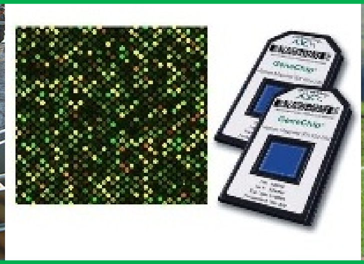
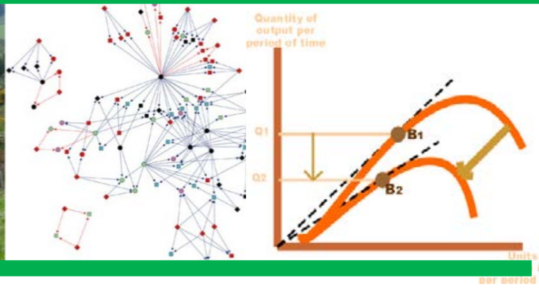
Breeding goals in an era of increasingly scarce and competing resources

Eileen Wall, Bob Rees and Dominic Moran

DISCLAIMER: Results will focus on ruminants and the UK – hopefully some messages for all types of livestock





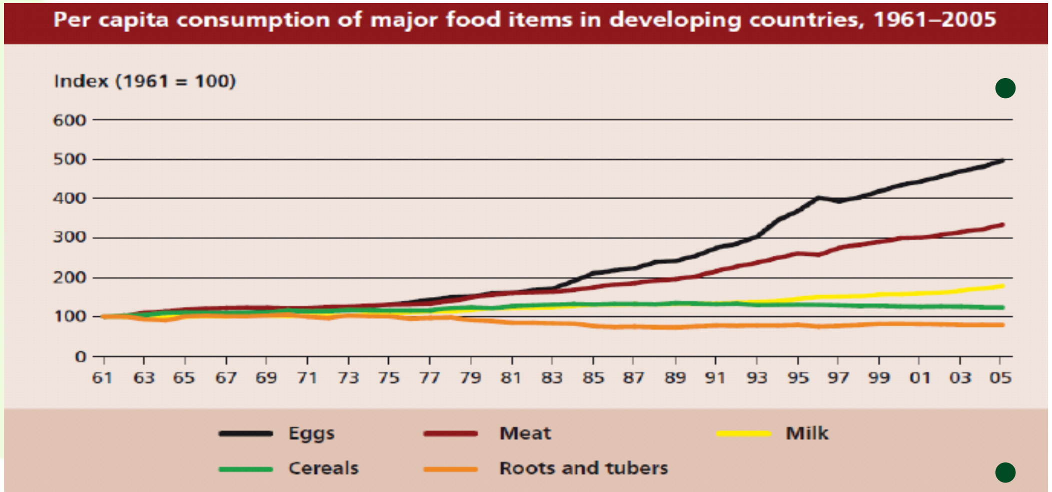
Scarce and competing resources

- Water – for irrigating crops (FUTURE!), competing for blue water, polluting risk?
- Energy – from the grid/generated for running the business, producing outputs to generate energy, competing for land for energy crops
- Ecosystem services – role of livestock in a balanced ecosystem, land degradation, social value and security
- Other natural resources – Minerals and vitamins
  - E.g., Phosphorus becoming a limiting factor in EU soils
- Policy drivers – climate change, both GHG emissions and resilience to future drivers

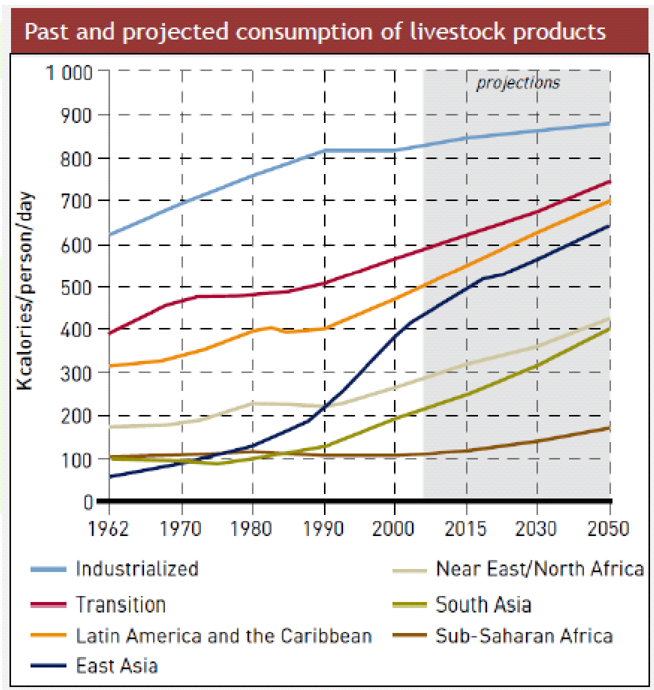
Scarce/competing resources to consider in breeding goals - LAND

- 30-45% of land in the world is pasture (80% agric land)
- ⅓ of arable land is used to feed animals
- 70% of the previous forest land in Amazon has been converted to grassland

Scarce/competing resources to consider in breeding goals - FOOD



Source: FAO, 2009b.



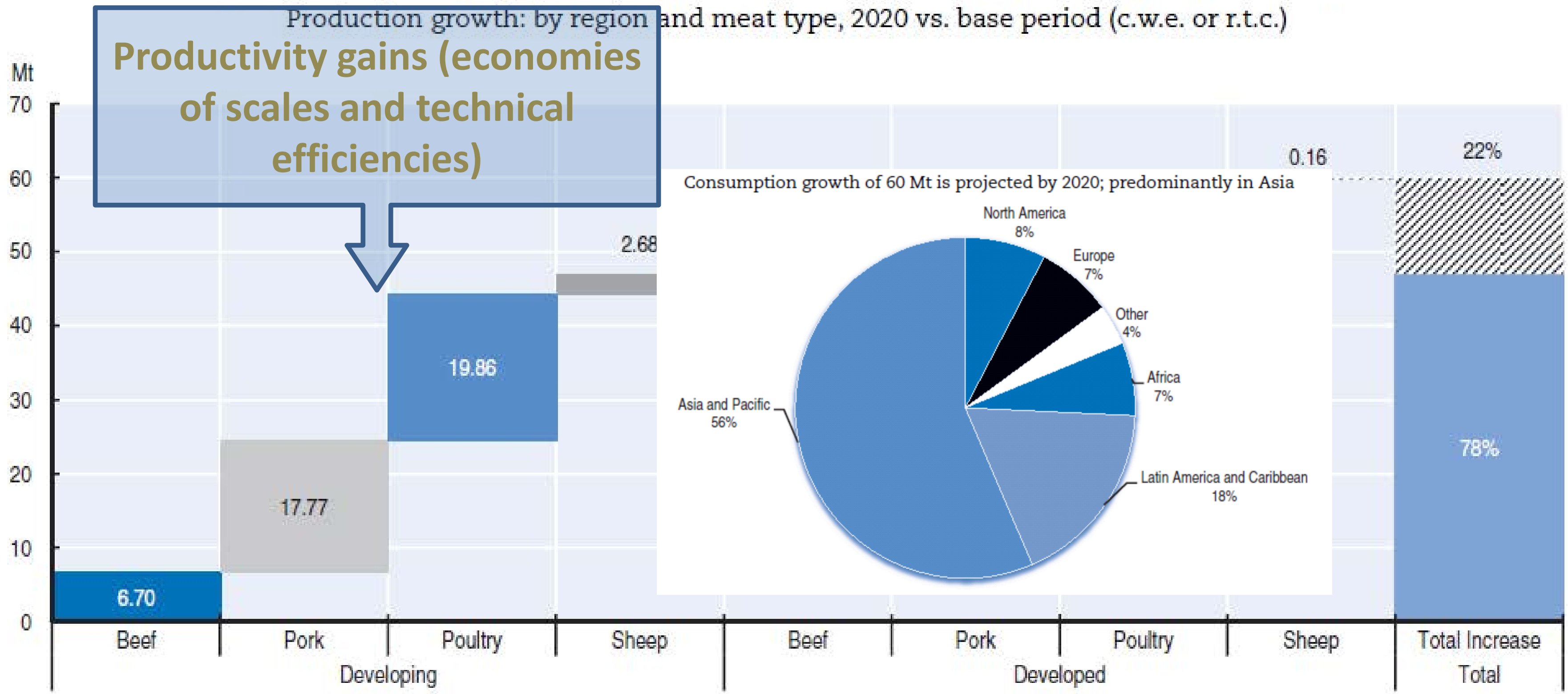
Source: FAO (2006a) and FAO (2006b).

- Developing countries
  - Milk consumption doubled
  - Meat consumption tripled
  - Egg consumption * 5
- As incomes grow the expenditure on livestock products grow
  - Growing economies and growing populations means increased demand for livestock products from developing countries

Growth expected in developing countries

Figure 7.2. **Meat production growth dominated by developing countries**

Production growth: by region and meat type, 2020 vs. base period (c.w.e. or r.t.c.)



Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932427075

Livestock products as a scarce resource

*…consider the **global food system** from **production to plate**.*

*Biological science…, must play a leading role …in providing a **range of scientific solutions to mitigate potential food shortages**. This will require significant funding of **cross-disciplinary science for food security.***

This is a unique time in history – decisions made now and over the next few decades will disproportionately influence the future

- *Sustainable agricultural intensification is defined as producing more output from the same area of land while reducing the negative environmental impacts and at the same time increasing contributions to natural capital and the flow of environmental services' (Pretty et al., 20113)*

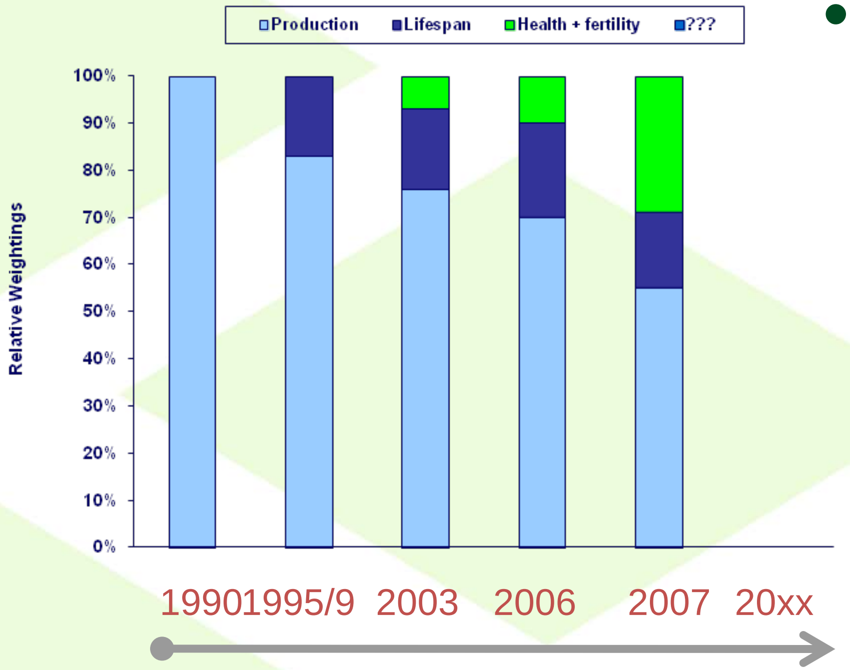
Current UK beef traits

Index	Goal Trait	Recorded Trait
Beef Value	Carcass Weight	Birth, 200 & 400 day weight
	Carcass Conformation Score	Muscling Score
		Ultrasonic Muscle Depth
	Carcase Fat Score	Ultrasonic Fat Depth
Calving Value	Gestation Length	Gestation Length
	Direct Calving Ease	Calving Difficulty Score
		Birth Weight
Maternal Value	Calving Interval (days)	Calving Interval
	Age First Calving (%)*	Age First Calving
	Lifespan (disposal age)	Lifespan
	Maternal Weaning Weight	200 Day Weight
	Maternal Calving Ease (%)	Calving Difficulty Score

Genetic improvement for sustainable intensification - beef

Trait change (in units, relative to 2008)	2012	2017	2022	Alt 2022
Carcass weight	6.16	13.86	15.4	23.8
Carcass conformation	0.16	0.36	0.4	0.2
Residual feed intake	-3.16	-7.11	-7.9	-108.3
Gestation length	0.08	0.18	0.2	0.3
Calving difficulty	0.04	0.09	0.1	0
Docility score	0.04	0.09	0.1	0

Sustainable intesification in dairy herd



- National dairy breeding goal in dairy is £PLI (**Profitable** Lifetime Index)
  - Includes the impact of production and fitness traits on system profitability
  - Traits are combined in an index by weighting trait breeding values by their relative economic value (i.e., their impact on net farm income)

Distributed genetic improvement and sustainable intensification - dairy

Trait change (in units, relative to 2008)	2012	2017	2022
Milk yield	317.2	713.6	792.9
Lifespan	0.22	0.50	0.55
Mastitis	0.002	0.005	0.006
Calving interval	1.5	3.3	3.7
Conception	-0.011	-0.024	-0.027
Condition score	-0.084	-0.189	-0.210

Defining sustainable intensification

- Process/change over time @ farm level
- **Environmental**: total rough grazing area/total area, total (farmed) woodland area to total area, permanent to temporary grass area
- **Economic**: livestock output:total output; interest cover:total debt, subsidies:gross margin, labour:gross margin….
- **Social**: total farmer hours to total hours worked, total hired labour to total hours worked
- **Intensification**: average stocking density/area of forage land

Distributed impact – industry costs and benefits

Trait change (in units, relative to 2008)	2012	2017	2022	Alt 2022
BEEF				
Reduction in GHG kg CO_2e/yr	-12,097	-33,072	-41,340	-64,794
Farmer profit £/yr	1,345,813	3,679,381	4,599,227	7,219,495
% red^n in grazed grass	1.07	2.45	2.77	4.54
DAIRY				
Reduction in GHG kg CO_2e/yr	-285,104	-666,093	-760,641	
Farmer profit £/yr	28,084,542	65,614,449	74,928,080	
% reduction in grazed grass	5.8	13.3	15.1	

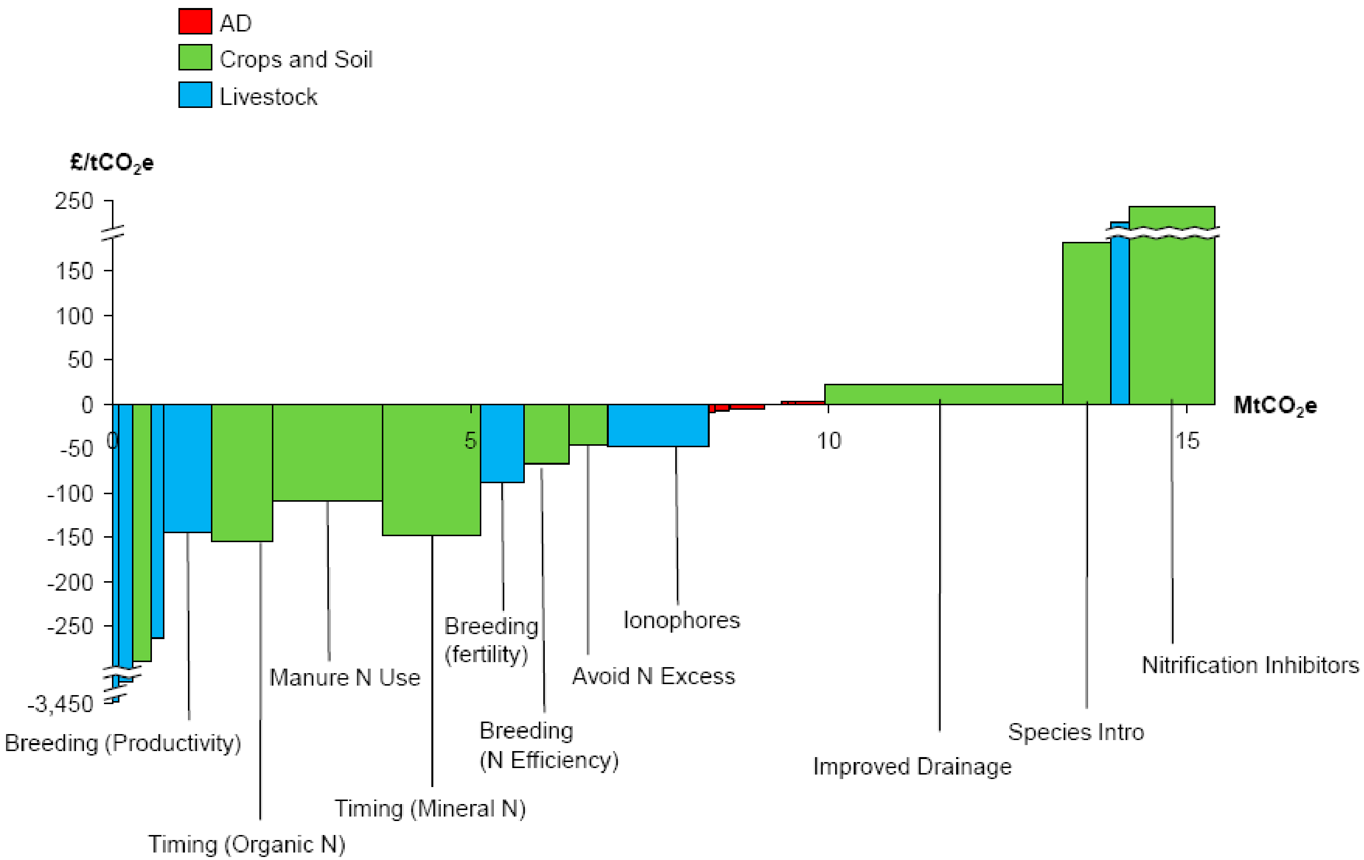
Value of adding genomics

- Adding genomic information to beef improves current economic response
  - 14 - 21% improvement
- Adding novel traits to goal (target for genomics) improves it further
  - 29 - 45% across beef breeds
- Large training populations for novel traits
- Genotyping costs (still) too high??

Is genetic improvement towards sustainable intensification a cost-effective GHG reduction tool?

- Only one of the livestock abatement measures
  - e.g., nutrition, breeding, anaerobic digestion, pasture mgmt
  - How much GHG reduction?
  - Are there associated effects?
  - How much does it cost to apply?
- Construct Marginal Abatement Cost Curves (MACC)
  - Displays GHG reduction and costs
- Outcome: Identify cost-effective reductions of GHG from livestock systems

Overall MACC



Source: CCC modelling

Notes: N = Nitrogen, AD = anaerobic digestion
Measures do not appear in exact cost-effectiveness order due to interactions between options. More details and a full measures list is available in the accompanying technical papers.

Building a low-carbon economy – The UK's contribution to tackling climate change. 1st Report of the CCC, Dec, 2008

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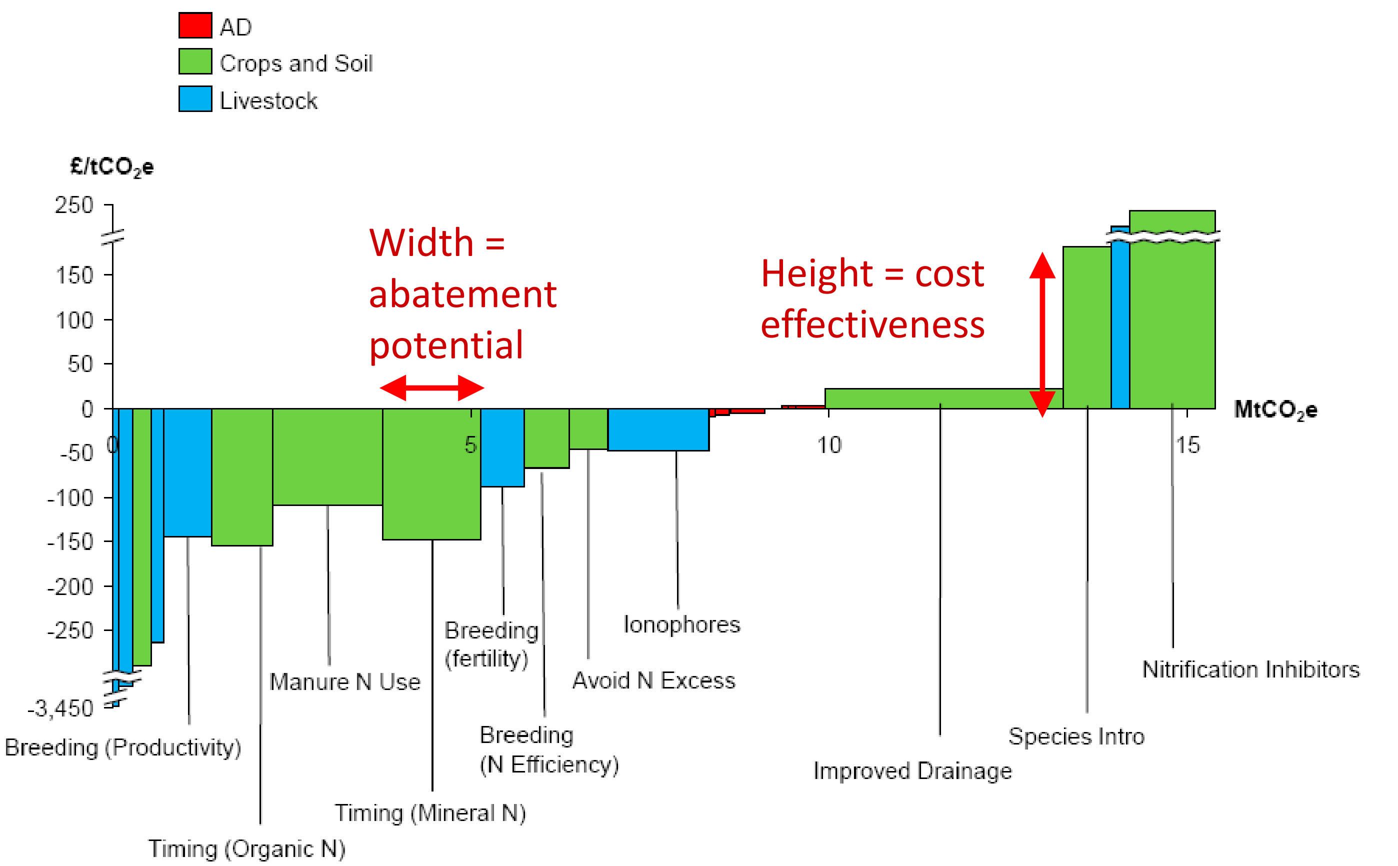

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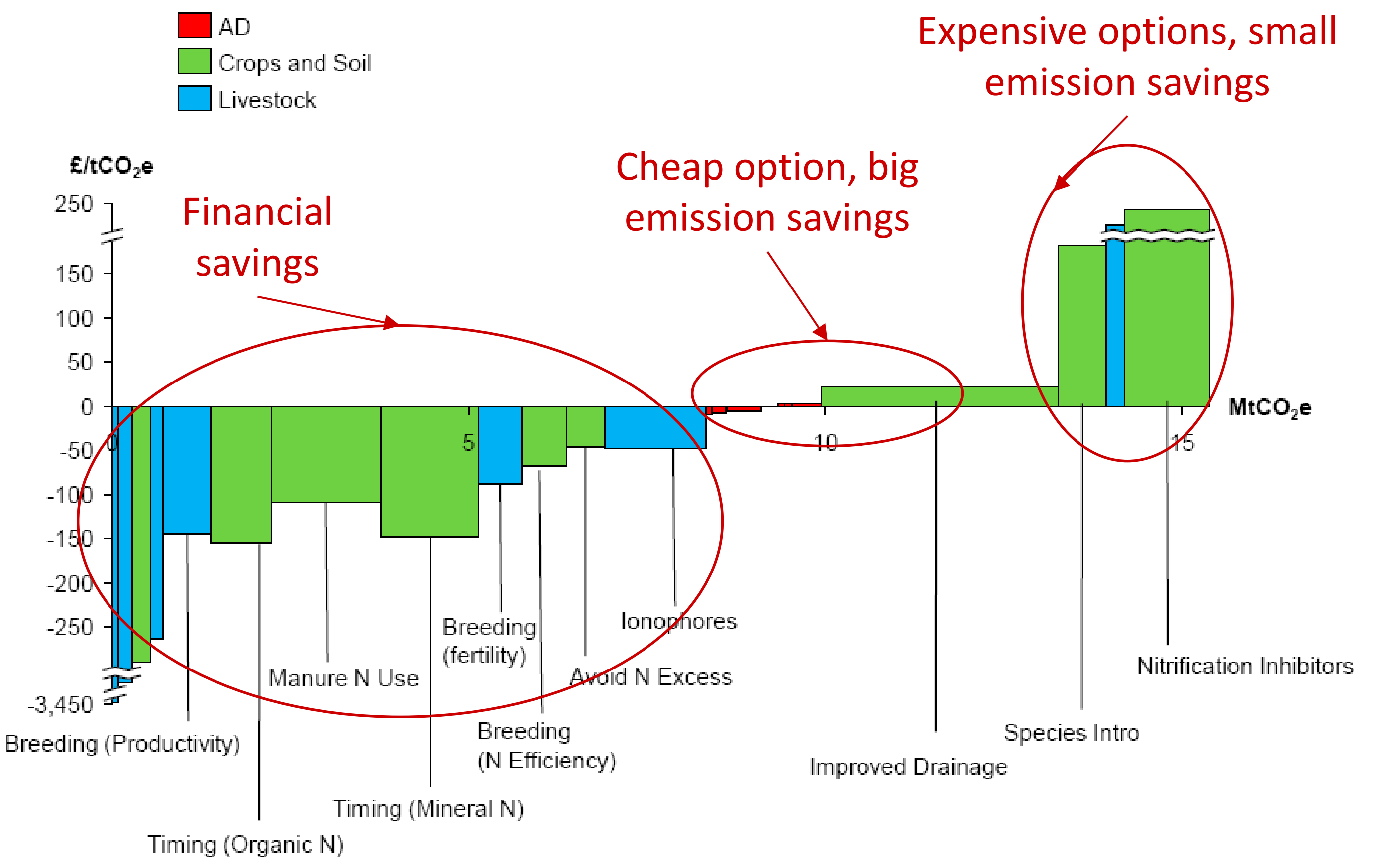

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- Genetic improvement is one of the cost-effective options for the UK livestock sector that will reduce greenhouse gases
- Applying cost-effective livestock tools reduces agriculture emissions by ~10% by 2022
- The addition of better rates of improvement (new goals) and increased uptake in beef ~ 14% by 2022
- The addition of genomics and feed intake record in beef ~ 15% by 2022
- The addition of genomic in dairy ~ 20% by 2022

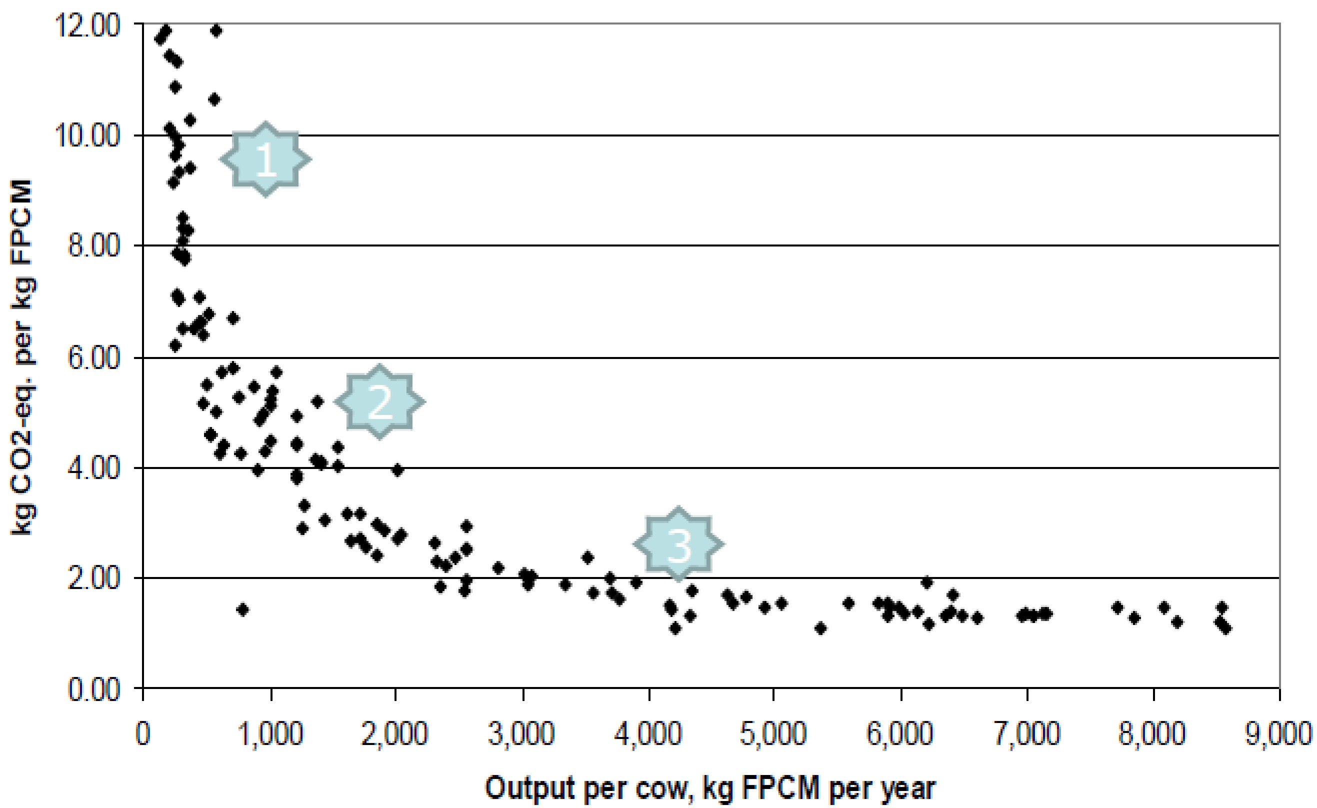
Summary - sustainable intensifcation

- Beef industry changes had small but favourable impact on GHG emissions and profitability
  - Environmental and social sustainability desirable, but what is the policy mechanism? CAP to ↑ uptake of improvement?
- Changes in dairy industry - 20 times higher than beef
  - Starting from a better base for genetic improvement
- Impact of reduction in grazed grass
  - Freed up for crops – improved LCA under CC
  - Increasing housing of animals?
  - Delivery of ecosystem services – land sparing vs land sharing
- Is intensification a goal – across the industry, within a sector of the industry?

What animals should we focus on?
Yield gaps globally

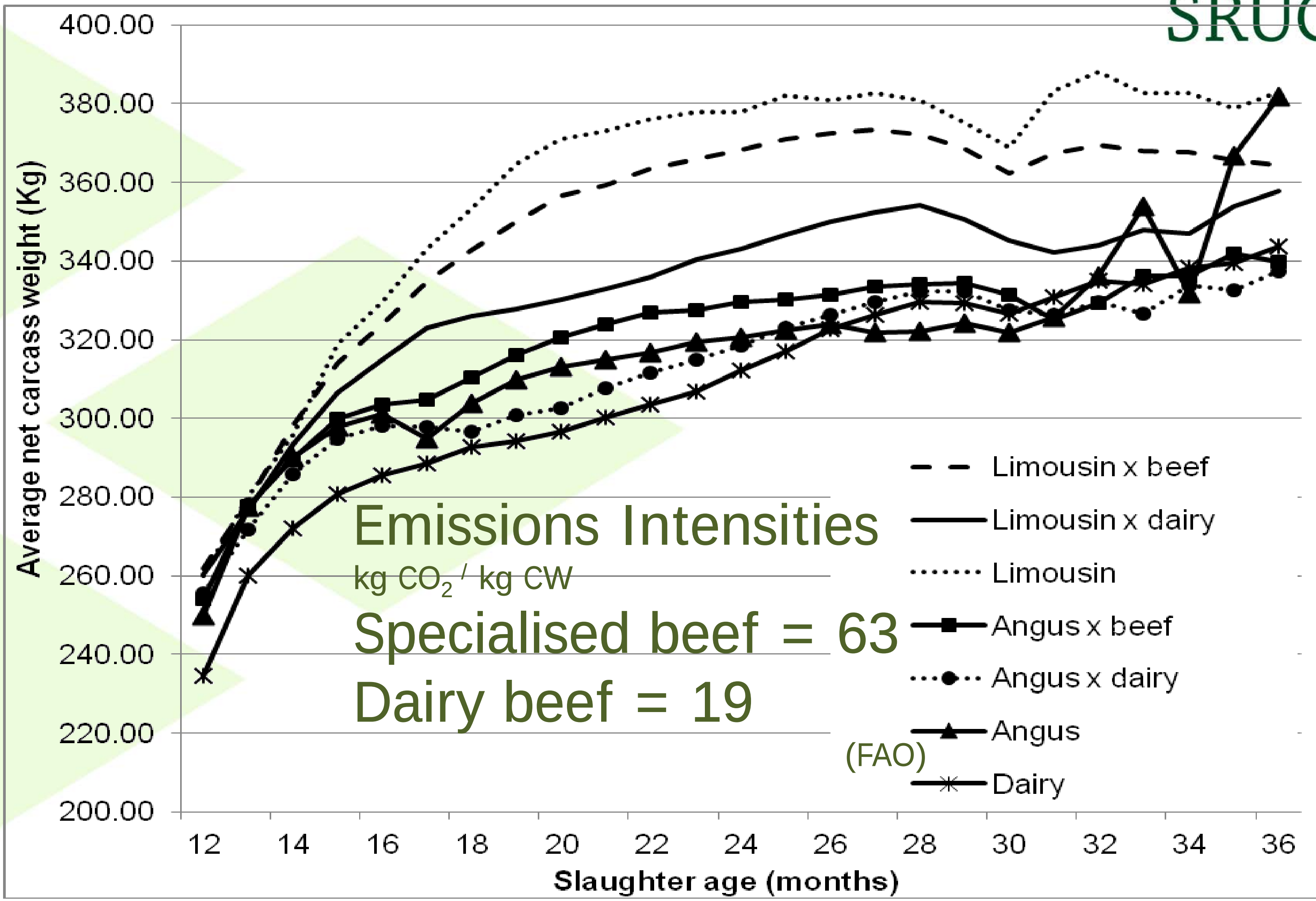
SRUC

MILK: Relationship between total greenhouse gas emissions and output per cow



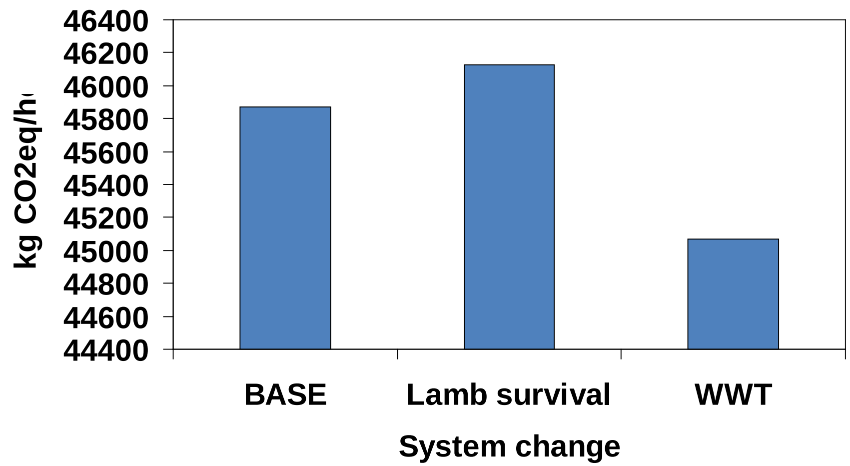
Source: FAO LCA Analysis

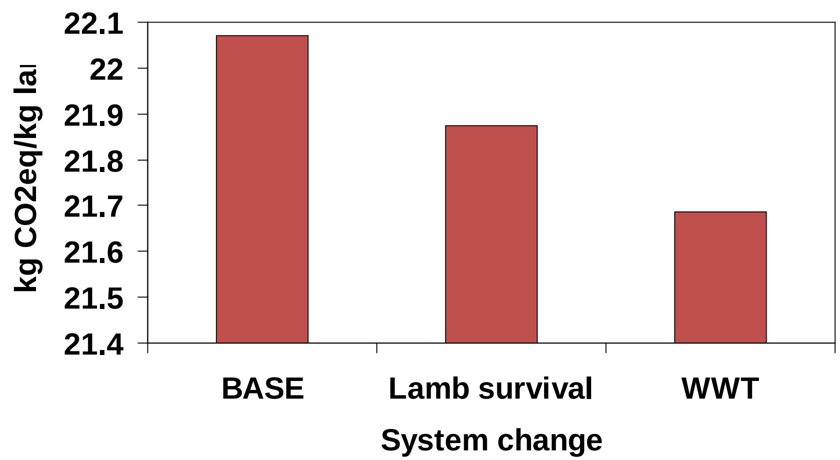
What animals should we focus on?
Beef vs dairy beef



Metrics of sustainability - What is correct for extensive system breeding goal

- GHG emissions impact of changing animal perf. (prod^n & funct^n)
- Change one trait at a trait
  - Improved weaning weight, reduces the duration to finishing = ↓ GHG emissions
- Per hectare & per product
  - Lamb survival = more animals within the system = ↑ emissions on the farm but ↓ emissions per unit product





Defra funded

Considerations going forward

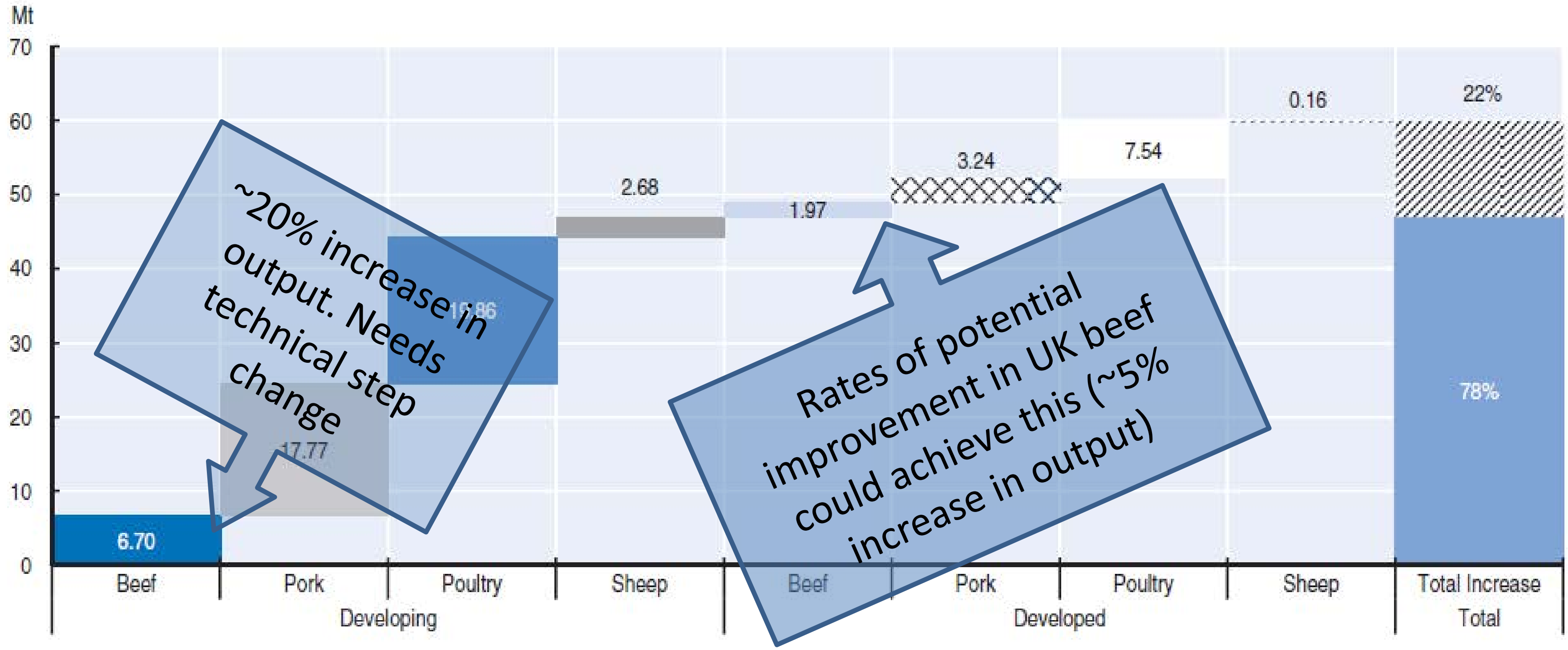
- Mitigation targets and monitoring
  - Finding measures that adapt AND abate (and *vice versa*), complement rather than conflicting
- Trade-offs
  - Ecosystem services, animal health & welfare

% cows housed	5	10	20
Heat stress losses (Engl)			
Low GHGs	£56,936	£113,871	£227,742
High GHGs	£7,263,763	£14,527,526	£29,055,052
Cost/benefit of adapting			
Low GHGs	-£3,163	-£6,326	-£12,653
High GHGs	£6,918,306	£13,836,611	£27,673,223

Growth expected in developing countries

Figure 7.2. **Meat production growth dominated by developing countries**

Production growth: by region and meat type, 2020 vs. base period (c.w.e. or r.t.c.)



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Considerations for breeding goals

- We need science to help deliver a “global” green revolution
  - Breeding goals for higher productivity for all farms
  - Breeding goal resilience (stable supply)
  - Manage trade-offs (ecosystem/sustainability)
    - Genetics not the only tool!
  - Who will win/loss?
  - Substitute “breeding goals” for “new technologies”

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