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Evaluating strategies to reduce greenhouse gas emissions from dairy production systems

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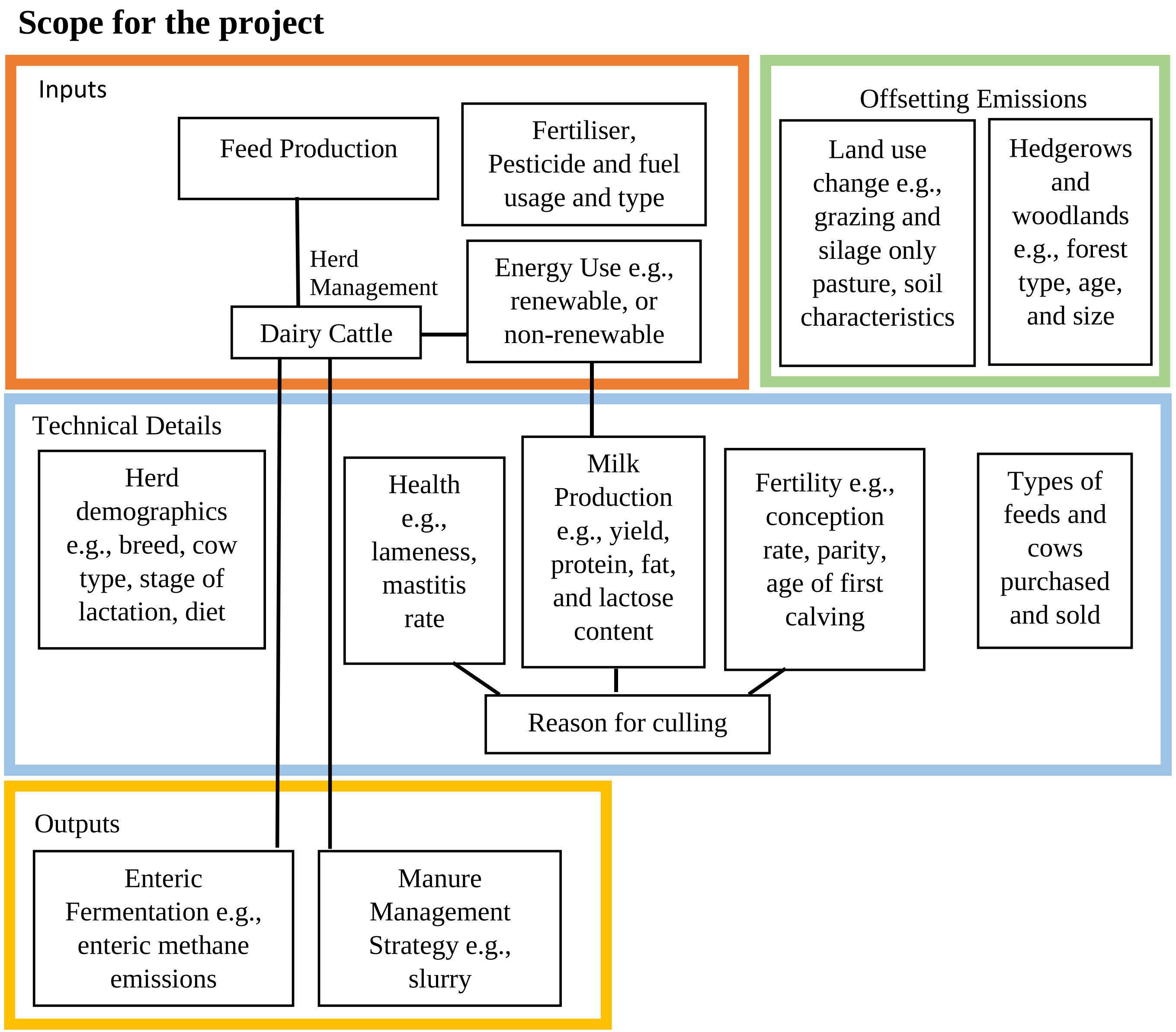
Overview

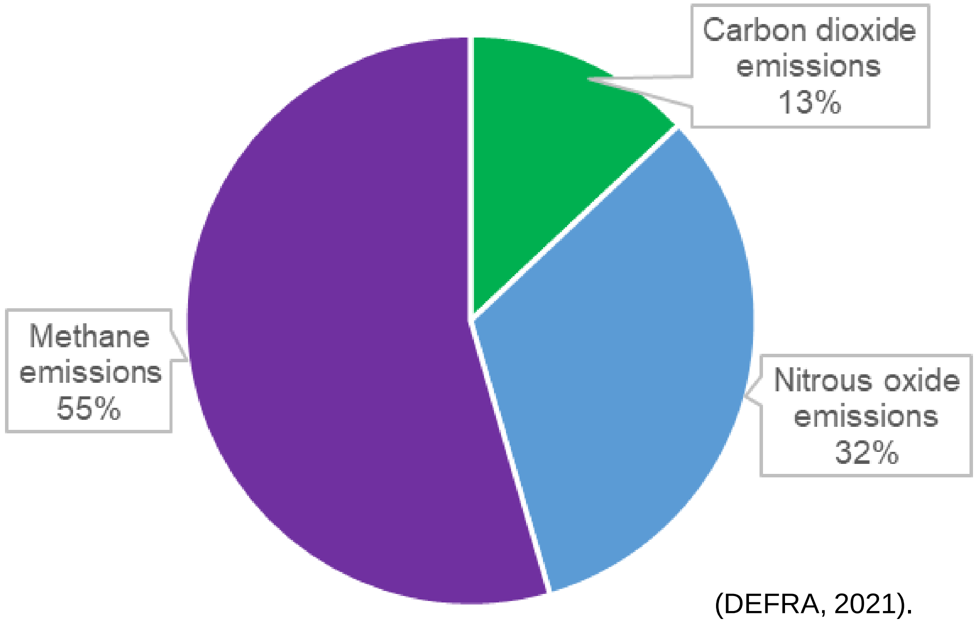
- Background
- Enteric Methane emissions
- The combined enteric prediction equation
- Next steps: Scenarios for the model



Background

- Methane has a global warming potential 25 times higher than carbon dioxide (IPCC, 2007)
- Cattle are the main cause of methane emissions from human activity (Pinares-Patiño *et al.*, 2016)
- Main process - enteric fermentation = **71%** of dairy cattle emissions (Gilardino *et al.*, 2020)

Estimated greenhouse gas emissions from the agricultural industry for the UK in 2019



(DEFRA, 2021).

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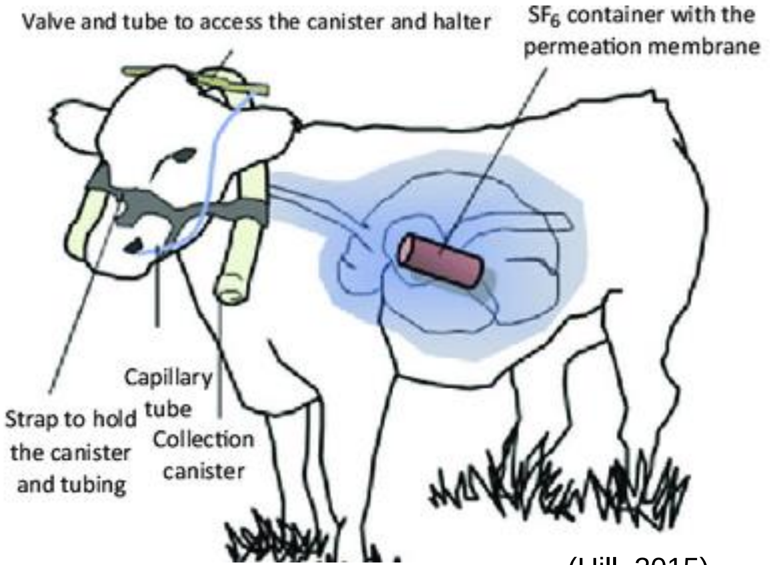
Enteric Fermentation

- Several methods for directly measuring enteric methane emissions, but difficult
  (Hristov *et al.*, 2018)

- Researchers have developed enteric prediction equations based on diet characteristics

- Equations vary in complexity - by the number and type of factors used

  e.g., dry matter intake, neutral detergent fibre and ether extract



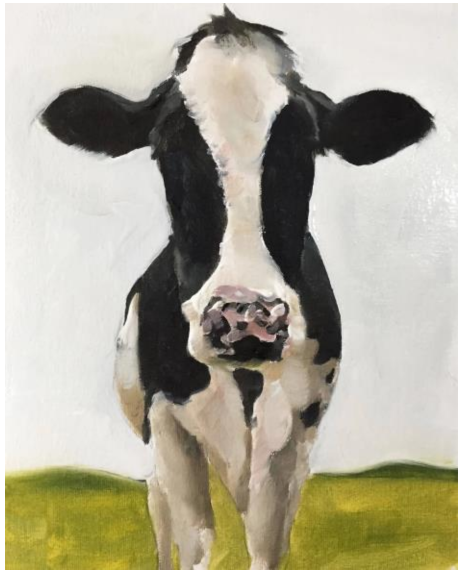
(Hill, 2015)

Aims and Objectives

Aims:

- Evaluate the variation between enteric methane emission results from prediction equations

- Create a “combined” enteric methane prediction equation utilising dietary composition variables



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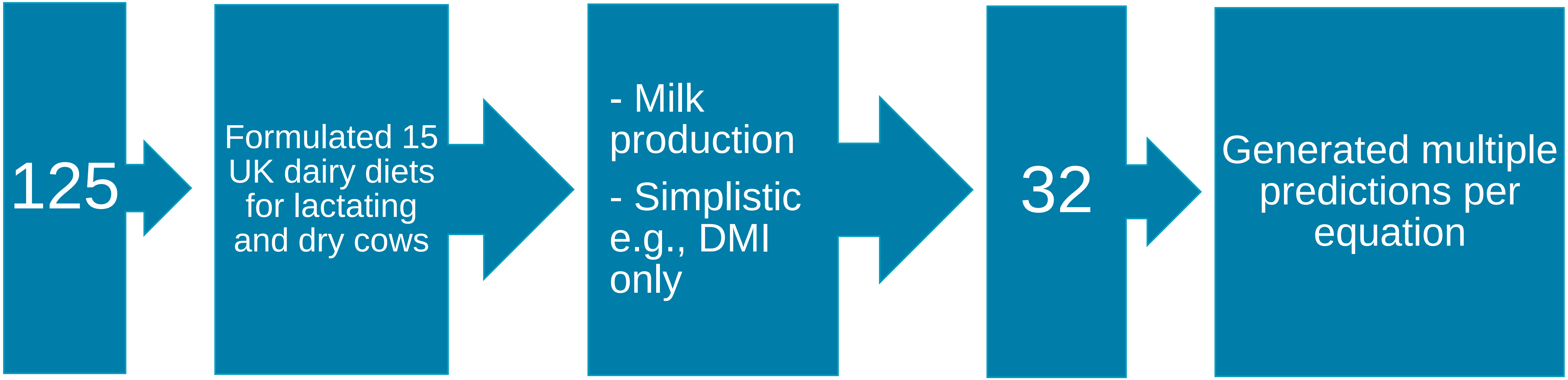
Footprint (2021). Cows looking over wall [Image] Available at: https://www.foodservicefootprint.com/the-low-carbon-cow-conundrum/ [Accessed on 04 March 2022].

Material and Methods

Collecting the enteric methane predictions:



Material and Methods

Creating the combined equation:

- Assessed the correlations between the dietary variables
- Chose the units for the equations e.g., percentage of NDF
- Built multiple mixed effect regression models
- Included random effects, to account for unexplained variation from:
    i. The varying cow type
    ii. Stage of production
    iii. Study design, and
    iv. Measurement methodology used
- Performances were analysed e.g., statical significance and root mean square error

Flickr (2010). Cow grazing red clover. [Image] Available at: https://www.flickr.com/photos/d70w7/4332077423/ [Accessed on 04 March 2022].

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Results

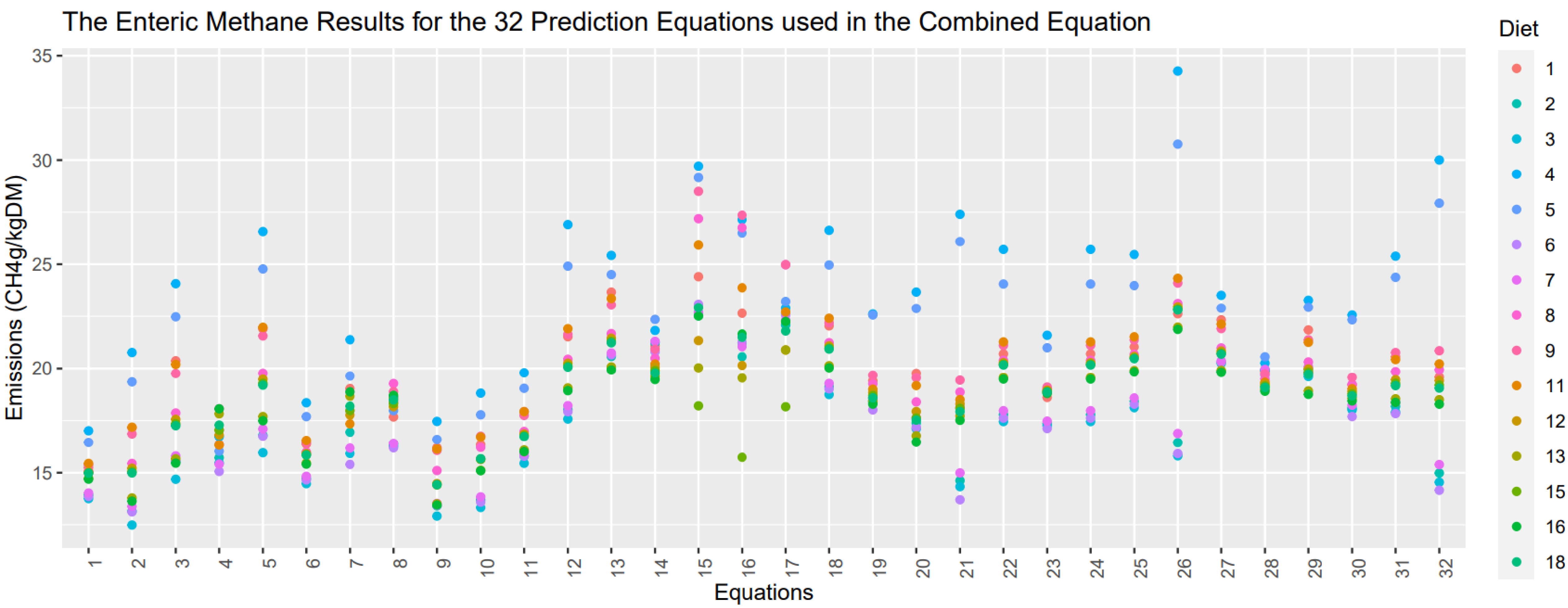

Figure 2. The variation in the results obtained from the 32 prediction equations against 15 dairy diets.

- The predicted methane emissions ranged from 12.49 to 34.27g CH_4/kg DM

Choosing the enteric combined equation

- Strong correlations between:
  i. Metabolised energy and crude protein
  ii. Metabolised energy and ether extract
- Assessed models based on coefficients, residuals of variation, root mean square error and r^2
- Final model chosen = Metabolised energy and neutral detergent fibre (ME and NDF)
- RMSE = 1.47 g CH_4/ kgDM and R^2 = 0.79

Table 1. The performance of the combined equation

Fixed Effect				Random Error Estimates			Random Effect
Term	Estimate	Standard Error	t-value	R^2	RMSE	MAE	Residual Variance
Intercept	19.23	0.42	46.06	0.79	1.47	0.97	2.32
NDF	1.88	0.1	19.75				
ME	0.31	0.1	3.22				

Evaluating the combined equations performance

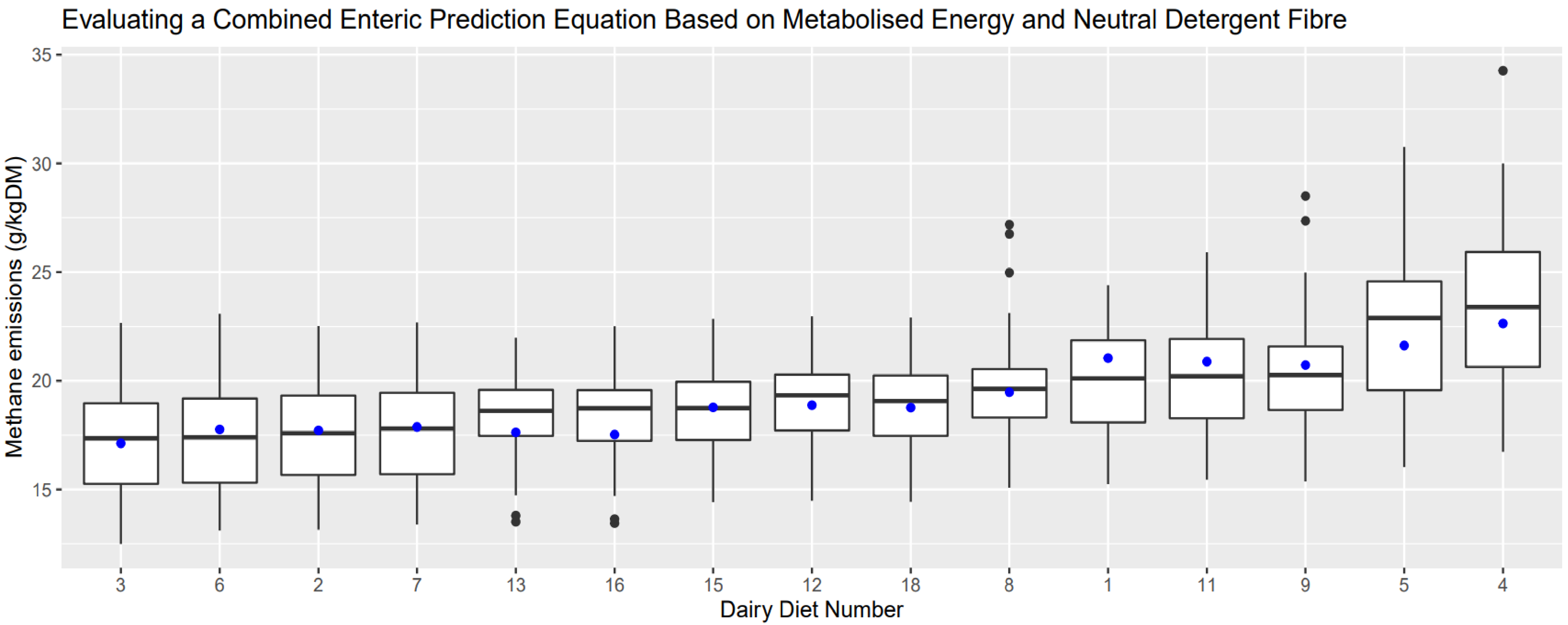

Figure 3. The performance of the combined prediction equation against each diet

- The combined equation offers a compromise in predictions between studies

Conclusion

- Existing prediction equations vary in complexity and their estimates
- An equation comprising of the variables ME and NDF most accurately reflected the predictions across all equations
- Application:
  - Universal (compromised) measure of enteric methane emissions from diets
  - Can be used in farm simulation models
- Future research developing equations should consider the generalisability of their study design and results

Farmers Weekly (2020). A guide to feeding copper to dairy cows. [Image] Available at: https://www.fwi.co.uk/livestock/livestock-feed-nutrition/a-guide-to-feeding-copper-to-dairy-cows [Accessed on 04 March 2022].

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What is next?
Simulation Scenarios

Scenarios to Assess with the Model

Scenarios:

1. Simulate the effect of replacement rates, increasing the length of productive lifespan (LPL) of dairy cattle, age of first calving on milk production and greenhouse gas emissions.

2. Examine and compare the potential of hedgerows, forestry, land use and land use change to offset emissions.

3. Protein alternatives – such as rapeseed, distillers and brewers' grains, lucerne, red clover, lupins and peas compared to imported and UK-grown soya.

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Thank you for listening – are there any questions?

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Acknowledgements:

- Supervisors: Dr. Luke O’Grady and Prof. Martin Green
- Richard Cooper (Map of Agriculture)

Funders:

- AHDB
- Dartington Cattle Breeding Trust
- Perry Foundation
- Seal-Hayne Educational Trust
- West Country Dairy Awards

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