Developing safe and effective enteric methane mitigation solutions for dairy cattle: Standards and scientific rigor matter

Joseph W. McFadden, Ph.D.

Associate Professor of Dairy Cattle Biology;
Northeast Agribusiness and Feed Alliance Faculty Fellow;
Cornell Atkinson Center for Sustainability Faculty Fellow

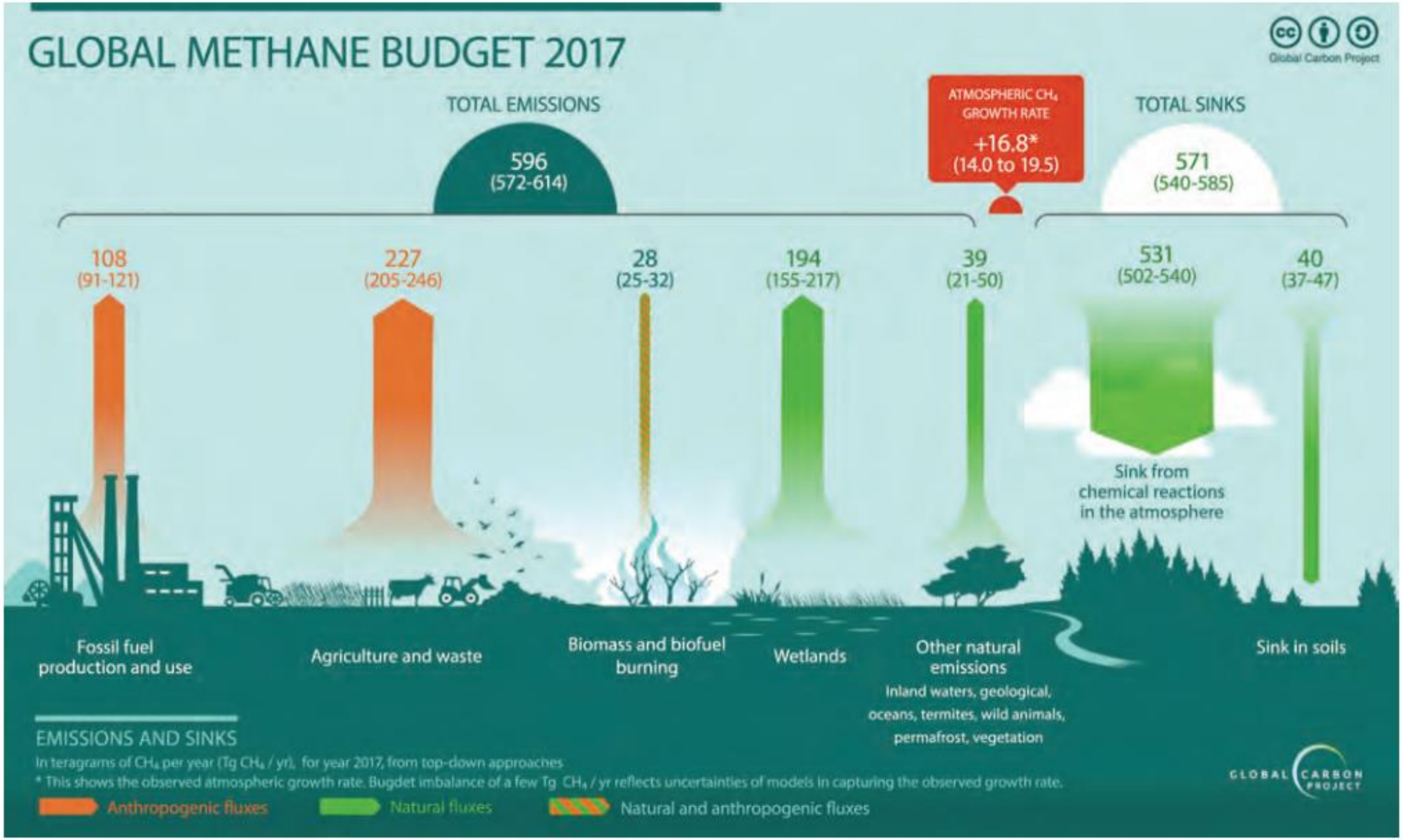
McFadden@Cornell.edu; X @RuminateOnThis

TIME

IDEAS • CLIMATE CHANGE

Cow Burps Have a Big Climate Impact. Solving That is Harder than You'd Think

Cornell CALS College of Agriculture and Life Sciences



GLOBAL METHANE BUDGET 2017
Global Carbon Project
TOTAL EMISSIONS
596
(572-614)
ATMOSPHERIC CH4 GROWTH RATE
+16.8*
(14.0 to 19.5)
TOTAL SINKS
571
(540-585)
108
(91-121)
227
(205-246)
28
(25-32)
194
(155-217)
39
(21-50)
531
(502-540)
40
(37-47)
Sink from chemical reactions in the atmosphere
Fossil fuel production and use
Agriculture and waste
Biomass and biofuel burning
Wetlands
Other natural emissions
Inland waters, geological, oceans, termites, wild animals, permafrost, vegetation
Sink in soils
EMISSIONS AND SINKS
In teragrams of CH4 per year (Tg CH4 / yr), for year 2017, from top-down approaches
* This shows the observed atmospheric growth rate. Bugdet imbalance of a few Tg CH4 / yr reflects uncertainties of models in capturing the observed growth rate.
Anthropogenic fluxes
Natural fluxes
Natural and anthropogenic fluxes
GLOBAL CARBON PROJECT

COP28 – Nestlé, Danone among food signatories to Dairy Methane Alliance

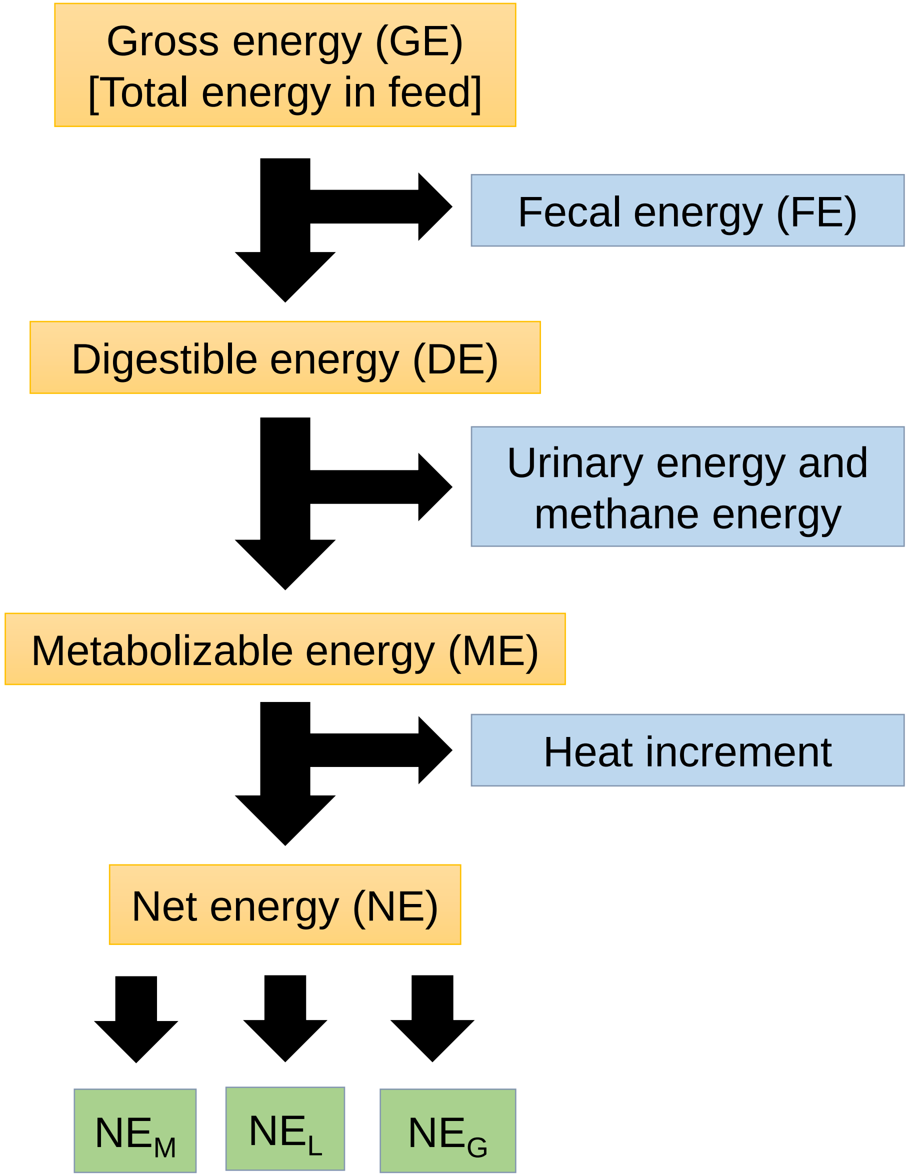
General Mills, Kraft Heinz, Bel Group and the US division of France-based dairy major Lactalis are part of the pact to cut methane emissions.

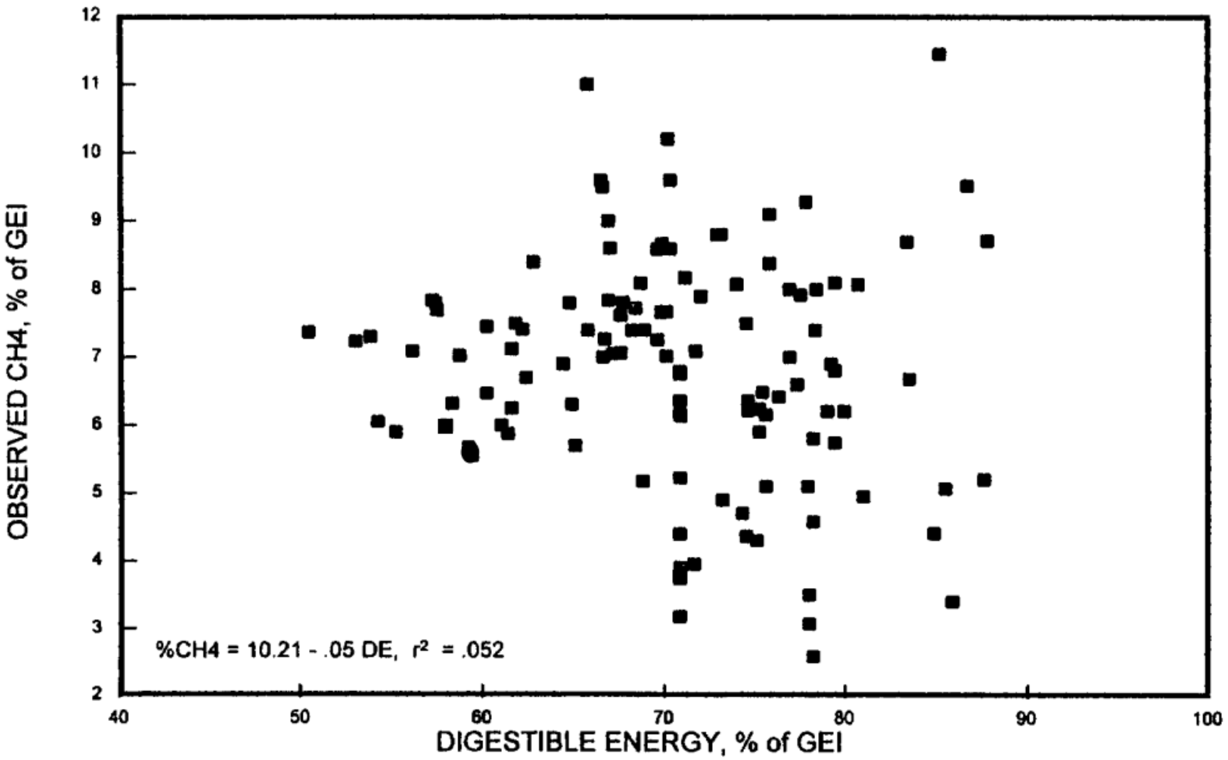
Accelerating Livestock Innovations for Sustainability

- Develop safe and effective tech to reduce enteric methane emissions
- Improve efficiency for smallholder dairy systems
- Advance manure management practices including landfill diversion
- Accelerate development and validation of alternative methane sensors
- Integrate data to enhance resource and environmental impact monitoring

*Our **goal** is to reduce global enteric and manure GHG emissions from ruminant production to mitigate climate change, and support farmer opportunities, human health and nutrition, and animal well-being.*

Understanding the energetics of methane and milk production is a priority





Johnson and Johnson, 1995

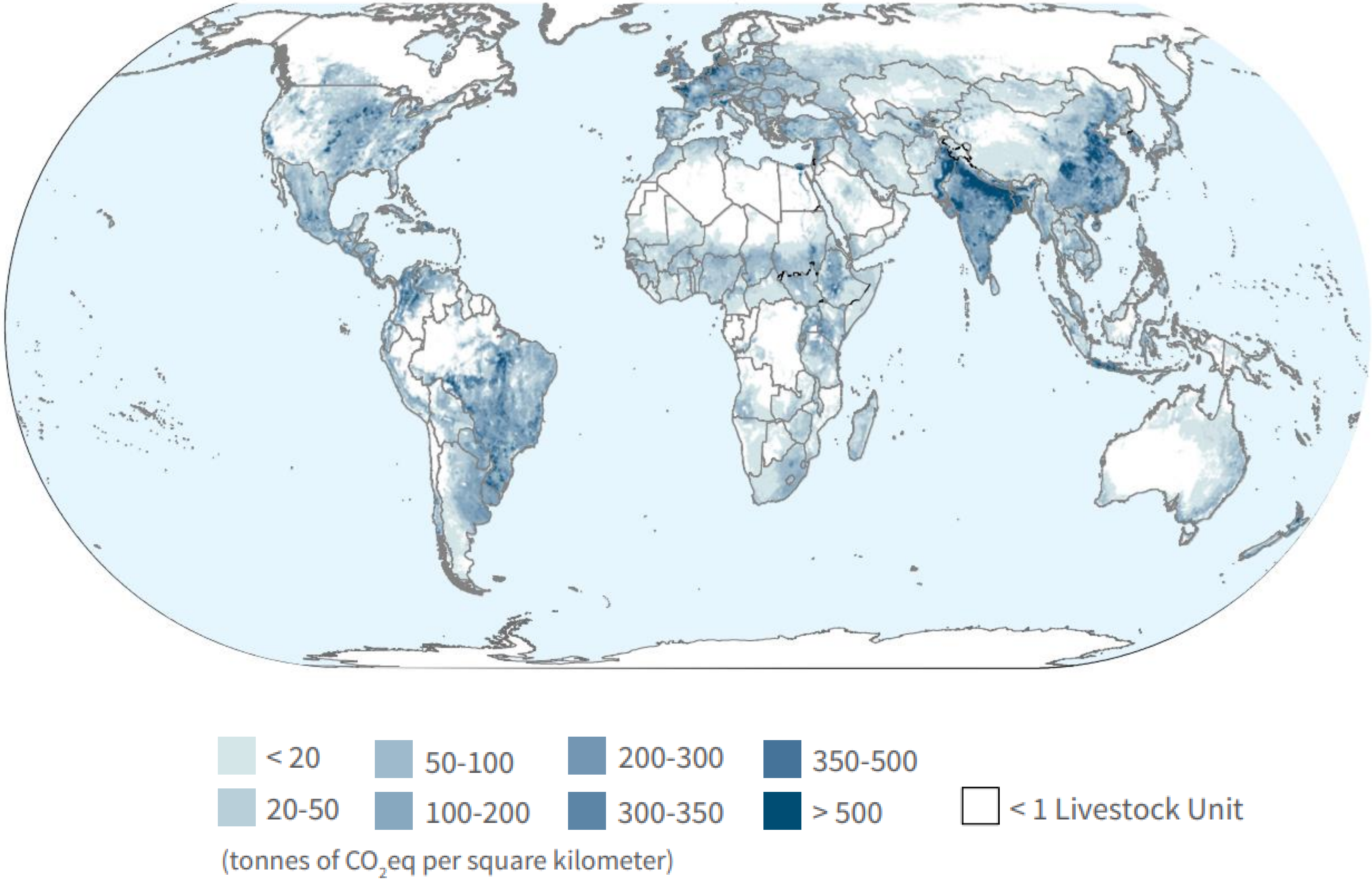
Additive	Efficacy: CH_4 reduction potential [1]	Efficacy: No. of academic papers [2]	Efficacy: Confidence in efficacy [3]	Potential animal welfare risks	Potential food safety risks	Potential co-benefits	Production system applicability [4]	Development needs
3-Nitrooxyproponal	Very High	> 20	5	None known	None known	Improved feed efficiency.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Asparagopsis	Very High	< 10	1	Damage to rumen wall	Bromide & iodine residues in animal tissue/products	Improved feed efficiency.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Nitrate	High	< 20	4	Toxicity in non-adapted animals	None known	Can reduce need for urea supplementation in animal feed.	TMR systems immediately. Grazing systems in future.	Validation in large-scale TMR systems required. Formulation for grazing systems.
Essential Oils	Low	< 20	2	None known	None known	Improved milk productivity (limited evidence & indication of reduced body growth).	TMR & grazing systems (where supplements are administered)	Peer reviewed studies of mitigation potential and productivity within TMR & supplement systems.
Saponin	Low	< 15	1	None known	None known	Improved protein supply by protozoa control.	TMR & grazing systems (where forage crops containing saponin are utilized)	Further research into CH_4 reductions, productivity impacts & saponin chemistry required.
Tannins	Low	< 15	2	None known	None known	Shift from urine to faecal excretion of nitrogen reducing risk of N_2O emissions.	TMR & grazing systems (where forage crops high in tannins are utilized)	Tannins may have a stronger role in forage-based mitigation than as feed additives.
Monensin	Low	> 20	5	None known	None known	Improved weight gain. Reduced risk of bloat & acidosis.	TMR & specialized grazing systems	Few needs – already a widely used product.
Microalgae	Low	< 5	1	None known	None known	PUFA levels in meat improved. Enhanced antioxidants in food products.	TMR & grazing systems (where supplements are administered)	Microalgae supply dependent on use in renewable energy sector.
Biochar	Low	< 5	1	None known	None known	Toxins & heavy metals absorption prevention in animals. Enhanced soil quality when excreta is applied to soils.	TMR & grazing systems (where supplements are administered)	Engineering of an acidified biochar required to achieve adequate efficacy.
Bacterial Direct Fed Microbes	Low	< 15	2	None known	None known	Improved productivity (though inconsistent). Improved calf health. Reduced incidence of E.coli in manure.	TMR & grazing systems (where supplements are administered)	Development of high efficacy bacterial strains.
Fungal Direct Fed Microbes	Low	< 15	1	None known	None known	Improved productivity (+ 3% in milk observed). Improved feed efficiency.	TMR & grazing systems (where supplements are administered)	Development of high efficacy fungal strains.

Hegarty et al. (2021)

Where are we going?

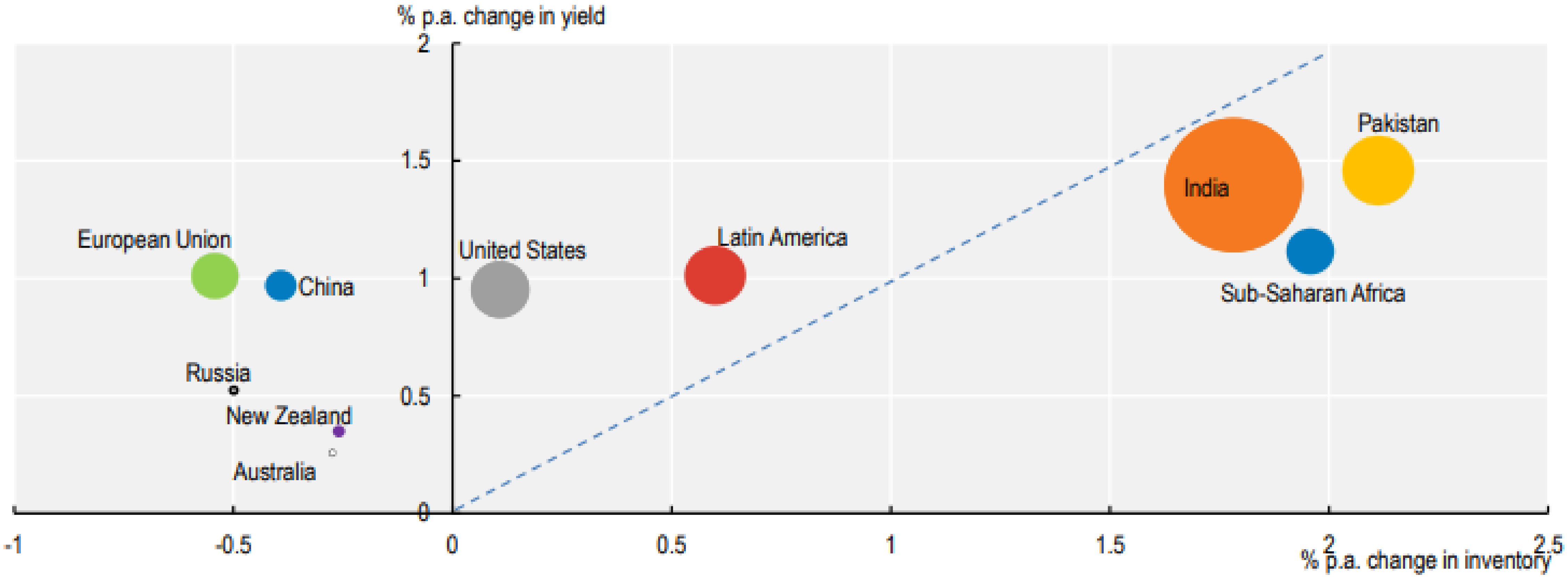
- How can we leverage fatty acids?
- Deep dive on seaweed, bromoform, and other halogens
- Fatty acid by bromoform interactions
- Methane mitigation during different energy balance and planes of nutrition
- Novel compound discovery
- Methane cost/benefit of disease and disease prevention

Total GHG emissions from global livestock supply chains



FAO, 2023

Dairy production growth in India and beyond

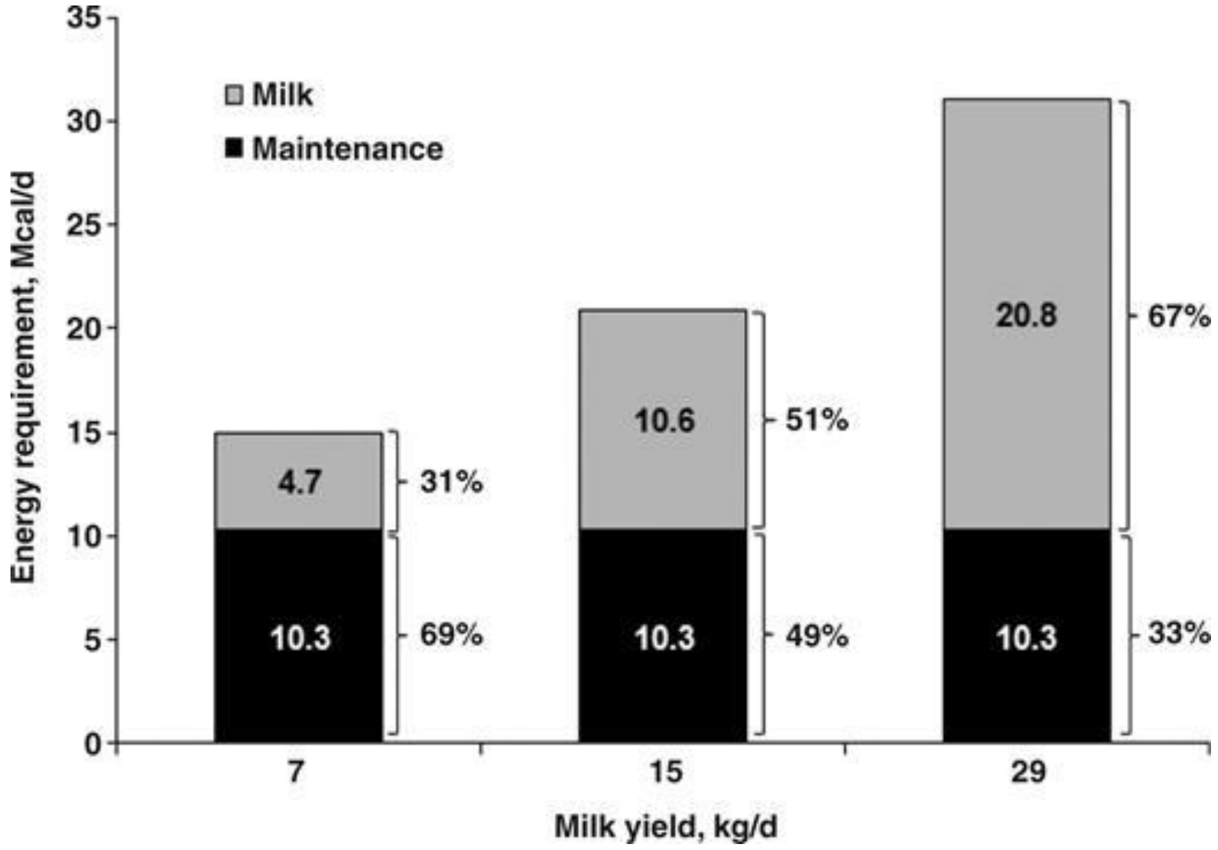


Note: The size of the bubble reflects absolute growth in dairy production between 2018-20 and 2030.
Source: OECD/FAO (2021), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

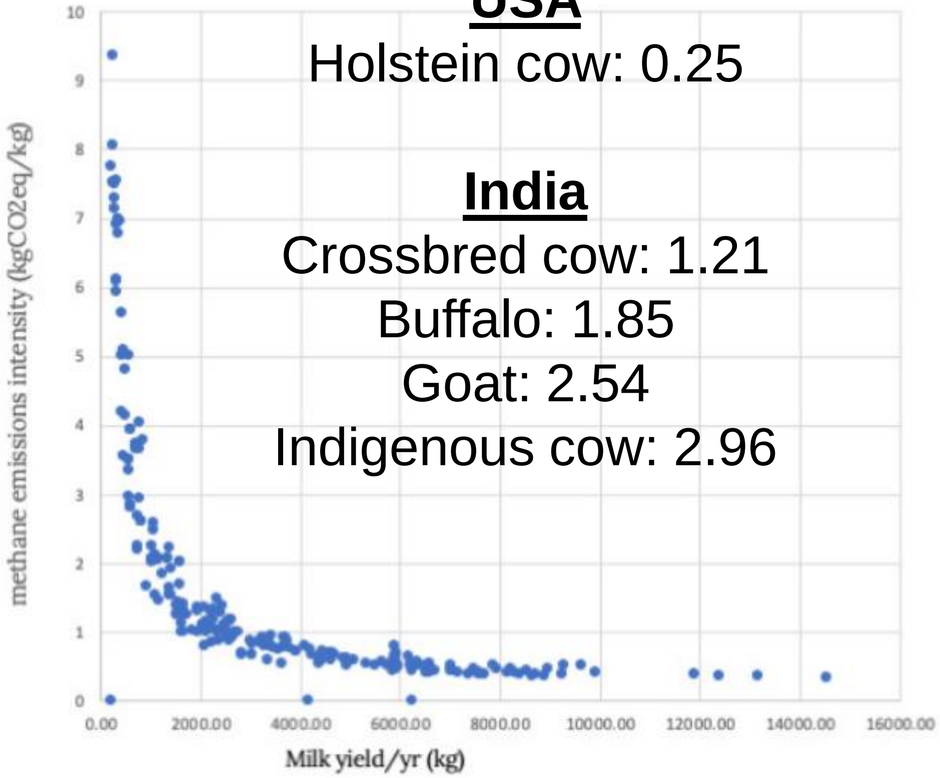
Enhanced efficiency has value for Global South

Enteric GHG emissions intensities (kg of CO_2e kg^{-1} milk):

A



B

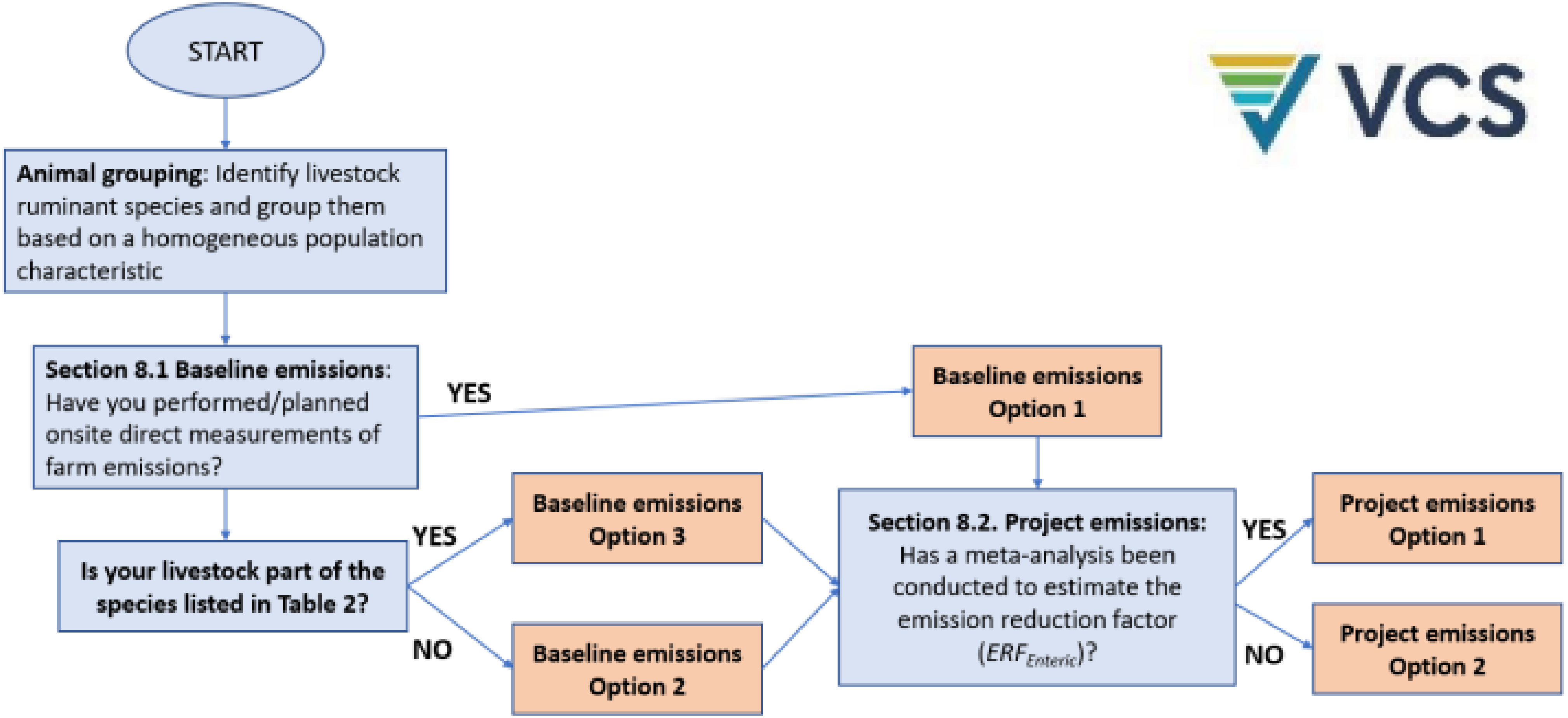


Capper et al. (2008); Patra (2017); Tricarico et al. (2020); Searchinger et al. (2021)

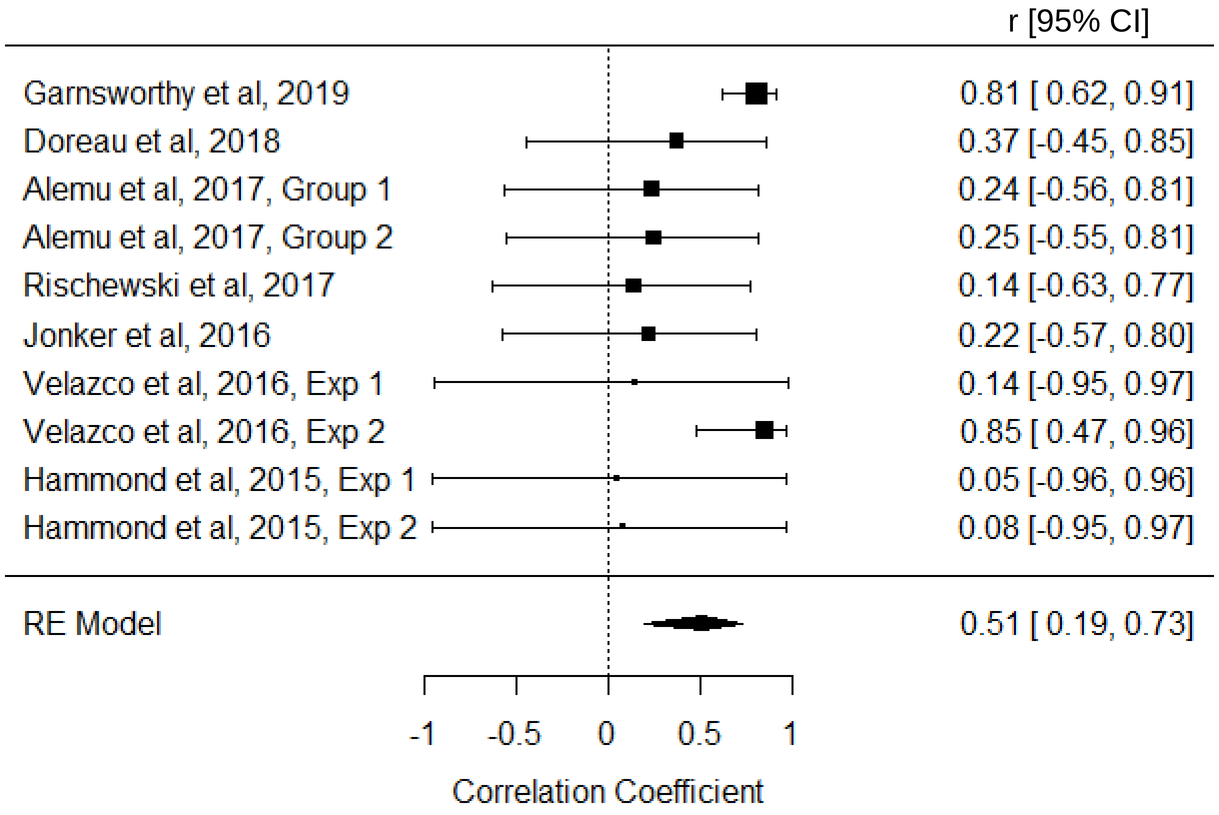
Enhancing efficiency in India is our priority

- Build a national feed library for India
- Establish v2.0 ration balancing plan
- Perform controlled and field trials to demonstrate benefit of and barriers to adopting ration balancing
- Establish baseline methane inventories for ingenious breeds
- Examine scalability of methane mitigators
- Validate a low cost methane sensor

Verified Carbon Standard methodology is here and we are not ready



Methane sensors require validation



I^2	T^2	Hedge's Q
38.28%	0.1207 (SE = 0.1530)	12.8259 (P = 0.1706)

- Agreement between alternative methane sensors and respiration chambers is moderate to poor.

Fontoura et al. (McFadden Lab)

Cornell CALS College of Agriculture and Life Sciences

Sensor validation is our priority

- 2-Step validation approach for technologies/protocols to measure enteric methane

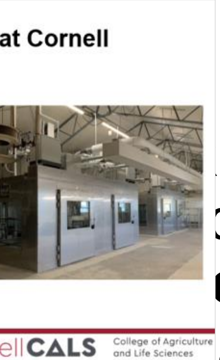
  - **Step 1:** Mass flow controller at different release rates (McGinn et al., 2021)

  - **Step 2:** In vivo test using a switchback design
    - 3-d: Alternative sensor (e.g., GreenFeed)
    - 3-d: Respiration Chamber
    - 5x repetition

McGinn et al. 2021. JAS 99:1-6.

Infrastructure development at Cornell

- Built four state-of-the-art **respiration chambers** to quantify total GHG emissions.
  - Climate-controlled; Real-time GHG, feed and water intake, and activity monitoring
  - Permits study of energetic efficiency
  - Now operational!



- **GreenFeed** units acquired/funded in 12 months
- amping up FDA clinical trial capabilities
- ompound discovery work (**Calan gates, BW ensor, etc…**)
- Accelerating compound discovery work (**GC, Ankom**)

Infrastructure development at Cornell

- Built four state-of-the-art respiration chambers to quantify total GHG emissions.
  - Climate-controlled; Real-time GHG, feed and water intake, and activity monitoring
  - Permits study of energetic efficiency
  - Now operational!
- 6 GreenFeed units acquired/funded in 12 months
- Ramping up FDA clinical trial capabilities compound discovery work (Calan gates, BW sensor, etc…)
- Accelerating compound discovery work (GC, Ankom)
- **Analyzing manure emissions on every study**

New faculty hires

- **Rumen Microbiology** expert to study the mechanisms of ruminal methanogenesis including inhibition and adaptation, and microbial-host interactions

- **Global Livestock Sustainability** expert to perhaps study pasture-based small-ruminant systems with an emphasis on international agriculture

- **Dairy Production Economics** expert to study carbon credit opportunities presented by the climate change economy

Summary

- We must prioritize the study of safety and efficacy (and effectiveness)
- We cannot generalize efficacy
- We need to call a spade a spade when it comes to technologies
- We cannot widen the gap in efficiency between developed and undeveloped world
- We need to acknowledge other perspectives; teach not preach; prioritize learning
- We need to be transparent with the consumer to build trust
- Scientists are the gatekeeper for solutions with positive impact

The numbers since arriving to Cornell

- 45 sponsored contracts providing $11M including 1 NSF, 3 USDA, 1 FFAR, 1 NGO, 1 CDFA award
- 110 individuals trained: 11 postdocs, 12 PhD students, 2 MS students, 1 MPS student, 9 interns, 75+ undergraduates, and 2 staff
- 53 invited talks
- 24 Op-Eds and popular press articles
- 40 peer-reviewed publications
- 78 scientific abstracts
- 4 respiration chambers
- 3 new faculty members
- 1 revitalized mission and prominence

No single person or institution will be our savior

- **Research Associate:** Dr. Nirosh Seneviratne
- **Admin coordinator:** Lindsay Sprague
- **Communication specialist:** Jackie Swift
- **LVT/Compliance officer:** Hiring soon
- **Postdoc associates:** Shambhvi Minhas
  Ashish Kumar
  Thurapi Azeera
  Diana Gomez
  Ananda Fontoura
  Yi Yang (arriving soon)
  Hiring soon (2)
- **Grad students:** Becca Culbertson
  Awais Javaid
  Miranda Farricker
  Fabian Oviedo
  Charlie You
  Victoria Ramos
  Vishwa Basnayake
- **25+ Undergrad/interns**

Support

- California Department of Food and Agriculture (2024)
- National Science Foundation Integrative Organismal Systems (2022)
- Foundation for Food and Agriculture Research Foundation Seeding Solutions (2019)
- USDA NIFA AFRI Foundational Program (2013, 2016, 2019, 2021)
- Foundation for Food and Agriculture Research Foundation Graduate Fellowship (2018)
- National Science Foundation Fellowship Program (2017)
- USDA Northeast Sustainable Agriculture Research and Education Program (2013, 2018, 2019)
- Northeast Agribusiness & Feed Alliance

*McFadden has received support as sponsored contracts, gifts, honorariums, and grants from **Cargill, Danone**, Perdue Agribusiness, Cotton Inc., **Gerstner Philanthropies**, **Environmental Defense Fund**, AB Vista, **Balchem Corporation, Global Methane Hub**, Adisseo, Elanco, Grōv, Vetagro, The Ballard Group, Phibro Animal Health, Berg+Schmidt, Global Agri-Trade, Perdue Agribusiness, ProAgni, Natural Biologics, Milk Specialties, Virtus Nutrition, The Cornell Atkinson Center for Sustainability, Progressive Dairy Solutions, Renaissance Ag, AMTS, Volac Wilmar, Lockwood Nutrition, WV HESP, WVU School of Medicine, New York State, Rumission, Cornell Center for Advanced Technology, Hatch formula funds, WVU CTSI, WVU Pediatrics Dept, Genesee Regional Market Authority, State of New York.*

Developing safe and effective enteric methane mitigation solutions for dairy cattle: Standards and scientific rigor matter

Joseph W. McFadden, Ph.D.
Associate Professor of Dairy Cattle Biology;
Northeast Agribusiness and Feed Alliance Faculty Fellow;
Cornell Atkinson Center for Sustainability Faculty Fellow

McFadden@Cornell.edu; @RuminateOnThis

Cows are not the new coal — here's why THE HILL

Cornell CALS College of Agriculture and Life Sciences