Relative Carbon Efficiency of four divergent Dairy Production Systems

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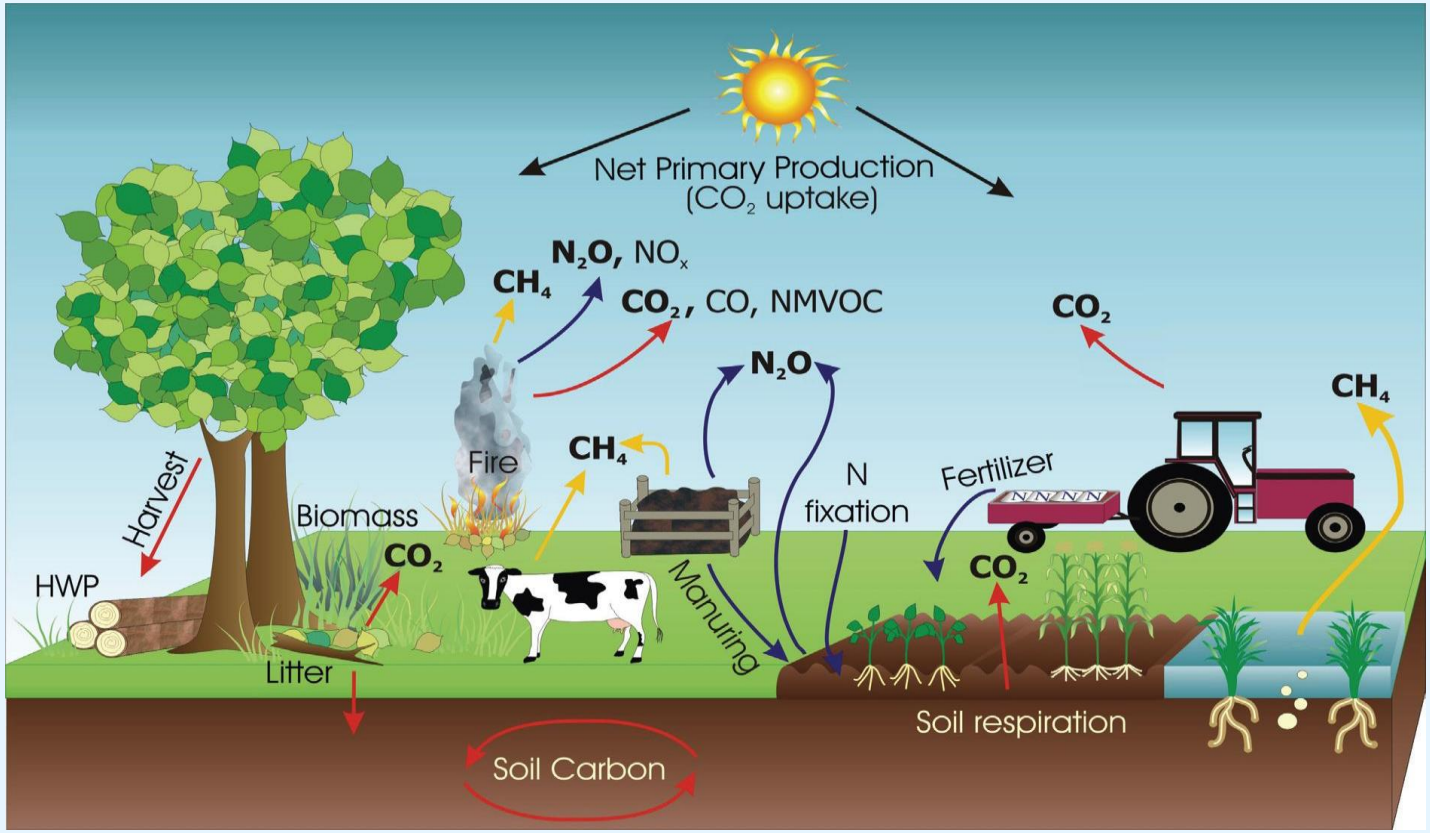
Introduction

- Dairy contribution to GWP at systems level



Background

- Substantial unavoidable component
  - ... but opportunities for mitigation
- Studies in literature examined dairy systems and components at national and farm levels
- Directly comparable analyses of potential for variation amongst production systems sparse

Aim of study

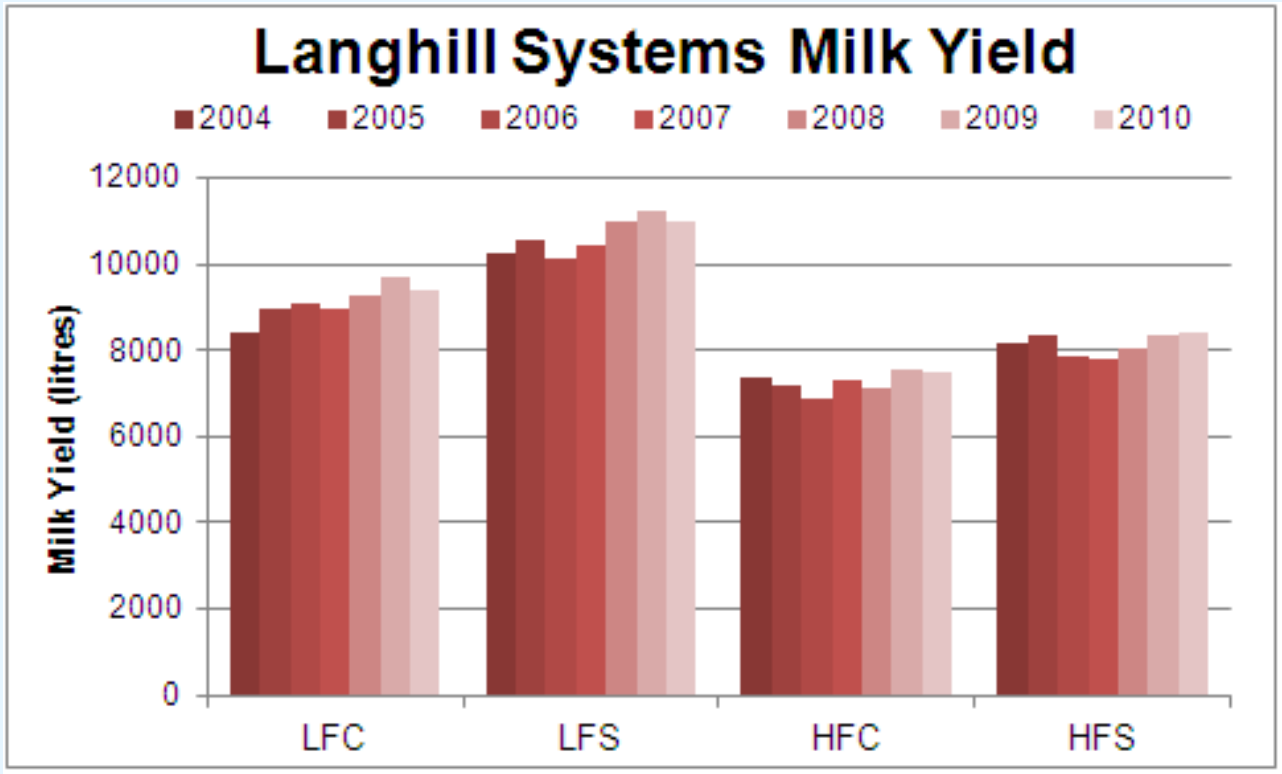
- Examine the relative environmental impacts of four divergent conventional dairy production systems
- Analysis by Life Cycle Assessment (LCA)
  - Direct comparison of 4 systems over 7 years
  - SAC Langhill database
  - Tier 3 methodology where possible
  - Impact Assessment using SAC Carbon Calculator

Dairy Production Systems

- Langhill herd at Crichton Royal Farm
- Long term Holstein-Friesian genetic & management systems project
- Four divergent dairy systems: HFC, HFS, LFC, LFS

Langhill Systems

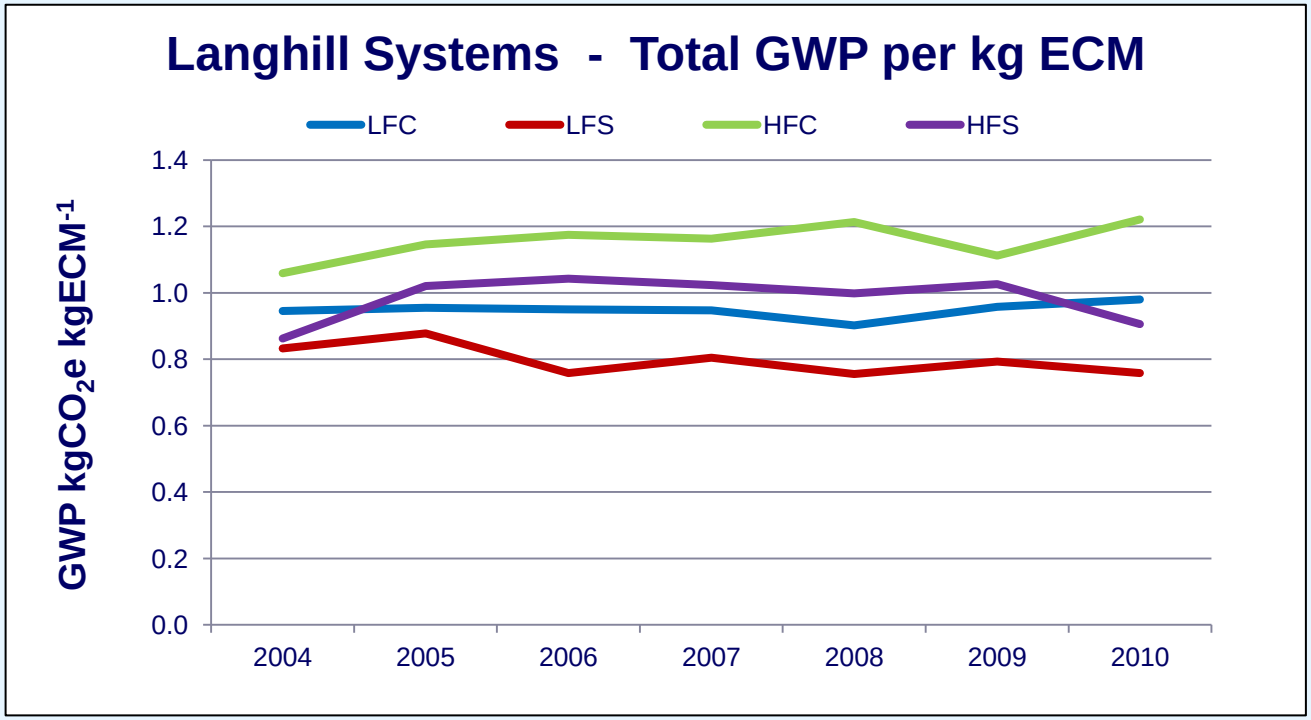
- Δ ~3000 litres per head annually between systems



Results

- GWP expressed per unit Energy Corrected Milk
- Rank analysis: clear separation between systems

(1) LFS (2) LFC (3) HFS (4) HFC (P<0.001)

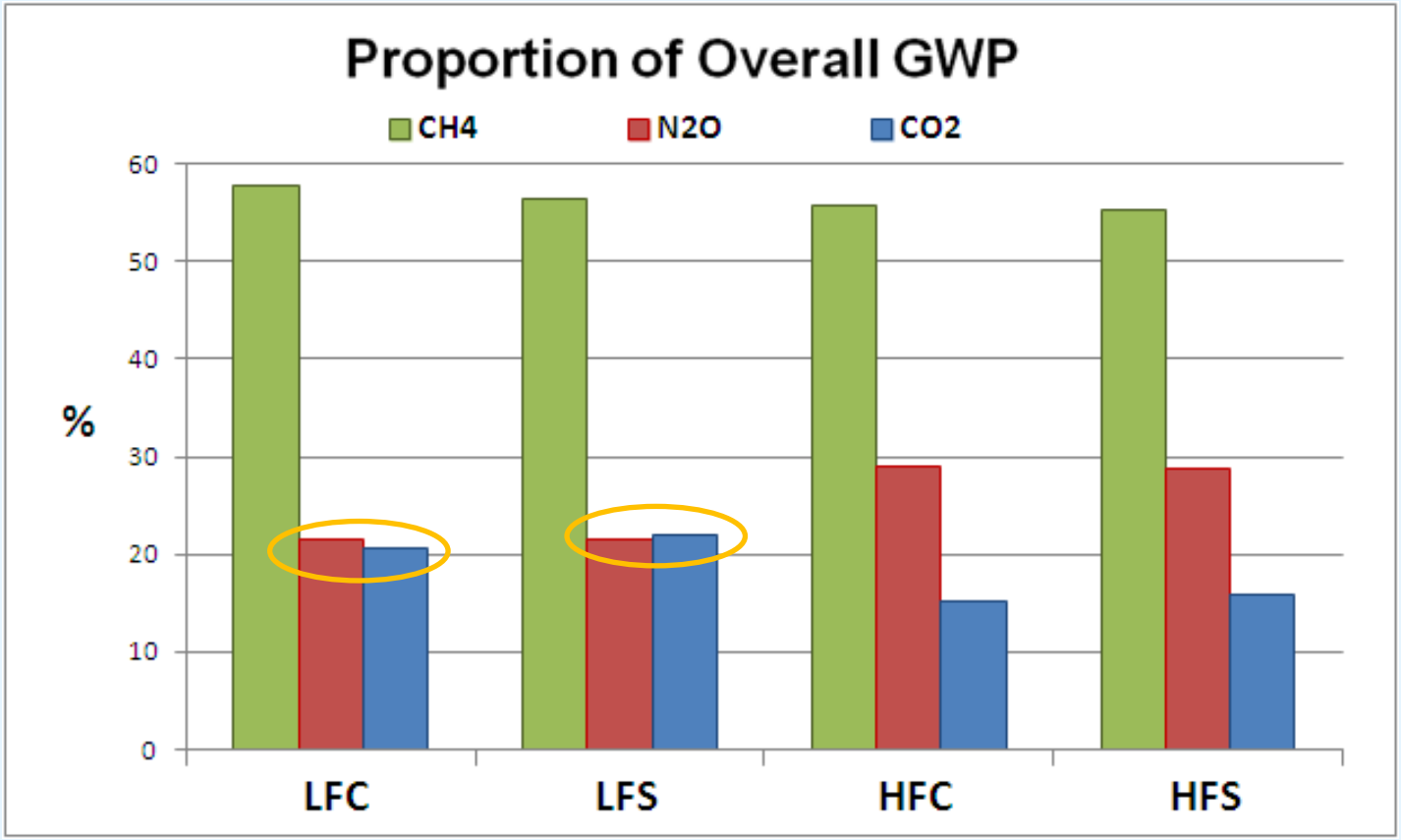


Results

- Low Forage more efficient than High Forage
- Select more efficient than Control

Discussion

- Contribution of each GHG:



Discussion

- GWP attributed to contributing factors:

		LFC		LFS		HFC		HFS	
		μ	sd	μ	sd	μ	sd	μ	sd
CH_4									
Enteric	$kgCO_2e\ kgECM^{-1}$	0.48	0.02	0.40	0.02	0.56	0.04	0.47	0.04
Excreta		0.09	0.00	0.07	0.00	0.10	0.01	0.09	0.01

- Gross enteric CH_4 emissions ~6% less per cow in HF but HFC 40% higher than LFS per kg ECM

- Similar gross CH_4 emissions from manure across systems
- LFS / HFC again extremes and LFC / HFS closely matched

Discussion

- GWP attributed to contributing factors:

		LFC		LFS		HFC		HFS	
		μ	sd	μ	sd	μ	sd	μ	sd
N_2O									
Fertiliser	$kgCO_2e\ kgECM^{-1}$	0.06	0.01	0.06	0.01	0.10	0.03	0.09	0.02
Excreta	"	0.15	0.01	0.12	0.01	0.24	0.02	0.20	0.02

- Gross emissions per cow, HF produce 29% more N_2O from inorganic fertilisers and 33% more from animal wastes
- Measured against productivity, HFC produces double the N_2O from animal wastes compared to LFS
- HF fertiliser emissions 59% higher than LF per kg ECM

Discussion

- GWP attributed to contributing factors:

		LFC		LFS		HFC		HFS	
		μ	sd	μ	sd	μ	sd	μ	sd
CO_2									
Import Fertiliser	$kgCO_2e\ kgECM^{-1}$	0.02	0.00	0.02	0.00	0.04	0.01	0.03	0.01
Import feeds	"	0.10	0.01	0.08	0.01	0.07	0.01	0.06	0.00
Electricity	"	0.03	0.00	0.03	0.00	0.02	0.00	0.02	0.00
Diesel use	"	0.05	0.01	0.04	0.01	0.05	0.01	0.04	0.01

- Gross emissions associated with feed imports 45% higher in LF, and electricity 34% higher

- Per kg ECM, margins smaller but HF still lower than LF

Summary

- Highest contributors to GWP in all systems:
  - enteric methane (48-50%)
  - followed by animal wastes (24-30%)
- But… key factors in variation between systems:
  - Off-farm CO_2 emissions higher in LF (due to imports)
  - N_2O emissions much higher in HF (due to increased land, fertiliser, excreted nitrogen and deposition at pasture)
- High gross LF emissions offset by high productivity Not the case for HF

Conclusions

- Observed potential for great variation in GWP amongst conventional dairy production systems
- System and genotype significantly influence GWP
  - Low Forage more efficient than High Forage
  - Select more efficient than Control
- Moving from HFC towards LFS system holds potential for up to 30% reduction in carbon footprint

Acknowledgements

Dr Mizeck Chagunda, Dr Kairsty Topp
Scottish Agricultural College

Dr Richard Ennos
University of Edinburgh

Colleagues and staff at:
SAC Dairy Research Centre, Dumfries
Crichton Royal Farm, Dumfries
Rural Business Unit, Bush

PhD Studentship funded by the Scottish Government

SAC

Success through Knowledge

Consistency across groups

- Staff
- Housing
- 3 x daily milking
- Health and fertility
- Young stock rearing
- S and C managed together
- Replacement rate - 3 lactations
- Same conserved forages offered
- One complete forage offered within system

Life Cycle Inventory

- Processes leading to milk leaving farm
- System-specific in depth data compiled on:
  - Populations & herd dynamics
  - Productivity
  - Energy and fuel use
  - Feeding intake and imports
  - Forage crops and land requirements
  - Fertiliser application
  - Management of animal wastes
  - Specific coefficients for $^{enteric}CH_4$ & $^{excreted}N$

Results

- Systems GWP per unit Energy Corrected Milk:

System		LFC		LFS		HFC		HFS	
		μ	s.d	μ	s.d	μ	s.d	μ	s.d
Milk Yield	kg ECM $hd^{-1}year^{-1}$	9246	800	10753	853	7281	533	8189	656
CO_2	$kgCO_2e\ kgECM^{-1}$	0.18	0.01	0.16	0.01	0.16	0.02	0.14	0.02
CH_4		0.56	0.03	0.46	0.02	0.66	0.04	0.56	0.05
N_20		0.21	0.02	0.18	0.02	0.34	0.05	0.29	0.04
Total GWP		0.95	0.05	0.80	0.05	1.17	0.13	0.99	0.14
Efficiency	**Rank* (P<0.001)**	**2**		**1**		**4**		**3**	