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

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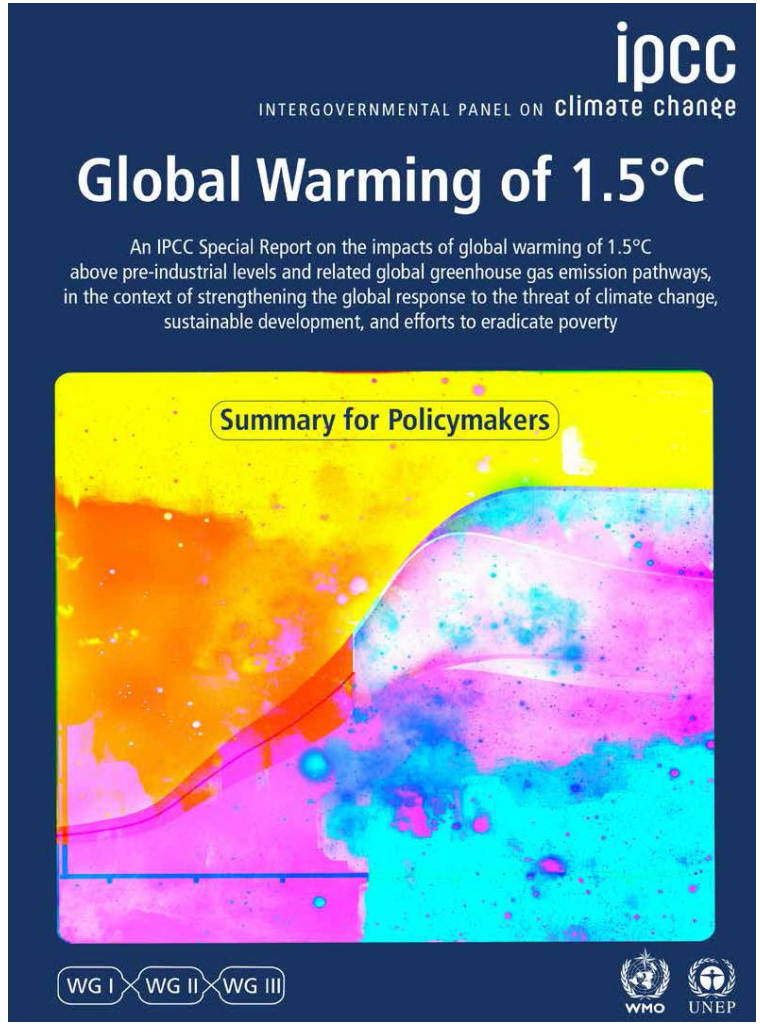
SRUC

*ELIN workshop, 3rd March 2021*

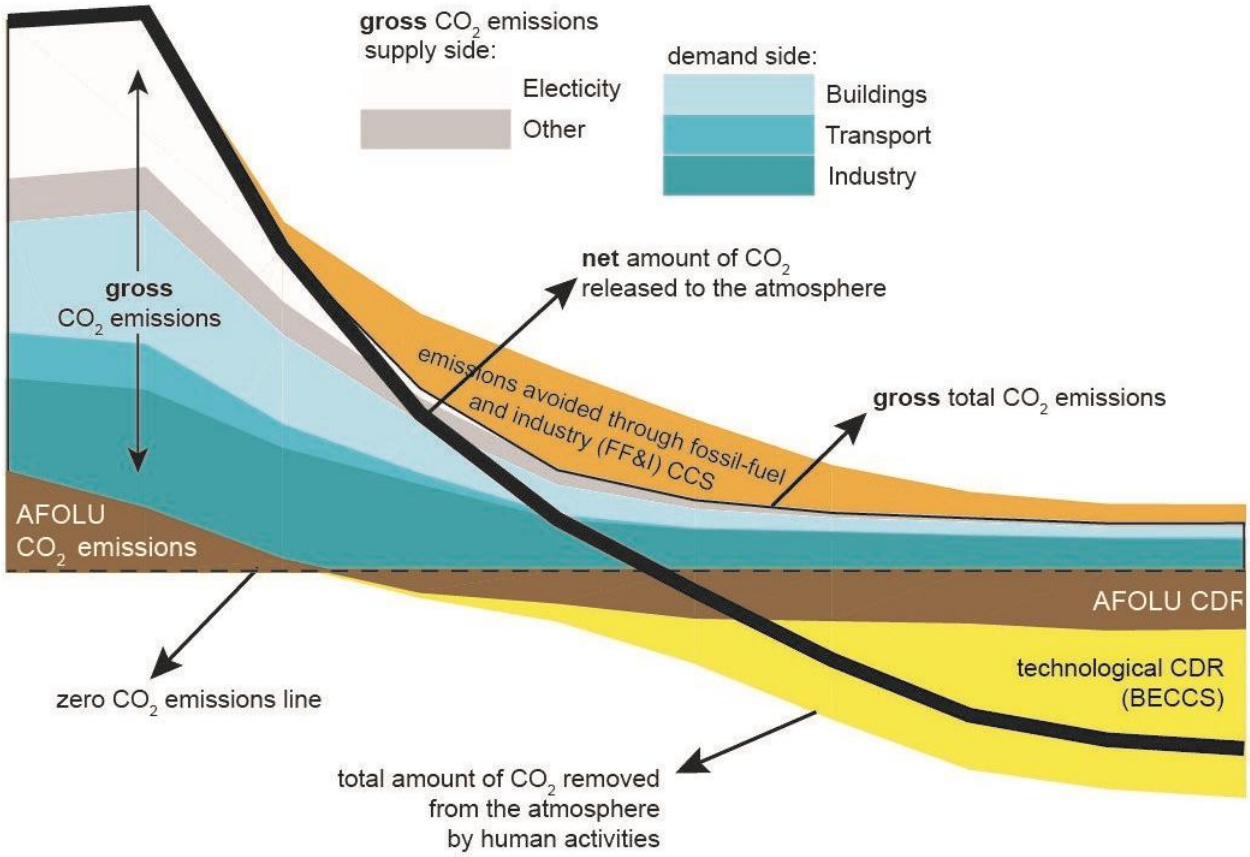
# Climate policy

- 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

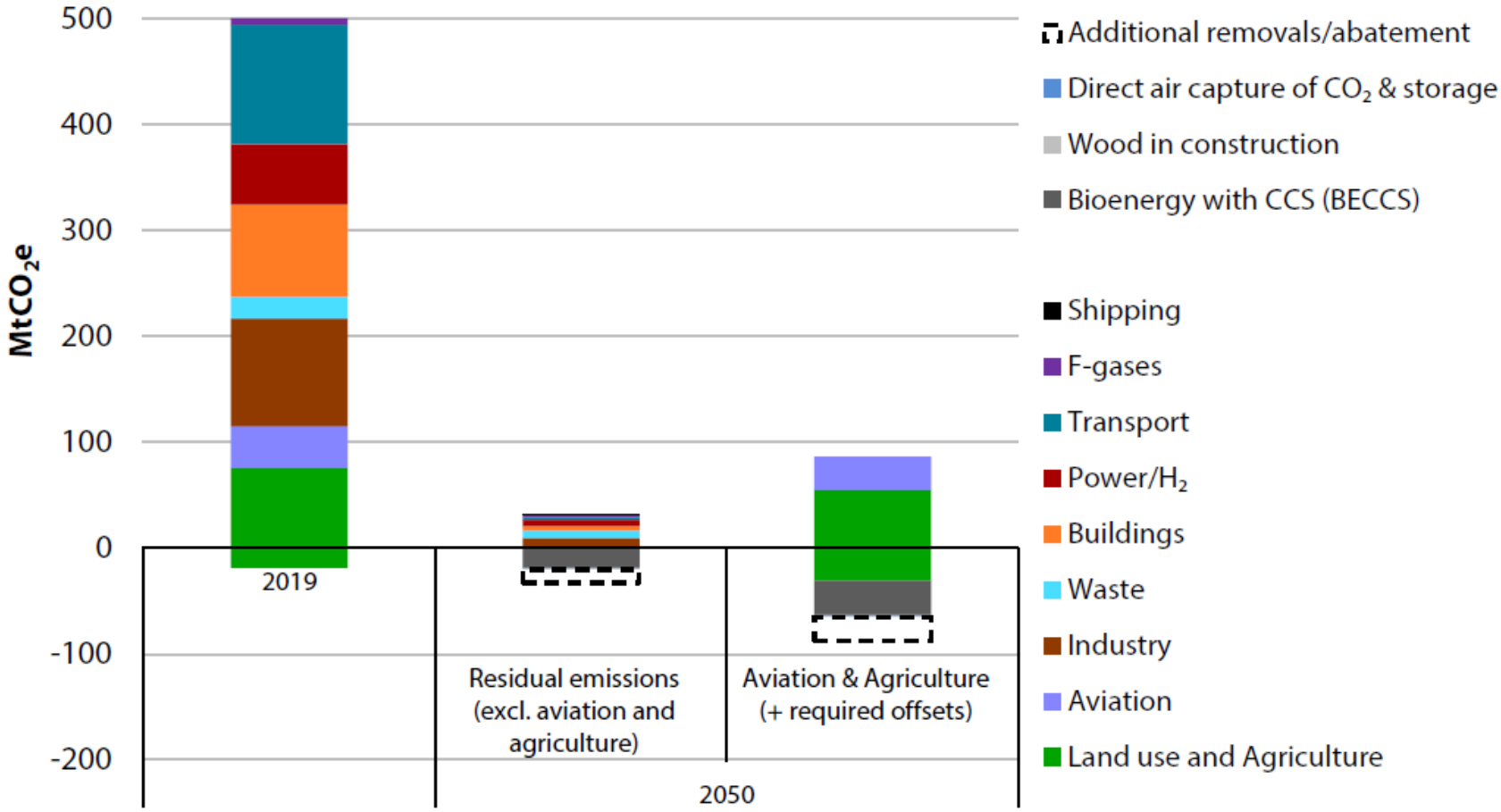
- The UK should set an ambitious target to reduce greenhouse gas emissions to 'net-zero' by 2050, ending the UK's contribution to global warming within 30 years.

- 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

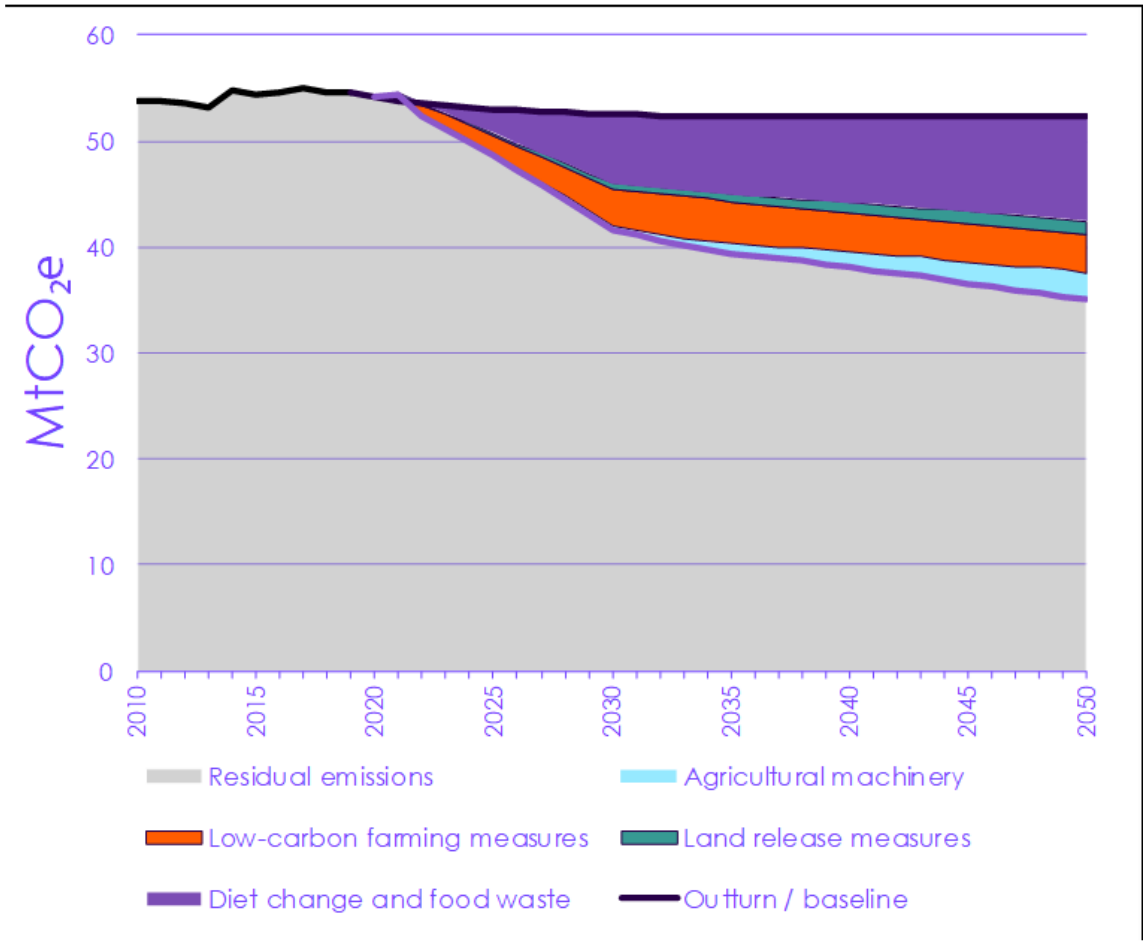
- Biological emissions
- Non-$CO_2$ greenhouse gases
- Emissions and uptake
- Food production is a basic human need
- Wider socio-economic implications
- Inertia

# Agriculture and land use contributions to net zero



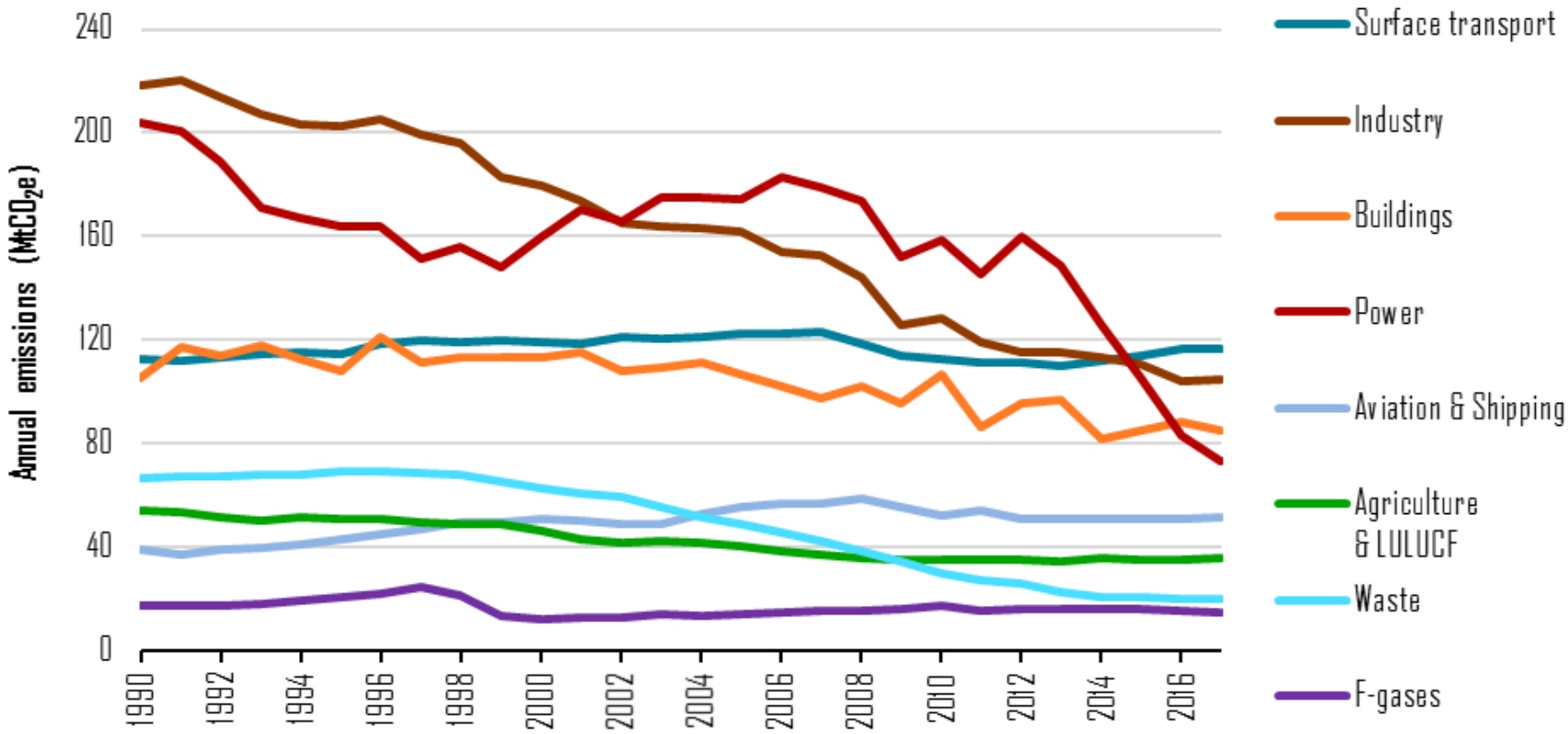

Committee on Climate Change 2019

# 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

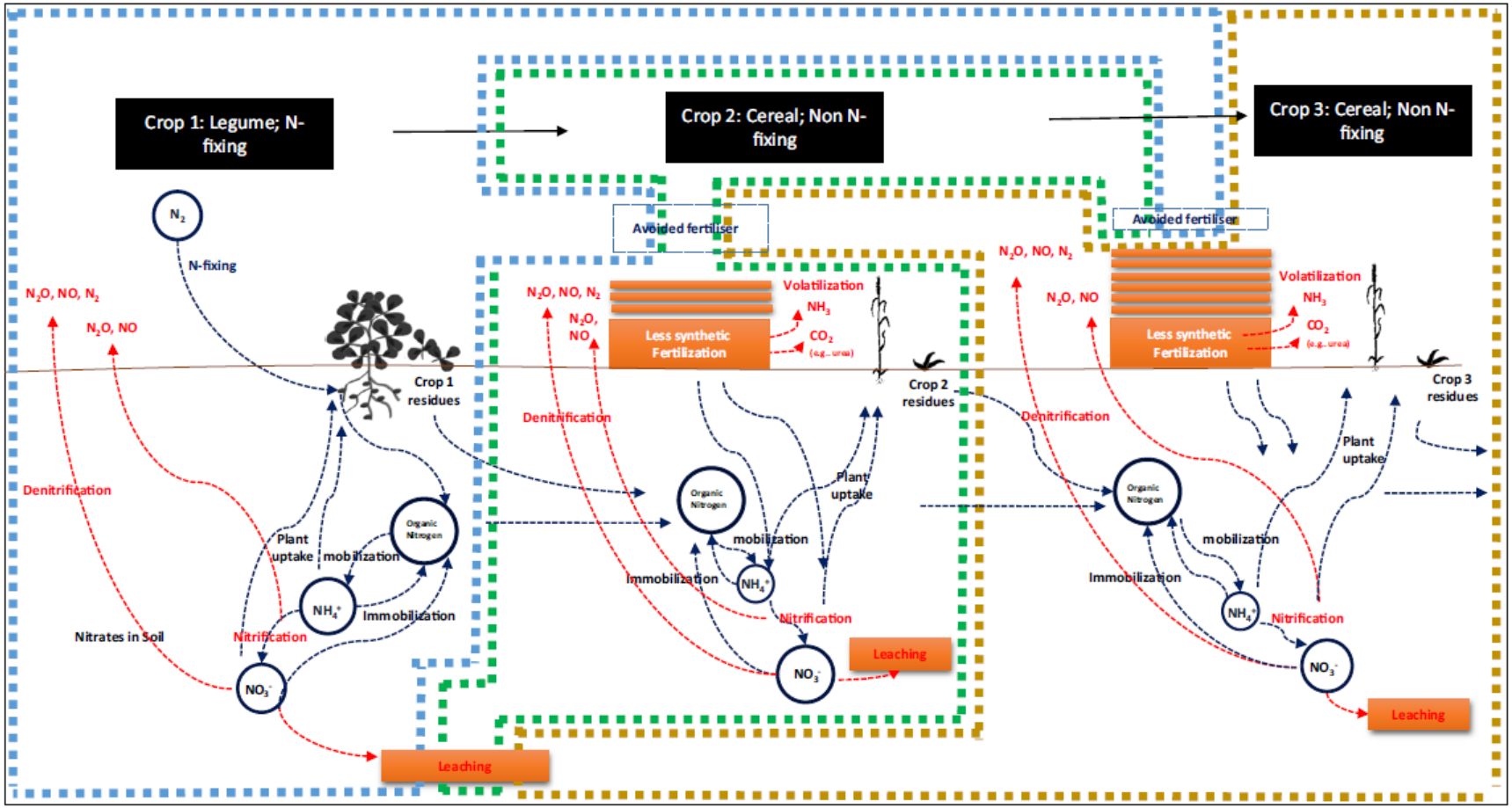
Intercrops

Forage

Main crops

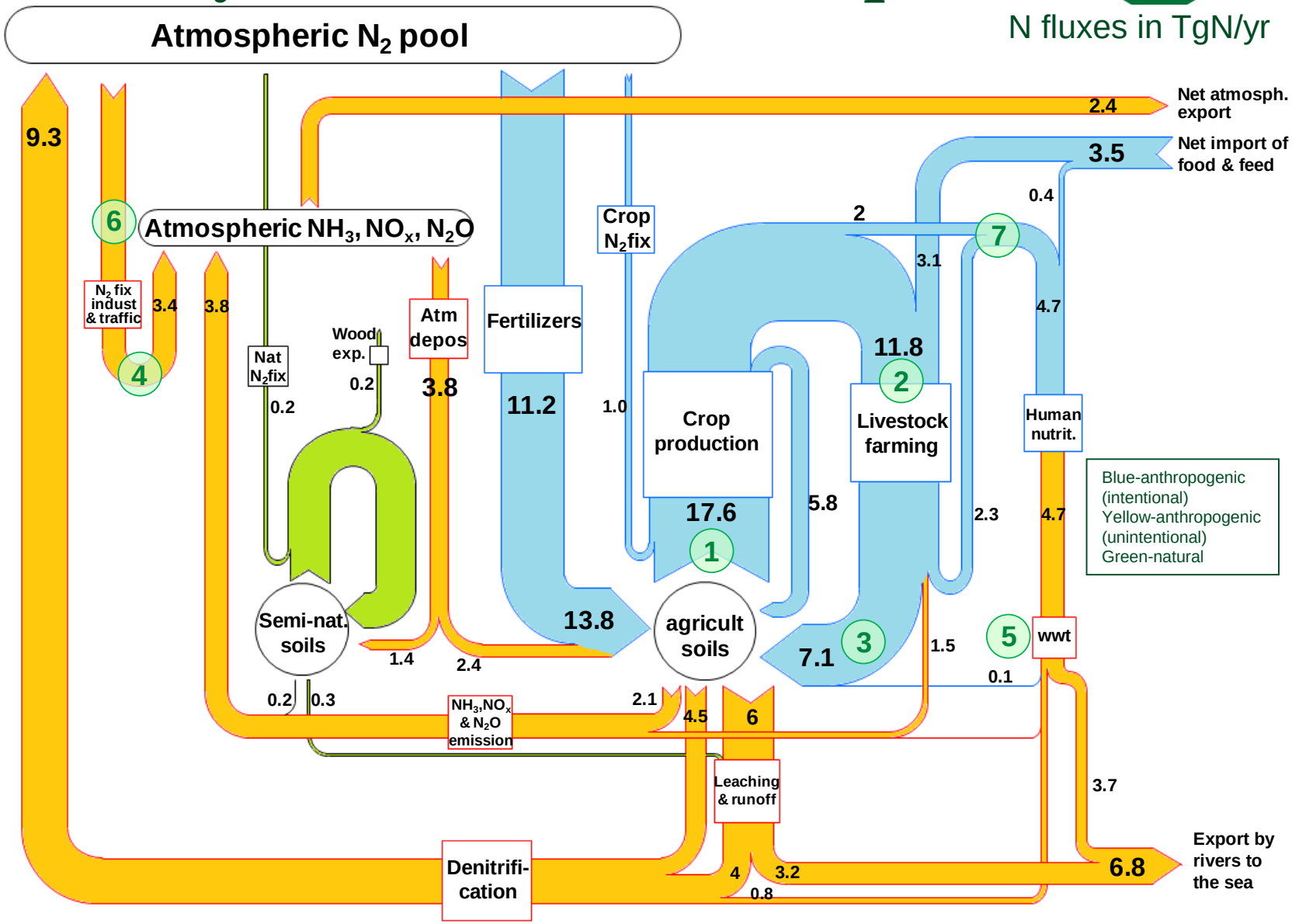
Rotational

# Capturing the contribution of legumes



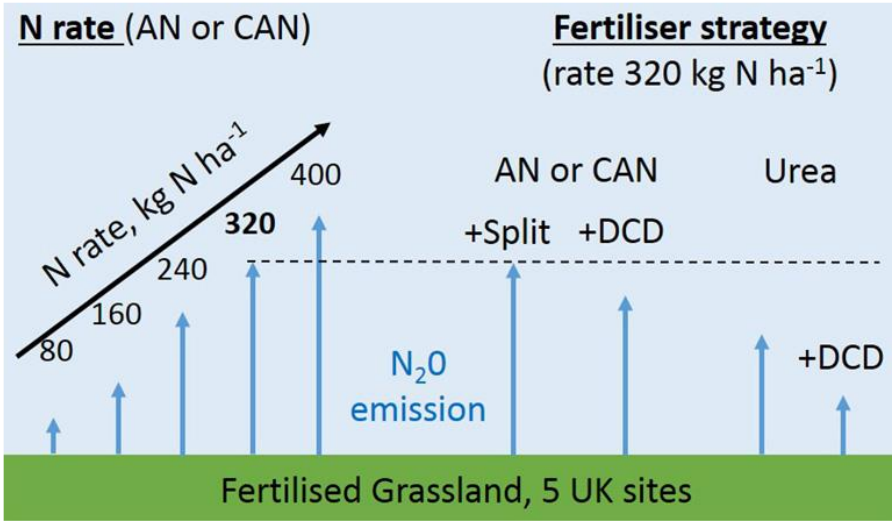

Costa et al 2020, Int J Life Cycle Assessment, doi.org/10.1007/s11367-020-01812-x

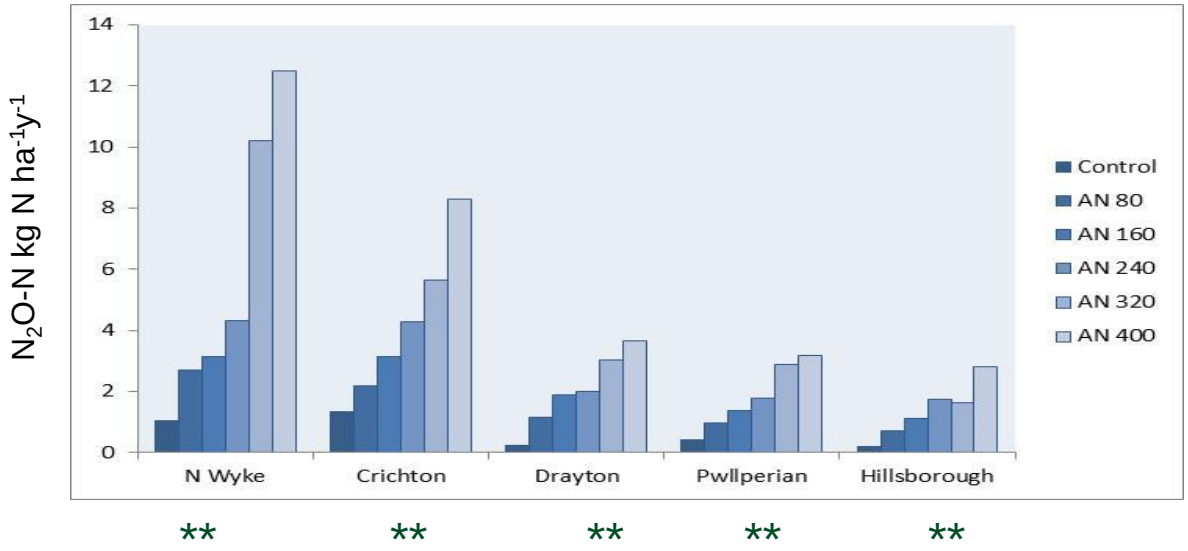
# Summary of N flows in Europe




Sutton et al 2011, European Nitrogen Assessment

# N2O emissions from grasslands



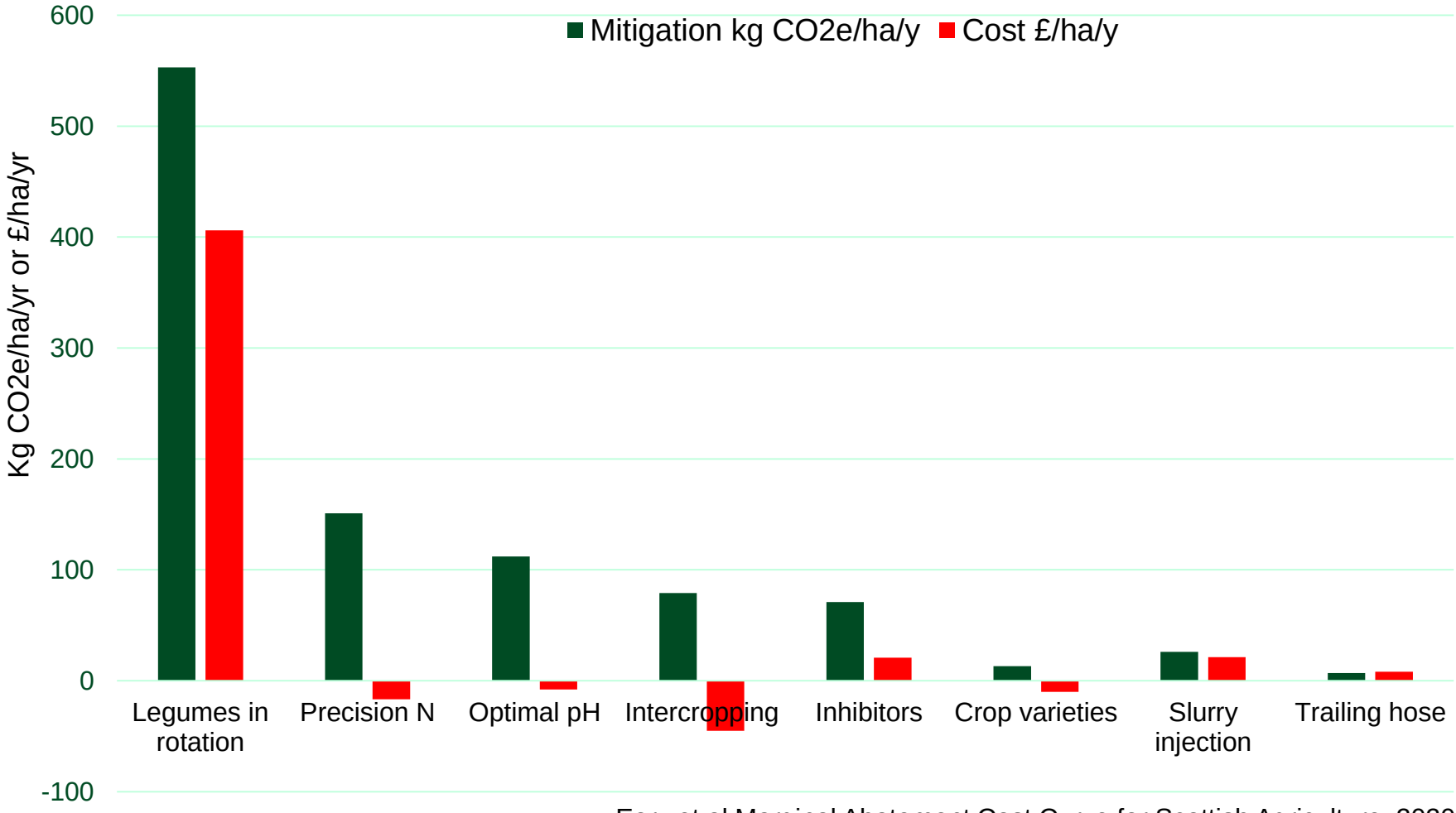

Cardenas *et al* 2019.
*Science of the Total Environment*

# 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



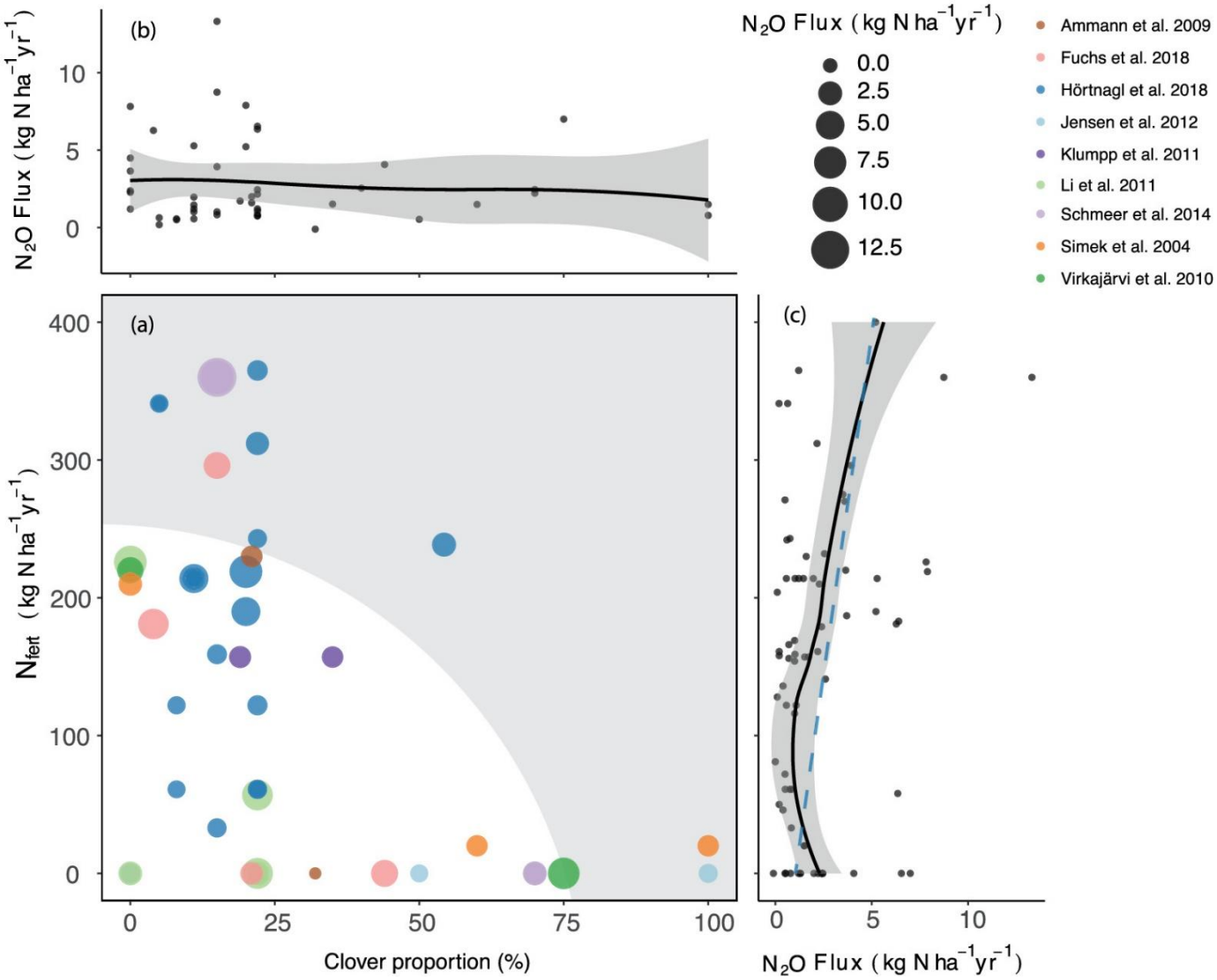

Eory et al Marginal Abatement Cost Curve for Scottish Agriculture, 2020

# 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

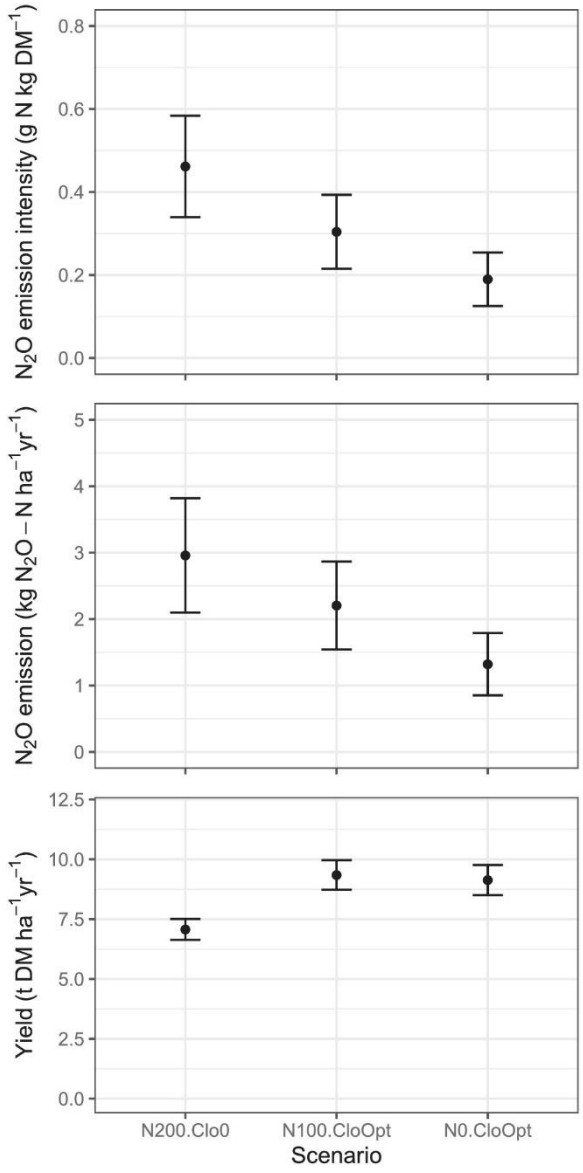



Global Biogeochemical Cycles, Volume: 34, 21 October 2020, DOI: (10.1029/2020GB006561)

# 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

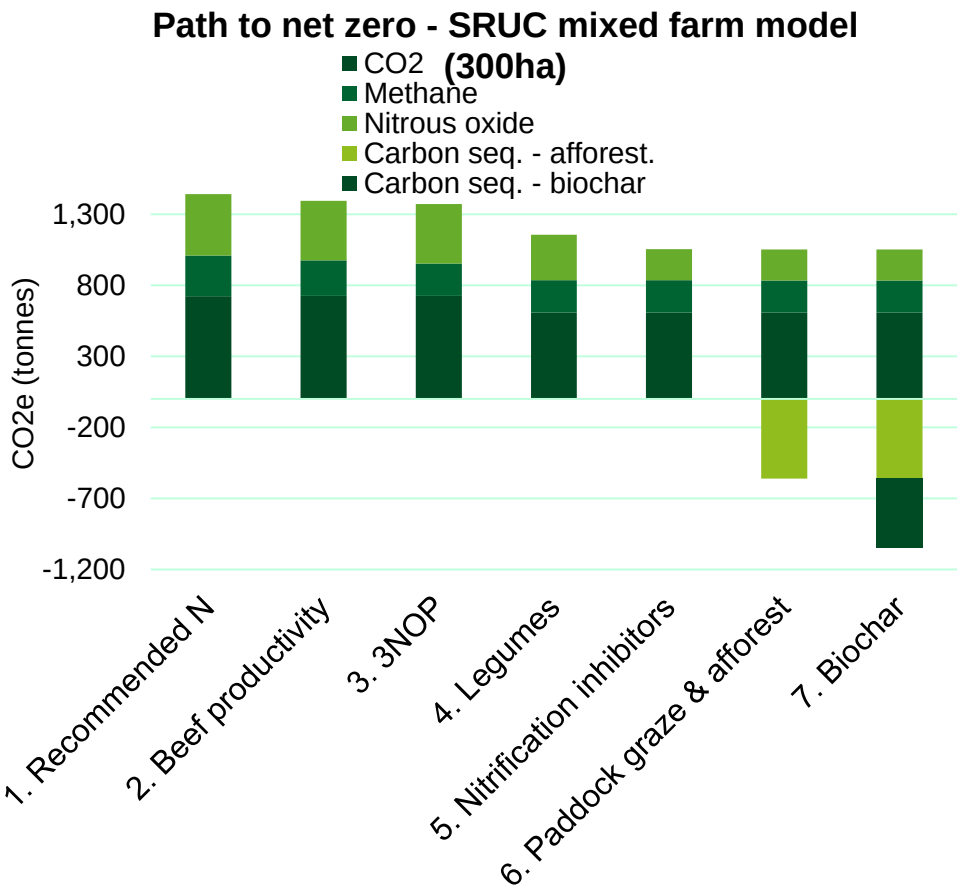
- If we replace arable and forage crops with legumes, what contribution could it make to net zero targets?
  - Reduced fertiliser inputs
  - Reduced soil based $N_2O$ emissions
  - Increased carbon sequestration

# 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?

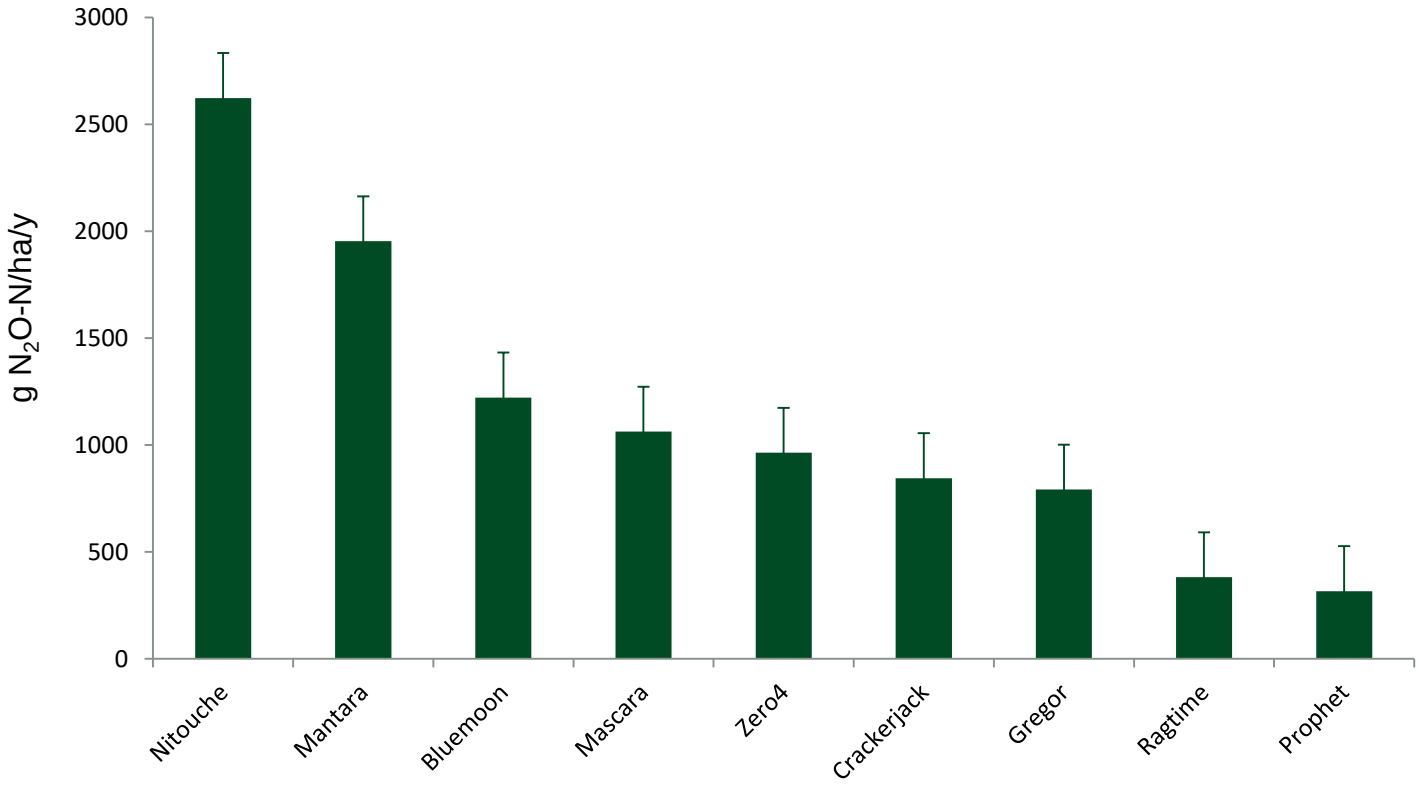



Management interventions reduce emissions by >30%
Offsets split between afforestation and biochar

# Legumes and net zero farming

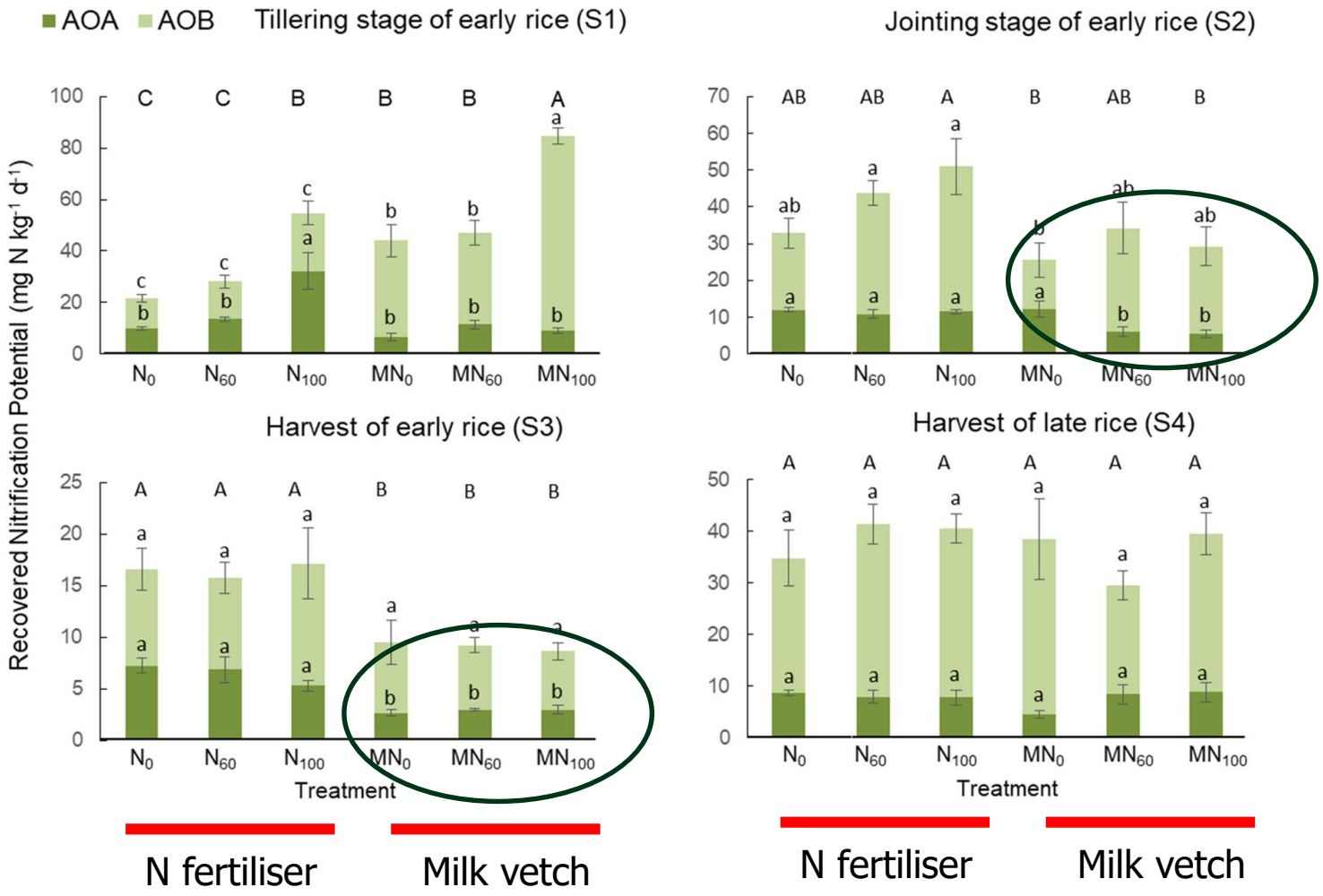
- Need to develop a holistic account of their role including direct and indirect impacts
- Still much we don't know:
  - Emissions form crop residues
  - Contributions to carbon sequestration
  - Wider impacts on microbial communities

# Nitrous oxide emissions pea cultivar matters



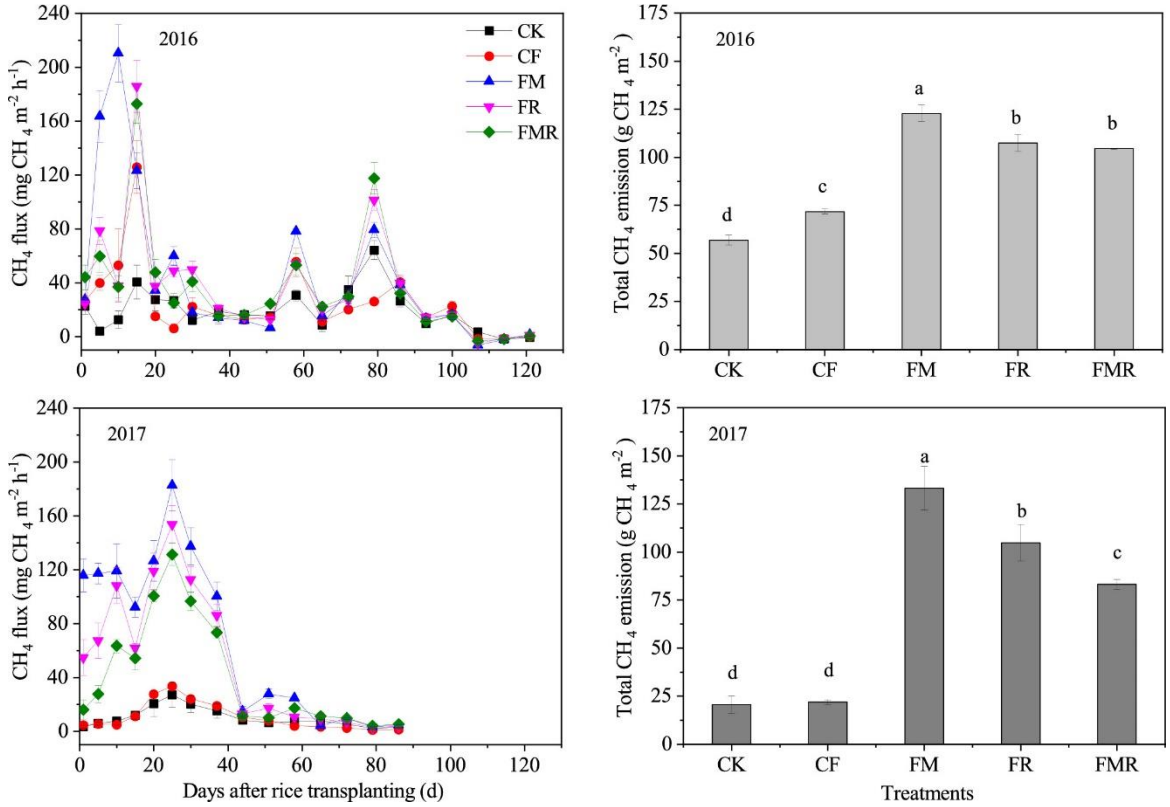

Pappa, unpublished data

# Legumes alter soil microbial activity



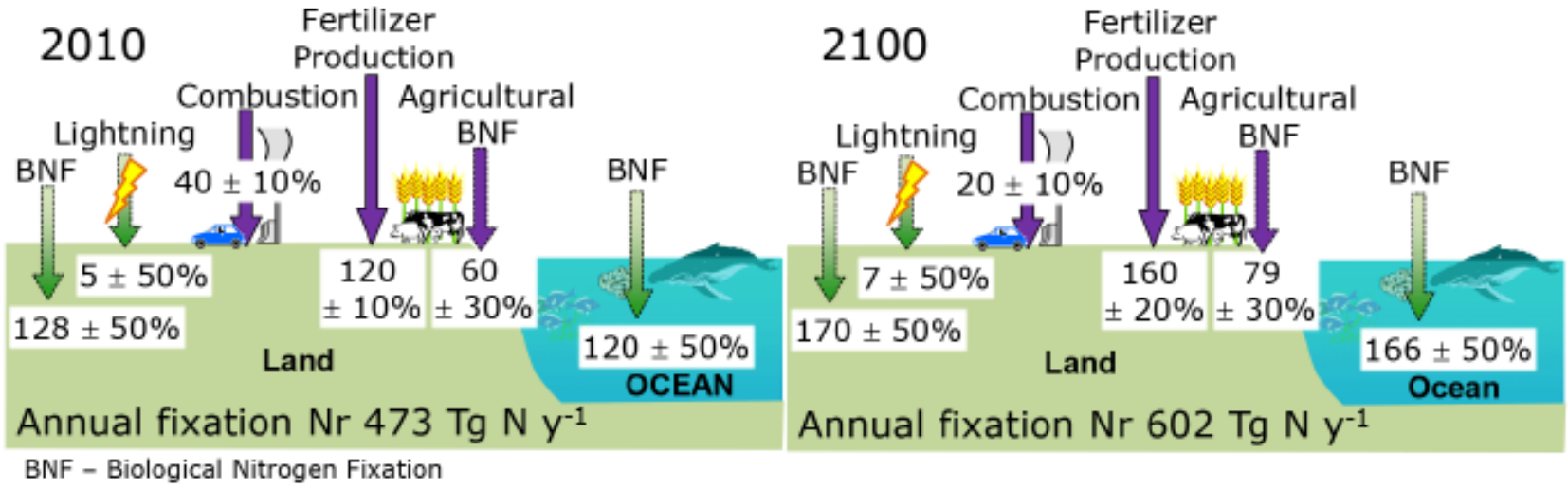

Gao et al 2020. Applied Soil Ecology 156 doi.org/10.1016/j.apsoil.2020.103698

# 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

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