Got Milk?...or should we?

Making sense of conflicting scientific guidance on dairy sustainability and climate impacts

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Robin R. White (rrwhite@vt.edu)

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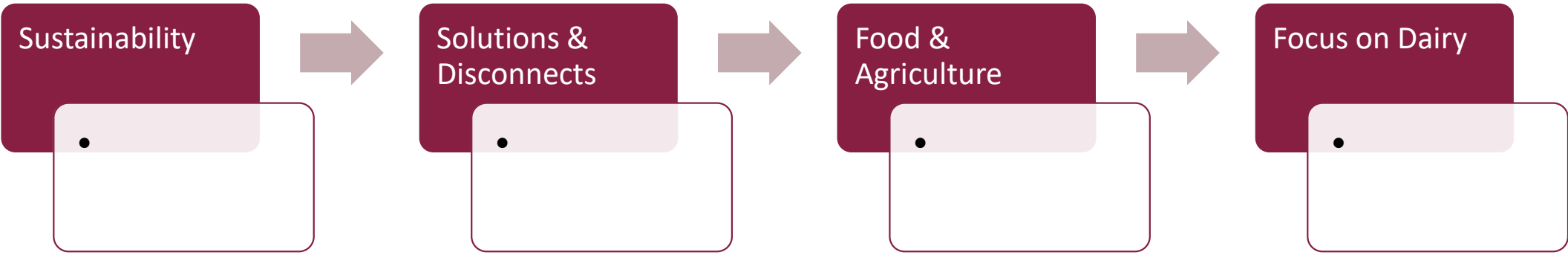
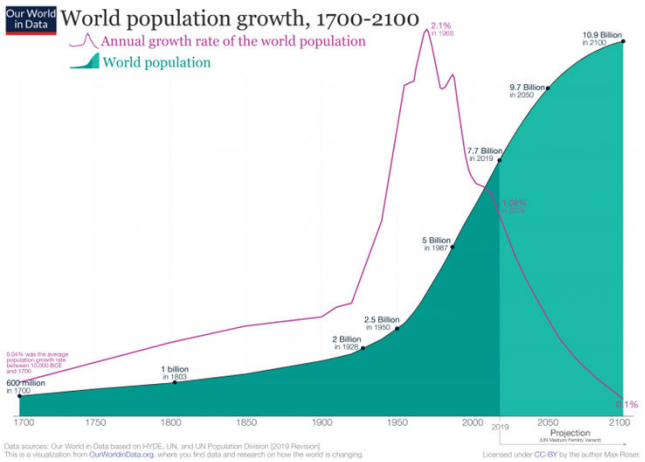
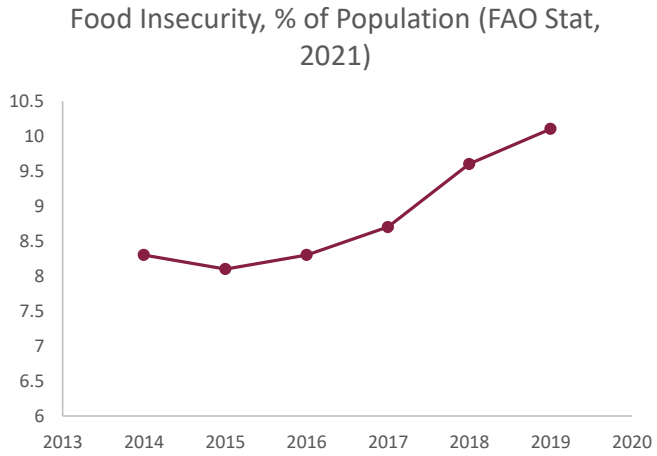
A Roadmap


Sustainability
Solutions & Disconnects
Food & Agriculture
Focus on Dairy

What is a sustainable food system?





One that contributes to food security and nutrition for all in such a way that the economic, social, cultural, and environmental bases to generate food security and nutrition for future generations are safeguarded.

- Von Braun et al. 2021 (https://www.un.org/sites/un2.un.org/files/scgroup_food_systems_paper_march-5-2021.pdf)

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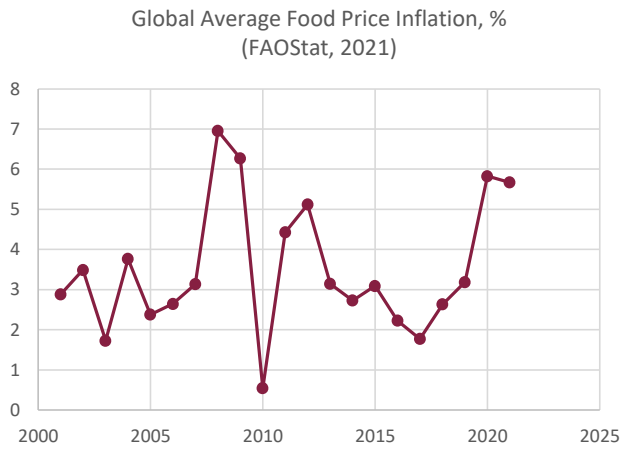

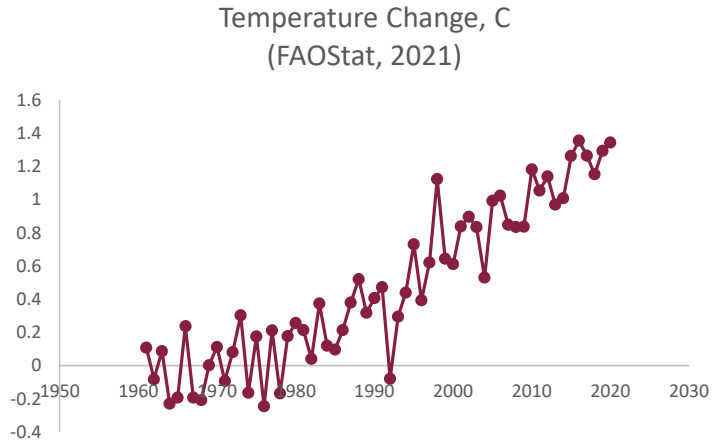

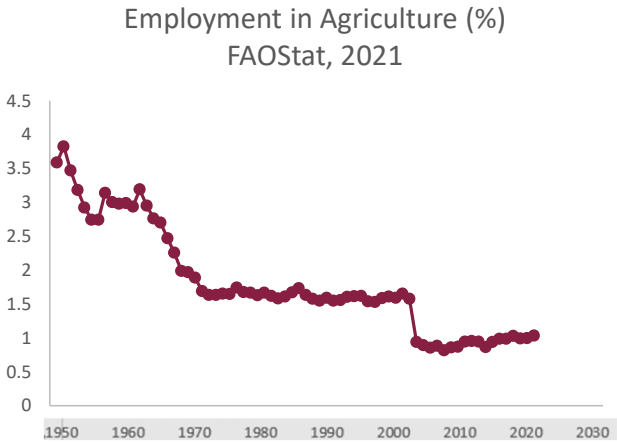

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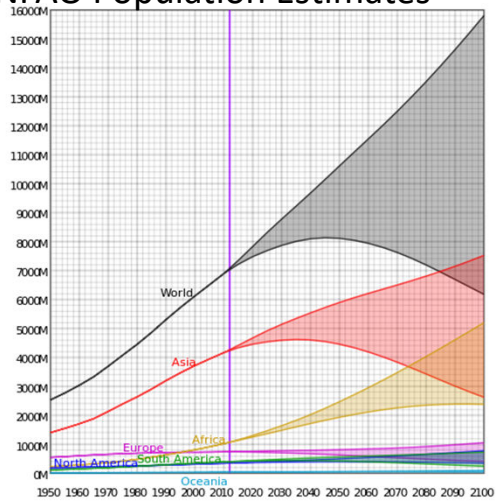
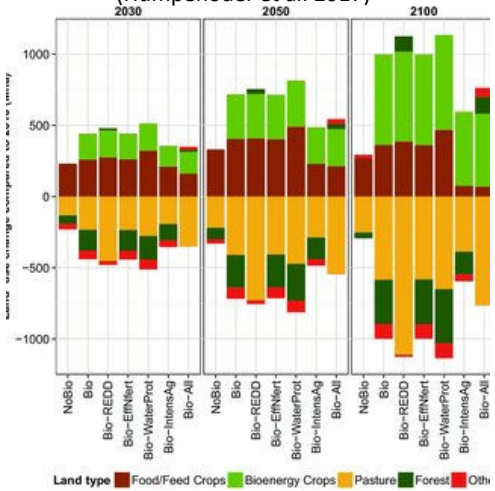
What is a sustainable food system?

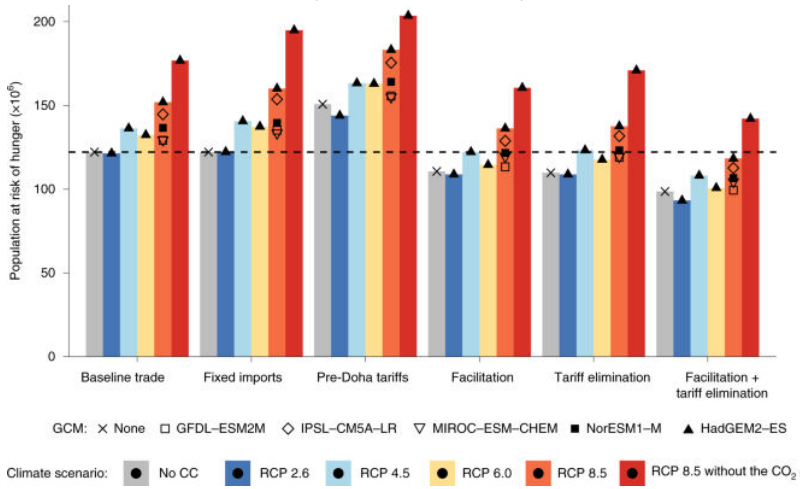
UNFAO Population Estimates



Projected Land-Use Change
(Humpenoder et al. 2017)



Strategies to Influence Global Hunger in 2050
(Janssens et al., 2020)



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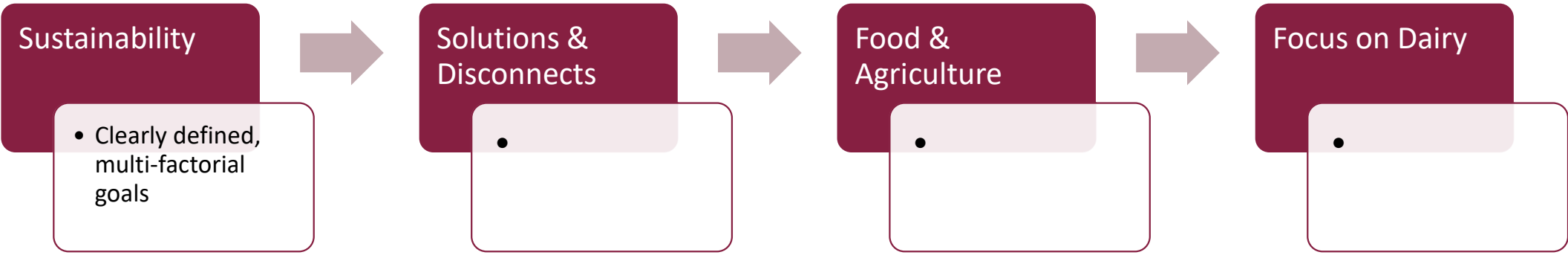
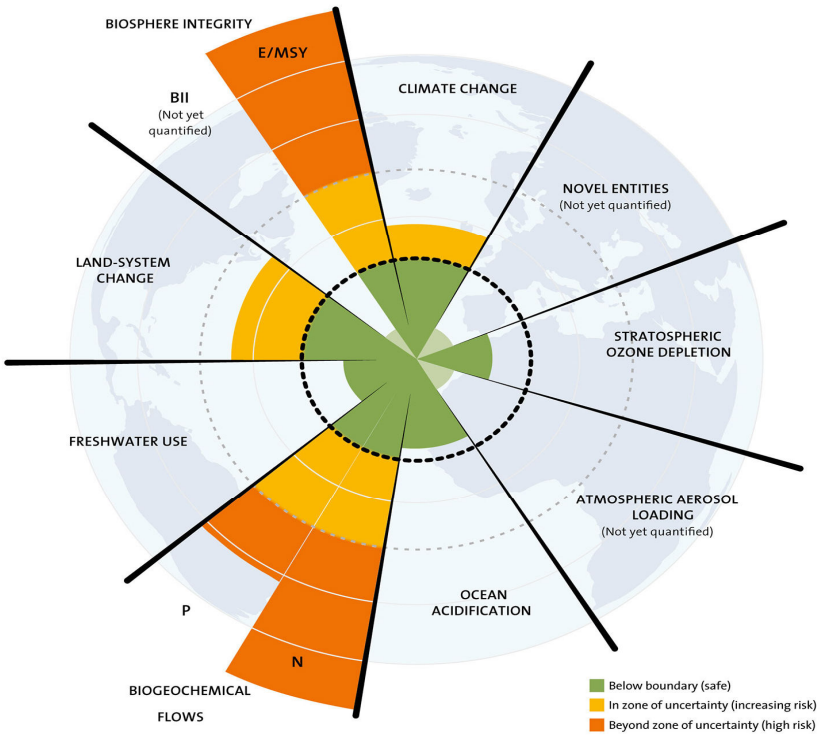
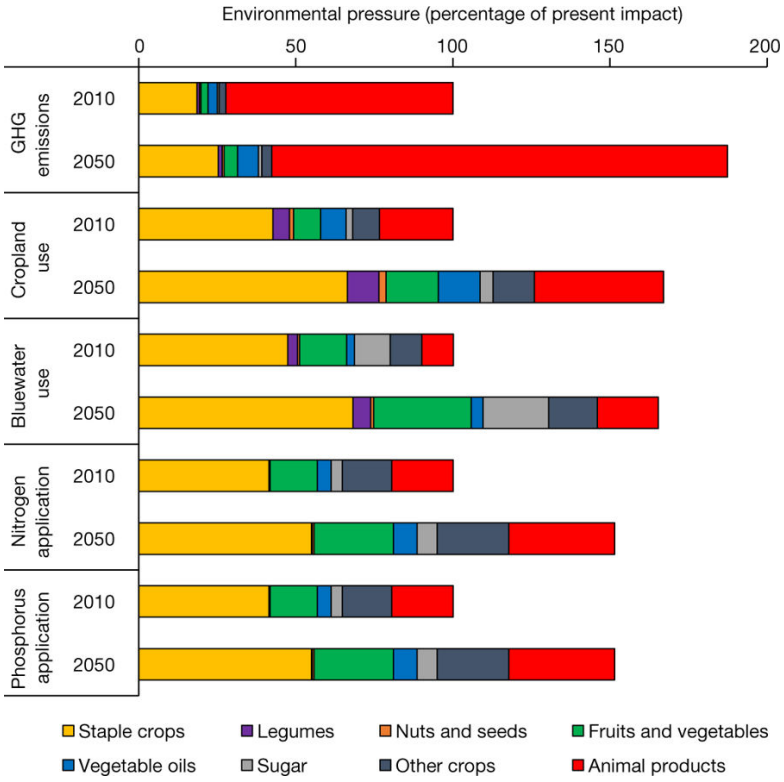
A Roadmap


Sustainability
• Clearly defined, multi-factorial goals
Solutions & Disconnects
•
Food & Agriculture
•
Focus on Dairy
•

Prioritizing Sustainability Challenges



Rockstrom et al., 2009



Springmann et al., 2018

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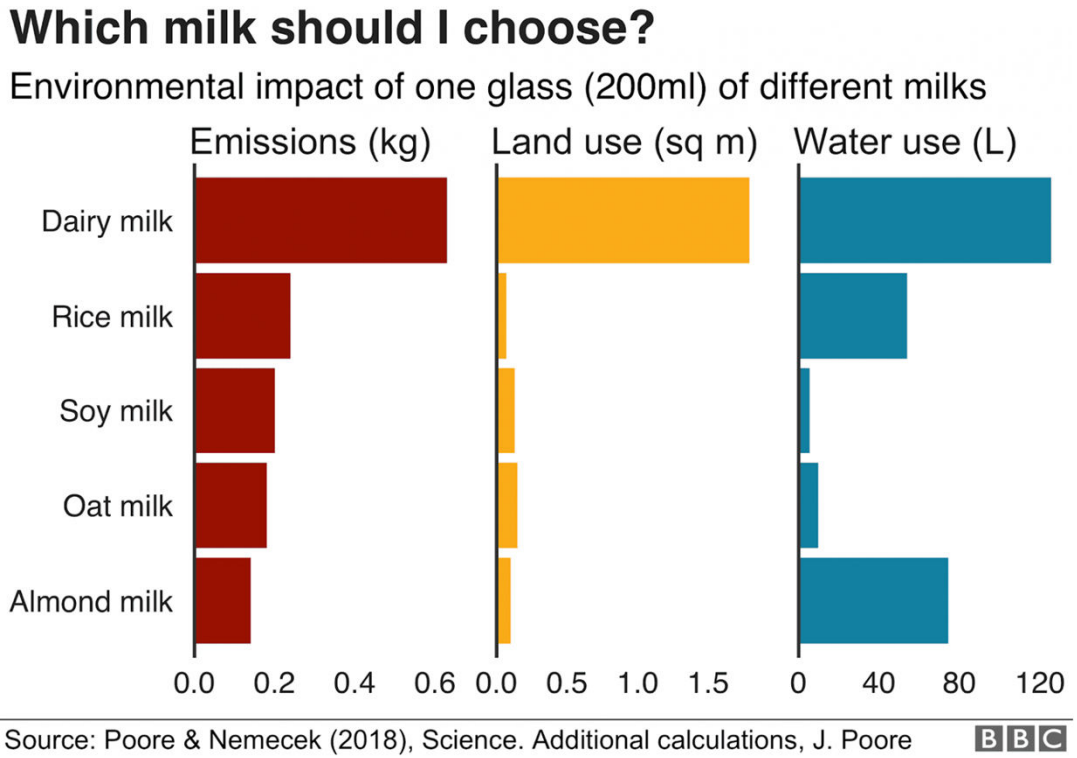
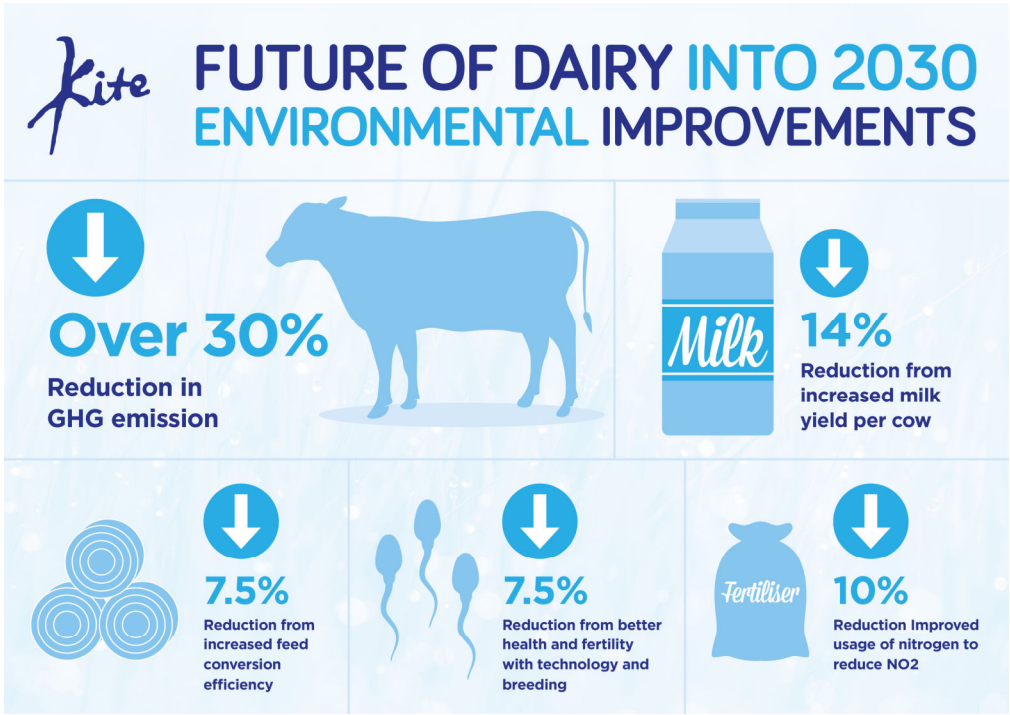
Substitution or System Improvement?





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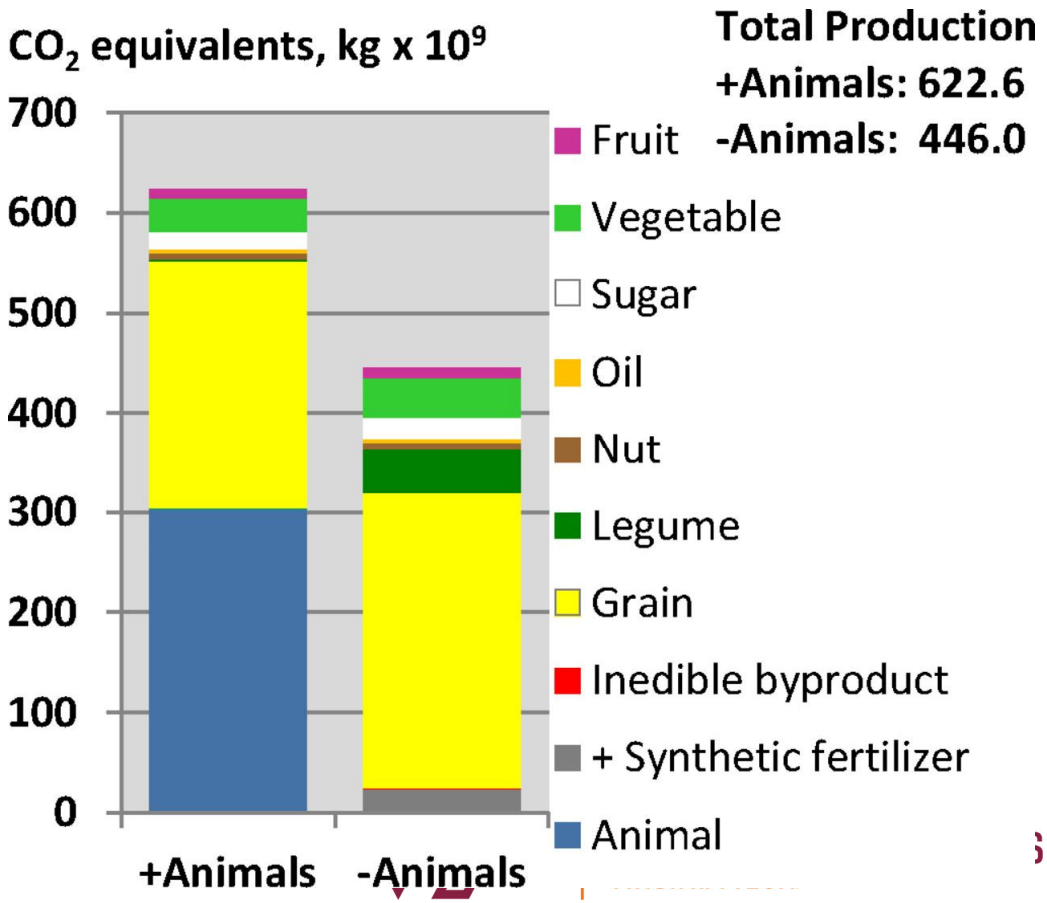
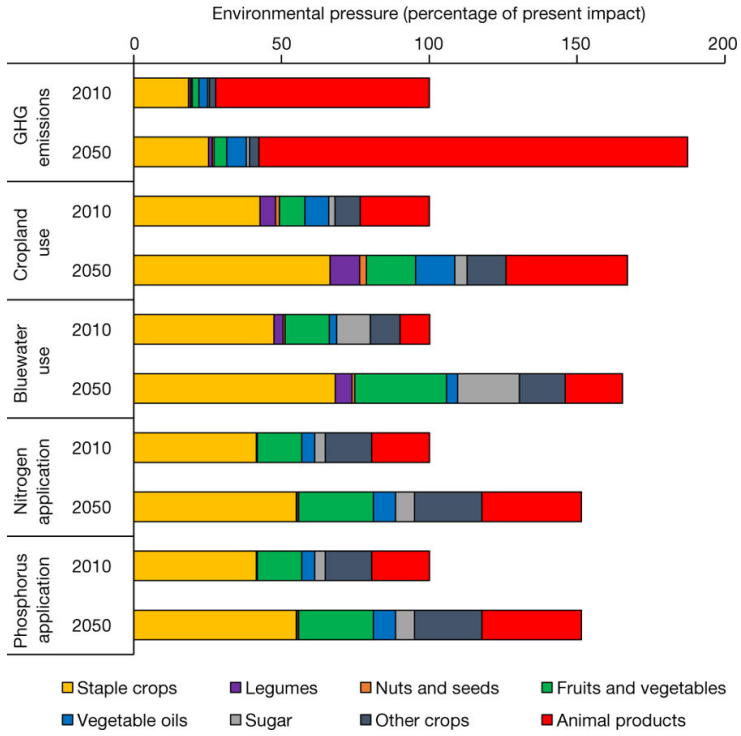
Eliminating Animal Source Foods

- 28% reduction in agricultural GHG, not the 50% associated with animals
- Regardless of accounting of fertilizer synthesis and byproduct disposal emissions, <3% change in total U.S. emissions



White, R. R., & Hall, M. B. (2017). Nutritional and greenhouse gas impacts of removing animals from US agriculture. *Proceedings of the National Academy of Sciences*, *114*(48), E10301-E10308.

Global Context Matters



Source	USA	Global
Livestock, % agriculture	41.8%	58.0%
Livestock, % total	3.89%	14.5%
Agriculture, % total	9.3%	25%

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Springmann et al., 2018

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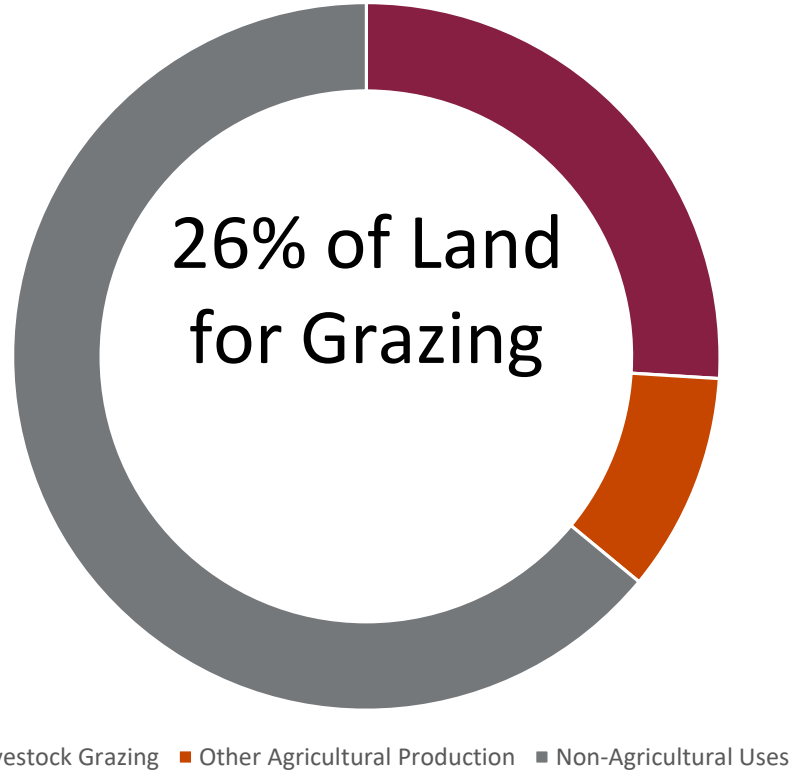
Timescale also needs to be considered



"each year, 13 billion hectares of forest are lost due to land conversion for agricultural uses [such] as pastures or cropland"

UNFAO: http://www.fao.org/3/ar591e/ar591e.pdf

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Global

1997 - 2012

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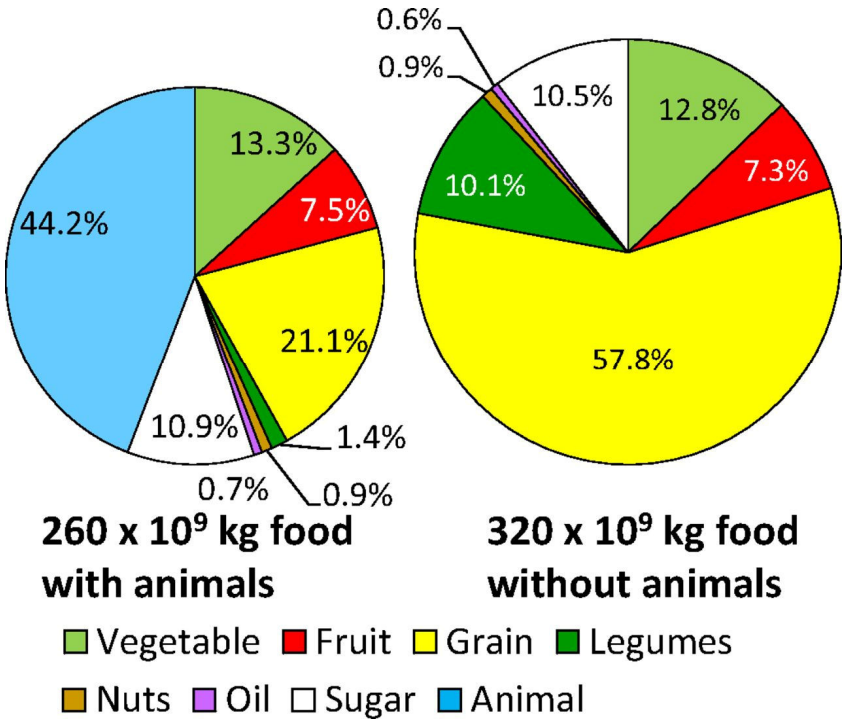
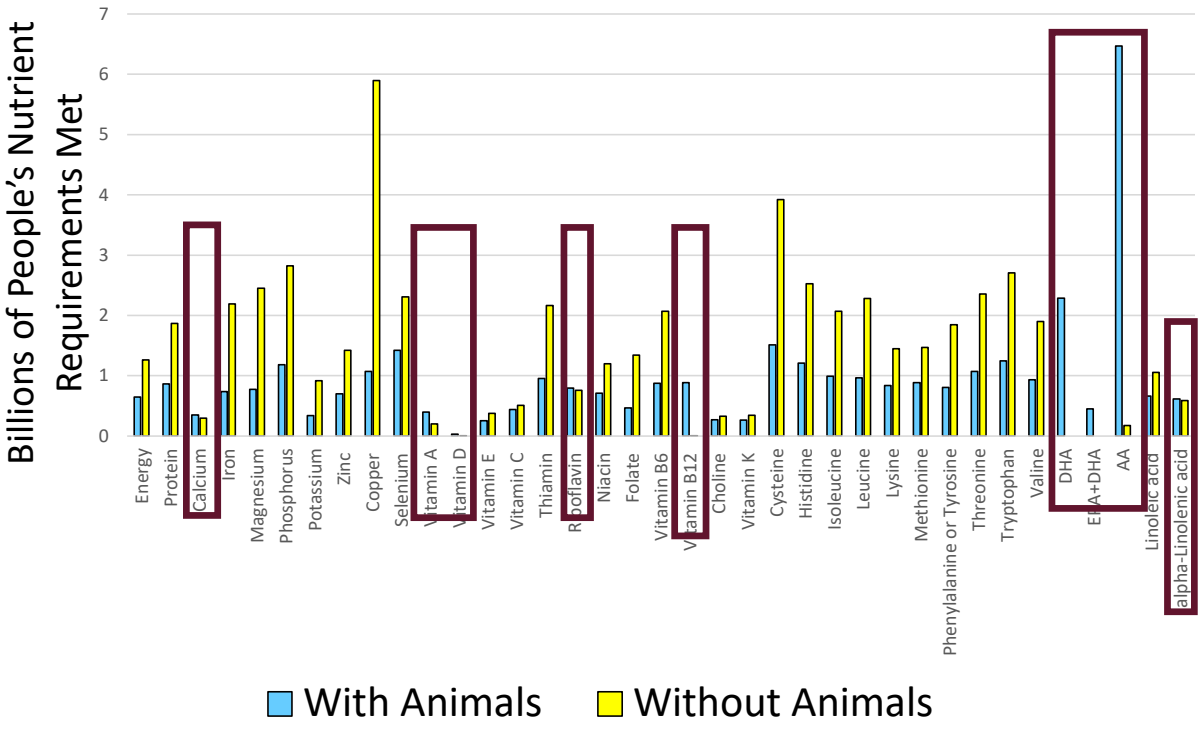
Timescale also needs to be considered

Land Use Type	2005 (1000 ha)	2018 (1000 ha)	Change (ha/y)
Urban Areas	71,037	74,904	297,000
Herbaceous Crops	1,221,098	1,235,250	1,089,000
Grassland	3,009,450	3,001,984	-571,000
Tree-covered Areas	4,977,582	4,976,059	-117,000
Mangroves	20,010	19,939	-5,500
Shrub-covered Areas	1,363,597	1,370,606	539,000
Aquatic/Flooded Areas	98,964	107,518	658,000
Snow and Glaciers	1,215,561	1,219,624	312,000

UNFAO: http://www.fao.org/faostat/en/#data/LC

Full system needs to be considered





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White, R. R., & Hall, M. B. (2017).

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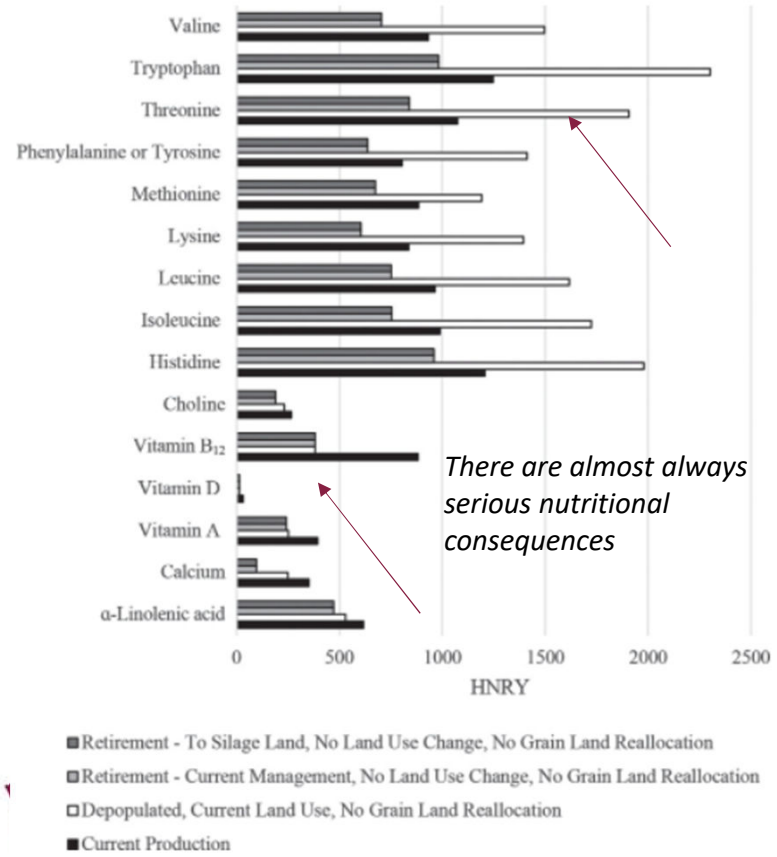
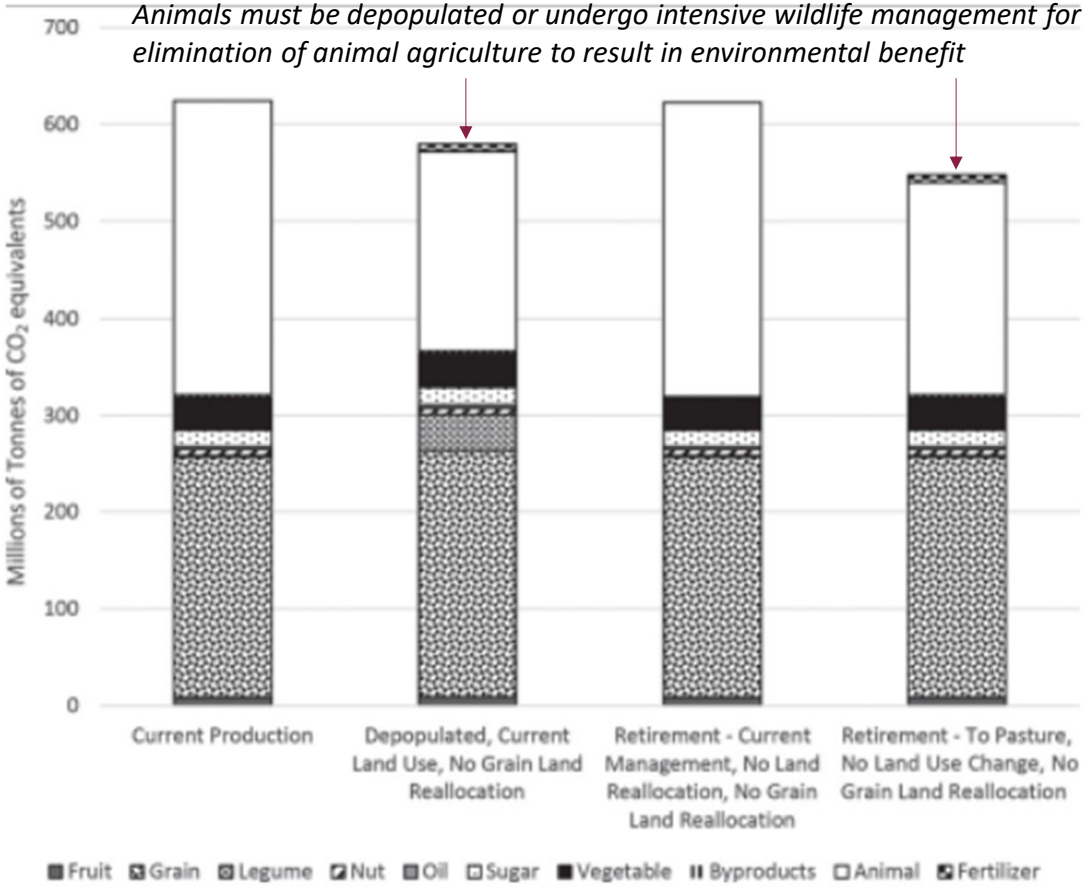
How we go about food system change matters



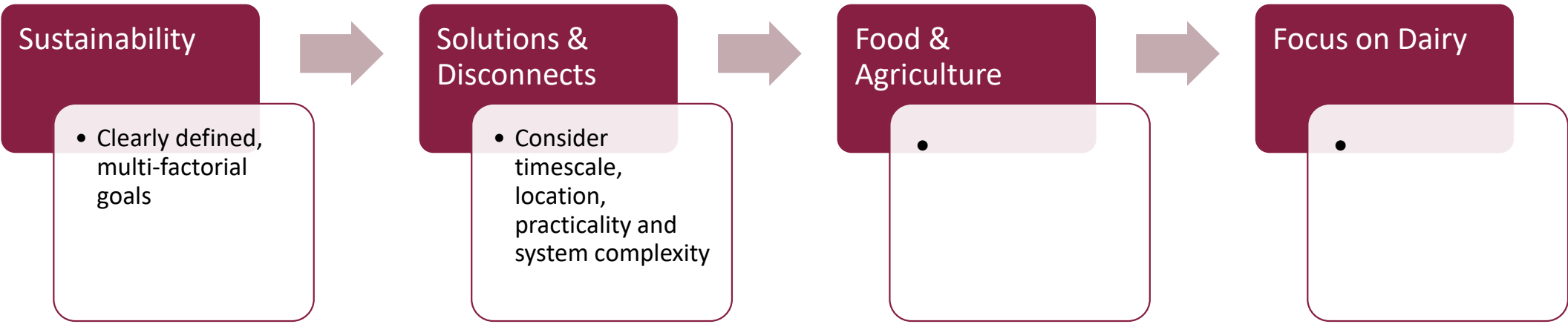
There are almost always serious nutritional consequences

Animals must be depopulated or undergo intensive wildlife management for elimination of animal agriculture to result in environmental benefit



Liebe DL, Hall MB, White RR. 2020

A Roadmap


Sustainability
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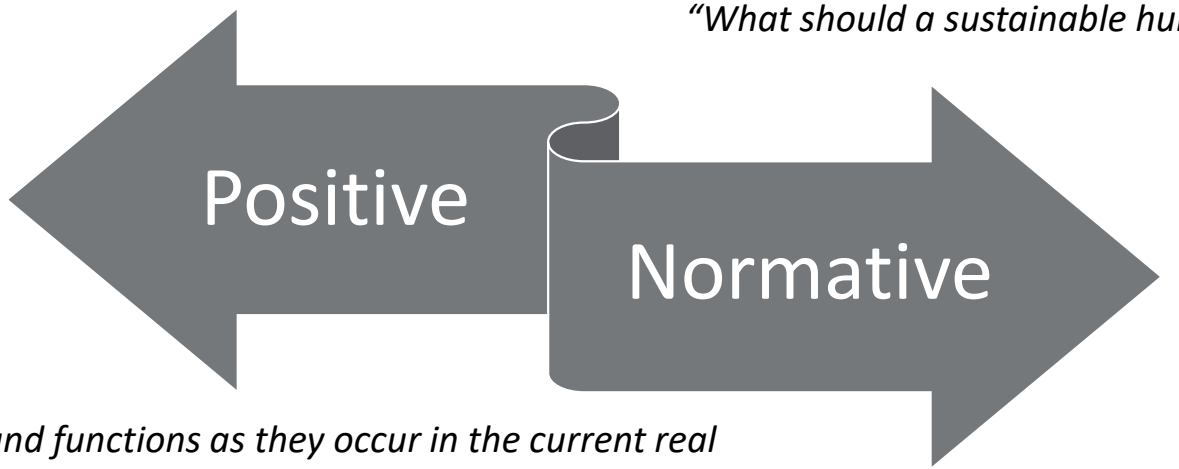
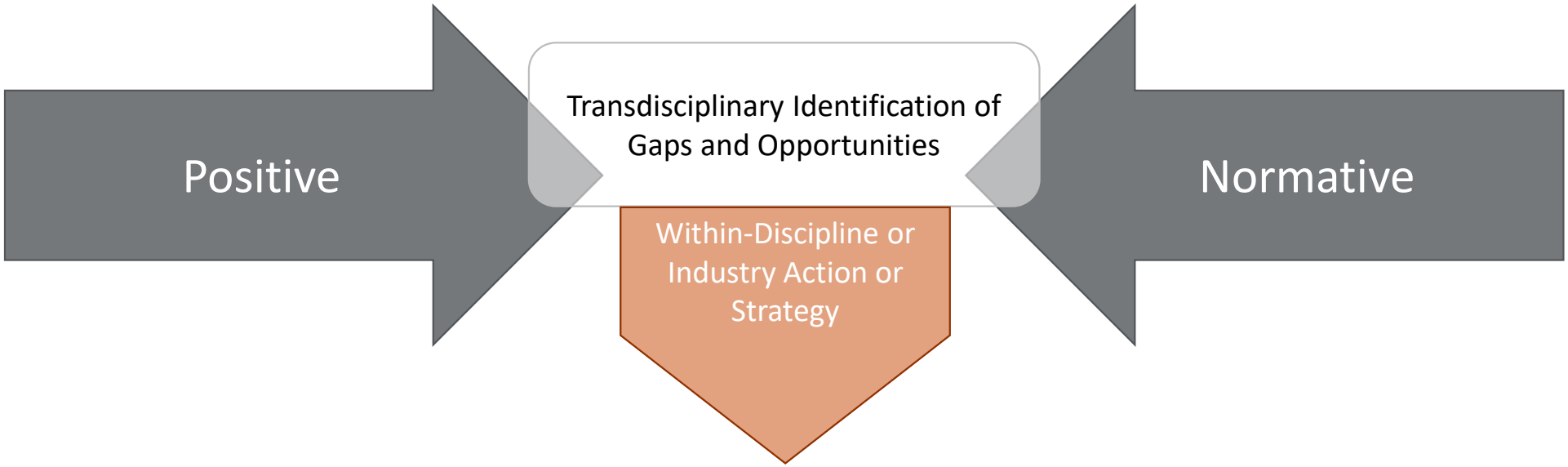
Approaches to Food Systems Investigation

Postulates aims and objectives, shaping the systems to serve the stated objectives.
"What should a sustainable human diet look like?"



Design systems structures and functions as they occur in the current real world, and identify where desirable change can be introduced.
"Where within the current food system do we have opportunities to enhance sustainability?"

A Philosophy for Food Systems Research



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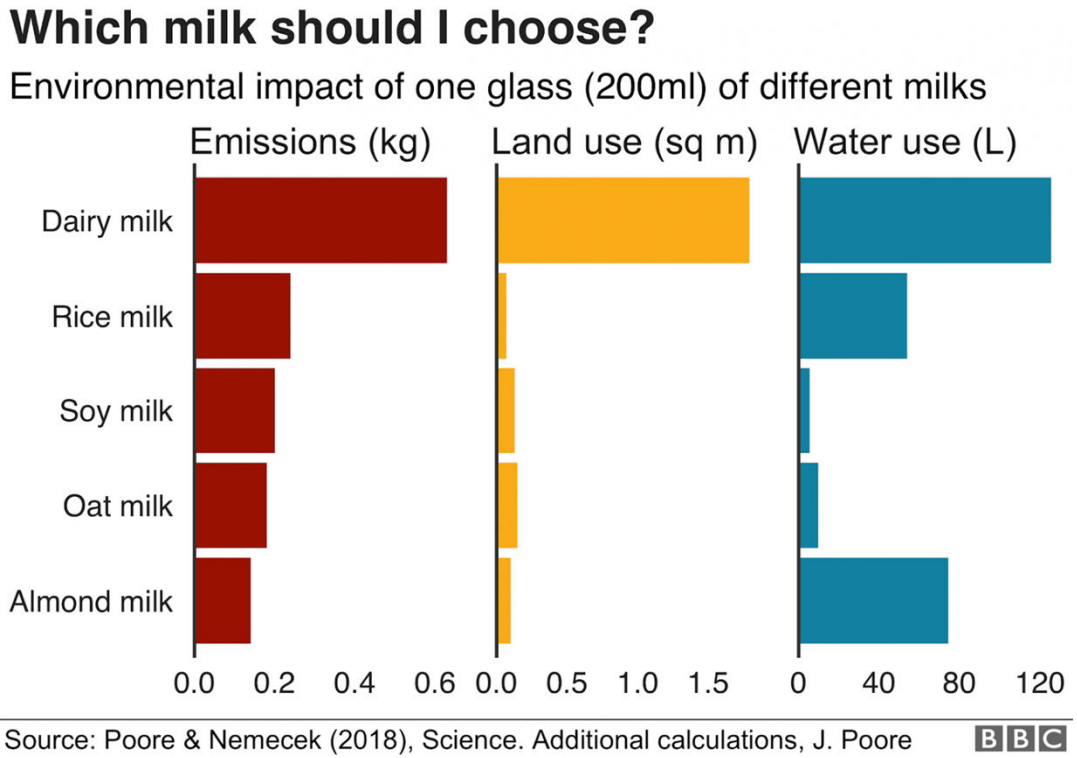

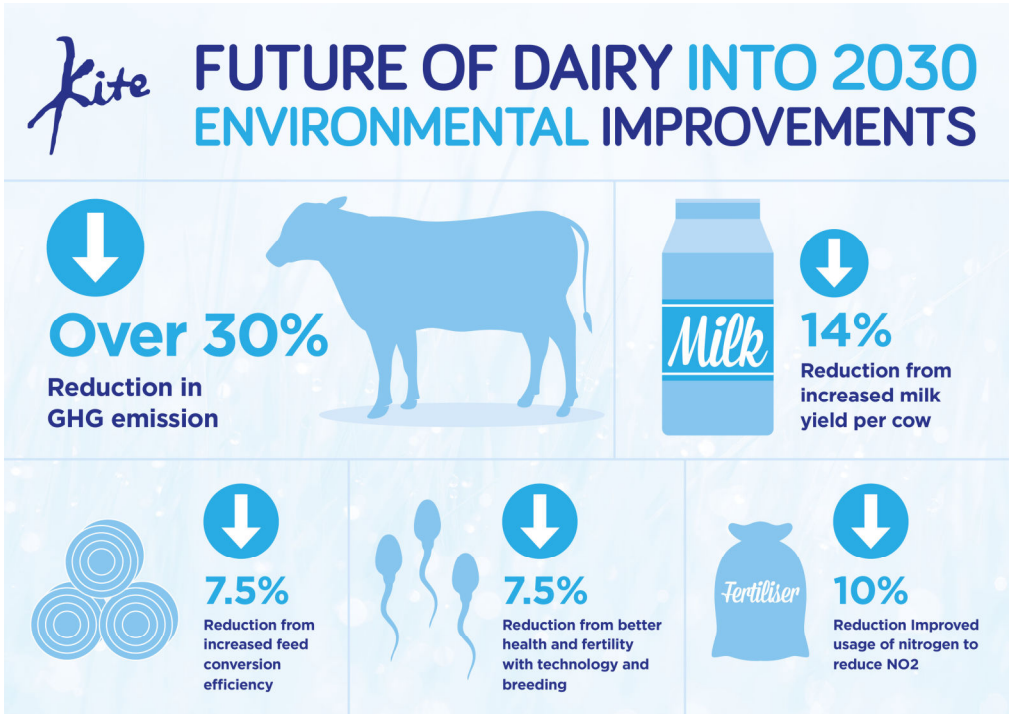

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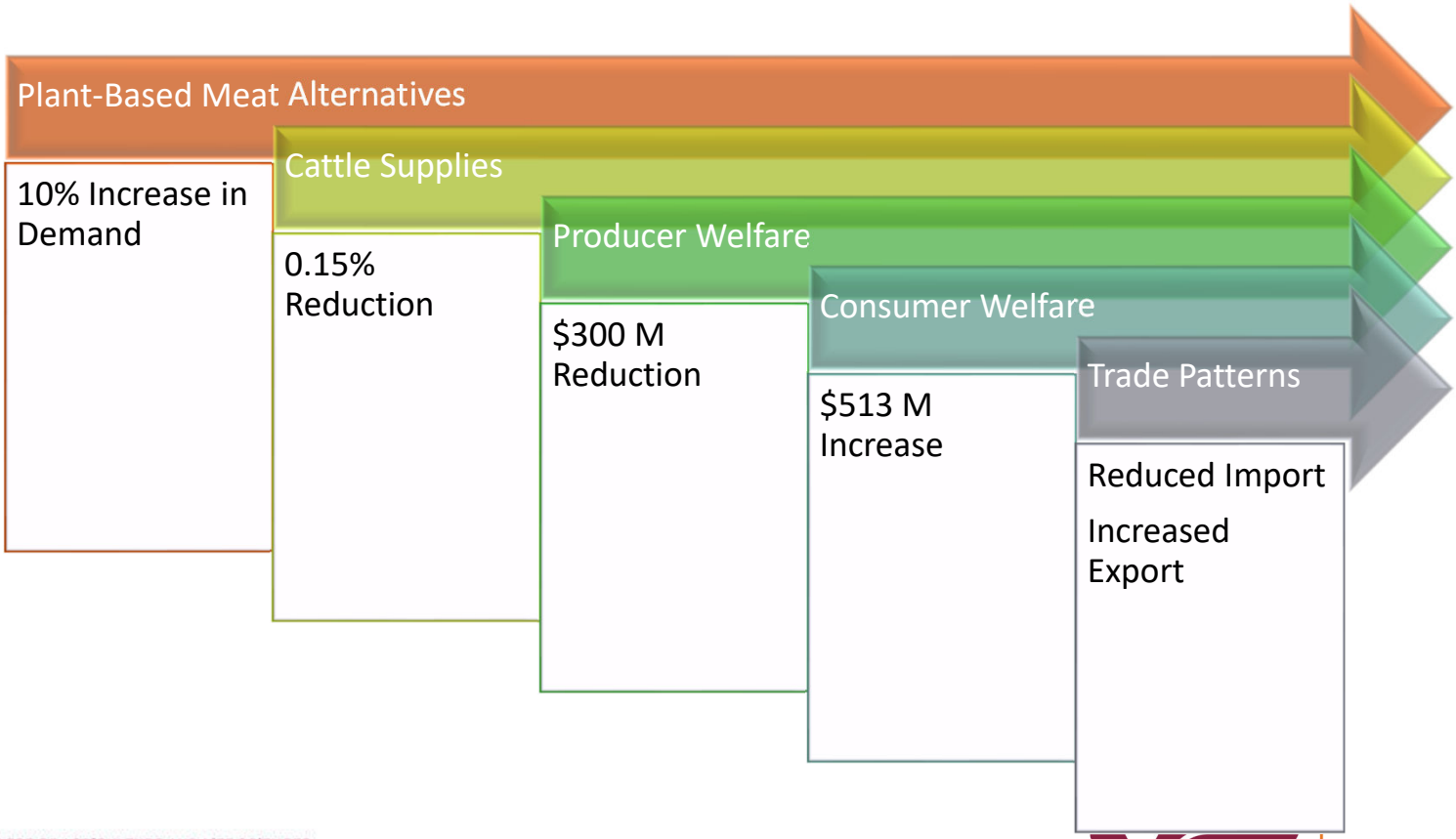
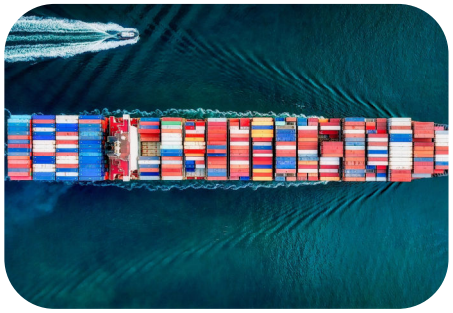
Economics Matters



Lusk et al., 2022.

Food Comes From Agriculture & Agriculture is About More Than Food

Raw Supply
Without Animals



Trade-Adjusted
Supply

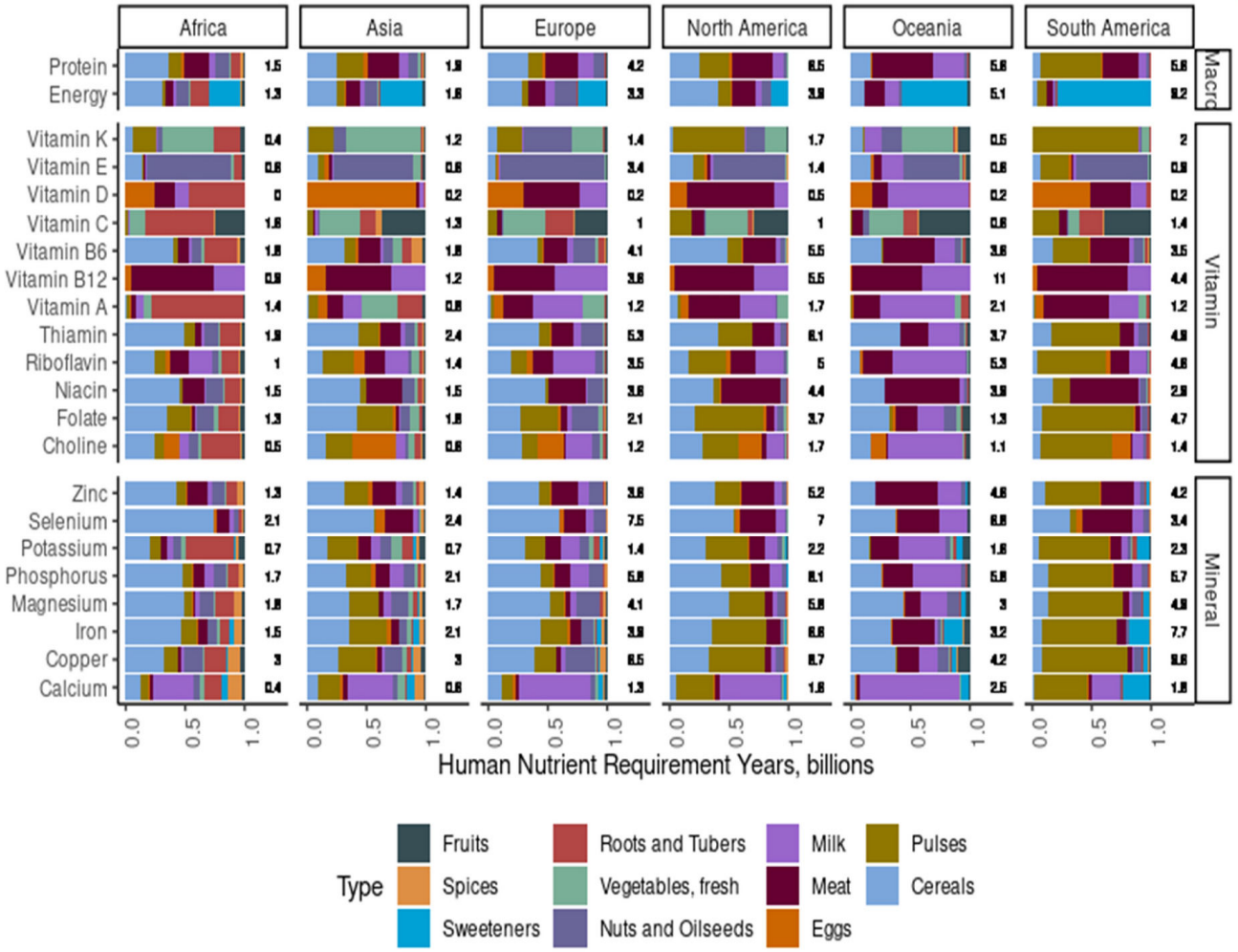
Waste-Adjusted
Supply

Animal-Adjusted
Supply

White, R.R. and Gleason, C.B., 2022.

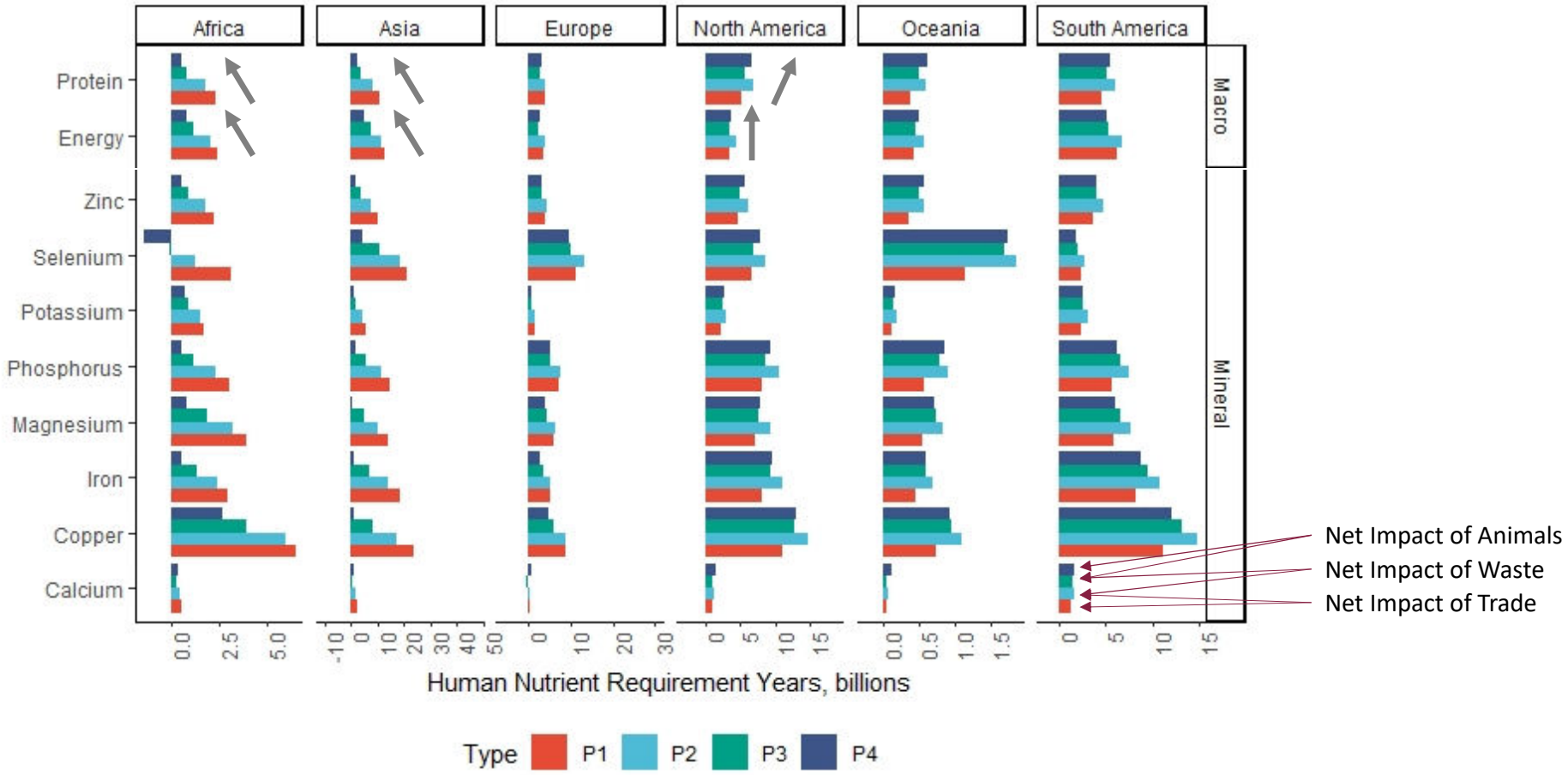
Nutrient Supplies & Their Sources

- The developed world dramatically over-produces most nutrients
- Some products are important sources (i.e., cereals); however, all nutrients have very diverse sourcing
- Nutrient sourcing importance re-ranks between geographical areas



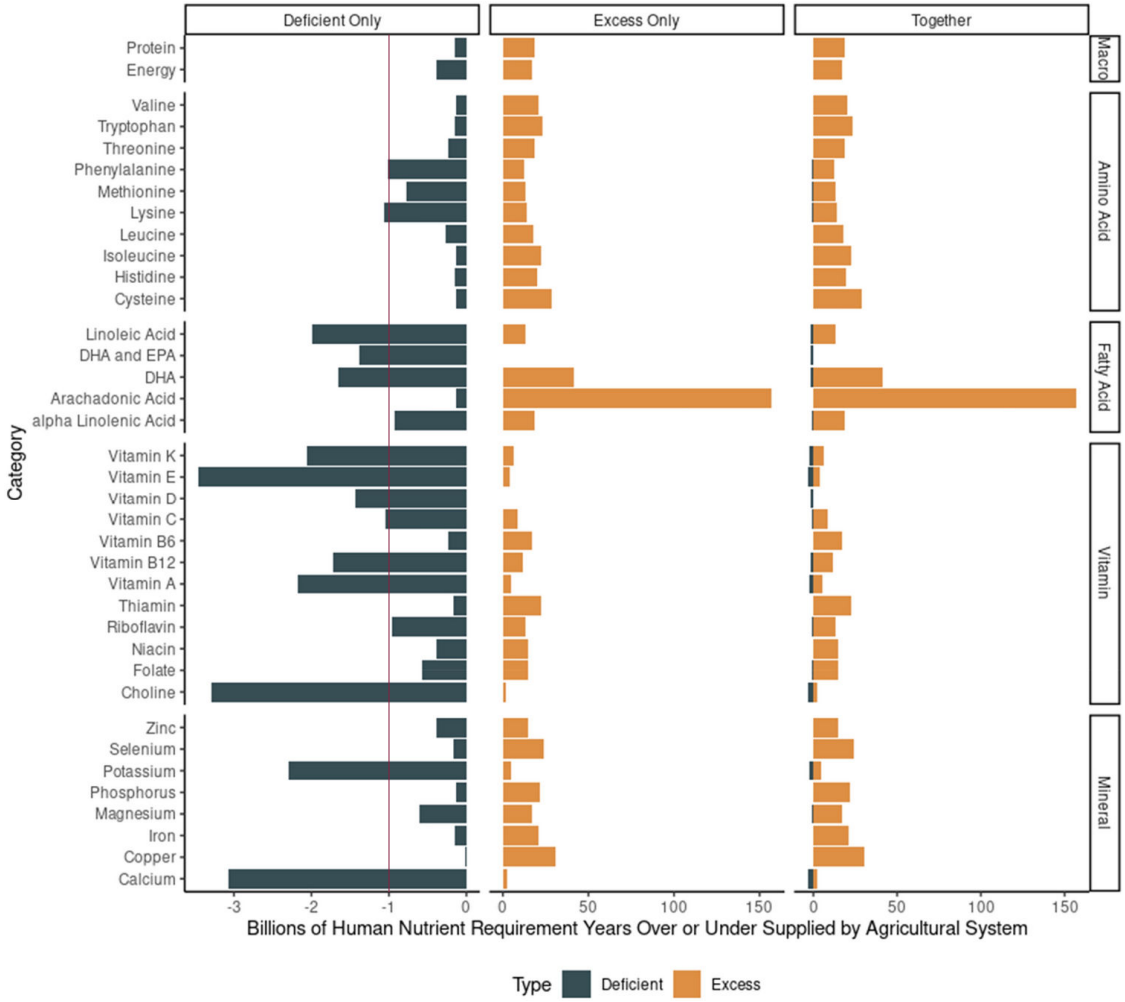
White, R.R. and Gleason, C.B., 2022.

There is Nutrient-Specific Disruption Between Agricultural Supply and Food

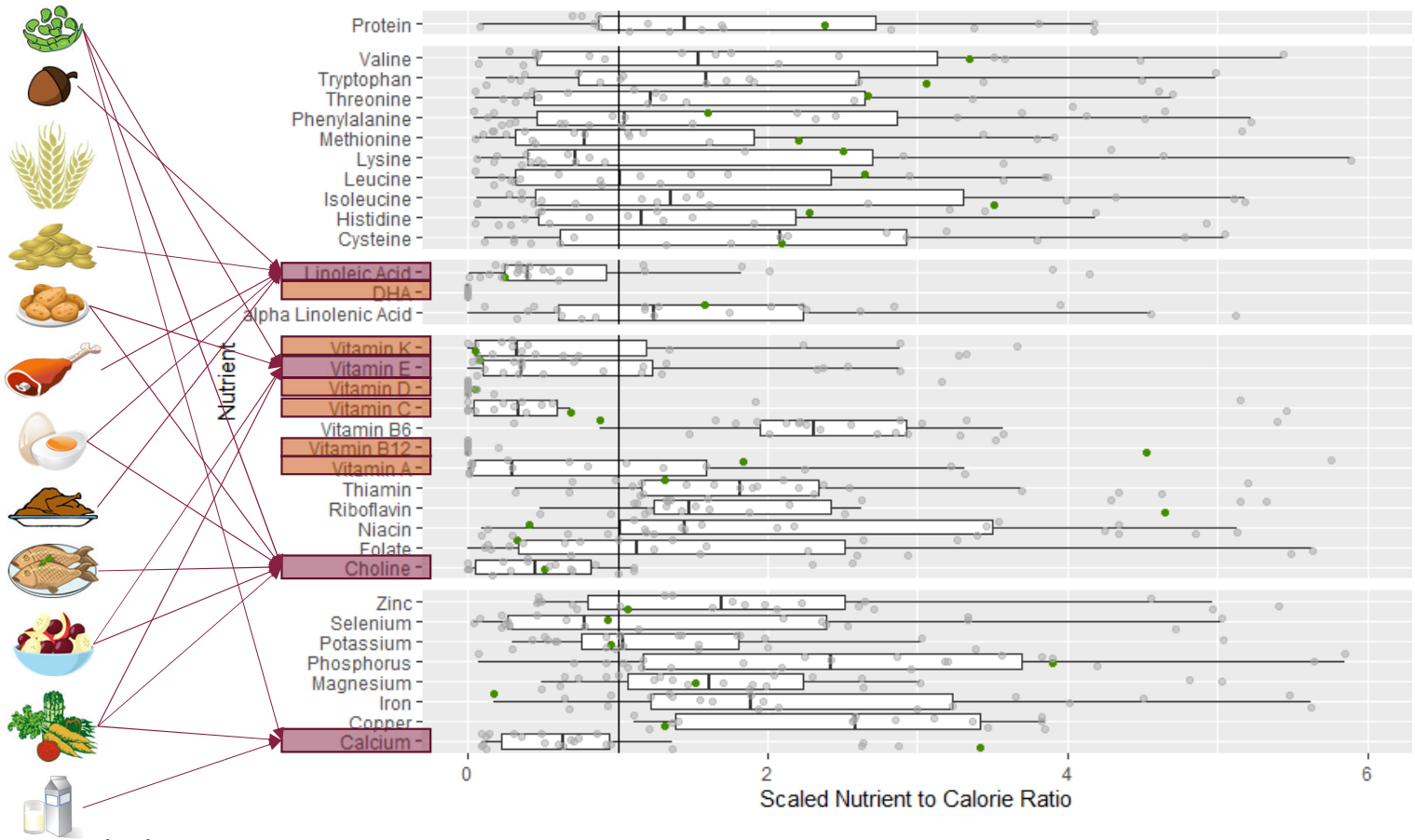


Country-Specific Analyses

- Over 3 billion people potentially at risk for limiting supplies of vitamin E, choline, and Ca based on domestically available nutrient supplies
- Over 1 billion at risk for limiting supplies of Lysine, linoleic acid, DHA, EPA, vitamins K, D, C, B12, and A, as well as potassium
- Excesses dramatically dwarf deficiencies for most nutrients
  - Exceptions: Ca, K, vitamins K, E, and A, choline, B12



Foods and Nutrient Distributions



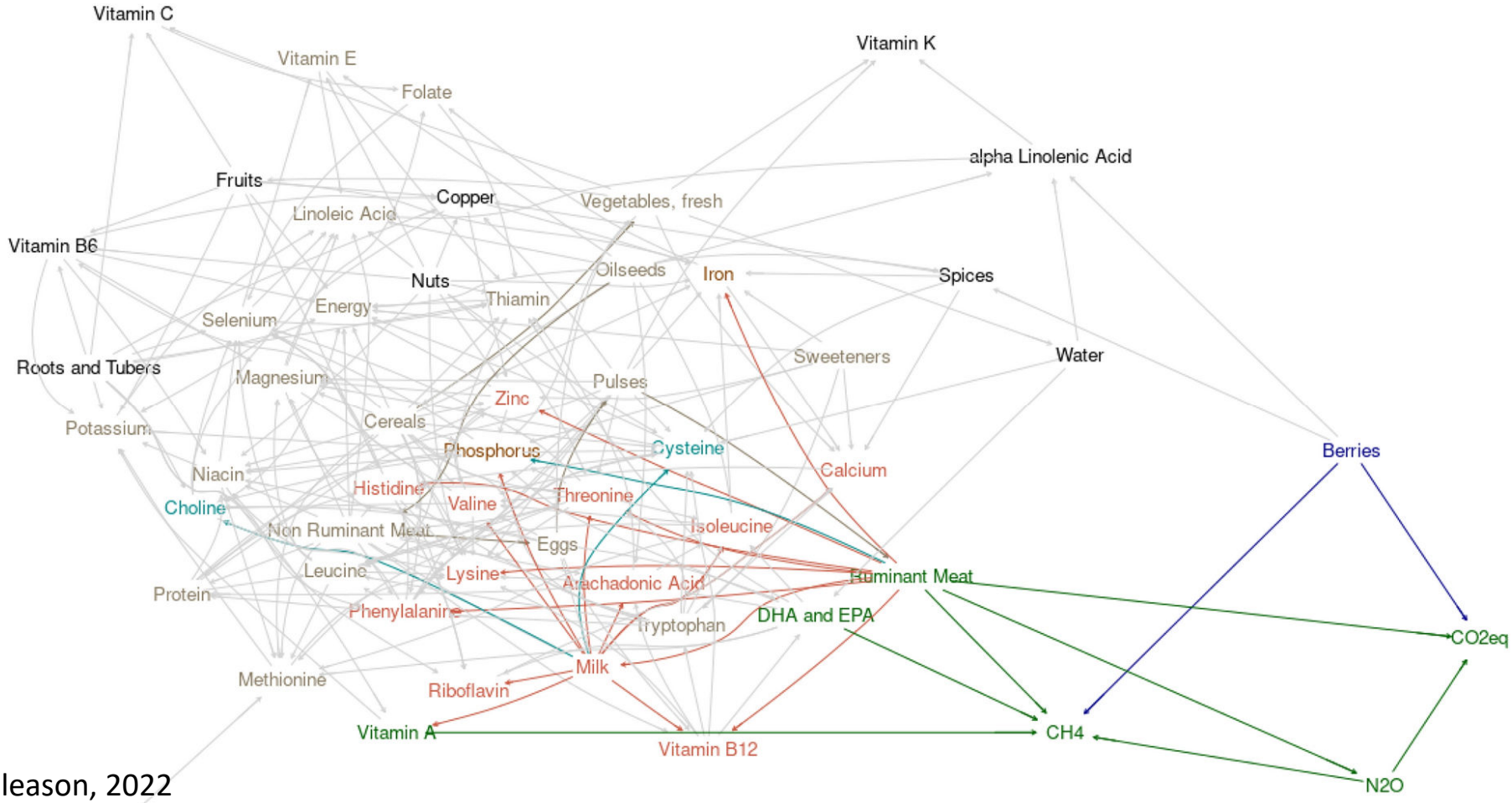
White and Gleason, 2022

Nutrient to calorie ratios help explore the nutrient density of foods.

Foods with low nutrient to calorie ratios contribute to the “obese but undernourished” phenomenon.

Food categories are complementary in their contributions to nutrient needs

Visualizing Food System Complexity



White and Gleason, 2022

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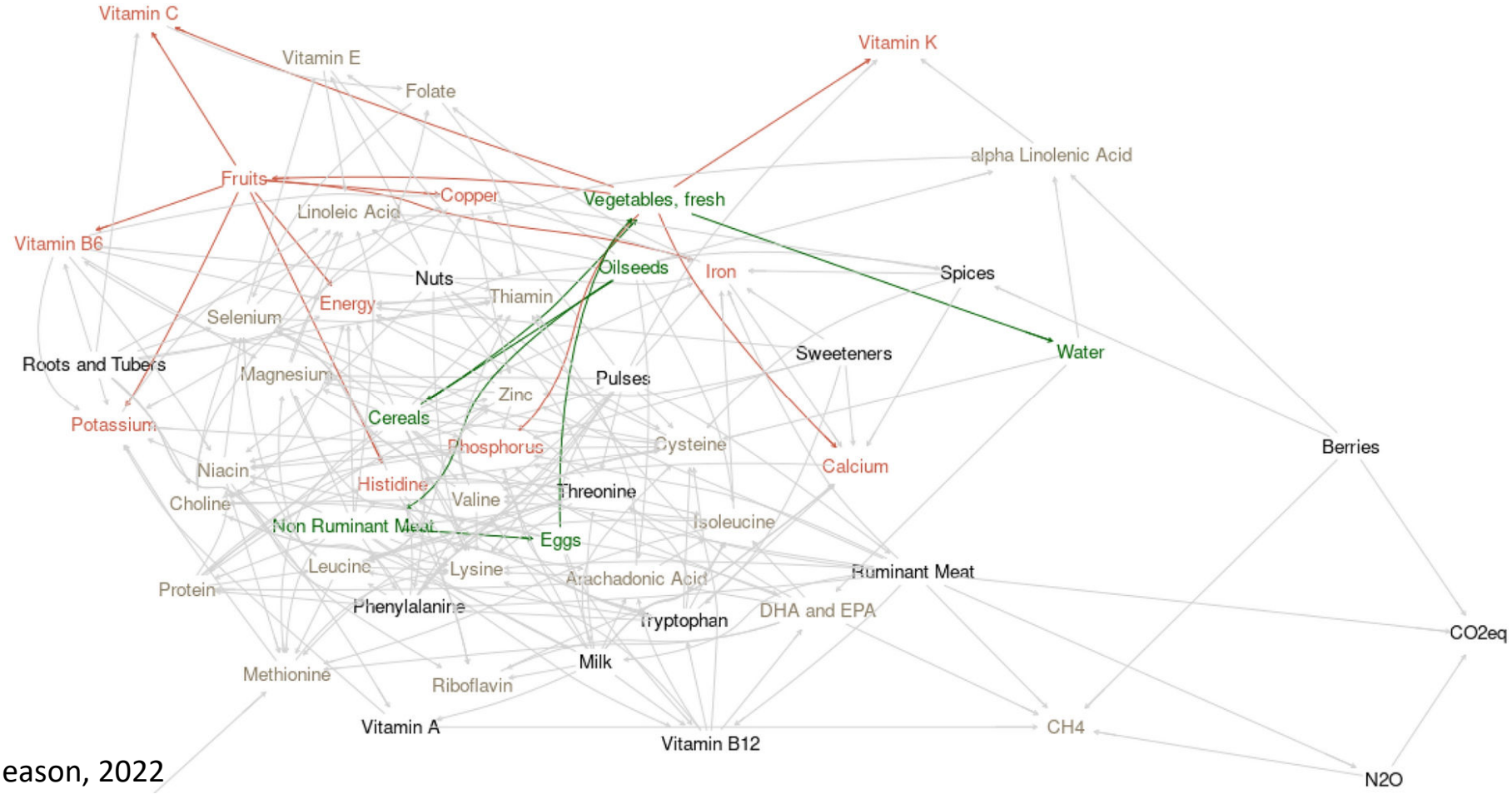
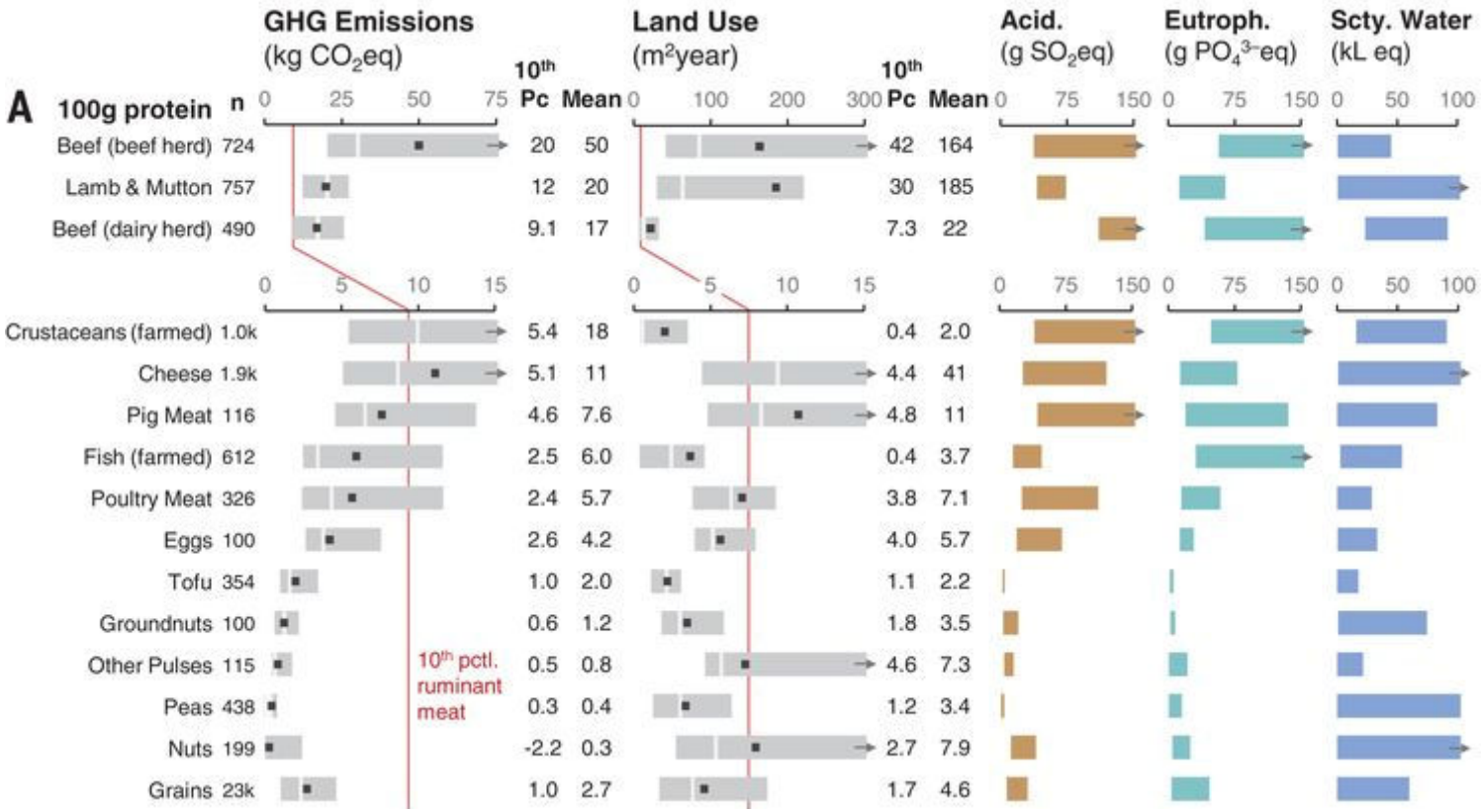


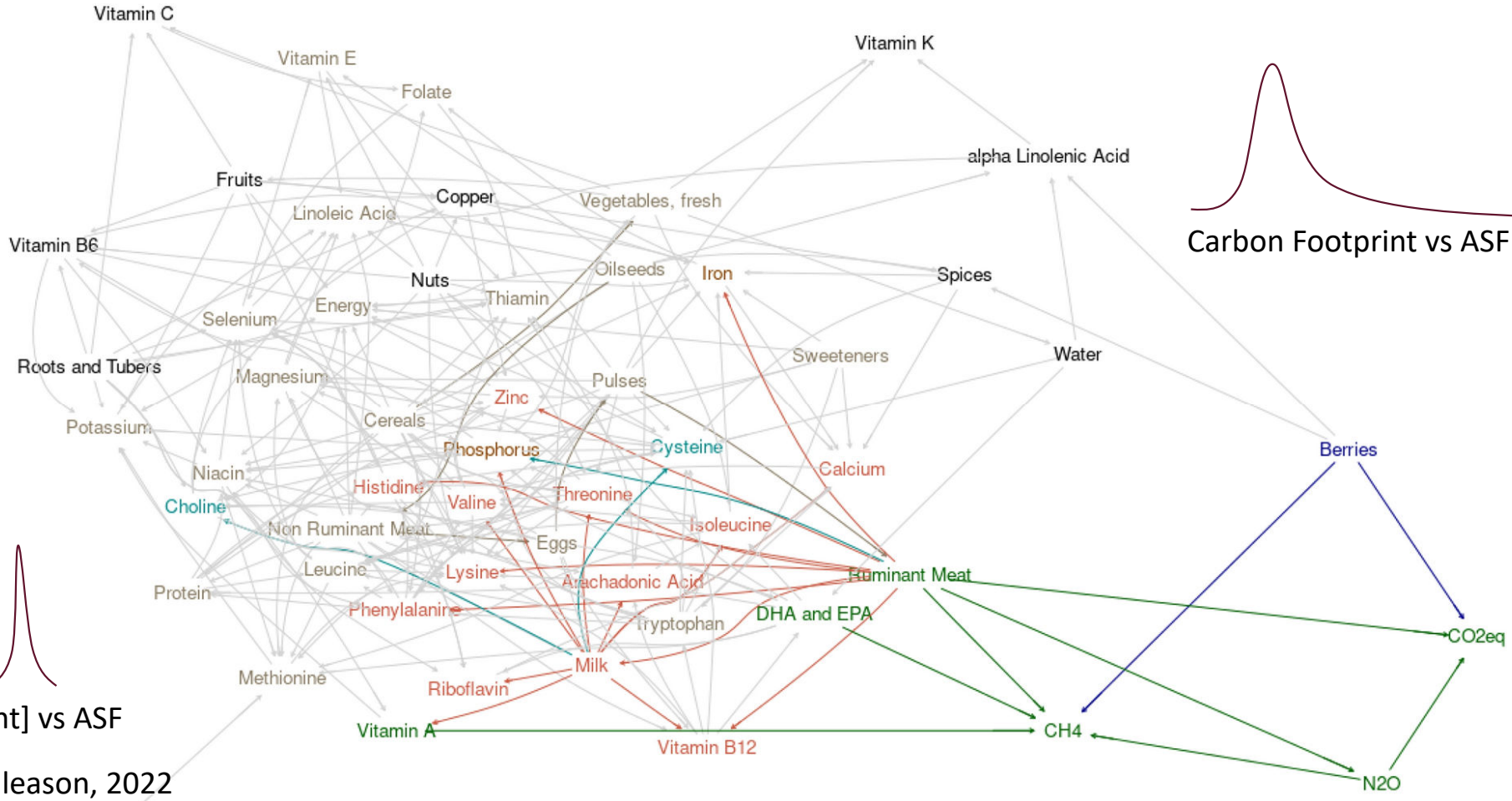
White and Gleason, 2022

Emissions Distributions are Variable and Skewed



Poore and Nemecek, 2018

Visualizing Food System Complexity



Carbon Footprint vs ASF

[Nutrient] vs ASF

White and Gleason, 2022

A Roadmap

Sustainability

- Clearly defined, multi-factorial goals

Solutions & Disconnects

- Consider timescale, location, practicality and system complexity

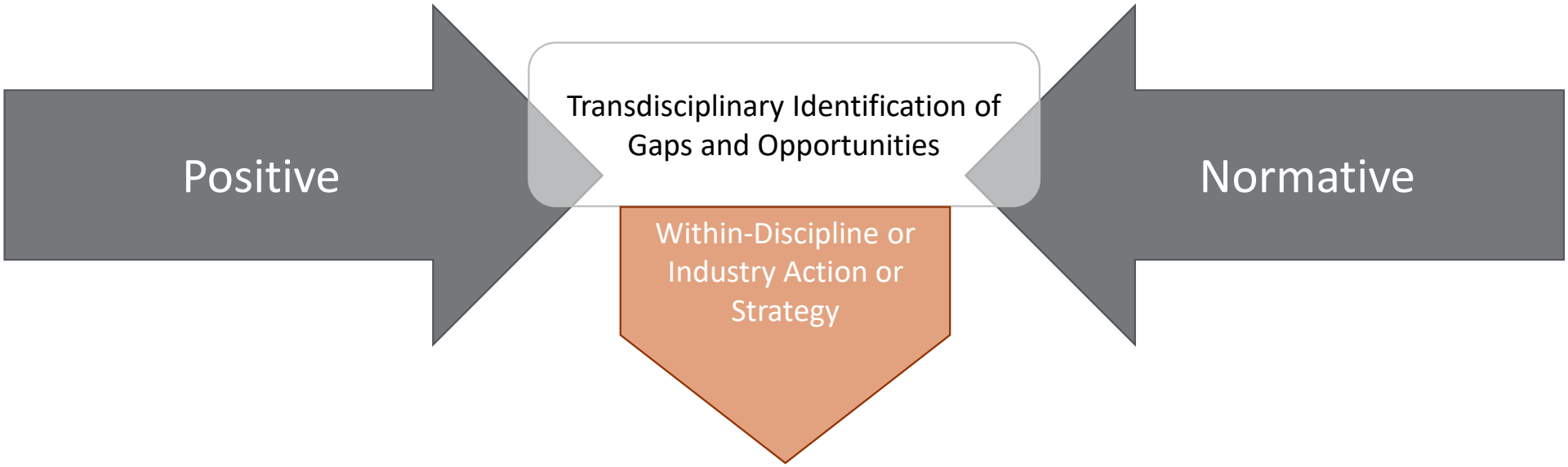
Food & Agriculture

- Food systems are complex and involve compromises

Focus on Dairy

-

A Philosophy for Food Systems Research



Desirable change:

Decoupling environmental impacts from production of animal products, fruits, and vegetables

The Goals are Already Set

UNDENIABLY DAIRY

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Home > Looking for Farmer Resources? > Farmer Blog & Checkoff News > Net Zero Initiative Is Right Move for Dairy at Right Time

Net Zero Initiative Is Right Move For Dairy At Right Time

August 4, 2020

Cargill expands climate change commitments

Company makes science-based commitment to reduce supply chain emissions by 30% by 2030; reinforces commitment to goals of the Paris Climate Agreement

2050 Environmental Stewardship Goals

By 2050, U.S. dairy collectively commits to:

1. Achieve GHG neutrality[1]
2. Optimize water use while maximizing recycling
3. Improve water quality by optimizing utilization of manure and nutrients

Tyson Foods Targets 2050 to Achieve Net Zero Greenhouse Gas Emissions

JBS is committing to be Net Zero by 2040.

The U.S. dairy industry is leading by example with a commitment to environmental sustainability, working toward a set of goals that include cleaner water with maximized recycling and carbon neutrality by 2050.

ALISHA STAGGS

Dairy Program Manager for TNC's North America Agriculture Program

Thinking About Links Between Efficiency and Sustainability

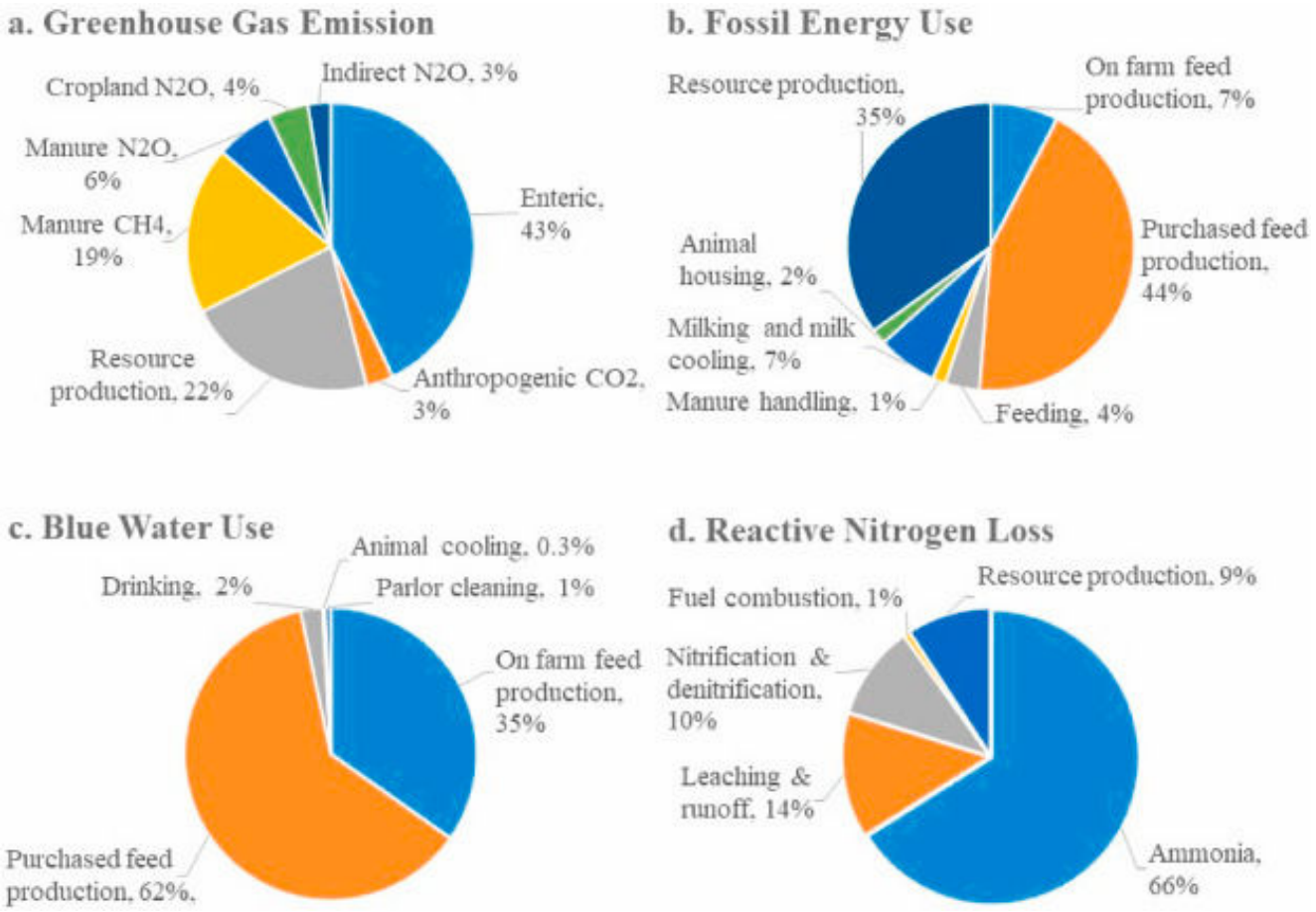
Fewer Animals

Fewer Days Alive

Direct Mitigation

Fewer Resource Inputs

Sources of Environmental Impacts on U.S. Dairies

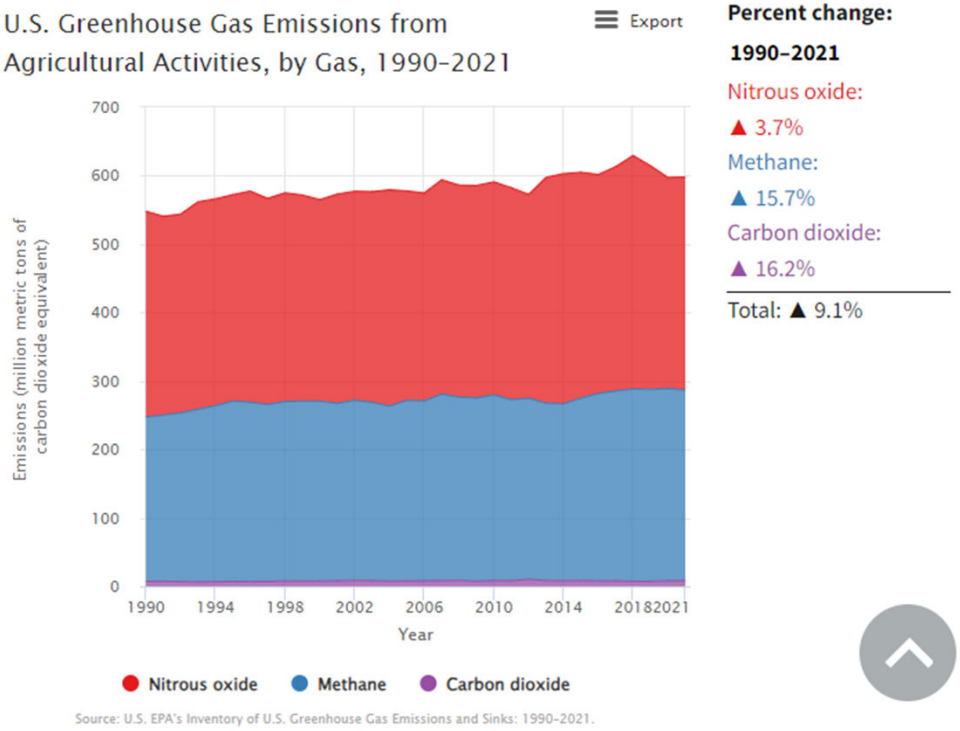


- Enteric methane, feed production, and manure management are the major GHGe contributors
- Feed production is also the major blue water use

Rotz et al., 2021

GHG Profiles and Why They Matter

Greenhouse Gas (GHG)	Atmospheric Lifetime (yrs)	Global Warming Potental (GWP)	Primary Current Sources
Carbon dioxide (CO_2)	50-200	1	Fossil fuel use, land use, cement
Methane (CH_4)	12±3	21	Fossil fuel use, agriculture
Nitrous oxide (N_2O)	120	310	Mostly agriculture, ~1/3 are anthropogenic
Hydrofluorocarbons (HFCs)	1.5 to 209	150 to 11,700	Alternative to ozone depleting substances
Perfluorocarbons (PFCs)	2,600 to 50,000	6,500 to 9,200	Primary aluminum production; semiconductor manufacturing
Sulfur Hexafluoride (SF_6)	3,200	23,900	Used in electric power transmission, magnesium and semiconductor industries



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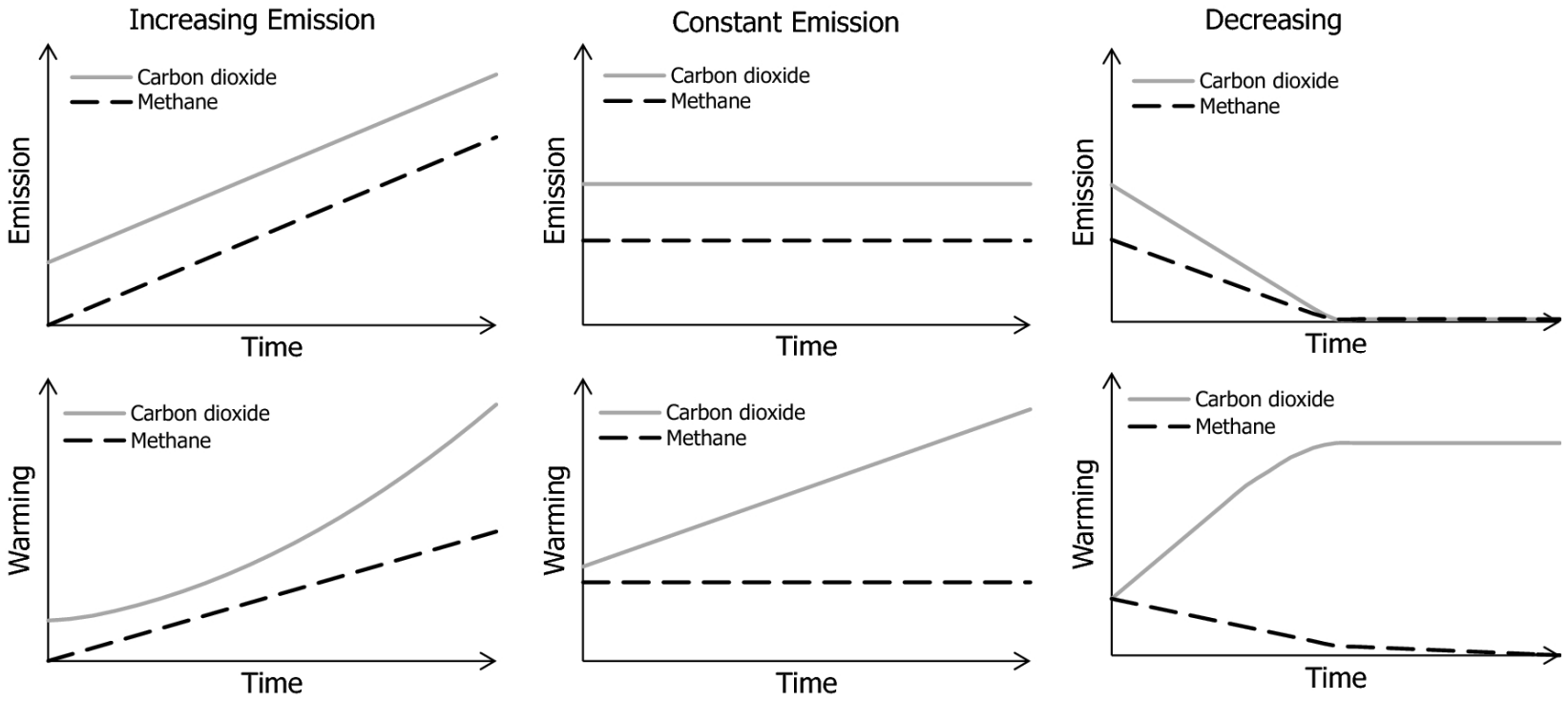
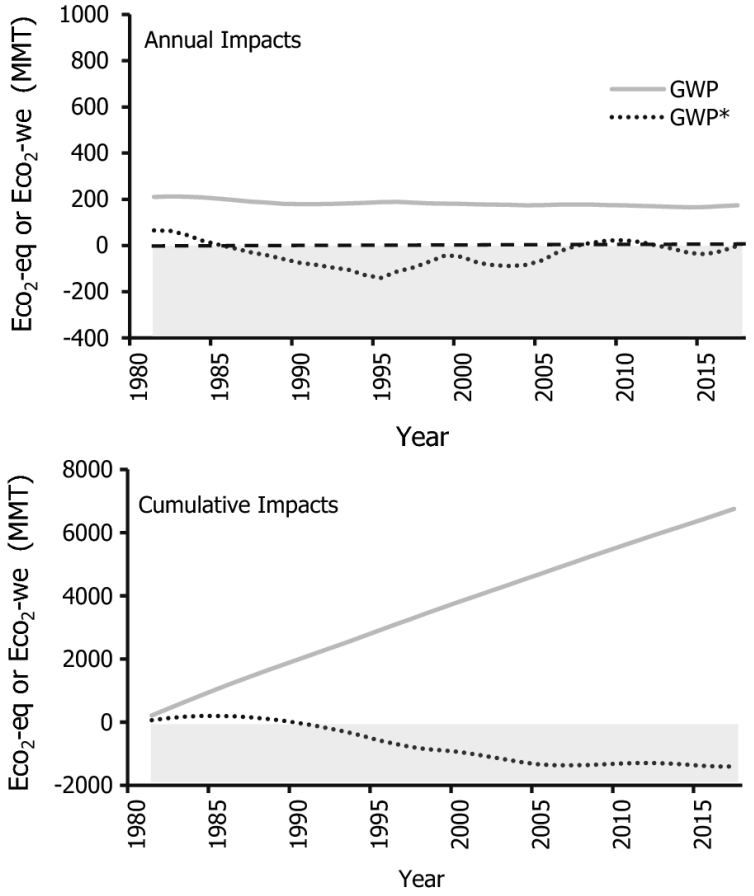
Why do we focus so intently on methane?



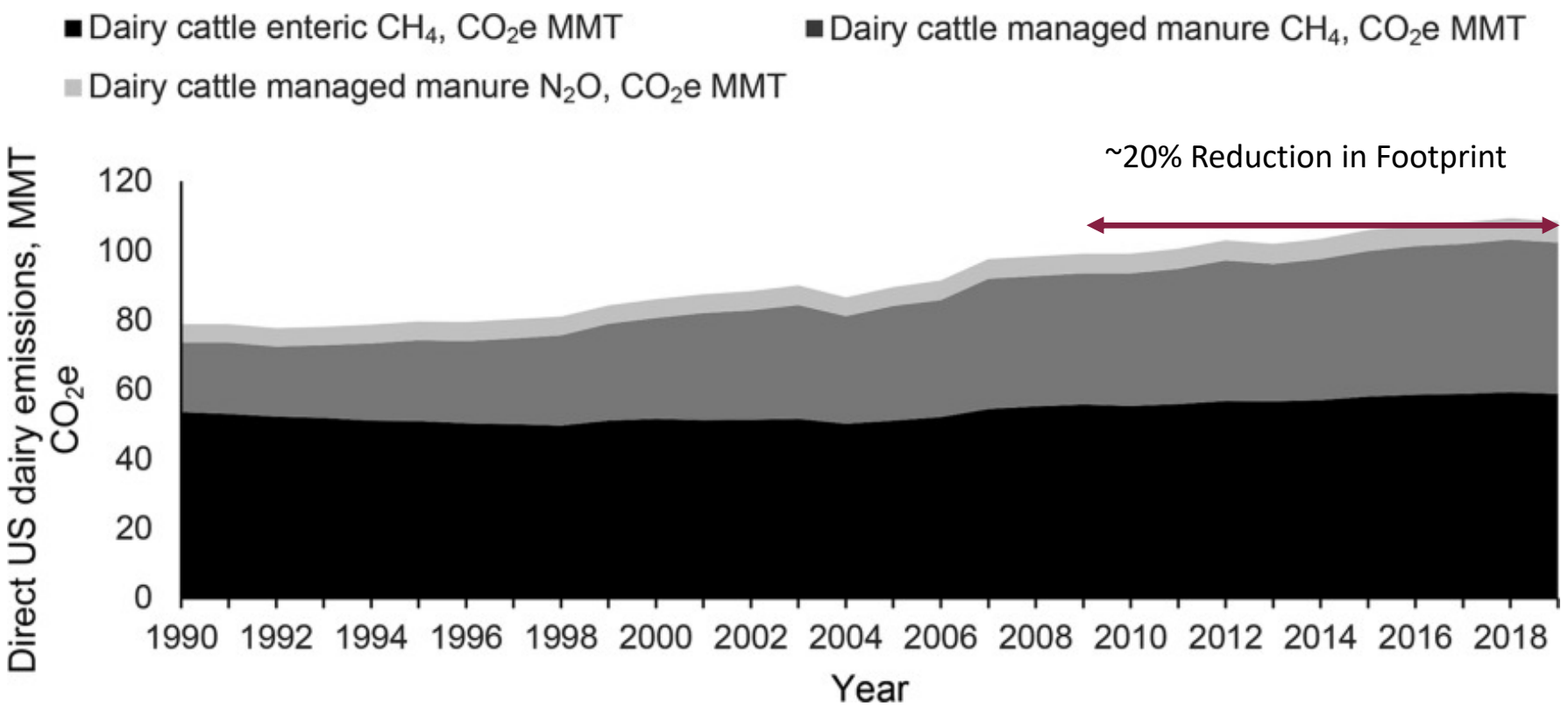
Benchmarking

- Under GWP* system, U.S. cattle industry has not contributed additional (“new”) warming since 1986
- In Ca, 1%/year reductions in CH4 would support neutrality within a decade



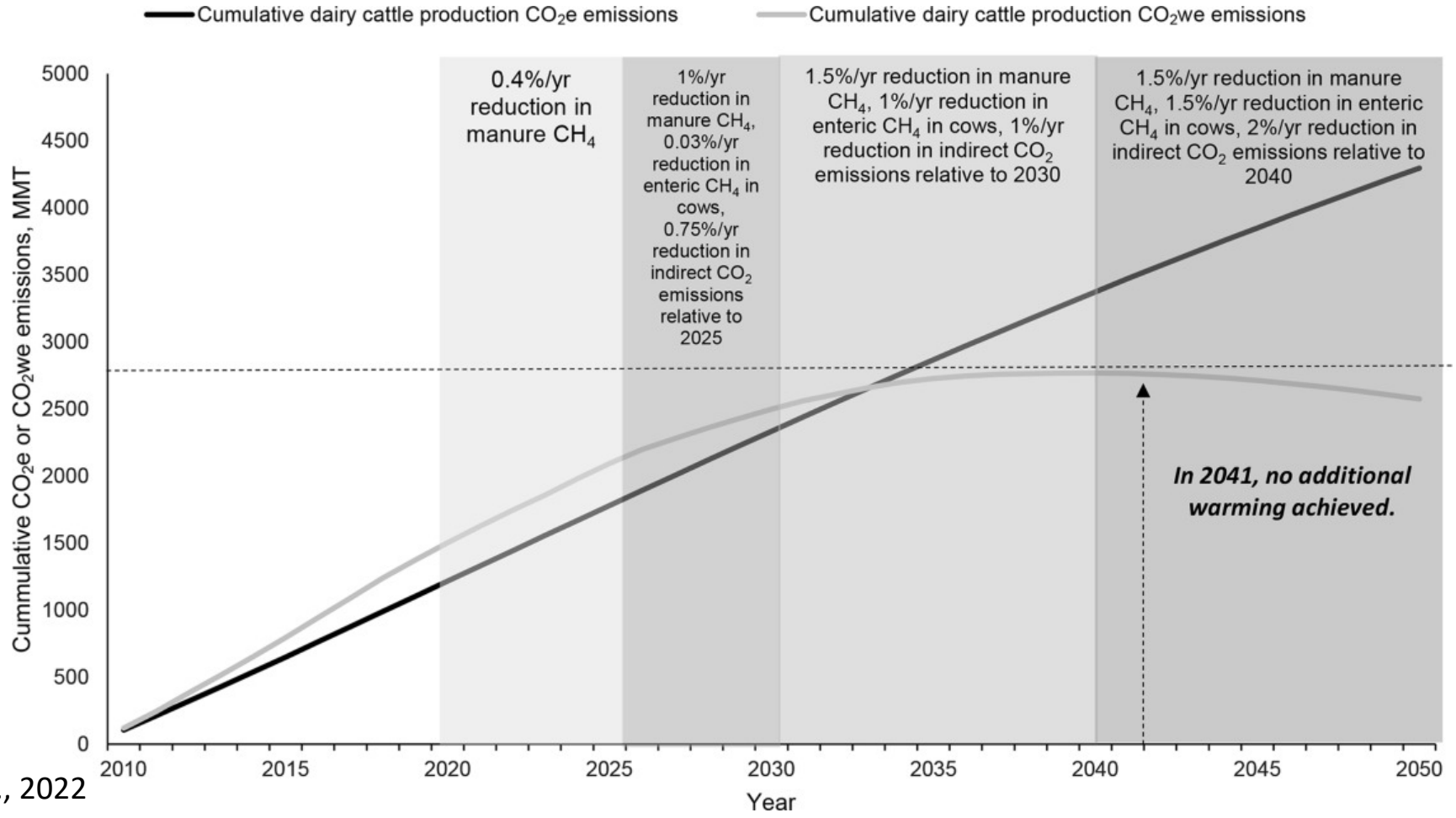
Liu et al., 2021

Time-series Changes in Emissions



Place et al., 2022

A Roadmap for Neutrality



Place et al., 2022

A Roadmap

Sustainability

- Clearly defined, multi-factorial goals

Solutions & Disconnects

- Consider timescale, location, practicality and system complexity

Food & Agriculture

- Food systems are complex and involve compromises

Focus on Dairy

- GHG neutrality is likely by 2040, but will likely shift farm system economics

Some Take Home Messages

- Food systems and sustainability metrics are not homogenous. *Careful consideration of the **context** of numbers is essential to proper interpretation.*

- The food system is **complex**, locally and globally. *Simple solutions often ignore that complexity.*

- There exists **complementarity** among the profiles of food produced which help satisfy human nutrient needs. *Food systems sustainability should consider and harness that complementarity.*

- The current food system is a study in **compromise.** Nutrient dense foods are environmentally intensive to produce. *Directly addressing the environmental impacts of those foods may help alleviate this need for compromise between nutritional and environmental objectives.*

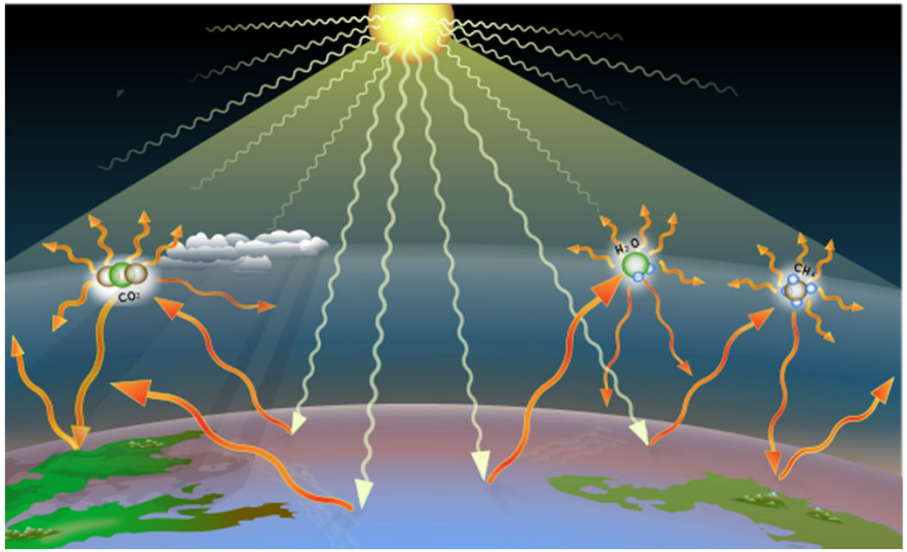
- The dairy industry has a well-defined pathway toward climate neutrality; however, the ways in which that transition will influence farm economics and food prices will depend on incentive/tax programs and structures

Some common questions…

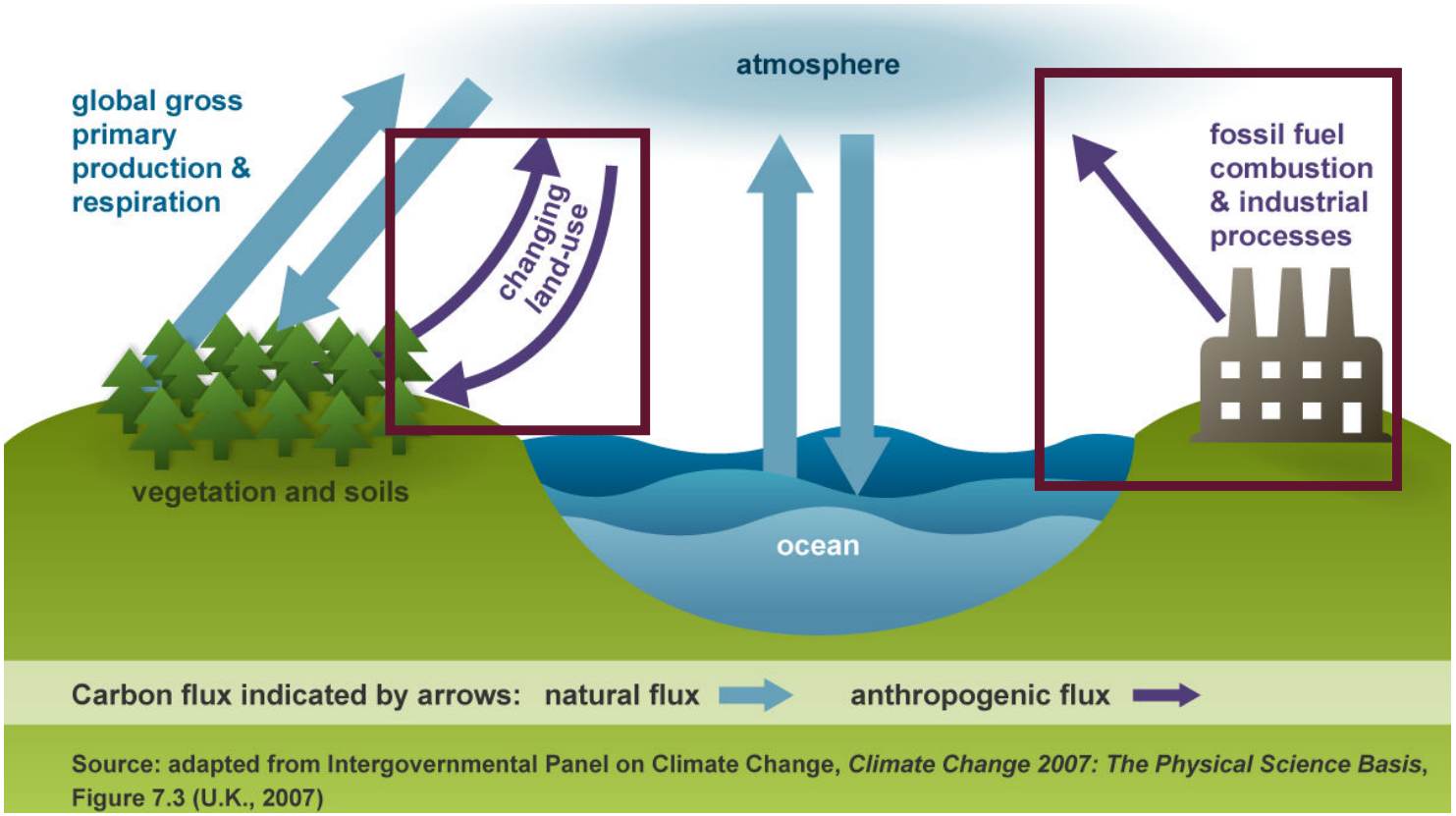
- What is climate change?
- Is climate change natural or caused by humans?
- Are cows causing climate change?
- What should I be doing in this space?

What is a GHG?

- Naturally occurring or human generated
- Trap and re-emit heat within the earth's atmosphere
- Carbon dioxide (CO2), methane (CH4), nitrous oxide, and fluorinated gases (HFC)



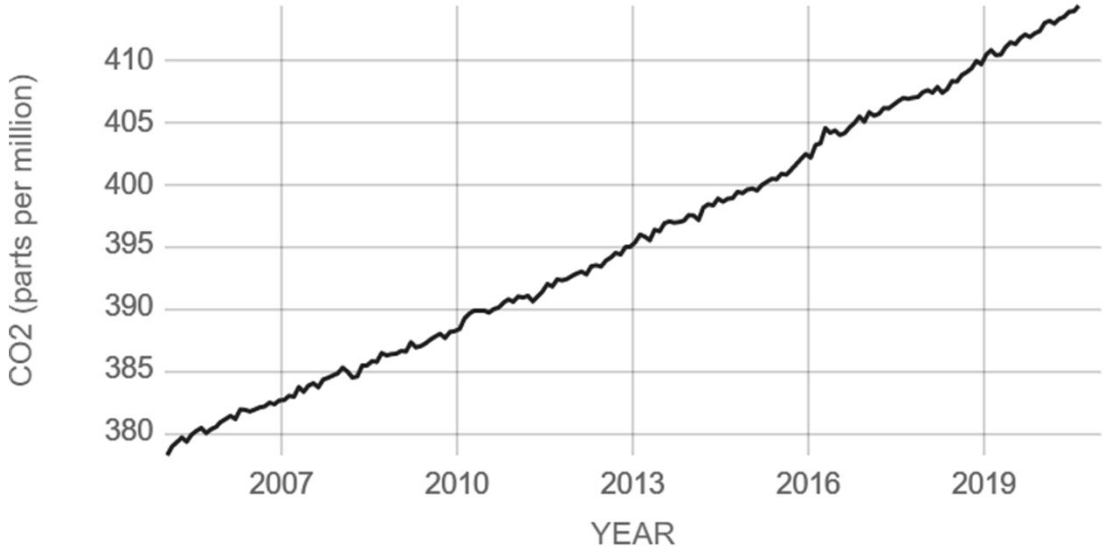
Sources of GHG



- Natural Sources: respiration, decomposition of organic matter, volcanic eruptions
- Human Activities: burning fossil fuels & contributing to land-use change

Some Data on Concentrations…

- Over past 170 years, CO_2 raised 47% above pre-industrial (<1850)
- Greater change than happened naturally over 20,000 year period

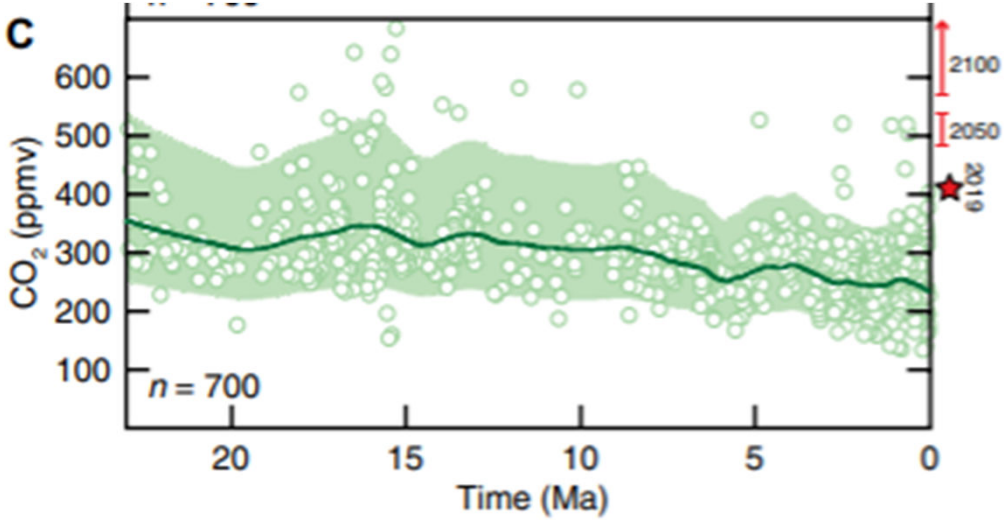


Source: climate.nasa.gov

How can we be sure concentrations are changing?

- Measurement of CO_2
  - Ice cores
  - Stomata
  - Direct observations

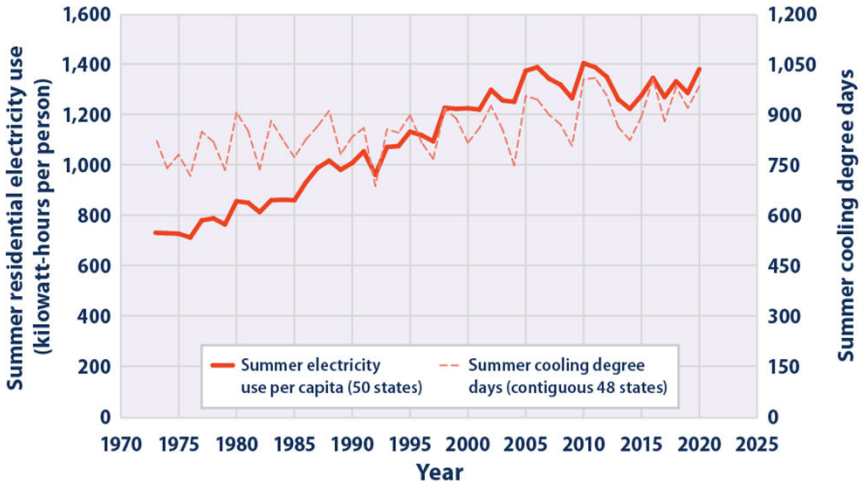
- New method (Cui et al. 2020)
  - Isotope residues in terrestrial plants
  - Consistent measurement for 23 million years
  - Figure 1 show at right

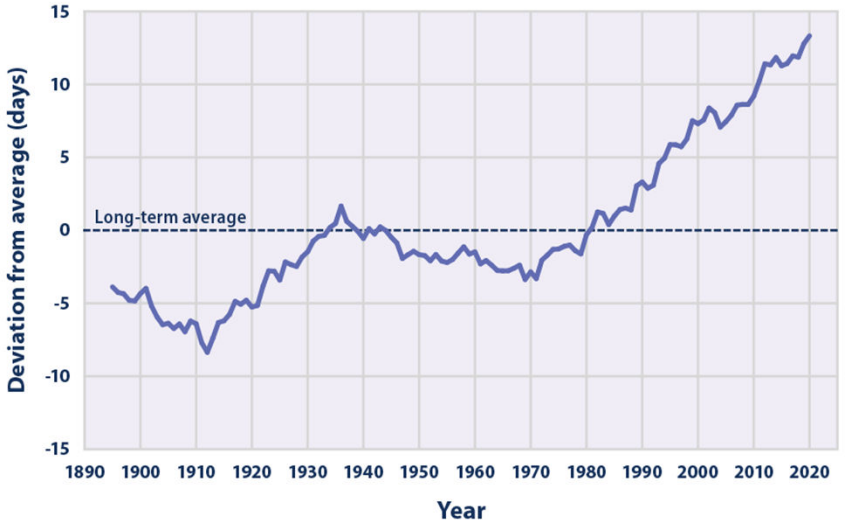


Red star: Present day CO_2
Red bars: IPCC Projections for 2050 and 2100 CO_2
Green line: Locally weighted fit through individual samples with shaded area reflecting 16th to 84th percentile range

U.S. EPA Data on Climate Change Indicators

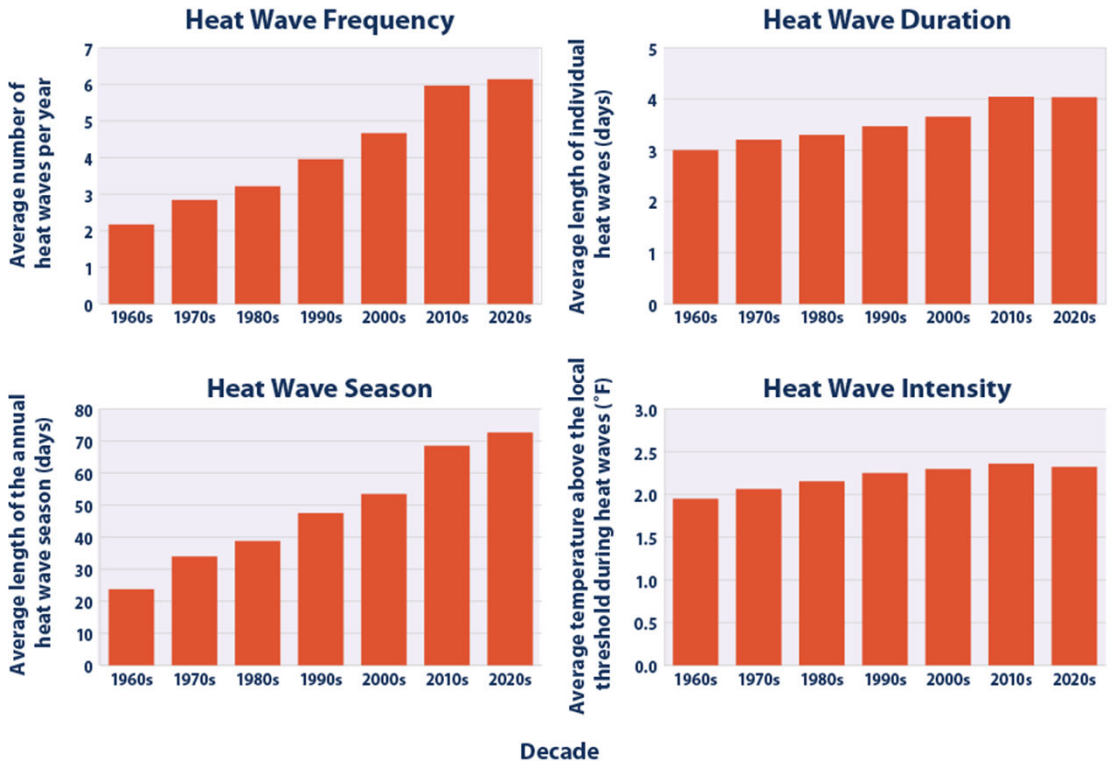
Summer electricity use per capita has doubled since 1970





Increasing deviation from average growing season length

U.S. EPA Data on Climate Change Indicators



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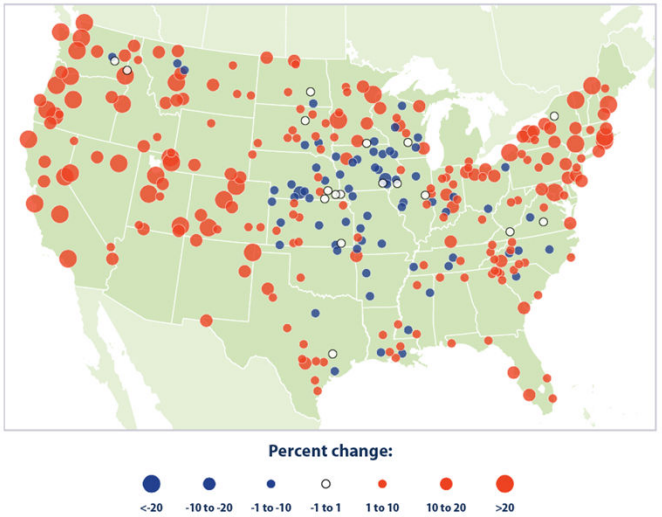
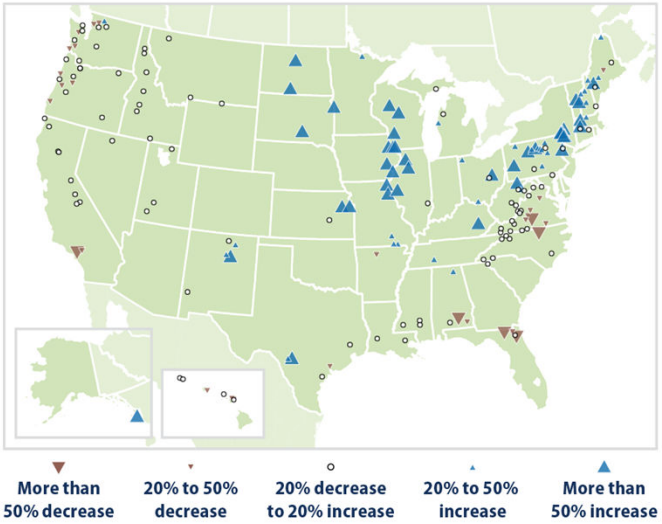
U.S. EPA Data on Climate Change Indicators

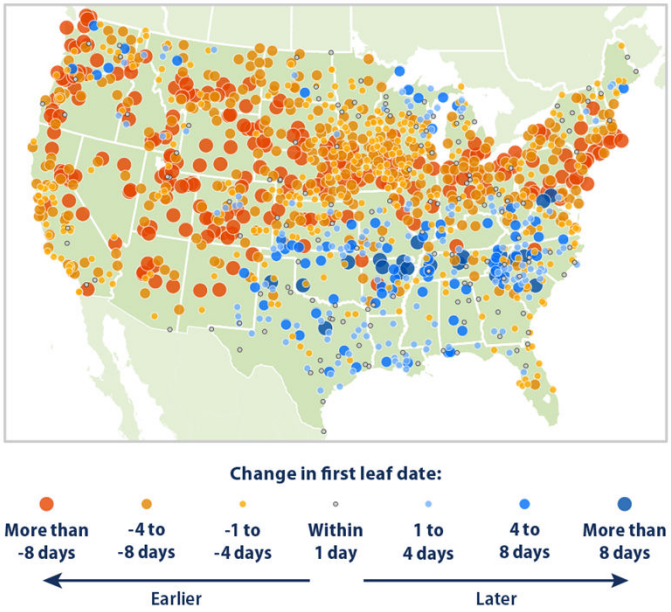
Growing Degree Day Changes (1948 – 2020)



Stream Flow Changes (1940-2018)



First Leaf Date Changes (1950s-2010s)



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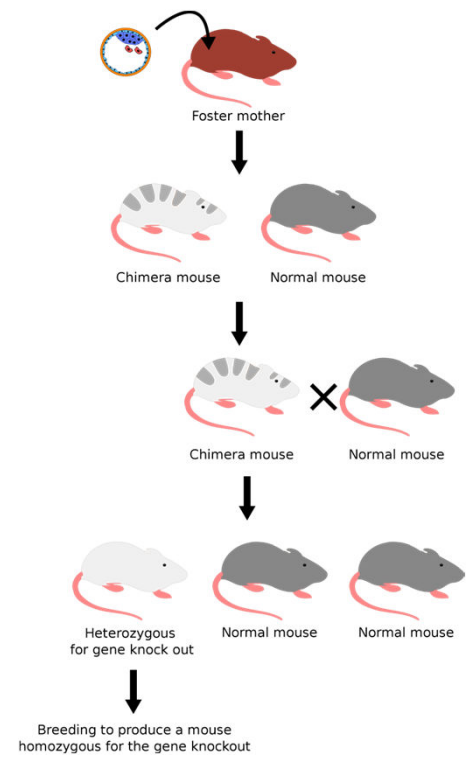
Some common questions…

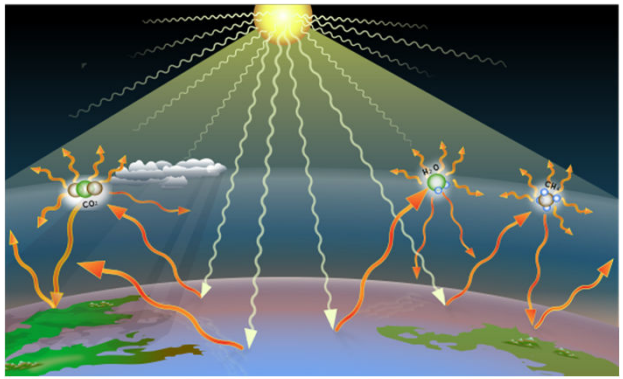
What is climate change?	Shifts in temperature and precipitation averages and patterns, linked with concentrations of GHG
Is climate change natural or caused by humans?	
Are cows causing climate change?	
What should I be doing in this space?	

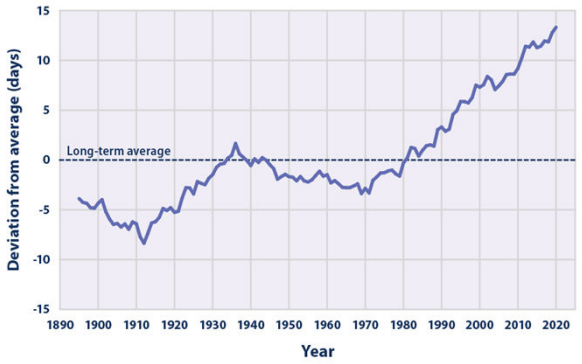
Correlation vs Causation



- Correlation is most commonly assessed in science
- Causation requires specific types of experimentation
  - Mechanism or function driven
  - "First principles"

- Which type of information do we have about climate change?





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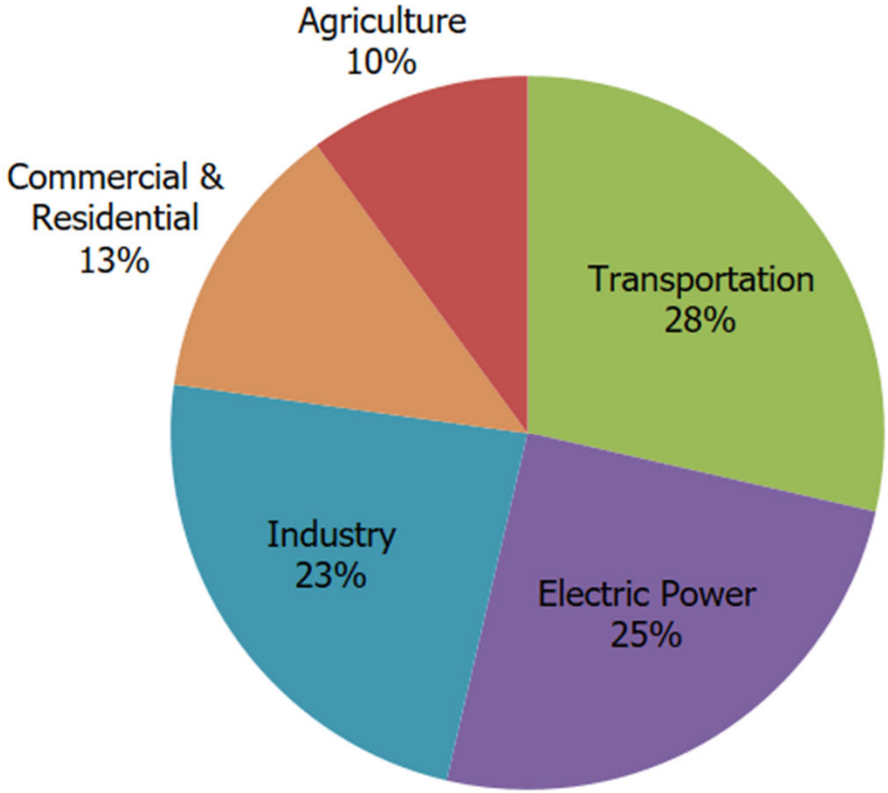
Some common questions…

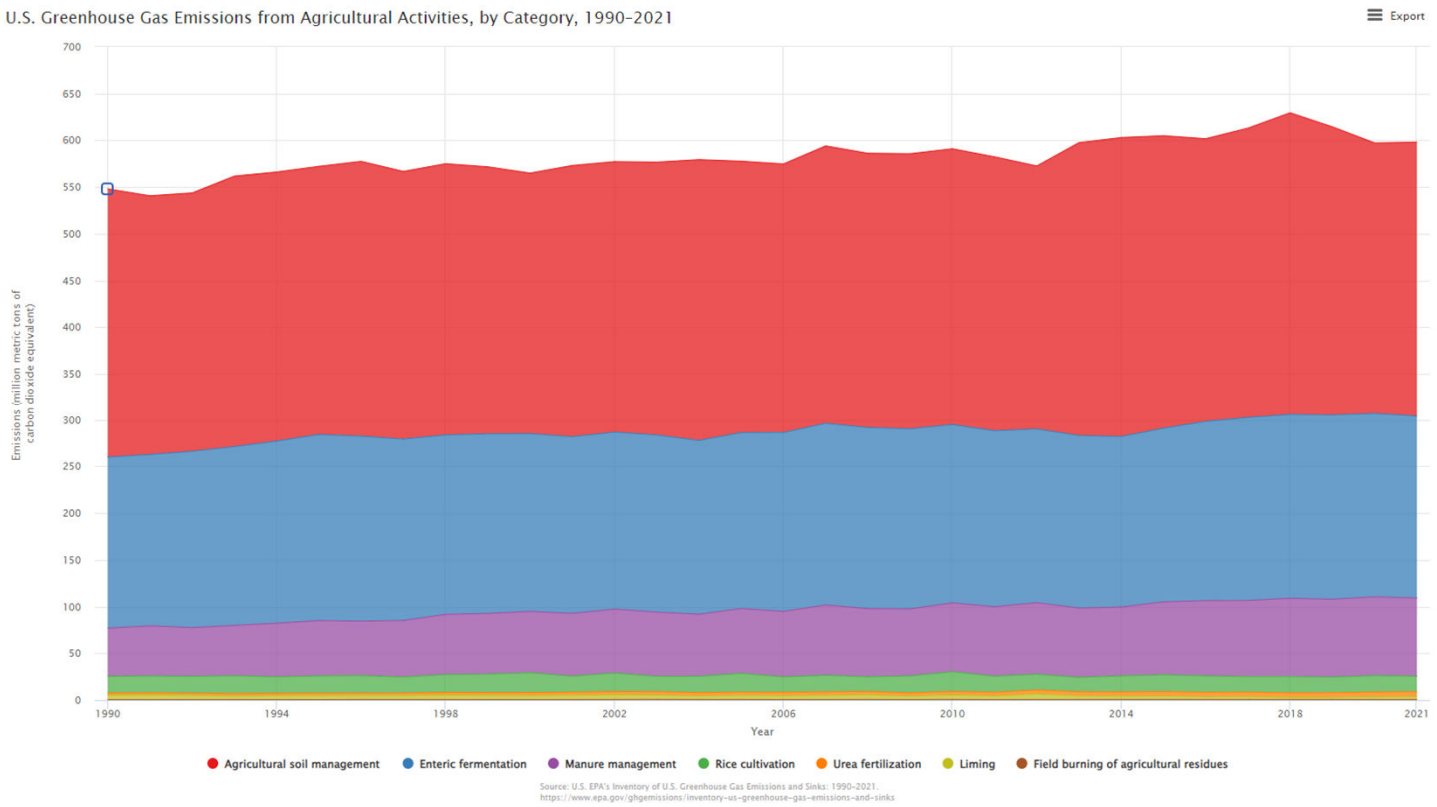
What is climate change?	Shifts in temperature and precipitation averages and patterns, linked with concentrations of GHG
Is climate change natural or caused by humans?	Decent causal evidence exists, and strong correlatory evidence is available
Are cows causing climate change?	
What should I be doing in this space?	

U.S. Agriculture and GHGe

Source	USA	Global
Agriculture, % total	9.3%	25%
Livestock, % agriculture	41.8%	58.0%
Livestock, % total	3.89%	14.5%



How Do Different Agricultural Activities Contribute?



Percent change:

1990–2021

Agricultural soil management:
▲ 2.1%

Enteric fermentation:
▲ 6.5%

Manure management:
▲ 62.3%

Rice cultivation:
▼ 6.2%

Urea fertilization:
▲ 115.7%

Liming:
▼ 35.0%

Field burning of agricultural residues:
▲ 14.7%

Total: ▲ 9.1%

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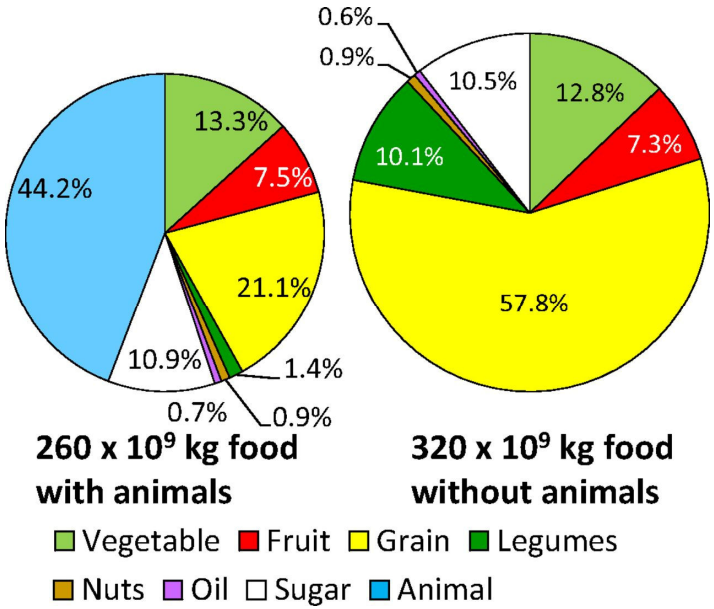
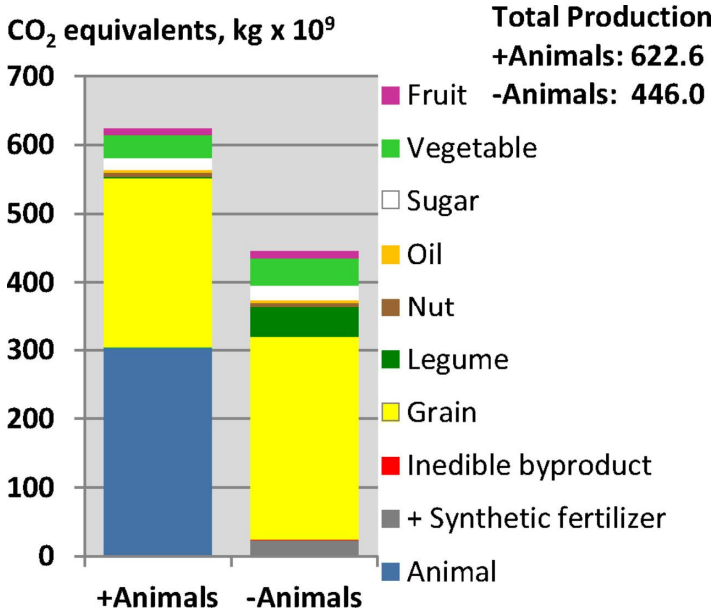
What happens if we get rid of animal agriculture?





More total food, more nutrient deficiencies, lower-than-expected reduction in emissions

Some common questions…

What is climate change?	Shifts in temperature and precipitation averages and patterns, linked with concentrations of GHG
Is climate change natural or caused by humans?	Decent causal evidence exists, and strong correlatory evidence is available
Are cows causing climate change?	They contribute, but so do all other sectors of the economy – provides opportunity to “do our part”
What should I be doing in this space?	