Legumes and net zero: the role of legumes in achieving carbon neutrality for UK agriculture?

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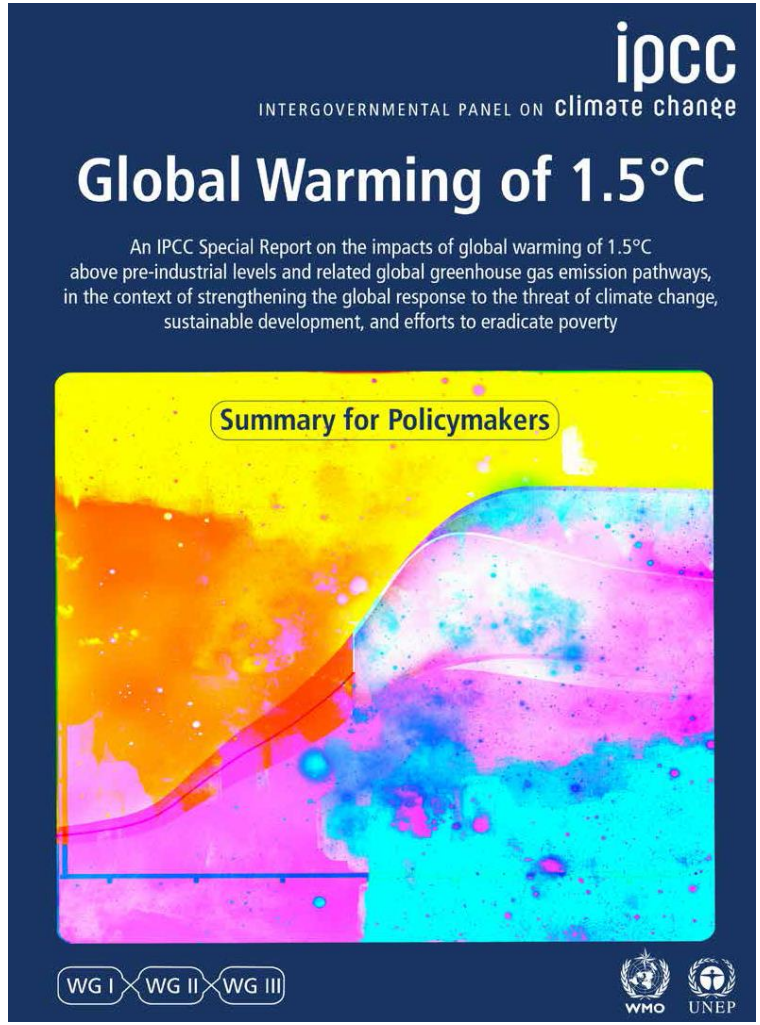
SRUC

ELIN workshop, 3rd March 2021

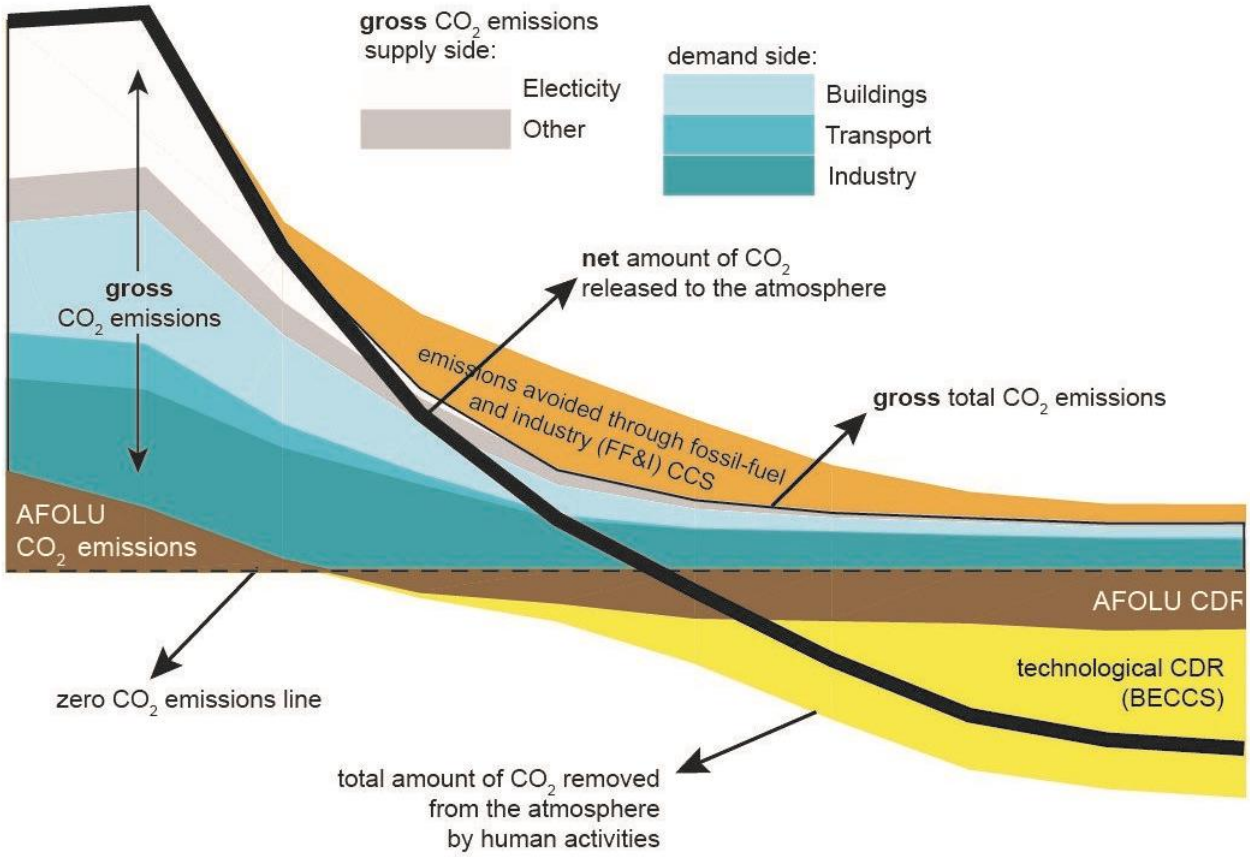
Climate policy

- Paris: Aims to keep global temperature rises to less than 2^{o}C, with an ambition to limit rises to 1.5^{o}C
- IPCC Multiple lines of evidence demonstrating increased risks for temperature rises of 2^{o}C



Pathways to 1.5°C

Annual Global CO_2 Emissions



IPCC, 2018

UK policy development

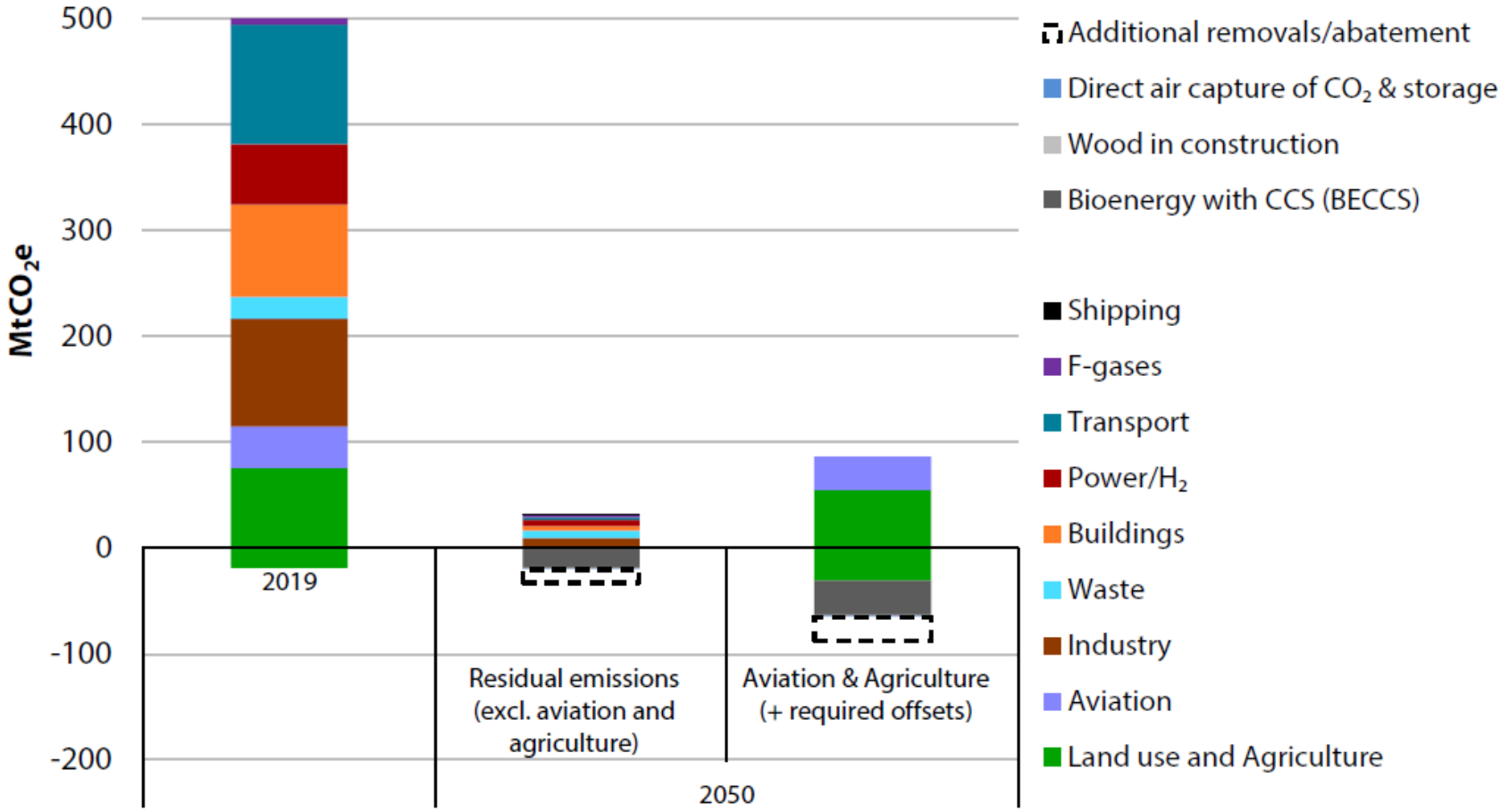
- The UK should set an ambitious target to reduce greenhouse gas emissions to 'net-zero' by 2050, ending the UK's contribution to global warming within 30 years.

- If replicated across the world, it would deliver a greater than 50% chance of limiting temperature increases to **1.5°C**.

Agriculture and land use are different

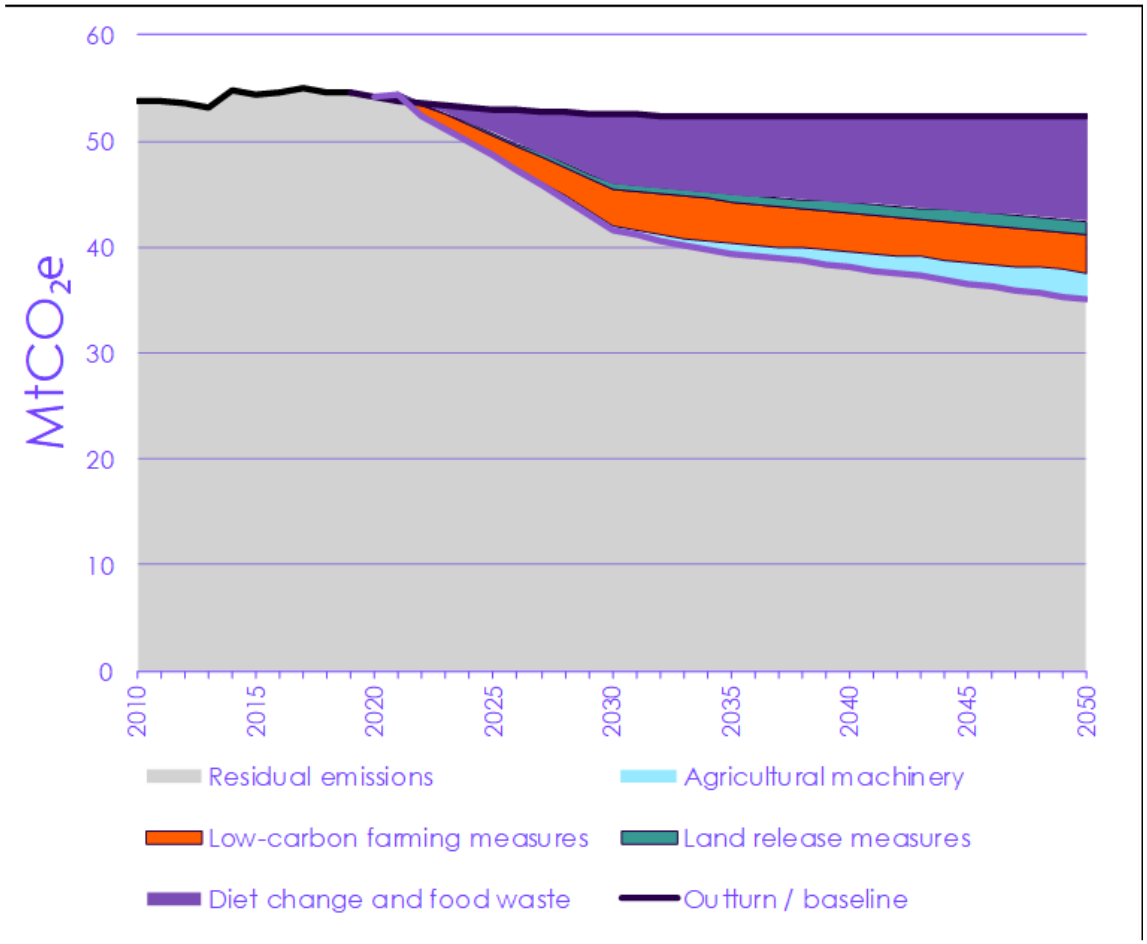
- Biological emissions
- Non-CO_2 greenhouse gases
- Emissions and uptake
- Food production is a basic human need
- Wider socio-economic implications
- Inertia

Agriculture and land use contributions to net zero



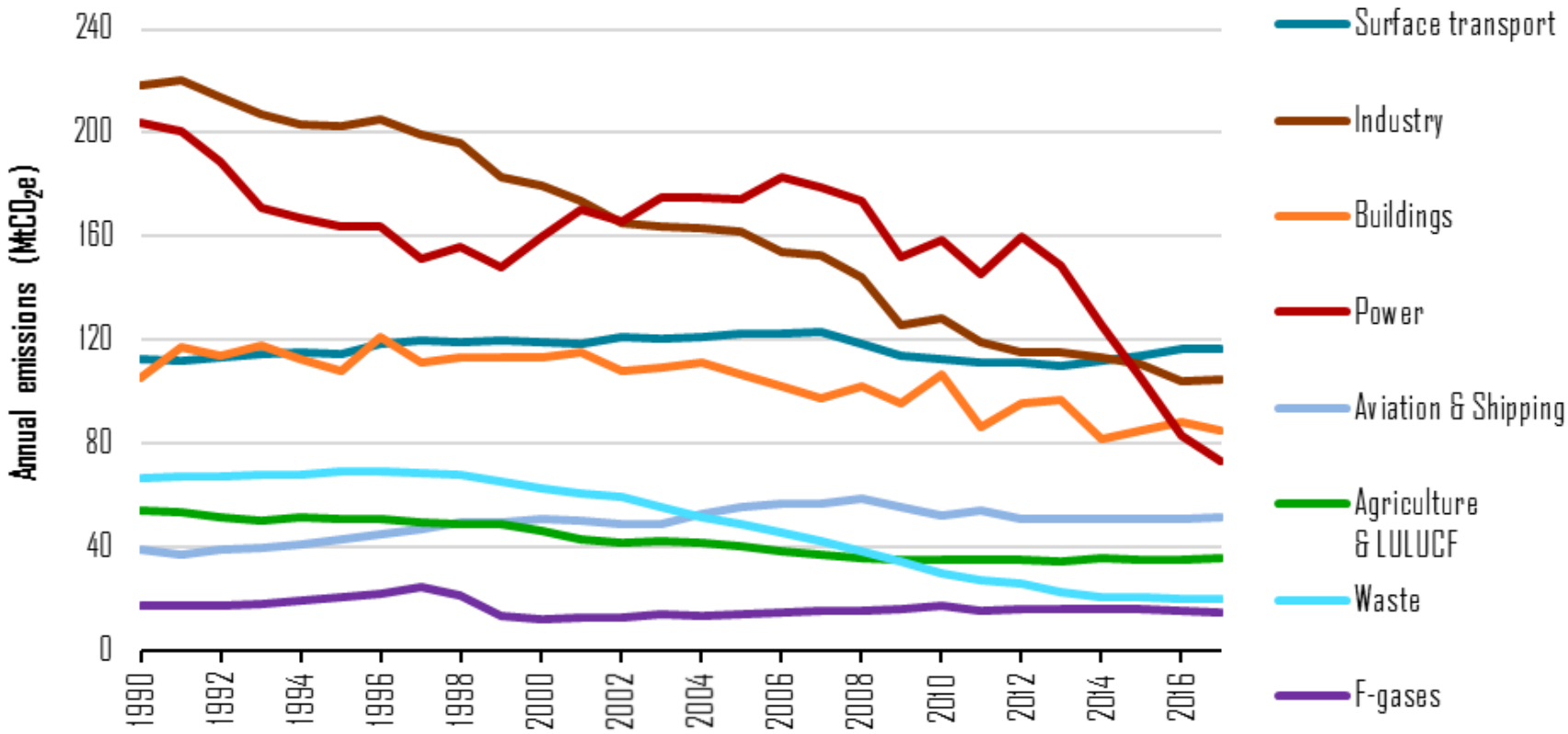
Committee on Climate Change 2019

Mitigation in the agricultural net zero pathway



The sixth carbon budget, the UK's path to net zero Committee on Climate Change Dec 2020.

UK greenhouse gas emissions



UK National Inventory Report

Legumes in farming systems

Cover crops

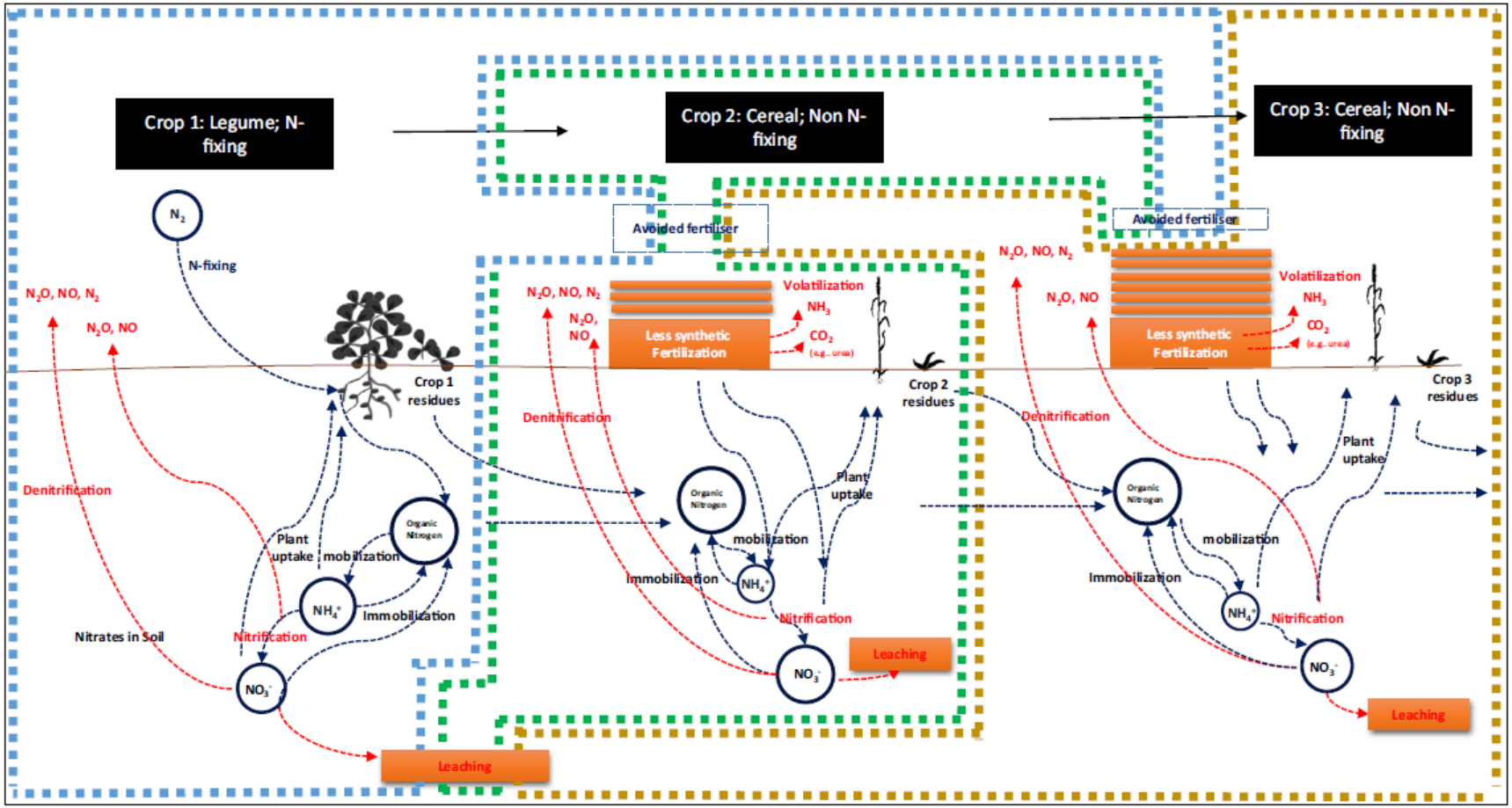
Intercrops

Forage

Main crops

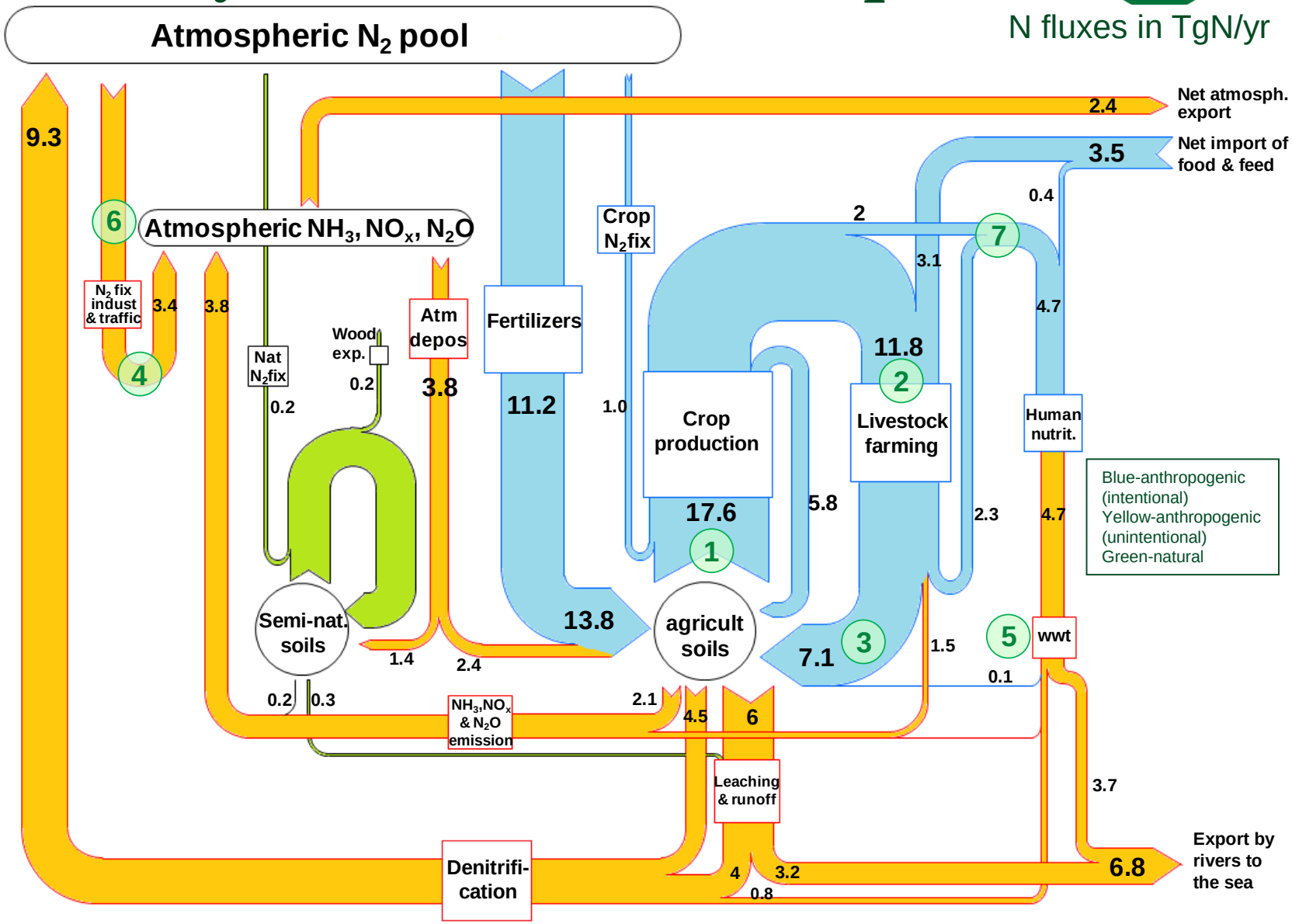
Rotational

Capturing the contribution of legumes



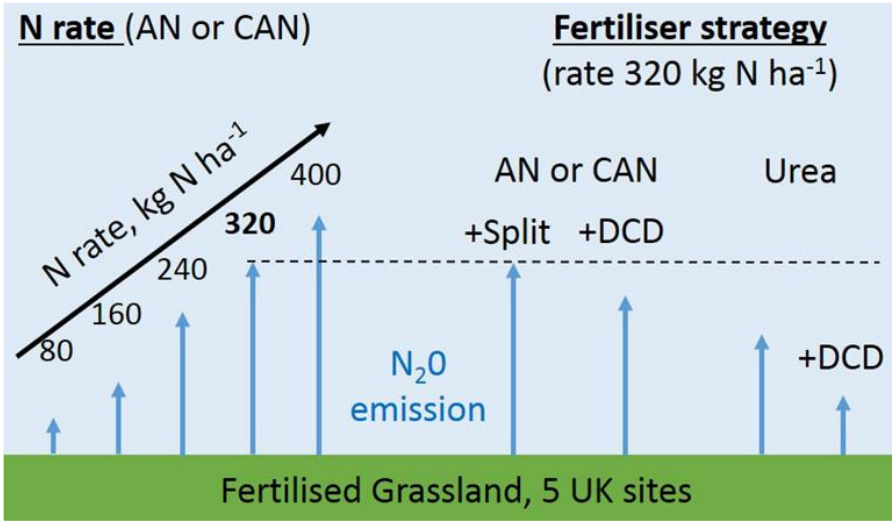
Costa et al 2020, Int J Life Cycle Assessment, doi.org/10.1007/s11367-020-01812-x

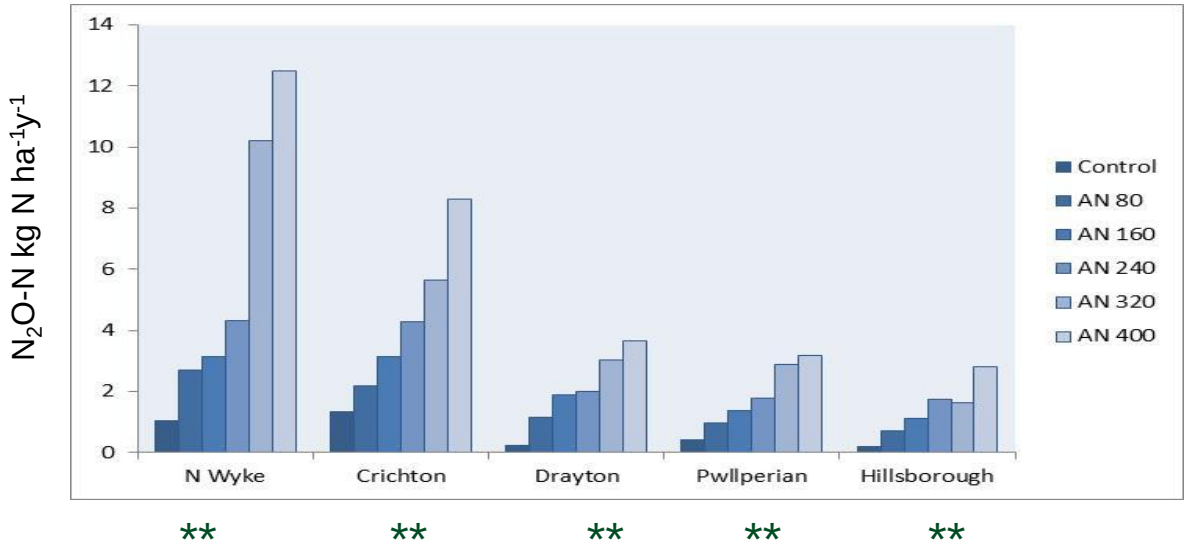
Summary of N flows in Europe



Sutton et al 2011, European Nitrogen Assessment

N2O emissions from grasslands





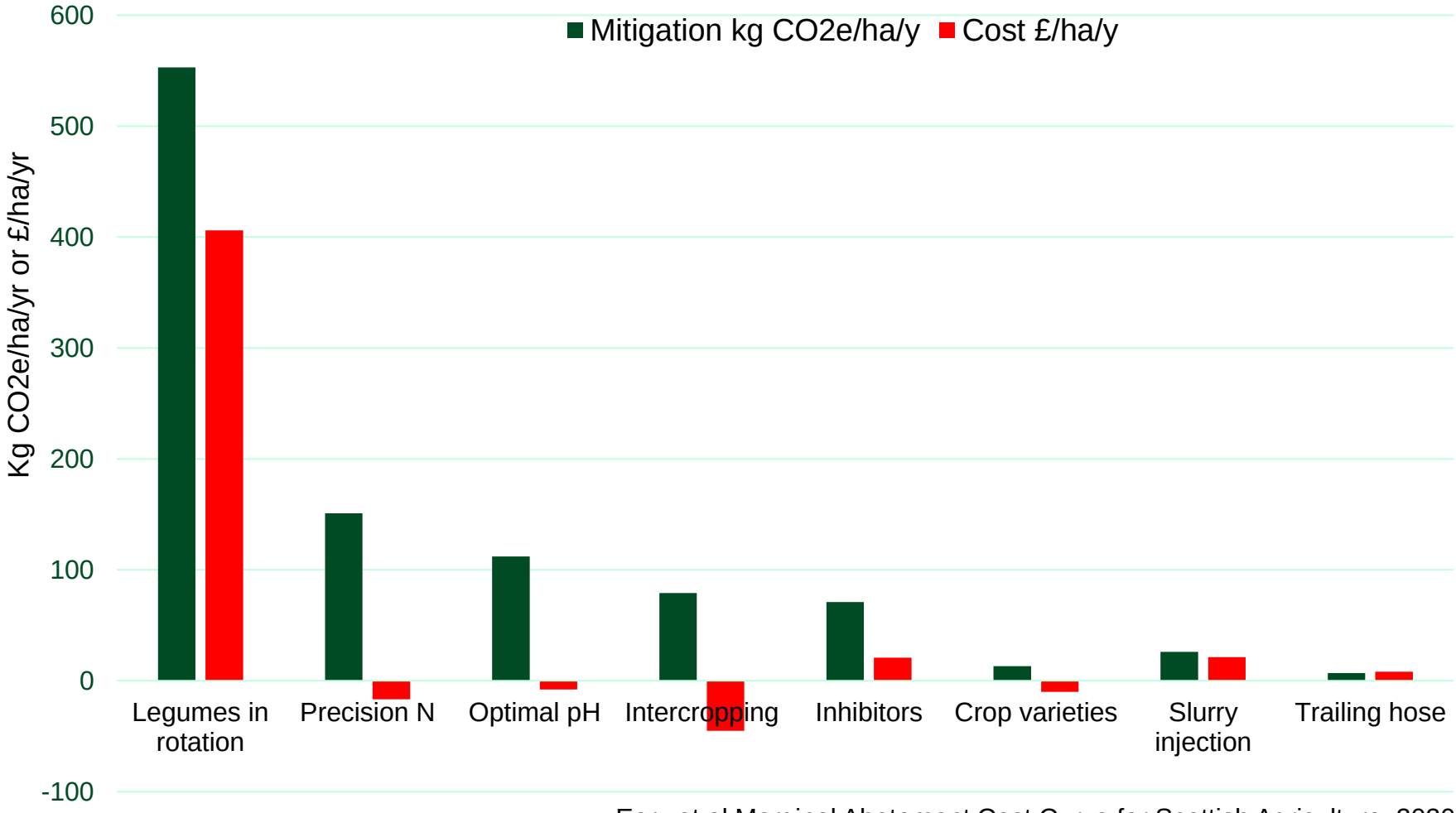
Cardenas *et al* 2019.
Science of the Total Environment

Comparison of N_2O emissions from legume and non-legume crops

Category and Species	Site Years	Total N_2O emissions per growing season or year (kg N_2O-N ha^{-1})	
		Range	Mean
Pure legume stands			
Alfalfa	14	0.67-4.57	1.99
White clover	3	0.50 – 0.90	0.79
Mixed pasture sward			
Grass-clover	8	0.10 – 1.30	0.54
Legume Crops			
Faba bean	1	-	0.41
Lupin	1	-	0.05
Chickpea	5	0.03 – 0.16	0.06
Field pea	6	0.38 – 1.73	0.65
Soybean	33	0.29 – 7.09	1.58
Mean of all legumes			**1.29**

Jensen et al., 2013, Agronomy for Sustainable Development

Carbon savings and costs



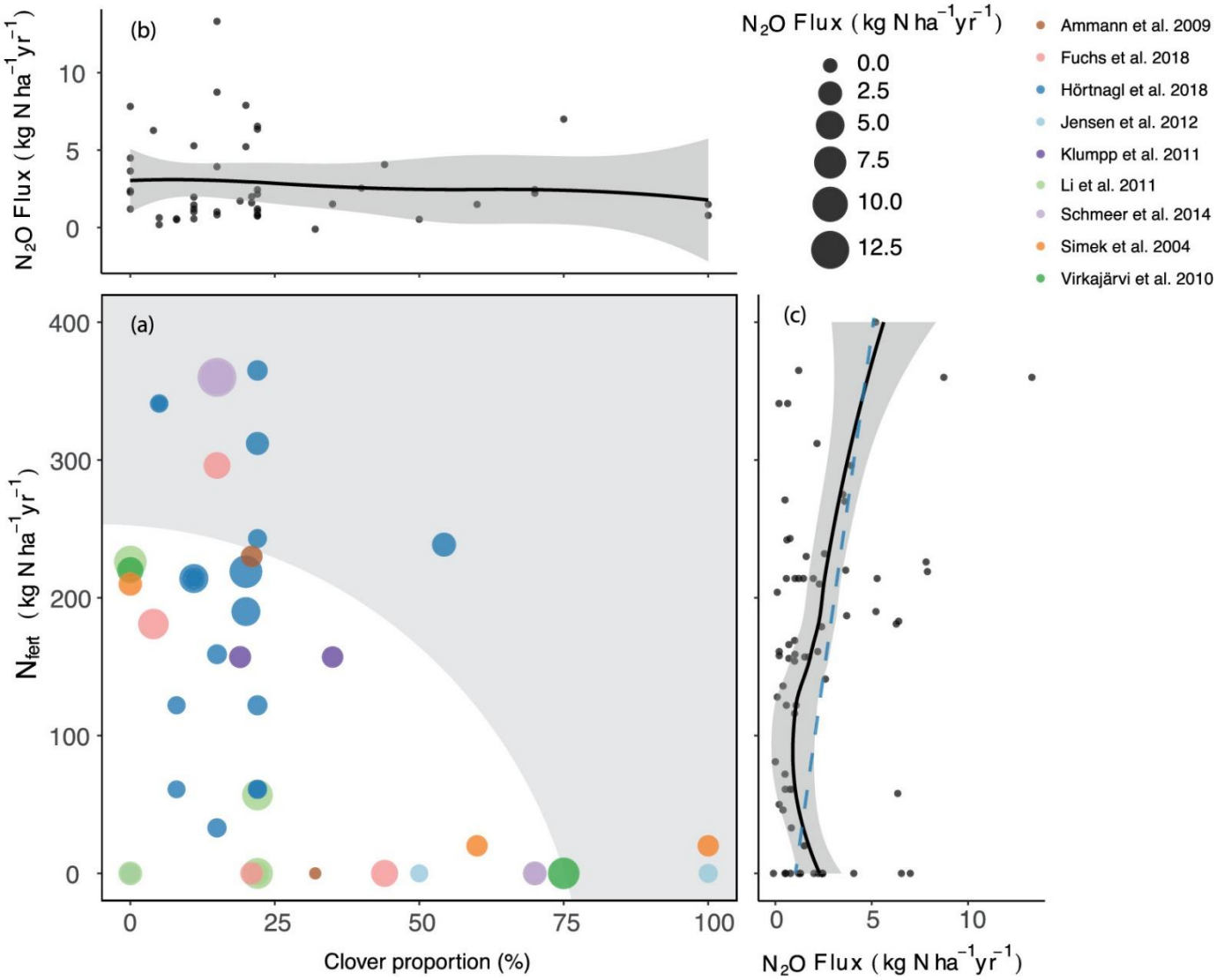
Eory et al Marginal Abatement Cost Curve for Scottish Agriculture, 2020

Mitigation: Legume-grass mixtures

- UK pastures have a relatively little leguminous forage
- Increasing grass clover swards would decrease N fertiliser requirements, reducing N_2O emissions and production costs with a saving of 0.5 t CO_{2e} /ha/y

Eory et al Marginal Abatement Cost Curve for Scottish Agriculture, 2020

Clover reduces N2O emissions

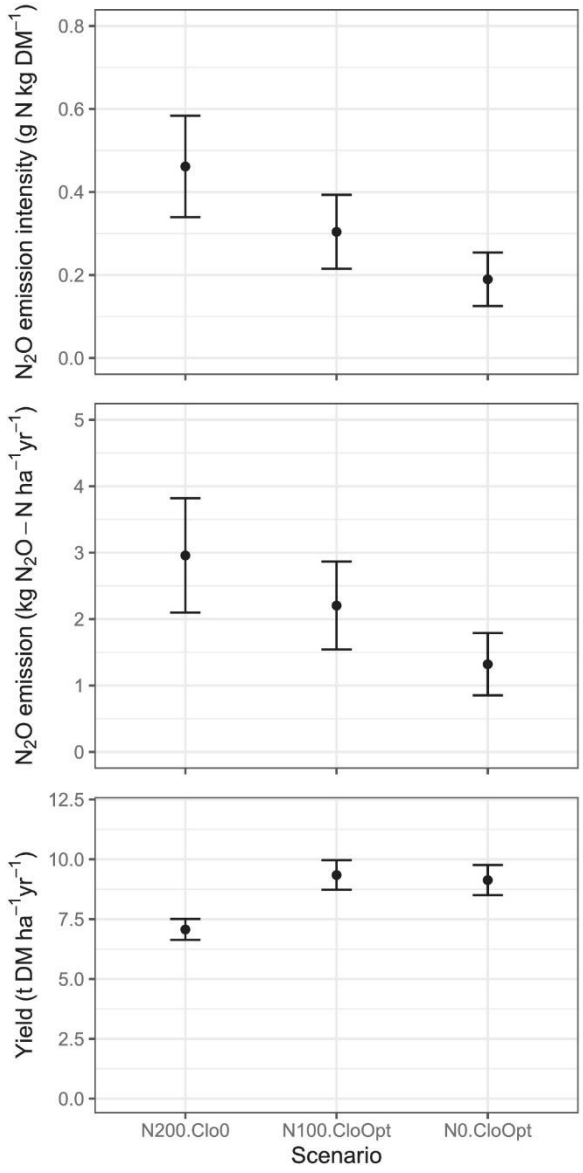


Global Biogeochemical Cycles, Volume: 34, 21 October 2020, DOI: (10.1029/2020GB006561)

Crop residues

- A highly uncertain component of the agricultural greenhouse gas inventory
- Emissions assumed to represent 1% of N contained in residue inputs
- Difficult to assess inputs and emissions associated with them
- Likely to be opportunities for mitigation

Replacing mineral N with clover



Global Biogeochemical Cycles, Volume: 34, Issue: 12, October 2020, DOI: (10.1029/2020GB006561)

Mitigation

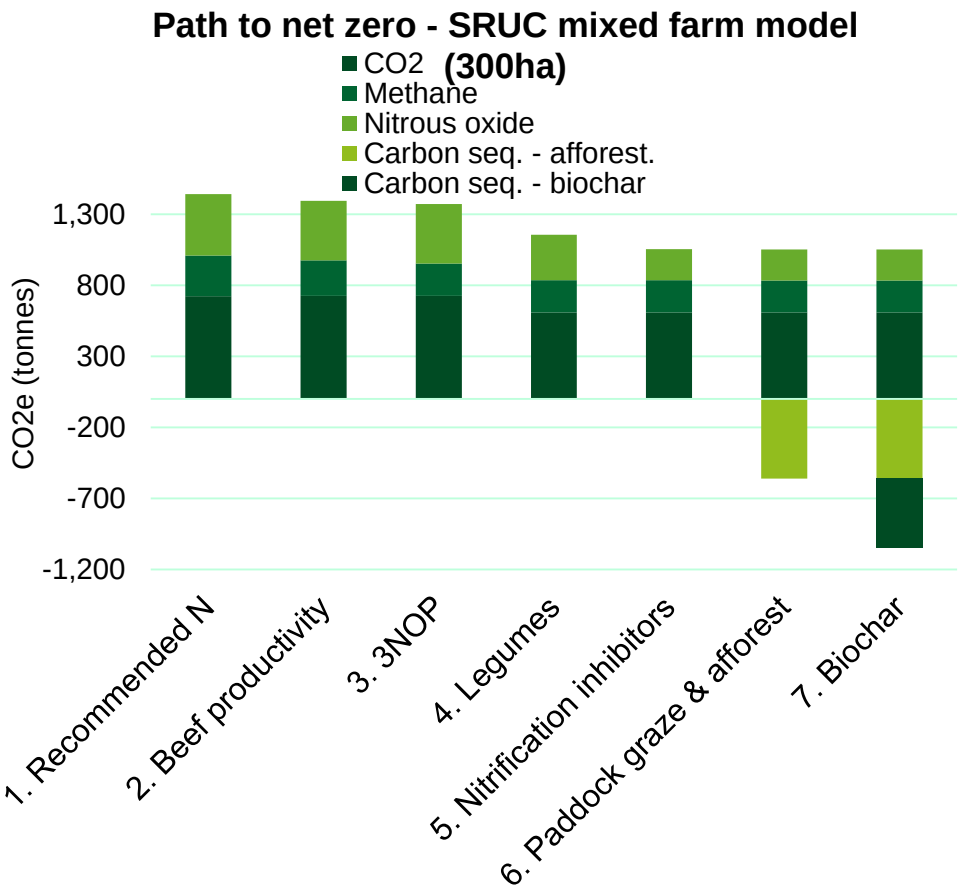
- If we replace arable and forage crops with legumes, what contribution could it make to net zero targets?
  - Reduced fertiliser inputs
  - Reduced soil based N_2O emissions
  - Increased carbon sequestration

Modelling farm level approaches to net zero

- Model a mixed farming enterprise using the AgreCalc* carbon footprinting tool
- Introduce a sequence of mitigation measures to reduce emissions
- Divide the remaining emissions between different GGRs

Sykes *at al*, 2016 Journal of Cleaner Production 164, 398-409

Net zero farming – how to get there?

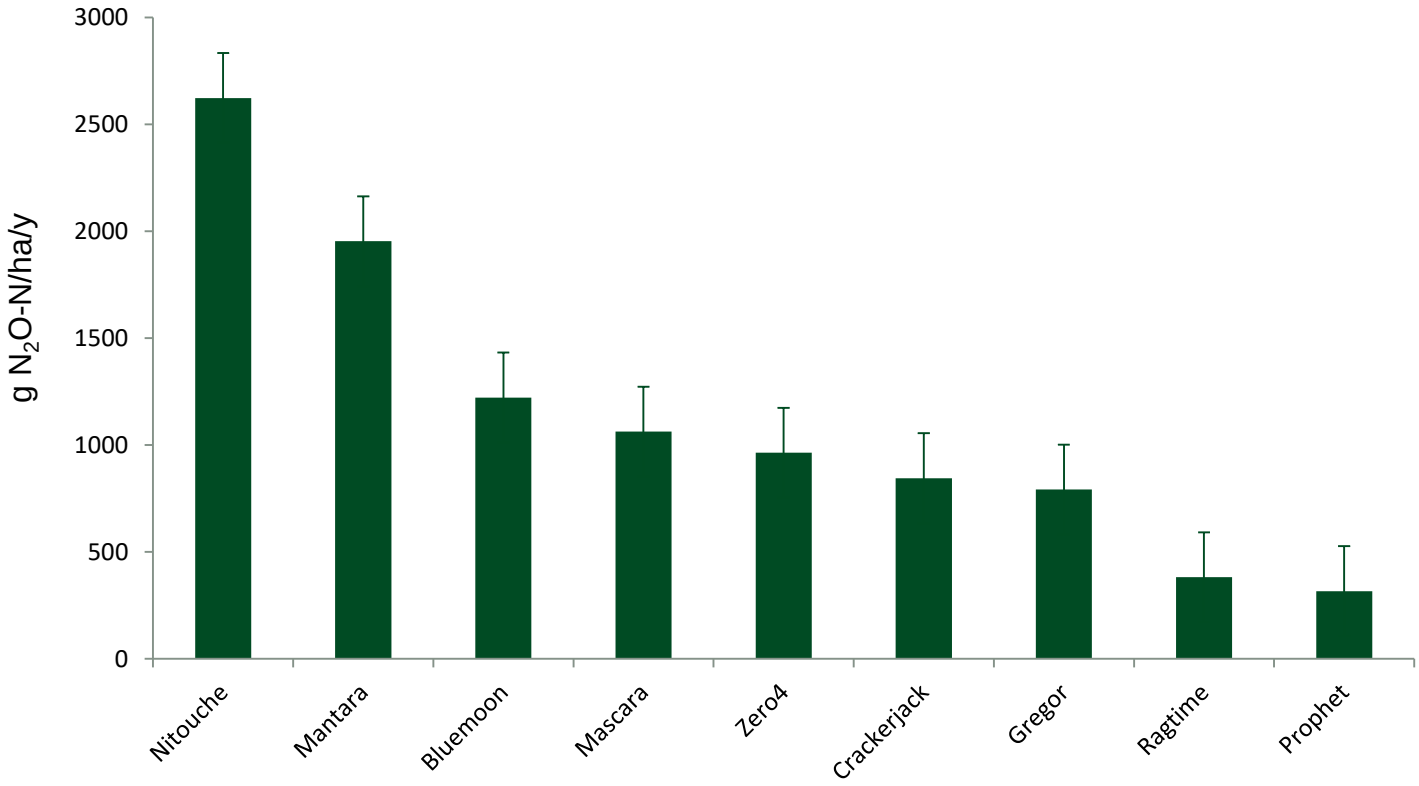


Management interventions reduce emissions by >30%
Offsets split between afforestation and biochar

Legumes and net zero farming

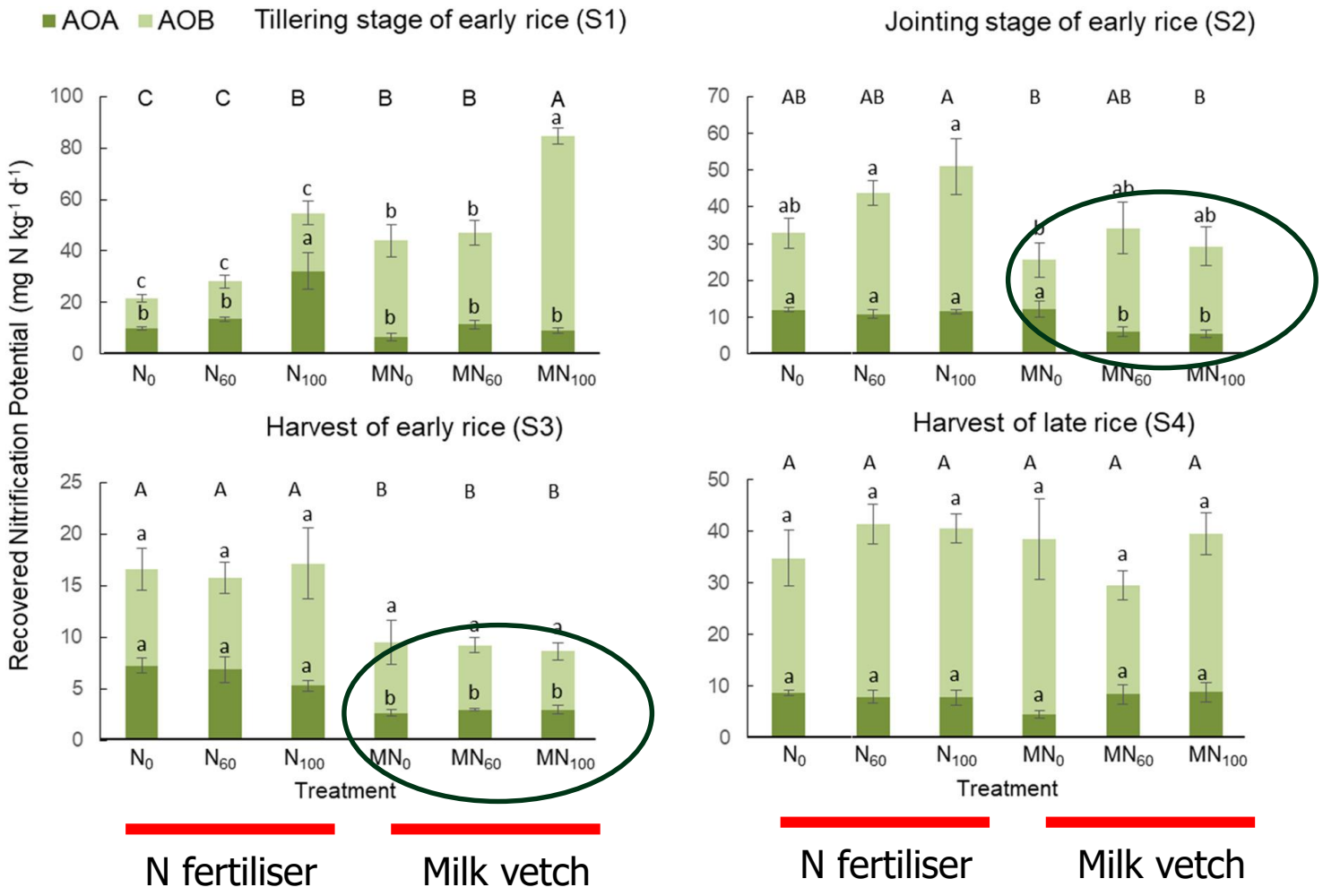
- Need to develop a holistic account of their role including direct and indirect impacts
- Still much we don't know:
  - Emissions form crop residues
  - Contributions to carbon sequestration
  - Wider impacts on microbial communities

Nitrous oxide emissions pea cultivar matters



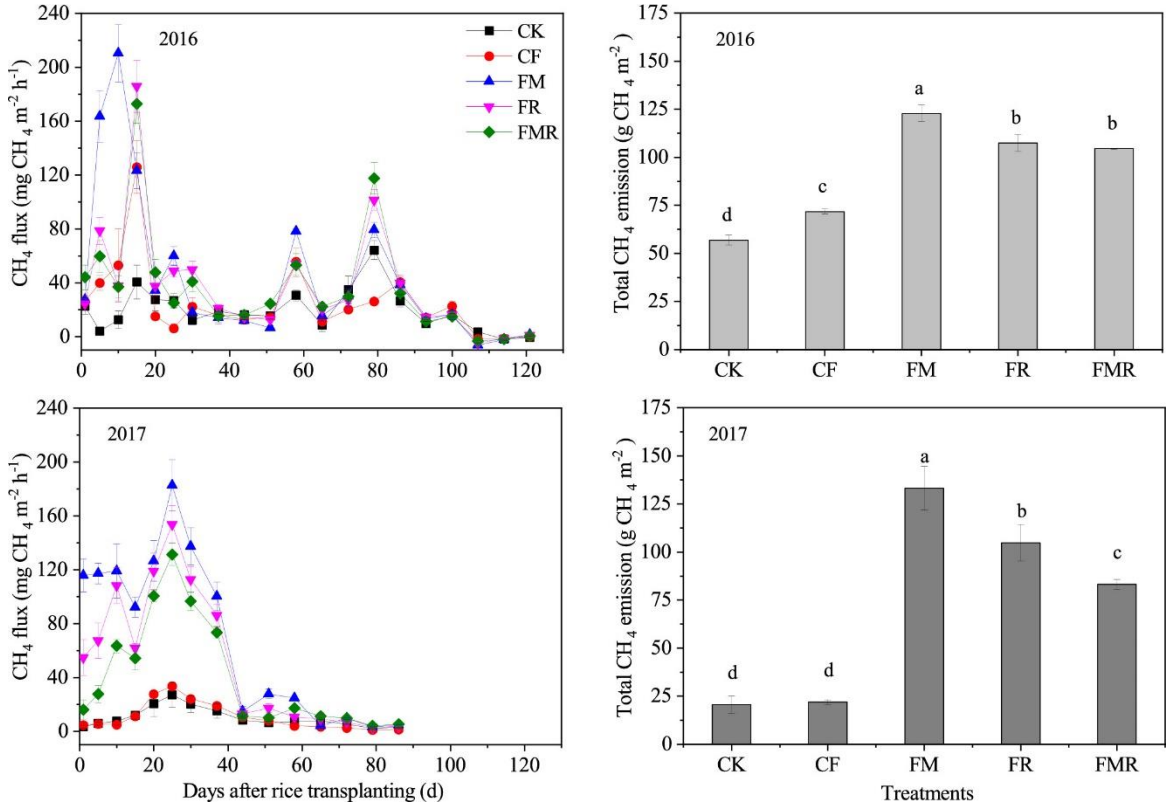
Pappa, unpublished data

Legumes alter soil microbial activity



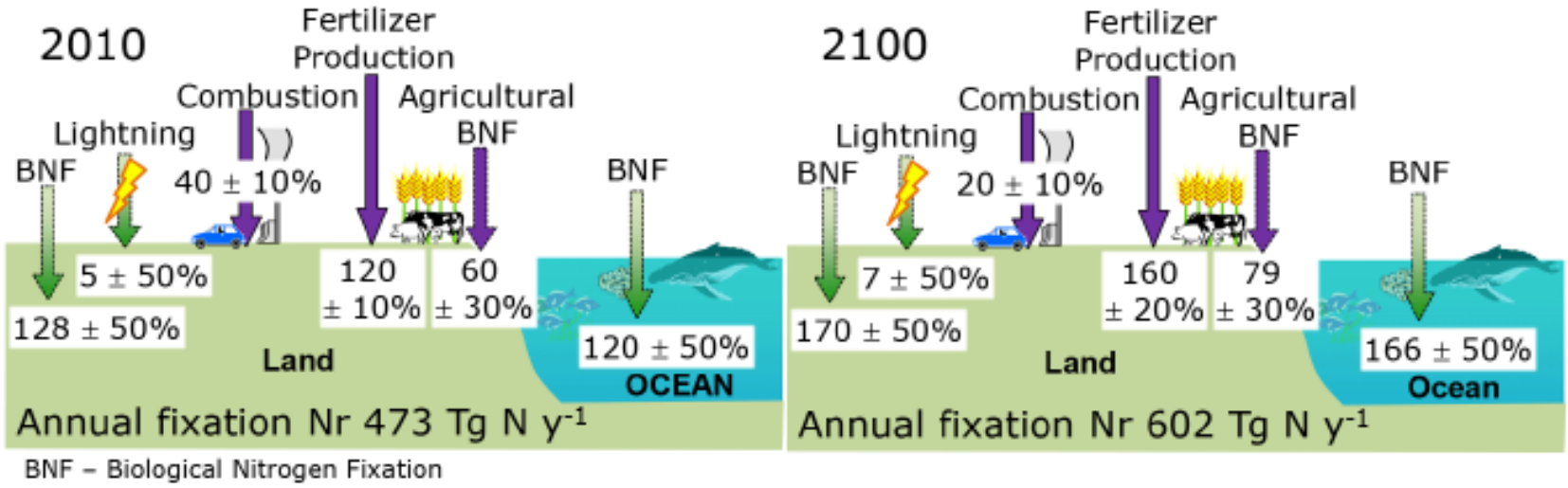
Gao et al 2020. Applied Soil Ecology 156 doi.org/10.1016/j.apsoil.2020.103698

Co-incorporation of Chinese milk vetch and rice straw minimizes CH4 emissions



European Journal of Soil Science, Volume: 71, Issue: 5, Pages: 924-939, First published: 21 December 2019, DOI: (10.1111/ejss.12930)

Future of the global N cycle



BNF – Biological Nitrogen Fixation

- Large increases in N inputs
- Can we increase the proportion of BNF used to drive global food production?

Fowler et al , 2015

Conclusions

- The pathway to net zero emissions will require deep cuts in greenhouse emissions across all sectors and significant GHG removals by the land use sector
- Legumes offer a vitally important contribution to GHG mitigation and co-benefits
- Legumes also provide wider environmental benefits and opportunities to address the nitrogen problem

Thankyou

We acknowledge funding from:

Scottish Government,

Committee on Climate Change,

Natural Environmental Research Council,

Biological and Biotechnological Research Council,

DEFRA and

The European Union