Net zero implications for agriculture and land use

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SRUC

Based on contributions from

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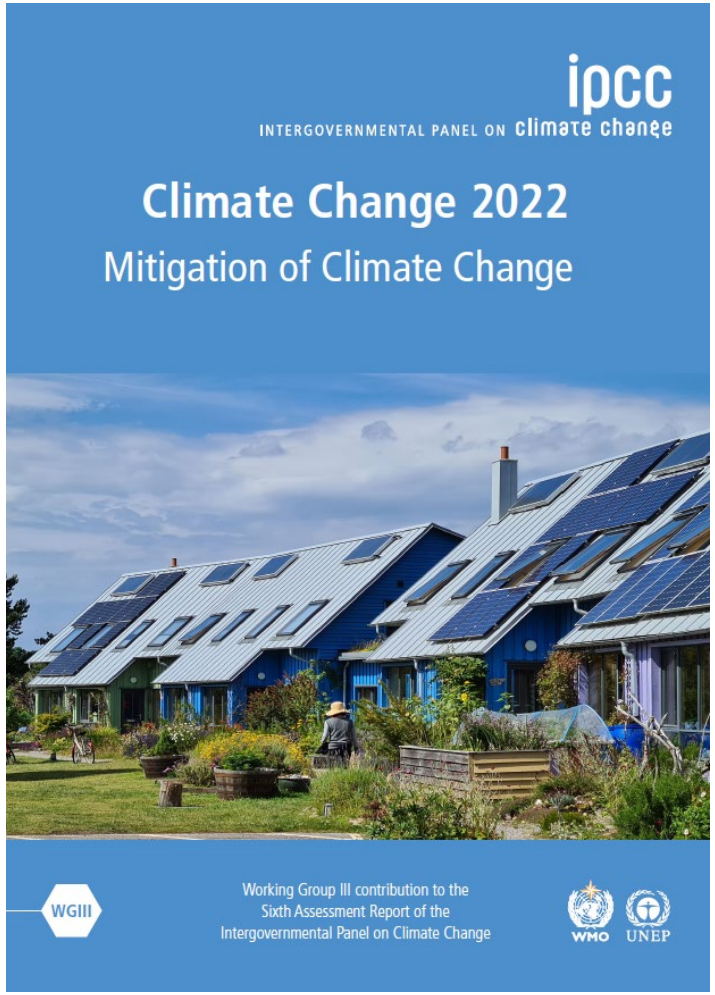
ZEA Conference, Denmark, 2-5th May 2022

Climate policy
“Now or never”

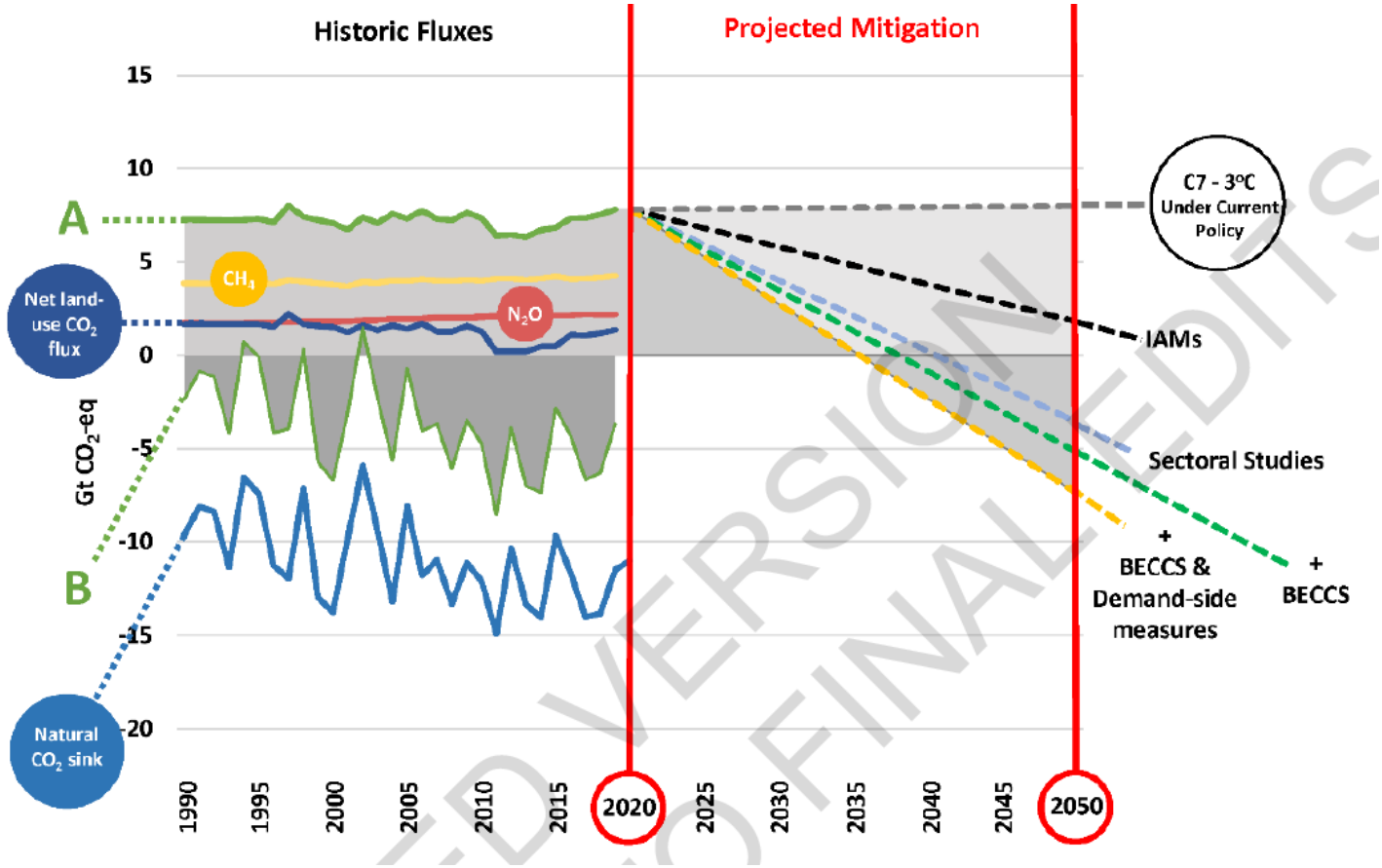
- Halt the rise in emissions by 2025
- Halve emissions by 2030 to achieve net zero by 2050
- Limiting temperature rise to < 1.5°C now highly unlikely



Agriculture and land-use are different

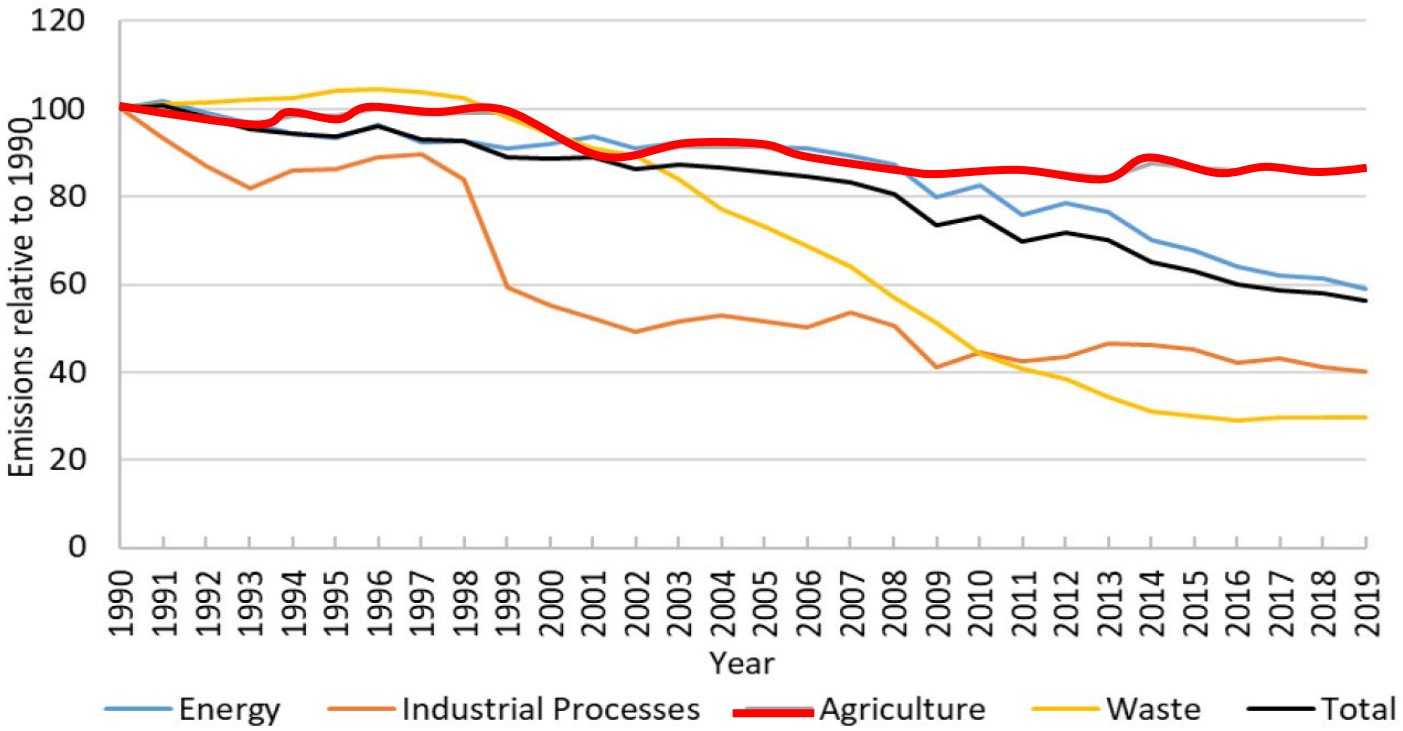
- Biological emissions
- Non-CO_2 greenhouse gases
- Emissions and uptake
- Food production is a basic human need
- Wider socio-economic implications
- Inertia

IPCCs projections for the agriculture and land use sector

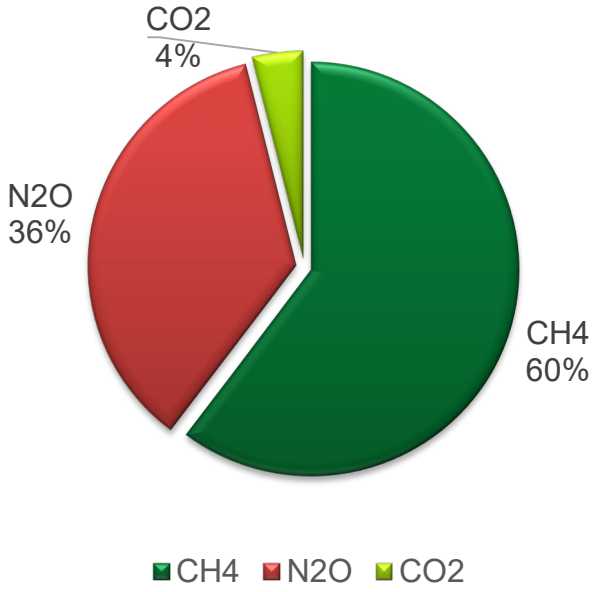


IPCC Working group III, 2022

UK greenhouse gas emissions



Trends in emissions by sector relative to 1990

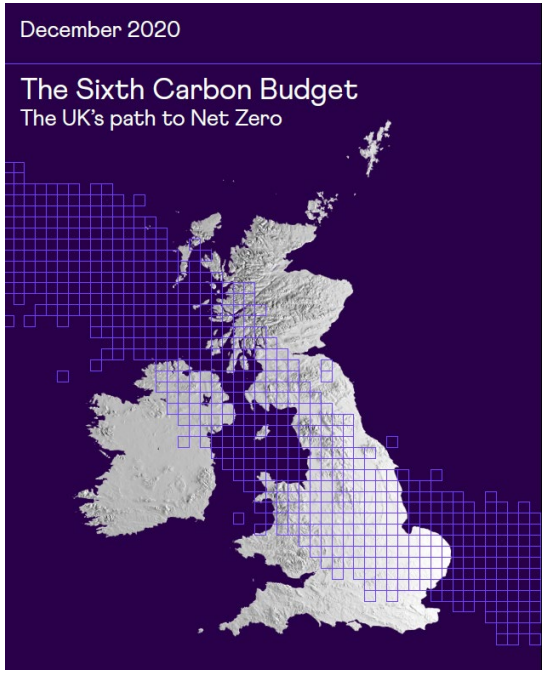


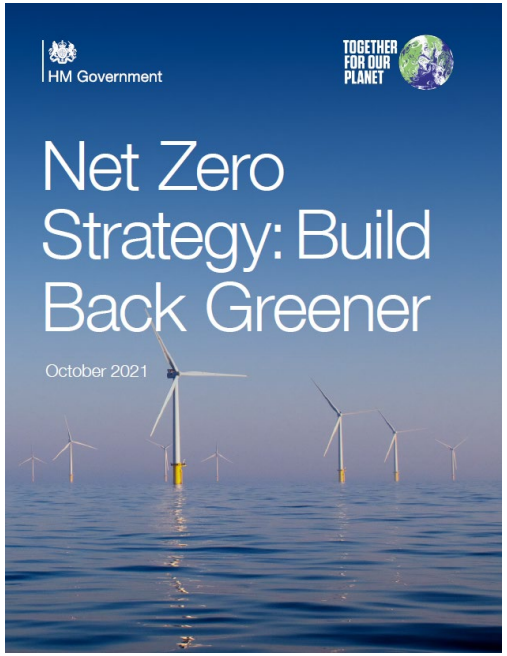
Agricultural emissions

UK National Inventory Report 2021

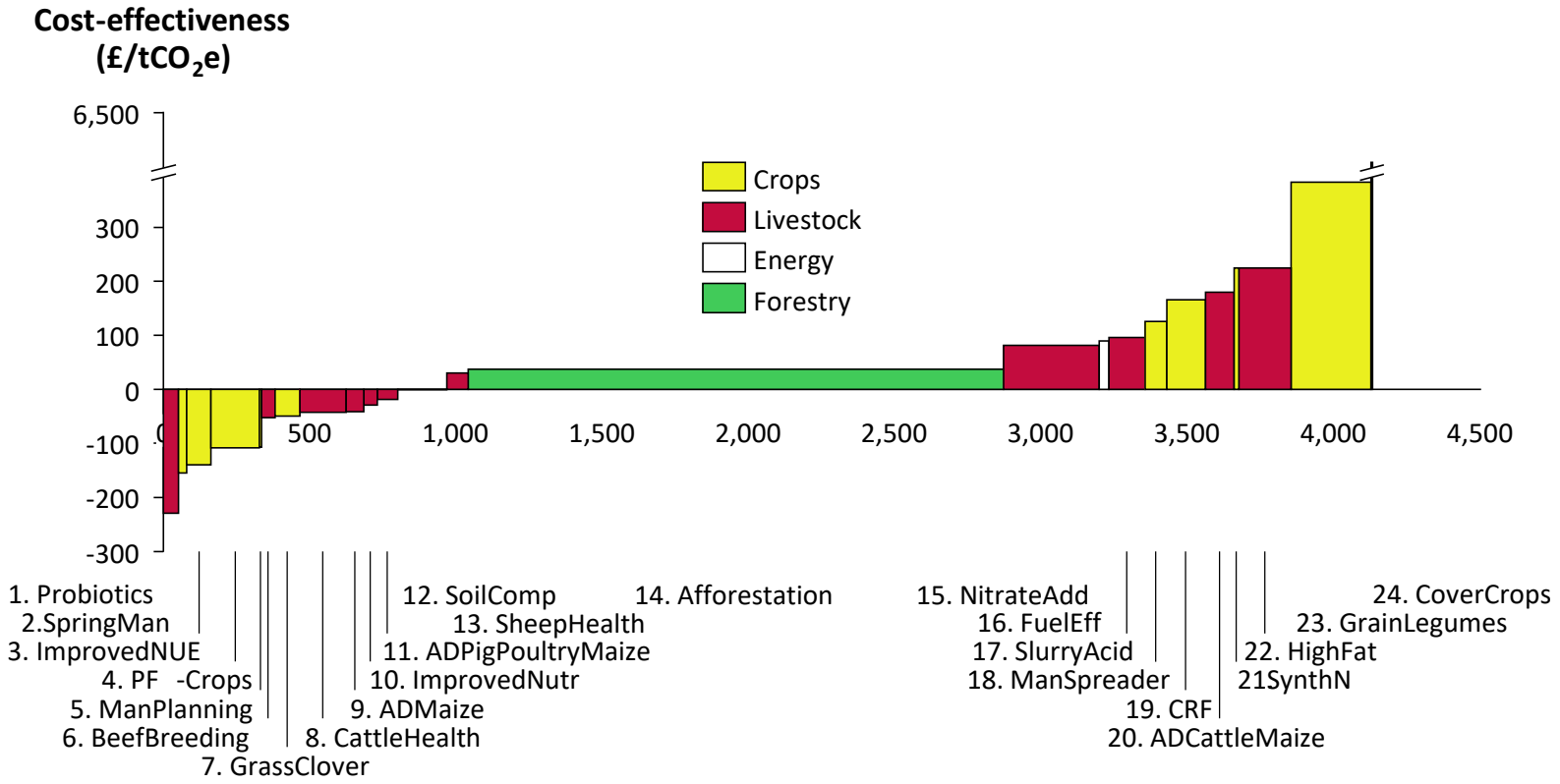
UK policy development

- The UK should set an ambitious target to reduce greenhouse gas emissions to 'net-zero' by 2050
- Agriculture and land use will be critical



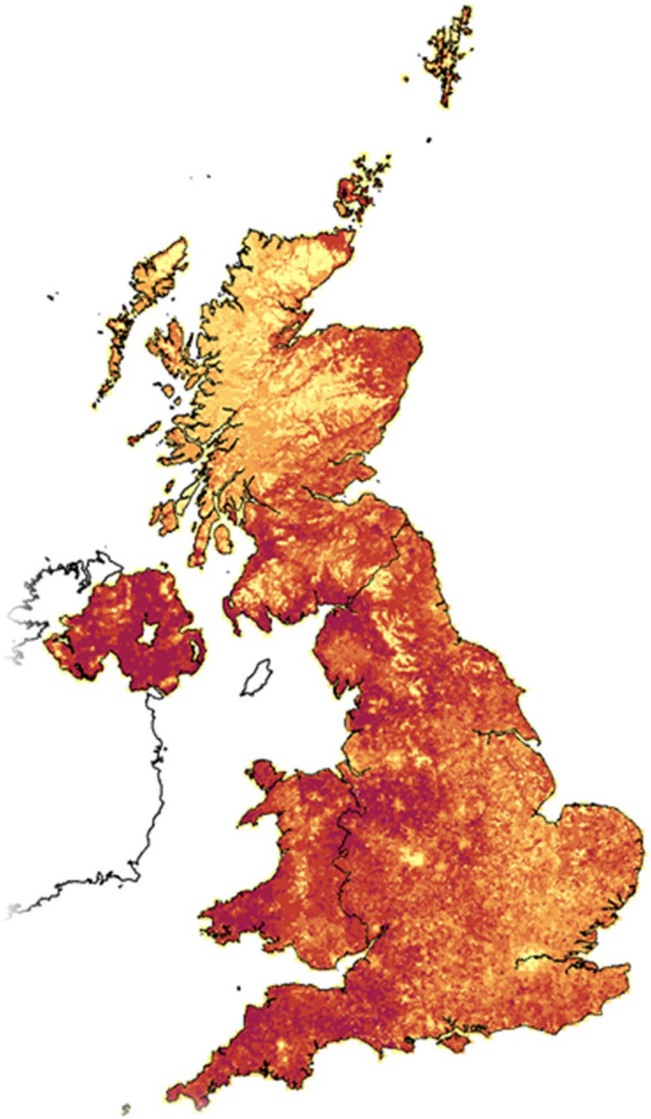


Carbon mitigation – where to start?



Eory et al. 2015

UK GHG Emission Inventory

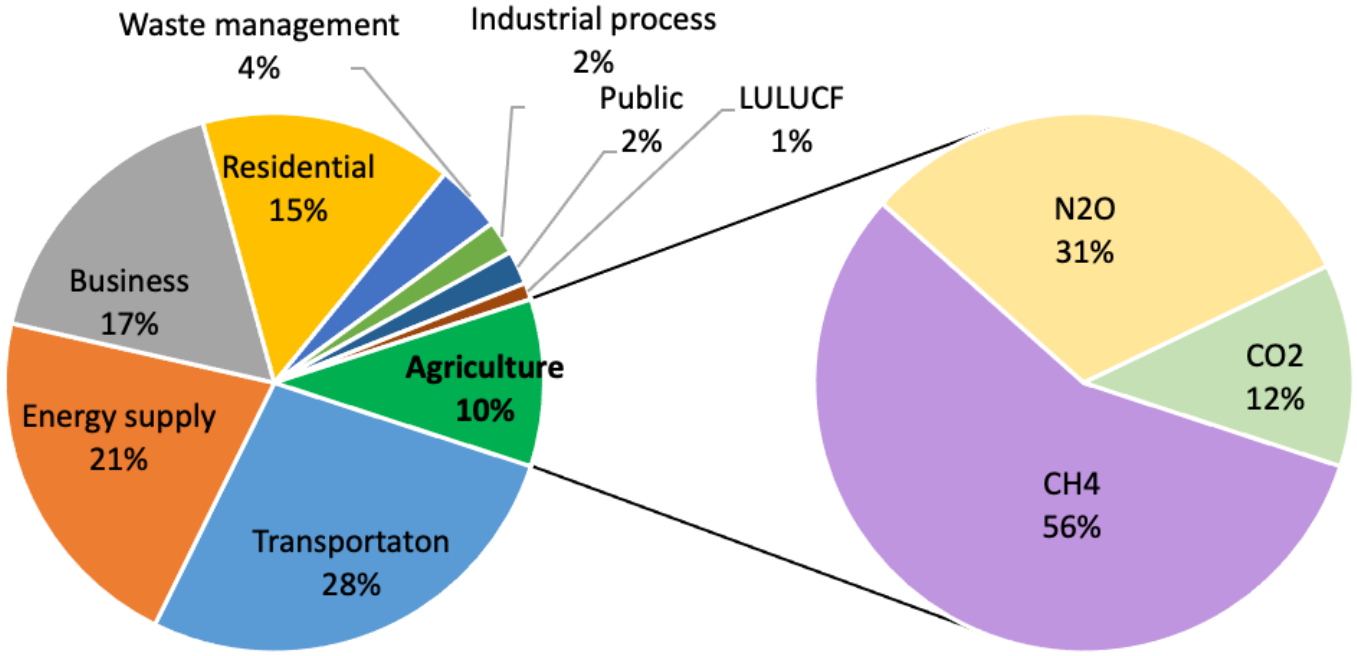


- For national level reporting under UNFCCC according to IPCC protocols
- Is the metric against which UK compliance with emission reduction targets will be assessed
- Comprises 5 reporting categories:
  - Energy
  - Industrial Processes
  - Agriculture
  - LULUCF
  - Waste

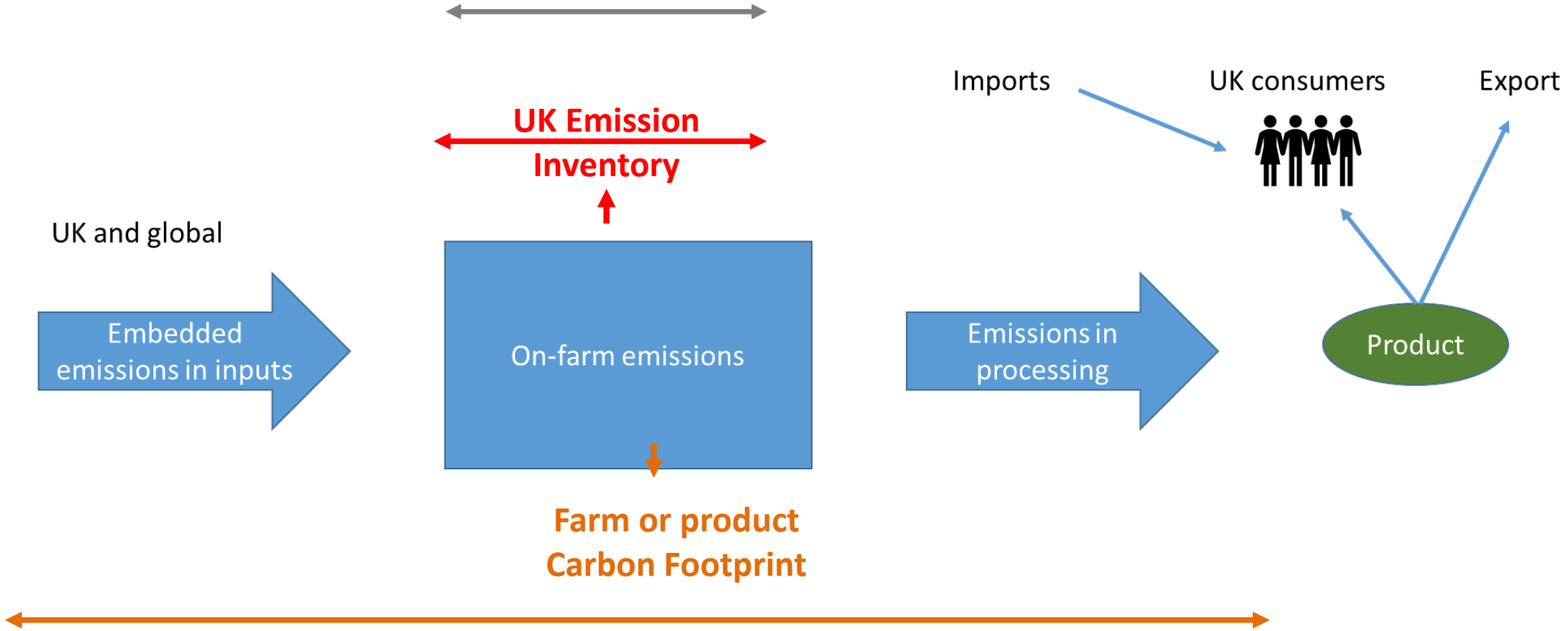
UK agriculture

Agriculture accounts for ~10 % of total GHG emissions in the UK

Livestock production is the main contributor



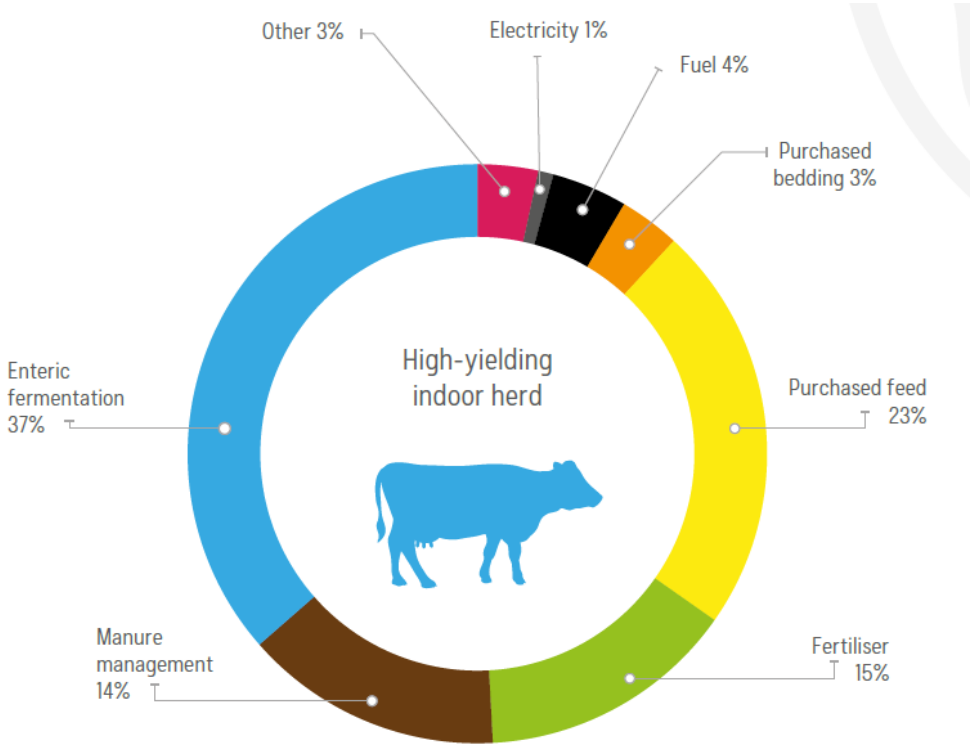
System boundaries very important



Dairy Case Study Farm
Higher-yielding indoor dairy herd

- 410 Holstein cows
- 252 ha platform
- 10,000 litres/cow

- **Total emissions**
  - **4851 t CO_2-eq**
  - **1.18 kg CO_2-eq/kg milk**



Dairy
Application of mitigations to National Inventory

Table 5 Impact of key mitigations on GHG emissions from the whole UK dairy sector and on the overall Agricultural Inventory.

	Impact on		
	GHG reduction for UK dairy sector		GHG reduction for whole of UK agriculture
Mitigation options	**kt CO_2-eq**	**%**	**%**
Methane inhibitor used in all dairy animals	2268	20.3	5.6
Methane inhibitor used only in cows	1764	15.8	4.4
Increased productivity	1006	8.7	2.5
Reduce age at first calving from 29 to 24 months	467	4.0	1.2
Use of nitrification inhibitor with dairy slurry application	178	1.6	0.4
Dairy slurry processed by AD	1343	12.0	3.3
Use of nitrification inhibitor with all N fertiliser applied to all UK grassland	246	9.7	0.6
Combined effect of mitigations 1,3,4,5,6	5030	45.0	12.5

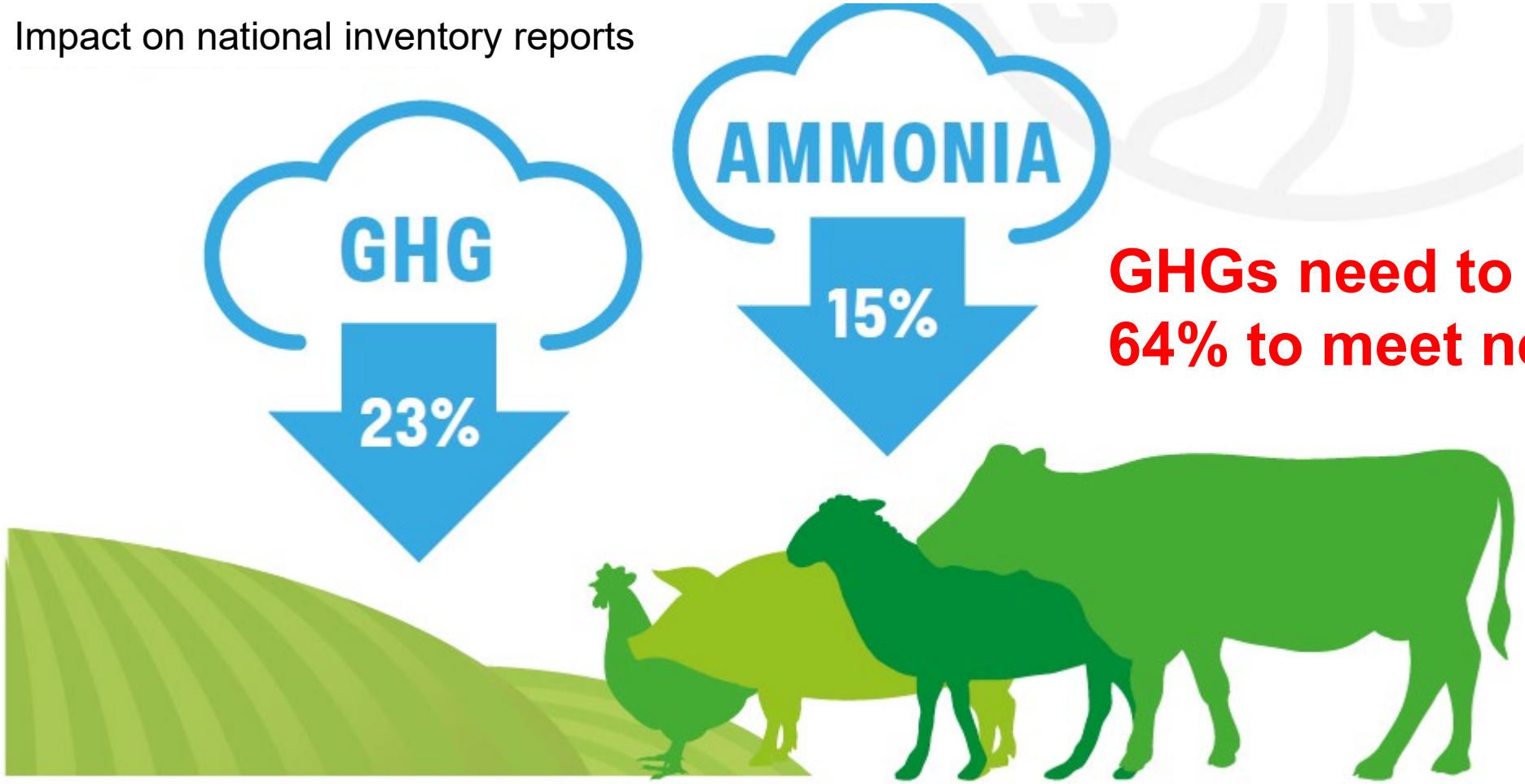
- Scaled down National Inventory model (200 cow herd) explored impact of improved productivity
- Land released, and utilised for forestry, delivered 15% reduction in net GHG emissions

Ruminant mitigation

1. Improved productivity efficiency (including animal and soil health)
2. Methane inhibitors
3. Improved application of manures & fertilisers, nitrification & urease inhibitors to reduce N_2O emissions. Fertiliser further reduced by use of forage legumes.
4. Afforestation of released land

Application of mitigation across all livestock sectors

Impact on national inventory reports

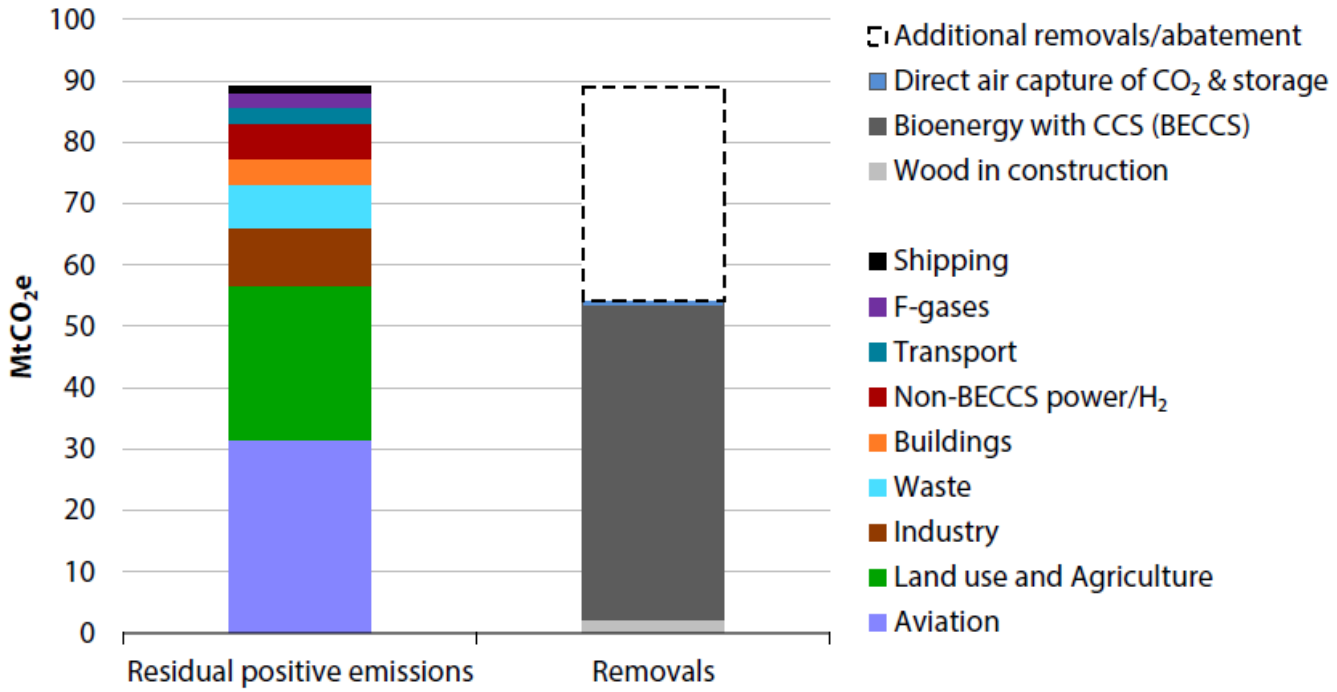


GHGs need to be reduced by 64% to meet net zero target

Greenhouse gas removals

- Mitigation is not enough
- Carbon removals needed for residual emissions to reach net zero targets

Balancing emissions & removals by 2050



Committee on Climate Change 2019

Carbon removals

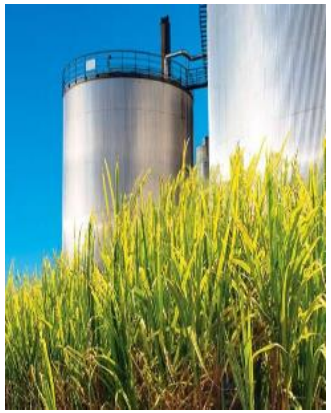
- Gross emissions from agriculture cannot be reduced to zero due to natural/biological processes
- Role for carbon removal strategies such as:

Forestry / agroforestry

Soil C sequestration

Biochar

Enhanced weathering



Bio-energy with Carbon Capture and Storage

Direct Air Capture & Carbon Storage

Carbon sequestration - opportunities & challenges

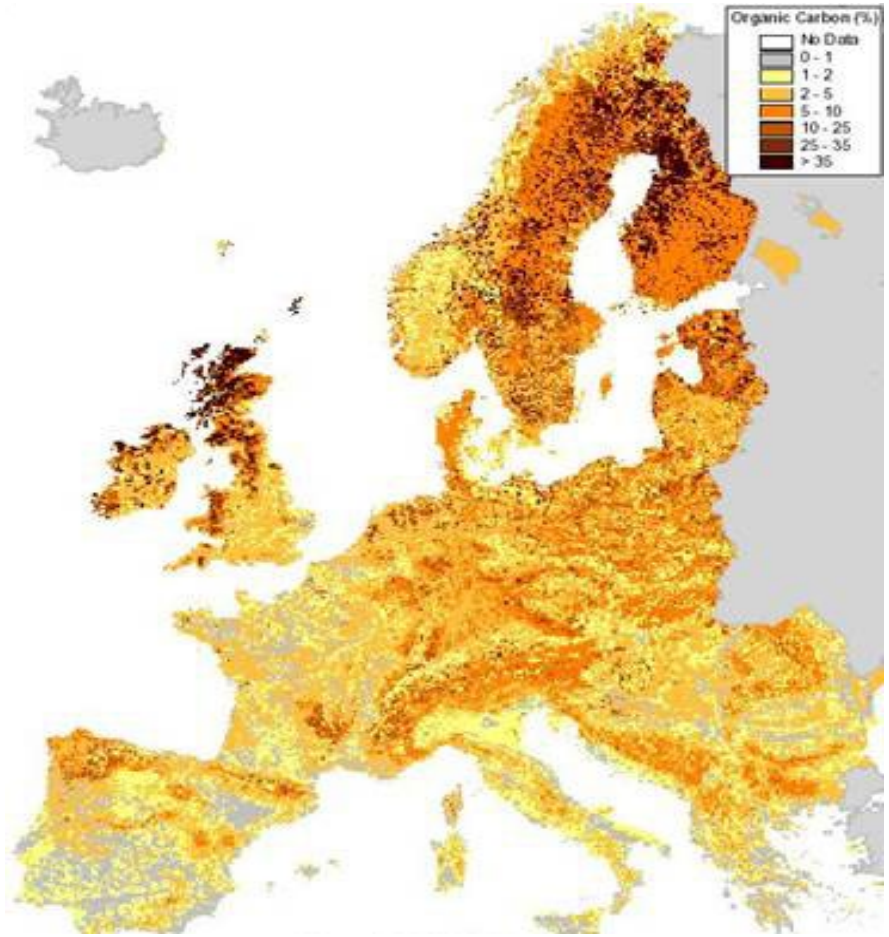
Opportunities

- Low cost GHG mitigation
- Co-benefits in terms of soil fertility, resilience & crop production
- Widespread opportunity

Challenges

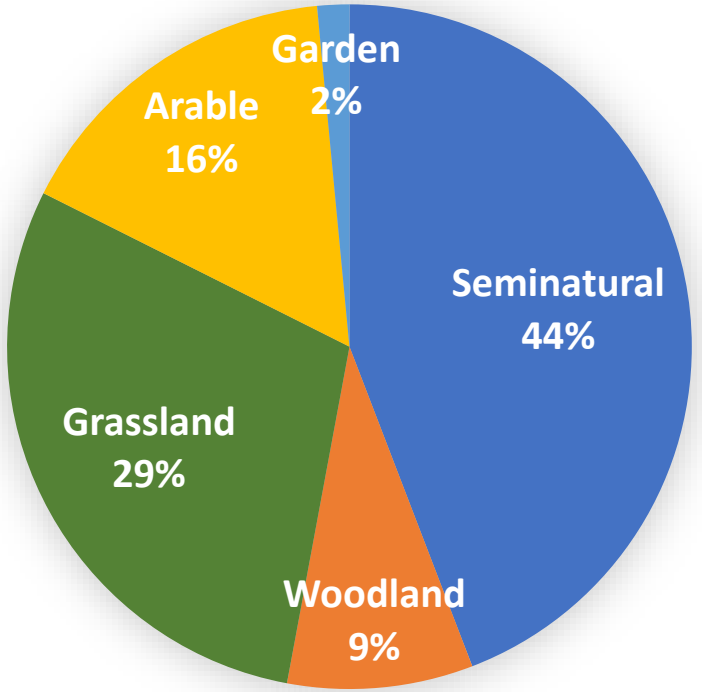
- Reversibility of carbon storage & carbon saturation
- Non-CO_2 emissions
- Measurement Reporting and Verification

UK soil carbon stocks



Total UK soil carbon stocks: 4560 MT

to 100cm depth - Bradley *et al.* (2005)

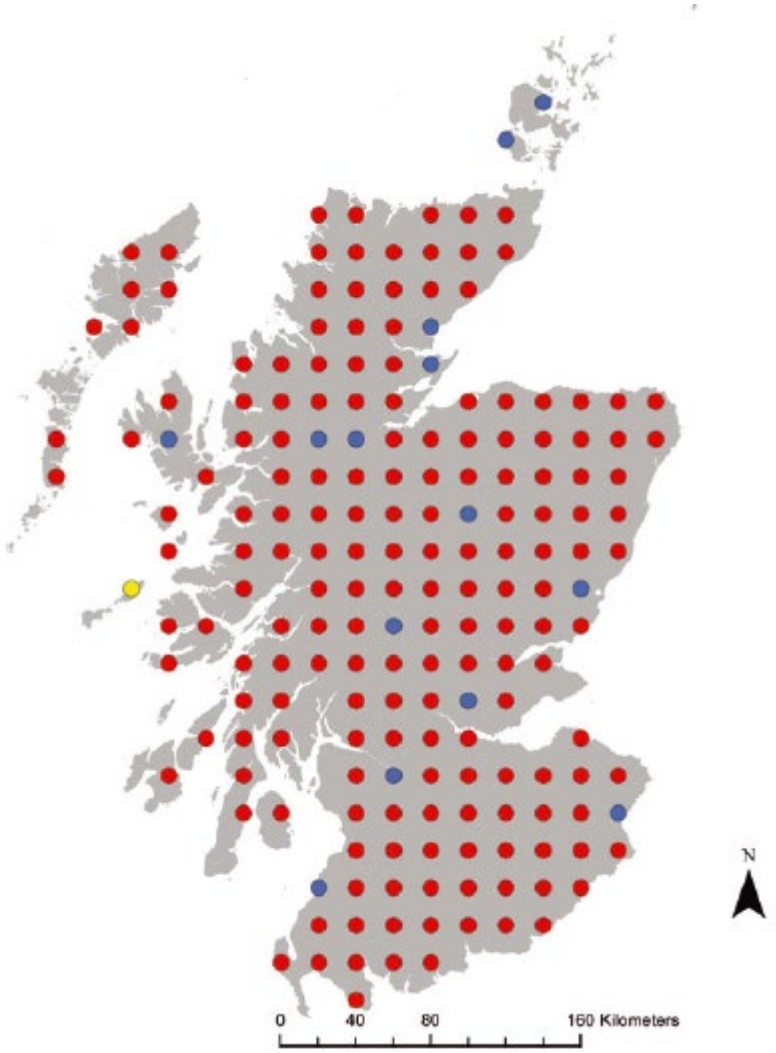


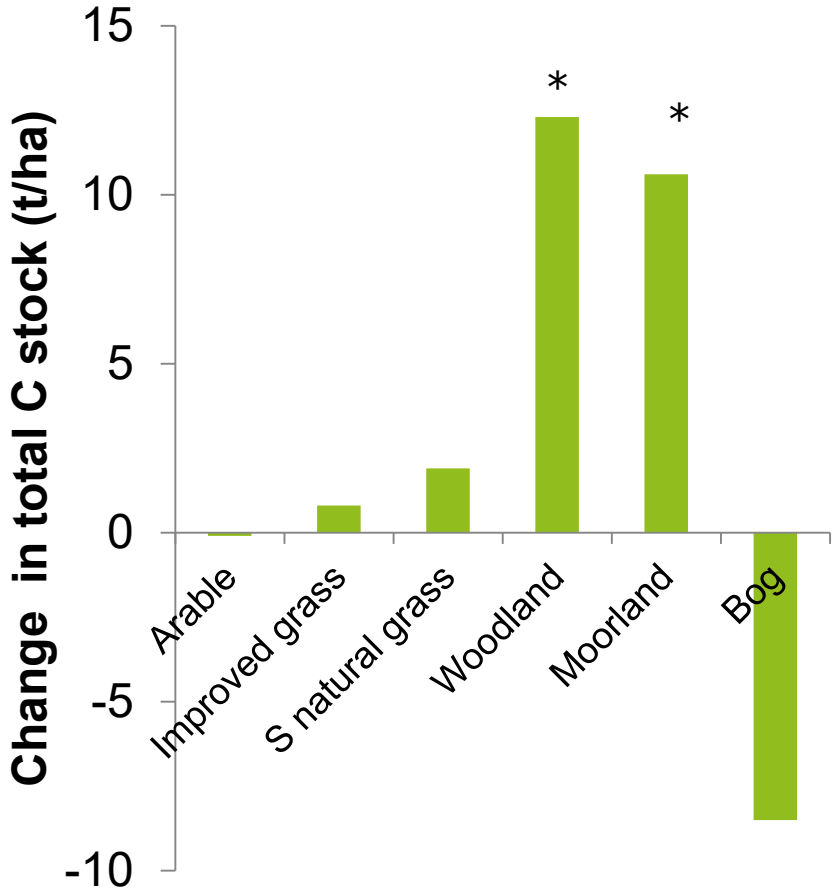
Reporting

- National inventory reporting assumes soil carbon stocks change only in response to land use
  - 20 year adjustment to new equilibrium conditions
- Without land use change, there is no change in soil C stocks in grassland or cropland
- New IPCC guidelines allow reporting of soil carbon stock changes within land use categories

Measurements

Changes in soil carbon in Scotland 1978-2009

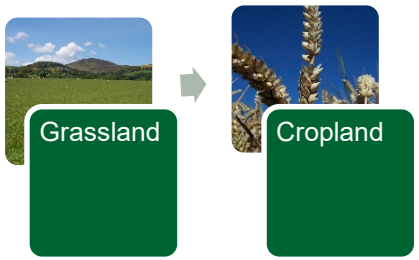


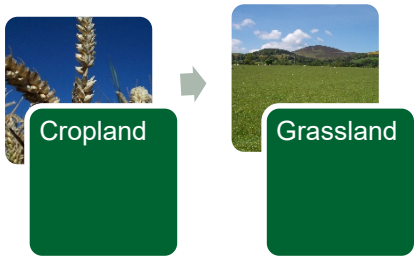


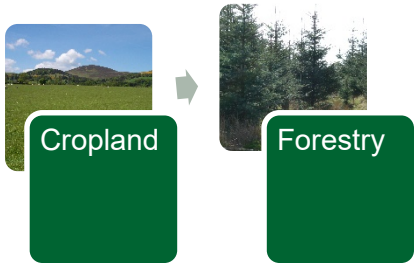
Lilly *et al*. 2013. European Journal of Soil Science, 64, 455-465

Achieving carbon sequestration

With land use change





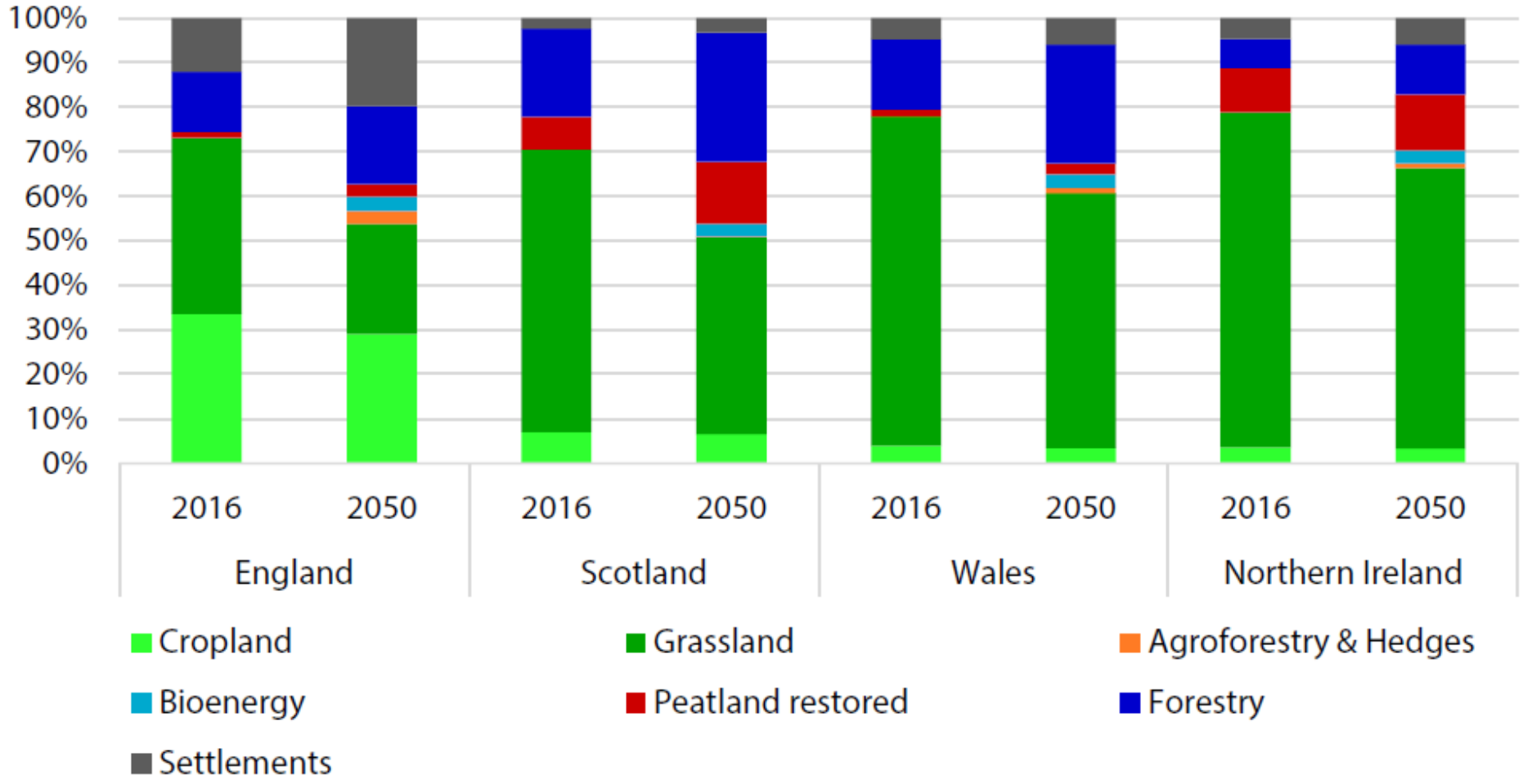


Change in soil carbon stock %
-59
+19
+50

Without land use change

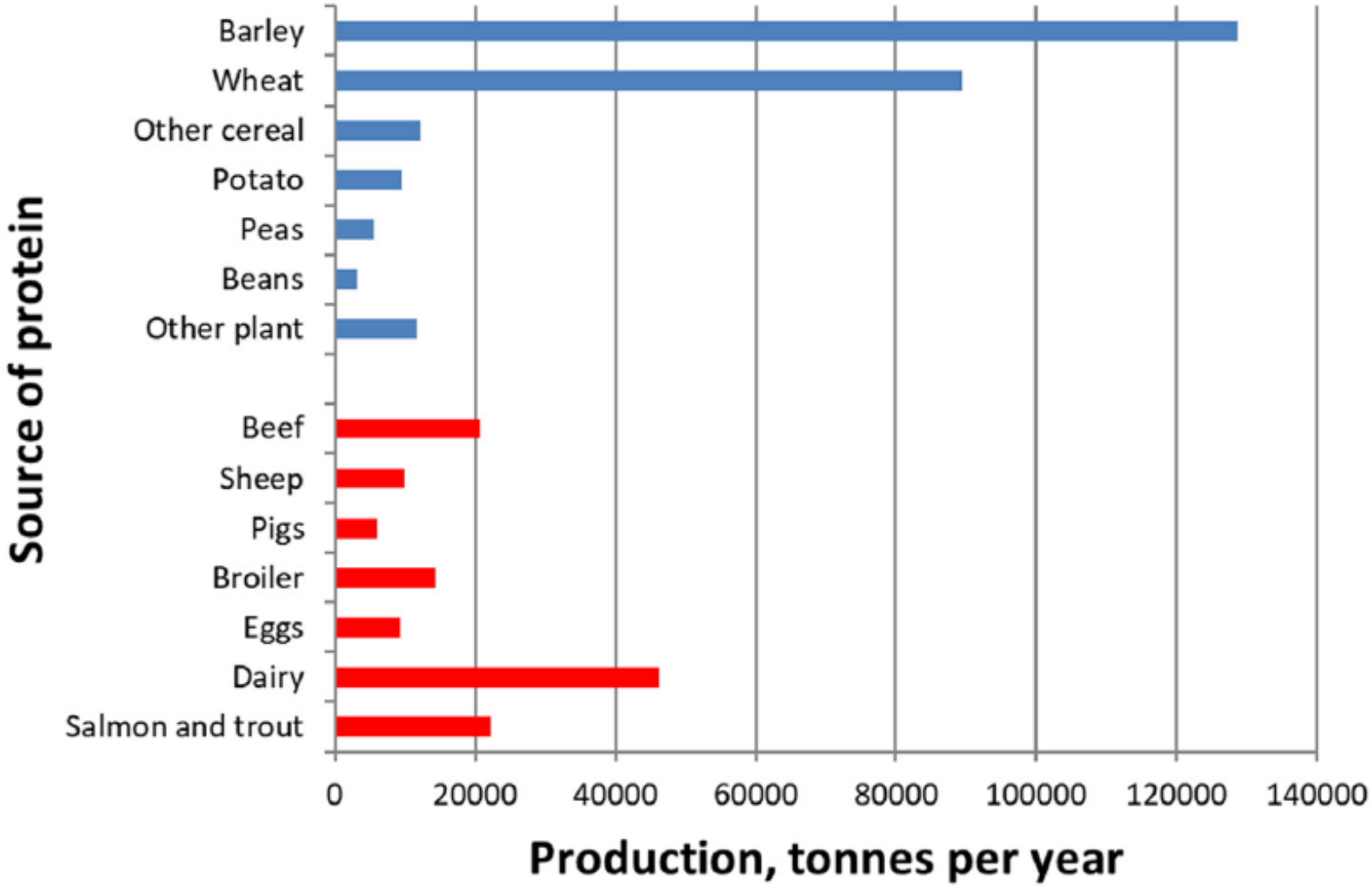
Change in soil carbon stock %
+30
+66
+6

Net zero: implications for land use



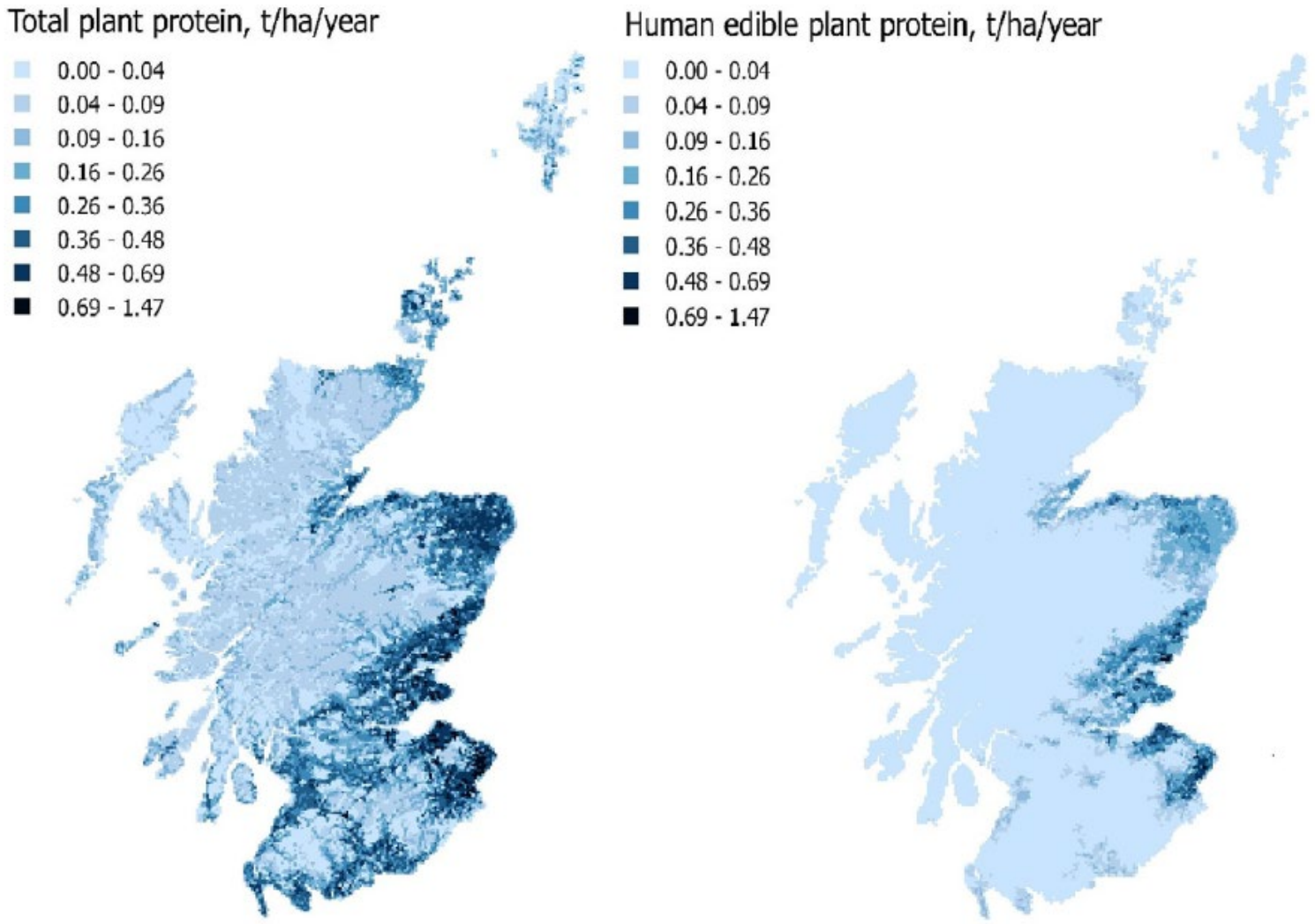
Committee on Climate Change 2020

Potentially edible protein in Scotland



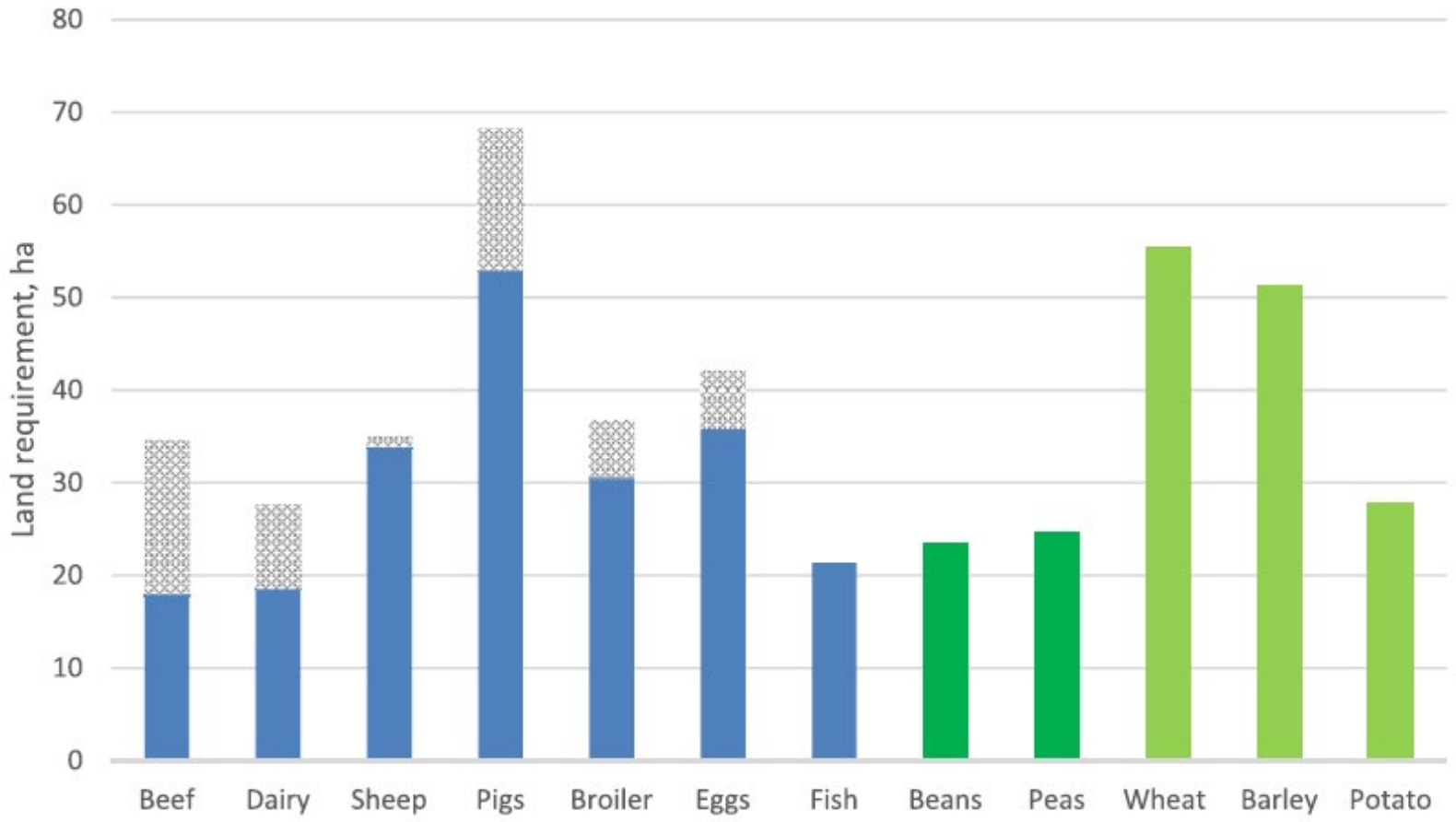
Leinonen et al, 2020

Implications for land use change

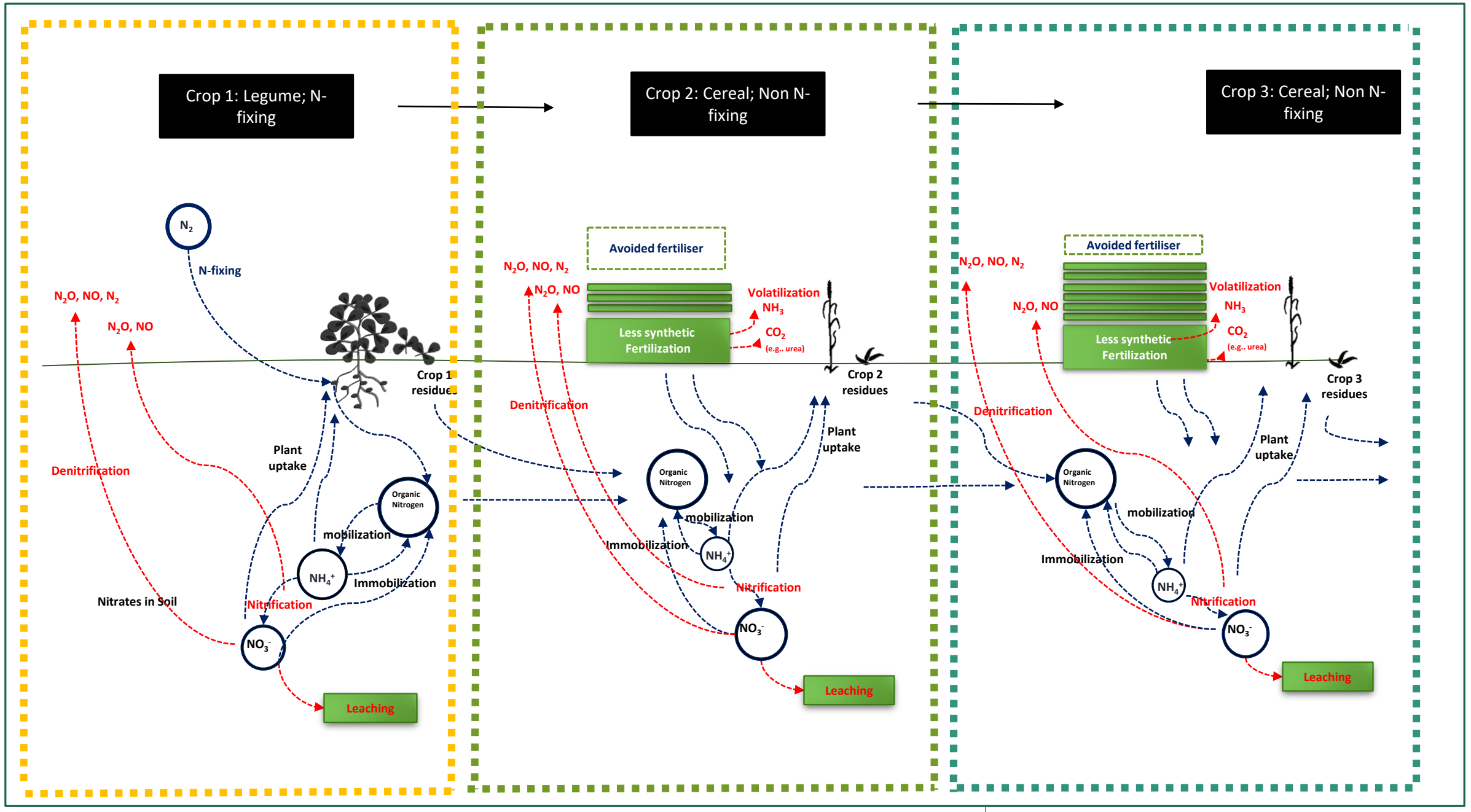


Leinonen et al, 2020

Arable land requirements per tonne of lysine production

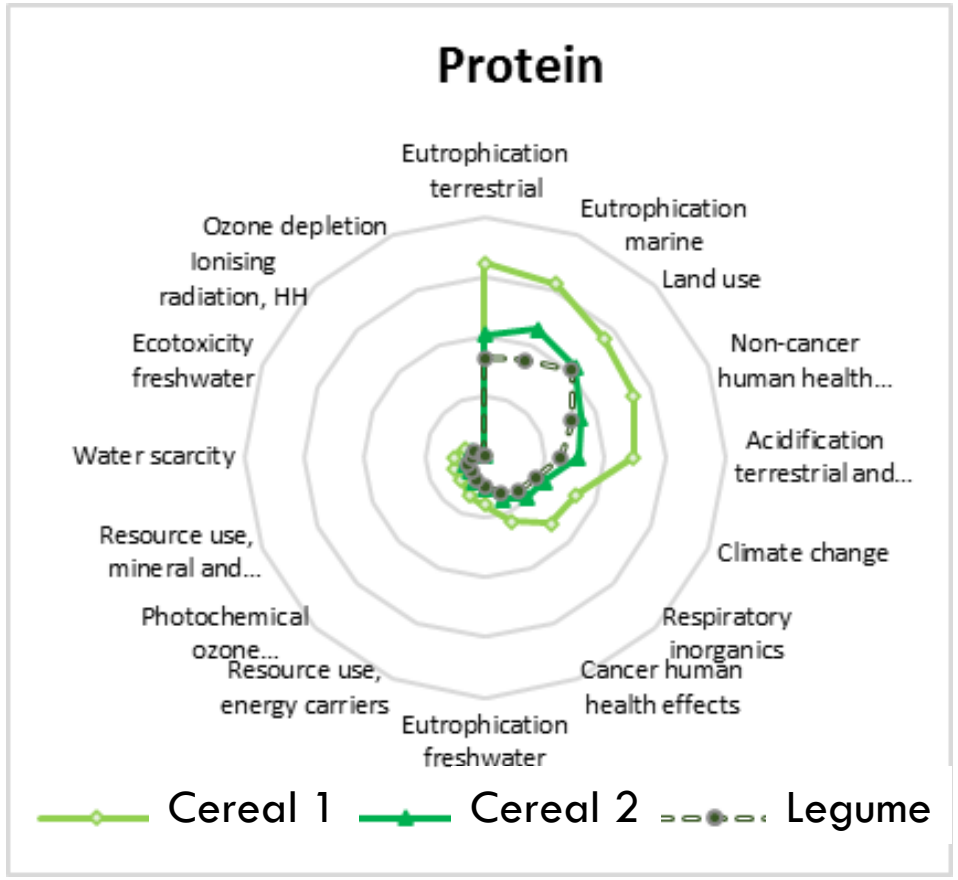


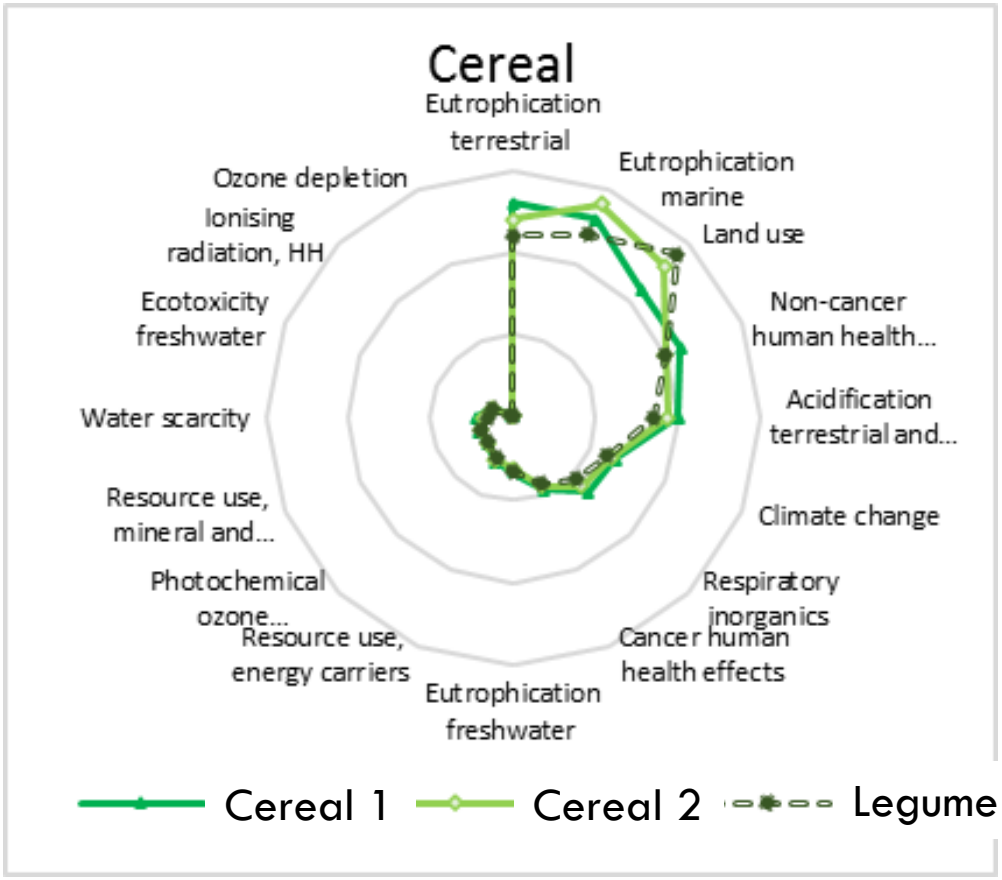
Leinonen et al, 2020



Costa et al. 2020

Representing rotational LCAs by different functional units





Costa et al, 2021

Concluding remarks

- Net zero will be a major challenge for agriculture and land use
- Structural changes will lead to alterations in land use and supply chains
- Need widespread application of existing mitigation technologies and new approaches
- GHG removals will be critical
- A more strategic approach to land use will be needed

Thank you

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