ALB Sustainability Research Project

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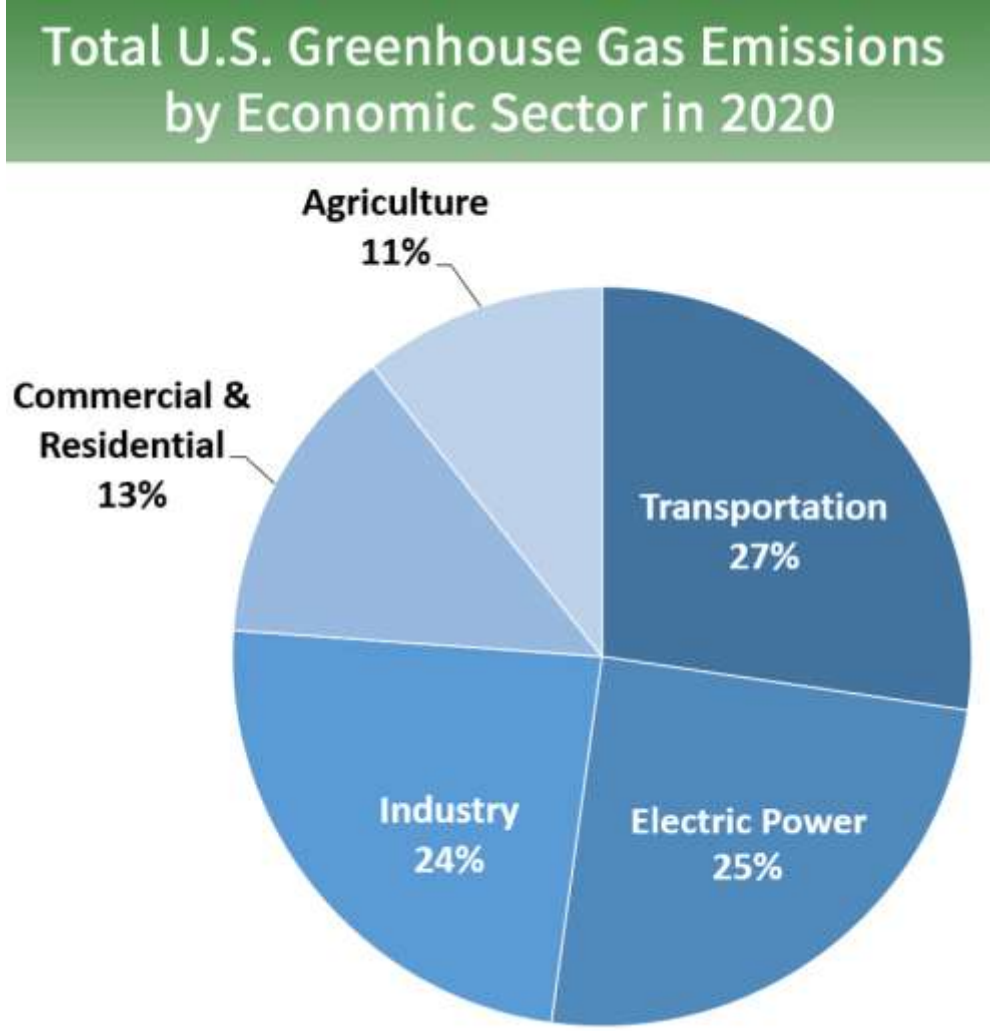
Photo courtesy of Cat Macaluso

Greenhouse gases

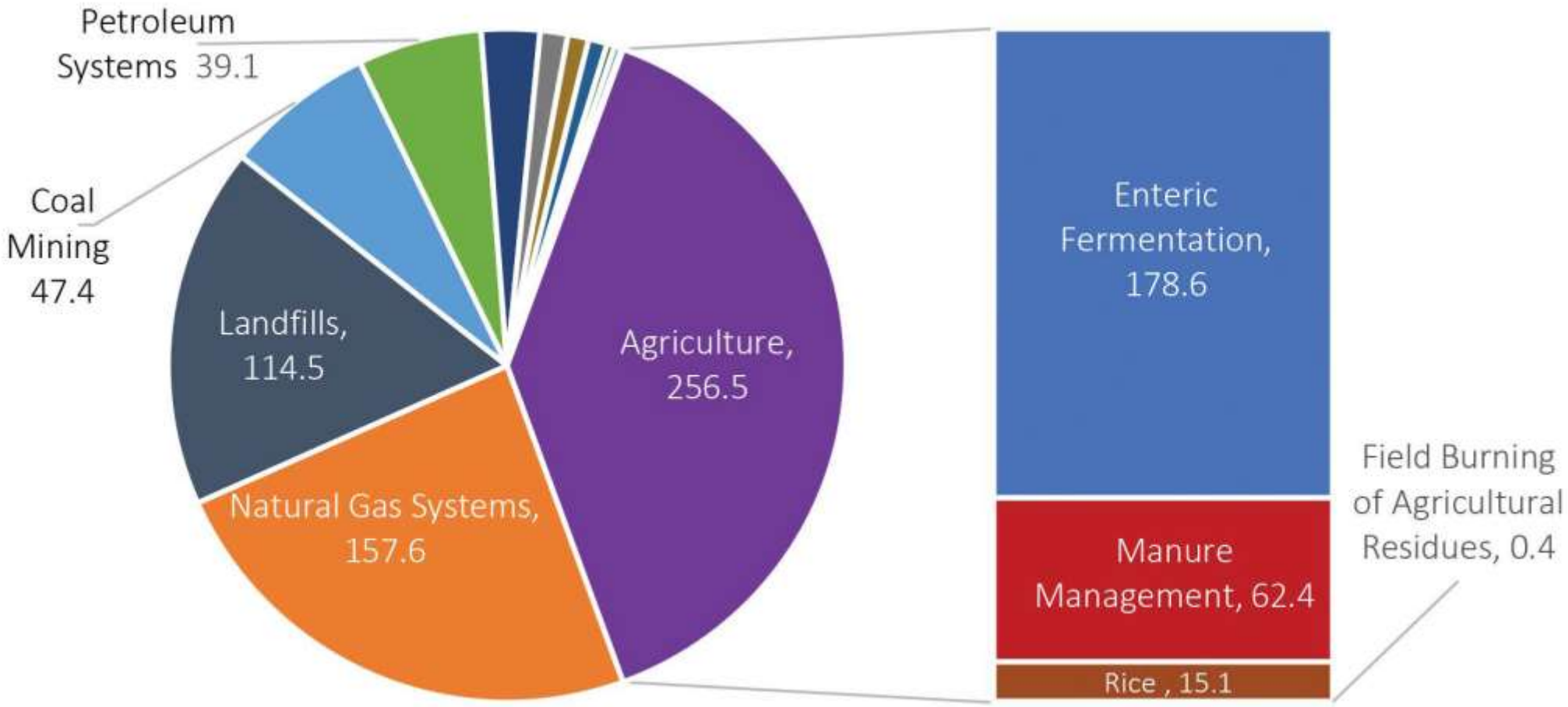
- Carbon dioxide (CO_2) 80%
  - Fossil fuels
  - Electricity production
  - Fertilizer, lime, herbicides/pesticides
- Methane (CH_4) 10%
  - Enteric fermentation
  - Manure
- Nitrous oxide (N_2O) 7%
  - Manure, Fertilizer



- **Animal agriculture is 3.9% of U.S. GHG emissions**
- **Ruminants ~2.3%, mostly cattle**
- **Sheep approximately 1/100th of cattle (0.023%)**

EPA.gov/ghgemissions

U.S. Methane emission sources in 2019



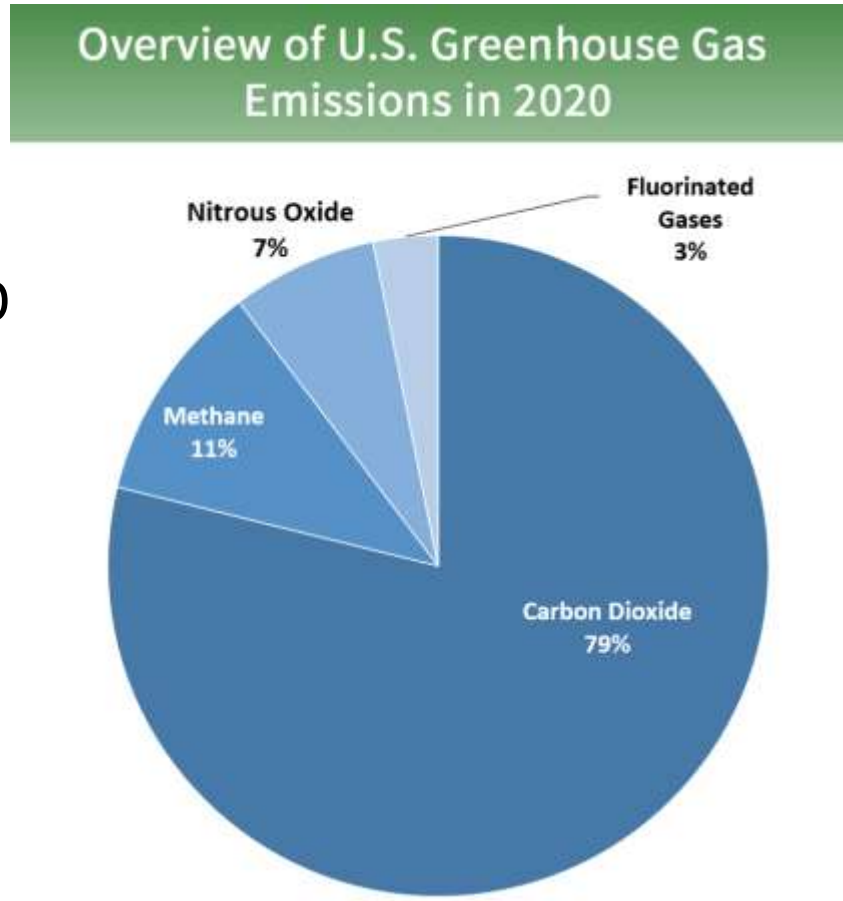
Values in million metric tons of CO2e, source: US Methane Emissions Reduction Action Plan

U.S. steps to reduce agricultural methane

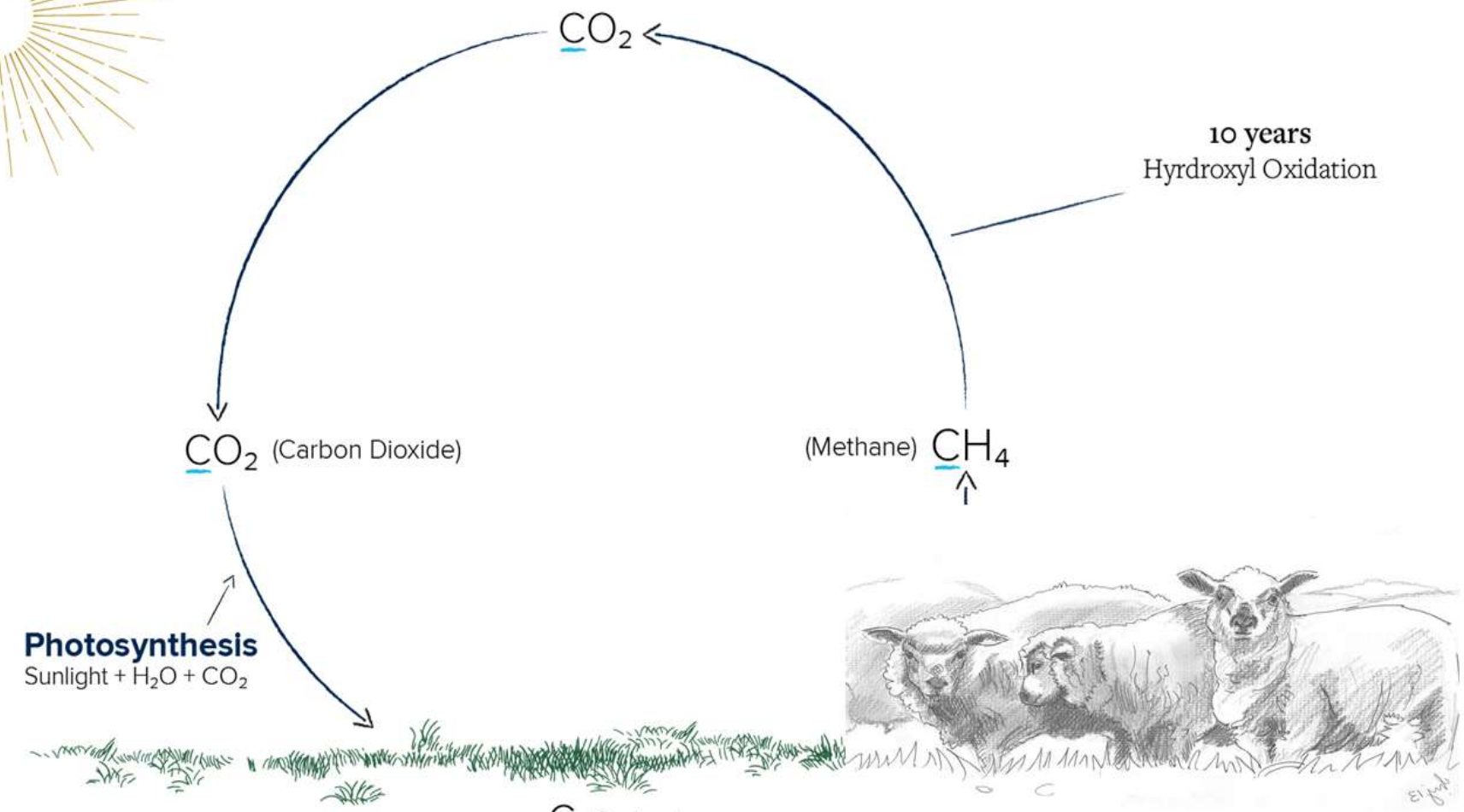
- Growing Climate Solutions Act (2021)
  - Establishes a system for trading carbon credits
  - Not just big farms who can afford monitoring and technology
- USDA enhanced Conservation Reserve Program
  - Additional 4 million acres able to receive higher rental rates
  - Climate incentive payments
- Partnerships for Climate Smart Commodities
  - $1 billion to incentivize and research climate beneficial practices
    - Manure management, on-farm renewable energy, feed additives, adoption potential
  - 141 selected projects
  - American Lamb Board recent recipient

Are all greenhouse gases the same?

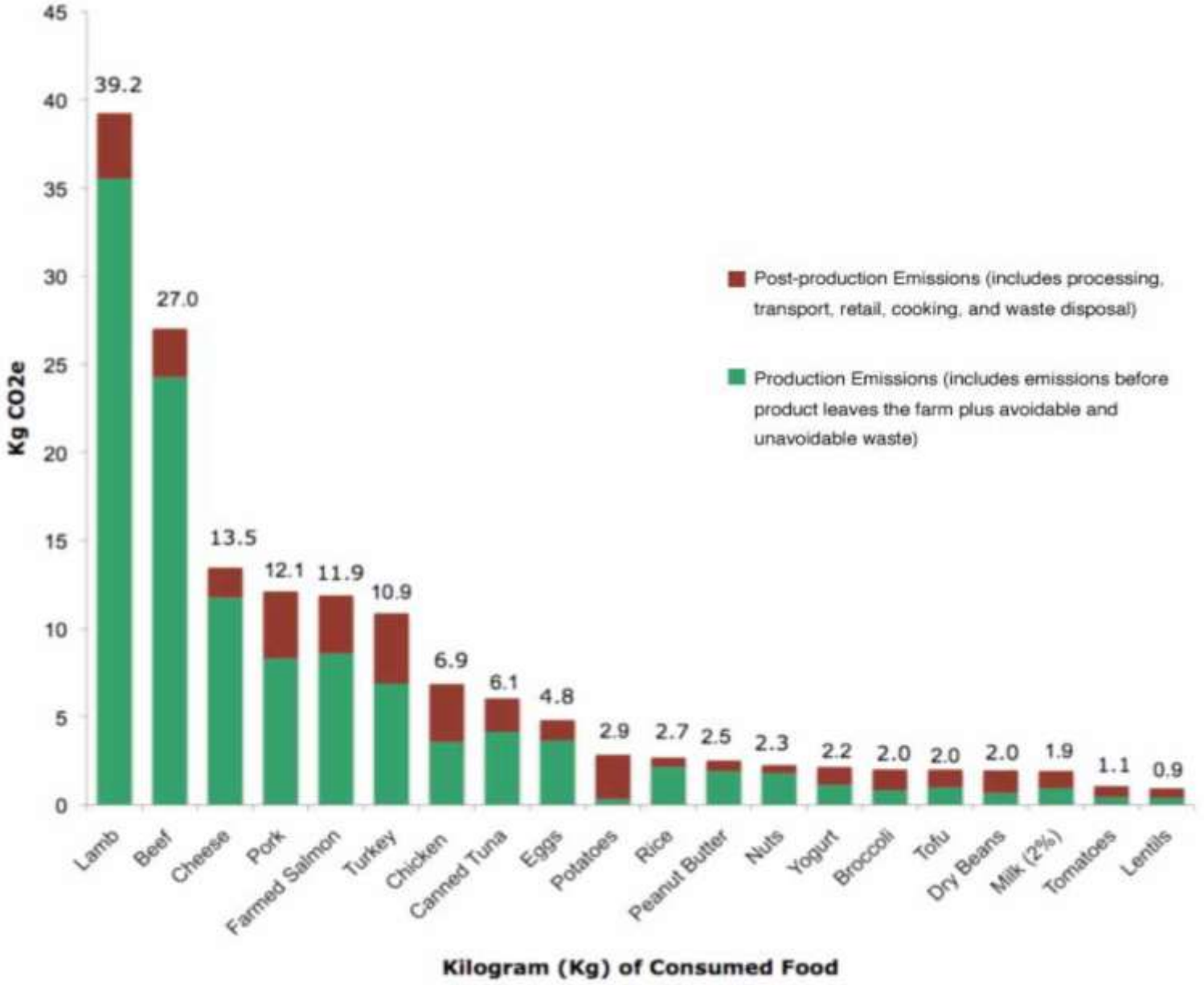
- Carbon dioxide (CO_2) is the standard metric for reporting GHG emissions
  - CH_4 and N_2O are reported as CO_2 equivalents – CO2e
  - Multiply each gas by its relative effect on warming
- Nitrous oxide (N_2O)
  - Ammonia and nitrogen oxides are converted into N_2O
  - Very strong GHG, ~300x more than CO_2
  - ~80% of N_2O emissions in U.S. are from N fertilization
- Methane (CH_4)
  - Bacterial fermentation product – rumen and manure
  - Currently accounted as 28x stronger GHG than CO_2

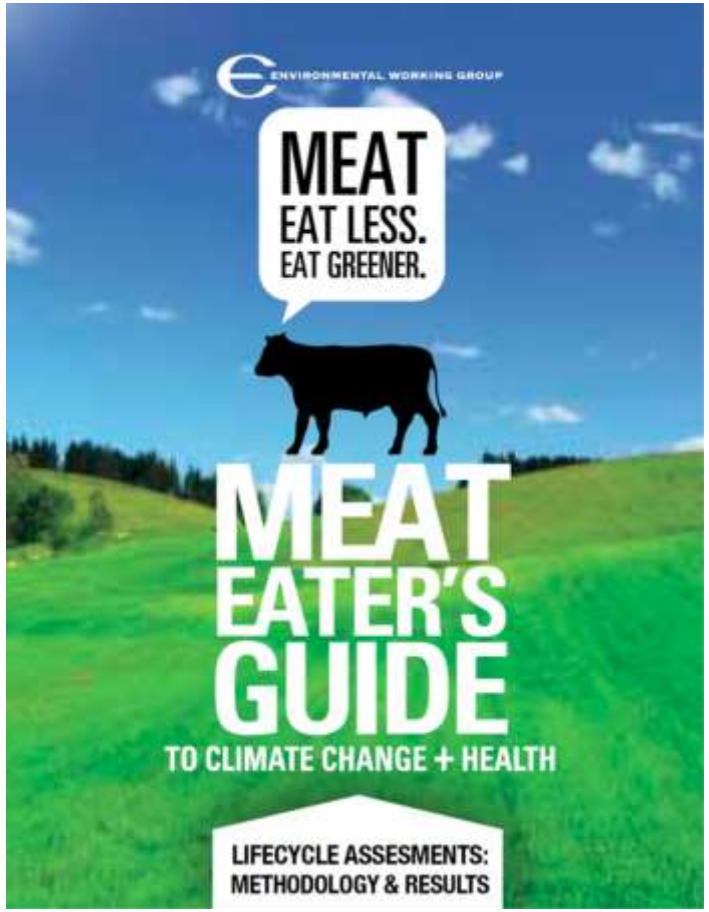


Biogenic Carbon Cycle



UCDAVIS CLEAR Center


Kg CO2e
45
40
35
30
25
20
15
10
5
0
39.2
27.0
13.5
12.1
11.9
10.9
6.9
6.1
4.8
2.9
2.7
2.5
2.3
2.2
2.0
2.0
2.0
1.9
1.1
0.9
Lamb
Beef
Cheese
Pork
Farmed Salmon
Turkey
Chicken
Canned Tuna
Eggs
Potatoes
Rice
Peanut Butter
Nuts
Yogurt
Broccoli
Tofu
Dry Beans
Milk (2%)
Tomatoes
Lentils
Post-production Emissions (includes processing, transport, retail, cooking, and waste disposal)
Production Emissions (includes emissions before product leaves the farm plus avoidable and unavoidable waste)
Kilogram (Kg) of Consumed Food


ENVIRONMENTAL WORKING GROUP
MEAT
EAT LESS.
EAT GREENER.
MEAT
EATER'S
GUIDE
TO CLIMATE CHANGE + HEALTH
LIFECYCLE ASSESMENTS:
METHODOLOGY & RESULTS

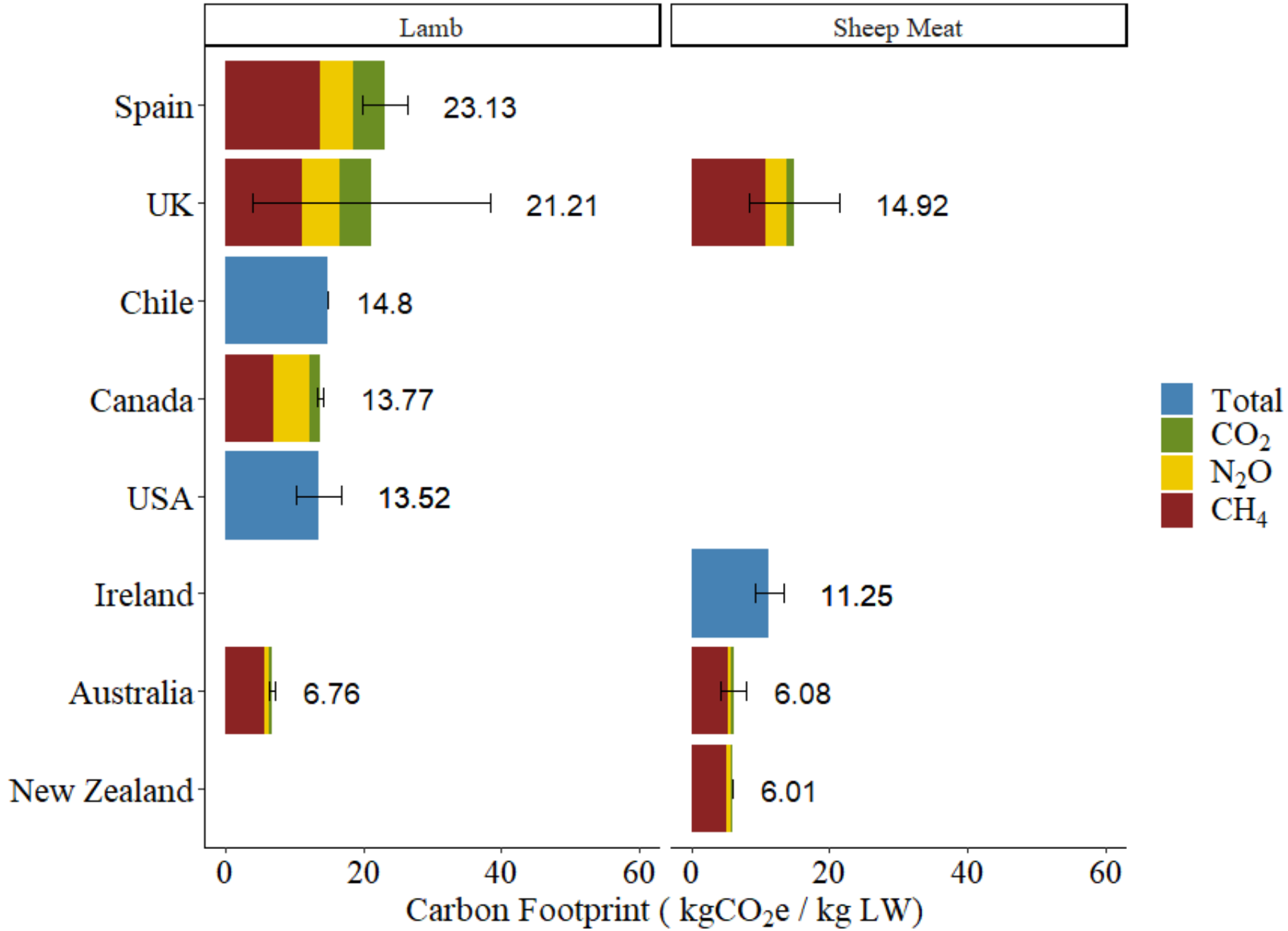
Top options for reducing your carbon footprint

Average reduction per person per year in tonnes of CO_2 equivalent

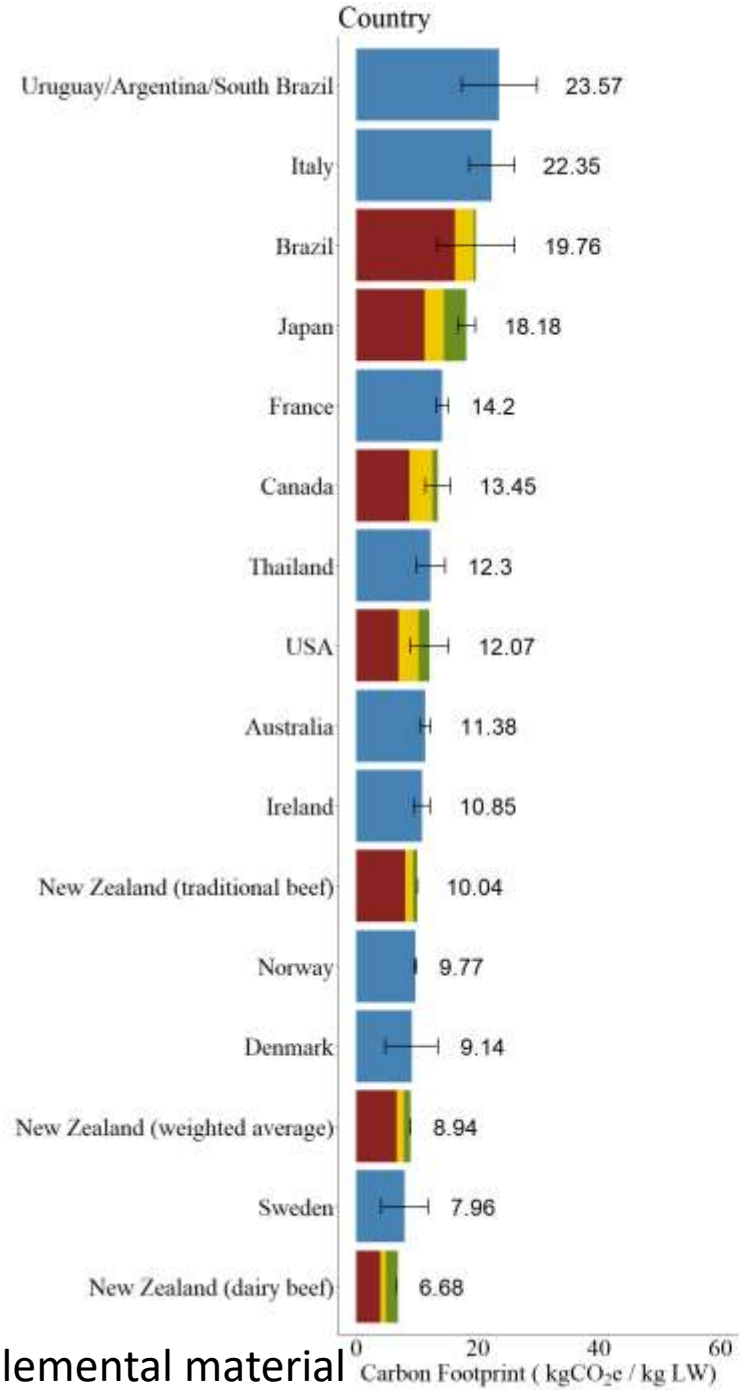
Live car-free **2.04**	Refurbishment /renovation **0.895**
Battery electric car **1.95**	Vegan diet **0.8**
One less long-haul flight per year **1.68**	Heat pump **0.795**
Renewable energy **1.6**	Improved cooking equipment **0.65**
Public transport **0.98**	Renewable-based heating **0.64**

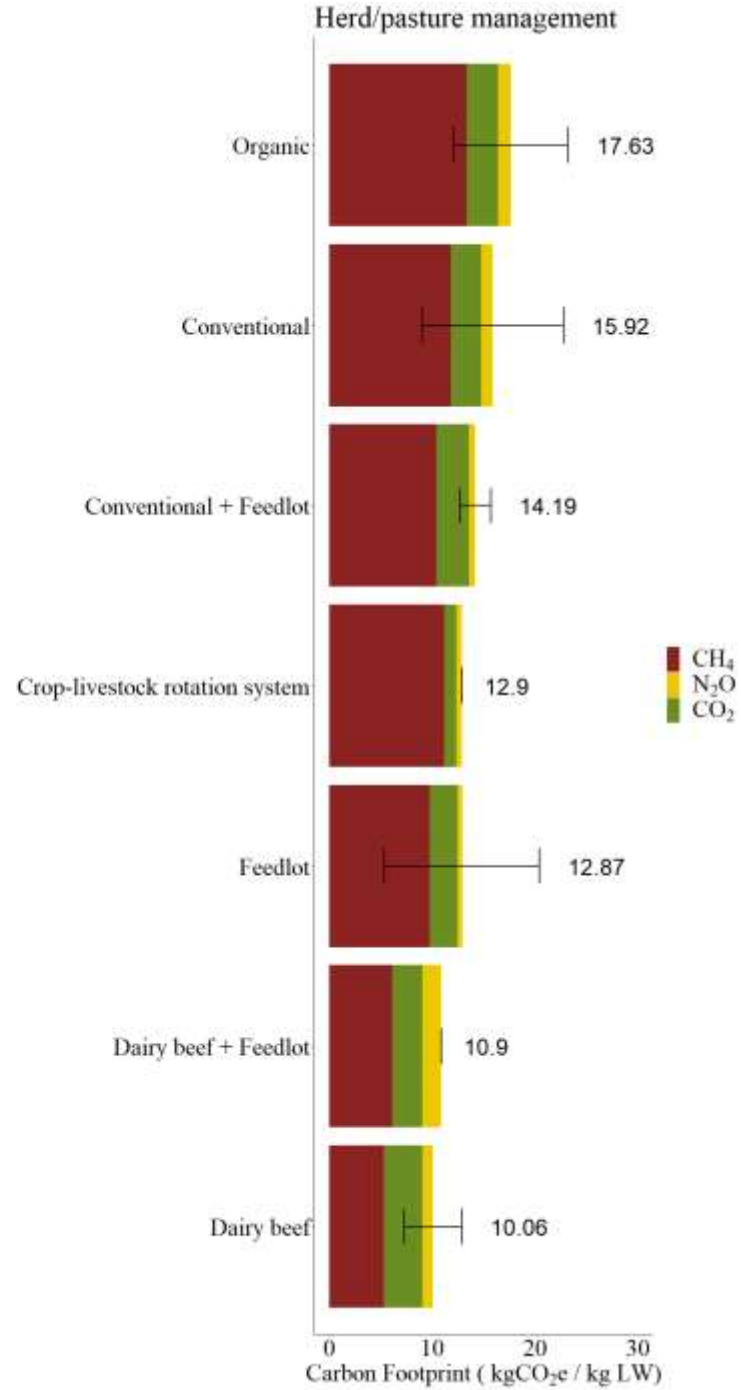
Source: Centre for Research into Energy Demand Solutions

BBC

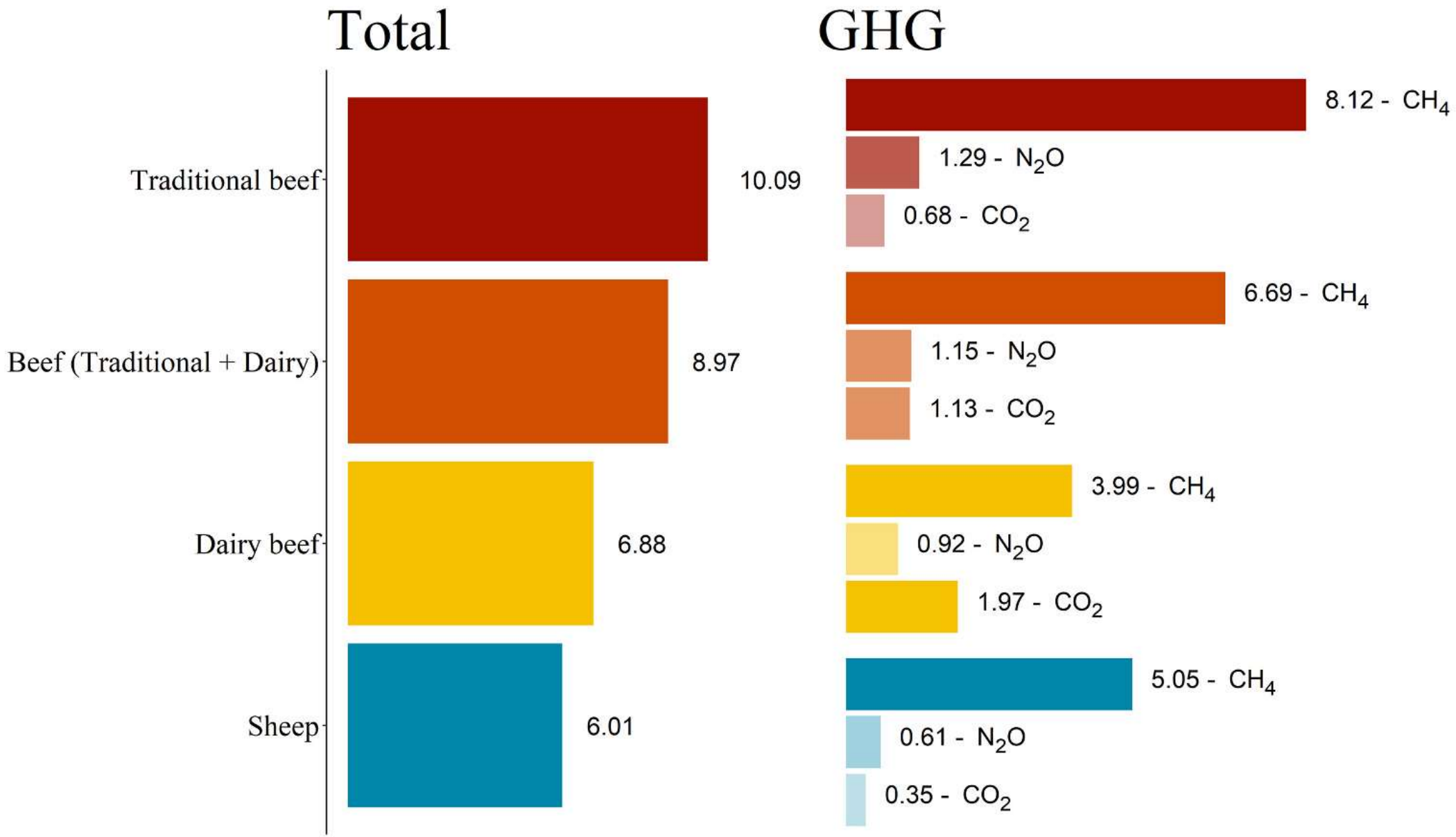


Mazzetto et al. 2023 supplemental material





Mazzetto et al. 2023 supplemental material



Mazzetto et al. 2023

31% of sheep GHG emissions allocated to wool production

Factors that influence estimates

$$\frac{\text{Emissions}}{\text{Product}}$$

- Numerator, kg CO_2e
  - Total farm GHG emissions
  - >50% enteric CH_4
  - Farm inputs 5-30%, often fossil fuels used to produce and transport them
  - Manure, fertilizer, feed
- Denominator, kg product sold
  - Number of lambs sold
  - Expression of kg lamb sold as liveweight vs carcass weight vs retail cuts

  ✓Weight at slaughter

  ✓Proportion of lambs retained or sold for breeding stock
  - Amount and/or relative economic value of wool

✓ = These factors are highly influenced by marketing decisions

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Evaluating the Environmental Footprint of the U.S. Sheep Industry

- Principle Investigator: Richard Ehrhardt
- Chief investigator: Erin Recktenwald
- Funded by: American Lamb Board
- Collaborators: Jason Rowntree and Kim Cassida
- Objectives:
  - Develop a GHG emission model for lamb production, partial LCA from cradle to farm gate
  - Collect data from a diversity of lamb production systems in the USA
  - Create a peer-reviewed report on the US lamb production footprint
  - Identify mitigation strategies to reduce GHG and develop an outreach plan

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Production categories

- **Intensive production:** high prolificacy, mainly housed ewes and lambs
- **Intensive grazing:** high prolificacy, moderately intensive grazing management
- **Extensive grazing:** moderate prolificacy, less intensive grazing management
- **Range:** native pasture, low inputs, mainly sold as feeder lambs
- **Feedlot:** intensively managed/fed lambs, indoors or dry lot

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Descriptive elements of US sheep production systems

	Intensive	Intensive graze	Extensive graze	Range
Number of breeding ewes	**1400** (200-4800)	**1600** (300-3900)	**280** (120-400)	**2800** (1500-4500)
% of year on pasture	**13** (0-31)	**65** (42-97)	**89** (55-100)	**94** (75-100)
Feed purchased/ewe/year, lb	**1200** (540-2000)	**690** (210-1800)	**290** (60-670)	**40** (0-90)
ADG of market lambs, lb/d	**0.77a** (0.74-0.82)	**0.44b** (0.35-0.58)	**0.53b** (0.45-0.61)	**0.54b** (0.46-0.61)
Weaned lambs/ewe/year	**1.88a** (1.6-2.2)	**1.62a** (1.5-1.7)	**1.18b** (0.9-1.5)	**1.01b** (0.8-1.3)

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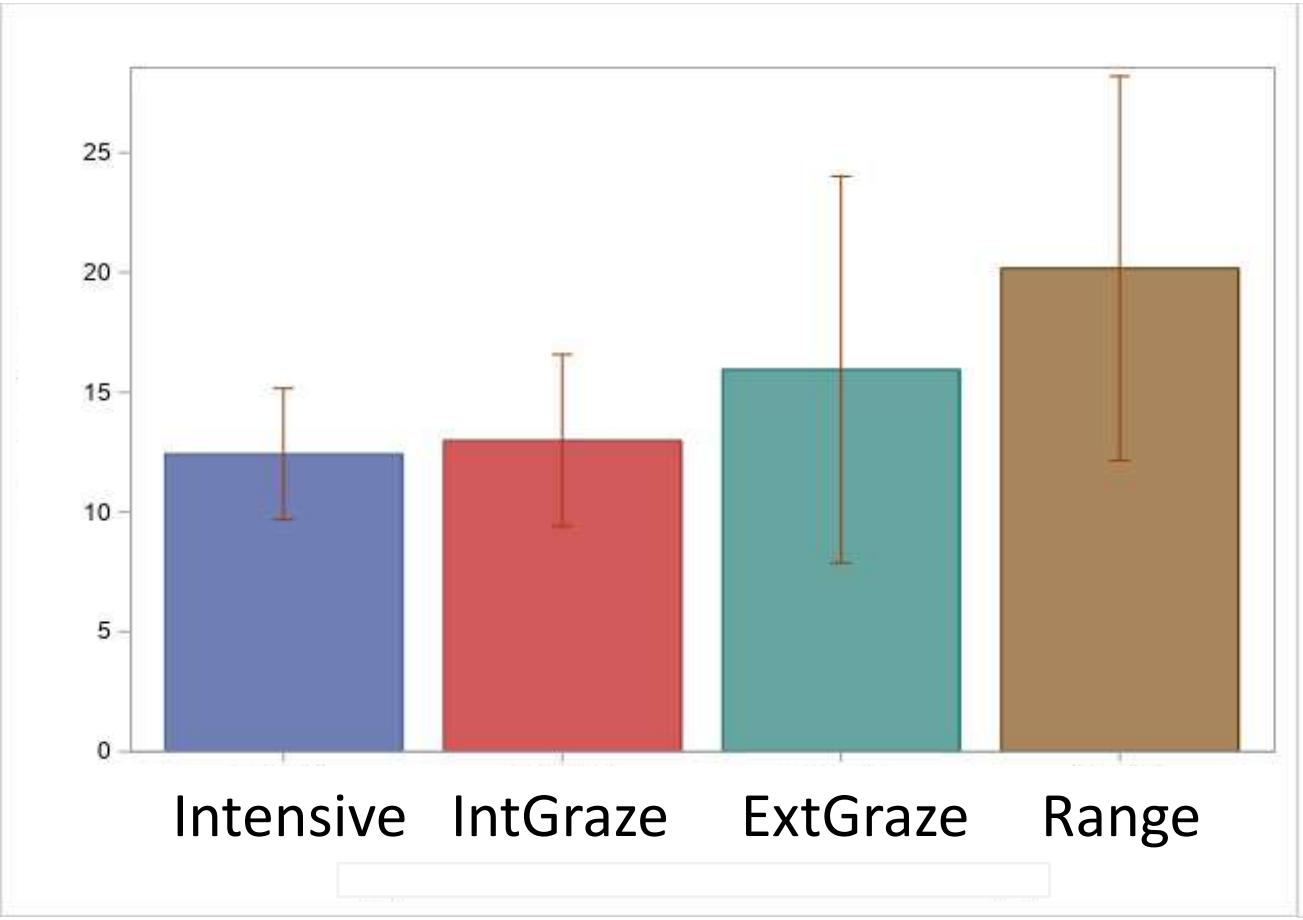
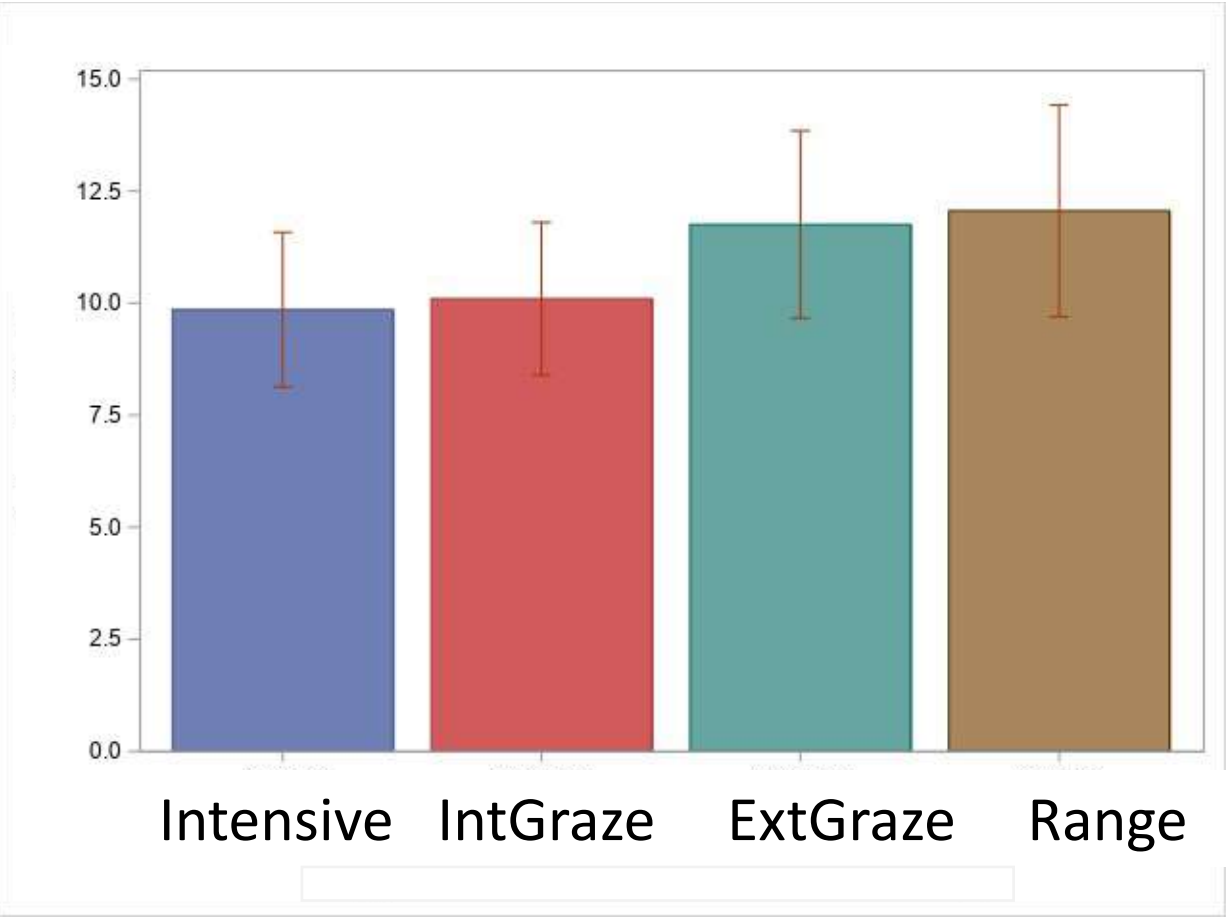
CO_2e/kg all lamb sold

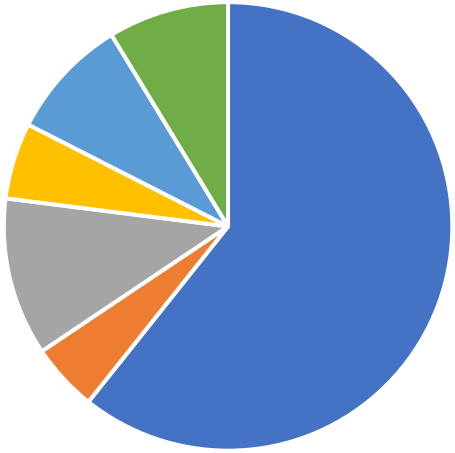


CO_2e/kg all product sold

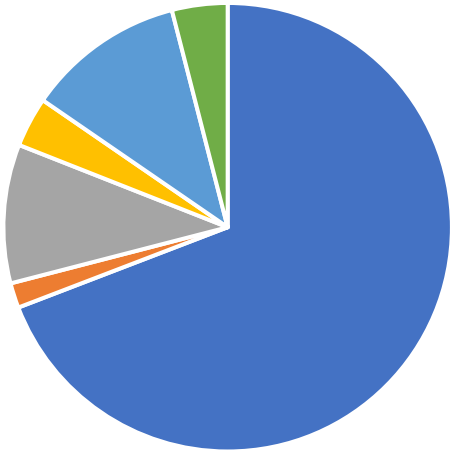


Intensive sources of GHG

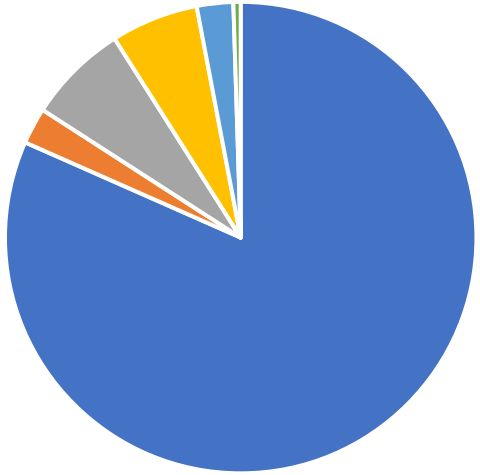
Intensive grazing sources of GHG



Extensive grazing sources of GHG



Range sources of GHG

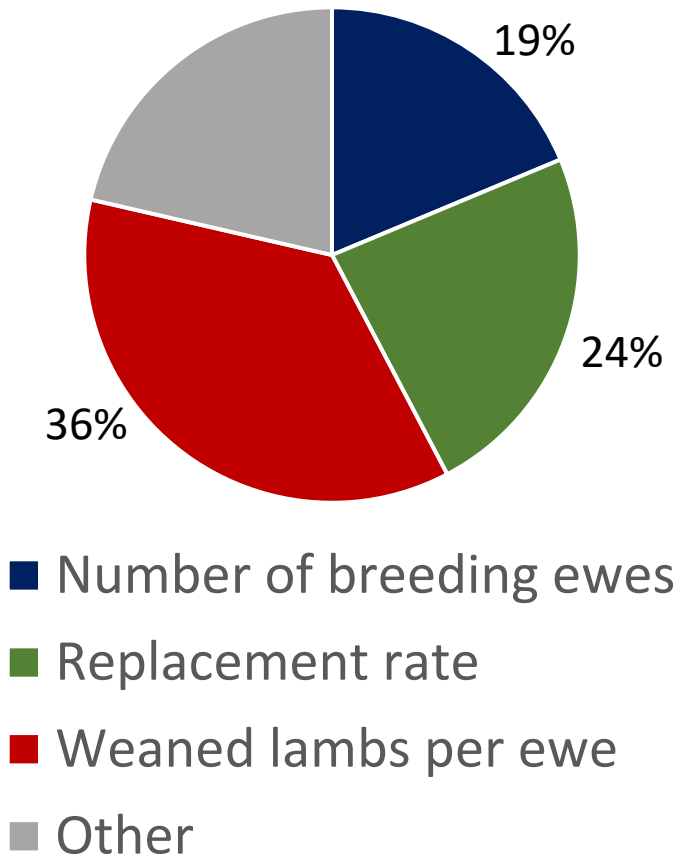


- Enteric CH4
- Manure
- Land
- Fuel and electricity
- Purchased feed
- Other

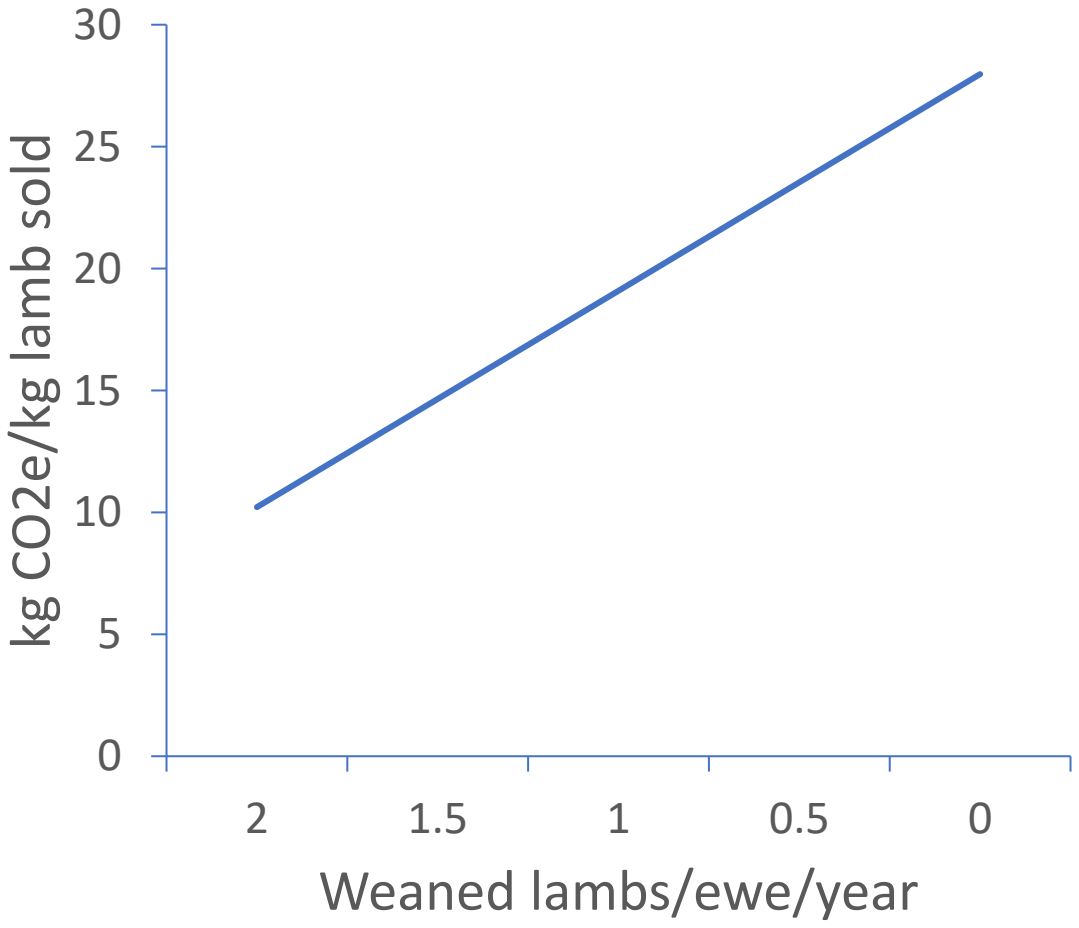
Factors that impacted GHG/kg lamb

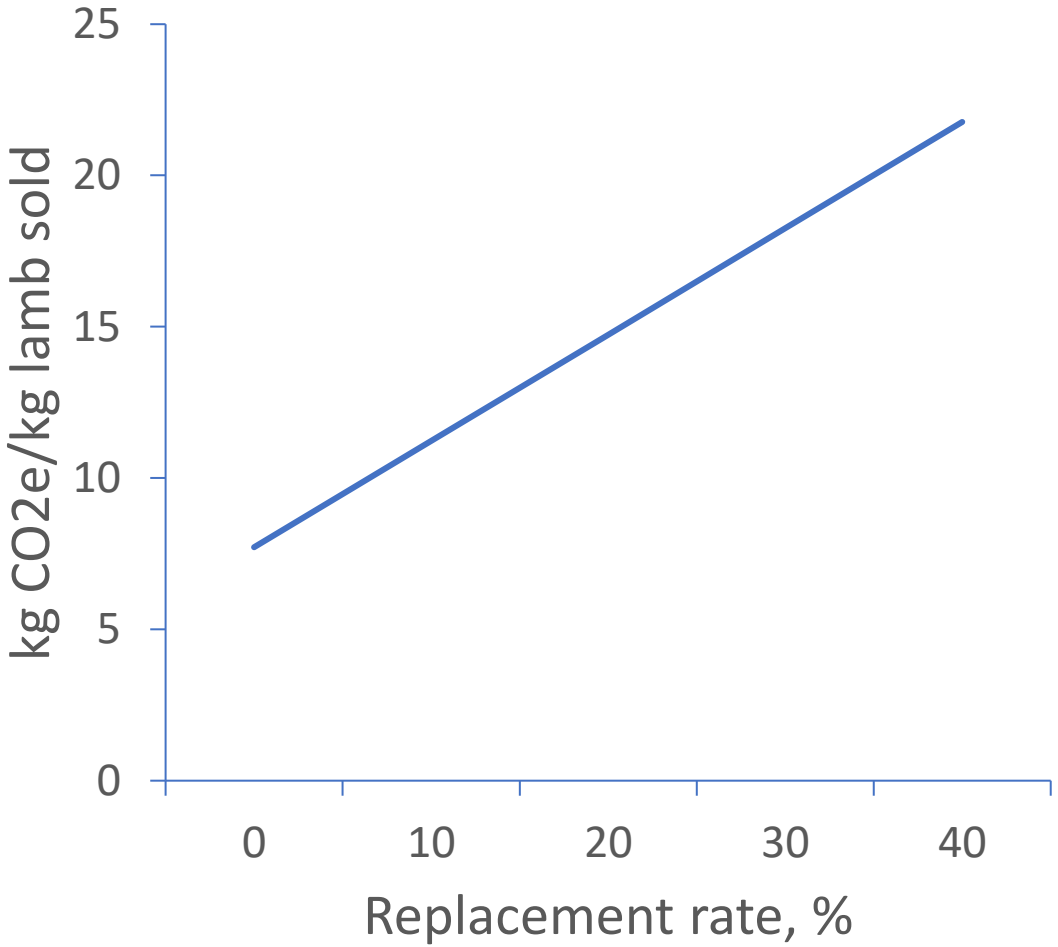
- Used statistical selection procedure (stepwise regression) to identify the most impactful GHG factors

1. **Weaned lambs per ewe**
2. **Replacement rate**
3. **Number of breeding ewes**
4. % of time on pasture
5. Kg feed per ewe
6. Ewe first breeding age
7. Fuel per ewe
8. ADG market lambs

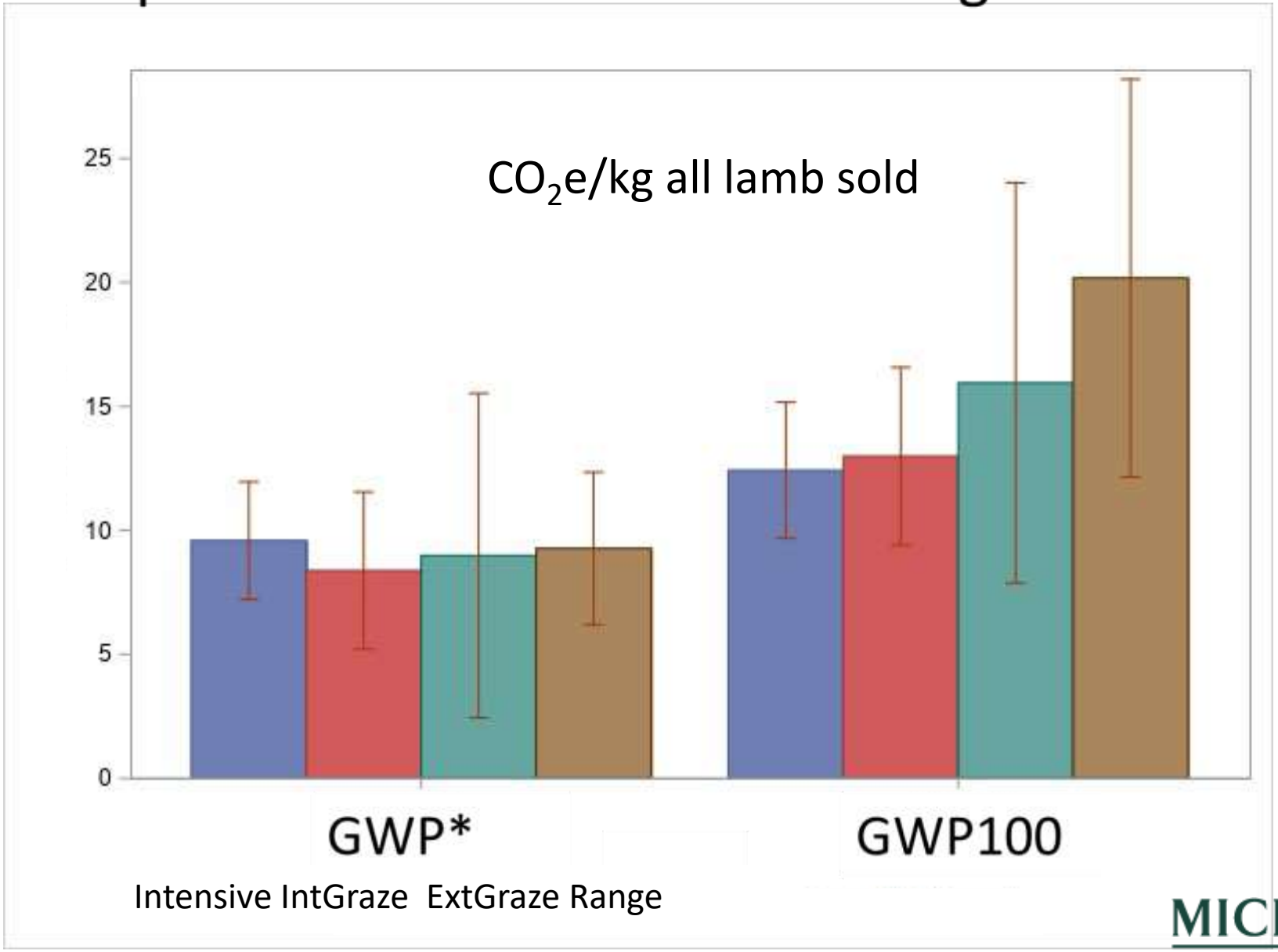


Change in GHG emissions due to performance





Comparison of Methane Accounting Methods



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Mitigation: Enteric CH_4 and Manure

- CH_4 production based on feed intake
  - Fewer animals, fewer days to produce product
  - Substantial impact on total emissions
- Feed additives: 3-NOP reduces enteric CH_4 by ~20-40%
  - Currently developing pasture-based product
  - Seaweed, lipids, essential oils
    - Bromoform safety
- Genetics: NZ and Ireland producing low-CH_4 emitting lines, 20% reduction
- Manure management options limited, ~2-10% of emissions
  - Focus of dairy, swine, poultry industries
  - Precision feeding – reduce N excretion
  - Impact of composting unknown, highly variable GHG due to aerobic and moisture
    - Adds biomass to soil, organic N, diverts from high emissions system

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Mitigation: Feeding strategies

- Feed composition
  - Improving forage quality generally reduces CH_4 yield, better performance with similar intake
  - Concentrate-based diets, change rumen fermentation so less favorable to CH_4 formation (not verified in sheep!)
- Forage selection
  - Tanniferous forages have ~10% lower CH_4 yield/kg intake (Arndt 2021)
  - Brassicas have ~25% lower CH_4/kg intake (NZ)
  - Plantain inclusion (30-50%) reduces nitrate leaching by 20-60%
  - Many plant species may have chemistry to lower CH_4 but remain unexplored *(US sheep may already be grazing such plants but we do not have this information to model).*

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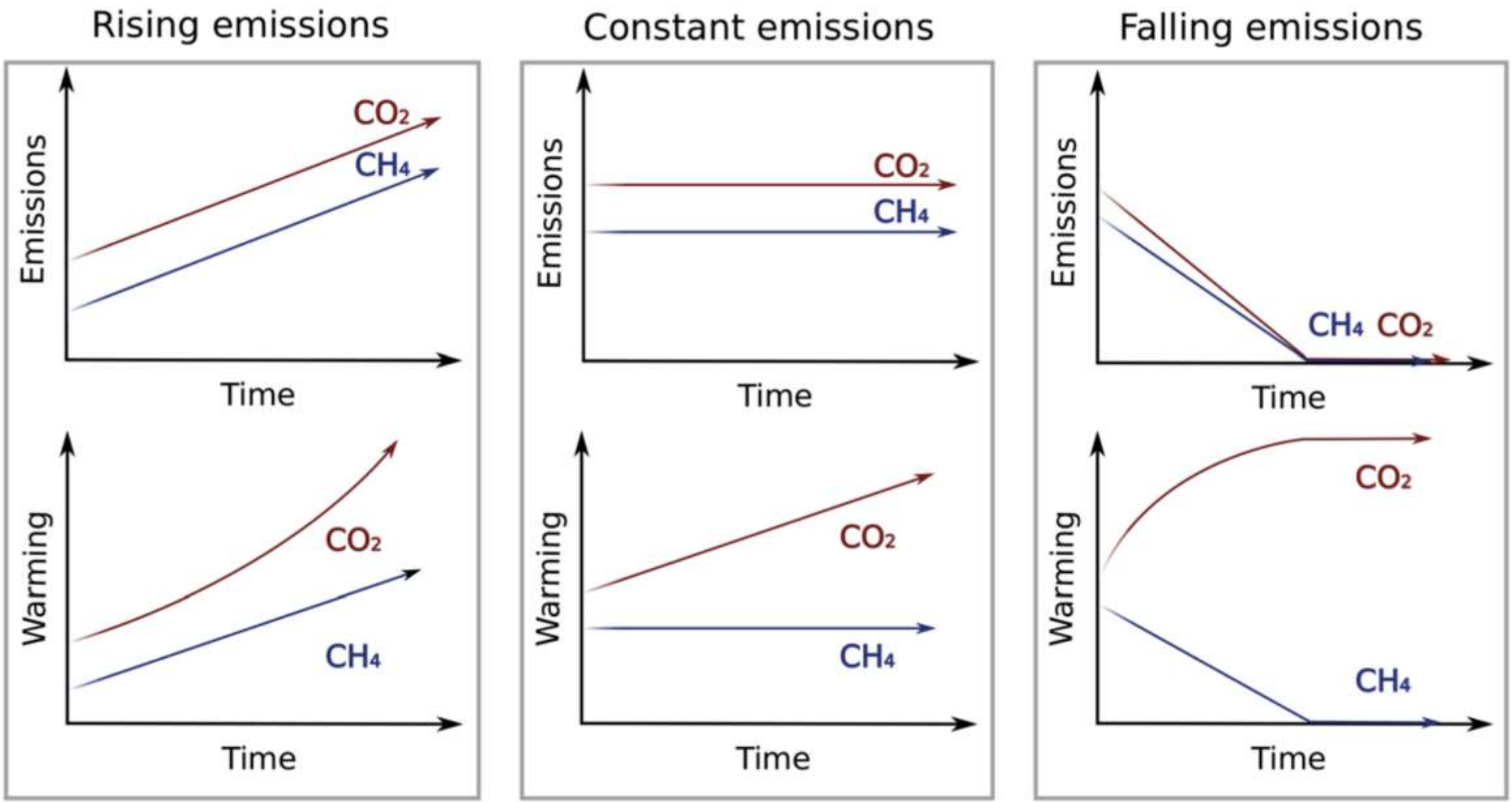

Climate Metrics for Ruminant Livestock by University of Oxford

Mitigation: Farm inputs and Energy use

- Majority of purchases are feed, fertilizer, fuel
- Feed production
  - Harvesting practices
  - Less fertilizer through precision management
    - Timing of applications
    - <5% of GHG on almost all farms
  - Efficient water use
    - Irrigation practices, drought-resistant species
- Fuel use, ~5% of emissions
  - Fewer passes on fields
  - More efficient technology
  - Renewable energy sources, Solar arrays

Solargrazing.org

Potential change in tonnes of Carbon

- Incorporate practices that decrease emissions from 20 to 15 kg CO2/kg lamb
- Abatement of 5 * 50 kg lambs * 1,000 lambs = ~250 metric tons CO2e
- 250 carbon credits * $20 = $5,000
- Benefits likely through improved production efficiency
  - Higher ewe productivity, better health, mortality
- Environmentally friendly often budget friendly too!

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Mitigation: Cover crops

- Large variability in soil OM and N emissions
  - Climate, seasonal weather, soil type, management, species
- Generally, inclusion of cover crops:
- Reduces N leaching
  - Groundwater contamination, N_2O formation
- Increases soil OM (C sequestration)
  - Better water infiltration and water holding capacity, less prone to compaction
  - More able to hold/supply nutrients, aid in decomposition and microbial life
- Slight decline in primary crop yield (?)

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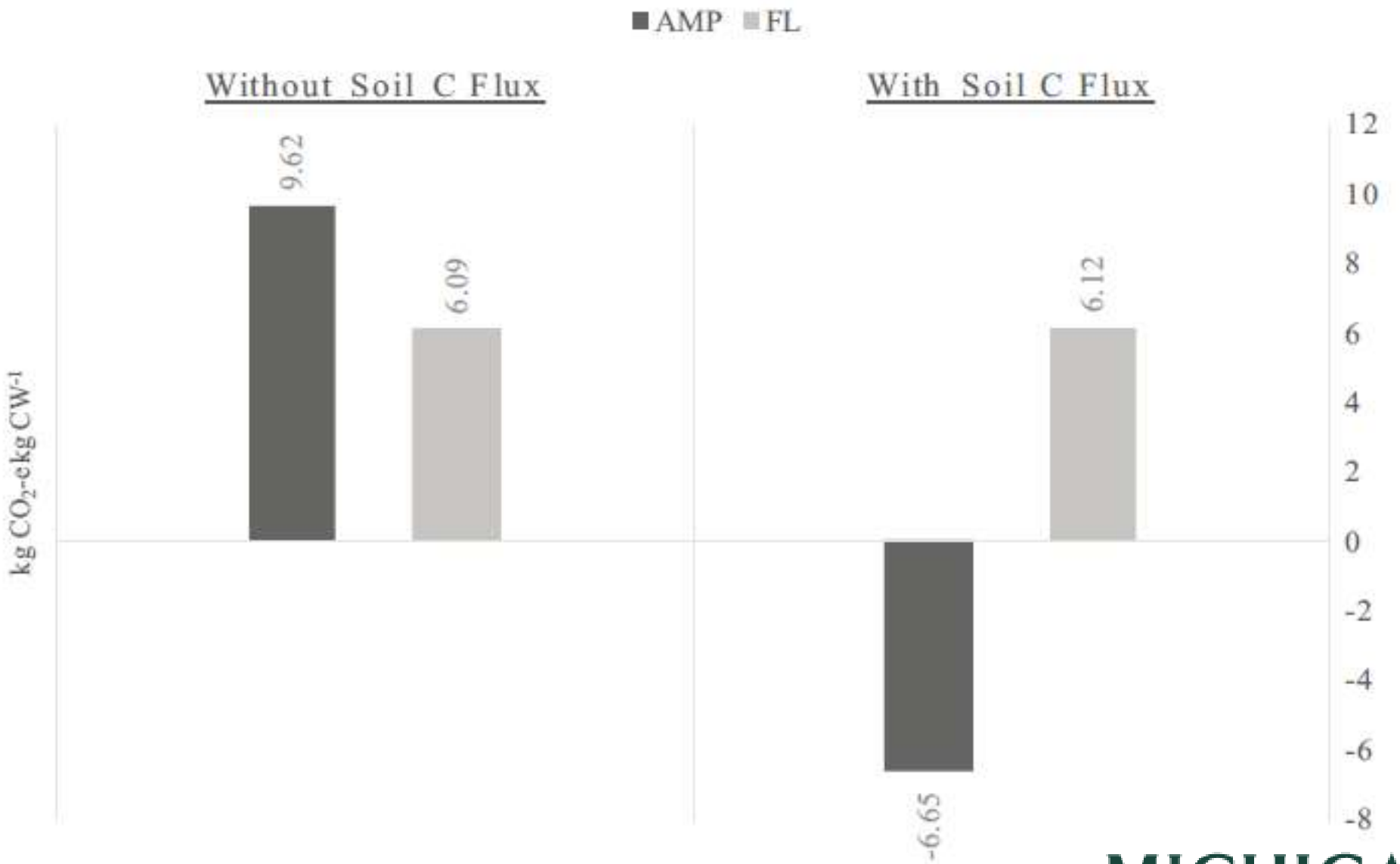
Grazing work at Lake City Research Station

- Compared beef cattle finishing systems: Feedlot vs Grass-fed
  - Adaptive multi-paddock grazing from May to November on alfalfa and cool season grasses



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Stanley et al, 2019

Mitigation: Grazing practices

- MSU beef grazing study, ~0.5% increase in SOC/year
  - ~3.5 Mg C/ha/year or ~5,000 kg CO_2/acre/year
  - ~ 500-1500 kg CO_2e/market lamb
- Dairy industry sustainability: indirectly via feed production
  - Promote cropping practices that increase SOC
- Major component of U.S. Roundtable for Sustainable Beef
  - ***Very difficult to estimate***
  - Temporary – weather, change practices, previous management
- New technologies being developed – satellite monitoring
- Value in maintaining carbon in land!

Pggrc.co.nz

MSU study and potential GHG mitigation

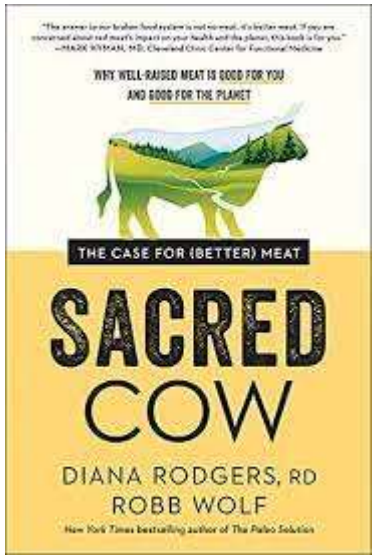
- GHG emissions varied numerically according production system
  - 12-20 kg CO_2e/kg lamb sold
  - Different GHG profiles across production systems: % Enteric CH_4
- GHG emissions on a total sheep product basis did not differ significantly between sheep production systems
- Emissions dependent on weaned lambs/ewe/year and replacement rate
  - Higher production efficiency = lower GHG
- Mitigation options:
  - Targeting enteric CH_4 (additives, tannins, brassicas, genetics)
  - Feeding practices: high quality forage, precision feeding (lower CP)
  - Manure storage and application
  - Feed production (cover crops, no or low-till, fertilizer use)
  - Grazing management (soil sequestration)
  - Farm energy use – shift to on-farm generation, renewables

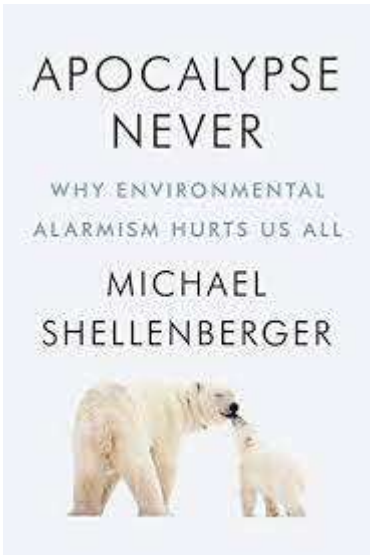
Positive contributions of sheep production to the environment

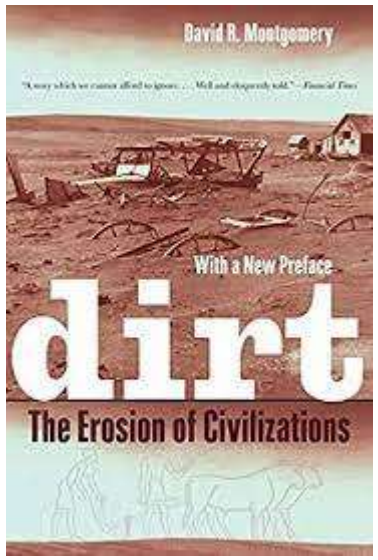
- Carbon maintenance/sequestration via proper grazing management
- Improved wildlife habitat and biodiversity with proper grazing management
- Control of invasive species
- Protection of water sheds via proper grazing management
- Wildfire: control of fuel loads
- *How do we value these positives that other animal industries may lack against the negative of methane emissions?*

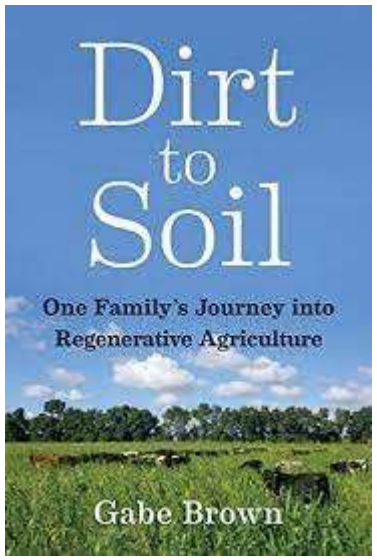
Awareness of an active and evolving science

- Twitter
  - Influencers
  - Academics and Institutions
- Centers, Universities, Initiatives, Books









Thank you!

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