Assessing Animal Sourced Foods Role in Sustainable Nutrition

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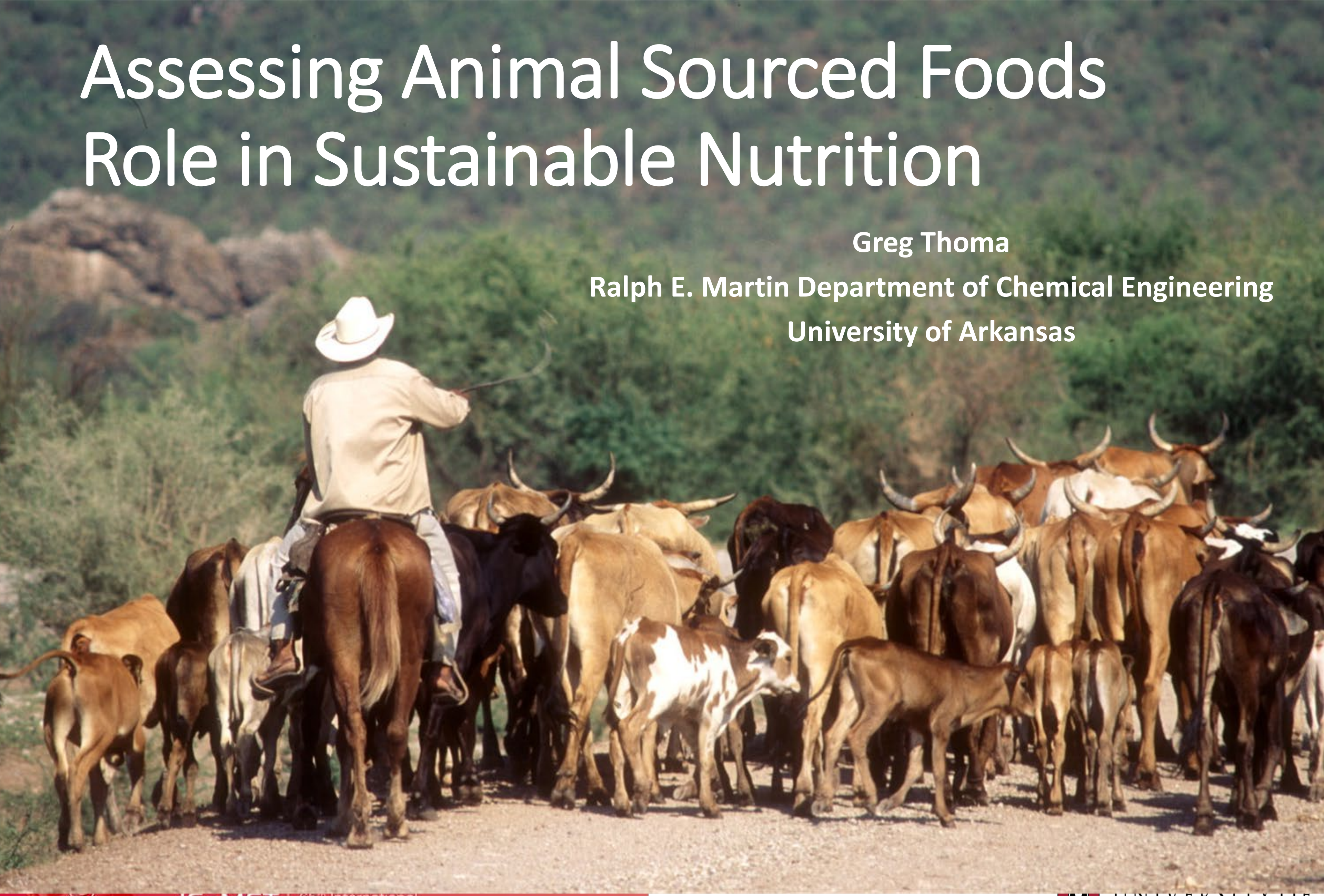

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Meat for Diversifying Markets

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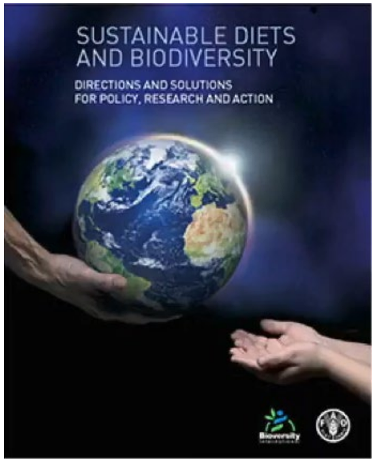
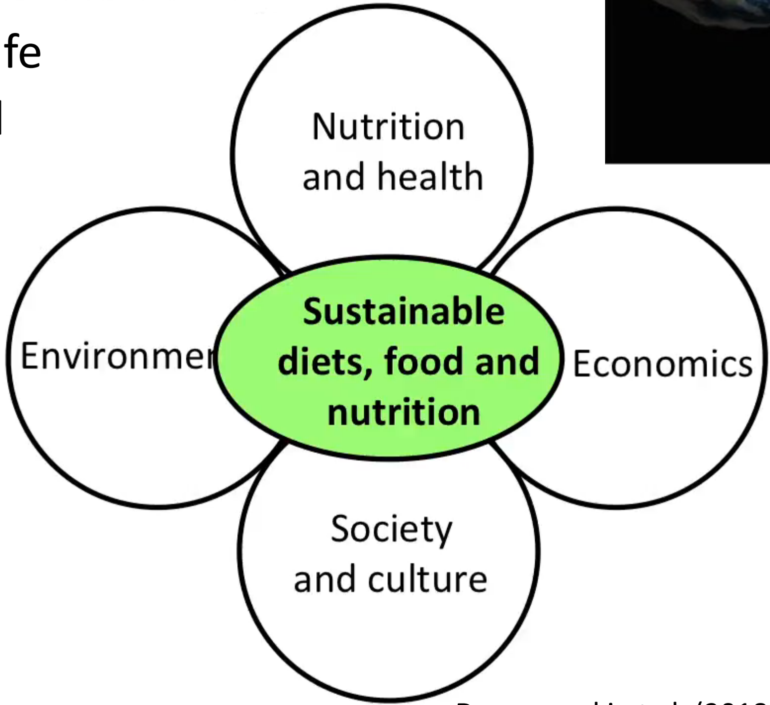
Sustainable Food Systems

- Are protective and respectful of biodiversity and ecosystems; culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (FAO, 2010).
- Tradeoffs:
  - Energy dense foods often nutrient poor and less expensive
  - Nutrient rich foods/diets often have higher environmental impact – many are animal sourced foods.
  - Cultural preferences





Drewnowski et al. (2018) Front. Nutr. 4:74. doi: 10.3389/fnut.2017.00074

Lifecycle Assessment

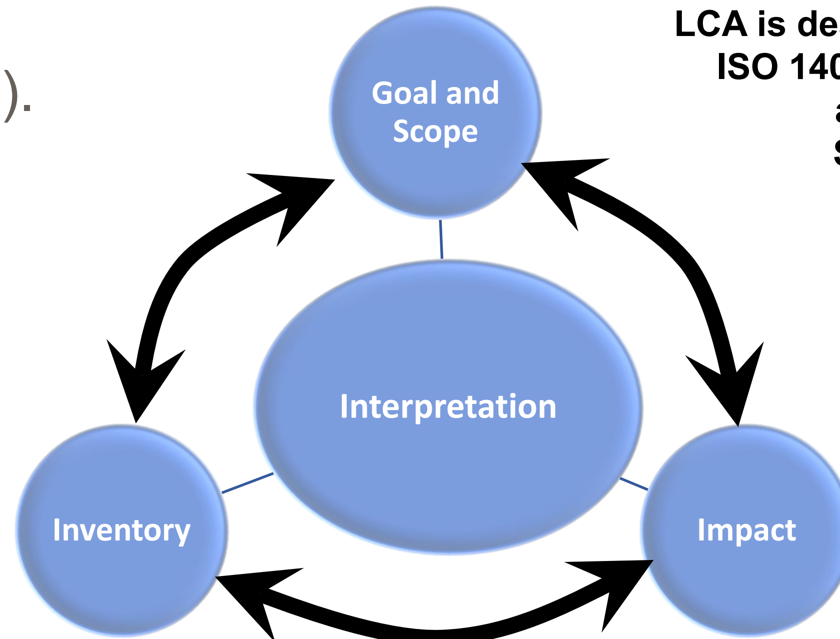
An Introduction to a Systems Framework for Evaluation of Alternate Solutions

Lifecycle Assessment

International Organization for Standardization

Systematic quantification of inputs and outputs for a system in terms of a functional unit (FU).

LCA is described in ISO 14040, 14044 and 14046 Standards



- **Product Development / Improvement**
  - **Selection of best materials or process options (e.g. conservation)**
- ***Identification of 'hotspots' for innovation***
- ***Benchmarking***
- **Product labels / marketing**
- ***Strategic planning***
- **Inform public policy**

- **Not: site assessment, EIA limitation of LCIA stage**

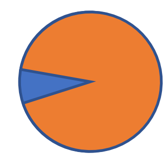
Attributes or characteristics of product or process

Environmental effects of product or process

‘Flavors’ of LCA: attributional and consequential

An *attributional product system* is composed of:

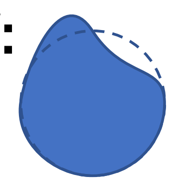
- an allocated share of the activities that have contributed to production, consumption, and disposal of a product,
- tracing the contributing activities backward in time,
- Thus, data on specific or market average suppliers are relevant



Engineering paradigm: processes linked *physically*

A *consequential product system* is composed of:

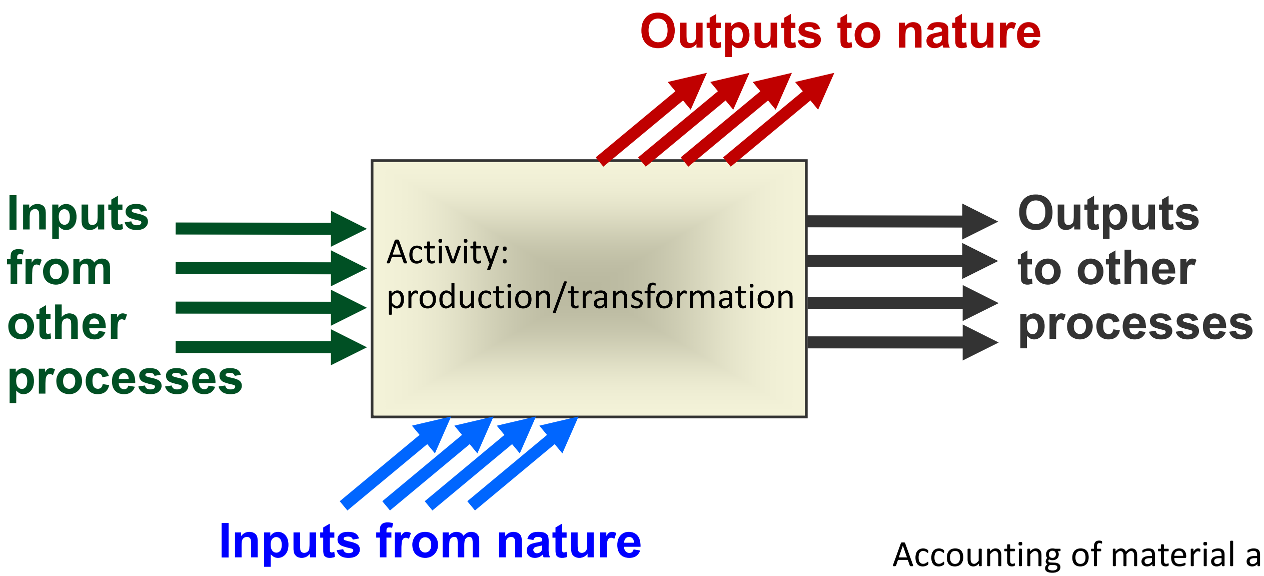
- the full share of those activities that are expected to change when producing, consuming, and disposing of a product,
- tracing the consequences of increased <u>*demand*</u> forward in time,
- Thus, data on marginal suppliers are relevant (whose activity responds to change in demand)



Economic paradigm: processes linked via *markets*

UNEP/SETAC (2011). Shonan LCA database guidance principles
Weidema, et al., 2018. Attributional or consequential Life Cycle Assessment: A matter of social responsibility. J. Clean. Prod. 174, 305–314.

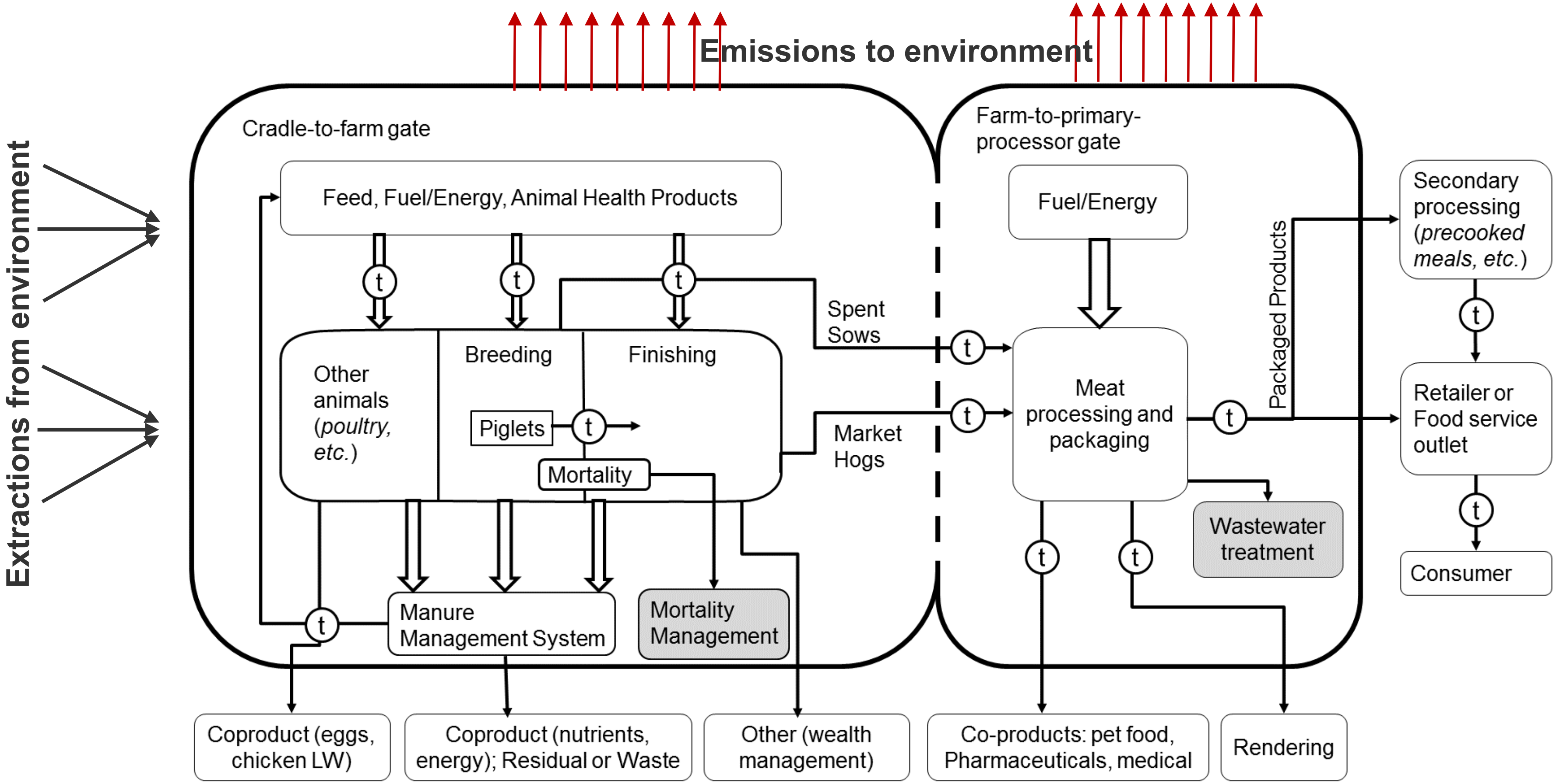
Unit processes: the building blocks of LCA (both flavors)



Accounting of material and energy flows

Life cycle inventory analysis:

system boundary with linked unit processes

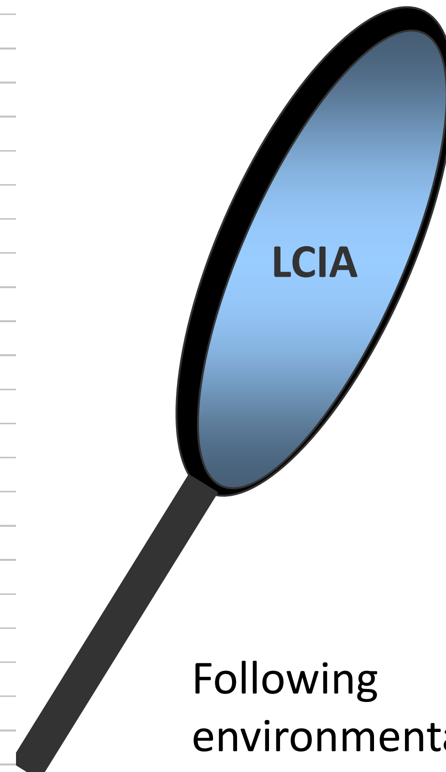


Life Cycle Impact Assessment

Inventory results (LCI)

Substance	Compartment	Unit	Total
Aluminum	Air	mg	27
Ammonia	Air	mg	776
Ammonium carbonate	Air	ng	441
Antimony	Air	µg	9.52
Antimony-124	Air	nBq	33
Antimony-125	Air	nBq	344
Argon-41	Air	Bq	7.34
Arsenic	Air	µg	97
Barium	Air	µg	100
Barium-140	Air	µBq	22.3
Benzaldehyde	Air	ng	17.5
Benzene	Air	mg	5.74
Benzene, ethyl-	Air	µg	149
Benzene, hexachloro-	Air	ng	56.2
Benzene, pentachloro-	Air	ng	80.9
Benzo(a)pyrene	Air	µg	23.7
Beryllium	Air	ng	227
Boron	Air	mg	9.87
Bromine	Air	µg	606
Butadiene	Air	pg	23.4
Butane	Air	mg	10.7
Butene	Air	µg	146
Cadmium	Air	µg	106
Calcium	Air	mg	1.36
Carbon-14	Air	Bq	28.6
Carbon dioxide, biogenic	Air	g	46.3
Carbon dioxide, fossil	Air	kg	20.8

Hundreds of individual emissions

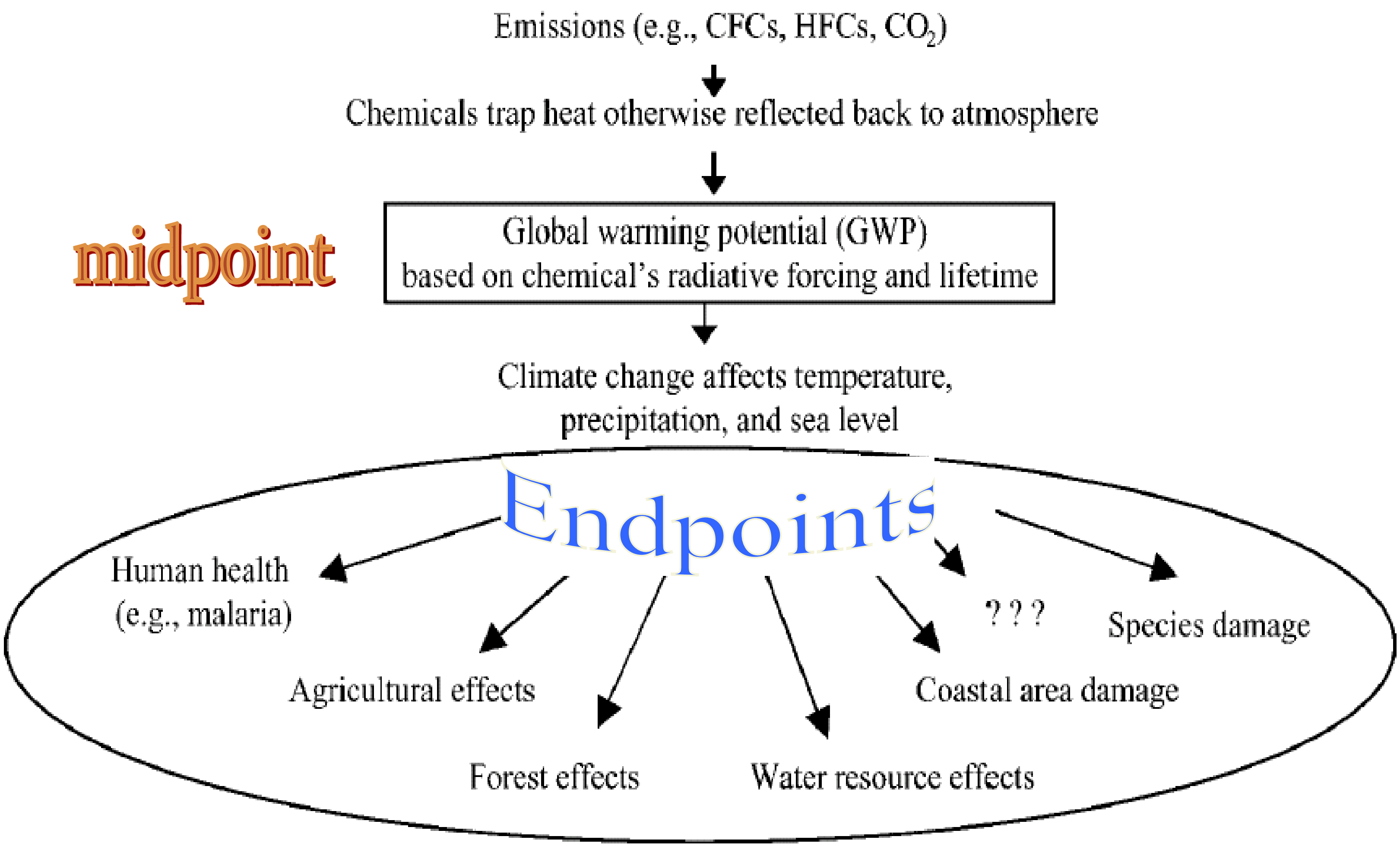


Impact Assessment results

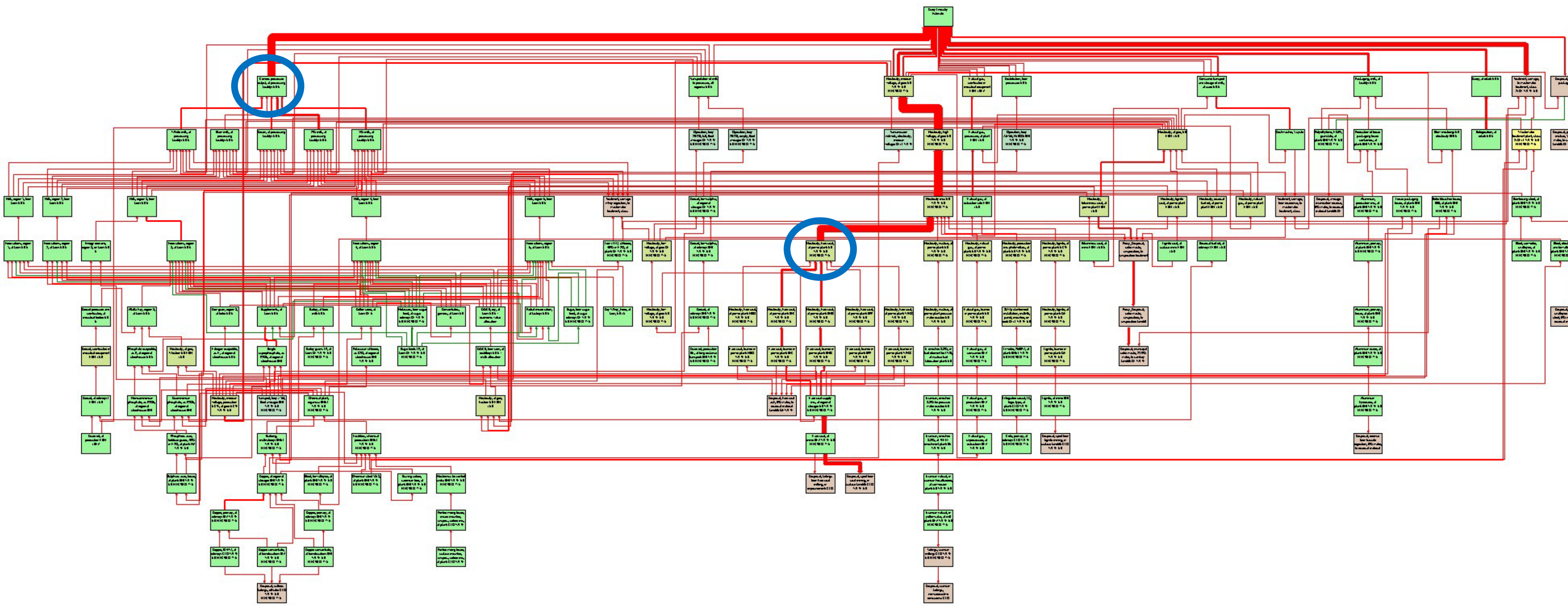
Impact category	Total
Carcinogens	2.35E-5
Resp. organics	3.03E-6
Resp. inorganics	0.0011
Climate change	0.000432
Radiation	1.21E-6
Ozone layer	5.16E-9
Ecotoxicity	1.15E-5
Acidification/ Eutrophication	0.000128
Land use	1.85E-6
Minerals	1.3E-6
Fossil fuels	0.00624

Following environmental cause-effect chain

Impact Assessment: Climate Change



Some Connections are More Important



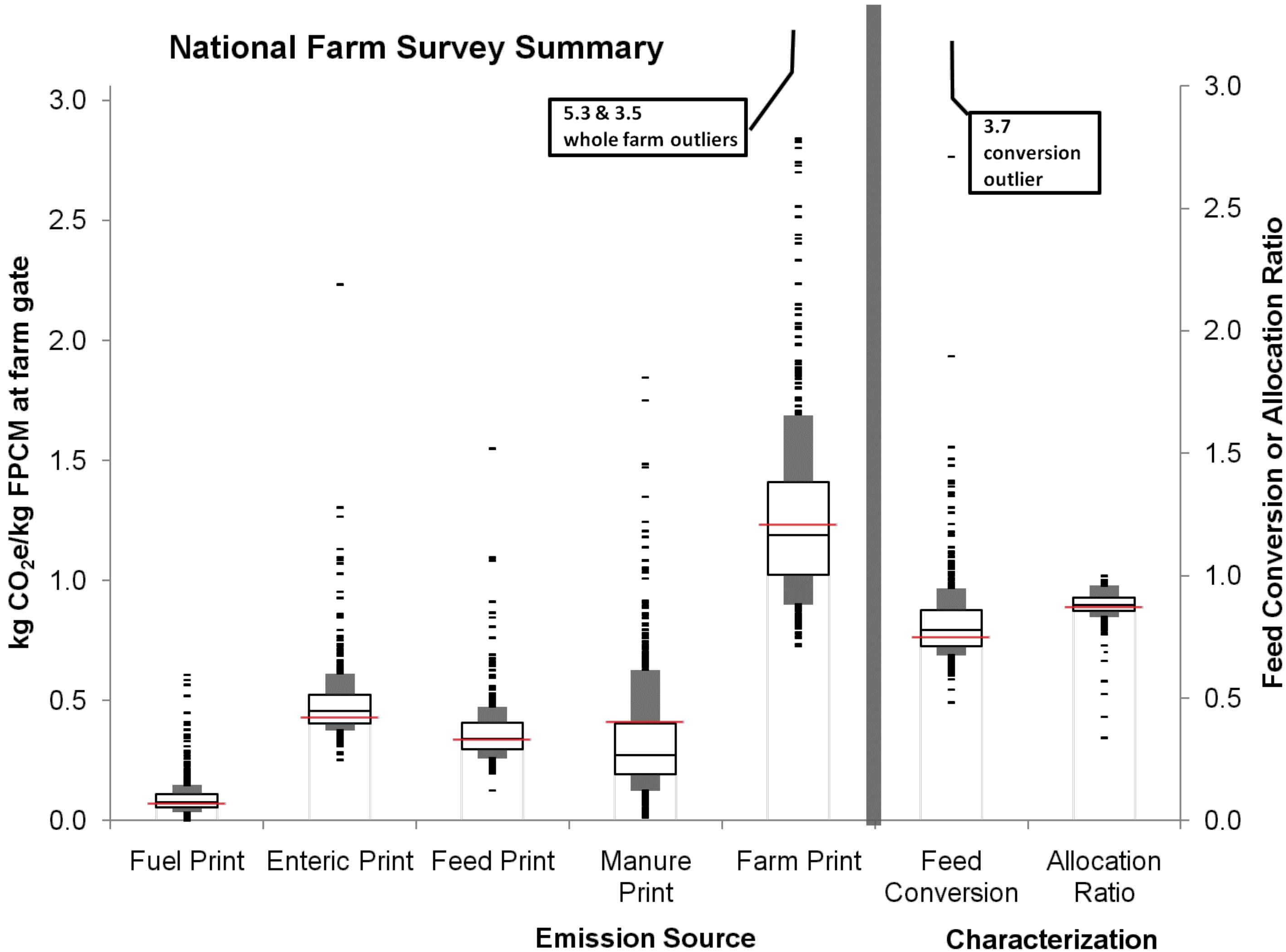
What can LCA tell us now?

Environmental focus on production and consumption

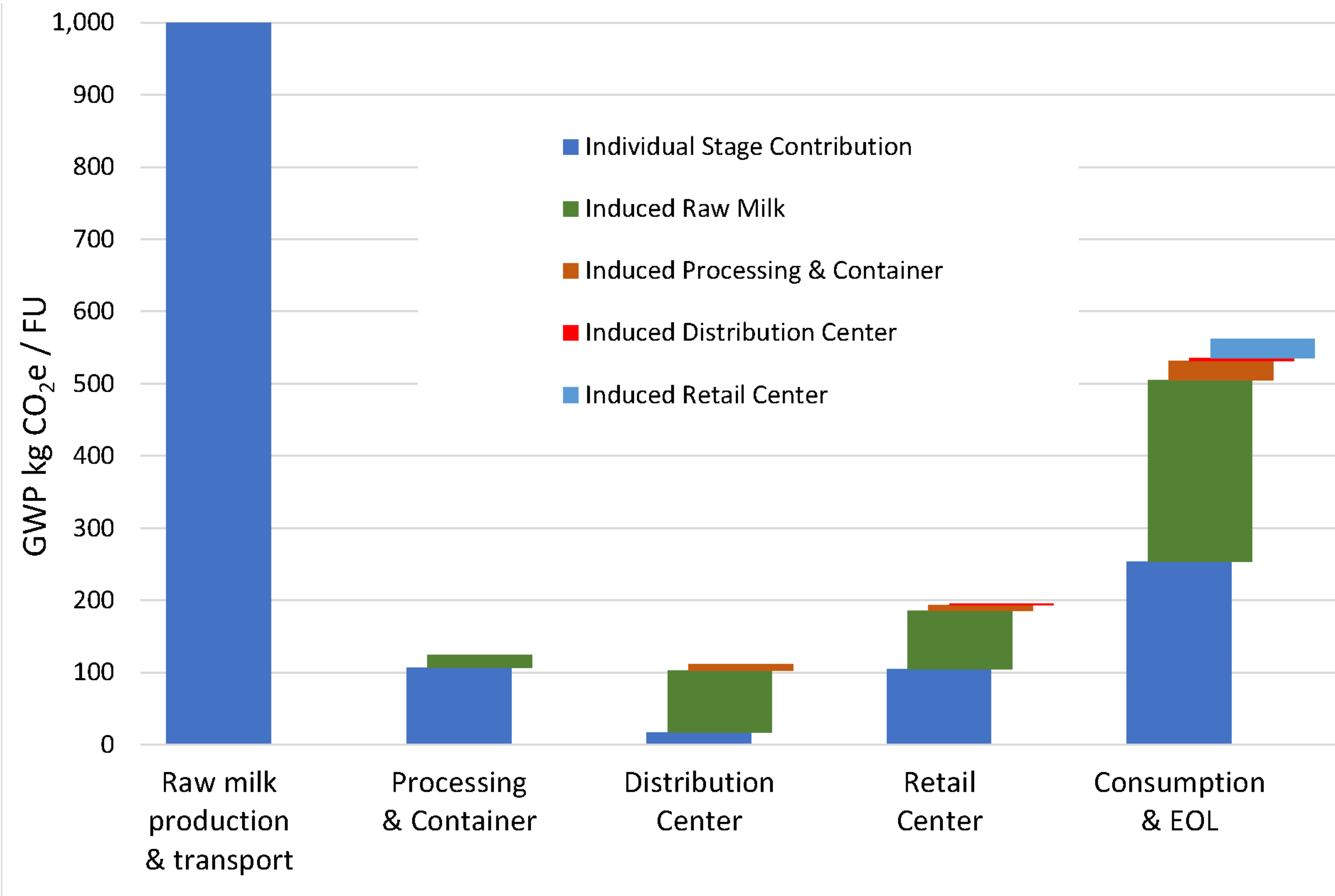
Carbon Footprint of Milk

Large variation in existing system implies opportunity for sector level improvement without radical or disruptive technology advancement:

We can make progress in the near term.

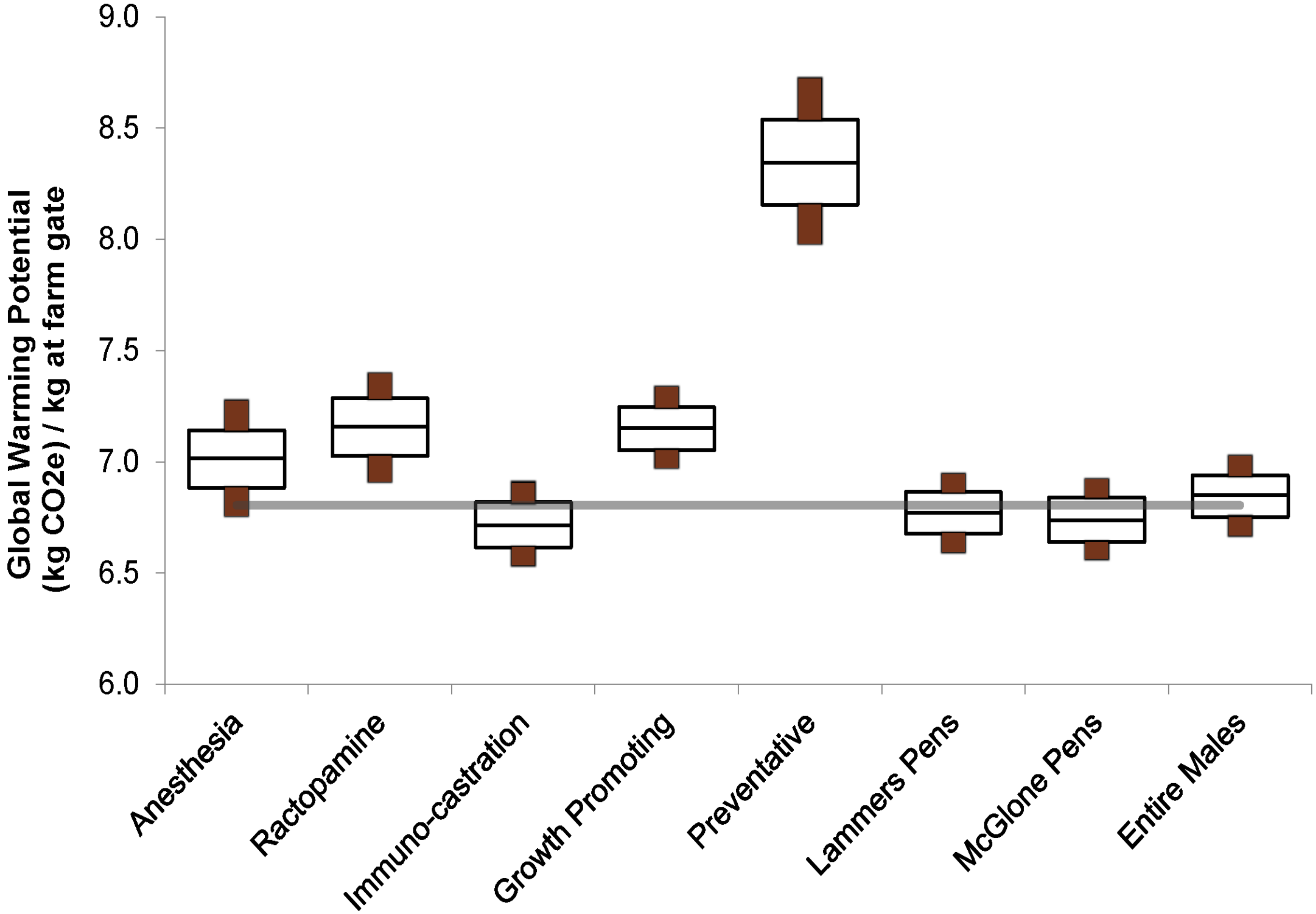


Food loss induced redistribution



Responsibility for upstream emissions is not normally attributed to downstream demand.

Estimated Change in GWP from Alternate US Pork Production Strategies: Tradeoffs



Production simulation model* used as input for LCA modeling in Simapro software (adds full upstream supply chain as well as Monte Carlo simulation)

*https://resilientfood.uark.edu

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Bandekar, et al., 2019. J. Anim. Sci. 97, 472–484. doi:10.1093/jas/sky425

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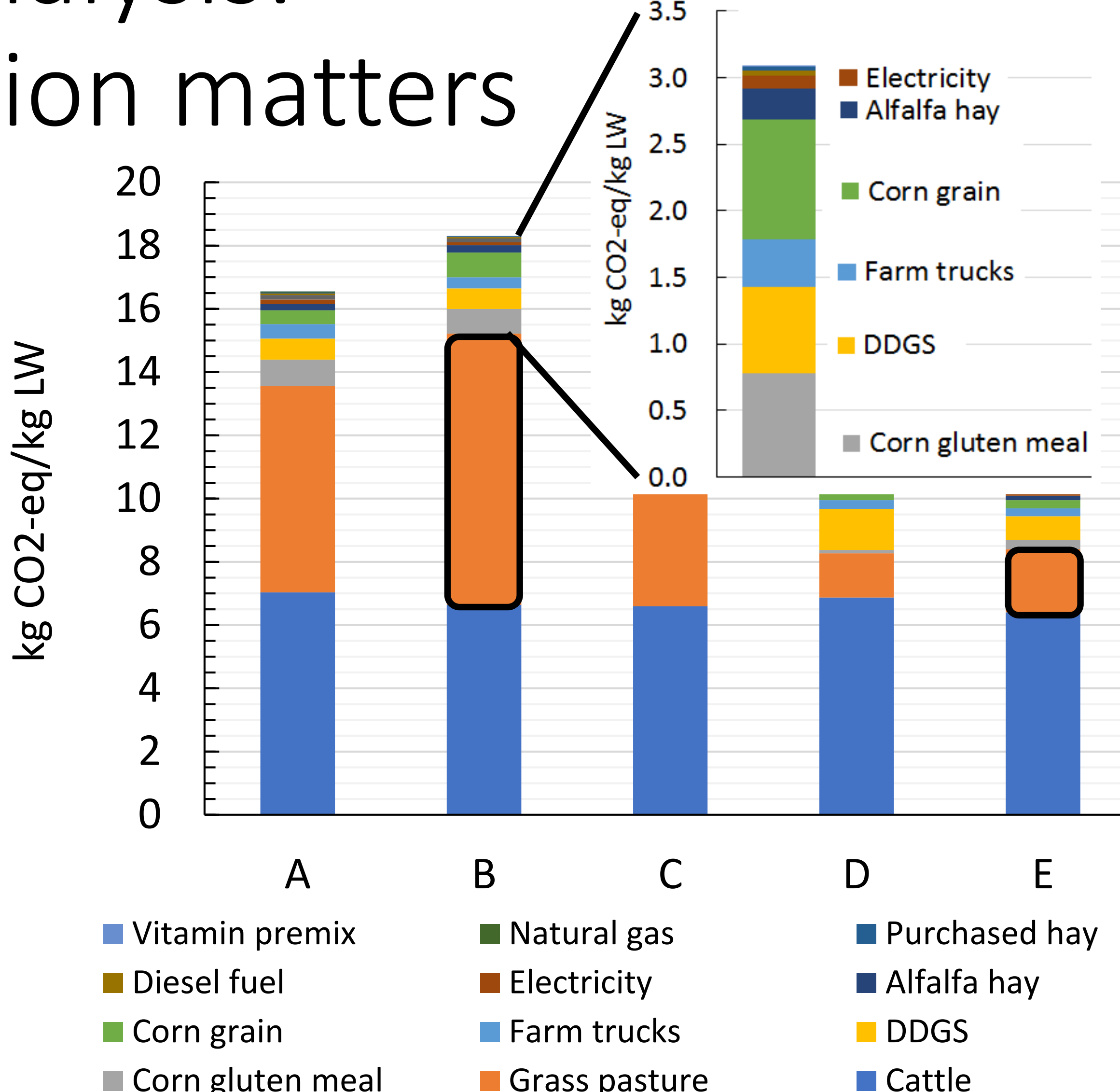
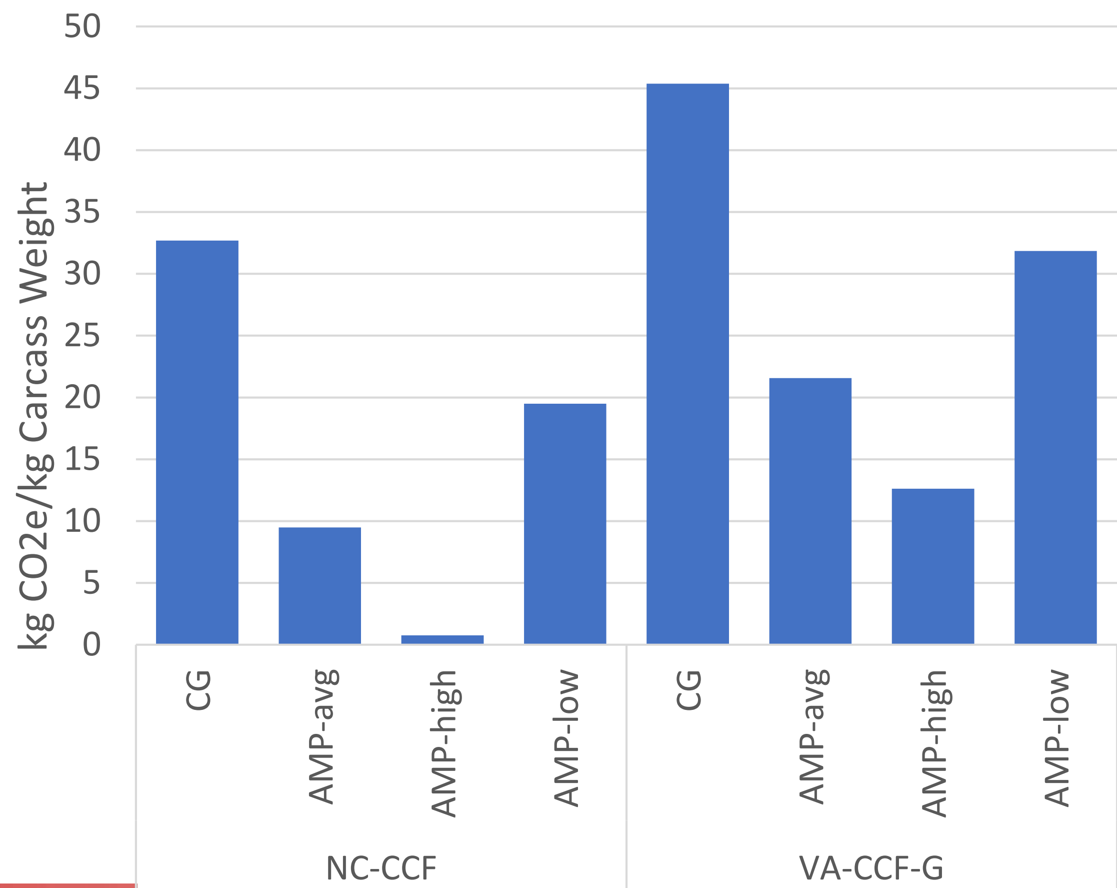
Contribution analysis: Beef farm location matters

- Matched farm size and practices
  Differences driven mainly by pasture-related emissions
  - Farm B pasture emits ~8X more N_2O per ha than Farm E
  - Pasture includes resource use associated with maintenance and emissions resulting from deposited manure and fertilizers

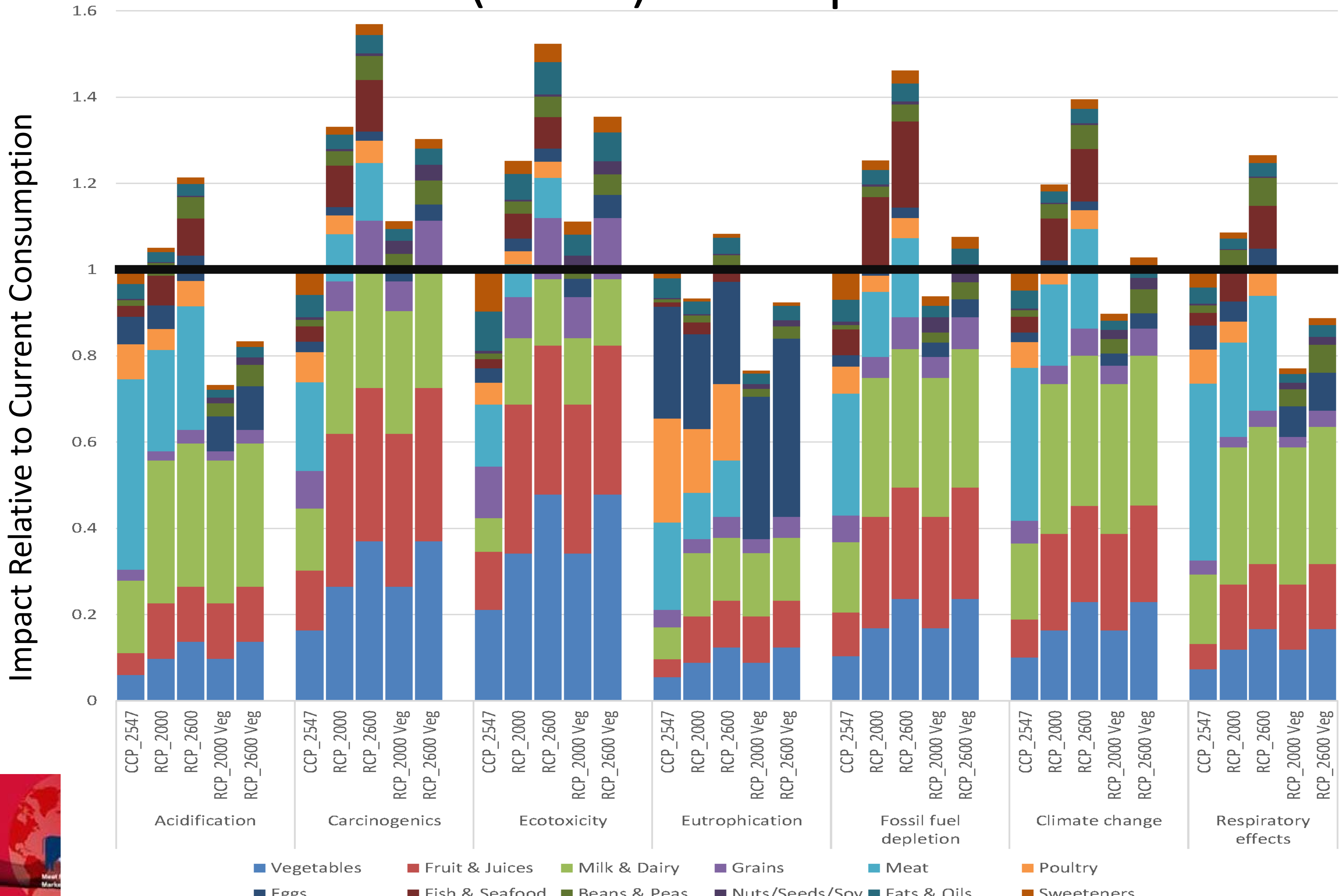


Adaptively Managed Paddock vs. Conventional Grazing

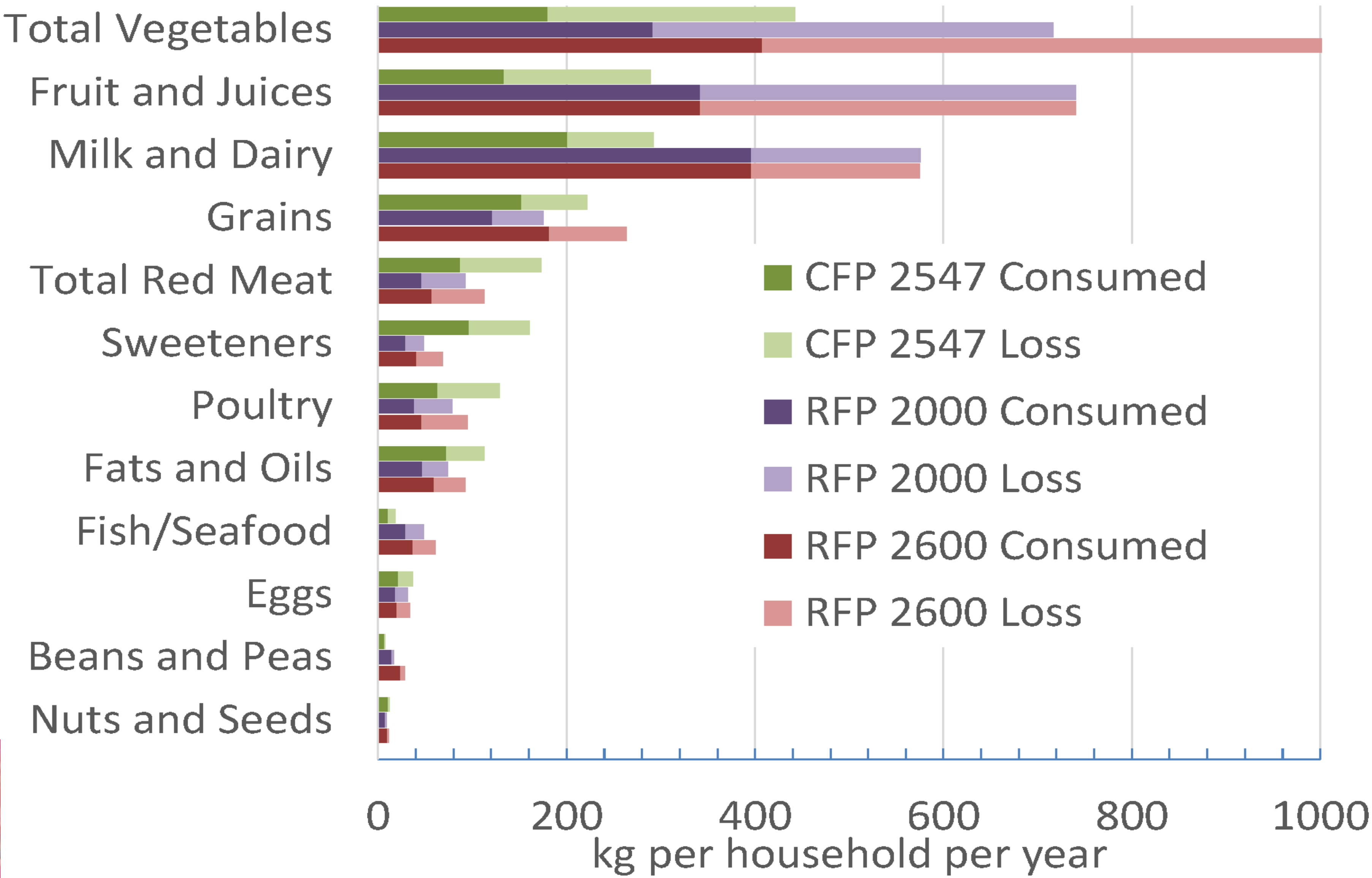
IFSM simulations of archetypical beef production in the Southeast. Both archetypes are Conventional Grazing (CG) Cow-Calf-Finish operations. NC is grain finished; VA is grass finished. The AMP alternatives were constructed by applying the low, average, and high carbon sequestration levels from Teague et al. (2017) on a per hectare basis, applied post-hoc to the archetype simulations.
Both farms produced approximately 250 kg CW (cull plus finished) per ha, and therefore the delta from AMP observed is similar for both.



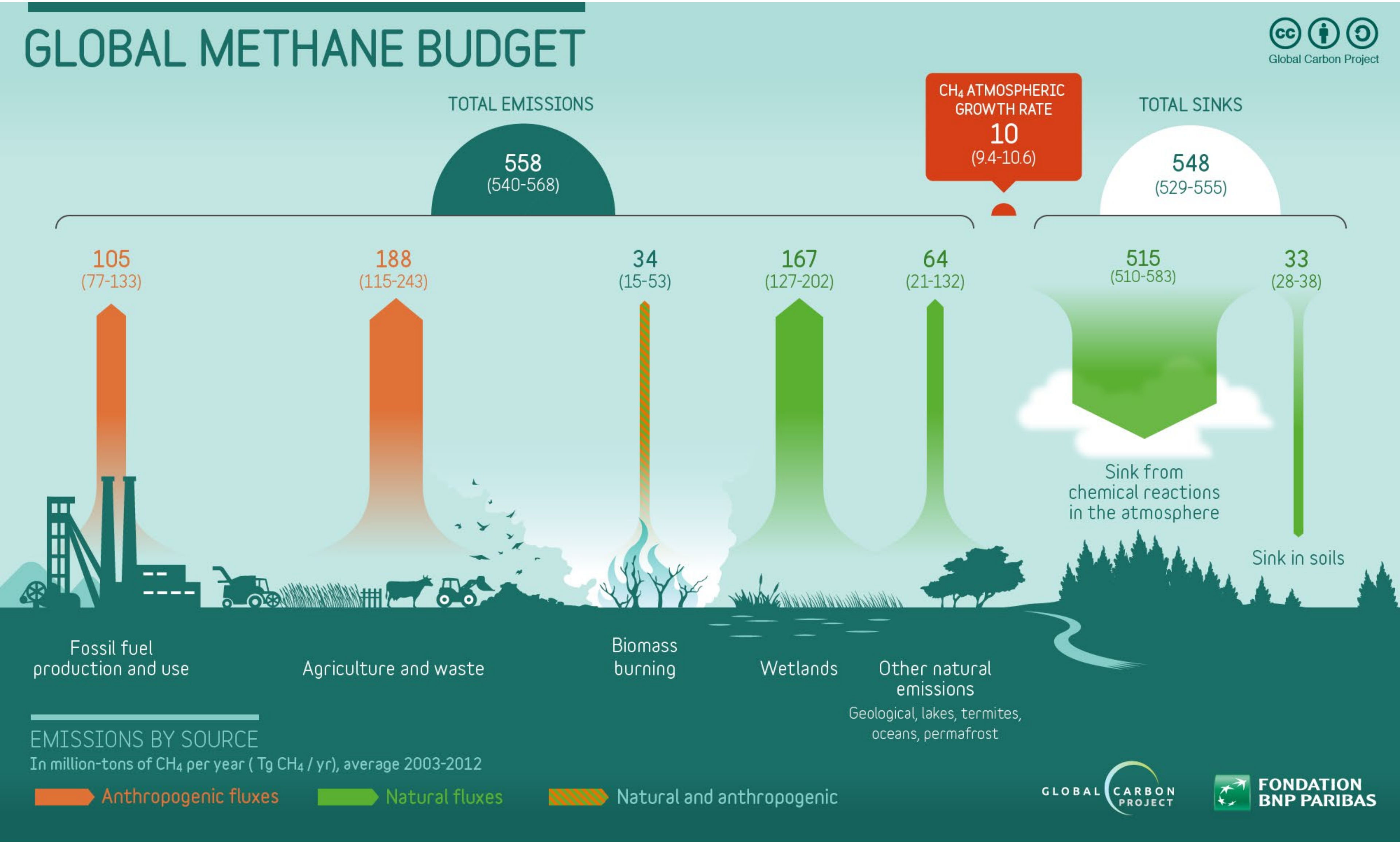
Household (USA) diet patterns



Food loss/waste effect

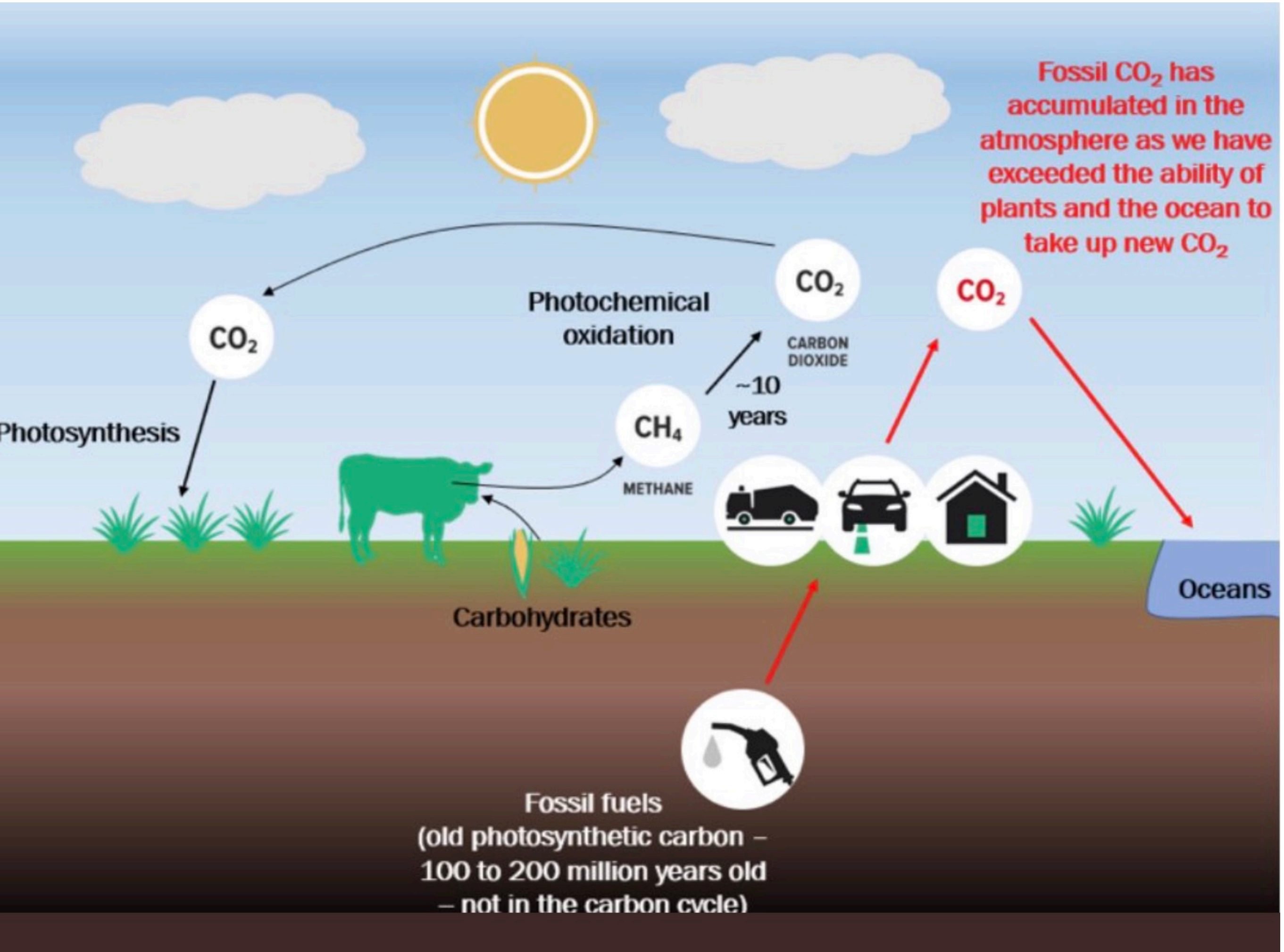



WISCONSIN STATE JOURNAL 2008
HEY STOP DESTROYING OUR PLANET.
BURP!!
SUV



https://www.global-carbonproject.org

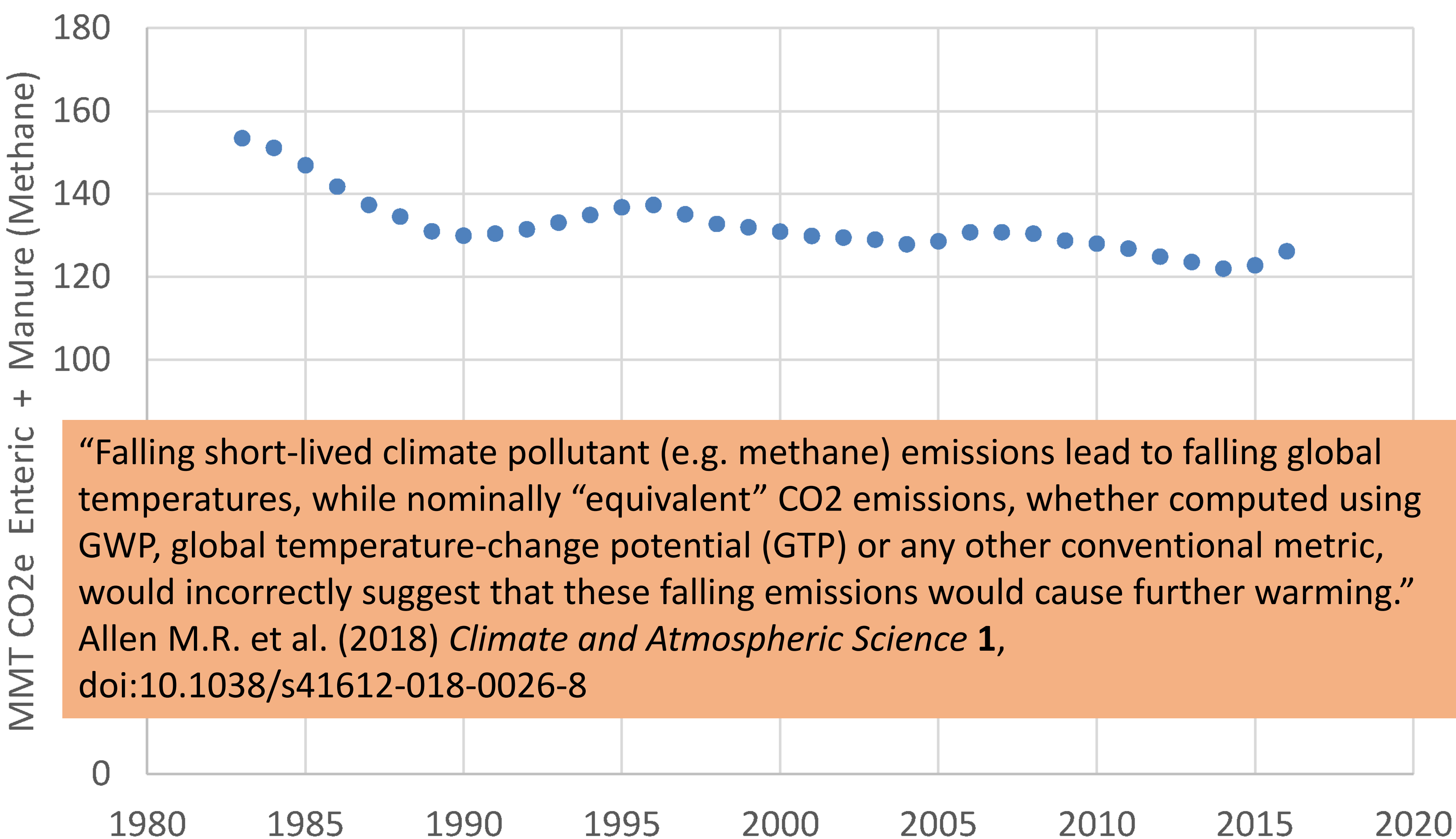
Biogenic CH4 ≠ Fossil CH4



Biogenic CH4 degrades to CO2 and is then recycled through photosynthesis. Unless there is an increase in the ***rate*** of biogenic CH4 emission, the net effect on the climate is neutral. The radiative forcing is driven by the concentration in the atmosphere while the GWP is calculated for each new 'puff' of CH4.

All already agree that the climate change impact of respiration is zero!

Trends in Beef Biogenic Methane

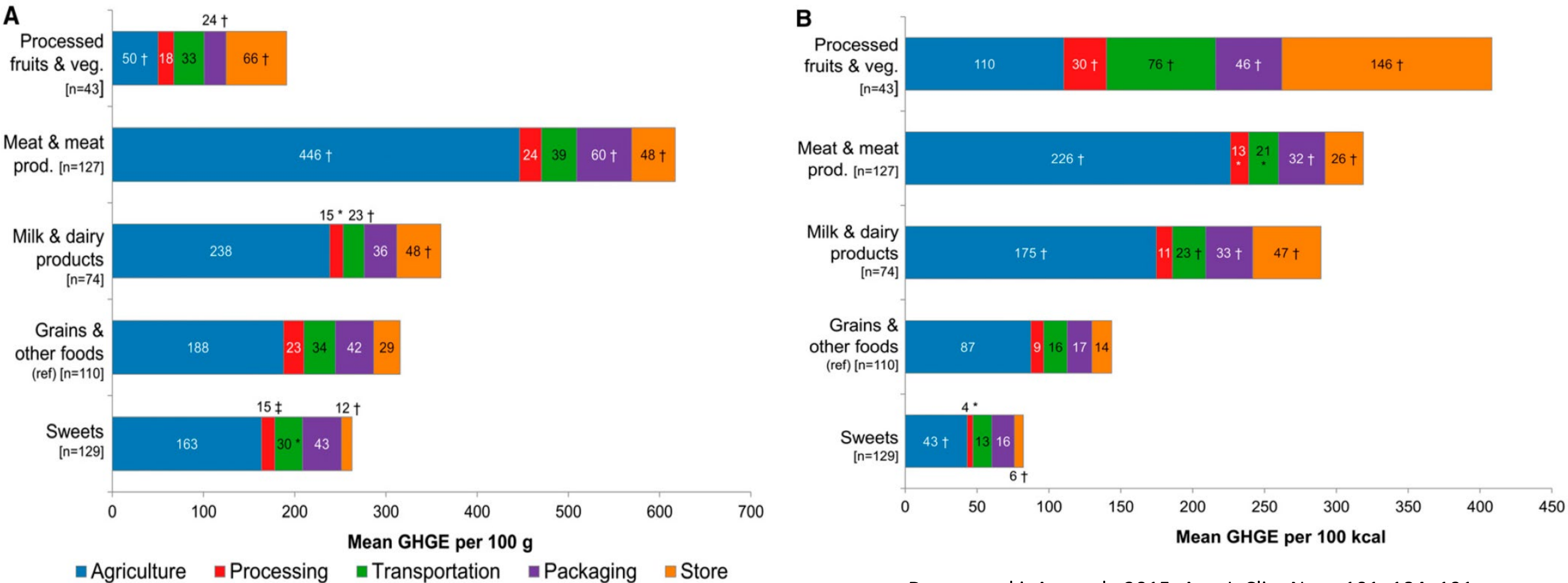


"Falling short-lived climate pollutant (e.g. methane) emissions lead to falling global temperatures, while nominally "equivalent" CO2 emissions, whether computed using GWP, global temperature-change potential (GTP) or any other conventional metric, would incorrectly suggest that these falling emissions would cause further warming."
Allen M.R. et al. (2018) *Climate and Atmospheric Science* **1**,
doi:10.1038/s41612-018-0026-8

Challenges in LCA of food systems

- Data Availability – proxy & substitution can introduce error/ uncertainty
  - Incompatibility of sources, not all in public domain, extant data not always specific to food
  - LCI in agriculture often modeled (multiple models, variable predictions)
- Spatially Extensive – but LCA integrates the supply chain
  - Geospatially explicit LCI and LCIA in nascent stages
- Dynamic Systems – LCA is (generally) a static model
  - Is a static model still useful – yes, many situations.
- Impacts modeled – not benefits (evolving this direction)
- Incomplete metrics (in LCA framework)
  - Biodiversity, Ecosystem Services, Carbon Sequestration, Ocean Plastics, Soil Health, ***Nutrition***

Challenge of Incorporating Nutrition in the LCA framework

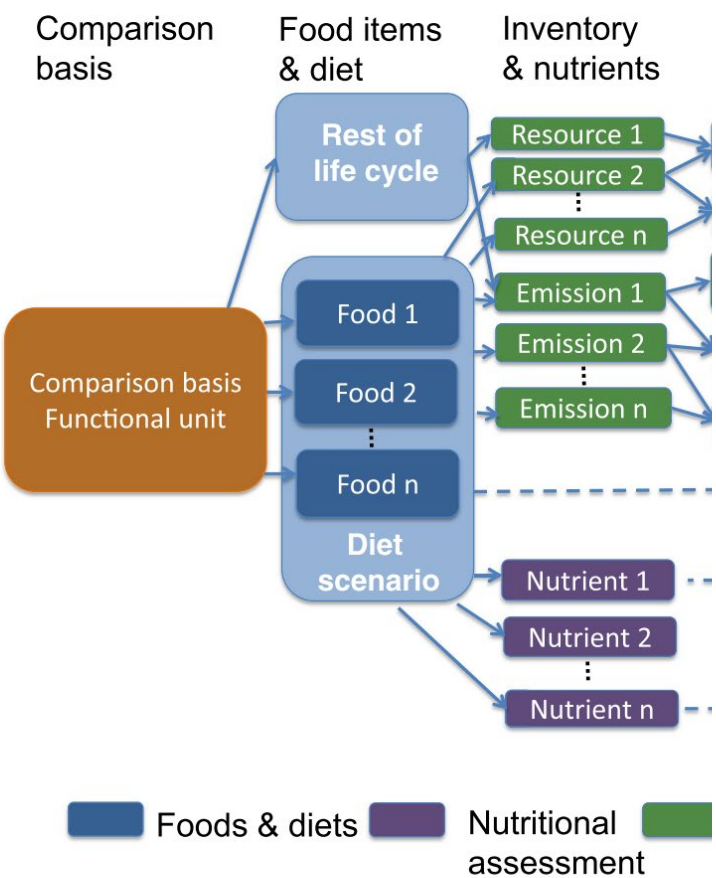


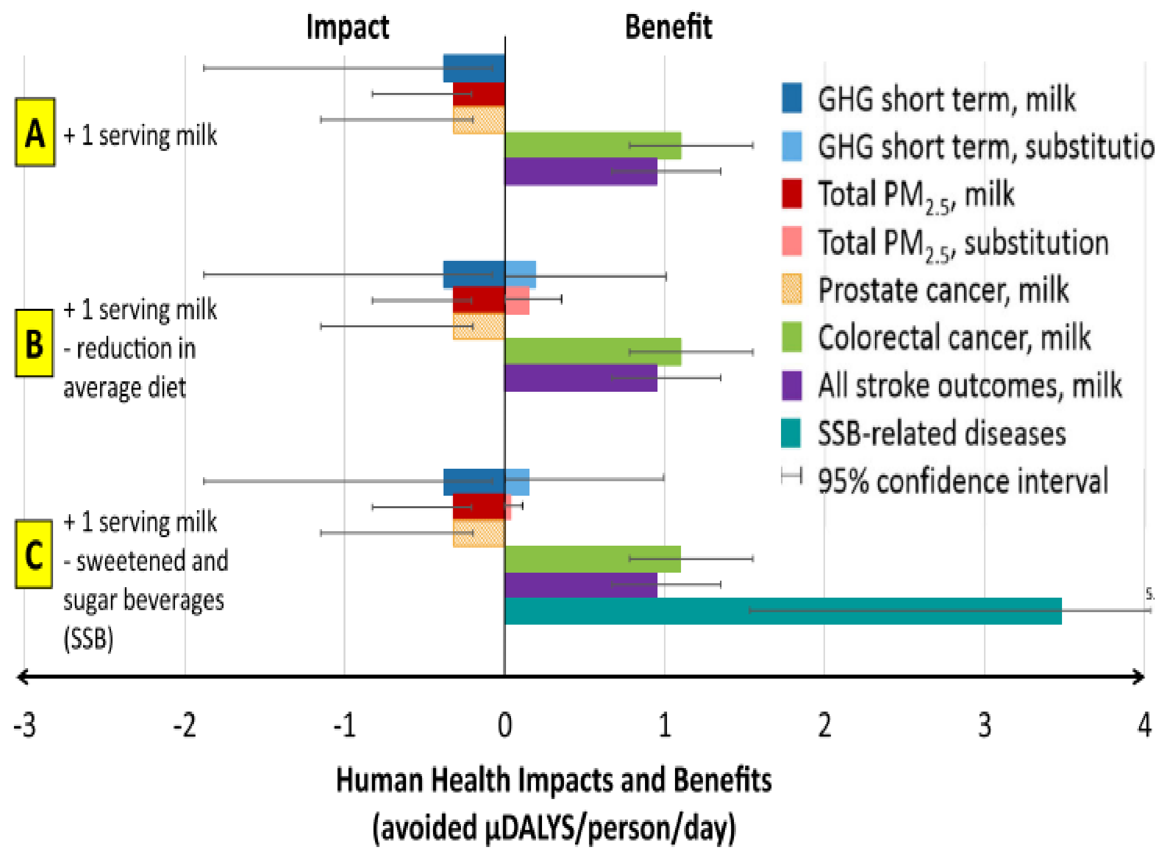
Drewnowski, A., et al., 2015. Am. J. Clin. Nutr. 101, 184–191.
DOI:10.3945/ajcn.114.092486

Incorporating Nutrition into LCA

- Impact or Function?
  - Nutrient content clearly a characteristic of foods – logical it be considered a functional characteristic
    - Comparison becomes problematic – how to get the same functional unit?
  - If nutrition effects are considered, then it is logical to consider the health impact in a conceptually similar manner to GHG emissions affecting climate
    - Comparison is less problematic – we can use a food, meal or diet as the functional unit
- NUTES
  - in development – based on RDA of 30 macro/micronutrients; no negative scores
- Nutrient Density/Indices
  - e.g., NRF9.3 and many others – accounts for beneficial and detrimental components of foods
- CONE LCA
  - Based on global burden of disease risks of NCD to assign DALY to food groups which can be summed with environmental DALY for a single human health impact score.
  - Relaxes the restrictions on functional unit (can now be a meal or diet).

COmbined Nutritional and Environmental Life Cycle Assessment





Stylianou, et al., 2016. Int. J. Life Cycle Assess. 21, 734–746. doi:10.1007/s11367-015-0961-0

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Assessment needs:
Data, metrics, integrated modeling

- Data should be transparent (to maximum extent feasible), validated, widely available, inexpensive. (e.g., NAL digital commons)
- Need for comparable metrics that span sectors, industries and geographies
  - Sustainability metrics should be science-based: life cycle assessment as system model supported by production, nutrition, economic and social components
- The same data and models should be used by producers, retailers, policymakers, NGOs and consumers.

Data	Production, processing, consumption, waste, disposal. Nutrient composition, dietary intake and link to health outcomes. Economics (cost, value added) of production and consumption chains: livelihoods and affordability; costs.
Metrics	Environmental footprints/index Affordability index Nutrient quality index (foods & diet); Safety and health outcomes (DALYs). Cultural and other choice restrictions
Integrated Modeling	Production (process/big data/ statistical); Environment/health (LCA); Economic (GEM, PEM, LCC); Cultural/regulatory factors; effect of climate on production/nutrition => evaluation of alternatives, tradeoffs identified

Some benefits of ASF not fully accounted in most LCA

- Production on marginal land not suited for row crops.
- Upcycling of low-quality feed (food waste and byproducts – citrus pulp, almond hulls) to high-quality protein.
    - US ASF provide 24% of energy, 48% of protein approximately 50% of the essential amino acids and essential fatty acids as well as micronutrients (White and Hall, 2017).
- Micronutrient health benefits: Fe, Zn, B-12, Se
- Extensive production systems enhance ecosystem services; potential for C sequestration in grasslands.
- Livelihoods, wealth management, draught power, nutrition for developing world.

Sustainability Assessment of Animal Sourced Foods

- Ensuring that future generations can provide for themselves (both quantity and quality = nutrition security).
- Systems framework is necessary for capturing and interpreting measures and metrics and identifying trade offs to support informed decisions.
- Resources are beginning to constrain production:
  - We need measures and metrics to document and track progress and
  - Identify ‘hotspots’ and trade-offs for informed decisions/policy – everyone in the supply chain should be involved => team must include social scientists.
- More development of the benefits of ASF needed within the model framework: nutrition, ecosystem services, livelihoods.
- Linkage and integration of multiple models and tools is essential to drive improved outcomes: Social, Economic, Environmental and Health

Questions?