Agriculture & LULUCF Research Overview: Emissions and Mitigation

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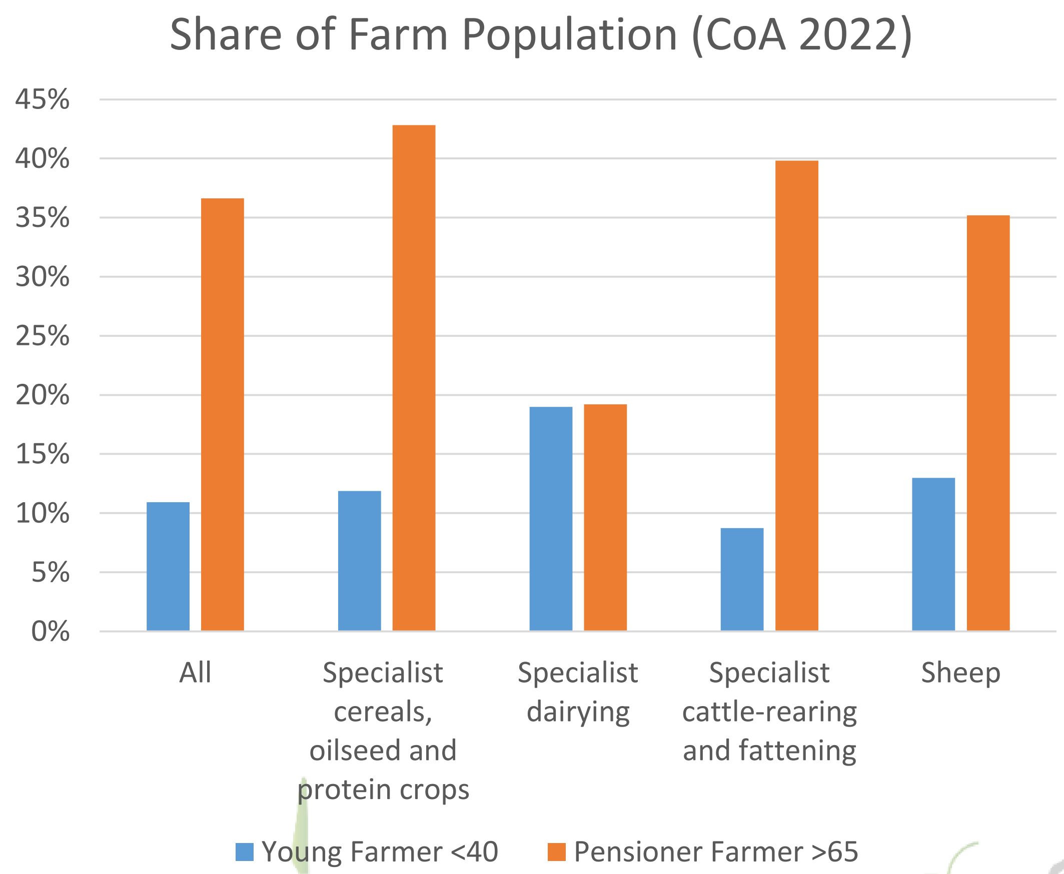
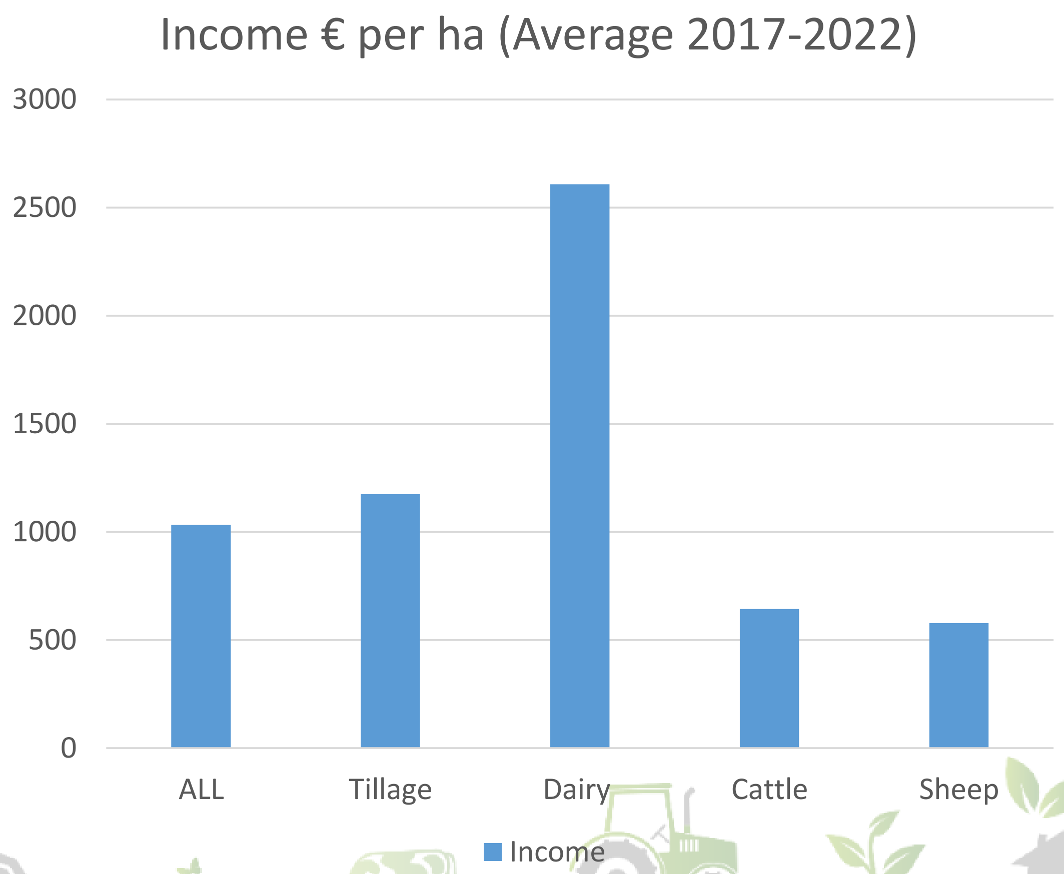
Presentation Outline

- Outline of farmer demographics/social sciences
- Emissions Overview
- Teagasc Climate Centre
- Teagasc Climate Centre research
- Inventory Refinement Science
- Mitigation Science
- Summary

Farming Demographics & Income Performance





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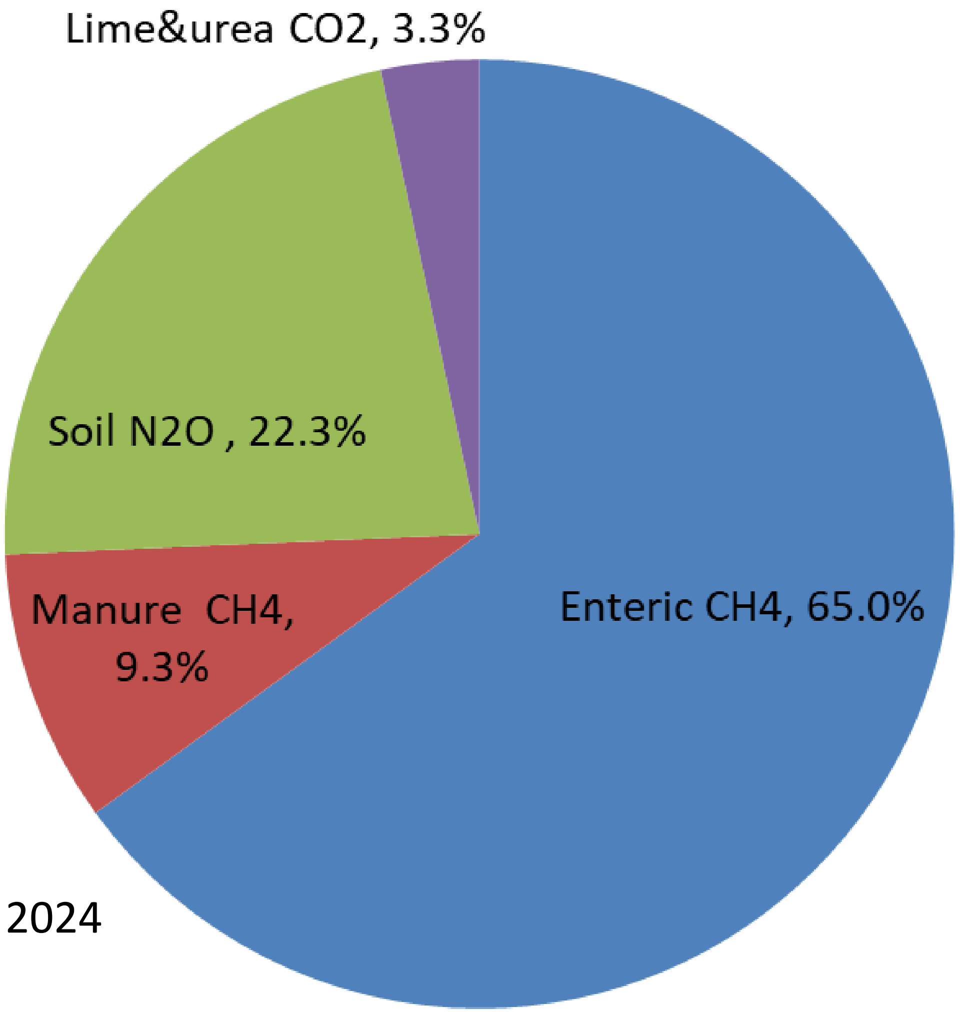
Agricultural Emissions

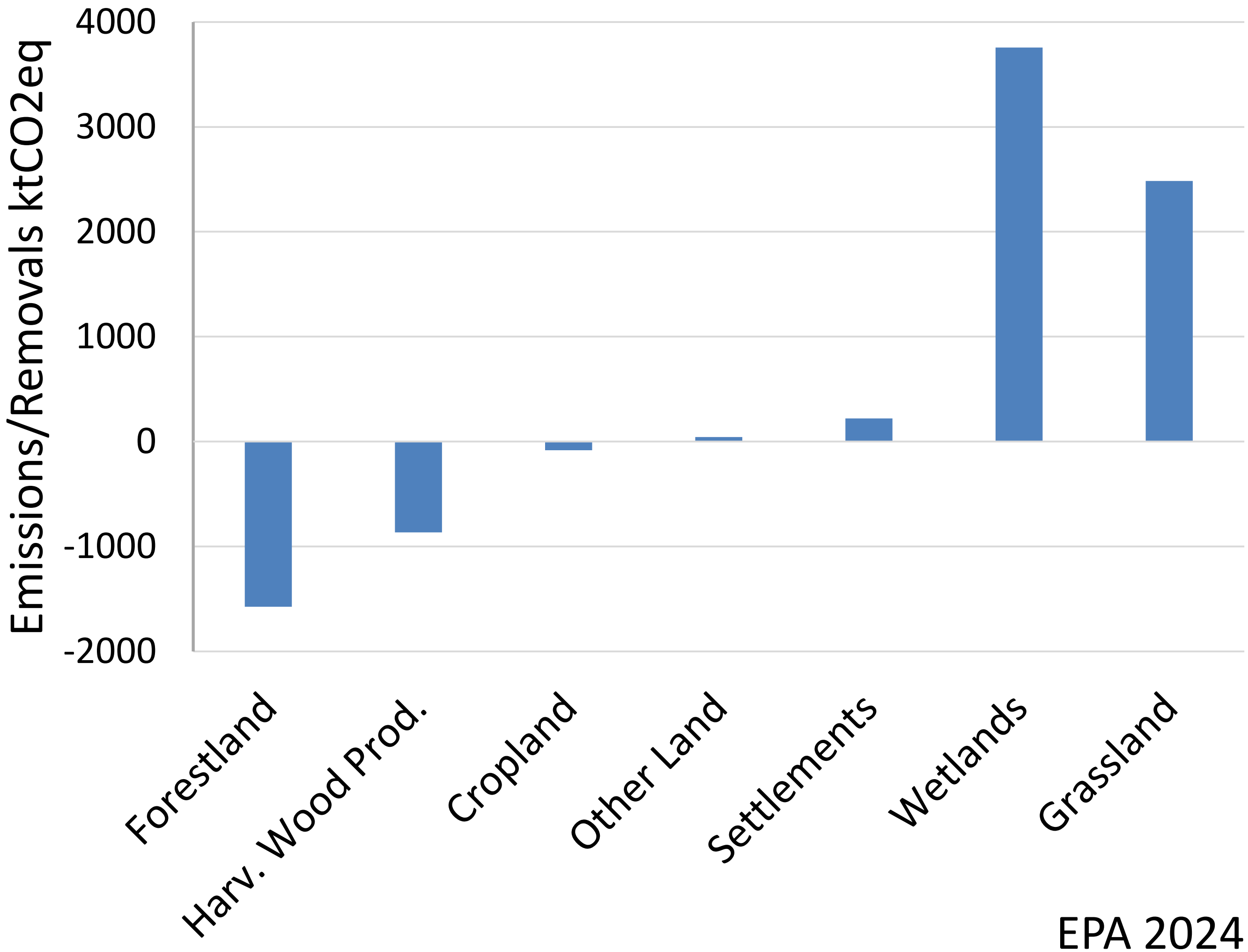
- Emissions Share
  - Methane (CH_4) c. 74%
  - Nitrous oxide (N_2O) 22%
  - CO_2 emission c. 3% (liming & urea)
- Currently modelling for CCAC
  - Projected emissions 2030-50
  - Potential Mitigation 2030-50



EPA 2024

LULUCF Emissions

- Latest EPA inventory (2024)
- Wetlands 3.8 Mt CO_2e
- Grasslands 2.5 Mt CO_2e
- Forestry/wood products -2.4 MT CO_2e
- Sectoral emissions growing since 2018
- Frequent inventory revisions
- Update LULUCF Projections to 2050



EPA 2024

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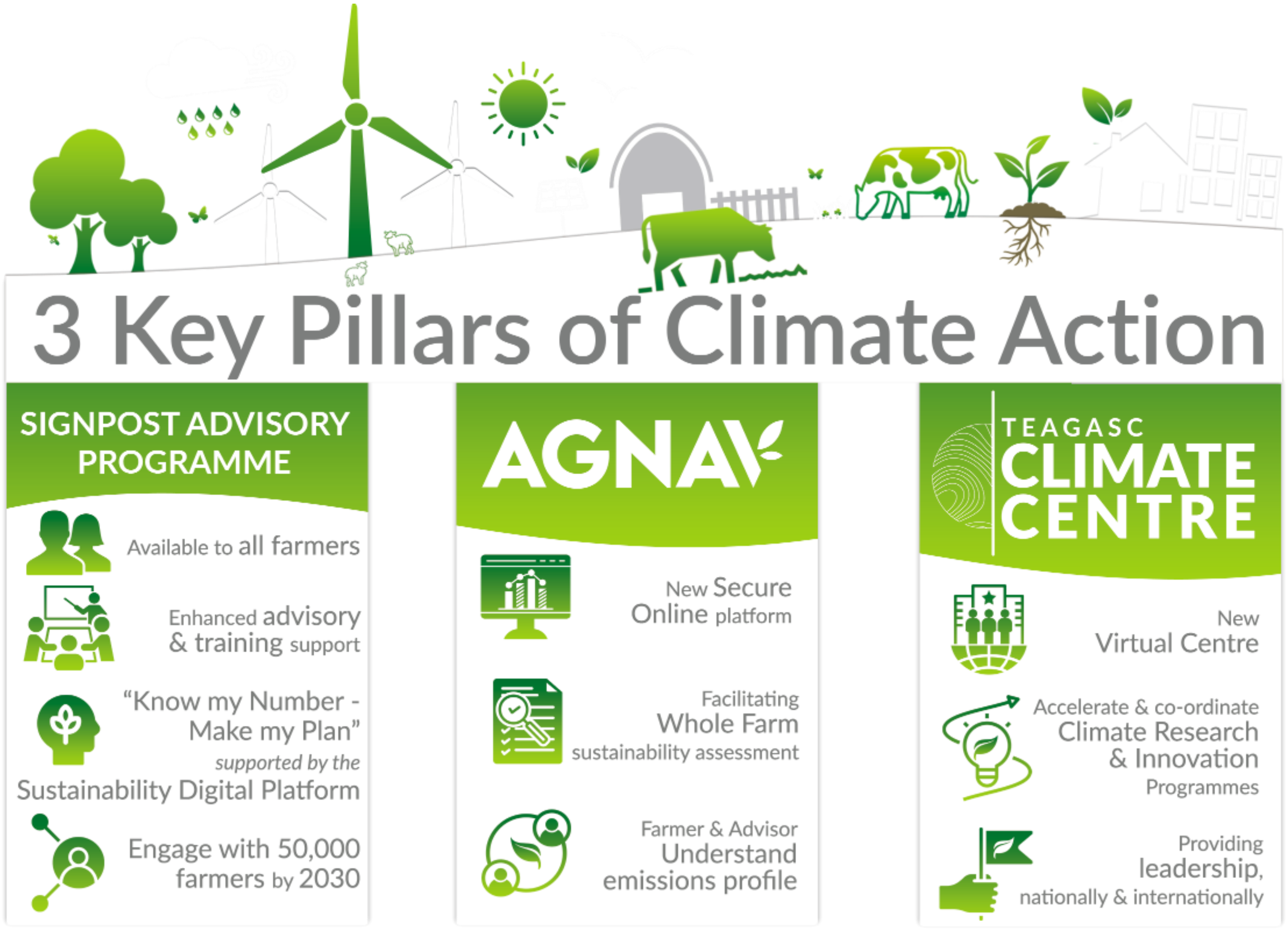
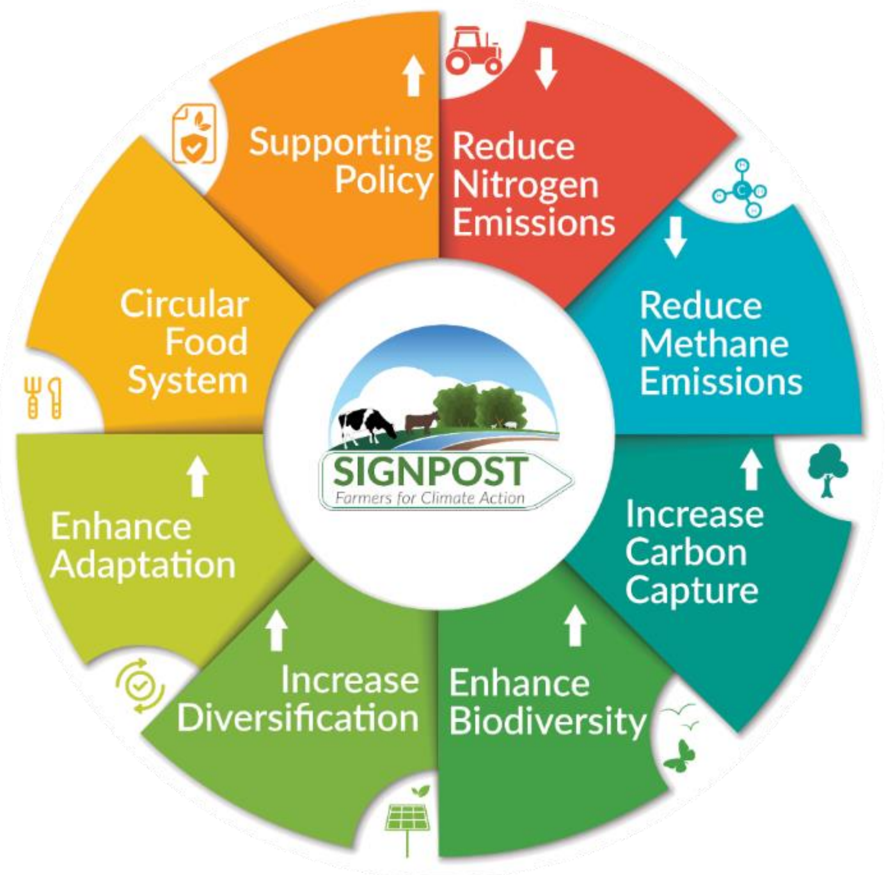
Teagasc Climate Strategy



Teagasc Climate Centre



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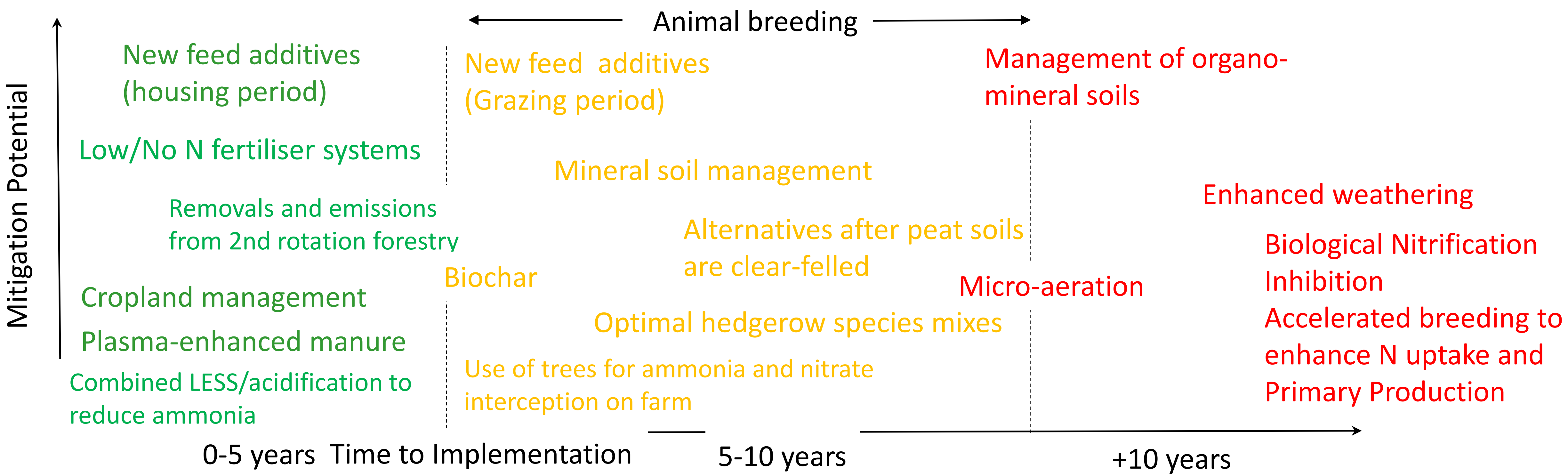
Modelling Pathways towards Net Zero

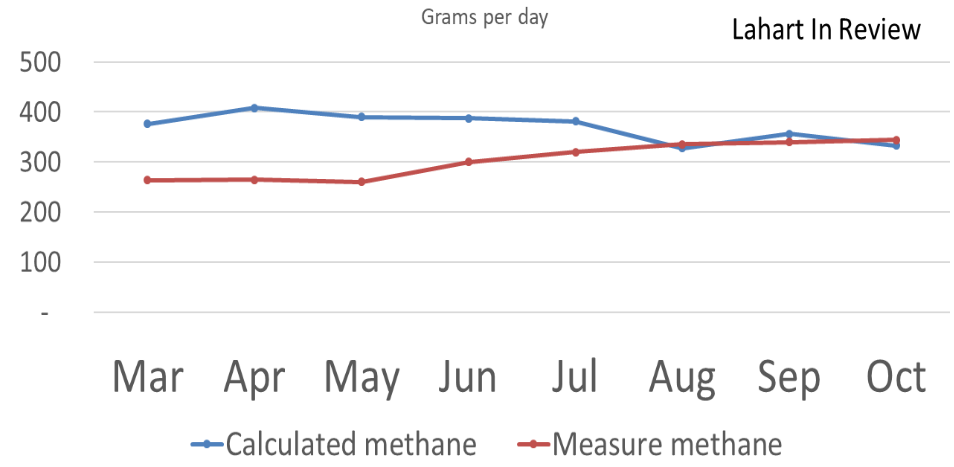
- Extending FAPRI modelling to project agricultural activity to 2050
- Extend BAU LULUCF emissions using process-based modelling
- Model future agricultural mitigation potential & adoption rates
- Model future LULUCF & land-based mitigation to 2050



Inventory Refinement Research

Methane (16.7 $MTCO_2e$ 65%)

- Cattle and Sheep
- Grazing
  - Grassland Management
- Grass silage
- Alternative forages
- Manure: volume/timing, housing/storage EF



Inventory Model calculation 285g/day

Item	High quality	Low quality	S.E	Treat
Bodyweight (kg)	630	606	13.66	0.195
BCS (1-5)	3.36	3.35	0.064	0.897
DMI (kg/DM/cow)	12.78	8.93	0.598	0.001
CH_4 (g/day)	254	213	7.123	0.001
CH_4 (g/kg DMI)	21	26	1.217	0.008

J. Dairy Sci. 107:383–397
https://doi.org/10.3168/jds.2022-22646

Evaluating enteric methane emissions within a herd of genetically divergent grazing dairy cows

B. Lahart,[1*] F. Buckley,[1,2] J. Herron,[1] R. Fitzgerald,[1] E. Fitzpatrick,[1] N. Galvin,[1] and L. Shalloo[1]
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[2]School of Biological Earth and Environmental Science, University College Cork, Distillery Fields, North Mall, Cork, Ireland T12 K8AF

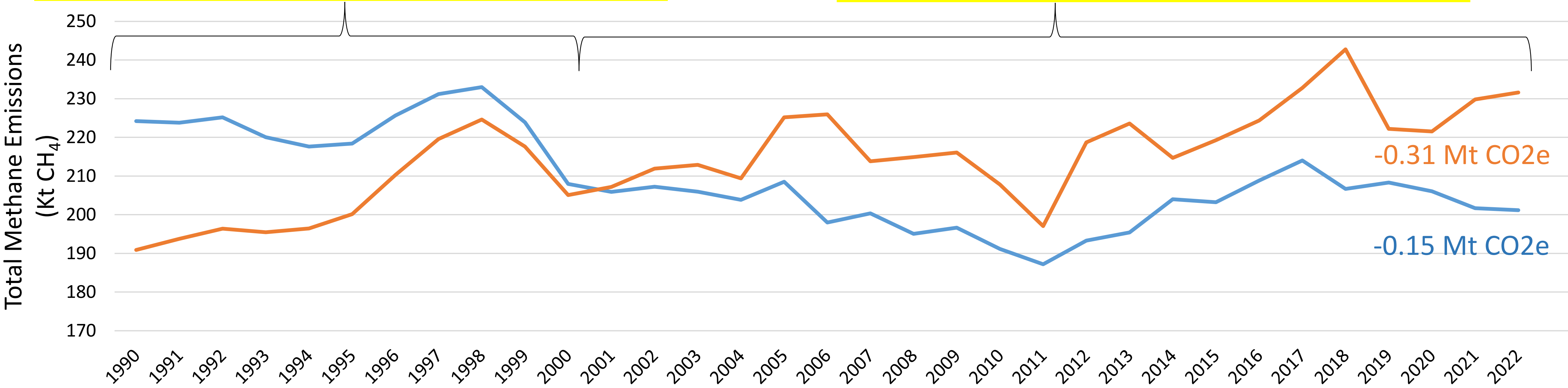
Enteric Methane Emission Factor

Study	Method	Emission factor
Wims et al. 2010	SF6	6.4
O'Neill et al., 2011	SF6	5.7
Ferris et al., 2020	SF6	4.9
Hynes et al., 2016	Chamber	5.6
Lahart et al., 2023	GreenFeed	5.2
Starsmore et al., 2023	GreenFeed	6.1
Jiao et al., 2014	SF6	5.6
Foley et al., 2008	SF6	6.3
Lovett et al 2005	SF6	5.6
Hidalgo et al 2014	SF6	6.8
Mean		**5.75**
IPCC 2019 used in inventory		**6.3**

Beef Methane Inventory Refinement

Average increase 1990-2000:
c. 9% [1 – 17%]
= 0.51 Mt CO_2e [0.08 – 0.93 Mt CO_2e]

Average reduction 2001-2022:
c. 8% [1– 15%]
= 0.48 Mt CO_2e [0.04 – 1.01 Mt CO_2e]

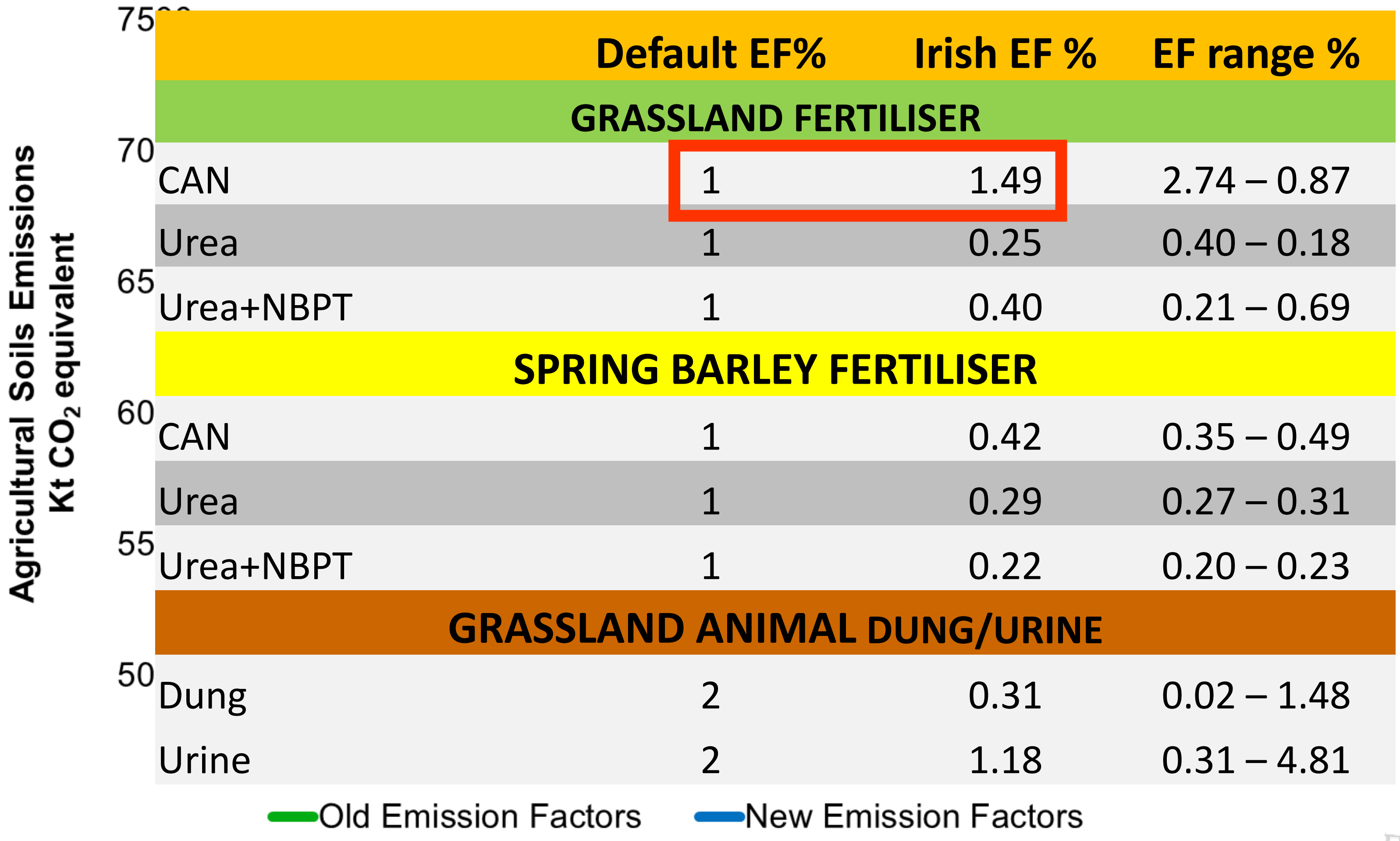


Main drivers of differences:

- Better characterisation of lifetime diet/diet changes across systems
- National concentrate consumption captured more effectively via substitution rates
- Update of methane Ym & prediction equations
- More effective capture of animal performance (lifetime growth, carcass, age slaughter)

Nitrous Oxide (5 MTCO$_2$e 22.3%)

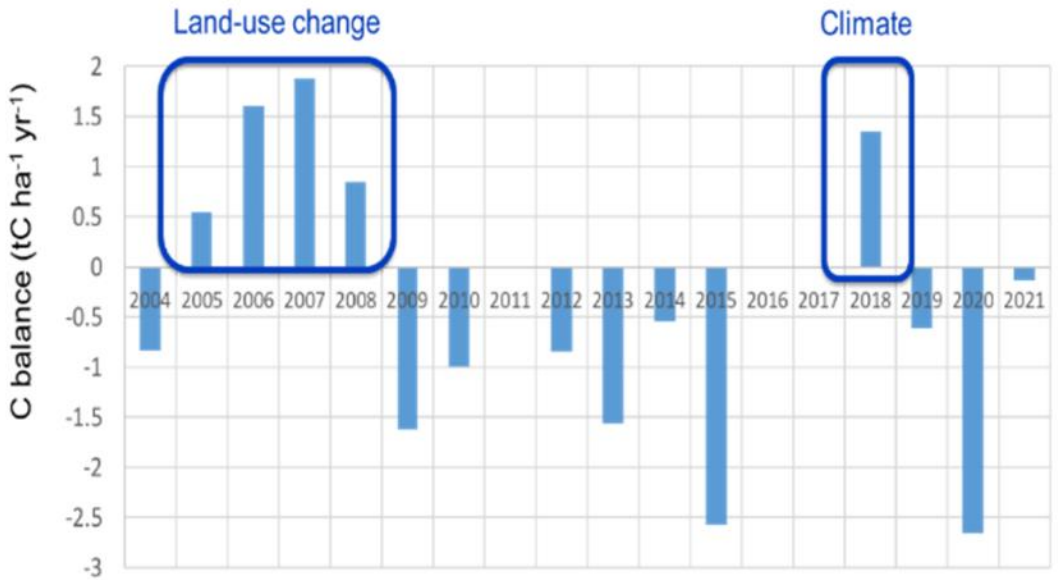
- Fertiliser type
- Manure/Digestate
- NH_3/N_2O – Digestate
- Peat drainage
- Soil type (peat/mineral)
- Tier 3 fertiliser model



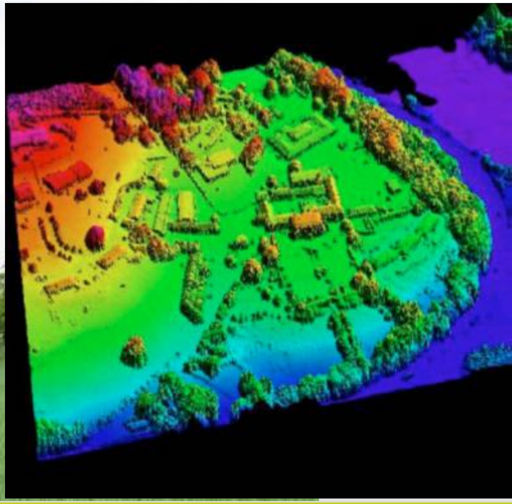
	Default EF%	Irish EF %	EF range %
GRASSLAND FERTILISER			
CAN	1	1.49	2.74 – 0.87
Urea	1	0.25	0.40 – 0.18
Urea+NBPT	1	0.40	0.21 – 0.69
SPRING BARLEY FERTILISER			
CAN	1	0.42	0.35 – 0.49
Urea	1	0.29	0.27 – 0.31
Urea+NBPT	1	0.22	0.20 – 0.23
GRASSLAND ANIMAL DUNG/URINE			
Dung	2	0.31	0.02 – 1.48
Urine	2	1.18	0.31 – 4.81

Carbon Dioxide (Ag. 0.75 & Grass 2.5Mt CO_2eq)

- Liming EF
- Soil Type
  - Emissions factors
  - improved mapping
- Land-use
  - Grassland on Mineral Soils
  - Cropland
  - Hedgerows
- Refine land management factors
  - Grassland: forage type, grazing intensity
  - Tillage: cover crops, Manure & Straw Incorporation
- Tier 3 model development



Murphy et al. In preparation



National Agricultural Soil Carbon Observatory

- Inventory highly uncertain
- Need to produce national emission factors
- Monitor long-term changes in soil carbon stocks
- 28 carbon towers - management, land-use, soil type and climate impacts
- Tier 3 model: measurements, biogeochemical models and satellite data

VistaMilk
Terrain-AI
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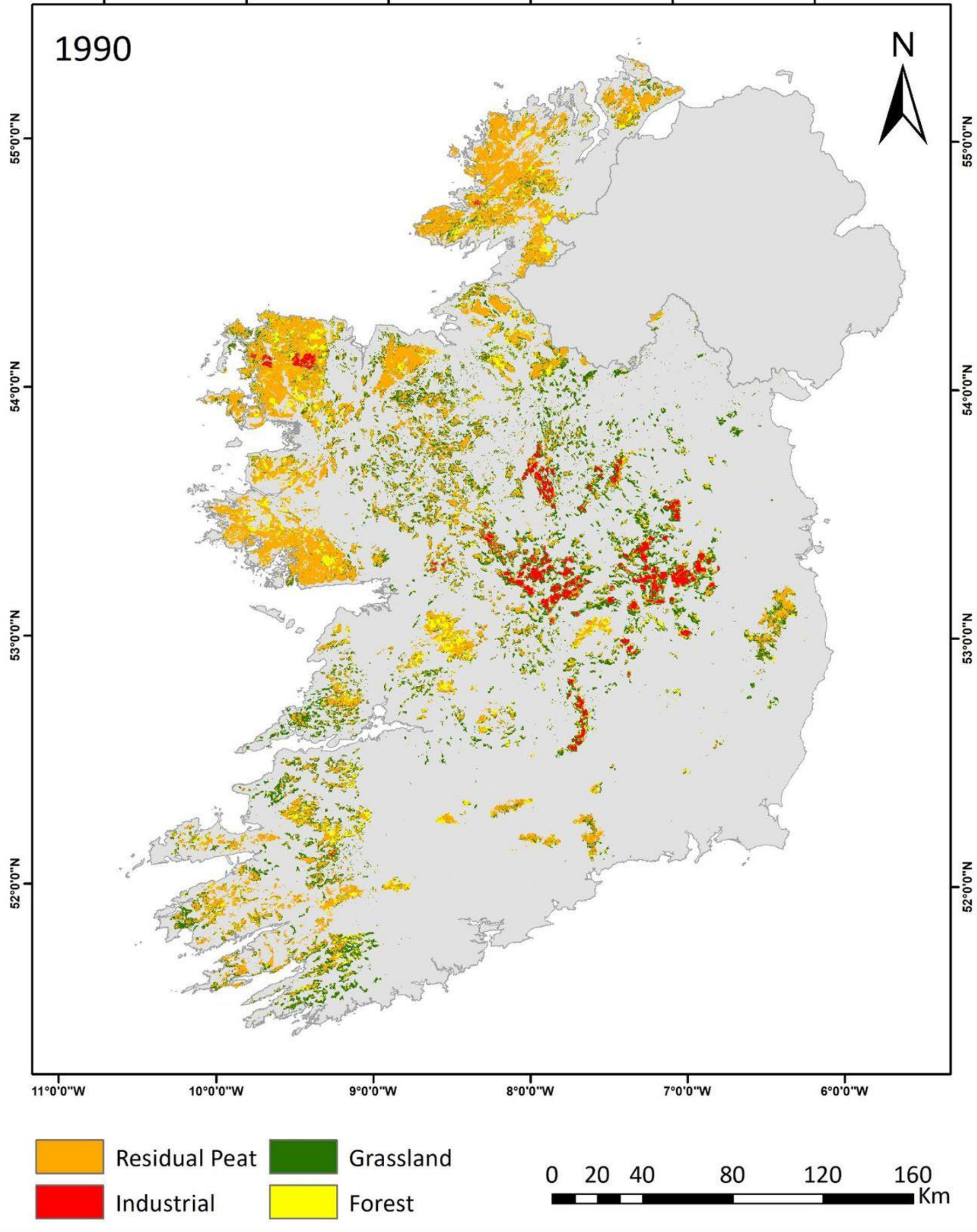
Agricultural Peat Soils

- Peat soils store 15-30% C globally
- Peat covers 21% Ireland
- Grassland peat soils emit ~~~7.1~~ **2.5** MTCO_2eq
- Research underway to refine:
  - Area of peat soils
  - Drainage and nutrient status of peat soils
  - Emission factor peat types & mitigation
- Raising the water table reduces emissions



Habib & Connolly 2023 Reg. Env. Change 23:124

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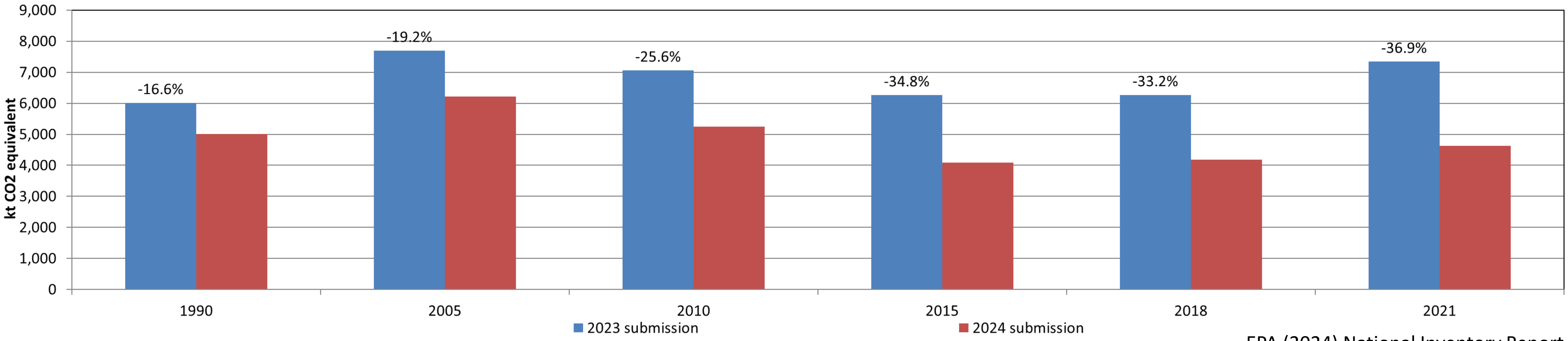
Inventory Refinement Impact LULUCF 1990-2021

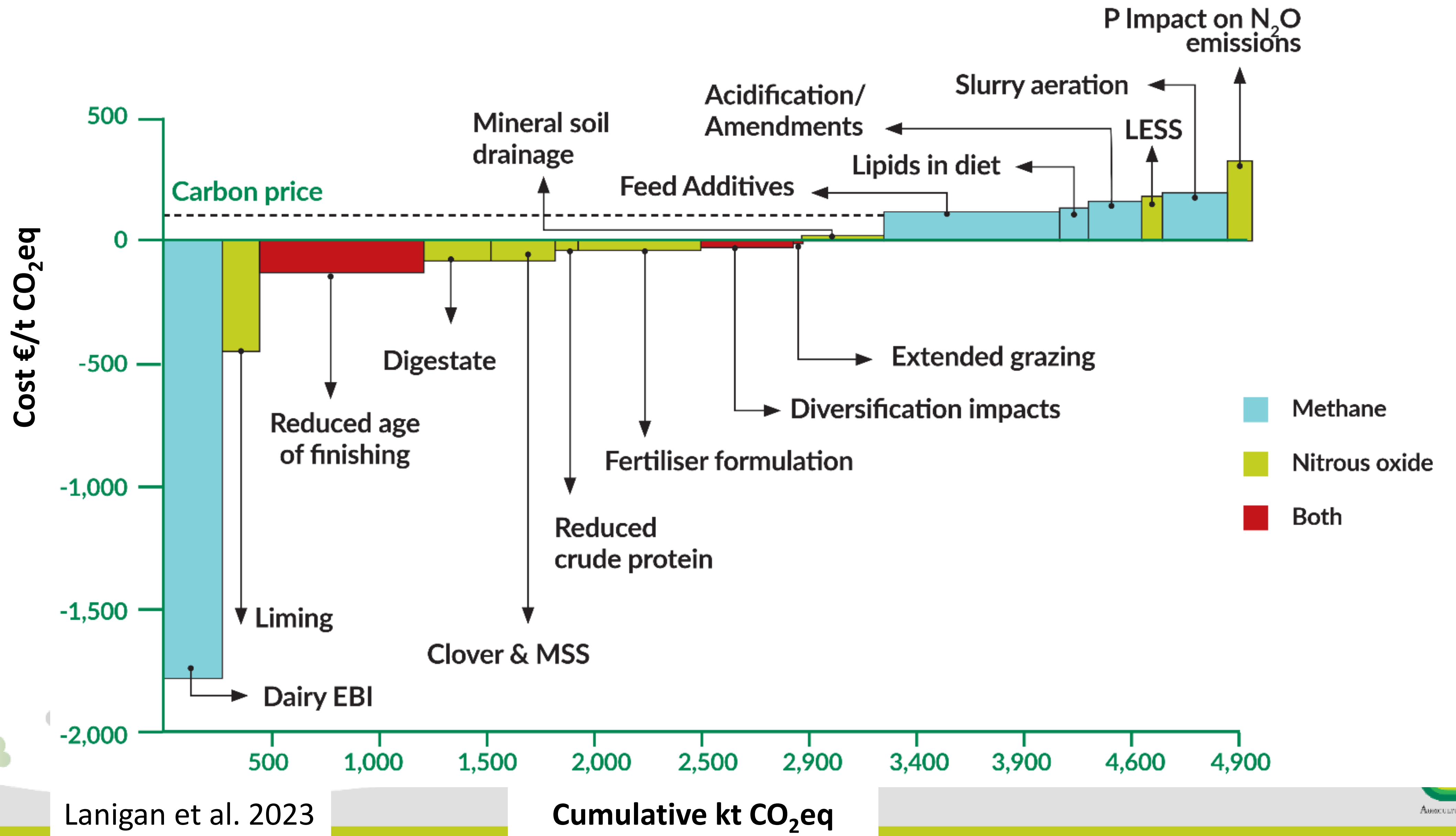


EPA (2024) National Inventory Report

- Grasslands -52.8% (2. 5 MTCO_2e)
- Wetlands +87.9% (3.8 MT CO_2e)
- Future research – soil type x land-use x management

Mitigation Research

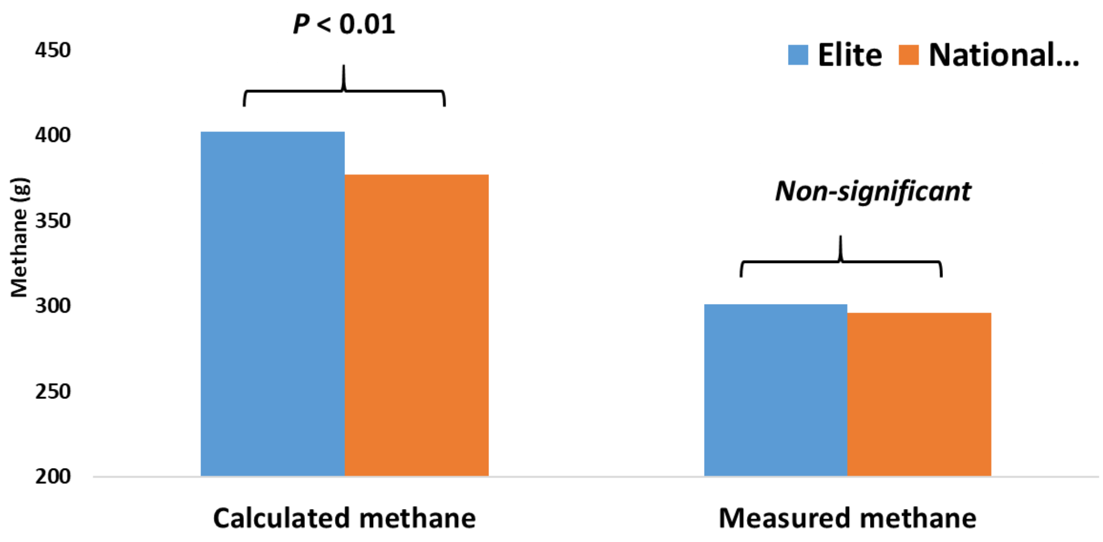
Agricultural Mitigation 2030 -MACC



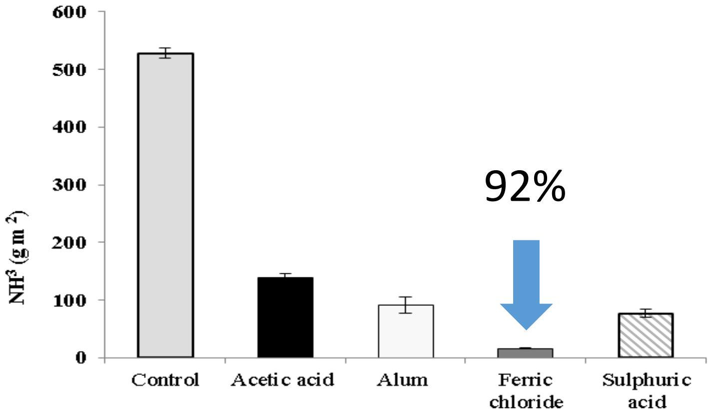
Lanigan et al. 2023

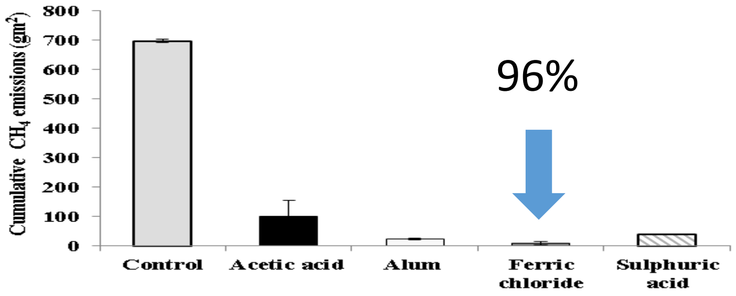
Methane Mitigation

- Genetic selection for low methane/N excretion
- Reduce Age of Finishing
- Feed supplements
  - Red seaweeds CH_4 -80%
  - Linseed oil CH_4 -19%
  - Rapeseed cake/oil CH_4 -8%
  - Brown seaweed extract CH_4 -7to -9%
- Manure additives CH_4 -96%



Lahart et al. 2024. Journal of Dairy Science, 107, 370-384.

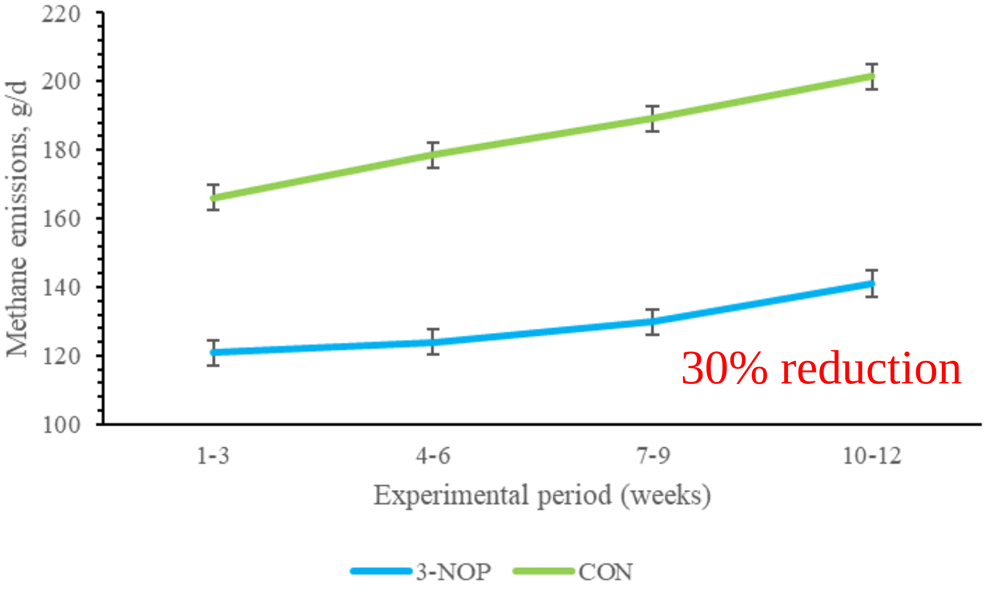




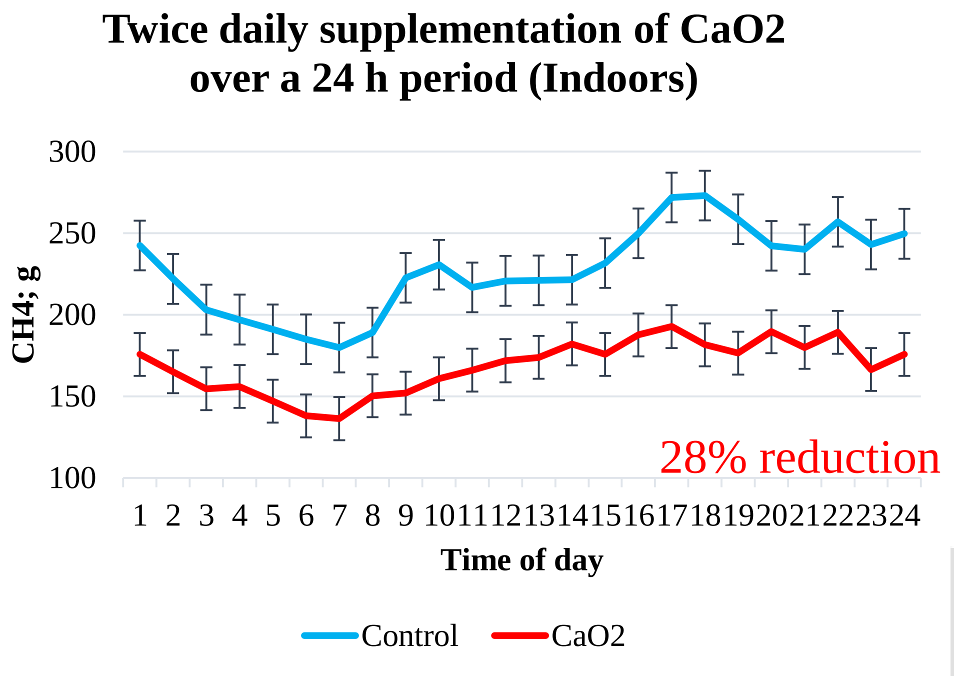
Kavanagh et al. 2019 J. Cleaner Production 237, 117822

Feed Additives Beef

- **3-NOP**[1]
  - TMR diet (50:50 F:C)
  - 30% ↓ CH_4 g/d
  - No effects on feed intake, digestibility, performance



- Calcium peroxide
  - ↓ CH_4 -28% (housed) -20% (grazing)
  - Potential effects on intake/digestability
  - Optimisation: delivery & slow release of O_2

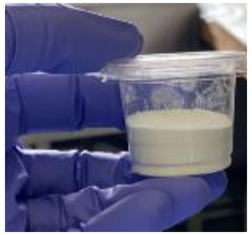


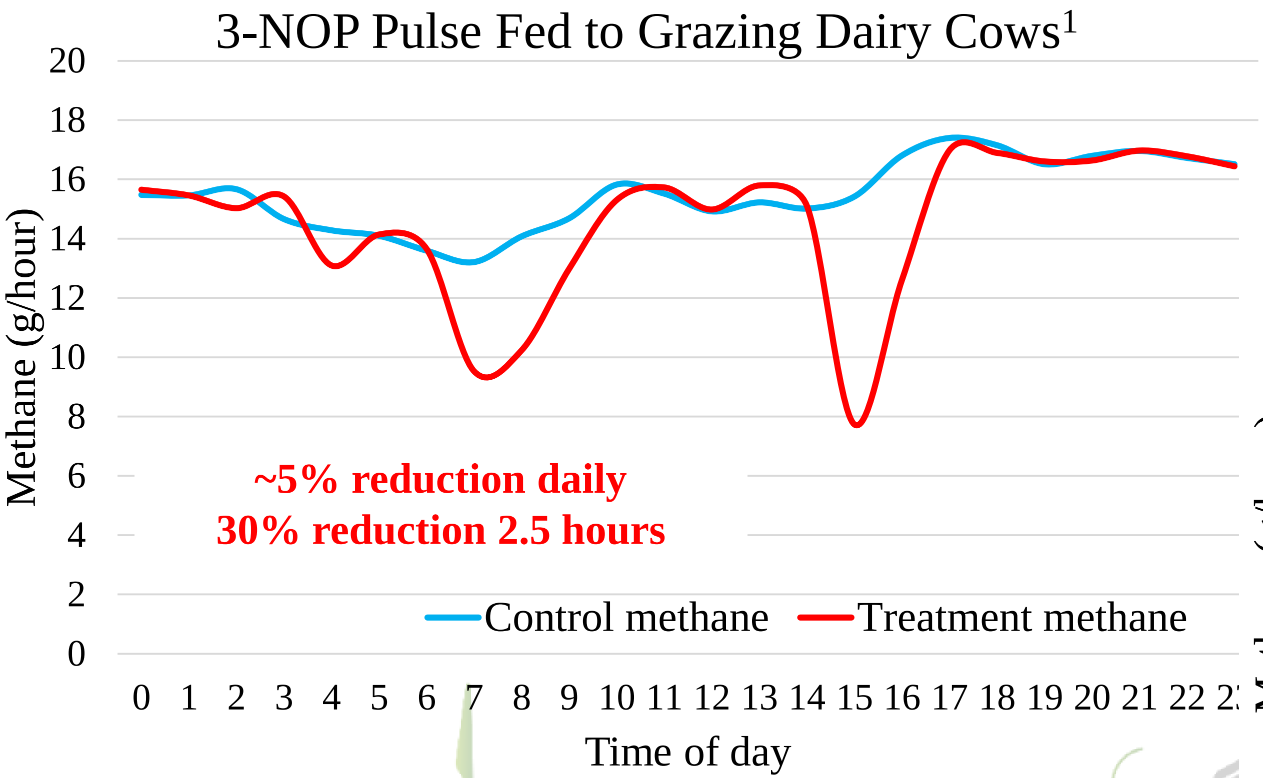
[1]Kirwan *et al.*, 2023; [2]Roskam *et al.*, Subm
Animal

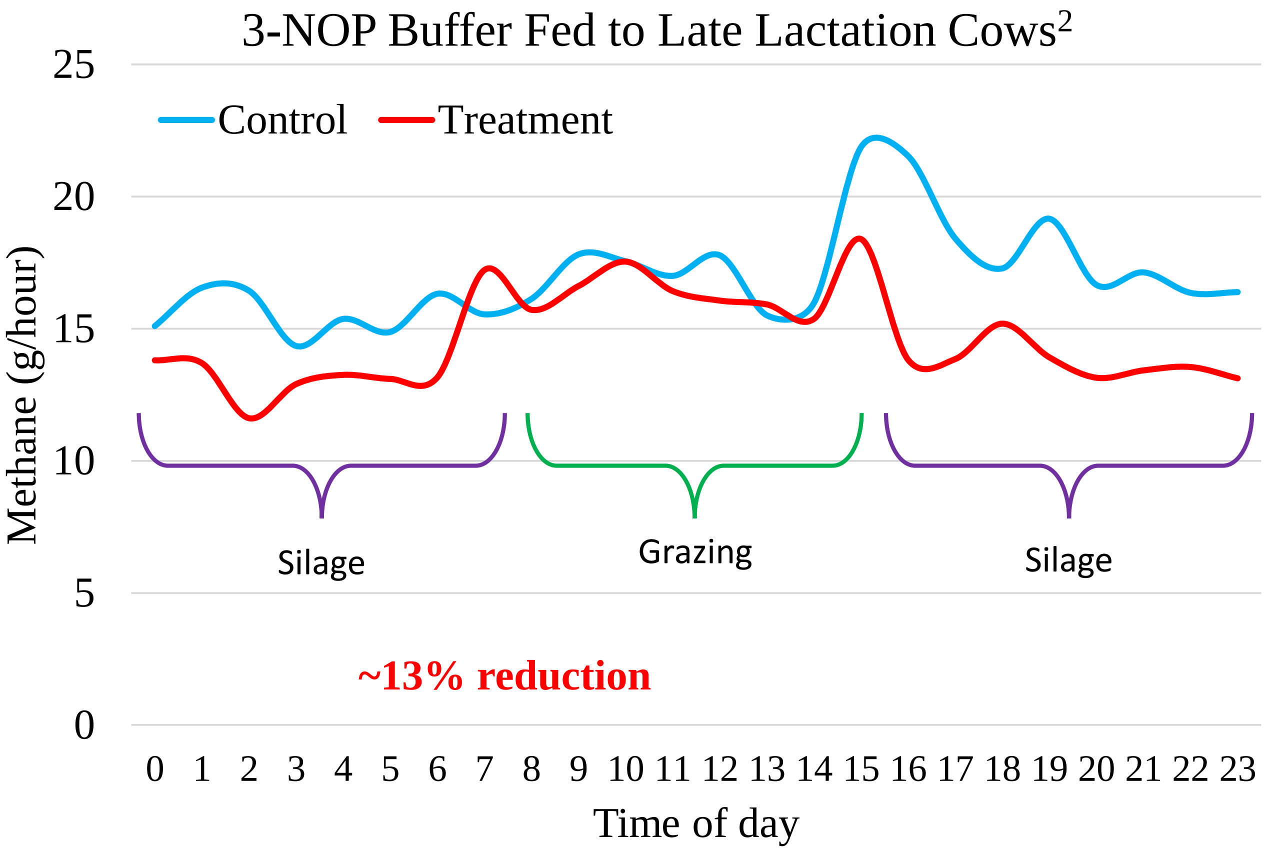
Feed Additives Dairy

3-NOP in Lactating Dairy Cows

- Practicality
- Slow release mechanisms
- Cost
- Residues
- Life cycle assessment



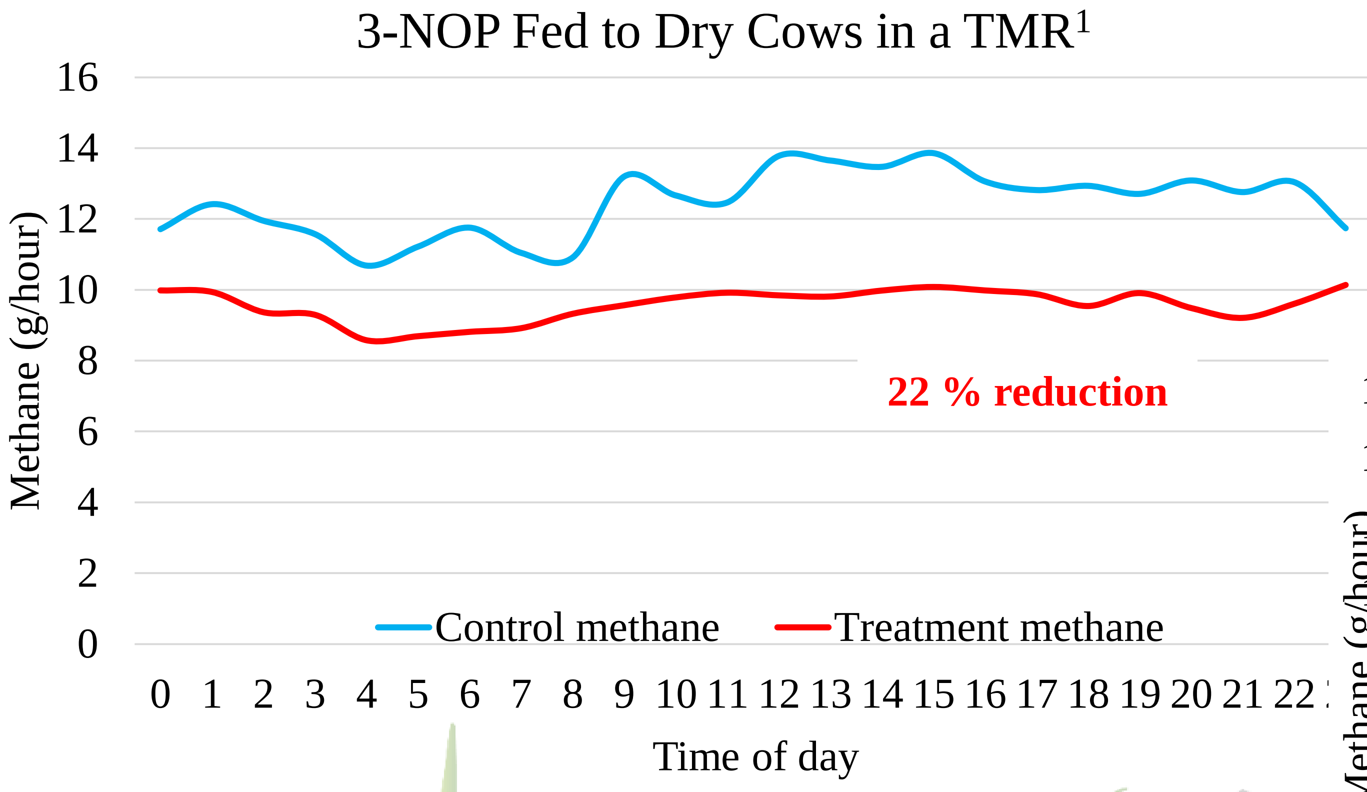


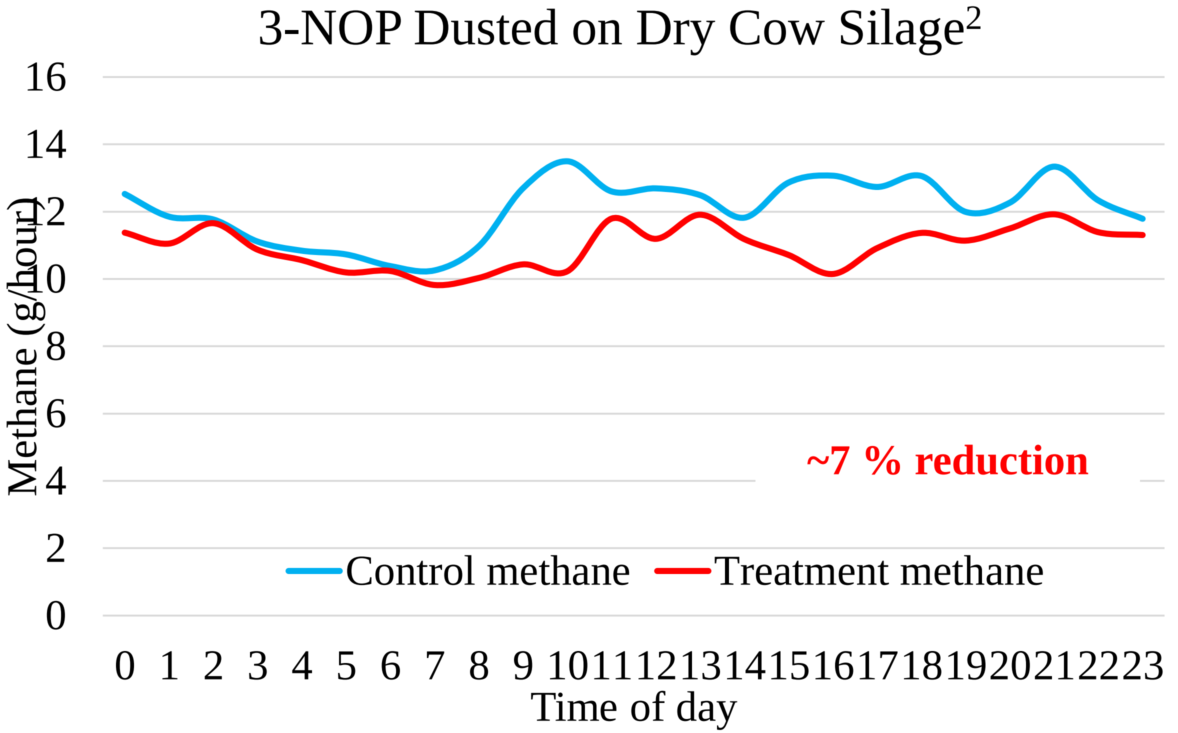


[1]Costigan *et al.* under review; [2]Costigan *et al.*, in preparation

Feed Additives

3-NOP in Non-lactating Dairy Cows

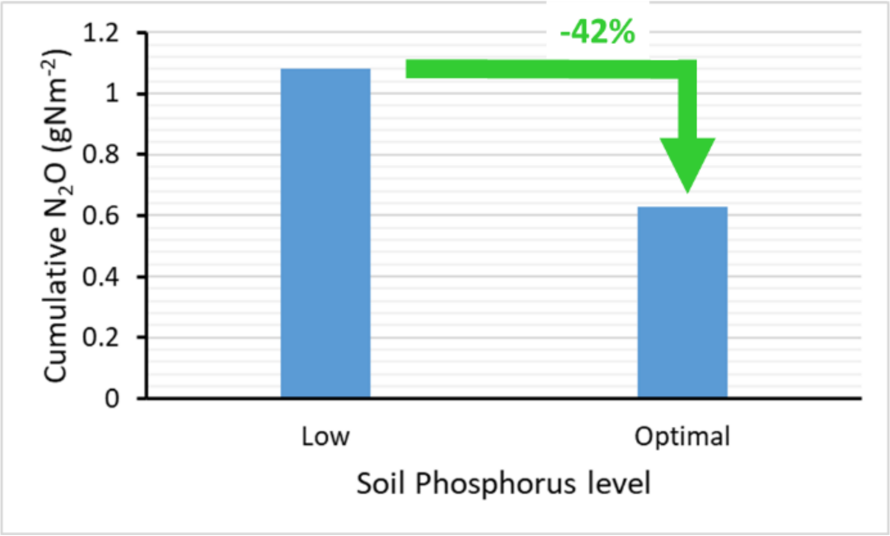




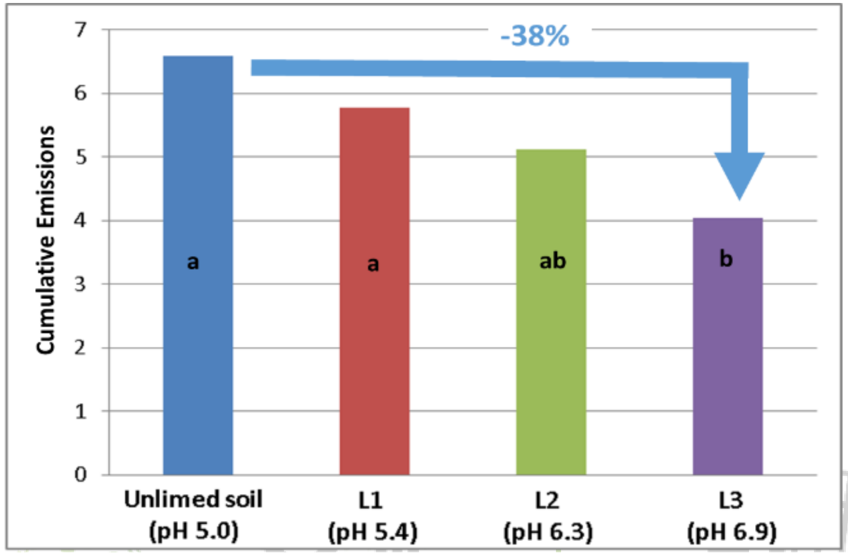
[1]Lahart *et al.*, in preparation; [2]Lahart *et al.*, preliminary results

Nitrous Oxide Mitigation - 1

- Soil Fertility
  - Optimal soil P -42%
  - Optimal soil pH -38%
- Multispecies swards (MSS) – fertiliser reduction
- Nitrification inhibition biological & chemical
- New low emission/organic fertilisers
- Precision grazing
- Low to no nitrogen integrated farming systems



Gebremichael et al. 2022. Scientific Reports, 12, p.2602.



Žurovec et al. 2021. Agriculture, Ecosystems & Environment 311: 107319

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Nitrous Oxide Mitigation - 2

- Soil Fertility
  - Optimal soil P -42%
  - Optimal soil pH -38%
- Multispecies swards (MSS) – fertiliser reduction
- Nitrification inhibition biological & chemical
- New low emission/organic fertilisers
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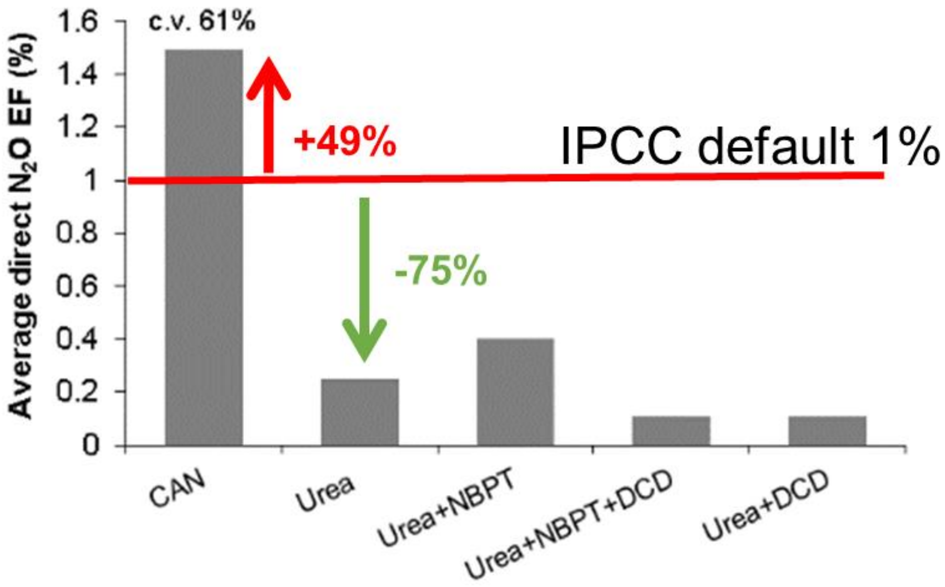
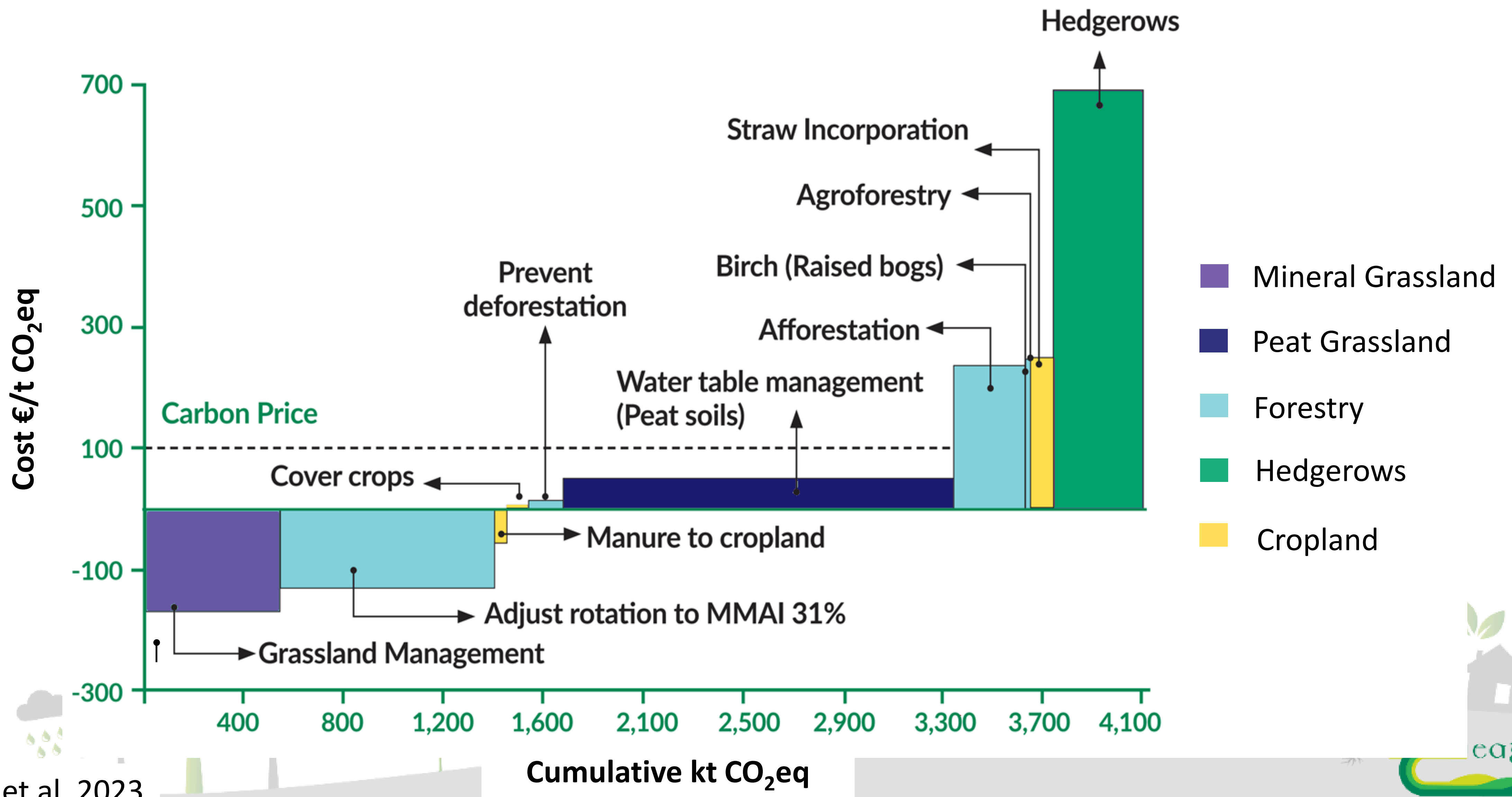


Harty et al. 2016. Sci. Total Env. 563: 576-586.

LULUCF 2030 – MACC



Lanigan et al. 2023

Carbon Dioxide Mitigation

- Multispecies swards/clover
- Improved soil fertility
- Integrated farming systems
- Forestry- type, management, attitudes, peat soils, 2nd rotation, adaptation
- Peat soil water table management
- Low input peat and peaty-mineral soils
- Biochar, Enhanced weathering

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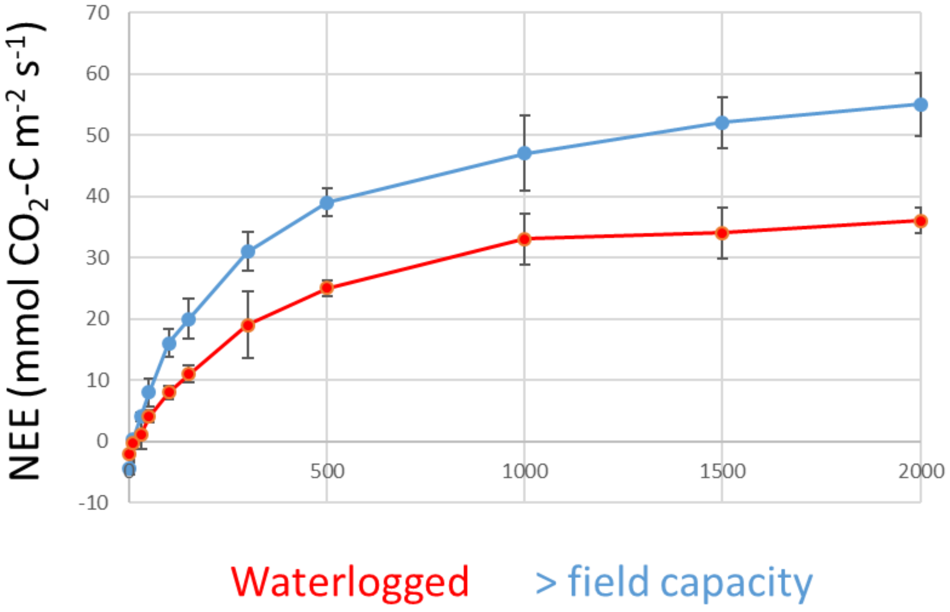
Other Research Areas

- Social and behavioral sciences
  - barriers to practice change
  - Socio-Economic consequences of system changes
- Monitoring, reporting and verification
- Impact of climate change
  - Emissions
  - Market opportunities
- Land-use optimization
- Protecting soil C (Land-use change)



Adoption - Knowledge Transfer

- Signpost demonstration farms (125)
  - Demonstration of mitigation practice
  - Farmers share experiences
  - Track progress
  - Signpost farms as “living labs”
- Signpost Advisory programme
  - Free advise to farmers
  - 10,000 farmers per year
- AgNav
  - Decision Support tool: C emissions calc. & GHG reduction plan
- Carbon farming – economic signals to reduce emissions

Summary/Take home Messages

- Considerable ongoing research CH_4, N_2O and CO_2
- New mitigation measures in development
- Barriers - measure cost/acceptability
- Research moving towards Tier 3 inventory modelling
- Importance of Knowledge Transfer
    - Signpost demonstration farms
    - Signpost advisors, AgNav (carbon sequestration)
- Farmer/Landowner Attitudes and Behaviour
    - Address demographic challenges
    - Acceptability of mitigation options

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