Trade-offs between methane and ammonia emissions after nutritional interventions in dairy cows

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Introduction

- Mitigation measures generally target one gas:
  - Disconnect between policies to reduce GHGs and those to improve air quality
- Quantifying and optimizing trade-offs between gases, will improve cohesion between different policy objectives
- Study aim: to develop a meta-analysis approach to identify synergies and trade-offs between different gaseous emissions.
  - Nutritional strategies to reduce methane or ammonia emissions in dairy cows

Data Collection

- Literature search (Scopus / Web of Science / Google Scholar)

- In vivo studies on lactating dairy cows that reported either:
  - Measured methane and ammonia
  - Measured methane and MUN
  - Rumen VFA concentrations and measured ammonia
  - Rumen VFA and MUN

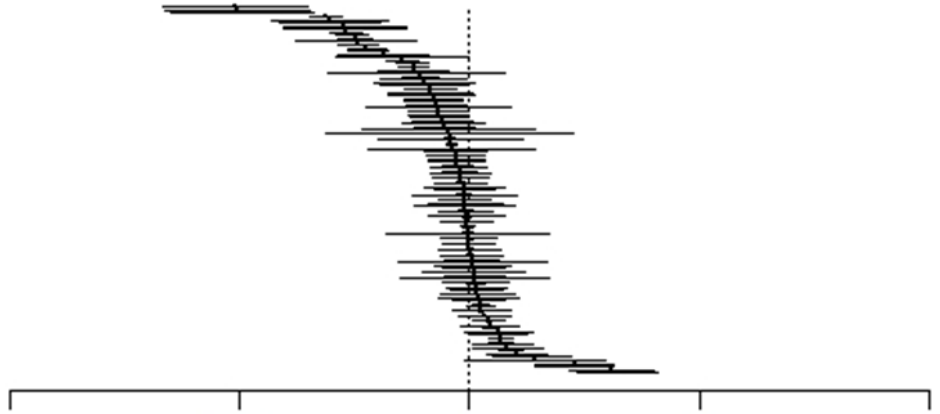
- Control and treatment means + SEM / SD were extracted

Description	Categories
Was the gas estimated using a proxy?	Yes / No
Measurement method	Technology used to measure emission
Climate of the study location	Temperate / Tropical
Experimental design	Independent control / Not independent control
Aim of study	To reduce methane / To reduce ammonia / Neither
Treatment type, relating to type of nutritional intervention	Additive (feed additive to reduce methane emissions)
	Energy (increased fat or oil content to reduce methane emissions)
	Fibre (reduced dietary fibre content to reduce methane emissions)
	Protein (reduced dietary protein to reduce ammonia emissions)
	Other (miscellaneous dietary manipulation to reduce either methane or ammonia)

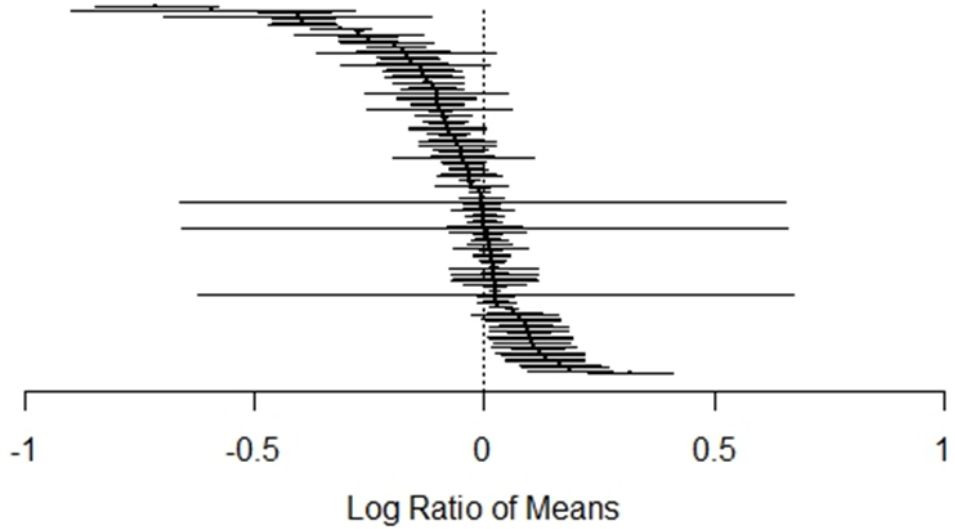
Initial modelling

- Metafor package in R
- Log transformed ratios of treatment to control means for methane and ammonia

Methane

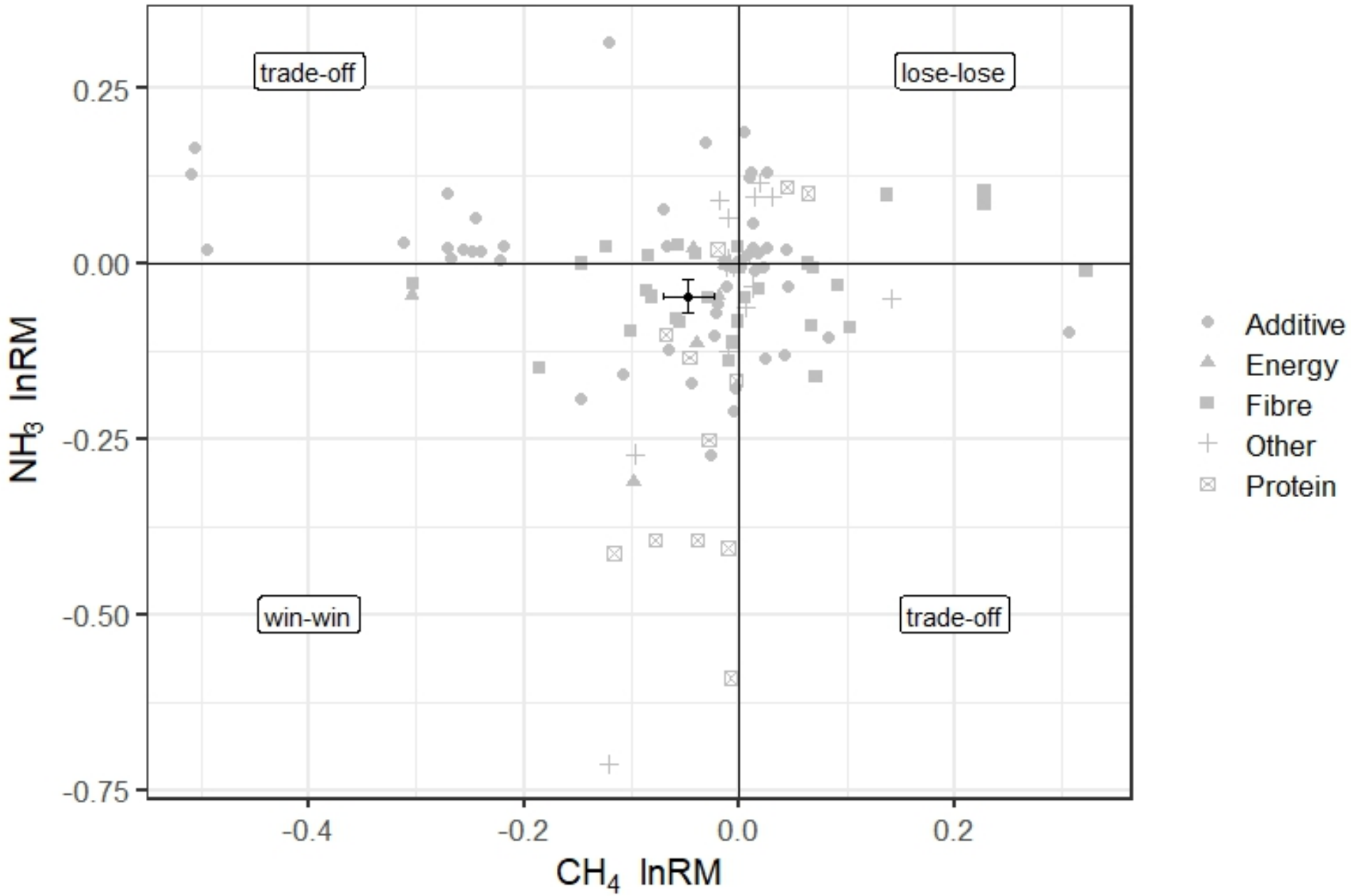


Ammonia

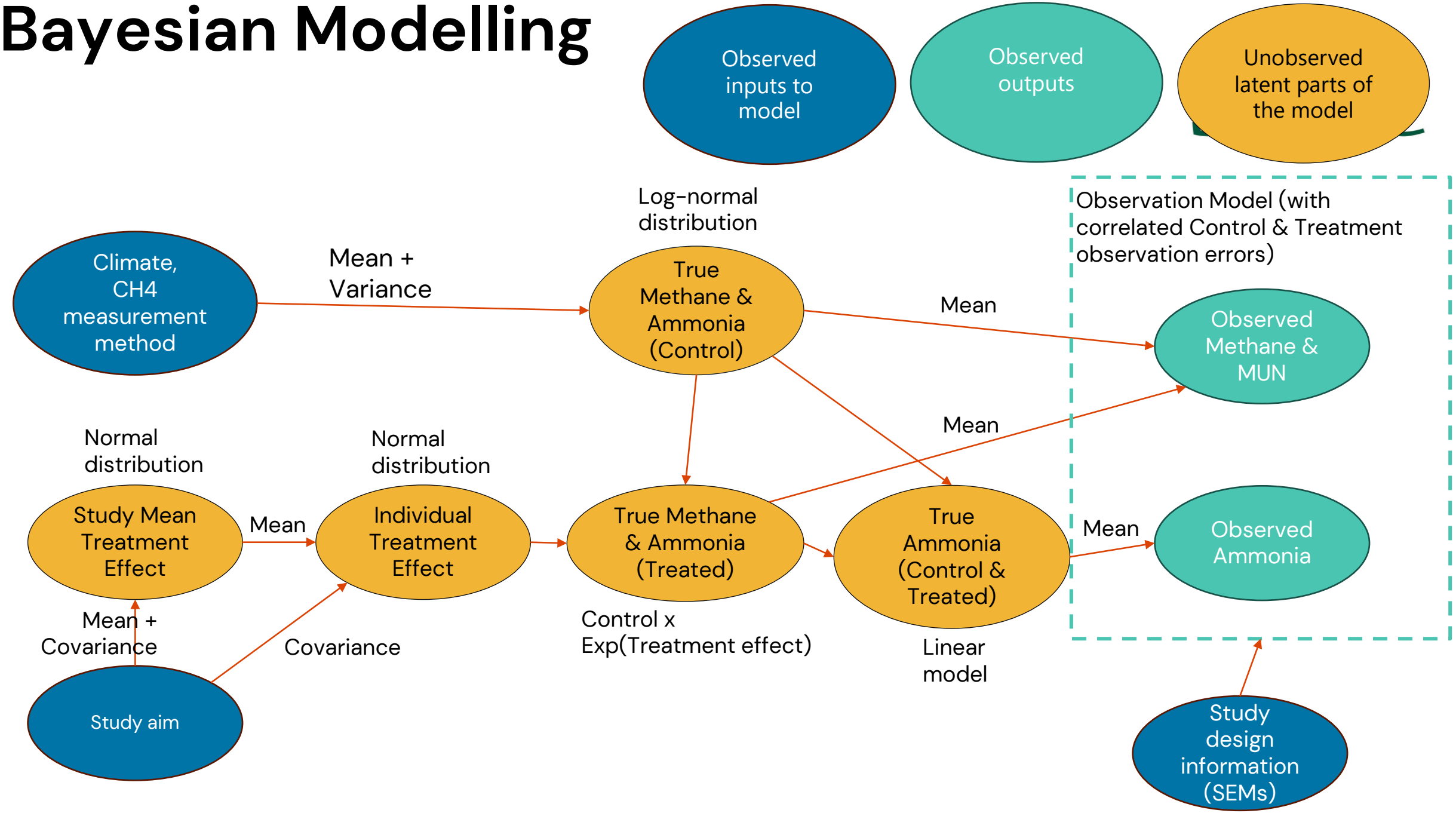


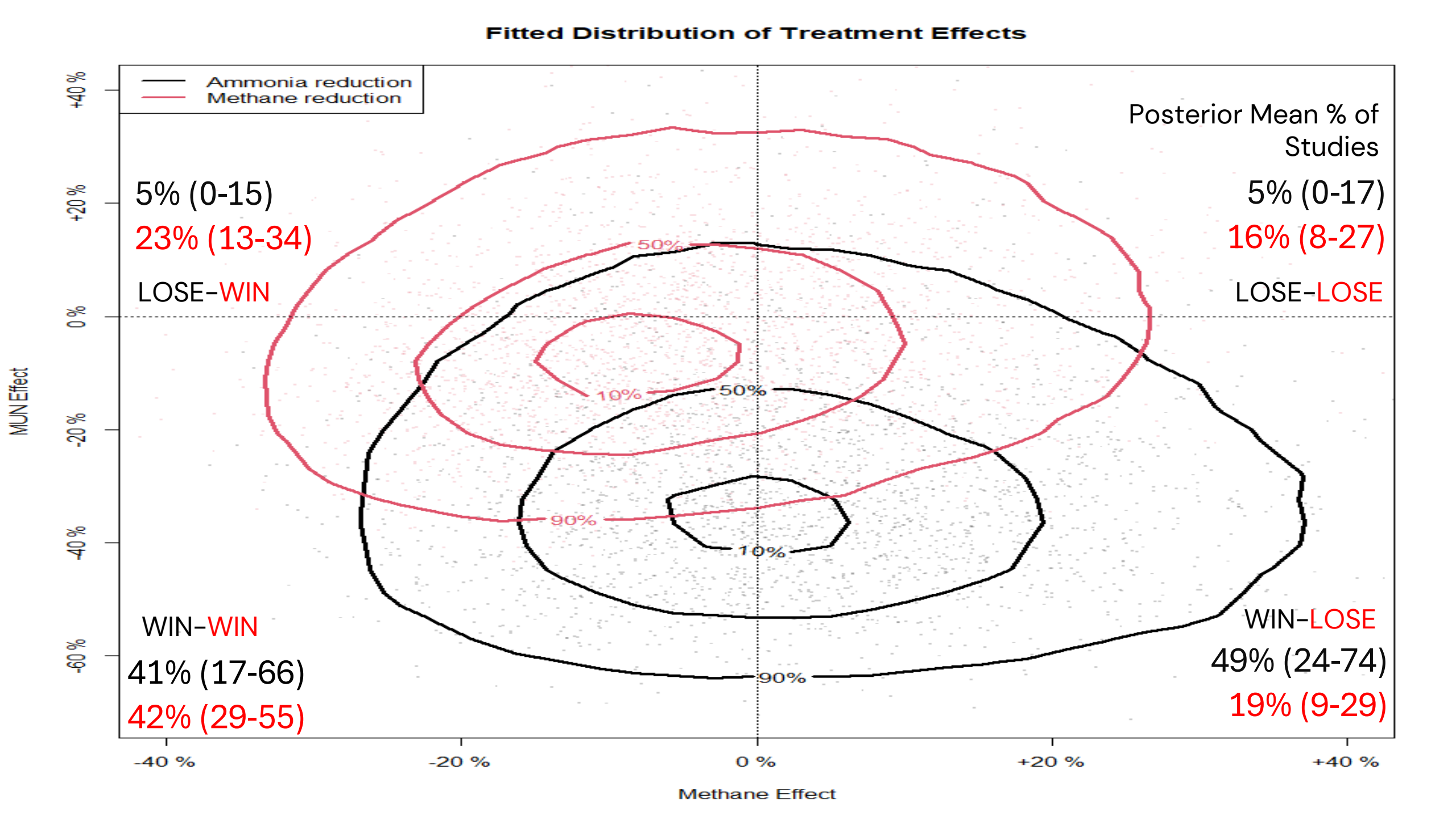
	Papers	Data points
methane + ammonia	9	36
methane + MUN	28	142
VFA + MUN	16	38

- Mixed effect model
- Random factor Paper(Treatment)
- Intercepts and 95%CI used as mean effect



Bayesian Modelling




Fitted Distribution of Treatment Effects
Ammonia reduction
Methane reduction
Posterior Mean % of Studies
5% (0-15)
23% (13-34)
LOSE–WIN
5% (0-17)
16% (8-27)
LOSE–LOSE
WIN–WIN
41% (17-66)
42% (29-55)
WIN–LOSE
49% (24-74)
19% (9-29)
50%
10%
50%
90%
10%
90%
+40 %
+20 %
0 %
-20 %
-40 %
-60 %
MUN Effect
-40 %
-20 %
0 %
+20 %
+40 %
Methane Effect

Further work and conclusions

- Fine tuning of prior sensitivity analysis
- Can we include treatment type in the model?
- More studies measuring multiple gases to ensure mitigation measures are delivering net environmental benefits

UltraGreenCow

- ~£700k grant from UKRI-BBSRC ALERTS 2023 call

- Increasing gas measurement capacity of our GreenCow respiration chamber facility

UKRI Biotechnology and Biological Sciences Research Council

SRUC

- Simultaneous measurement of METHANE, CO_2, NITROUS OXIDE, HYDROGEN and AMMONIA

- Cutting-edge technology to improve accuracy and energy efficiency of emissions measurement

IREMS

- Laser based system – existing technology requiring ruggedisation, calibration, validation for agricultural applications
- Real-time, continuous measurement of a wide range of emissions (inc. methane, ammonia and nitrous oxide)
- Long path lengths allowing measurement on a barn or field scale

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