains.

The main method by which local authorities can reduce GHG emissions arising from waste, as well as promote products with lower embedded emissions, is by encouraging a circular economy. 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. This therefore reduces the production of new raw materials and their associated GHG emissions, in addition to reducing the emissions arising from decomposing materials in landfill. Providing and promoting more recycling options, and making these readily accessible, is therefore an important avenue enabling local authorities to minimise waste-related emissions as well as embedded emissions in consumer goods.

Emissions from food waste are also significant, as wasted food not only emits GHGs in landfill, but, more importantly, has a large emissions cost associated with the unnecessary food production. Eliminating food waste can therefore reduce an individual's food footprint by as much as 12%, and also save them money. Therefore, a reasonable target for individuals, and for businesses such as hotels and restaurants, should be to eliminate as much wastage of edible food as possible. Further emissions reductions can be achieved by processing remaining "inedible" food parts in garden composts and anaerobic digesters, a choice that local authorities can influence by promoting composting and by making food and garden waste collection options available across the region.

Local authorities could reduce emissions arising from all waste streams by supporting partners in strategic planning to deliver the multiple benefits of environmentally sound waste management. This can be achieved through referencing the new Environment Act (2021) when processing and scrutinising planning applications.