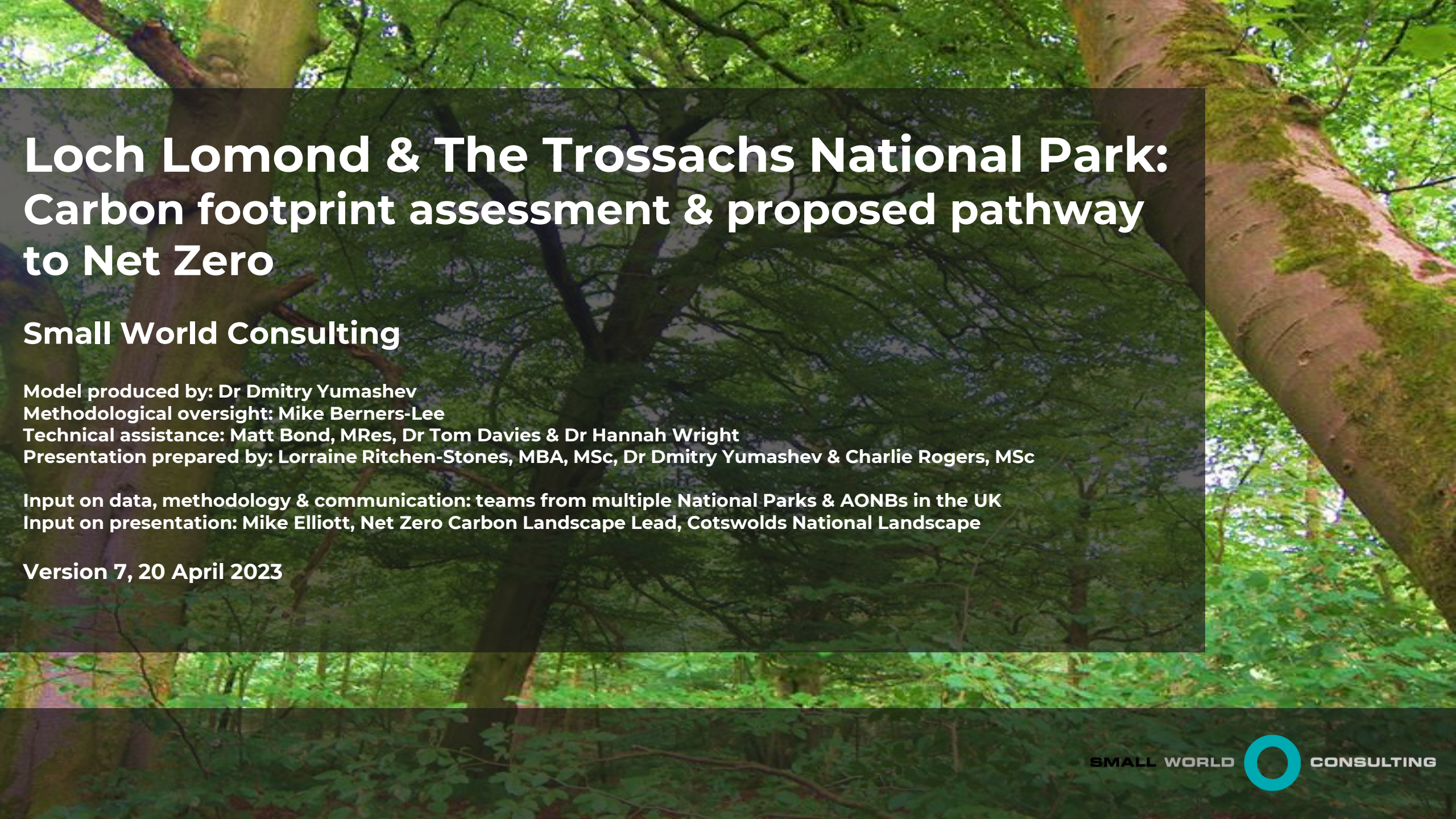


Loch Lomond & The Trossachs National Park: Carbon footprint assessment & proposed pathway to Net Zero

Small World Consulting

Model produced by: Dr Dmitry Yumashev
Methodological oversight: Mike Berners-Lee
Technical assistance: Matt Bond, MRes, Dr Tom Davies & Dr Hannah Wright
Presentation prepared by: Lorraine Ritchen-Stones, MBA, MSc, Dr Dmitry Yumashev & Charlie Rogers, MSc

Input on data, methodology & communication: teams from multiple National Parks & AONBs in the UK
Input on presentation: Mike Elliott, Net Zero Carbon Landscape Lead, Cotswolds National Landscape

Version 7, 20 April 2023

SMALL WORLD CONSULTING

Part 1:
Context

SMALL WORLD CONSULTING

Climate & ecological emergency

Extreme weather events

Droughts, storms, wildfires
Uninsurable property losses
Multi-breadbasket failure

Rising sea levels

Flooding, soil contamination
Loss of agricultural land/habitats

Natural resource depletion

Loss of groundwater and topsoil due to changing rainfall patterns

Spreading pests & diseases

Supported by shifting climate
Rising CO_2 levels weaken crop defenses

Loss of nutrition

Rising CO_2 levels decrease nutritional value of staple crops

Biodiversity loss

Shrinking habitats & mass extinction
Mis-timed spring emergence
Greater risk of disease

Wild food depletion

Ocean acidification
Loss of freshwater/land habitats

Reduced access to food

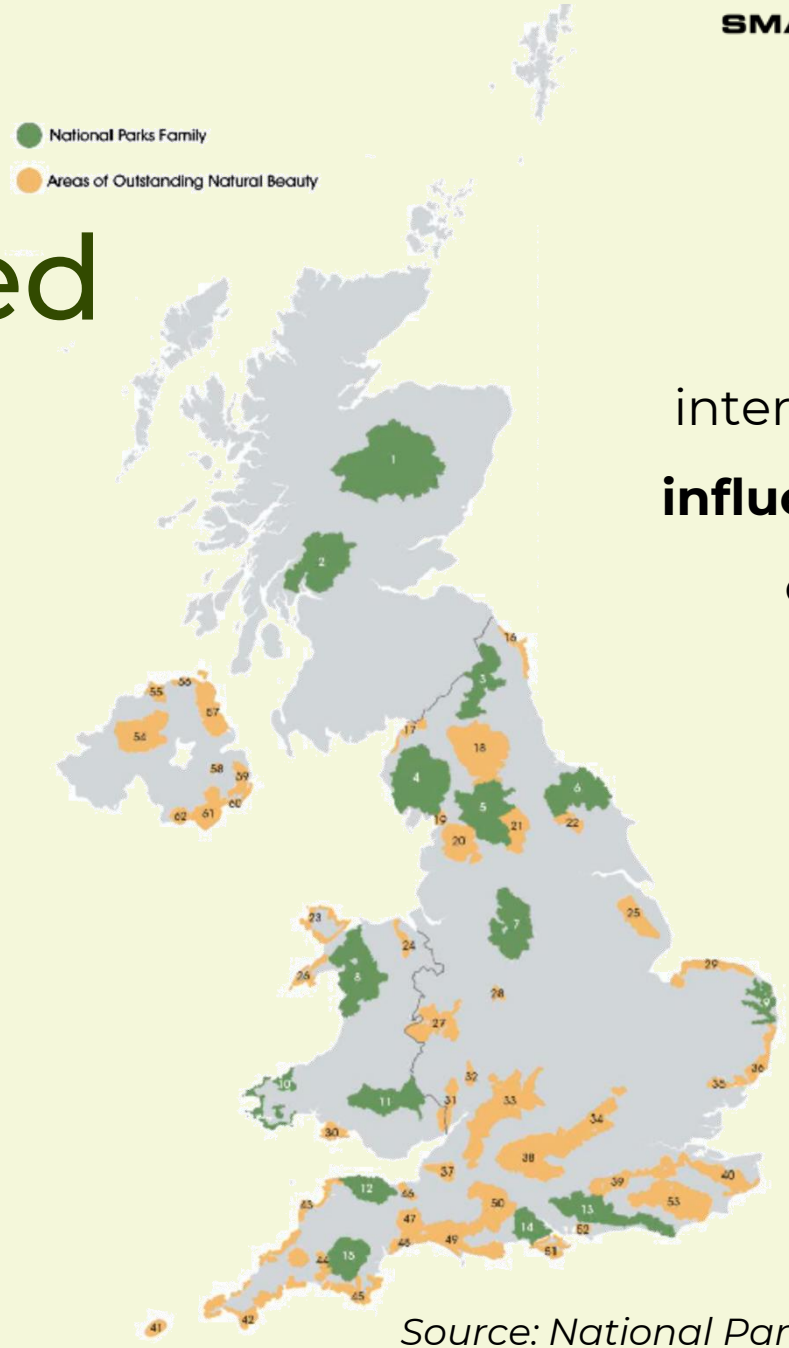
Trade disruption & increased conflict
Rising food prices
Risk of displacement on unprecedented scale

SMALL WORLD CONSULTING

SMALL WORLD CONSULTING

Role of protected landscapes

- 15 National Parks and 46 AONBs
  - 18% of UK land area
  - 1.5 million residents
  - 250 million visitors/year



Source: National Parks website

High national and international profiles mean **influence can exceed scale of own emissions**

Major challenges and opportunities for protected landscapes

Cutting emissions in line with cutting-edge research

Being land stewards and planning authority leaders

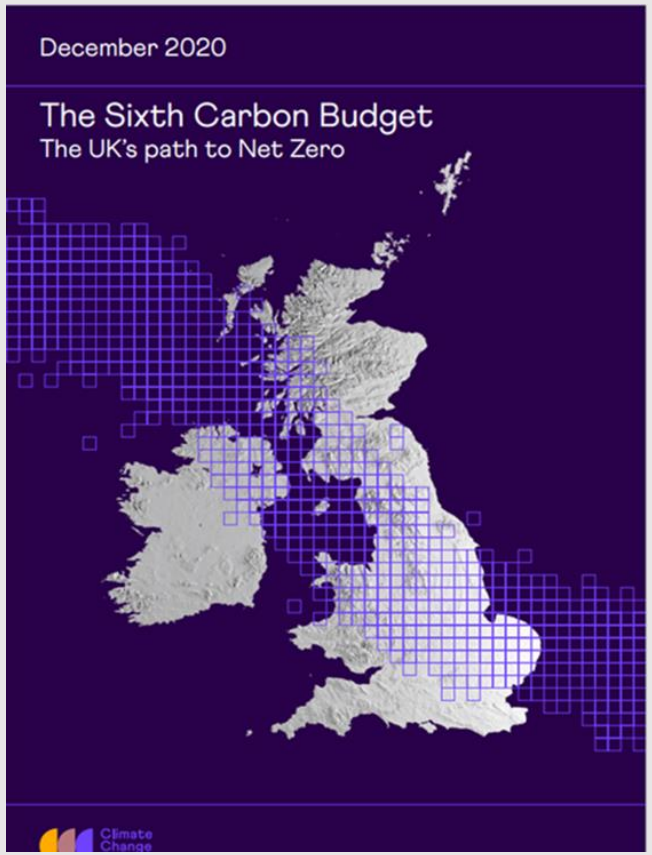
Creating better places to live, work and visit

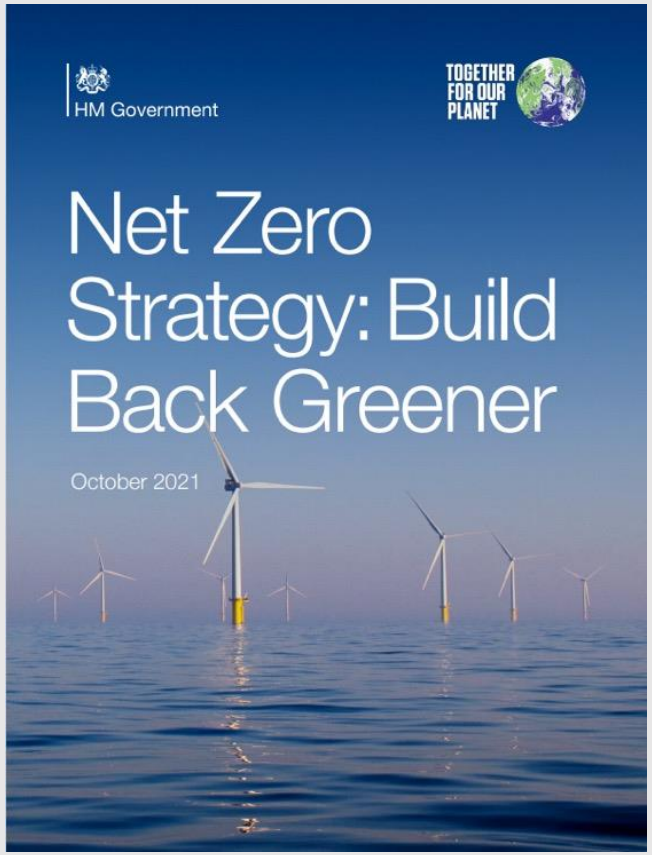
Adopting and scaling up land use measures

- Woodland creation
- Peatland restoration
- Renewable energy production
- Regenerative agriculture

SMALL WORLD CONSULTING

Policy landscape



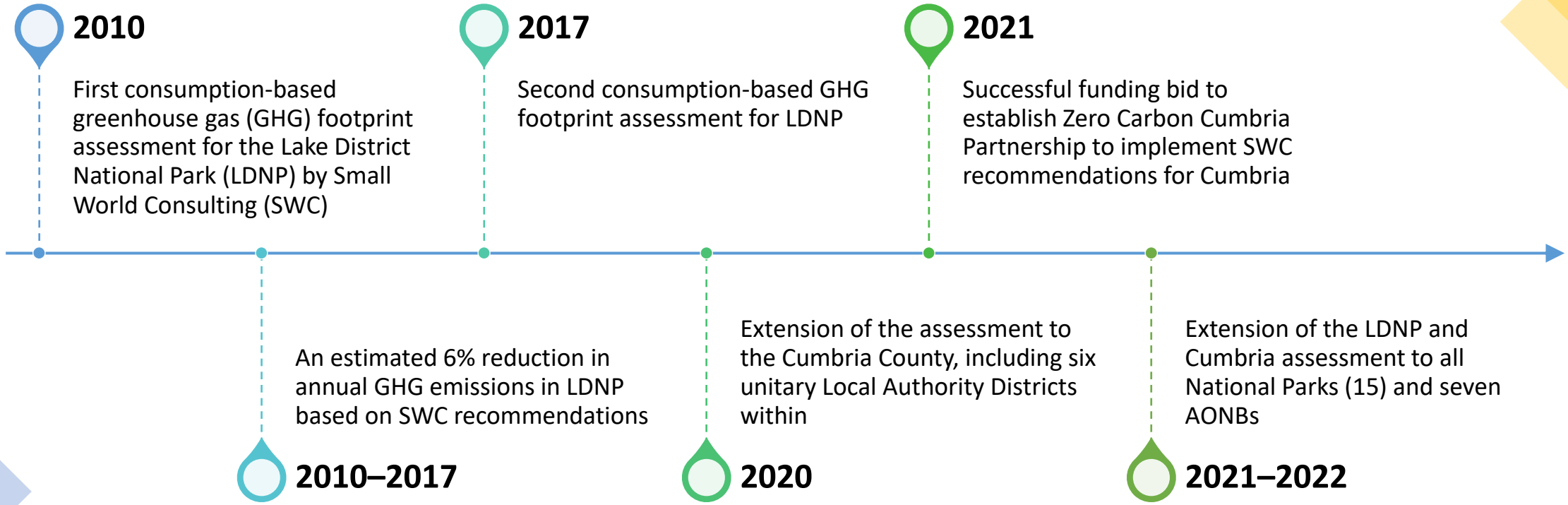


UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

SMALL WORLD CONSULTING

Background


2010
First consumption-based greenhouse gas (GHG) footprint assessment for the Lake District National Park (LDNP) by Small World Consulting (SWC)
2010–2017
An estimated 6% reduction in annual GHG emissions in LDNP based on SWC recommendations
2017
Second consumption-based GHG footprint assessment for LDNP
2020
Extension of the assessment to the Cumbria County, including six unitary Local Authority Districts within
2021
Successful funding bid to establish Zero Carbon Cumbria Partnership to implement SWC recommendations for Cumbria
2021–2022
Extension of the LDNP and Cumbria assessment to all National Parks (15) and seven AONBs

The Programme

SMALL WORLD CONSULTING

Tranche 1 Q1 2021	Tranche 2 Q2 2021	Tranche 3 Q3 2021	Tranche 4 Q4 2021-22	Tranche 5 Q1 2022
Pilot modelling tool	**Continuous improvement of the model based on shared learning**			**AONB pilot**
April - June	July - Sept	Oct - Dec	Jan - March	April – July
• South Downs • The Broads (two regions)	• Cairngorms • North York Moors • Peak District	• Loch Lomond & The Trossachs • Brecon Beacons • Snowdonia	• Pembrokeshire Coast • Anglesey • Clwydian Range & Dee Valley • Gower • Llyn • Wye Valley • Cannock Chase • Cotswolds • Six remaining National Parks	• *Completion of all assessments*

The Programme: Key Aims & Trivia

SMALL WORLD CONSULTING

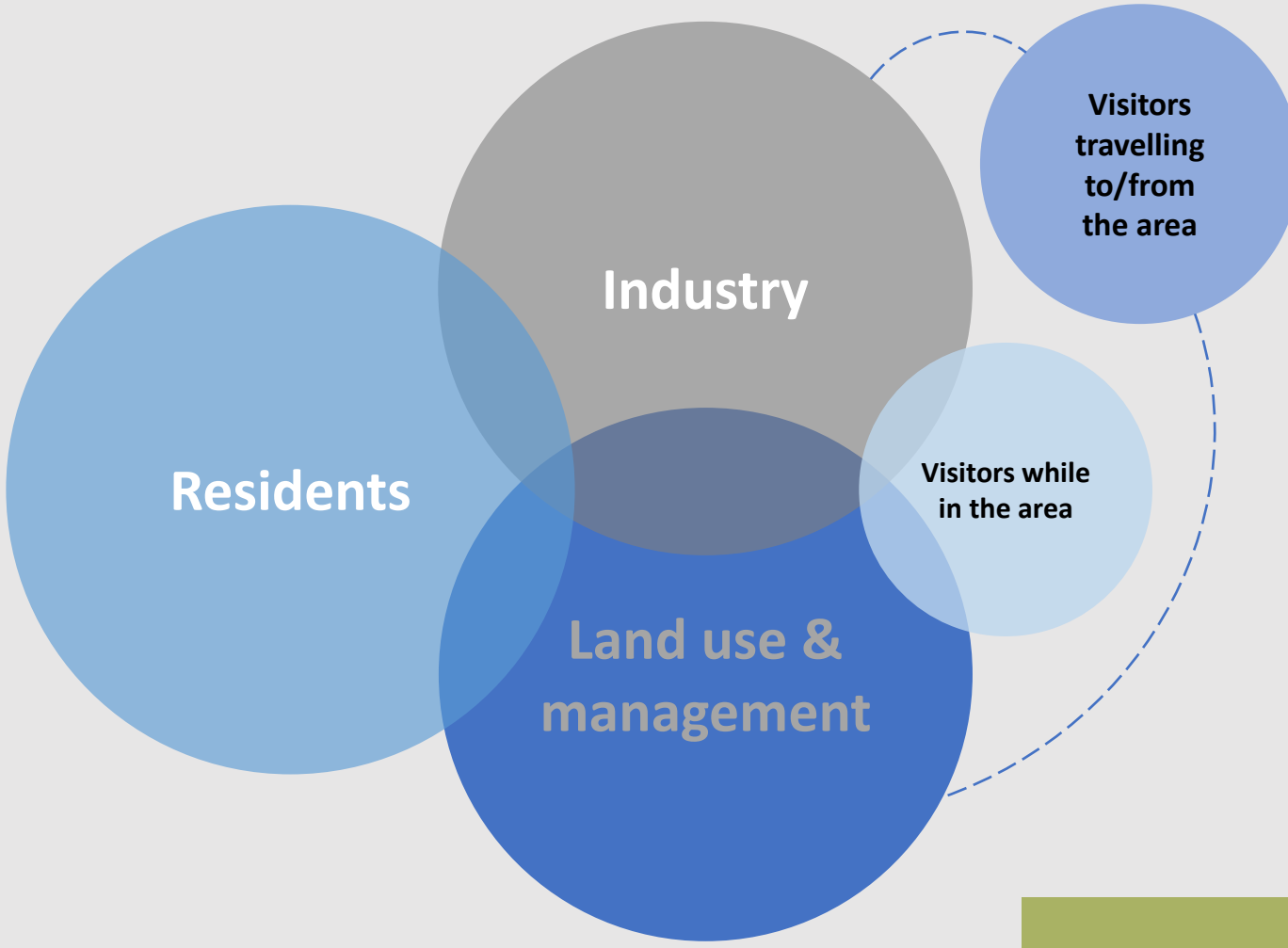
- Helps National Parks (NPs) and AONBs to respond to the climate & ecological emergencies
- Helps NPs & AONBs to actively contribute to meeting UK's 2050 Net Zero target
- Aims to establish stronger links with the UK Government & devolved administrations
- Facilitates mutual learning across the family of Protected Landscapes
- Draws on the latest science & data (including land use)
- Introduces standard data exchange protocols
- Allows one to add more landscapes with minimal effort (including local authorities)
- Allows one to update assessment in future years with minimal effort (to monitor progress)
- Total number of landscapes: 22 (15 NPs and 7 AONBs)
- Total budget (excl. VAT): ~£230k
- Total duration: 16 months (April 2021 to July 2022)

Part 2:
Approach

Assessment boundaries

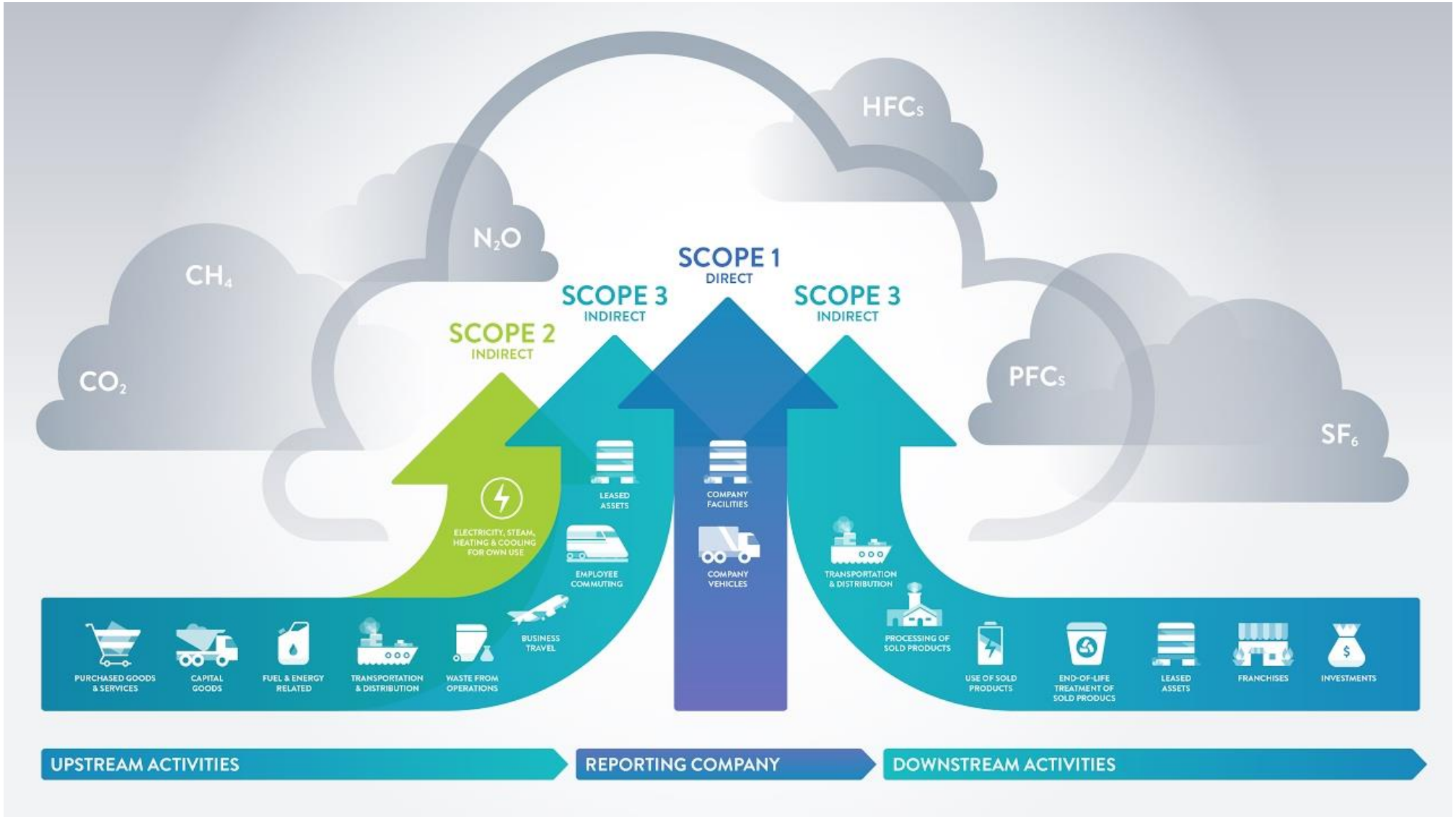
SMALL WORLD CONSULTING

- **Consumption-based approach**: full footprint of lifestyles, goods & services
- Approach taken by **leaders** to accelerate low-carbon transition
- All estimates are subject to uncertainties, particularly industry
- Industry / business overlaps with
  - Land use and management
  - Residents' lifestyles
  - Visitors while in the area
  - Visitors travelling to/from the area
- Carbon baseline assessment year: **2019**



A brief introduction to carbon accounting

SMALL WORLD CONSULTING



Source: Greenhouse Gas Protocol

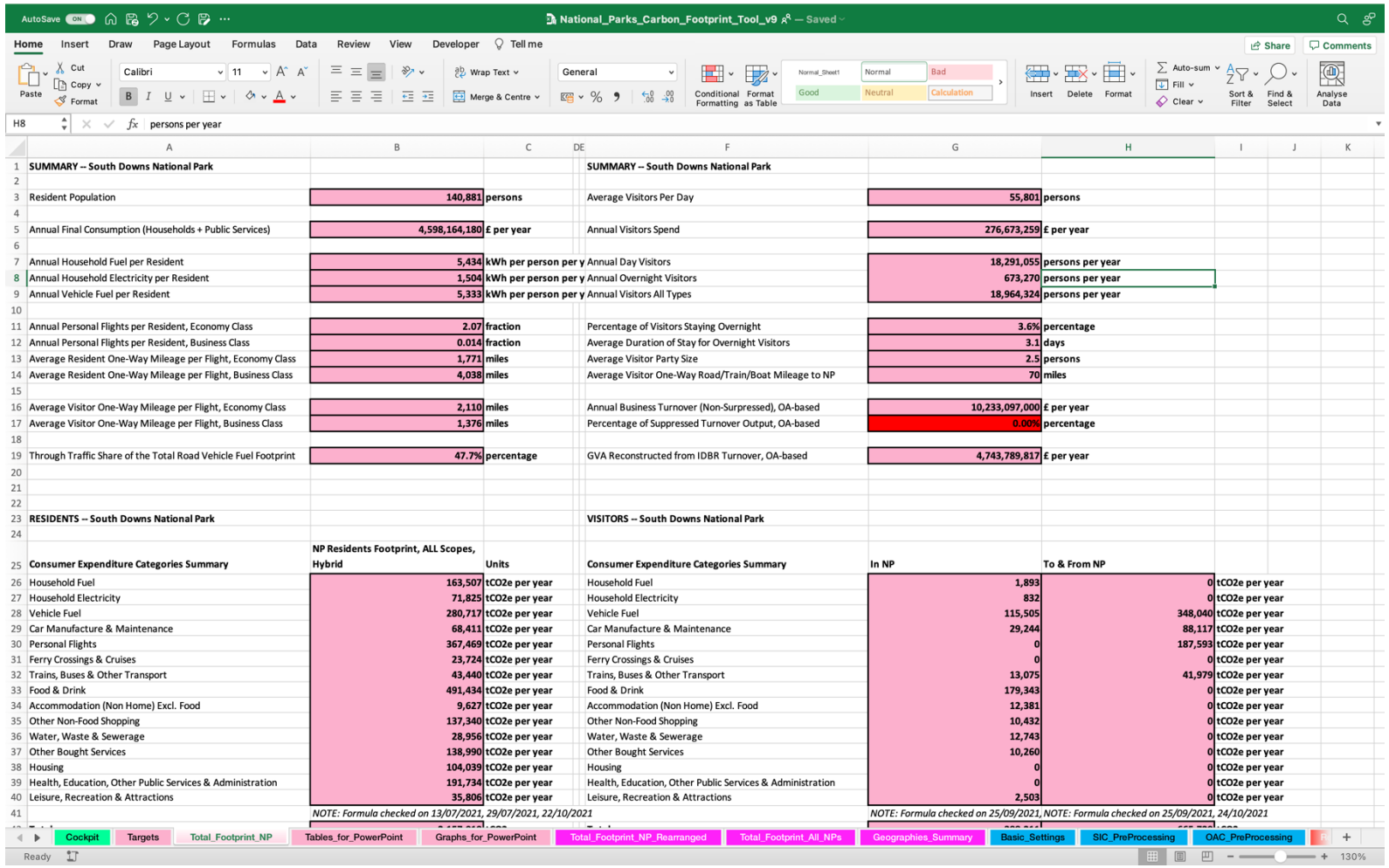
** Downstream Scope 3 is excluded from the assessment of Industry, although it is included when products are consumed by Residents and Visitors*

Summary of Datasets

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

The Model

- Interactive for ALL UK National Parks and 7 AONBs (unitary Local Authorities to follow)
- Excel Workbook with Macros (~100 Sheets)
- Python, R, GIS & Excel pre-processing
- ~30 UK-wide & Custom / SWC datasets
- Six geographies, 105 & 269 industry sectors, ~30 demographic groups
- Scope 1, 2 & 3 GHG footprints for Residents, Visitors & Industries, ~15 output categories
- Targets for six footprint sub-categories, including nature-based climate solutions
- Example pathways to Net Zero
- Comparison between NPs and AONBs



National_Parks_Carbon_Footprint_Tool_v9 — Saved

	A	B	C	F	G	H
1	**SUMMARY -- South Downs National Park**			**SUMMARY -- South Downs National Park**		
3	Resident Population	140,881	persons	Average Visitors Per Day	55,801	persons
5	Annual Final Consumption (Households + Public Services)	4,598,164,180	£ per year	Annual Visitors Spend	276,673,259	£ per year
7	Annual Household Fuel per Resident	5,434	kWh per person per y	Annual Day Visitors	18,291,055	persons per year
8	Annual Household Electricity per Resident	1,504	kWh per person per y	Annual Overnight Visitors	673,270	persons per year
9	Annual Vehicle Fuel per Resident	5,333	kWh per person per y	Annual Visitors All Types	18,964,324	persons per year
11	Annual Personal Flights per Resident, Economy Class	2.07	fraction	Percentage of Visitors Staying Overnight	3.6%	percentage
12	Annual Personal Flights per Resident, Business Class	0.014	fraction	Average Duration of Stay for Overnight Visitors	3.1	days
13	Average Resident One-Way Mileage per Flight, Economy Class	1,771	miles	Average Visitor Party Size	2.5	persons
14	Average Resident One-Way Mileage per Flight, Business Class	4,038	miles	Average Visitor One-Way Road/Train/Boat Mileage to NP	70	miles
16	Average Visitor One-Way Mileage per Flight, Economy Class	2,110	miles	Annual Business Turnover (Non-Surpressed), OA-based	10,233,097,000	£ per year
17	Average Visitor One-Way Mileage per Flight, Business Class	1,376	miles	Percentage of Suppressed Turnover Output, OA-based	0.00%	percentage
19	Through Traffic Share of the Total Road Vehicle Fuel Footprint	47.7%	percentage	GVA Reconstructed from IDBR Turnover, OA-based	4,743,789,817	£ per year
23	**RESIDENTS -- South Downs National Park**			**VISITORS -- South Downs National Park**		
25	**Consumer Expenditure Categories Summary**	**NP Residents Footprint, ALL Scopes, Hybrid**	**Units**	**Consumer Expenditure Categories Summary**	**In NP**	**To & From NP**
26	Household Fuel	163,507	tCO2e per year	Household Fuel	1,893	0 tCO2e per year
27	Household Electricity	71,825	tCO2e per year	Household Electricity	832	0 tCO2e per year
28	Vehicle Fuel	280,717	tCO2e per year	Vehicle Fuel	115,505	348,040 tCO2e per year
29	Car Manufacture & Maintenance	68,411	tCO2e per year	Car Manufacture & Maintenance	29,244	88,117 tCO2e per year
30	Personal Flights	367,469	tCO2e per year	Personal Flights	0	187,593 tCO2e per year
31	Ferry Crossings & Cruises	23,724	tCO2e per year	Ferry Crossings & Cruises	0	0 tCO2e per year
32	Trains, Buses & Other Transport	43,440	tCO2e per year	Trains, Buses & Other Transport	13,075	41,979 tCO2e per year
33	Food & Drink	491,434	tCO2e per year	Food & Drink	179,343	0 tCO2e per year
34	Accommodation (Non Home) Excl. Food	9,627	tCO2e per year	Accommodation (Non Home) Excl. Food	12,381	0 tCO2e per year
35	Other Non-Food Shopping	137,340	tCO2e per year	Other Non-Food Shopping	10,432	0 tCO2e per year
36	Water, Waste & Sewerage	28,956	tCO2e per year	Water, Waste & Sewerage	12,743	0 tCO2e per year
37	Other Bought Services	138,990	tCO2e per year	Other Bought Services	10,260	0 tCO2e per year
38	Housing	104,039	tCO2e per year	Housing	0	0 tCO2e per year
39	Health, Education, Other Public Services & Administration	191,734	tCO2e per year	Health, Education, Other Public Services & Administration	0	0 tCO2e per year
40	Leisure, Recreation & Attractions	35,806	tCO2e per year	Leisure, Recreation & Attractions	2,503	0 tCO2e per year
41		*NOTE: Formula checked on 13/07/2021, 29/07/2021, 22/10/2021*			*NOTE: Formula checked on 25/09/2021, NOTE: Formula checked on 25/09/2021, 24/10/2021*	

Cockpit | Targets | Total_Footprint_NP | Tables_for_PowerPoint | Graphs_for_PowerPoint | Total_Footprint_NP_Rearranged | Total_Footprint_All_NPs | Geographies_Summary | Basic_Settings | SIC_PreProcessing | OAC_PreProcessing

Output Variables	Units	Dartmoor National P	Exmoor National Par	Northumberland Na	North York Moors N	Peak District Nationa	The Broads	The Broads - Adjacer	New Forest National	South Downs Nationa	Lake District Nationa	Yorkshire Dales Nati	The Loch Lomond an	The Cairngorms Nati	Brecon Beacons Nat	Pembrokeshire Coas	Snowdonia National Park
		E26000001	E26000002	E26000004	E26000005	E26000006	E26000007	E26000007X	E26000009	E26000010	E26000011	E26000012	S21000002	S21000003	W18000001	W18000002	W18000003
SUMMARY																	
Resident Population	persons	33,986	9,585	1,364	24,294	40,732	17,747	38,062	35,040	140,881	40,028	22,448	14,962	19,211	37,681	22,928	26,707
Annual Final Consumption (Households + Public Services)	£ per year	1,124,157,641	328,319,552	46,173,739	814,299,670	1,355,141,688	588,551,160	1,243,131,339	1,207,581,356	4,598,164,180	1,315,931,378	759,993,090	491,640,403	627,084,035	1,203,947,595	762,560,481	858,733,588
Annual Household Fuel per Resident	kWh per person per	4,407	1,505	395	3,925	6,467	3,490	4,601	6,176	5,434	6,352	4,042	4,718	3,787	7,994	7,038	4,804
Annual Household Electricity per Resident	kWh per person per	1,375	1,318	1,586	1,515	1,274	1,054	949	1,944	1,504	1,494	1,481	1,912	1,868	1,428	1,391	1,255
Annual Vehicle Fuel per Resident	kWh per person per	6,452	4,506	3,135	4,852	5,749	3,851	4,252	6,150	5,333	7,081	7,138	6,471	5,675	5,918	4,442	4,809
Annual Personal Flights per Resident, Economy Class	fraction	1.08	0.24	0.10	0.60	1.60	0.69	0.66	0.97	2.07	1.25	0.88	0.08	1.35	1.19	1.09	0.90
Annual Personal Flights per Resident, Business Class	fraction	0.002	0.000	0.003	0.000	0.018	0.001	0.001	0.012	0.014	0.005	0.006	0.000	0.000	0.006	0.000	0.001
Average Resident One-Way Mileage per Flight, Economy Class	miles	2,968	2,579	2,630	2,529	1,665	2,101	2,086	2,815	1,771	1,960	2,278	3,122	797	1,796	1,876	1,965
Average Resident One-Way Mileage per Flight, Business Class	miles	609	0	645	0	4,936	4,228	4,228	2,733	4,038	3,762	1,649	0	443	6,763	0	4,591
Average Visitor One-Way Mileage per Flight, Economy Class	miles	1,893	1,650	5,112	5,881	2,473	2,557	2,858	3,202	2,110	2,400	2,919	5,396	2,229	3,068	2,766	2,693
Average Visitor One-Way Mileage per Flight, Business Class	miles	0	0	0	0	3,898	0	0	5,066	1,376	0	0	0	0	3,422	0	0

Choose the National Park to analyse:	South Downs National Park

Sheet #	Sheet Names
1	Cockpit
2	Targets
3	Total_Footprint_NP
4	Tables_for_PowerPoint
5	Graphs_for_PowerPoint
6	Total_Footprint_NP_Rearranged
7	Total_Footprint_All_NPs

SMALL WORLD CONSULTING

Part 3:
Results

SMALL WORLD CONSULTING

Key Stats: Loch Lomond & The Trossachs National Park

SMALL WORLD CONSULTING

Output Variable	Value	Unit	Source
Land Area	**186,500**	ha	Official Figures / CEH LCM
Resident Population	**14,962**	persons	ONS Mid-2019 LSOA Population; ONSPD 2019; BEIS 2019 Postcode Electricity Meters; Custom Postcodes
Resident Population Density	**0.08**	persons per ha	Based on the Above
Annual Final Consumption (Households + Public Services)	**32,859**	£ per person per year	ONS 2019 Consumption; ONSPD 2019; ONS 2011 Census Demographics; Custom Postcodes
Annual Household Fuel per Resident	**6,289**	kWh per person per year	BEIS 2019 Postcode Gas; BEIS 2018 Residual Fuels; ONSPD 2019; Custom Postcodes
Annual Household Electricity per Resident	**1,912**	kWh per person per year	BEIS 2019 Postcode Electricity; ONSPD 2019; Custom Postcodes
Annual Vehicle Fuel per Resident	**6,471**	kWh per person per year	BEIS 2018 Road Fuels; ONSPD 2019; Custom Postcodes
Annual Personal Flights per Resident, Economy Class	**0.08**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate
Annual Personal Flights per Resident, Business Class	**0.000**	fraction	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes; SWC Population Estimate
Average Resident One-Way Mileage per Flight, Economy Class	**3,122**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Average Resident One-Way Mileage per Flight, Business Class	**0**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Annual Business Turnover, COA-based	**369,536,000**	£ per year	IDBR 2019; ONSPD 2019; Custom Postcodes
Percentage of Suppressed Turnover Output, COA-based	**9.23%**	percentage	IDBR 2019; ONSPD 2019; Custom Postcodes

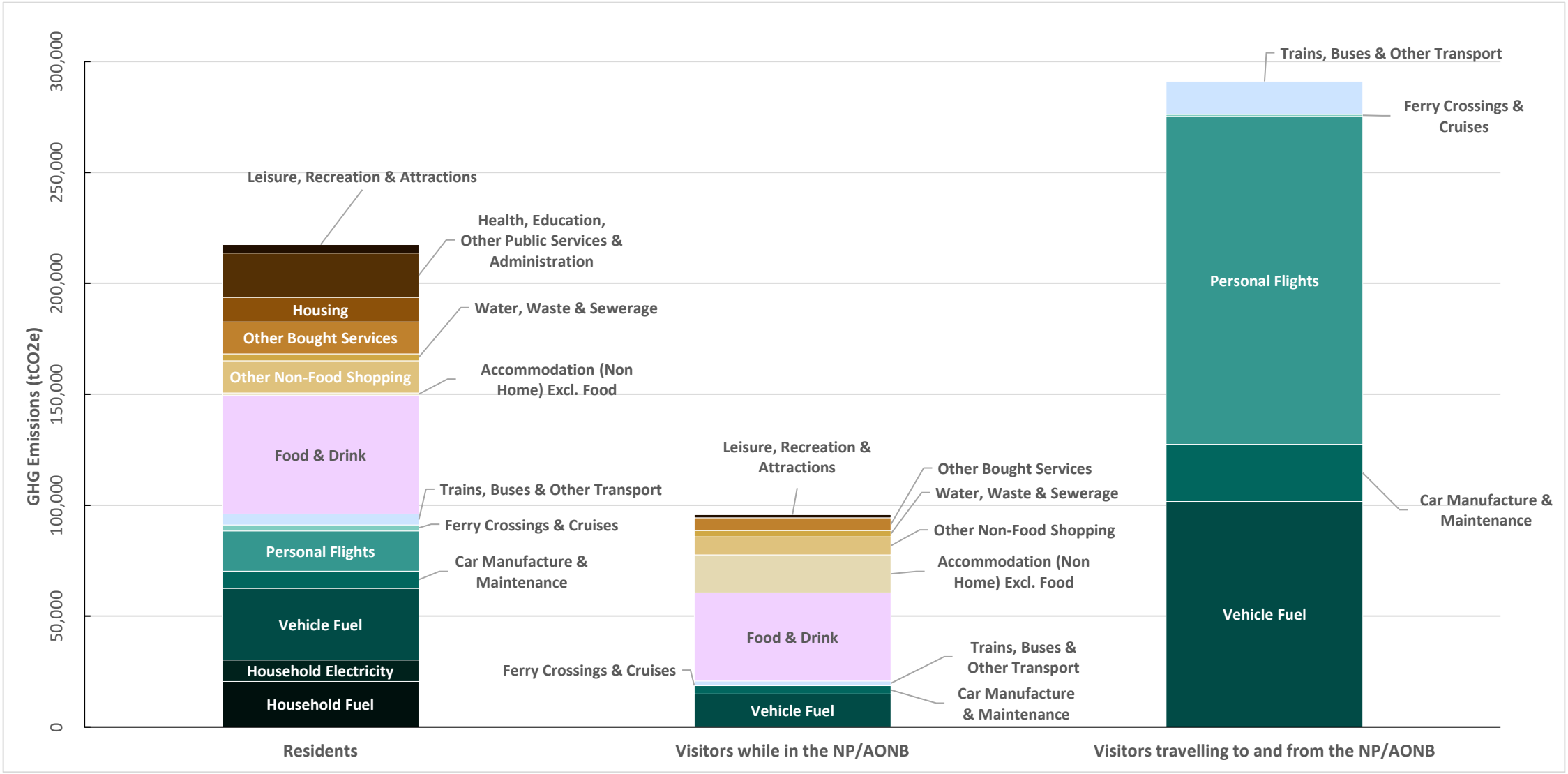
Output Variable	Value	Unit	Source
Average Visitors Per Day	**12,384**	persons	STEAM 2019
Visitor Population Density	**0.07**	persons per ha	Based on the Above
Annual Visitors Spend	**243,332,534**	£ per year	STEAM 2019
Annual Visitors All Types	**2,725,751**	persons per year	STEAM 2019
Percentage of Visitors Staying Overnight	**30.8%**	percentage	STEAM 2019
Average Duration of Stay for Overnight Visitors	**3.1**	days	STEAM 2019
Average Visitor Party Size	**2.9**	persons	Visitor Survey
Average Visitor One-Way Road/Train/Boat Mileage Travelled	**170**	miles	Visitor Survey
Estimated Fraction of Trips by Car	**72.4%**	percentage	Visitor Survey
Estimated Fraction of Trips Involving Flights	**15.0%**	percentage	Visitor Survey
Average Visitor One-Way Mileage per Flight, Economy Class	**5,396**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes
Average Visitor One-Way Mileage per Flight, Business Class	**0**	miles	CAA 2019 Passenger Survey; ONSPD 2019; Custom Postcodes

SMALL WORLD CONSULTING

Residents
217,433 tCO_2e/year

Visitors while in the area
95,712 tCO_2e/year

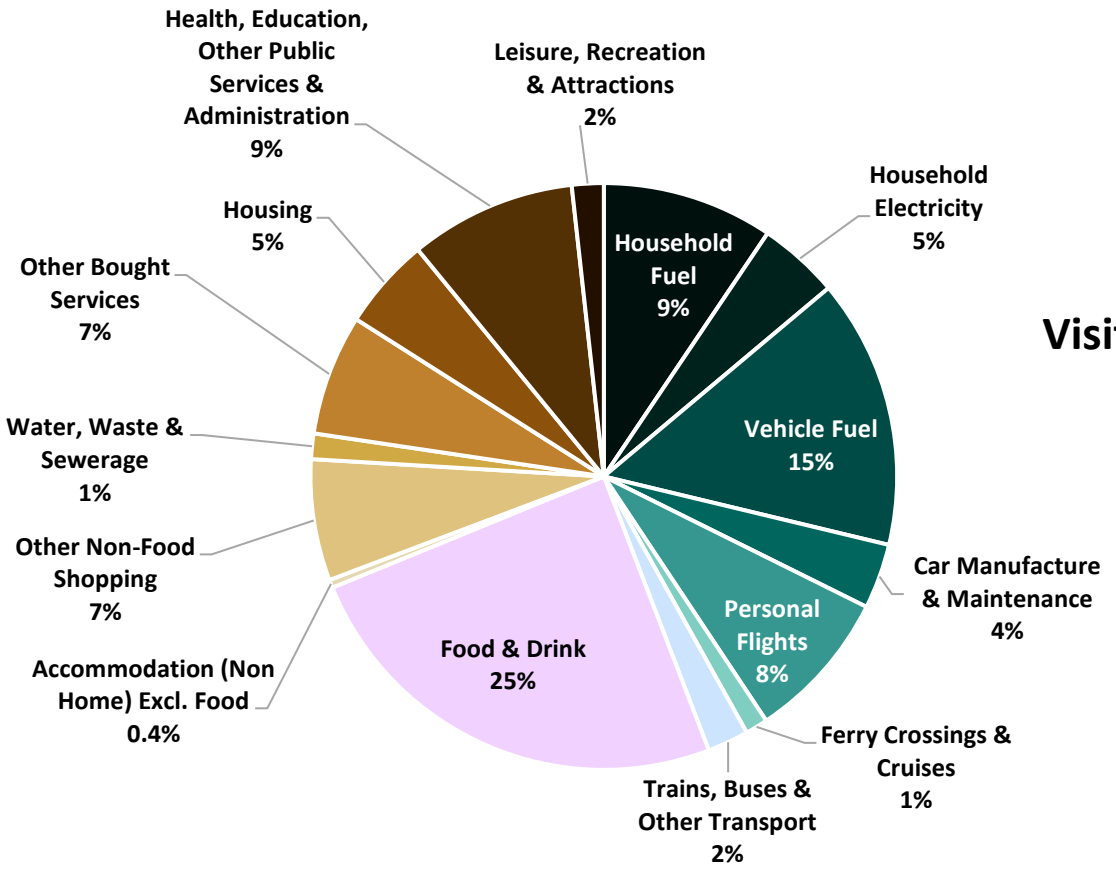
Visitors travelling to & from the area
290,978 tCO_2e/year



➢ **Consumption-based GHG emissions for Residents and Visitors. See Appendix for sector definitions and data sources**

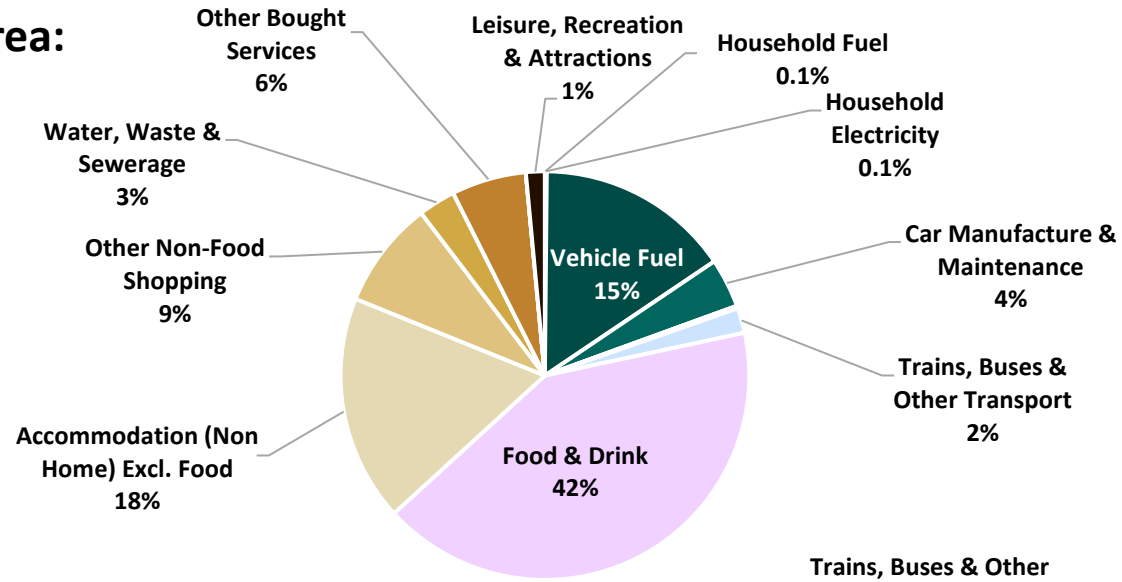
SMALL WORLD CONSULTING

Residents: 217,433 tCO_2e/year

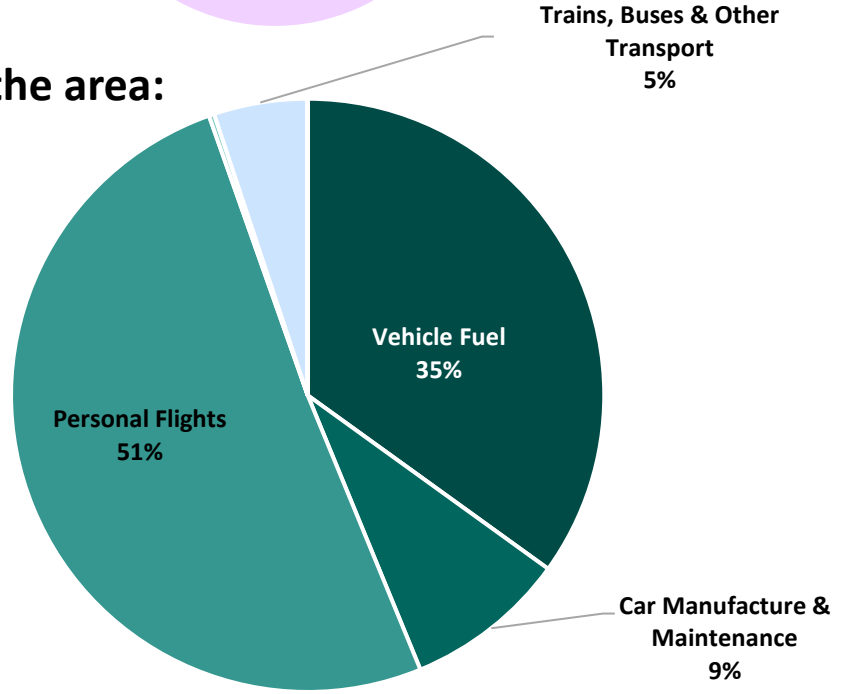


➢ Residents' GHG emissions, by percentage

Visitors while in the area: 95,712 tCO_2e/year



Visitors travelling to & from the area: 290,978 tCO_2e/year

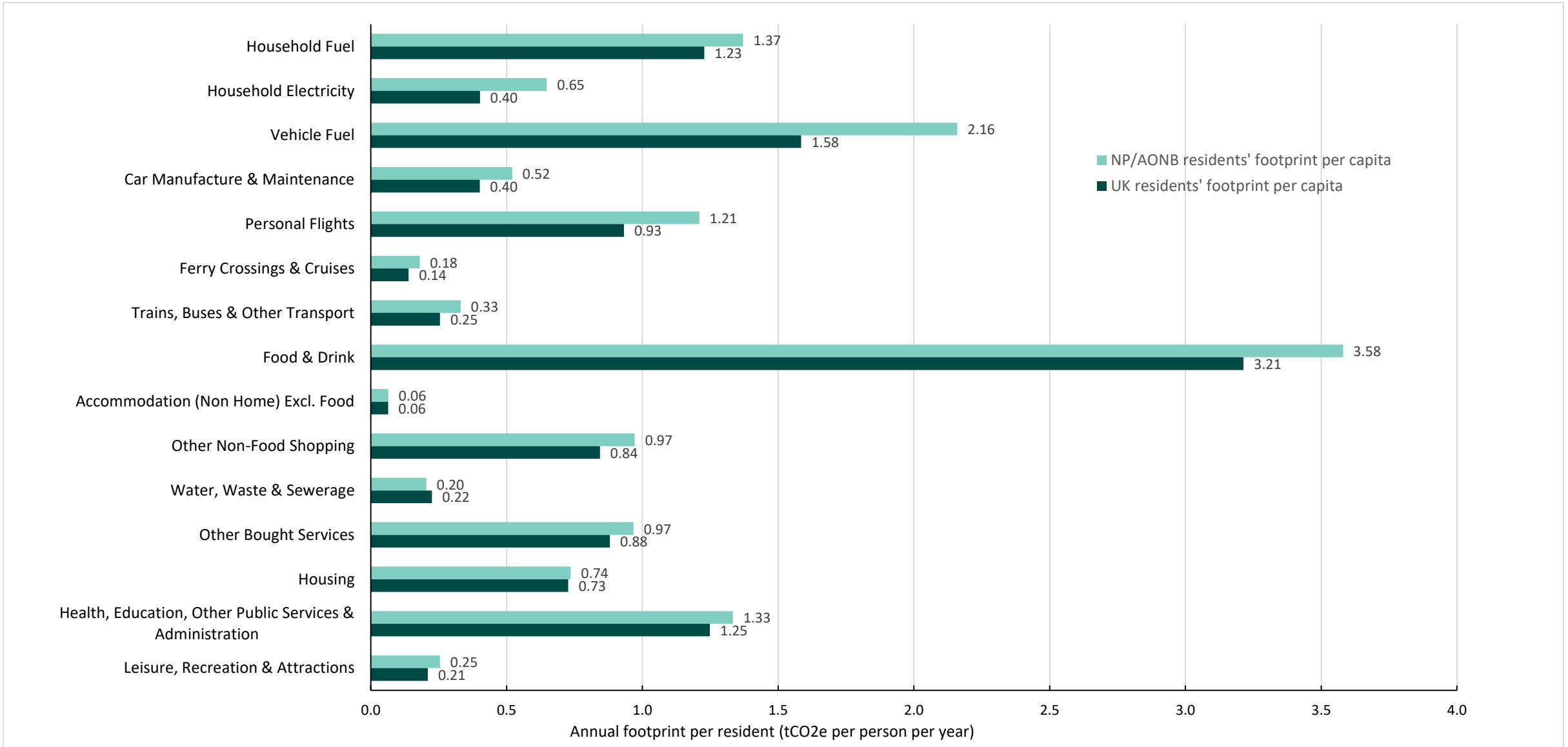


➢ Visitors' GHG emissions while in (top) and on the way to & from (bottom) the area, by percentage

SMALL WORLD CONSULTING

Residents' Total
14.5 tCO_2e/year
per capita

UK Total
12.4 tCO_2e/year
per capita



➢ **Residents' GHG emissions compared with UK national average per capita, by category**

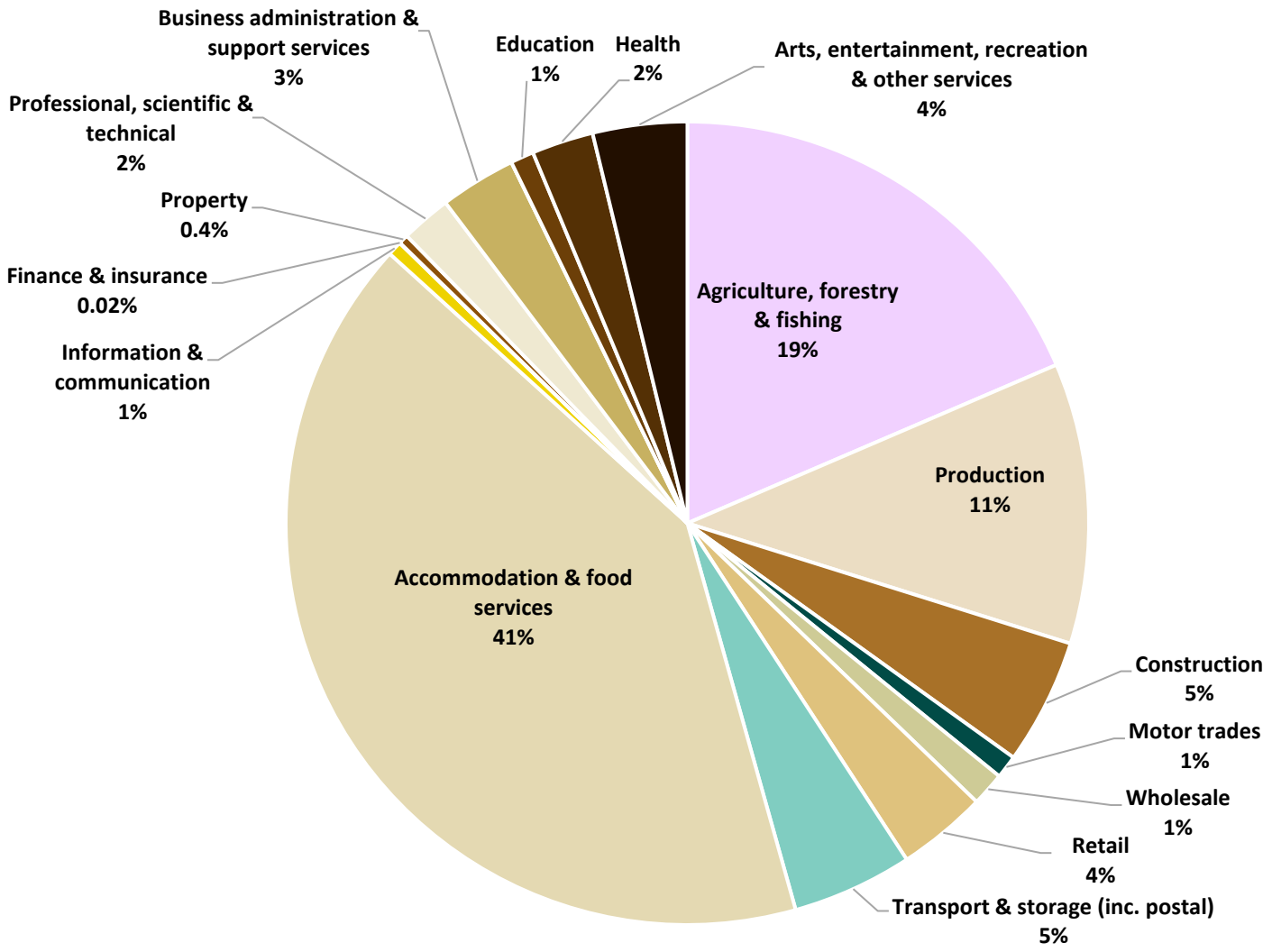
Emissions from major roads within the landscape

- Selected major roads:
  64,386 tCO_2e / year (smaller set)
  105,600 tCO_2e / year (larger set)
- Through traffic (not stopping in the area):
  95,707 tCO_2e / year
  ~**91%** of total major road emissions
- Comparison: Total residents' footprint:
  217,433 tCO_2e / year

Assessment of Industry Footprint: Caveats

- Aside of the consumption-based footprint of residents and visitors, we also include, for perspective, a rough assessment of the footprint of industries and their supply chains
- We use the Office for National Statistics (ONS) Inter-Departmental Business Register (IDBR) data for business turnovers in Census Output Areas (COA) rather than Local Authority Gross Value Added (GVA) data since it is more geographically specific
- Note that the reported turnover data does not necessarily reflect on the actual geographical distribution of locations where business revenue is being generated
- Because of ONS IDBR data confidentiality constraints, we also had to include all COA geographies overlapping with each landscape's boundary, leading to marginal overestimates of the total turnover and the resulting industry footprint within the landscape
- We excluded all overlapping COA geographies known to contain large emitters as per the National Atmospheric Emissions Inventory dataset
- The industry footprint assessment is comparatively crude since COA-level business turnover data has only 15 broad sectors, and the footprint calculation is based on the associated industry-specific carbon intensity averages for the UK
- The use of the UK-average carbon intensities could have a particular effect on the agriculture and forestry sector footprints because these sectors are known to have unique features across most National Parks and AONBs
- Note that this assessment overlaps with our more detailed analysis of residents and visitors, since it is not feasible to eliminate double-counting when local businesses sell to residents and visitors

Industry (IDBR data): 52,938 tCO_2e/year



➢ **Industry GHG emissions, by sector**

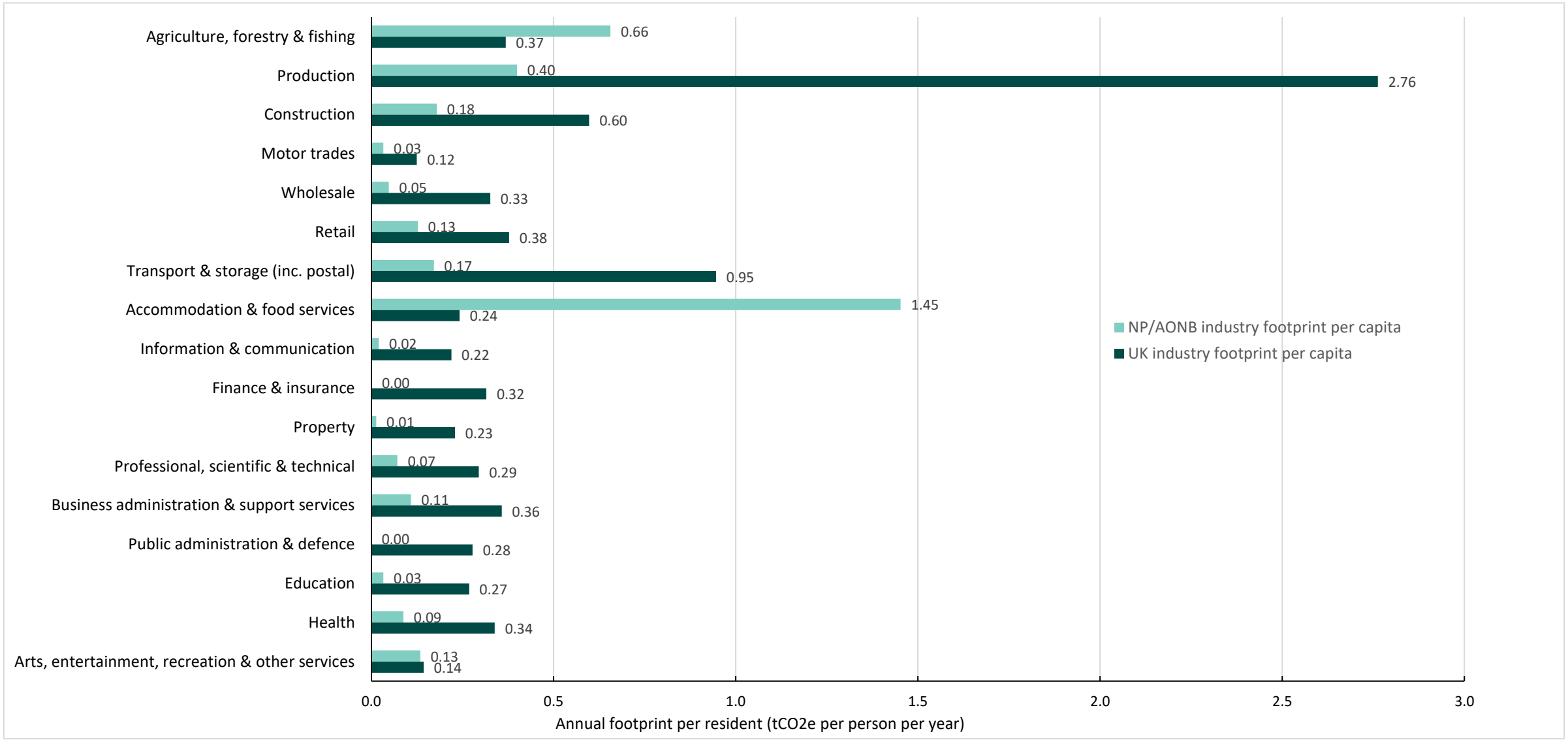
This breakdown mostly excludes:

➢ **Land use CO_2 – 121,510 tCO_2e/year**

The "Agriculture & Forestry" IDBR sector* partially includes:

➢ **Land use non-CO_2 49,254 tCO_2e/year**

** IDBR turnover data for agriculture & forestry used here is closely matched to the landscape boundary, but the corresponding footprint estimate is based on UK-average carbon intensity of these sectors*



➢ **Industry GHG emissions compared with UK national average per capita, by sector**

Part 4: Pathway to Net Zero

SMALL WORLD CONSULTING

Six categories for emission reduction targets

Energy-only GHG
Residents, visitors, industry (incl. supply chain)

Travel to/from the area
Visitors (excl. flights, incl. car manufacturing)

Food & drink
Residents, visitors

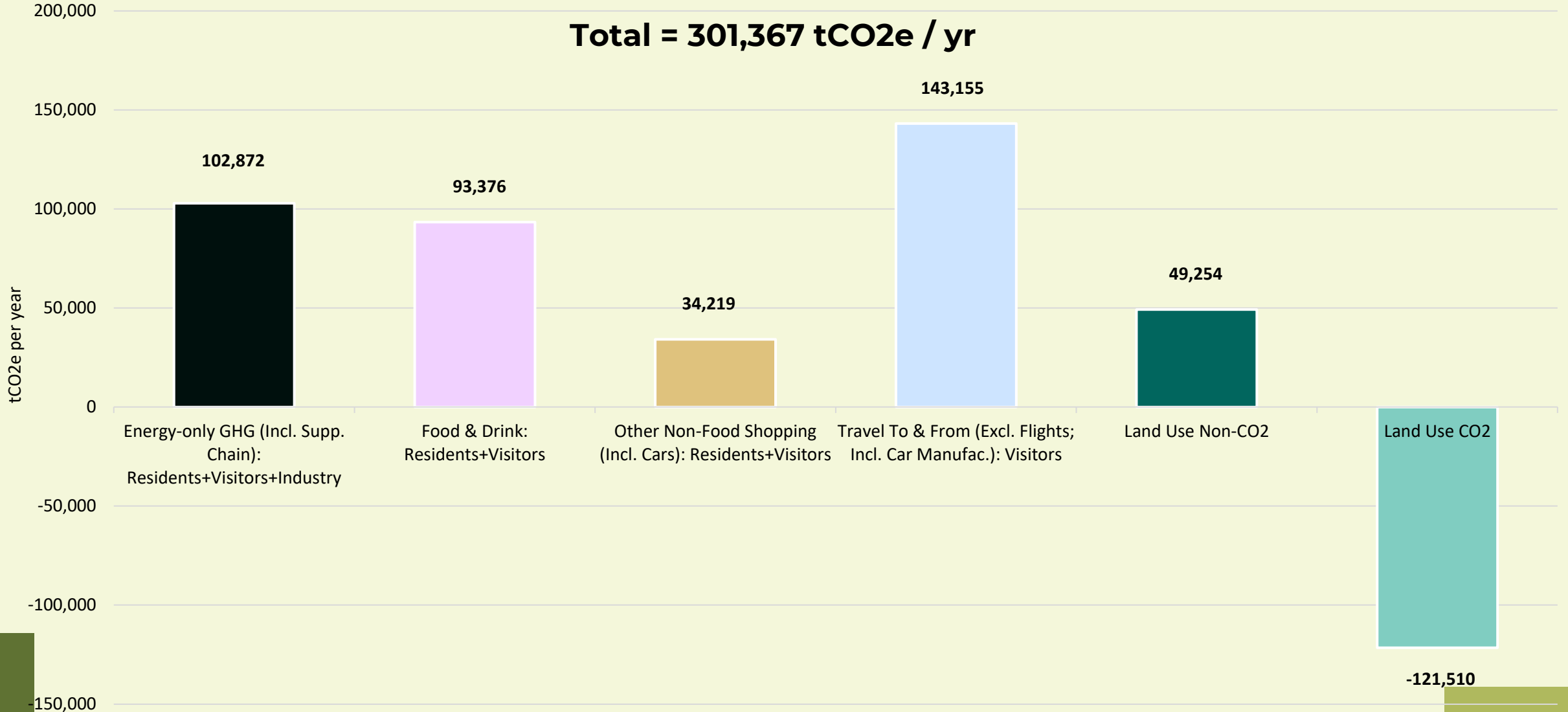
Land-based non-CO_2
(e.g. livestock, fertiliser use)

Non-food shopping
Residents + visitors (incl. car purchases)

Land-based CO_2
(e.g. sequestration, soil degradation)

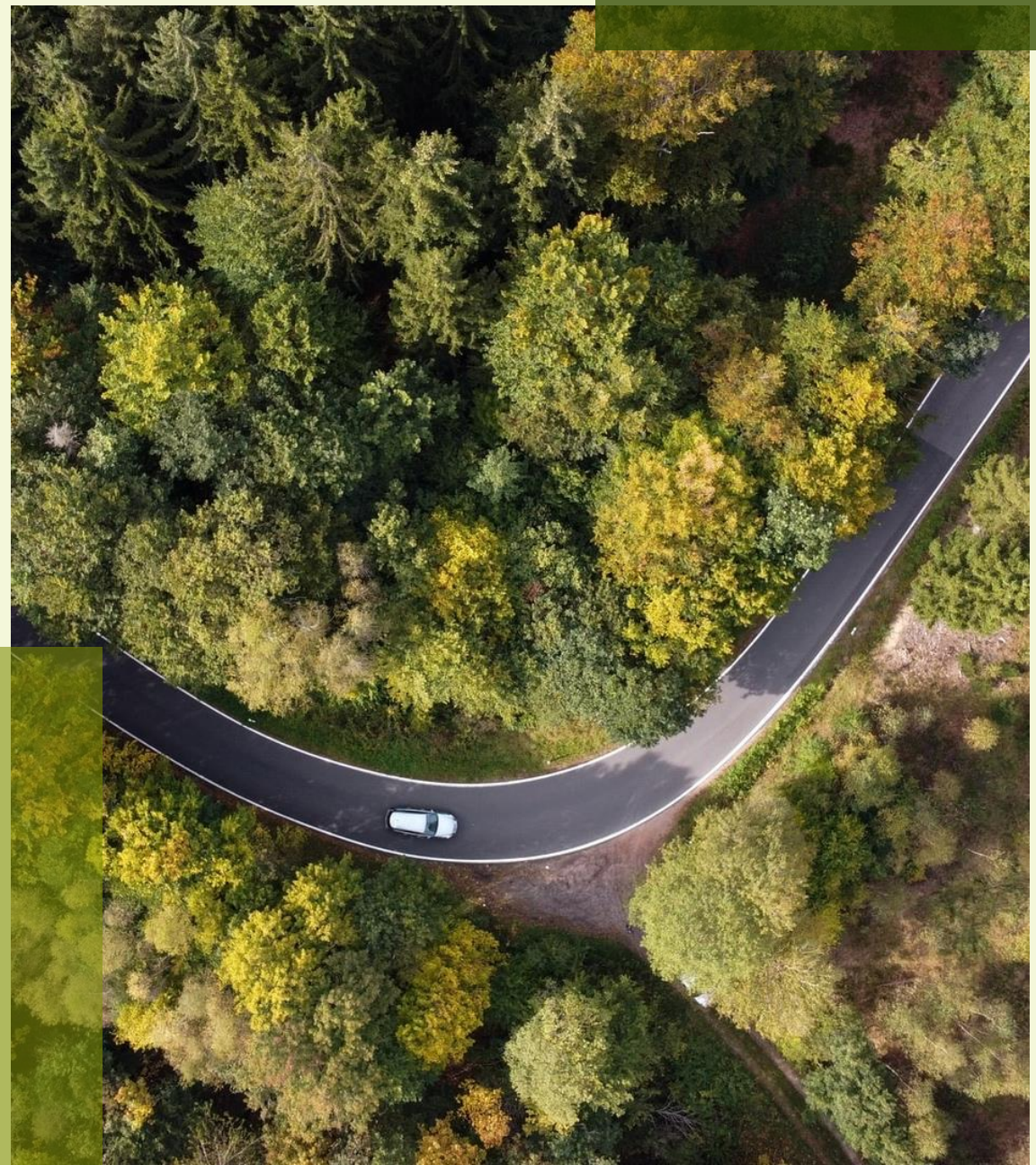
SMALL WORLD CONSULTING

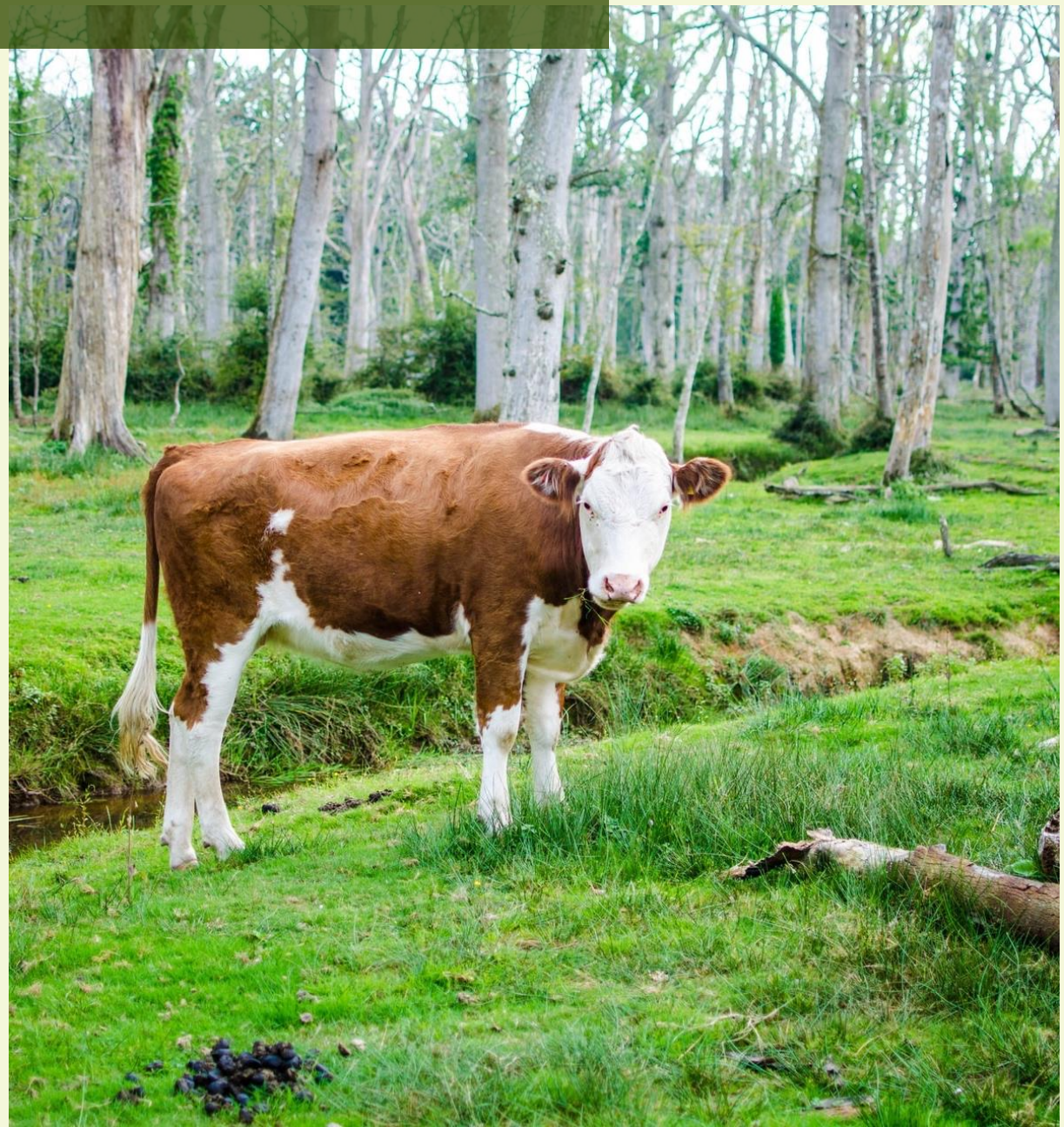
2019 baseline emissions



Emission reduction & carbon sequestration targets

- Derived from science-based assessments, including:
  - UK’s Sixth Carbon Budget
  - Tyndall Carbon Budget Tool
  - UK’s National Food Strategy
  - UNFCCC Paris Agreement
- Proposed emissions reductions / carbon sequestration targets require **immediate, ambitious action** to be taken across ALL six emission categories





Land use change / management options

- New native broadleaf/mixed woodland
- New productive coniferous woodland
- Peatland restoration
- Agroforestry (improved grassland + cropland)*
- Hedgerows (improved grassland + cropland)*
- Introducing legume species (improved grassland)
- Introducing cover crops (cropland)*

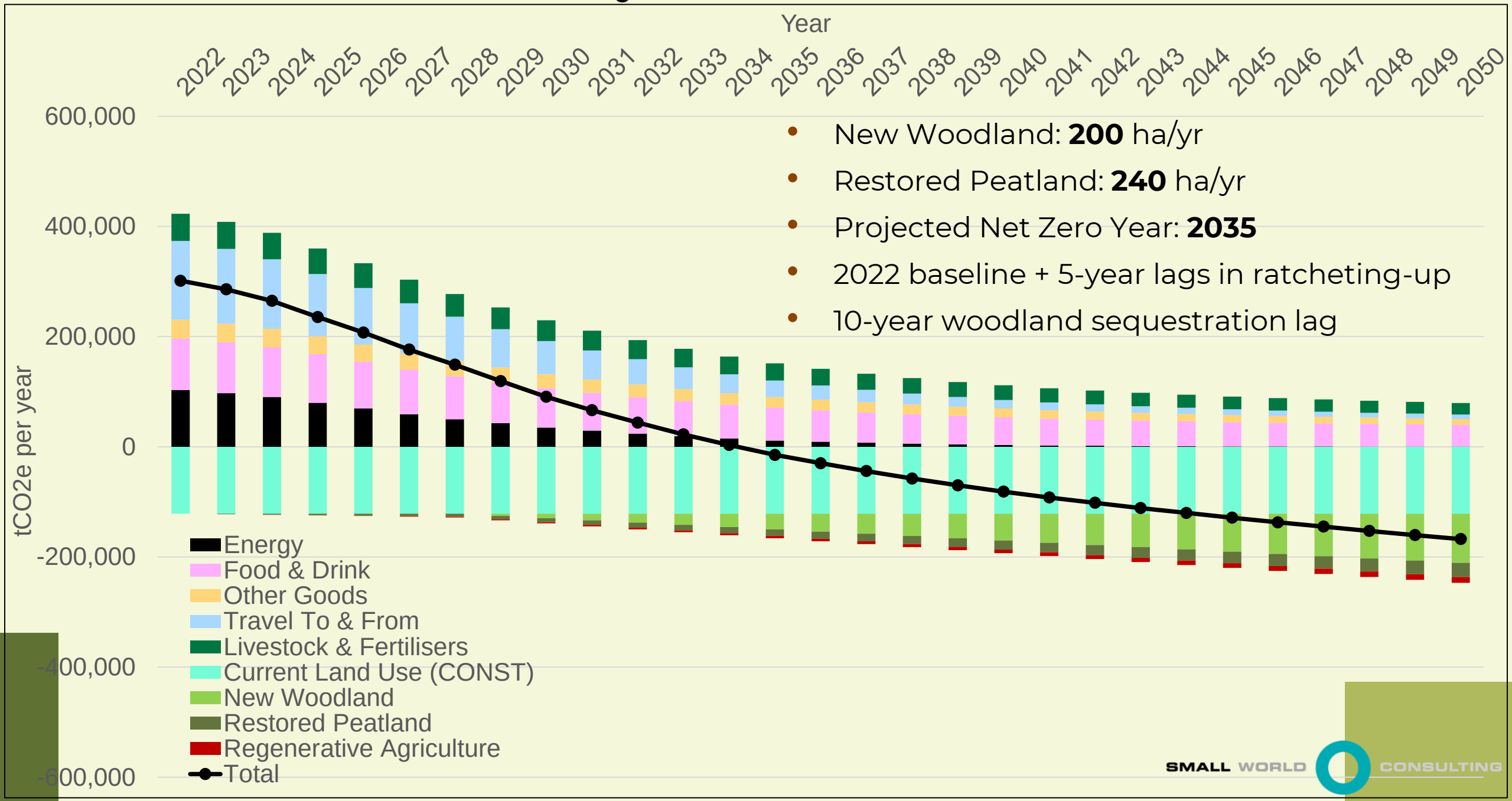
** NOTE: Grey colour means the option is not relevant for the given landscape*

Net Zero Pathways: Key Assumptions & Caveats

- Energy decarbonisation is aligned with an estimated fair share of the remaining emissions for the LLTNP to limit global warming to 1.5°C
- Three pathways for woodland creation and peatland restoration:
  i. current levels persist;
  ii. “Future Nature Roadmap” targets are adopted;
  iii. high-end targets by Small World Consulting (SWC) are adopted
- Current woodland creation and peatland restoration rates started in 2018
- All measures take 5 years to ratchet up from current levels to required rates
- 10-year lag between planting trees and onset of carbon uptake
- The pathways presented here are designed to provide strategic goals rather than operational roadmaps
- Net zero pathways are relative in that they depend of the agreed assessment boundary as well as on local circumstances for each area

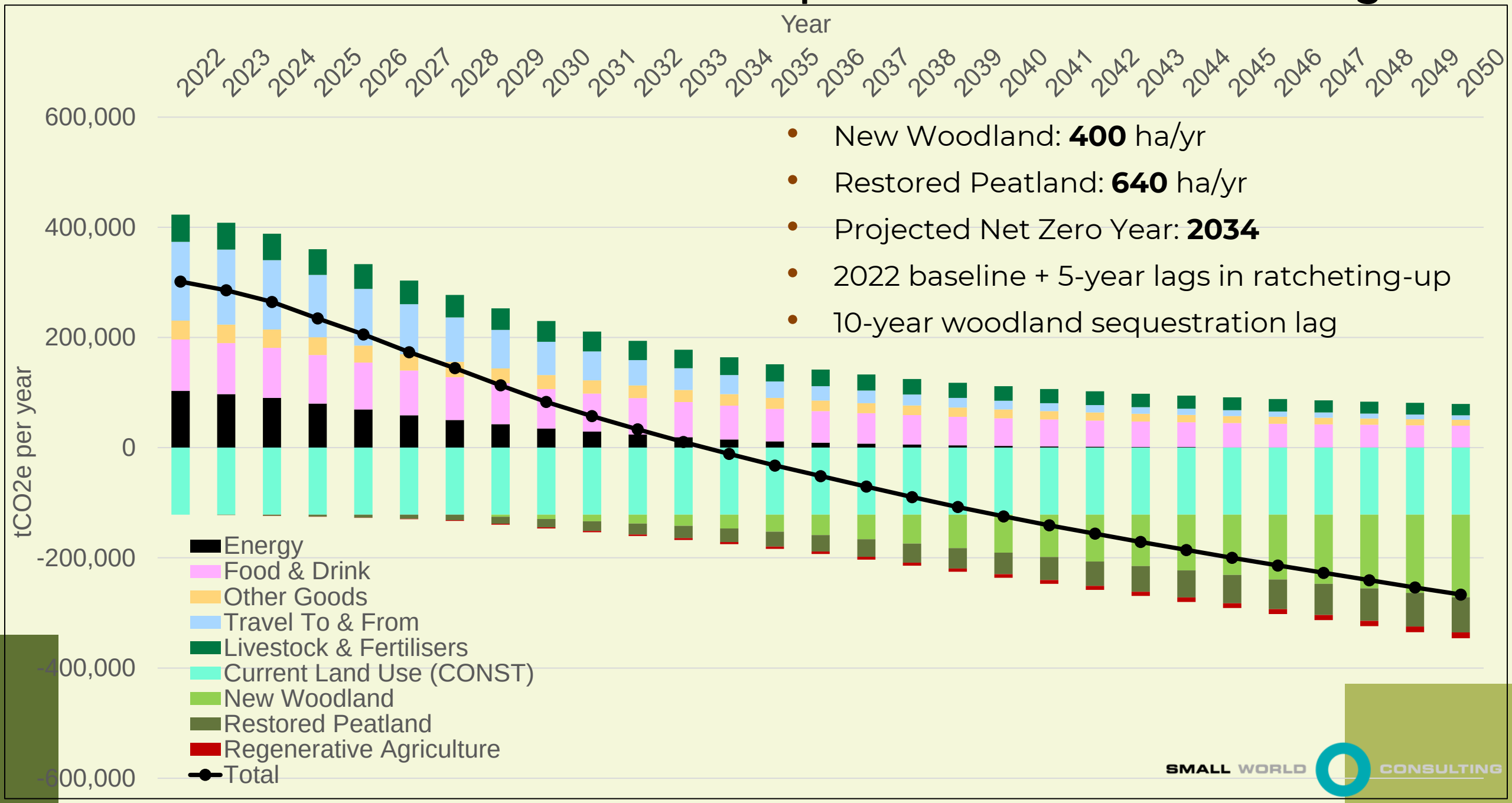
SMALL WORLD CONSULTING

Alternative Net Zero Pathway 1: Current Woodland & Peatland Rates



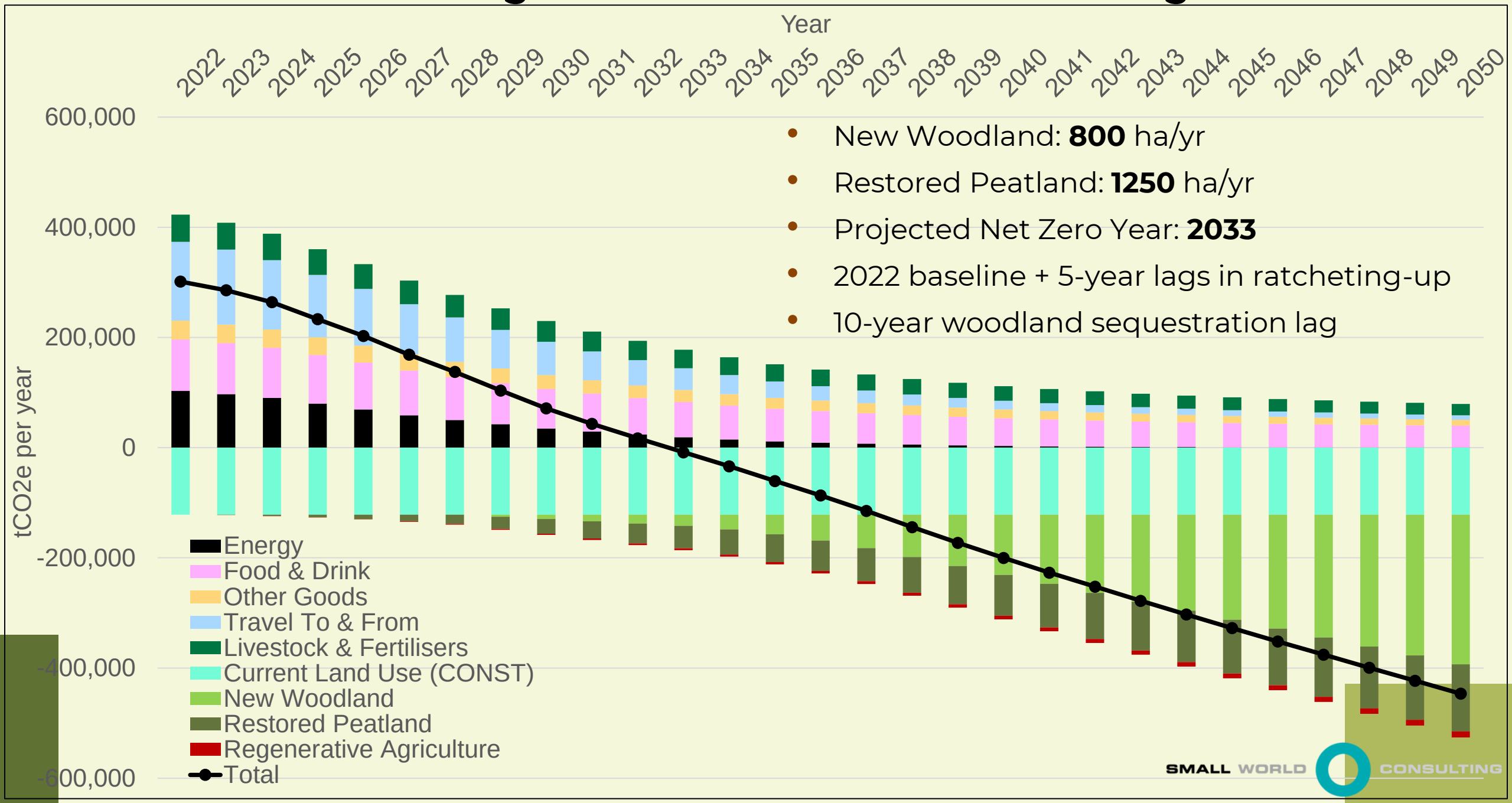
SMALL WORLD CONSULTING

Alternative 2: “Future Nature Roadmap” Woodland & Peatland Targets



SMALL WORLD CONSULTING

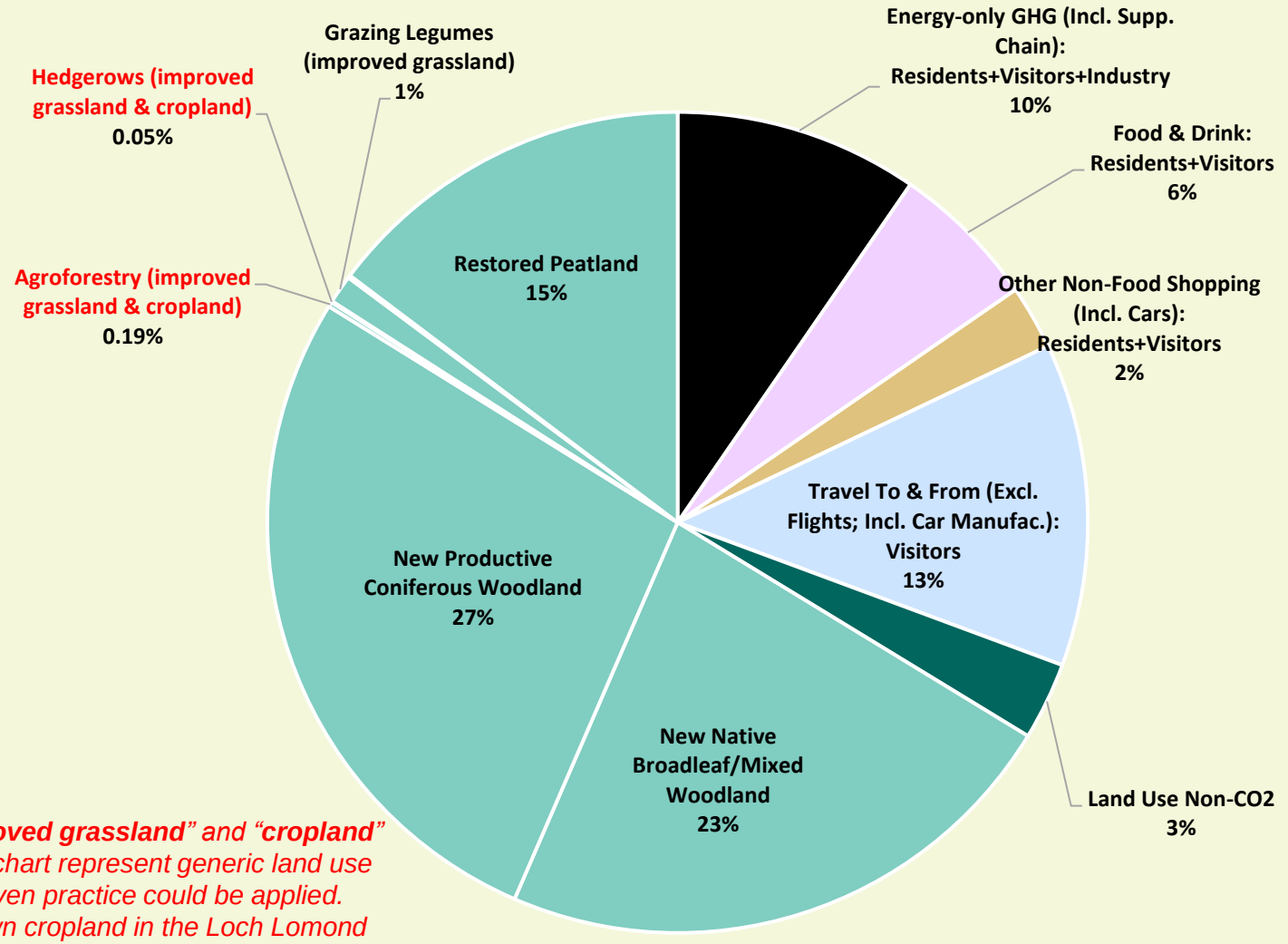
Alternative 3: SWC's High-End Woodland & Peatland Targets



Summary: emission reduction & carbon sequestration targets (with alternative 3 for woodland & peatland)

- Energy decarbonisation (excl. transport): **~13%** / yr
- Transport: **~10%** / yr
- Food & other goods: ~**5%** / yr
- New woodland: **800** ha / yr
- Restored peatland: ~**1,250** ha / yr
- Regenerative agriculture: ~**200** ha / yr

% breakdown of total proposed reduction in net annual GHG emissions from 2019 to 2050 (~1 $MtCO_2e$ / year), by category:



*Note: The "**improved grassland**" and "**cropland**" labels in the pie chart represent generic land use types where a given practice could be applied. There is no known cropland in the Loch Lomond & The Trossachs National Park*

SMALL WORLD CONSULTING

Appendices

Appendix 1. Land use data

- For Loch Lomond & The Trossachs National Park, we used the 2019 CEH Land Cover Map, the 2016 Carbon and Peatland Map of Scotland, and in-house land use knowledge. This serves as a basis for assessing land use change options to reduce land-based emissions and enhance carbon sequestration.
- NOTE: All land use datasets have considerable uncertainties. We adopted the CEH Land Cover Map classification for land use assessments across all National Parks and AONBs on the current programme.
- (*) Likely misclassification in the CEH Land Cover Map (there is no known cropland in the National Park).

CEH Land Cover (Habitat) Type	CEH LC Code	Habitat Area (ha)	Peat Area (ha)	Estimated % of Peat Area in Healthy Condition
Broadleaved woodland	1	20,023	1,707	100%
Coniferous woodland	2	35,588	11,366	0%
Arable and horticulture (*)	3	1,447	0	NA
Improved grassland	4	9,430	497	0%
Neutral grassland	5	2	0	NA
Calcareous grassland	6	0	0	NA
Acid grassland	7	77,999	40,956	25%
Fen, marsh, swamp	8	0	0	NA
Heather	9	13,358	8,603	25%
Heather grassland	10	7,920	3,363	25%
Bog	11	1,525	666	25%
Saltmarsh	19	54	3	100%
Urban	20	278	39	0%
Suburban	21	1,060	61	0%
Total	**NA**	**168,684.0**	**67,260.2**	**NA**

Appendix 2. Agriculture management options

- For agricultural land, we follow broad principles and recommended uptake levels for Regenerative Agriculture outlined in the Sixth Carbon Budget (UK-wide Net Zero pathway)
- We use available generic estimates for soil and biomass carbon sequestration fluxes associated with selected practices (e.g. Bossio et al. (2020) “The role of soil carbon in natural climate solutions.” *Nature Sustainability*)
- Improved grassland (where applicable): the focus is on introducing legume species (natural nitrogen fixers), increasing hedges on field margins, and introducing agroforestry practices
- Arable & horticulture (where applicable): the focus is on introducing cover cropping, increasing hedges on field margins, and introducing agroforestry practices
- There is robust evidence that these measures increase annual carbon sequestration rates in soil and biomass (where applicable), and have co-benefits such as improved soil health and productivity, reduced risk of erosion, enhanced biodiversity, greater habitat connectivity, and improved flood resilience
- However, it is important to note that while these measures are vital in many aspects, their carbon sequestration rates are several times lower than typical 30-year averages for a newly planted woodland
- Other points to note:
    - To keep the additional sequestered carbon in soil (and biomass), the practices need to be maintained indefinitely
    - Soil carbon stocks are vulnerable both to gradual climate warming (due to faster decomposition of organic matter) and growing weather extremes (due to higher rates of soil erosion & run-off)
    - It is possible that soil carbon losses could negate plant biomass gains in warmer climates with higher atmospheric CO2 concentrations. The net effect is still highly uncertain and will likely vary depending on local conditions

Appendix 3. Woodland creation options

- Our chosen UK-wide woodland creation target from the Sixth Carbon Budget is **50,000 ha/year** between present and 2050, representing medium to high levels of ambition as part of the proposed Net Zero scenario for 2050
- We apportion the UK woodland target to each NP/AONB using two methods: (i) according to present-day woodland area in the NP/AONB, and (ii) according to a minimum suitable area within the NP/AONB (high-level woodland opportunity mapping)
- Target (ii) is used to propose a more ambitious custom target (iii). For most protected landscapes, the ambition is around two times the minimum target (ii) based on suitable areas, reflecting on the bigger role that protected landscapes & other rural areas are likely to play in scaling up nature-based climate solutions. The proposed higher ambition approach is supported by field-level woodland opportunity mapping performed by several landscapes (e.g. Cotswolds, Northumberland)
- For Loch Lomond & The Trossachs, the resulting woodland target is given below:

Woodland Target Apportioned by Current Woodland Area in NP/AONB	658	ha per year
Minimum Woodland Target Apportioned by Suitable Areas in NP/AONB	384	ha per year
Custom Woodland Target in NP/AONB	800	ha per year

- Recognising natural limitations for new woodland creation in some landscapes (e.g. dominated by calcareous grassland), we are open to the idea of sharing the ambitions woodland targets with the neighbouring unitary Local Authorities (LAs) that may have more suitable areas
- However, this needs to be factored in their own Net Zero pathways, as typical LAs have a footprint of the scale of the Cotswolds AONB and the South Downs NP, and would need ambitions woodland creation programmes of their own
- IMPORTANT: The resulting woodland creation (and, where applicable, peatland restoration) targets represent possible and/or desirable scenarios but **require detailed field-level opportunity / feasibility mapping**
- Such mapping should be done in the context of current and proposed future land use policies overseen by UK Government and devolved administrations, and well as reflecting on the development of private carbon offset markets

Appendix 4. Peatland restoration options

- Our chosen UK-wide peatland restoration target from the Sixth Carbon Budget is just over **50,000 ha/year** between present and 2050 as part of the proposed Net Zero scenario for 2050
- We apportion the UK peatland target to each NP/AONB according to its estimated degraded peat area
- We use the BEIS classification for modified / degraded peatland and apply the associated emission factors derived from Evans et al. (2017) “Implementation of an Emissions Inventory for UK Peatlands”, summarised in the table below:

Peat Condition & Drainage Status	Direct CO2	DOC CO2	POC CO2	Direct CH4	Ditches CH4	Direct N2O	Total	Units
Eroding modified bog (bare peat), Drained	6.18	1.14	5	0.14	0.68	0.14	13.28	tCO2e per year per ha
Eroding modified bog (bare peat), Undrained	6.18	0.69	5	0.15	0	0.14	12.16	
Modified bog (heather/grass dominated), Drained	0.13	1.14	0.3	1.26	0.66	0.06	3.55	
Modified bog (heather/grass dominated), Undrained	0.13	0.69	0.1	1.33	0	0.06	2.31	
Cropland peat, Drained	28.6	1.14	0.3	0.02	1.46	6.09	37.61	
Intensive grassland peat, Drained	21.31	1.14	0.3	0.68	1.46	2.67	27.56	
Extensive grassland peat, Drained	6.96	1.14	0.3	1.96	0.66	2.01	13.03	
Forested peat, Drained	0.365	1.14	0.3	0.06	0.14	1.31	3.315	

Appendix 5. All land use targets and carbon fluxes

Land Use / Management Category	Land Use Change Target (ha/yr)	Change in Carbon Flux (tCO2e/yr/yr)
New Native Broadleaf/Mixed Woodland	400.0	-7,382
New Productive Coniferous Woodland	400.0	-8,847
Agroforestry (improved grassland & cropland)	26.2	-61
Hedgerows (improved grassland & cropland)	1.5	-16
Grazing Legumes (improved grassland)	175.3	-360
Restored Eroding Modified Bog (bare peat), Drained	0.0	0
Restored Eroding Modified Bog (bare peat), Undrained	12.0	-146
Restored Modified Bog (heather/grass dominated), Drained	955.0	-3,390
Restored Modified Bog (heather/grass dominated), Undrained	0.0	0
Restored Cropland Peat, Drained	0.0	0
Restored Intensive Grassland Peat, Drained	11.9	-329
Restored Extensive Grassland Peat, Drained	0.0	0
Restored Forested Peat, Drained	272.8	-904
Total	**2,283.1**	**-21,469**

Note: The totals include very small contributions from the "cropland" habitats that appear to have been misclassified by the CEH Land Cover Map (there is no known cropland in the Loch Lomond & The Trossachs National Park). These are likely to be reclassified as grassland in subsequent assessments

Appendix 7. Footprint category definitions and data sources

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

SMALL WORLD CONSULTING

Appendix 8: Residents' GHG emissions

Consumer Expenditure Categories Summary	Emissions	Units
Household Fuel	20,515	tCO2e per year
Household Electricity	9,695	tCO2e per year
Vehicle Fuel	32,310	tCO2e per year
Car Manufacture & Maintenance	7,791	tCO2e per year
Personal Flights	18,099	tCO2e per year
Ferry Crossings & Cruises	2,690	tCO2e per year
Trains, Buses & Other Transport	4,947	tCO2e per year
Food & Drink	53,574	tCO2e per year
Accommodation (Non Home) Excl. Food	966	tCO2e per year
Other Non-Food Shopping	14,539	tCO2e per year
Water, Waste & Sewerage	3,060	tCO2e per year
Other Bought Services	14,468	tCO2e per year
Housing	11,013	tCO2e per year
Health, Education, Other Public Services & Administration	19,957	tCO2e per year
Leisure, Recreation & Attractions	3,809	tCO2e per year
Total	**217,433**	**tCO2e per year**

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

SMALL WORLD CONSULTING

Appendix 9: Visitors' GHG emissions

Consumer Expenditure Categories Summary	Emissions while in the area	Emissions from travelling to & from the area	Units
Household Fuel	90	0	tCO2e per year
Household Electricity	53	0	tCO2e per year
Vehicle Fuel	14,745	101,687	tCO2e per year
Car Manufacture & Maintenance	3,733	25,745	tCO2e per year
Personal Flights	0	147,823	tCO2e per year
Ferry Crossings & Cruises	194	846	tCO2e per year
Trains, Buses & Other Transport	1,890	14,876	tCO2e per year
Food & Drink	39,802	0	tCO2e per year
Accommodation (Non Home) Excl. Food	17,141	0	tCO2e per year
Other Non-Food Shopping	8,156	0	tCO2e per year
Water, Waste & Sewerage	2,814	0	tCO2e per year
Other Bought Services	5,666	0	tCO2e per year
Housing	0	0	tCO2e per year
Health, Education, Other Public Services & Administration	0	0	tCO2e per year
Leisure, Recreation & Attractions	1,428	0	tCO2e per year
Total	**95,712**	**290,978**	**tCO2e per year**

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

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

SMALL WORLD CONSULTING

Appendix 10: Industry GHG emissions (IDBR-based)

** Large emitters report Scope 1 only; they have been excluded from the IDBR figures*

Industry Categories Summary (IDBR sectors)	ALL Scopes	Units
Agriculture, forestry & fishing	9,819	tCO2e per year
Production	5,981	tCO2e per year
Construction	2,685	tCO2e per year
Motor trades	494	tCO2e per year
Wholesale	716	tCO2e per year
Retail	1,906	tCO2e per year
Transport & storage (inc. postal)	2,569	tCO2e per year
Accommodation & food services	21,735	tCO2e per year
Information & communication	307	tCO2e per year
Finance & insurance	9	tCO2e per year
Property	202	tCO2e per year
Professional, scientific & technical	1,070	tCO2e per year
Business administration & support services	1,624	tCO2e per year
Public administration & defence	0	tCO2e per year
Education	496	tCO2e per year
Health	1,317	tCO2e per year
Arts, entertainment, recreation & other services	2,010	tCO2e per year
Total	**52,938**	**tCO2e per year**
ENERGY-ONLY INDUSTRY (subset of INDUSTRY)		
Industry Road Fuels	6,951	tCO2e per year
Industry Fuels Excl. Road	10,474	tCO2e per year
Industry Electricity	5,955	tCO2e per year
Total	**23,380**	**tCO2e per year**
LARGE EMITTERS (Scope 1) *		
Large Emitters	0	tCO2e per year
INDUSTRY-RELATED FLIGHTS (subset of INDUSTRY)		
Industry-related flights	865	tCO2e per year
Land Use		
Land Use CO_2	-121,510	tCO2e per year
Land Use Non-CO_2	49,254	tCO2e per year

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