# The role of animal science in addressing global issues - *Sheep and Cattle*

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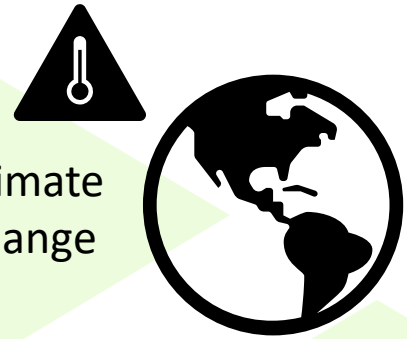
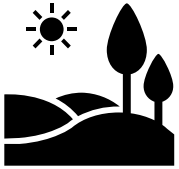
SRUC Research

*Leading the way in Agriculture and Rural Research, Education and Consulting*

# Global issues – sheep and cattle



Climate change

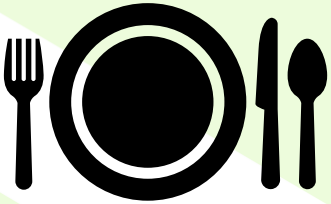


Land management & biodiversity

Communities and social issues

**Livestock systems**

Human health and wellbeing



Food security

Animal health and welfare

Trade and markets

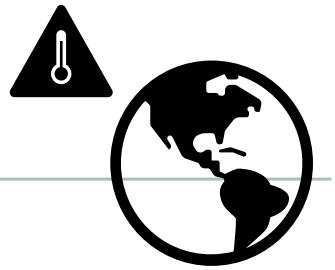
Traceability, standards, ethics, quality

# Livestock and Landscapes

(https://www.fao.org/3/ar591e/ar591e.pdf)

- **Environment:**
  - Large % of planet used for livestock grazing (26% ice-free land) or livestock feed prodn. (33% of croplands)
  - Livestock → 7% total GHG emissions
- **Social:**
  - 1bn poor people (mostly pastoralists in South Asia and sub-Saharan Africa) depend on livestock for food and livelihoods
  - Globally, livestock provides 25% protein intake and 15% dietary energy
- **Economy:**
  - Globally, livestock contribute about 40% of agricultural gross domestic product (GDP)
  - Livestock provides livelihoods and incomes for at least 1.3 bn people
- **Governance:**
  - Rising population and incomes in the developing world → surging demand for animal products (>double by 2030)
  - Meeting increasing demand is a major sustainability challenge

# Enteric methane ($CH_4$)



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## COP26: US and EU announce global pledge to slash methane

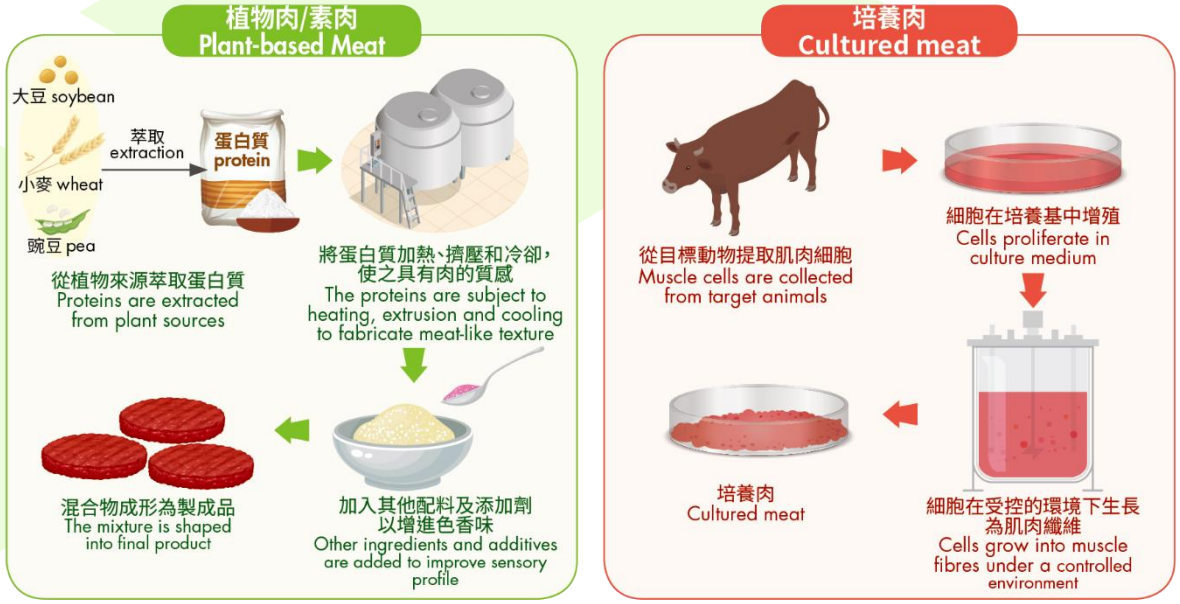
2 November

The Global Methane Pledge aims to limit methane emissions by 30% compared with 2020 levels.

→ What is the future for ruminant production and consumption?
→ Can animal science play a role?

# Plant-based or cultured “meat”?

- Is this the future?
  - Cut out animal proteins, plant-based diet
  - Meat alternatives - cell-cultured meat




Plant-based Meat and Cultured Meat - New Food Fads (cfs.gov.hk)


(Credit: Firn/Shutterstock) What Is Cell Cultured Meat and When Can You Try It? | Discover Magazine

# Eat only monogastrics?

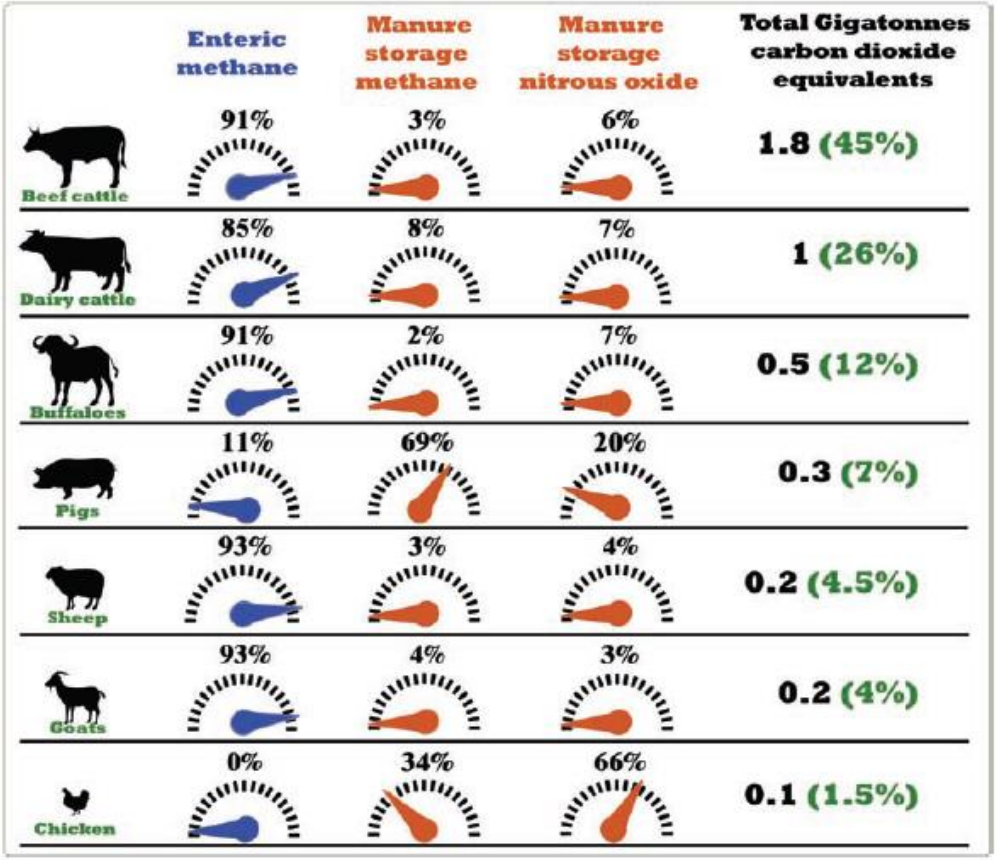



**Figure 1.** Greenhouse gases incidence of enteric fermentation and manure storage by animal type, expressed as Gigatonnes of carbon dioxide equivalents. Data referred to 2010 (FAO, 2017).

Grossi, Goglio, Vitali and Williams 2019. Livestock and climate change: impact of livestock on climate and mitigation strategies. Animal Frontiers 9, 69-76.

# Produce more sustainable beef and lamb

- Technology
- Breeding
- Nutrition
- Management

## Global issues – sheep and cattle

Climate change

Land management & biodiversity

Communities and social issues

Livestock systems

Human health and wellbeing

Food security

Animal health and welfare

Trade and markets

Traceability, standards, ethics, quality

# Animal science success stories

## – to feed a growing population

- Animal welfare improvements
- Breeding to improve yield, reduce environmental impact and improve health
- Technology to improve efficiency of production and management, detect health/welfare issues, traceability of food
- Nutrition to improve production, promote health (animal and human) and reduce GHG
- Resistance to drugs – e.g. targeted selective treatment, antibiotics
- **Collaborative international projects**
  **– global solutions to global issues**

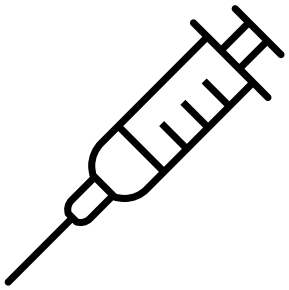
# Animal Welfare Research

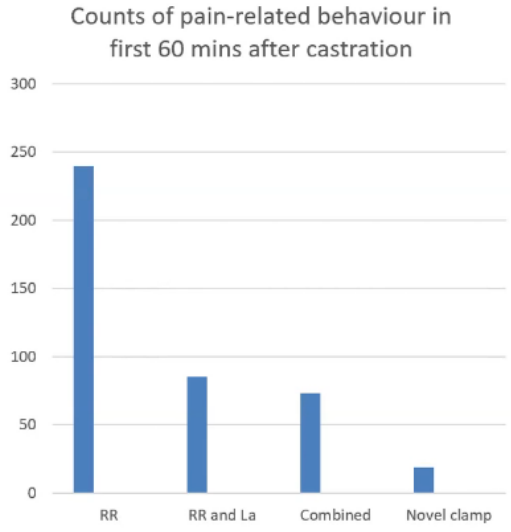
frontiers in Veterinary Science
ORIGINAL RESEARCH
published: 10 January 2020
doi: 10.3389/fvets.2019.00495

**Prioritization of Farm Animal Welfare Issues Using Expert Consensus**

*Fiona C. Rioja-Lang[†], Melanie Connor[1], Heather J. Bacon[1], Alistair B. Lawrence[2] and Cathy M. Dwyer[1,2*]*

- Sheep and Cattle – nutrition, transport, environment, management, maternal behaviour, survival, stress, mental state, health…
- Examples – tail docking, castration, dehorning
- Science to test beliefs that pain is low and short-term
- Fully understand effects on physiology, behaviour, health… over time




Cathy Dwyer et al., SRUC

# Animal Welfare Research

- Animal science innovations - often not adopted in practice (Weary et al, 2016)
  - solutions don't address the societal concerns that motivated the research
  - solutions don't address perceived constraints within the industry
  - Social science research may help address these limitations.
    - Understand barriers to adoption
    - Tailored extension activities (e.g. alt. ways to keep animals clean vs tailing)
- Animal Science informs welfare policy

**Animal Welfare Committee (AWC)** (previously FAWC) advises the Department for Environment, Food and Rural Affairs (Defra) and the Scottish and Welsh Governments on the welfare of animals kept by people.

The RSPCA welfare standards for farm animals, as used by the RSPCA Assured scheme, play a particularly important role in helping to translate the results of scientific research into higher-welfare systems and practices that farmers can feasibly use.

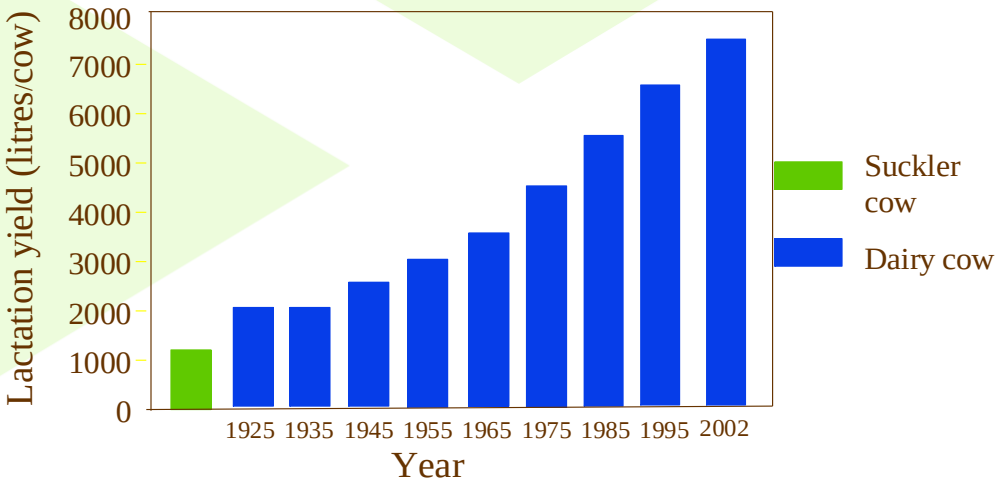
# Qualitative Behaviour Assessment (QBA)

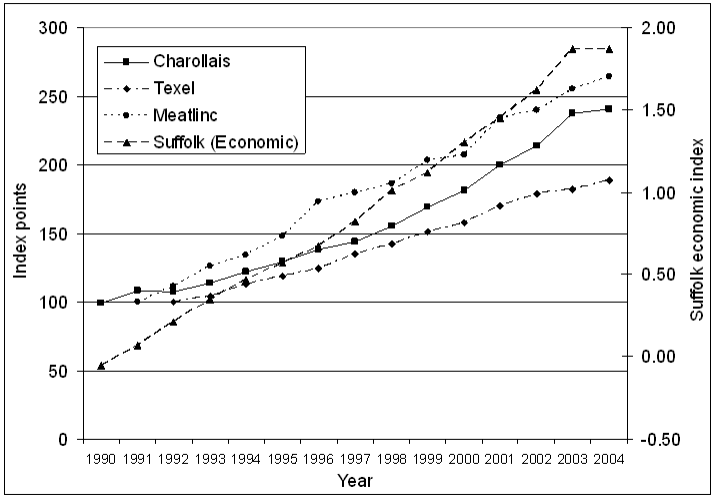
- QBA - you describe and record the emotionally expressive qualities observed in your animals' behaviour
  - Mobile app developed by Prof Francois Wemelsfelder (SRUC)
  - practical and easy to use on farm
  - underpinned by rigorous scientific research
  - allows animal welfare inspectors to record different expressive qualities of behaviour (e.g. relaxed, tense, playful, anxious), indicative of an animal's emotions well-being
  - Rolled out across Waitrose supply chain

# Breeding and genetic research

- For improved yield and quality of product (meat, milk)
  - growth rates, carcass weights and composition, meat/milk quality
- Research results implemented in national breeding programmes
  - close links between research providers, performance recording agencies and genetic evaluations providers

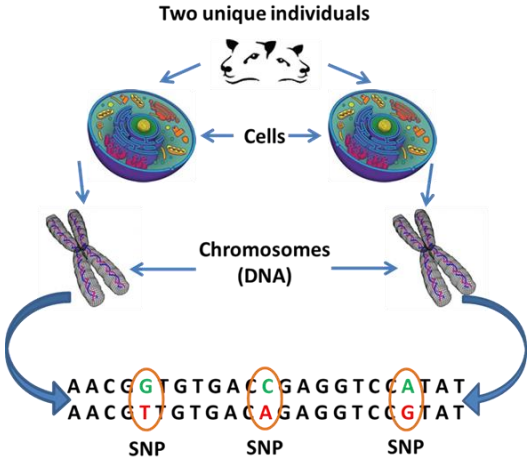
"Genetic gain within the UK is currently worth £10.7m to the sheep industry and £4.9m per annum to the beef industry, with much of this work underpinned by research, delivery and knowledge exchange." (ahdb.org.uk)



# Breeding and genetic research

- For wider breeding goals:
  - improved health and fertility; reduced losses; increased longevity
    - Less unproductive animals in flock/herd
    - Lower waste
  - improved feed efficiency; reduced methane emissions
    - Reduced environmental impact
- Potential use of genomic selection


# Breeding and genetic research

Schuster J, De Vries A, Kelton D and Orsel K 1-12-2020. Invited review: Academic and applied approach to evaluating longevity in dairy cows. Journal of Dairy Science 103, 11008-11024.

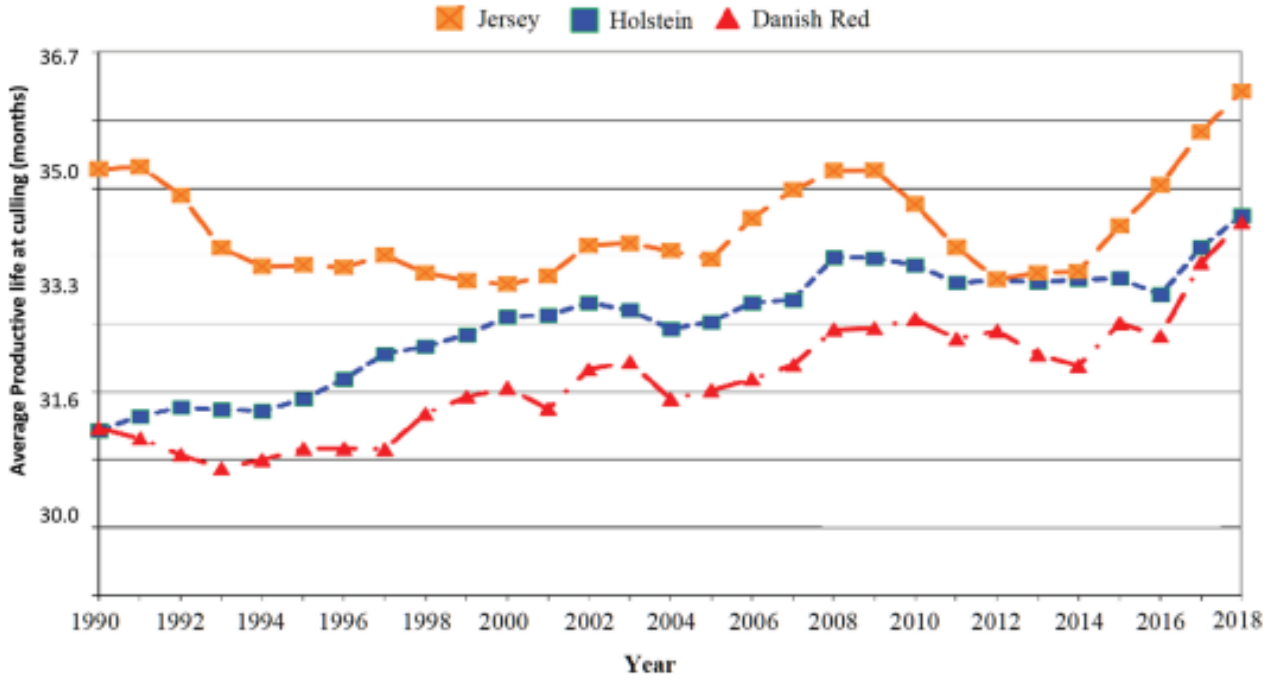



**Figure 4.** The average length of productive life (days from first calving to culling) for Jersey, Holstein, and Danish Red cows in Denmark between 1990 and 2018. Image modified and used with permission from SEGES (2019).

Denmark - Increase in longevity (productive life) across breeds (esp. higher producing)

# Breeding and genetic research

Schuster J, De Vries A, Kelton D and Orsel K 1-12-2020. Invited review: Academic and applied approach to evaluating longevity in dairy cows. Journal of Dairy Science 103, 11008-11024.

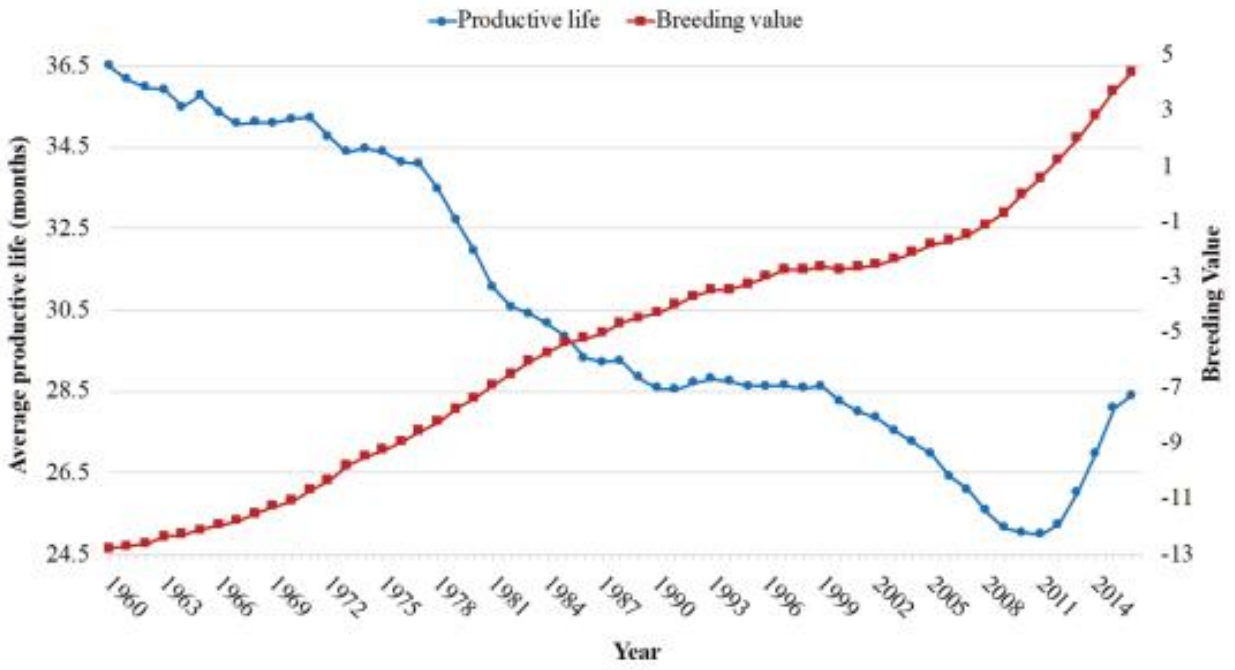
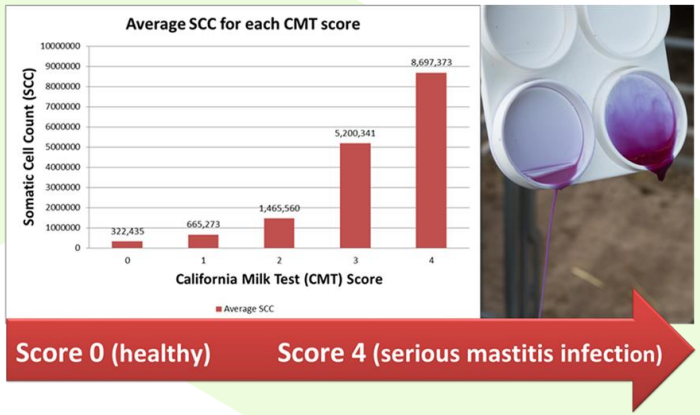


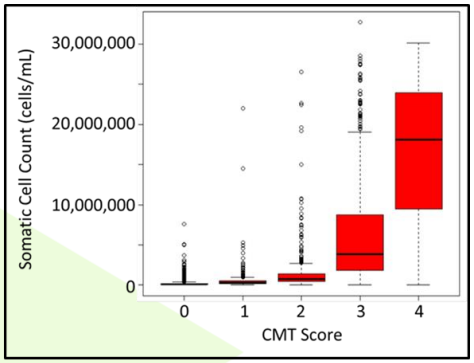

**Figure 2.** Genetic and phenotypic trends in the average length of productive life (months from first calving to culling) in the United States between 1960 and 2016. Source: Council on Dairy Cattle Breeding (2019).

US - Increase in measured longevity since 2009 largely due to increased genomic selection

# Breeding to reduce Mastitis & Footrot

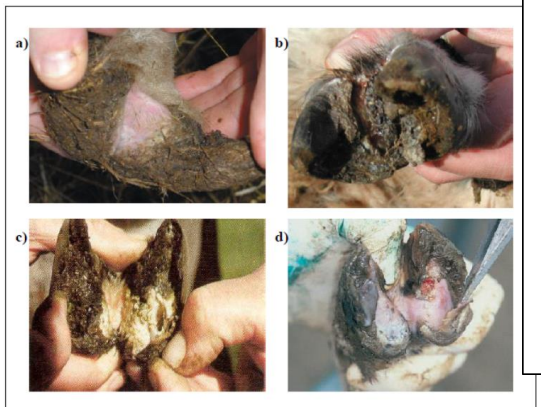
- California Mastitis Test ($h^2$ = 0.10)
  - Good predictor of Somatic Cell Count ☺

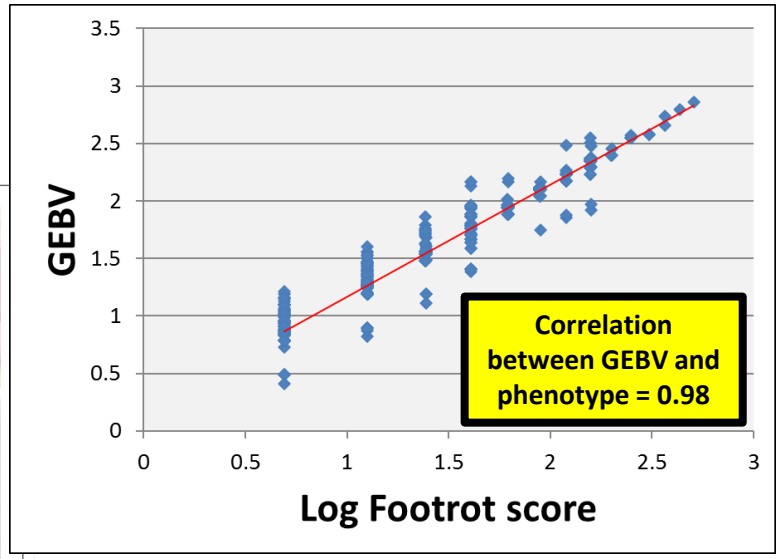



Genomic breeding values (GEBVs) for mastitis and footrot produced for UK Texel sheep

- Foot Scores ($h^2$ = 0.18)



# Technology research

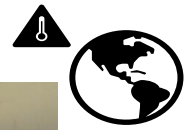
- Tech to improve production and management efficiency, detect health issues, improve traceability of food
- Smart, data-driven solutions
- Industry research partners (e.g. tech providers) → on-farm implementation

# Eat (less) high quality meat?

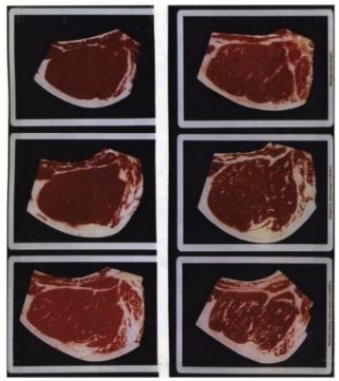
- Understand factors affecting meat quality
- Predict MQ in the supply chain:
  - Live animal
  - Carcass / meat cut
- Incentivise MQ
- Improve MQ
  - Breeding
  - On-farm management
  - Processing







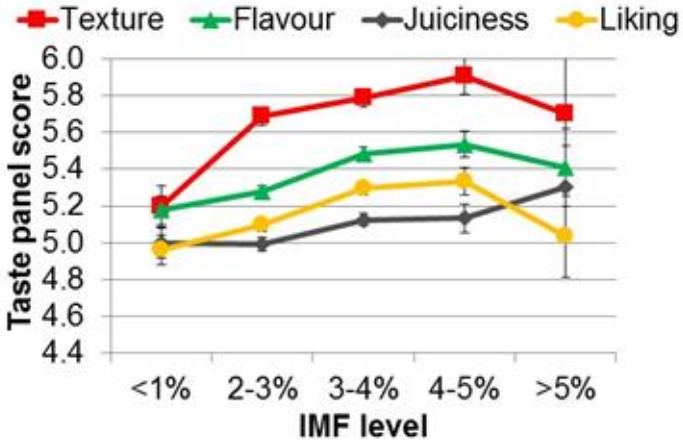



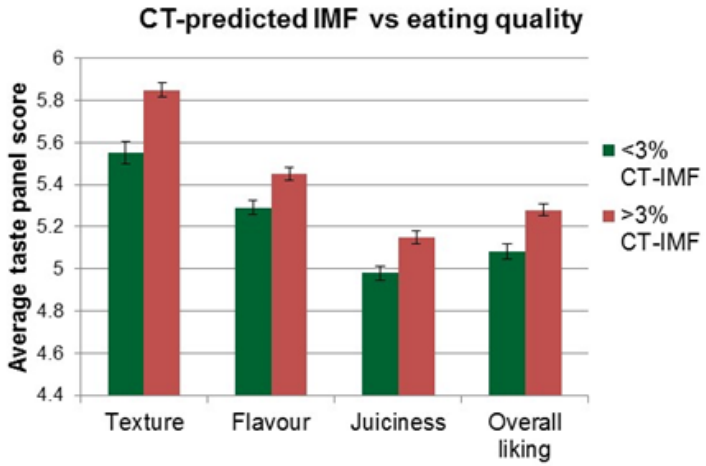


https://www.ivv.fraunhofer.de/en/product-performance/odor-optimization/gas-analysis.html

# Taste vs Waste project (2014-2019)

- Lamb intramuscular fat (IMF) linked to eating quality
- Vis-NIR and CT of lamb loin cuts can predict IMF (mod-high accuracy)
- IMF predictors heritable in crossbred lambs:
  - NIR-IMF = 29%
  - CT-IMF = 21%

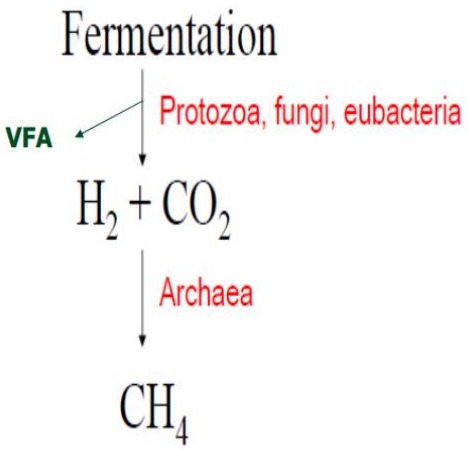


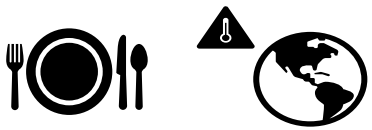




Funded by Innovate UK

# Animal Nutrition Research

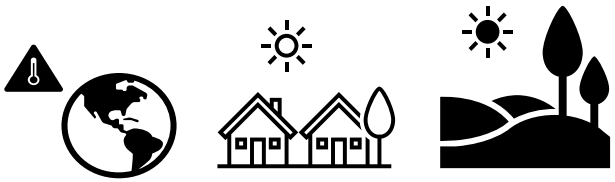
- To increase production levels
  - diet comparisons; additives
  - across different systems / breed types; interactions
- To reduce GHG emissions
  - diet composition – forage vs concentrates; fibre; lipids
  - additives / inhibitors – e.g. oils, garlic, cinnamon, coriander, 3-nitrooxypropanol (3-NOP), nitrates, seaweeds
  - Feed production methods and system-wide Carbon footprint



# Animal Nutrition Research

- Impact on land use
  - 26% planet's land use for grazing livestock
  - 33% croplands used for livestock feed production (https://www.fao.org/3/ar591e/ar591e.pdf)
  - Land use allocation for livestock production - deforestation, desertification, carbon released from cultivated soils
  - Grazing management to increase carbon sequestration:
    - not exceeding pastureland carrying capacity - stocking rate
    - rotational grazing
    - excluding degraded pasturelands from livestock grazing



# Resistance to medicines

SRUC

**Antimicrobials**

- include antibiotics, antivirals, antifungals and antiparasitics
- medicines used to prevent & treat infections in humans, animals and plants.

**What is antimicrobial resistance (AMR)?**

- when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines
- makes infections harder to treat, increases risk of disease spread, severe illness and death
- antimicrobial medicines become ineffective and infections become difficult or impossible to treat

World Health Organization

**Why is antimicrobial resistance a global concern?**

- emergence and spread of drug-resistant pathogens → AMR
- threaten our ability to treat common infections
- rapid global spread of multi- and pan-resistant bacteria (“superbugs”) - not treatable with existing antimicrobial medicines

https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

# Resistance to medicines

**Antimicrobials**

- include **antibiotics**, antivirals, antifungals and **antiparasitics**
- medicines us[illegible] prevent & treat infections in humans, [illegible]als and plants.

Antibiotics to treat infections in sheep and cattle

Anthelmintics to treat gastro-intestinal parasites in sheep and cattle

**Wh[illegible] (AMR)?**

- [illegible] parasite[illegible]
- make [illegible] harder to treat, increases risk [illegible] spread, severe illness and death
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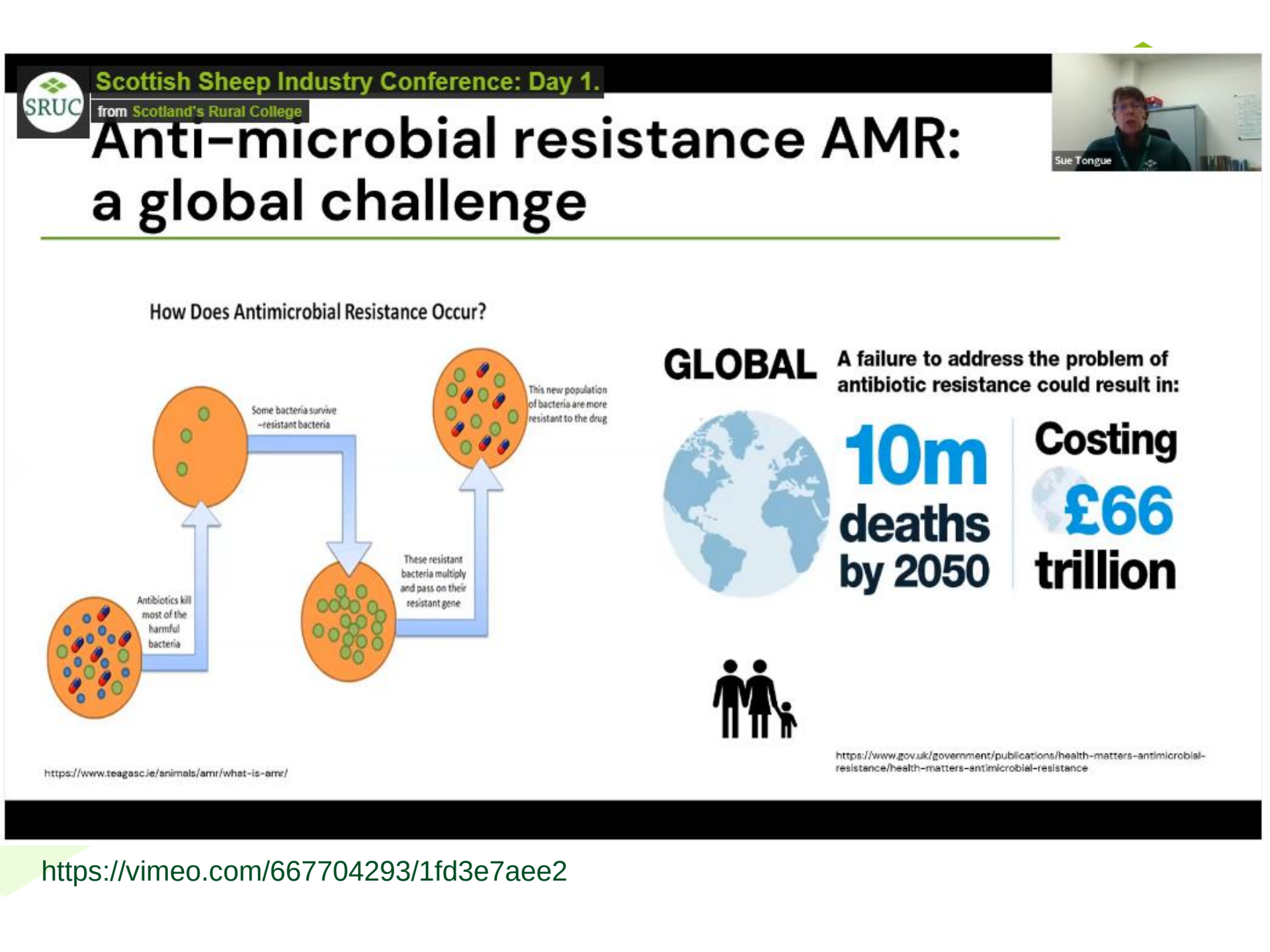
https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance

Scottish Sheep Industry Conference: Day 1.

from Scotland's Rural College

# Anti-microbial resistance AMR: a global challenge




## How Does Antimicrobial Resistance Occur?




https://www.teagasc.ie/animals/amr/what-is-amr/

## GLOBAL

**A failure to address the problem of antibiotic resistance could result in:**



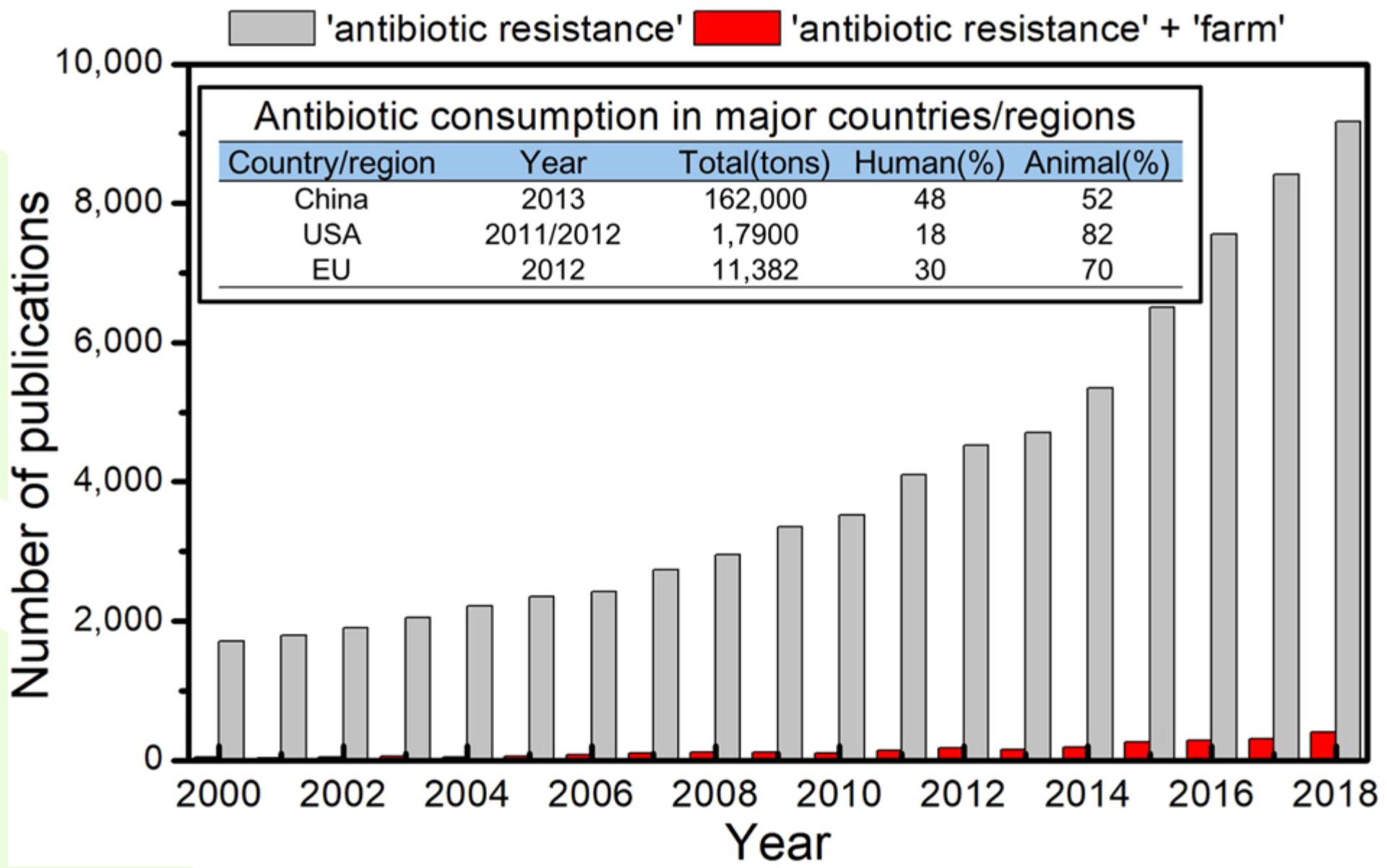
**10m deaths by 2050**

**Costing £66 trillion**



https://www.gov.uk/government/publications/health-matters-antimicrobial-resistance/health-matters-antimicrobial-resistance

https://vimeo.com/667704293/1fd3e7aee2




Web of Science results (2000-2018) - increase in the number of annual publications related to resistance propagation in the environment. However, the number of publications related to antibiotic resistance in animal husbandry does not fit with the dominant use of antibiotics in this sector

- He, Y., Yuan, Q., Mathieu, J. *et al.* Antibiotic resistance genes from livestock waste: occurrence, dissemination, and treatment. *npj Clean Water* **3,** 4 (2020). https://doi.org/10.1038/s41545-020-0051-0

Scottish Sheep Industry Conference: Day 1.

from Scotland's Rural College


# Antimicrobial use – why record it?


RESPONSIBLE USE OF MEDICINES IN AGRICULTURE ALLIANCE

ruma

## Targets Task Force 2017 set sector targets

https://www.ruma.org.uk/wp-content/uploads/2017/10/RUMA-Targets-Task-Force-Report-2017-FINAL.pdf

45:00

- Science driving tools and initiatives to record AMU from vets, farmers and others to inform decisions and policy

https://vimeo.com/667704293/1fd3e7aee2

Scottish Sheep Industry Conference: Day 1.

from Scotland's Rural College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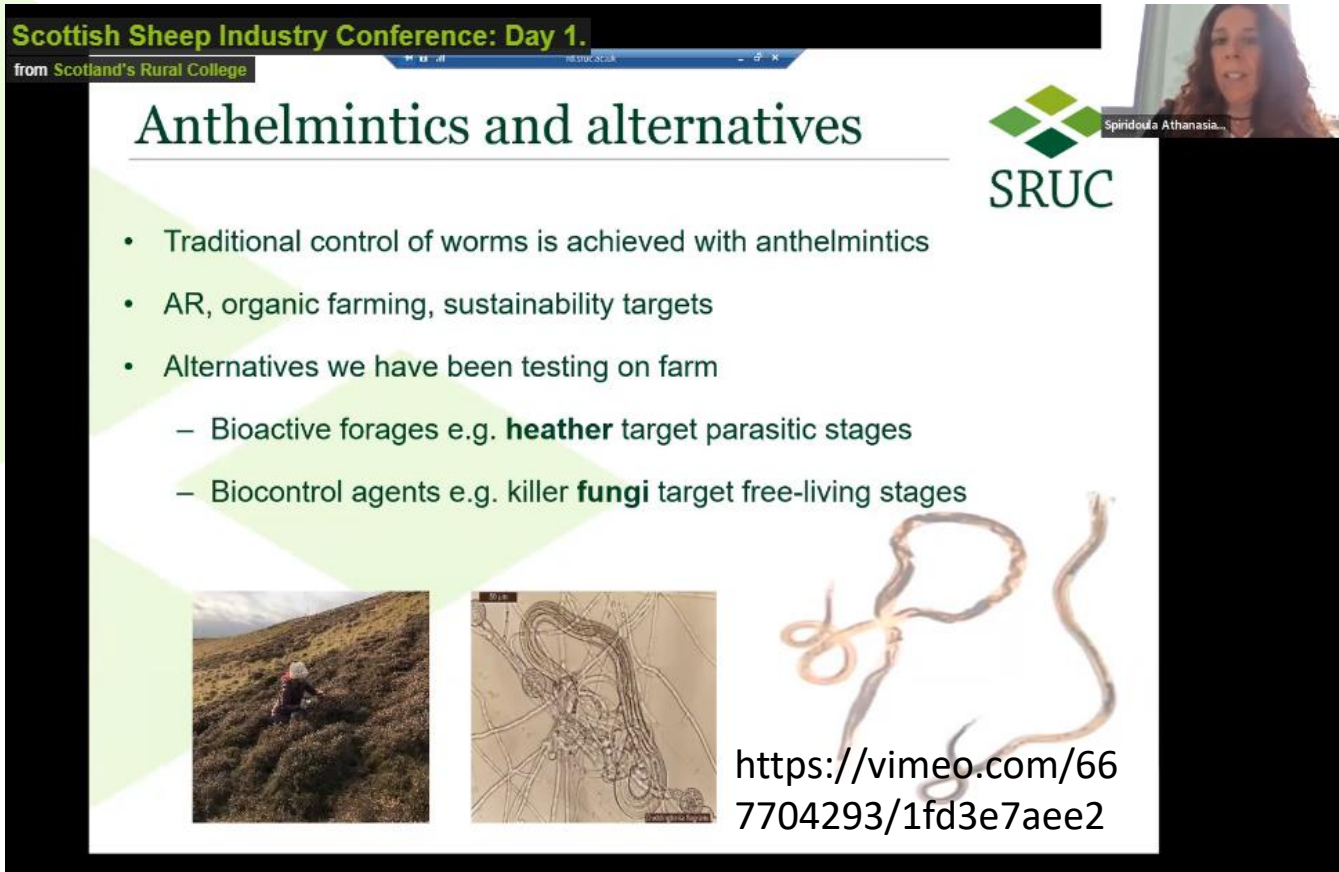
# Why?

- Flock - monitoring & benchmarking
- Improved flock health & decreased medicine costs
- Farm assurance
- Sector – evidence to support & enhance low use reputation
- Targets Task Force 2
- Support product retention for use in livestock
- National - trade

https://vimeo.com/667704293/1fd3e7aee2

# Nutritional solutions to reduce anthelmintics

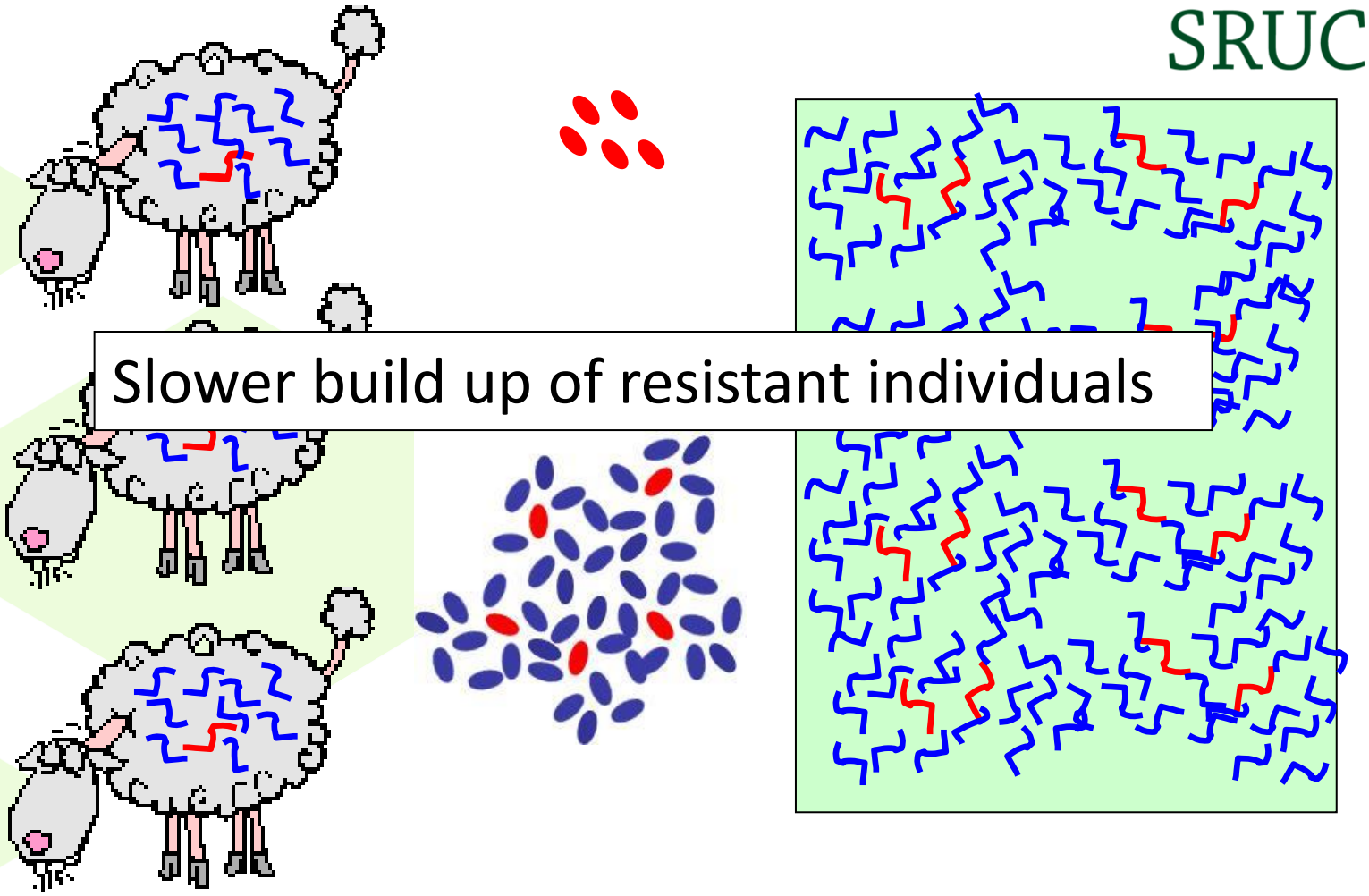
- Alternatives to anthelmintics
  - grazing bioactive forages, e.g. chicory, birdsfoot trefoil and sainfoin - reduce negative effects of parasitism in sheep
  - Heather
  - Fungi




**Spiridoula Athanasiadou et al., SRUC**

# Targeted selective treatment

Anthelmintic Treatment



Slower build up of resistant individuals

Susceptible worms

Resistant worms

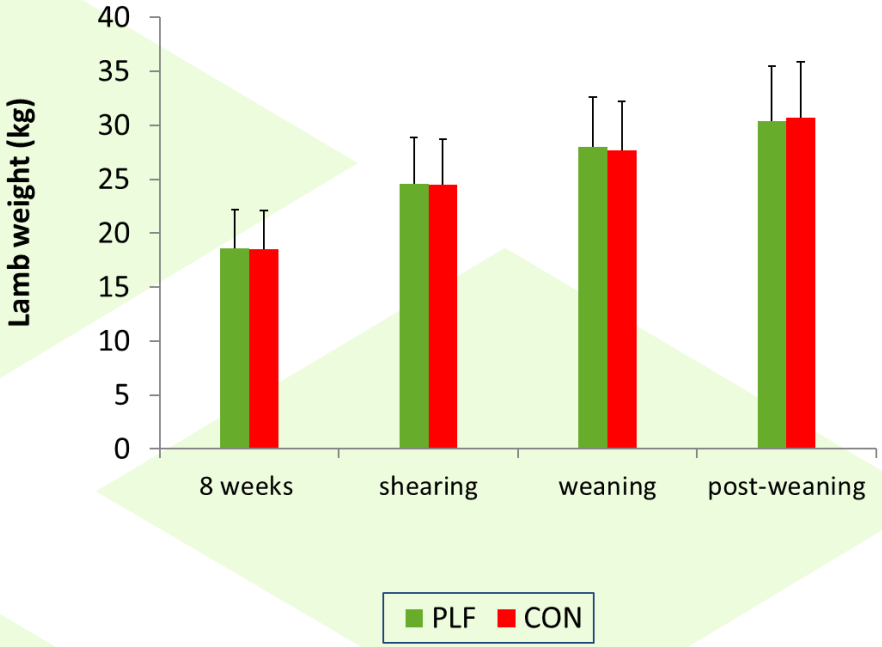
**Slide provided by Fiona Kenyon, Moredun RI**

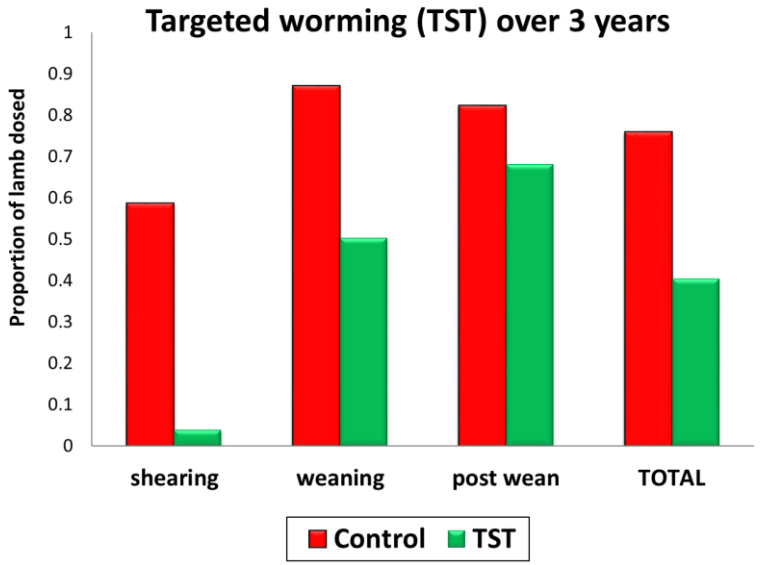
# Targeted Worming

- Collaboration with Moredun Research Institute
- Only worm lamb that do not thrive:
  - ⇨ better for animal
  - ⇨ dilute resistance to anthelmintics

- Compare target weight (algorithm) with actual weight (PLF)
  - ≥ target weight: no dose
  - < target weight: dose
- Control - wormed on pooled FEC (to heaviest weight)

# Targeted Selective treatment (TST) – results over 3 years



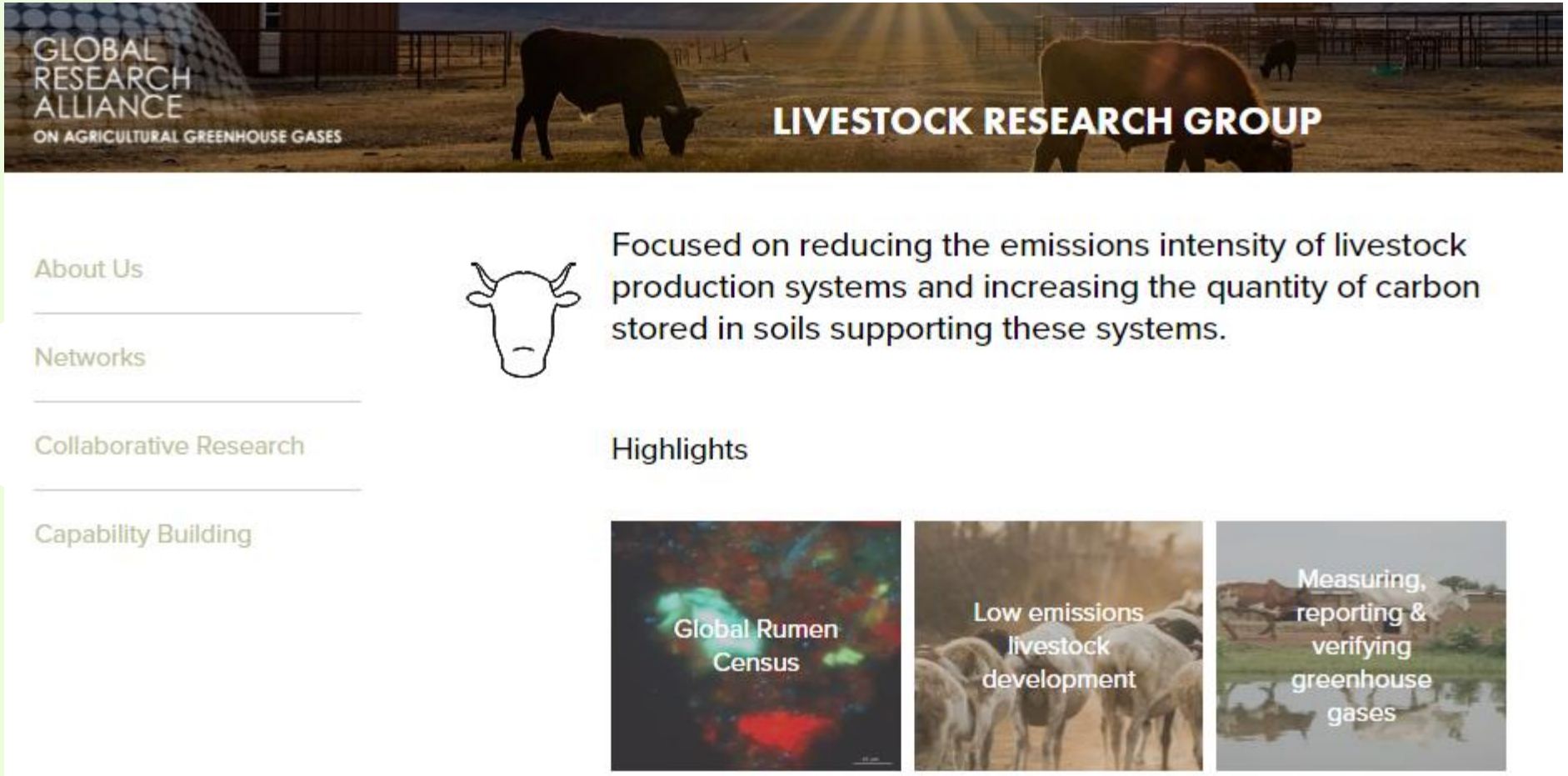

- Similar growth rates of lambs
- Lower use of anthelmintic

**Wormer use:**
Con: 29.6 l
TST: 16.5 l

- Smart Sheep project
  - incorporation of TST algorithm to weigh head for commercial use

Claire.Morgan-Davies@sruc.ac.uk

# Global Research Effort




- https://globalresearchalliance.org/research/livestock/

# Collaborative International Projects

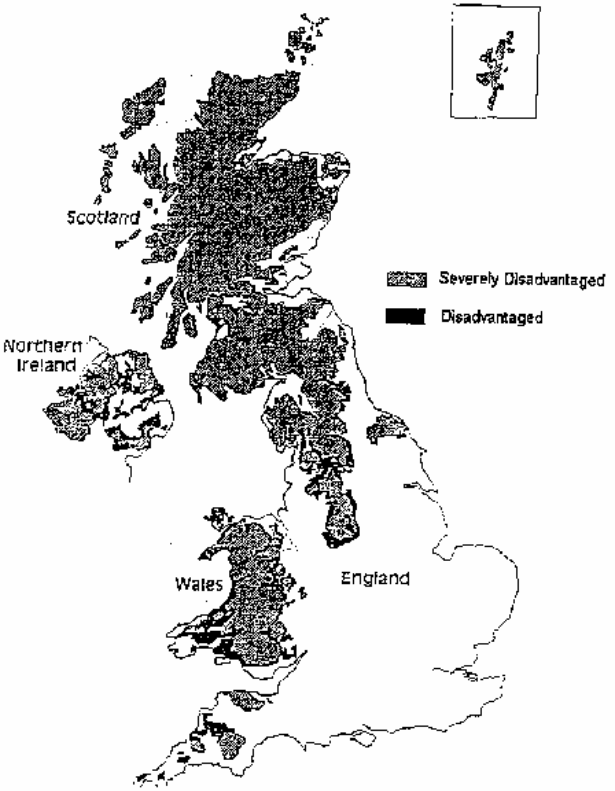
- iSAGE
  - Georgios.Banos@sruc.ac.uk & Joanne.Conington@sruc.ac.uk
- SMARTER
  - Joanne.Conington@sruc.ac.uk & Sebastian.Mucha@sruc.ac.uk
- SusSheP
  - Claire.Morgan-Davies@sruc.ac.uk & Nicola.Lambe@sruc.ac.uk
- GrassToGas
  - Joanne.Conington@sruc.ac.uk & Nicola.Lambe@sruc.ac.uk
- SheepNet / Eurosheep
  - Claire.Morgan-Davies@sruc.ac.uk & Cathy.Dwyer@sruc.ac.uk
- TechCare
  - Claire.Morgan-Davies@sruc.ac.uk
- SM@RT
  - Claire.Morgan-Davies@sruc.ac.uk

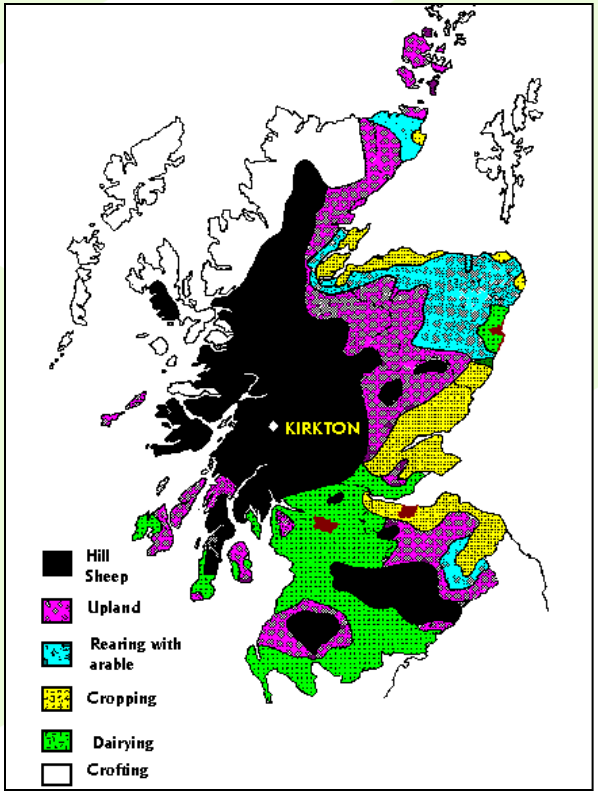
# Case study: Extensive sheep and beef production in a (Scottish) hill environment

# UK Hill environments

- much of British Isles

- dominated by sheep production, some extensive beef cattle




- Less Favoured Areas (LFA) - unsuitable for many other uses

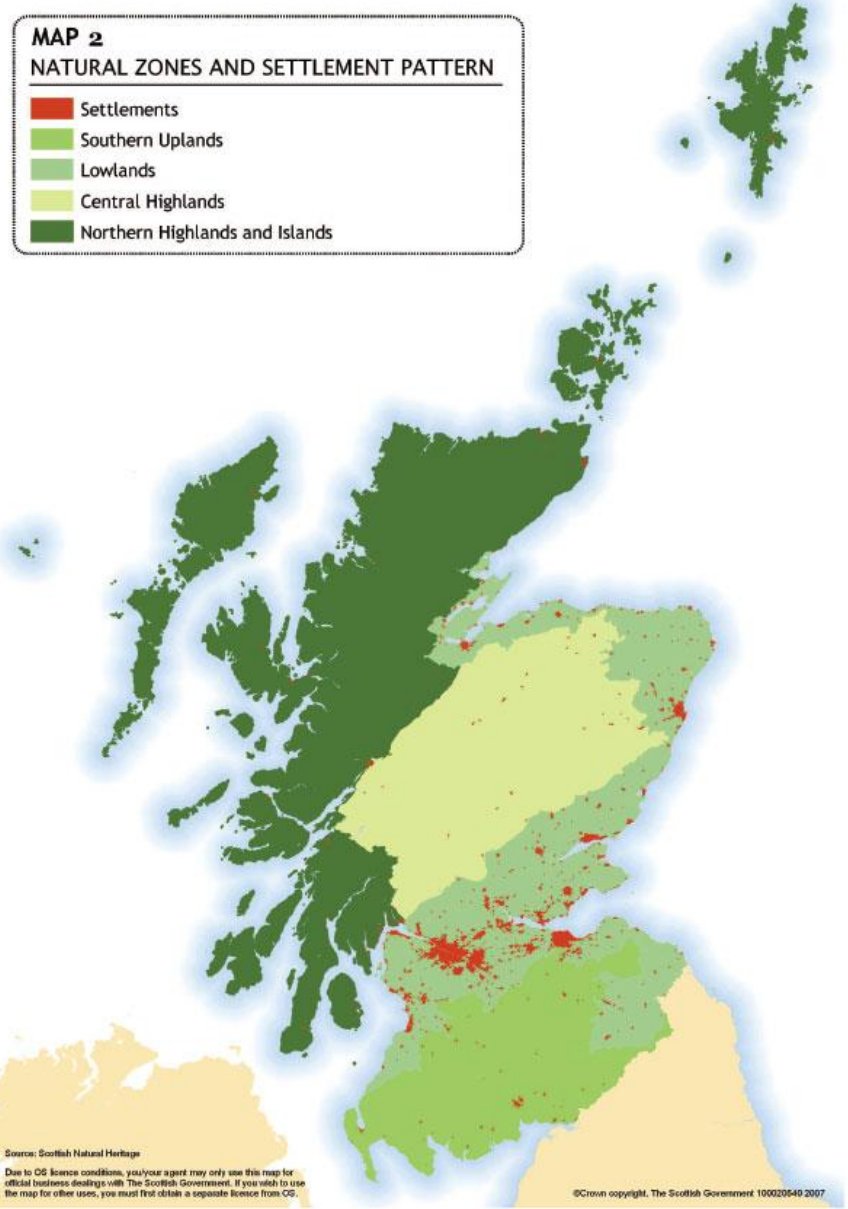
# UK Hill environments

- climate : harsh, wet

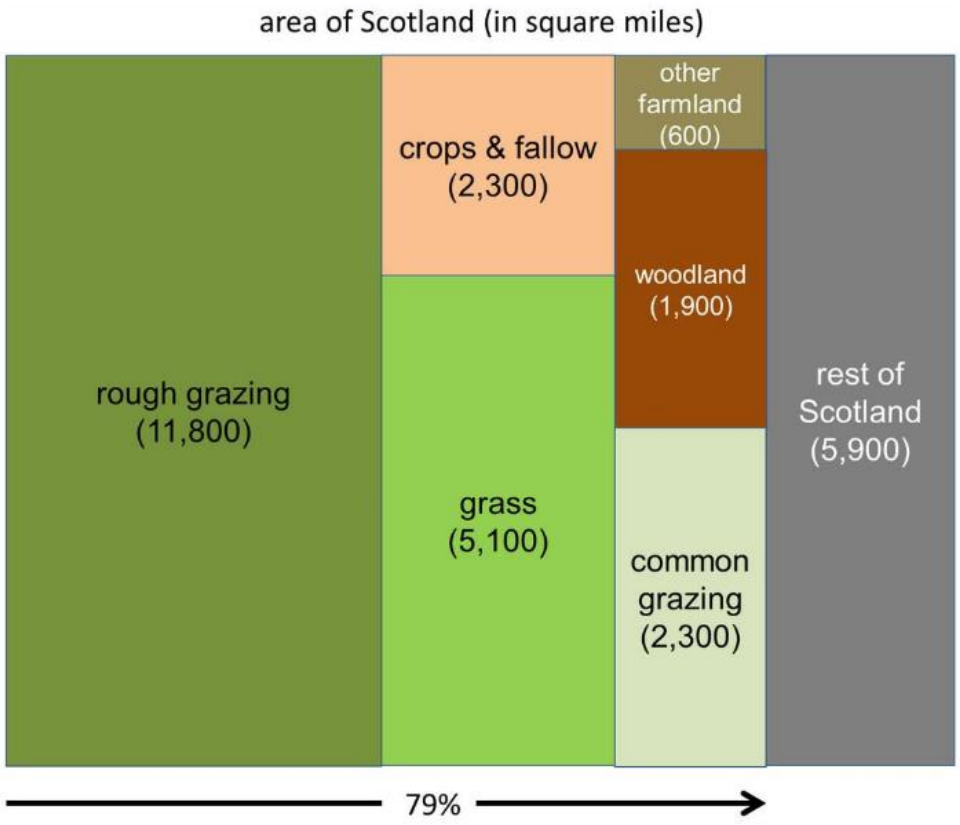
- poor soil and vegetation quality:
  low digestibility for much of year

- topography :
  - often rocky
  - steep
  - wet peat areas

# The uplands of Scotland:

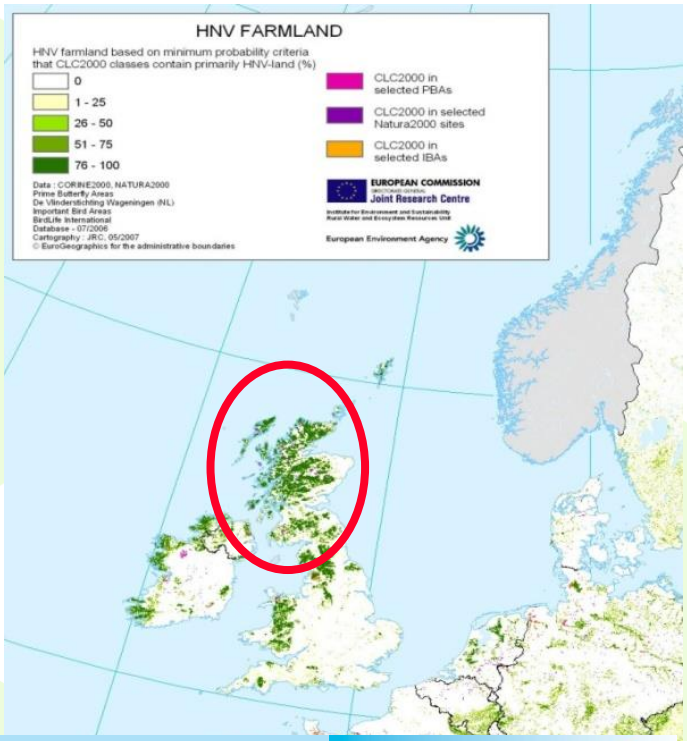


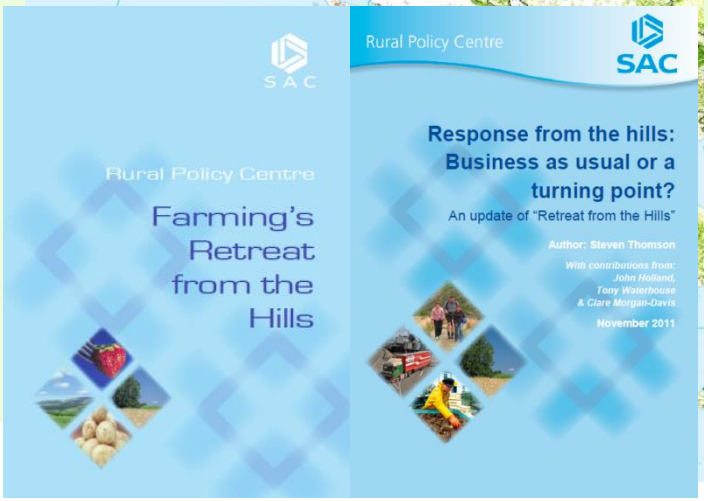

Agricultural land accounts for 79% of Scotland's land area

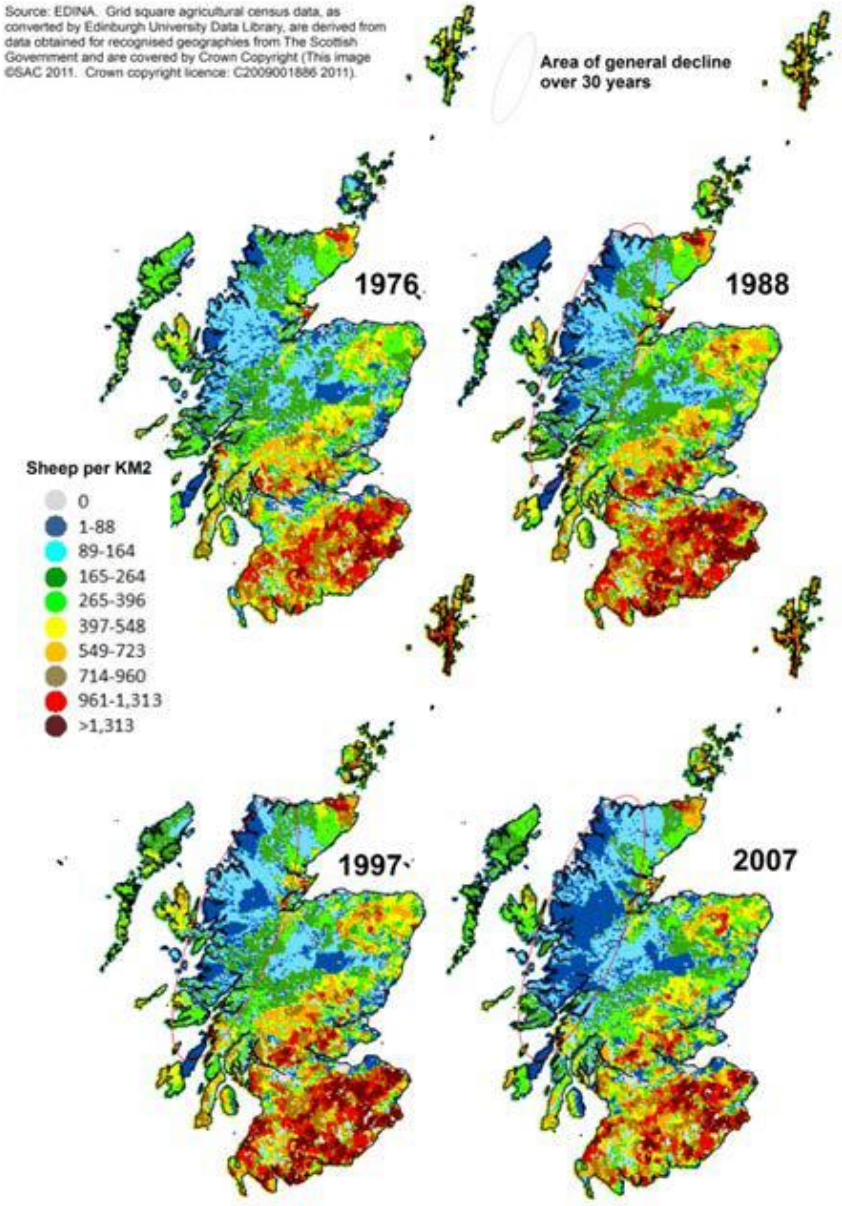



8% of Scotland's agricultural land is suitable for arable farming, with nearly 70% deemed of severely limited agricultural use (rough and common grazing)

# Sheep per 2 km$^2$ over time:



# Agricultural challenges in upland Scotland

**Range of agricultural production challenges, e.g.:**

- Low productivity
- Poor nutrition
- Pests and Disease
- Climate change
- Predation
- Blackloss

Low lambing percentages in spring

and/or

Low survival of lambs through to autumn

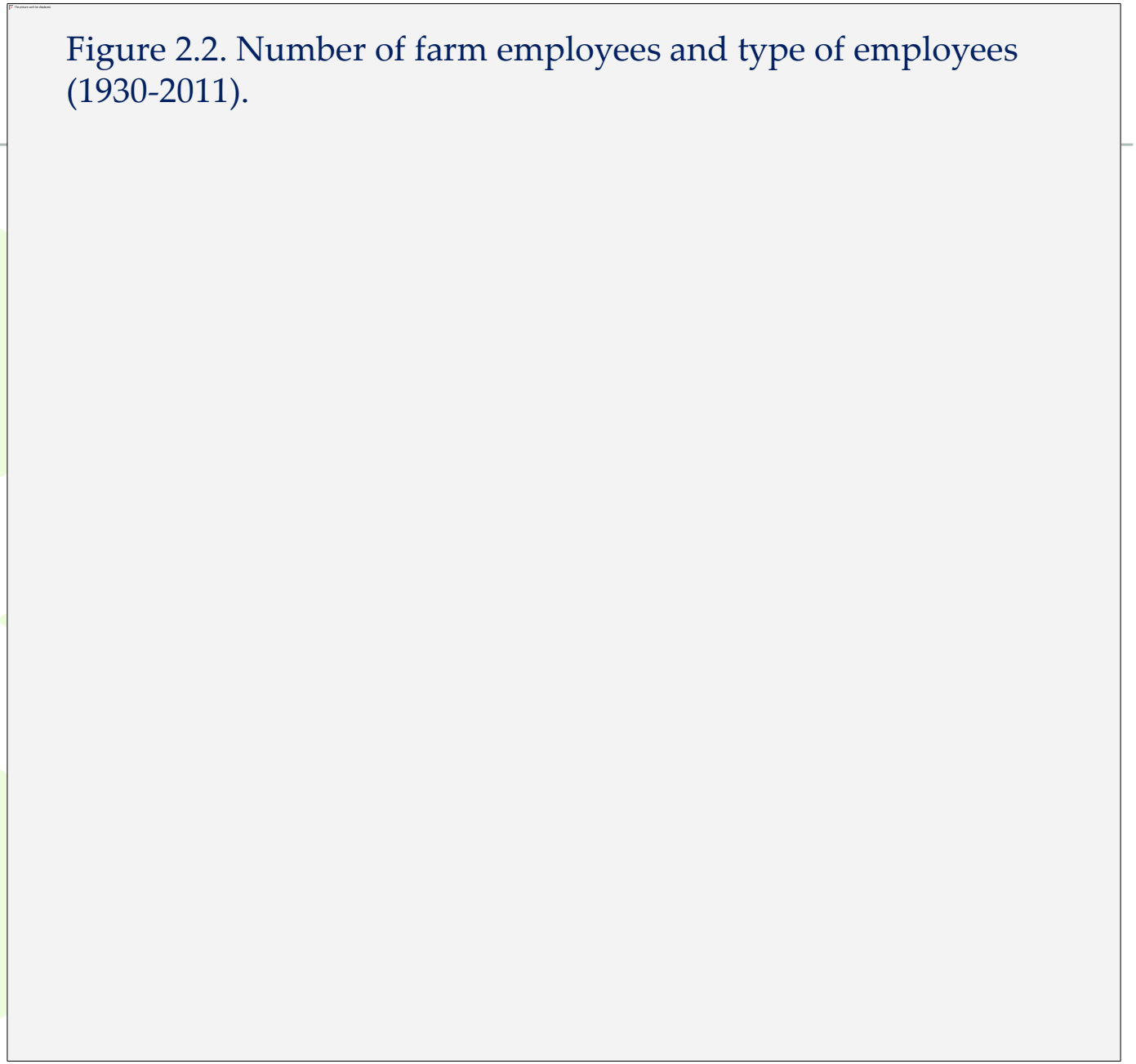





# Livestock management in hill systems

- low labour input; infrequent gathering / inspection

Figure 2.2. Number of farm employees and type of employees (1930-2011).

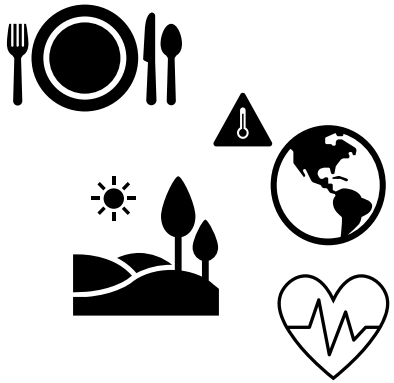


PhD thesis
Claire
Morgan-Davies

Source: Department of Agriculture for Scotland, 1932, 1940, 1948; Department of Agriculture and Fisheries for Scotland, 1962, 1966, 1976; Scottish Government, 2010a, 2011a, 2012a)

# Livestock management in hill systems

- low labour input; infrequent gathering / inspection
- lambing April / May; calving spring/ summer / autumn,
  to fit with nutrition

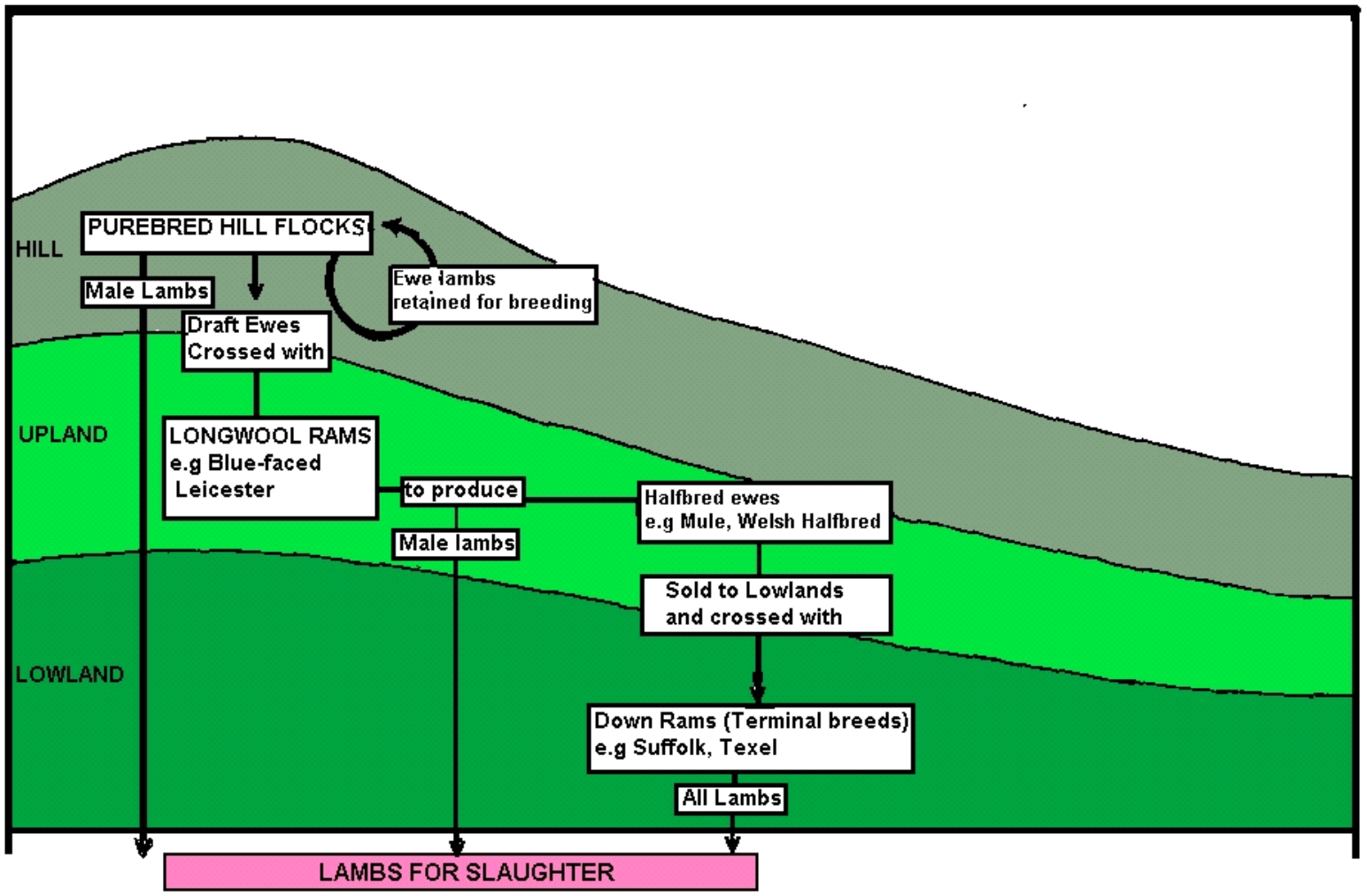


- suppl. feed only at key times – hay, silage, mineral blocks

- castration of males
- suitable markets – light lamb (Med.), store lamb

- drafting of 4-crop ewes – stratified UK sheep production

# Stratification in the British Sheep Industry




From Cooper and Thomas (1991)

# Hill Sheep Breeding project 1998-2011

– Improved genetics relevant for hill sheep

**Scottish Blackface - Breeding goal traits**

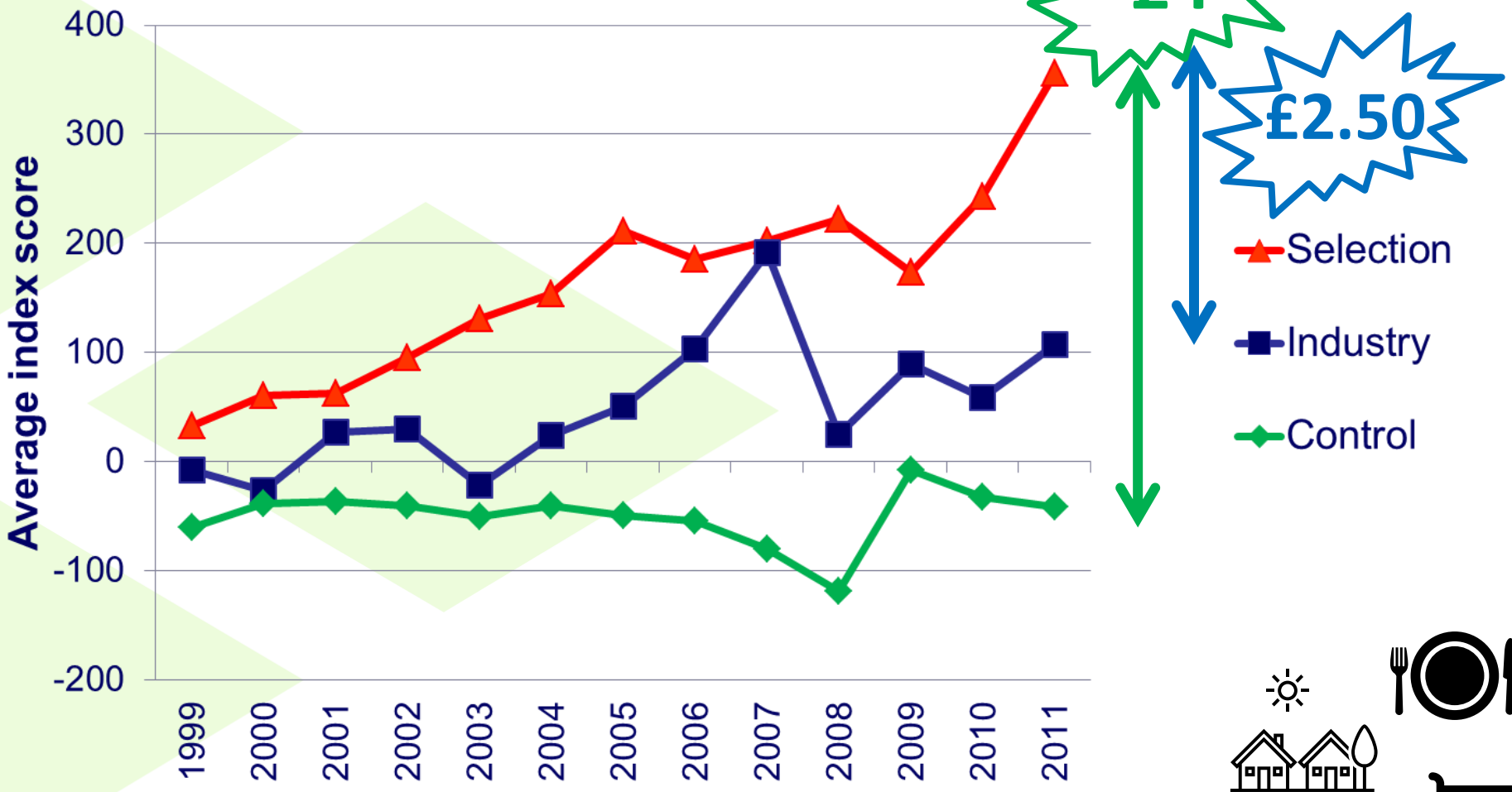
## Ewe Traits

mature size
longevity
lambs lost
lambs reared
maternal wean weight
fleece weight

## Lamb Traits

weaning weight
carcass fat class
carcass conformation
carcass weight

# Hill Sheep Breeding project



# Range of wider issues which upland farming has a role in addressing:

# Policy simulations for the Scottish hills

- Scottish hills are diverse and multi-use systems
- Many policies relating to land use in Scotland, especially for hill areas
- How do land use policies and priorities compare for the Scottish hills?

Land Use Policy 27 (2010) 387–398

Contents lists available at ScienceDirect

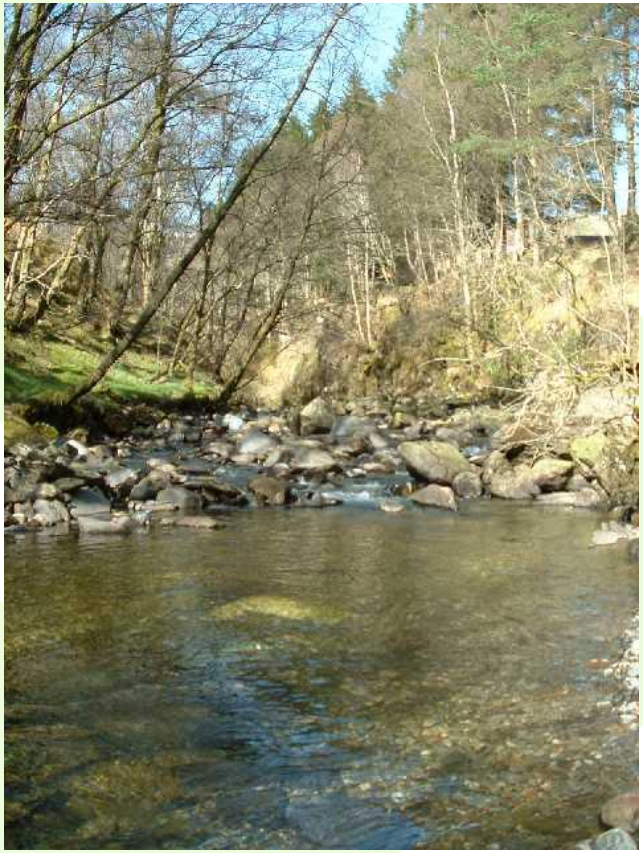
Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Future of the hills of Scotland: Stakeholders' preferences for policy priorities

Claire Morgan-Davies*, Tony Waterhouse

# Adaptive Conjoint Analysis (ACA)



- Market Simulation Function within an Adaptive Conjoint Analysis (ACA Sawtooth Software)
- 80 stakeholders involved in hills/uplands of Scotland (scientists, land use advisers, policy officers, local communities, land managers and farmers)
- Computerised ACA asked their preferred policy action to support various hill system approaches
- 7 different policies profiles created, to reflect current land use issues for the Scottish hills:
    - Carbon Footprint
    - Wild Land
    - Livestock
    - Forestry
    - Biodiversity
    - National Parks
    - Tourism

# Results from ACA - attributes

- The relative importance of each attribute of the hills for policy targets (all respondents)

| Attribute | **Relative importance (%)** |
|---|---|
| Land Use Management | 17.0 |
| Vegetation cover | 18.3 |
| Livestock System | **22.9** |
| Farming Products | 21.1 |
| Local Economy | 20.7 |

# Results from ACA – policy profiles

| Policy profiles / Respondents | Carbon Footprint | Tourism | Wild Land | Live--stock | Forestry | Bio--diversity | National Parks |
|---|---|---|---|---|---|---|---|
| All stakeholders | 11.2 | 18.2 | 2.6 | 14.1 | 5.4 | **33.5** | 14.9 |
| *By area of interests:* | | | | | | | |
| Livestock Production | 9.7 | 17.7 | 1.1 | 23.8 | 3.9 | **24.5** | 19.3 |
| Forestry/Woodlands | 22.3 | 14.5 | 3.4 | 7.0 | 12.7 | **30.7** | 9.4 |
| Nature Conservation | 7.9 | 18.1 | 4.2 | 8.2 | 4.5 | **48.0** | 9.1 |
| Animal care and welfare | 16.9 | **25.0** | 0.8 | 12.1 | 6.9 | 22.1 | 16.3 |
| Rural communities | 14.2 | 19.3 | 2.3 | 11.8 | 5.7 | **26.6** | 20.1 |
| Access/Recreation | 6.8 | 16.3 | 4.9 | 6.9 | 5.9 | **50.4** | 8.9 |

*Table 2. How policy profiles 'fit' stakeholders' preferences – the high numbers represent a good fit, the low numbers represent a poor fit. For example, the Livestock Production group favoured the policy statements from the Biodiversity profile most and those from the Wild Land least.*

# Conclusions from ACA

- Difficult to design hill land use policies that suit everybody: diff interest groups = diff preferences
- Stakeholders would prefer the rural, environmental and land use policy priorities to deliver a system in which livestock has a part to play
- Policies based on a mix of diff outcomes (e.g. Biodiversity profile) better perceived overall
- Simulations a useful tool to help elaborate future land use policies

# Potential conflicts of global issues

## Pros of extensive systems

- more “natural”
- high quality protein from poor quality land
- meat high in omega-3
- lower AMU?
- rural employment
- promotes biodiversity
- ??

## Cons of extensive systems

- less meat per unit land/ animal
- more methane per kg meat
- less control over animal welfare
- lone working/wellbeing
- ??

# Conclusions:

- Animal Science (including sheep and cattle) is helping to inform industry and policy to meet global challenges
- International collaboration is key:
  - Avoids duplication of research effort / funding
  - Pools expertise
  - Accelerates industry implementation
  - Global problems requires global solutions

# Thank you for your attention!