10/6/2021

Opportunities for genetic improvement of beef system sustainability

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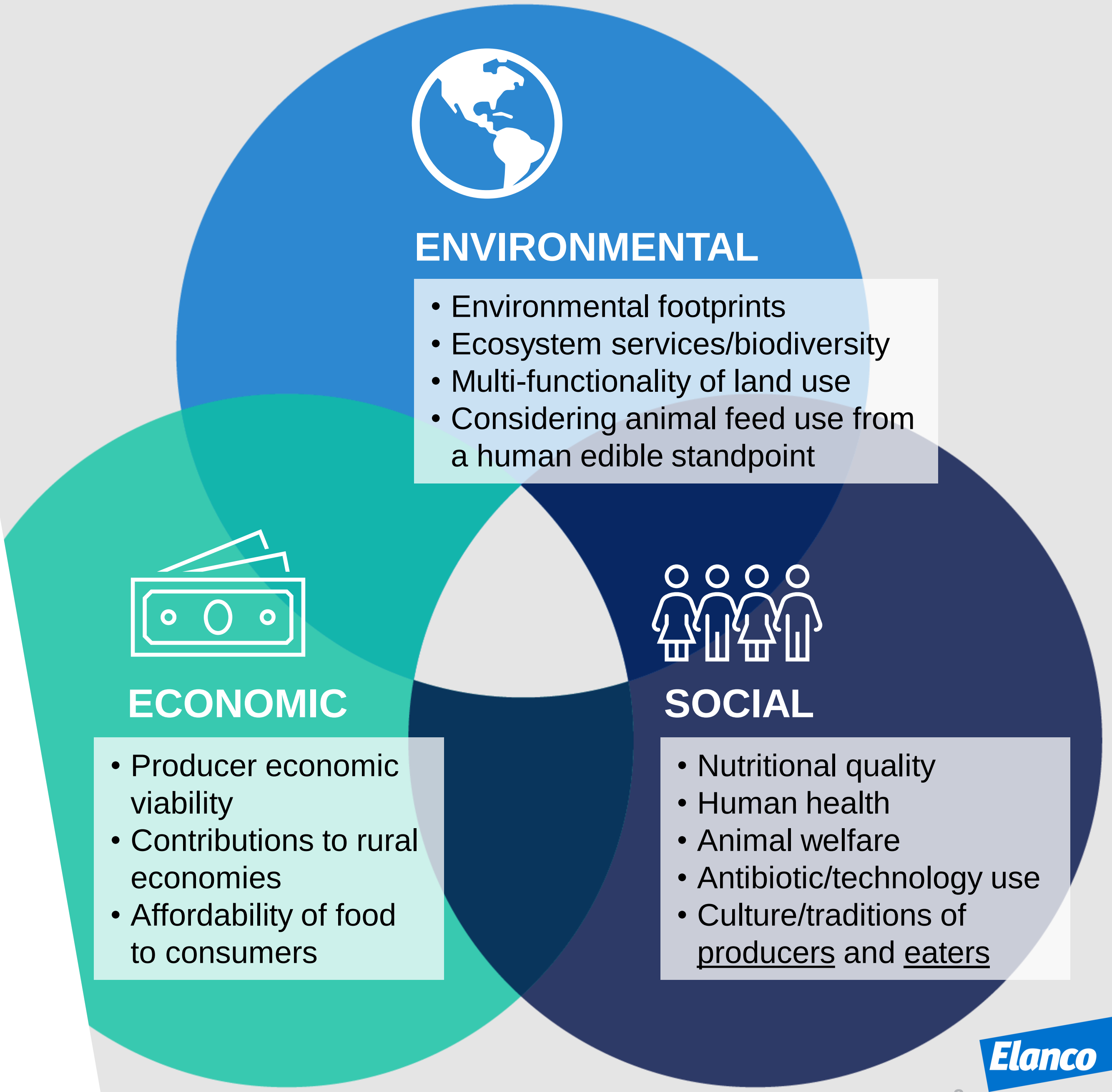
Chief Sustainability Officer

You manage what you measure

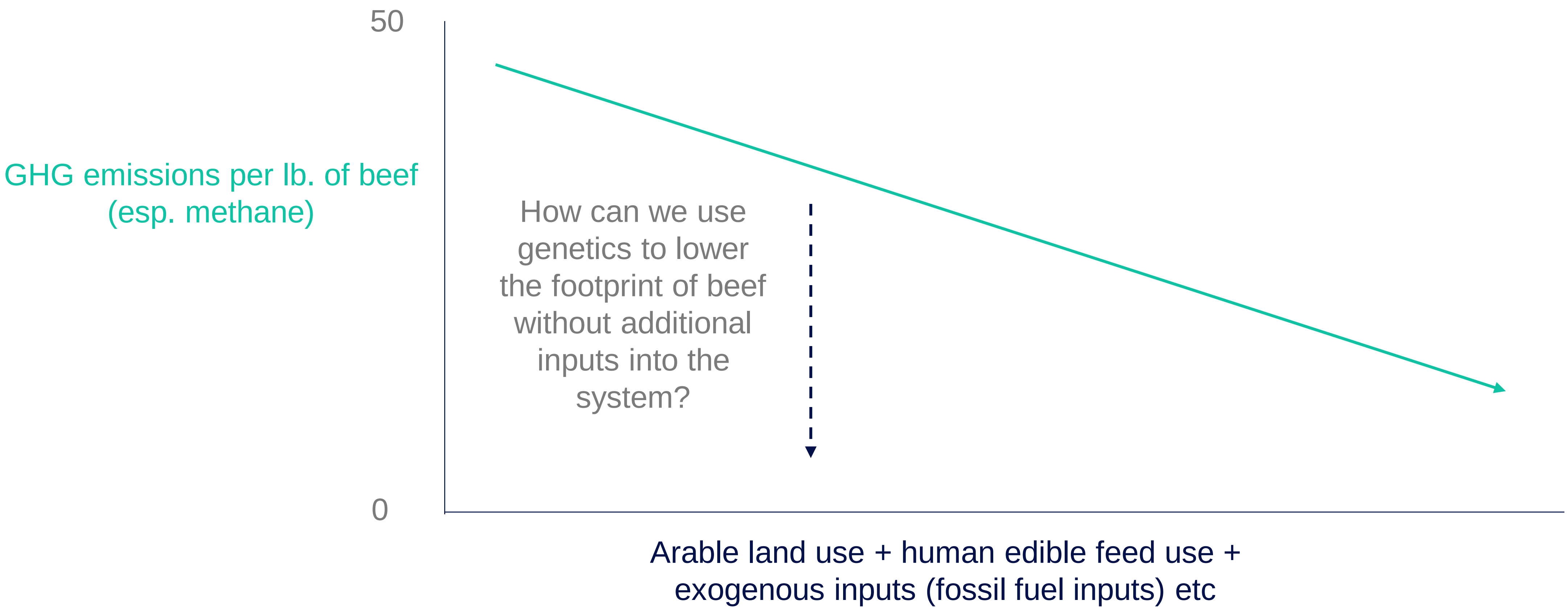
The sustainability of our food system requires balancing multiple important criteria

Overarching needs:

- Whole systems approaches
  - Focus on the nexus of different aspects of sustainability
  - Characterize and quantify interrelatedness of food, fiber, and fuel industries and integration of plant and animal agriculture
- Recognize the role of value judgments and uncertainty

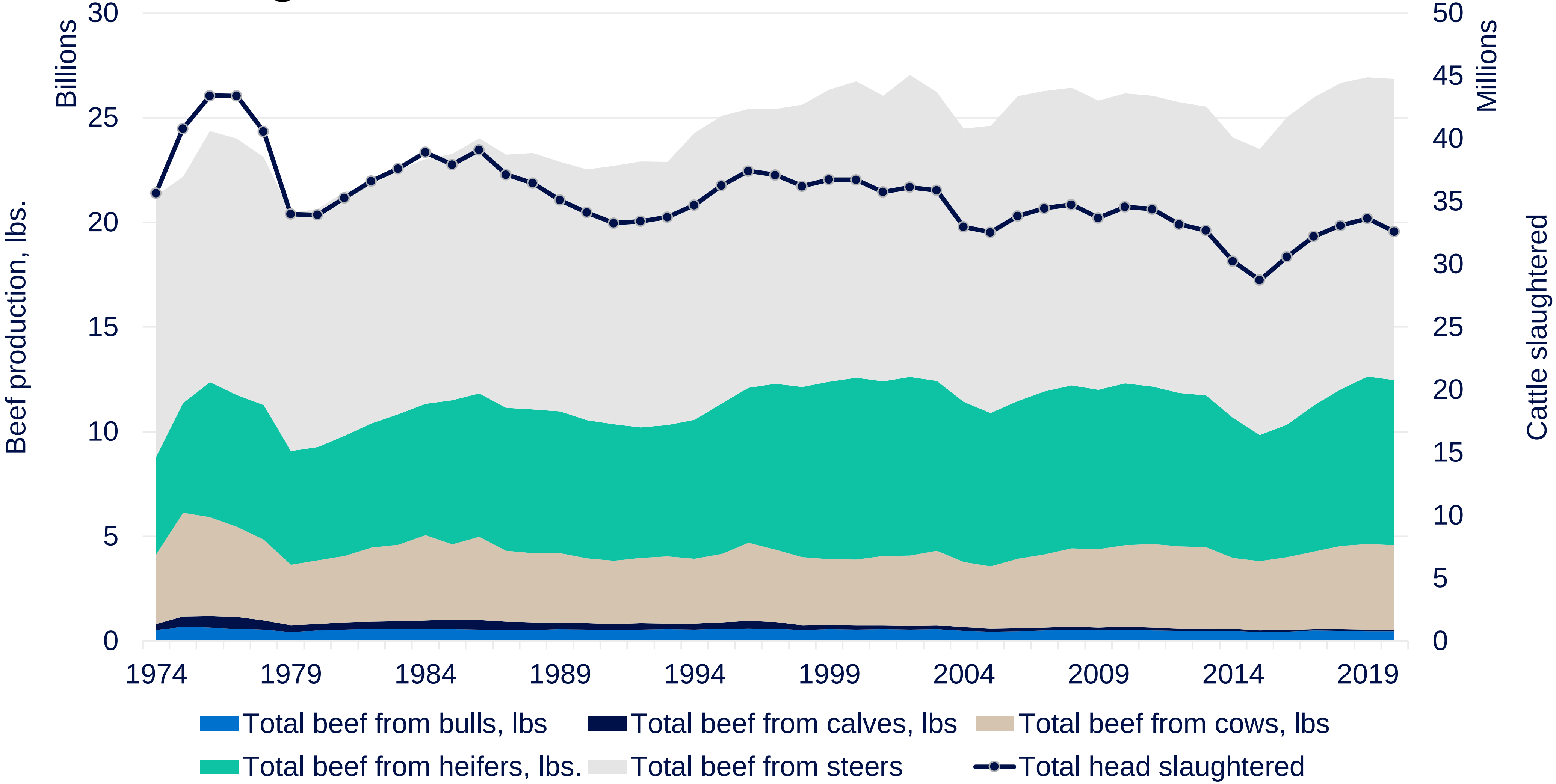


Simplified sustainability tradeoffs with beef and reducing GHG emissions



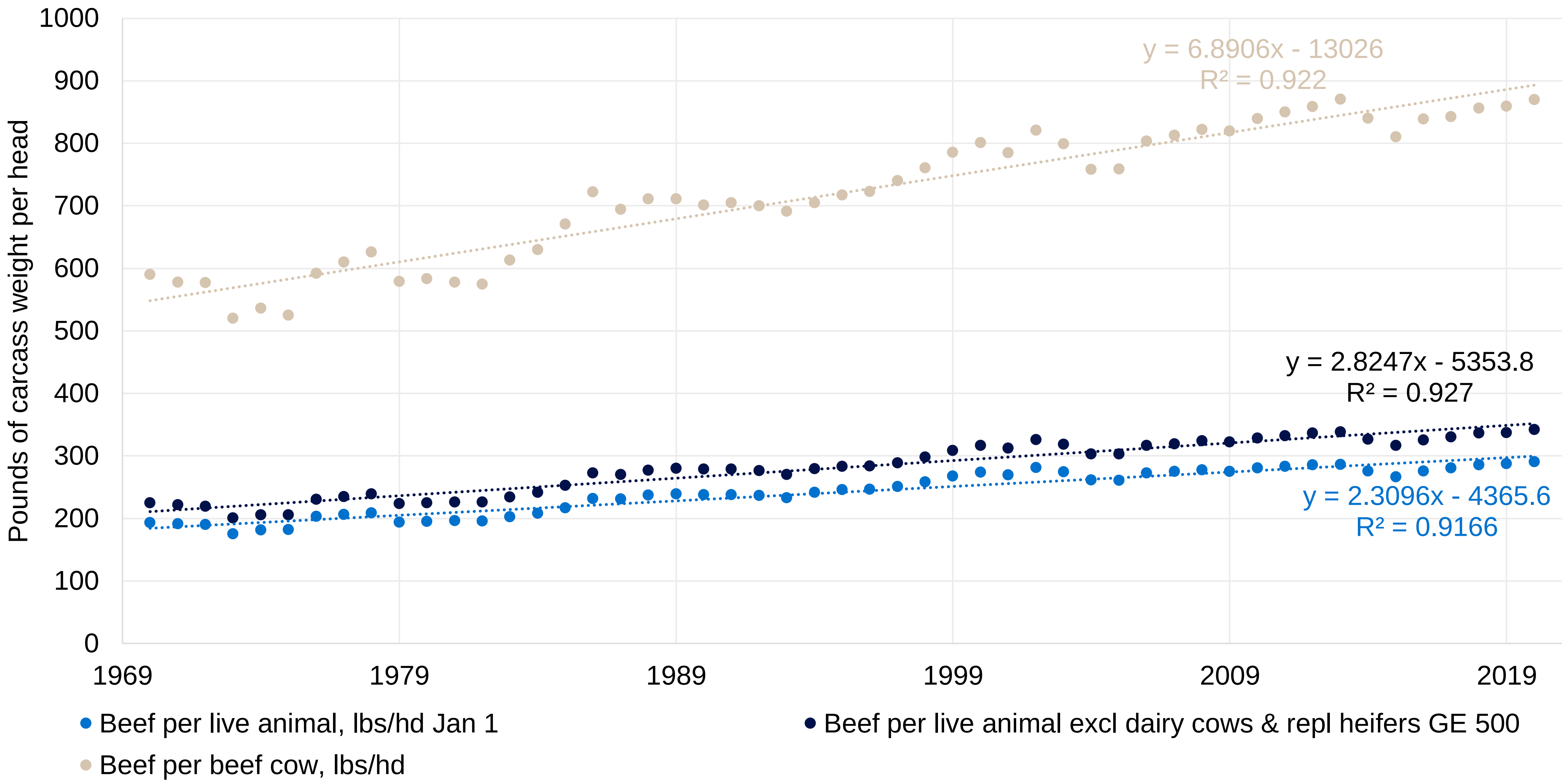
Trends in the US beef industry

Trends in federally inspected beef production & slaughter. Production is up 26%, slaughtered head down 9% since 1974



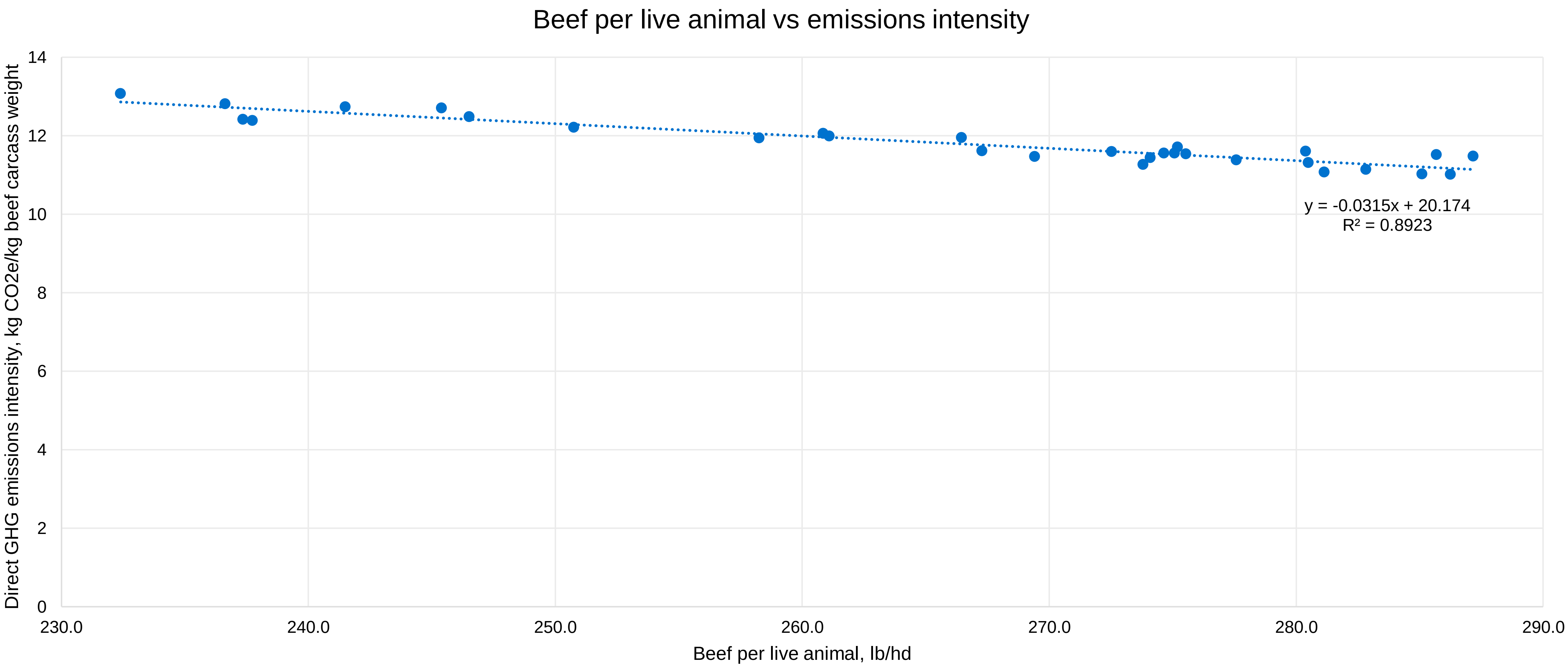
Source: USDA'NASS Quick Stats

Trends in beef produced per animal



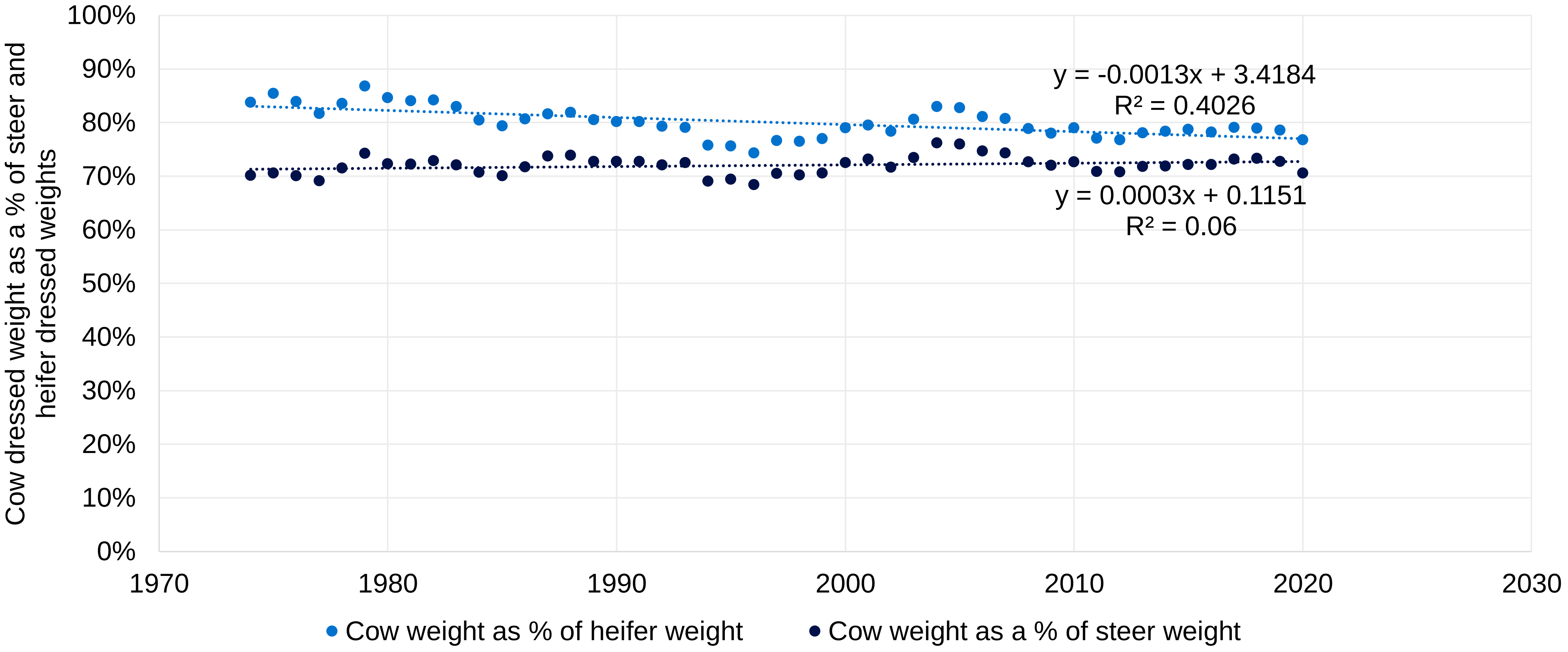
Source: USDA NASS Quick Stats

Beef production per live animal and emissions intensity of beef are inversely related



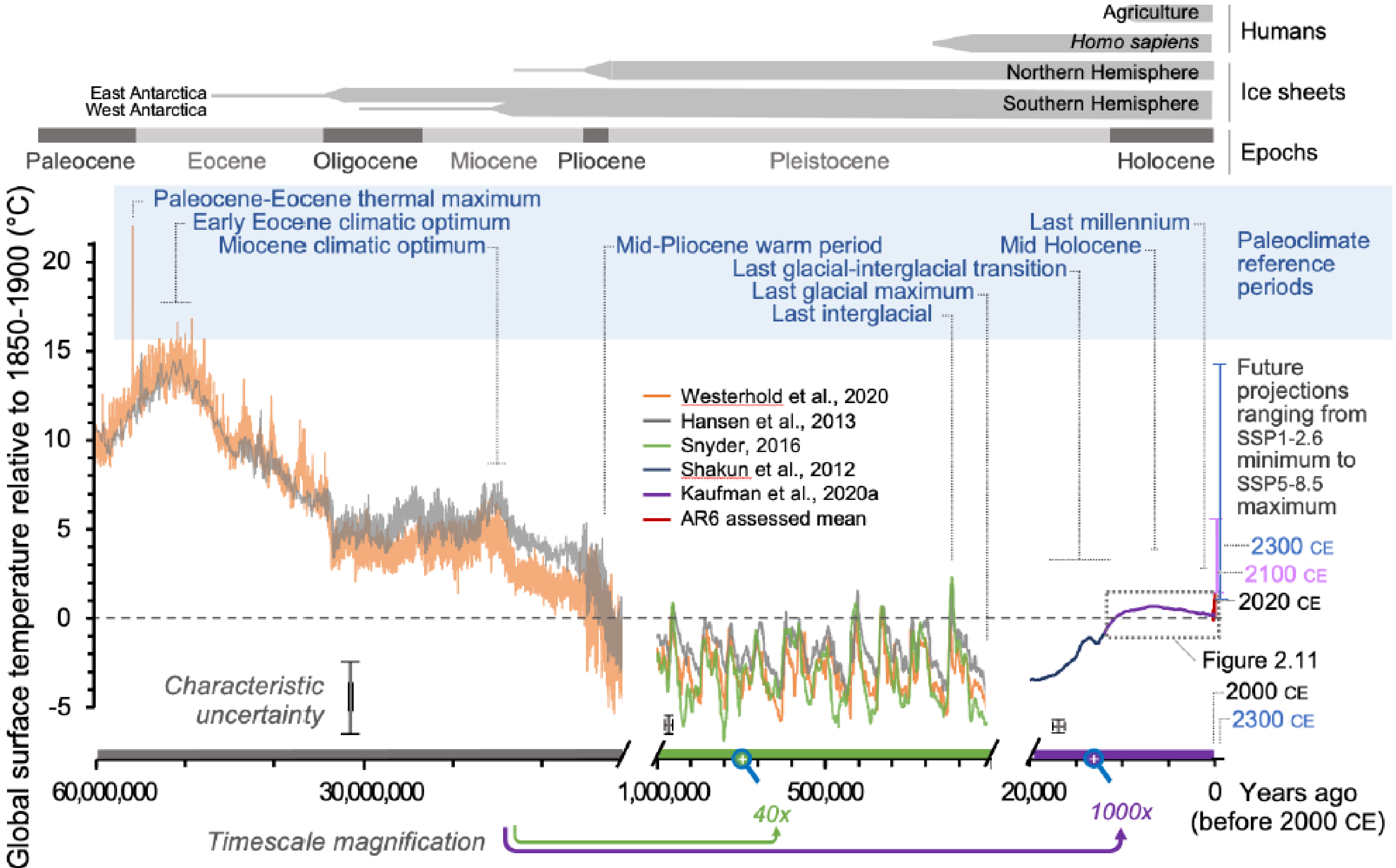
Sources: USDA NASS Quick Stats and US EPA GHG Inventory

Cow slaughter weight as a % of heifer and steer slaughter weights – can we further decouple & reduce total herd maintenance costs?



Climate in Context

Earth’s Recent Surface Temperature History



Cross-Chapter Box 2.1, Figure 1: Global mean surface temperature (GMST) over the past 60 million years relative to 1850-1900 shown on three time scales.

Gulev, S. K., P. W. Thorne, J. Ahn, F. J. Dentener, C. M. Domingues, S. Gerland, D. Gong, D. S. Kaufman, H. C. Nnamchi, J. Quaas, J. A. Rivera, S. Sathyendranath, S. L. Smith, B. Trewin, K. von Shuckmann, R. S. Vose, 2021, Changing State of the Climate System. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

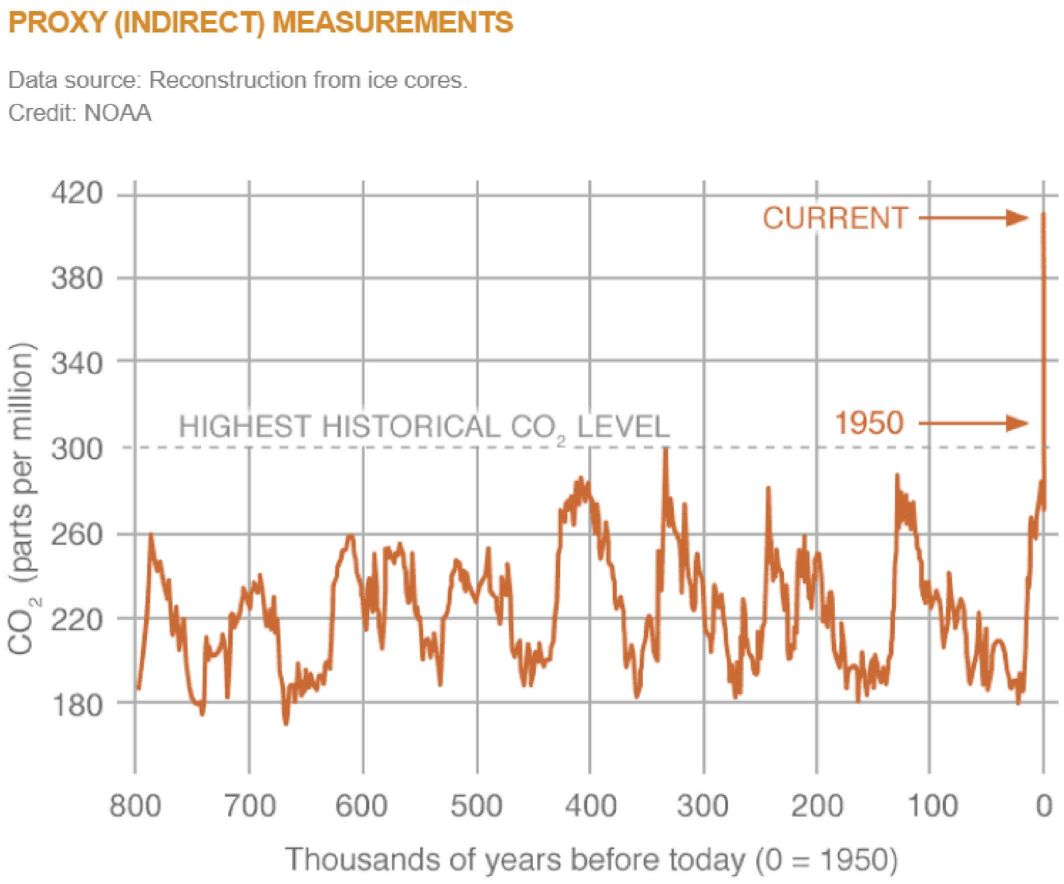
Greenhouse effect keeps global average temperature at ~57 °F.

Without the greenhouse effect, global average temperature would be less than 0°F.

Available at: https://climate.nasa.gov/climate_resources/188/graphic-the-greenhouse-effect/

Carbon dioxide (CO_2) concentrations within the atmosphere have increased rapidly in the past few decades

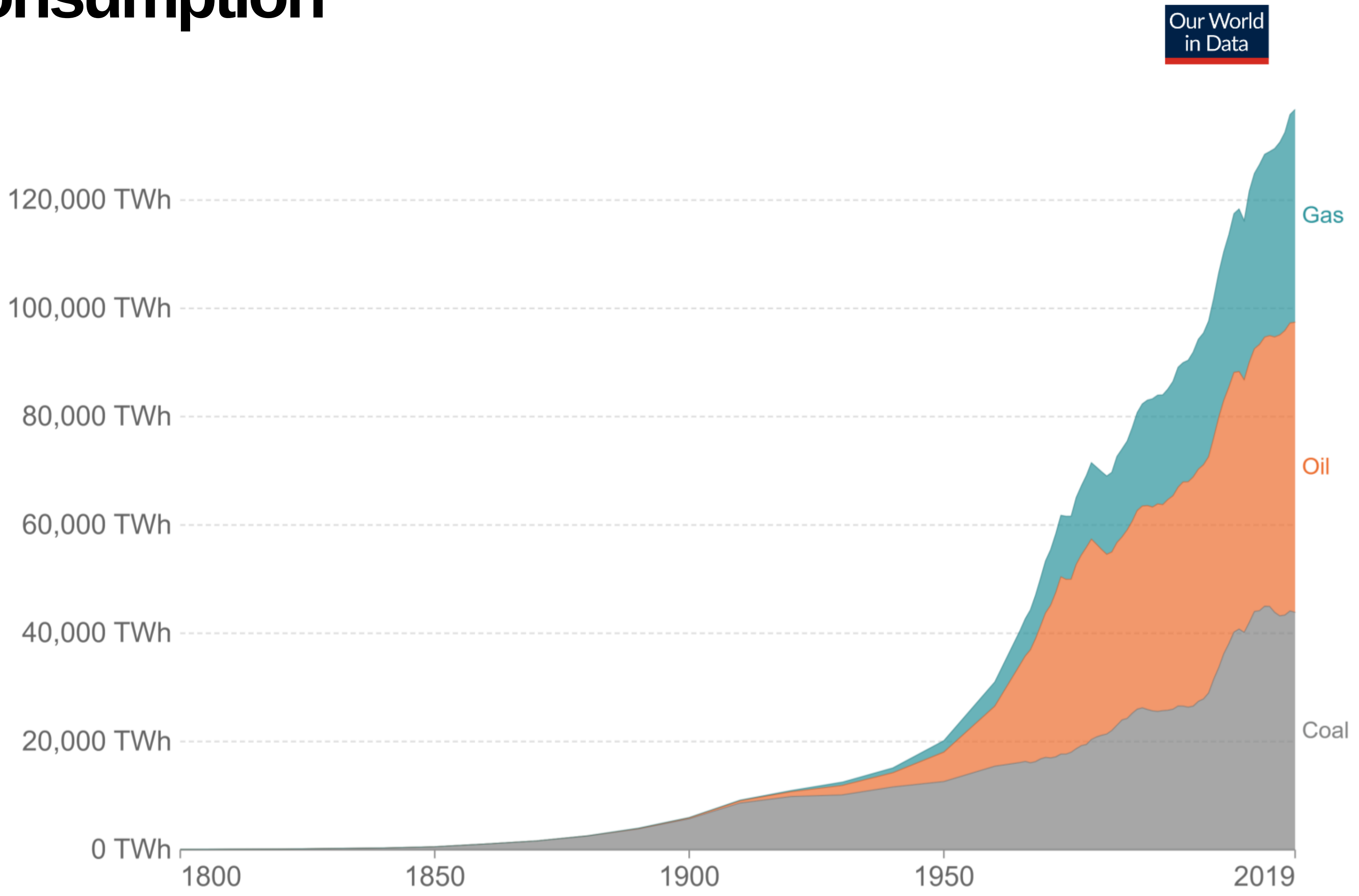
"Over the past 171 years, **human activities have raised atmospheric CO2 concentrations by 48%** above pre-industrial levels found in 1850. This is **more than what had happened naturally over a 20,000 year period** (from the Last Glacial Maximum to 1850, from 185 ppm to 280 ppm)."



Available at: https://climate.nasa.gov/vital-signs/carbon-dioxide/

Global Fossil Fuel Consumption

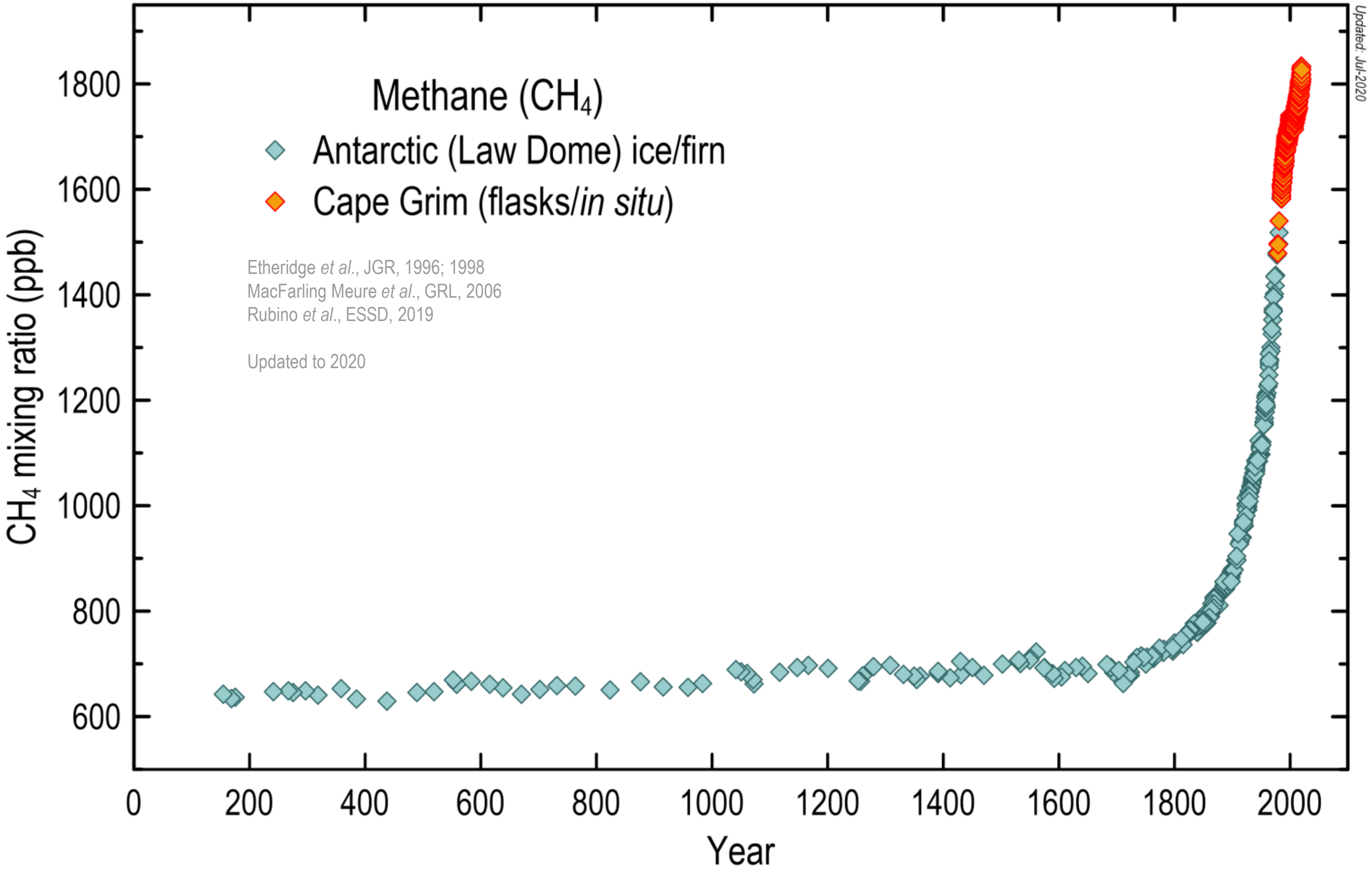
Global primary energy consumption by fossil fuel source, measured in terawatt-hours (TWh)



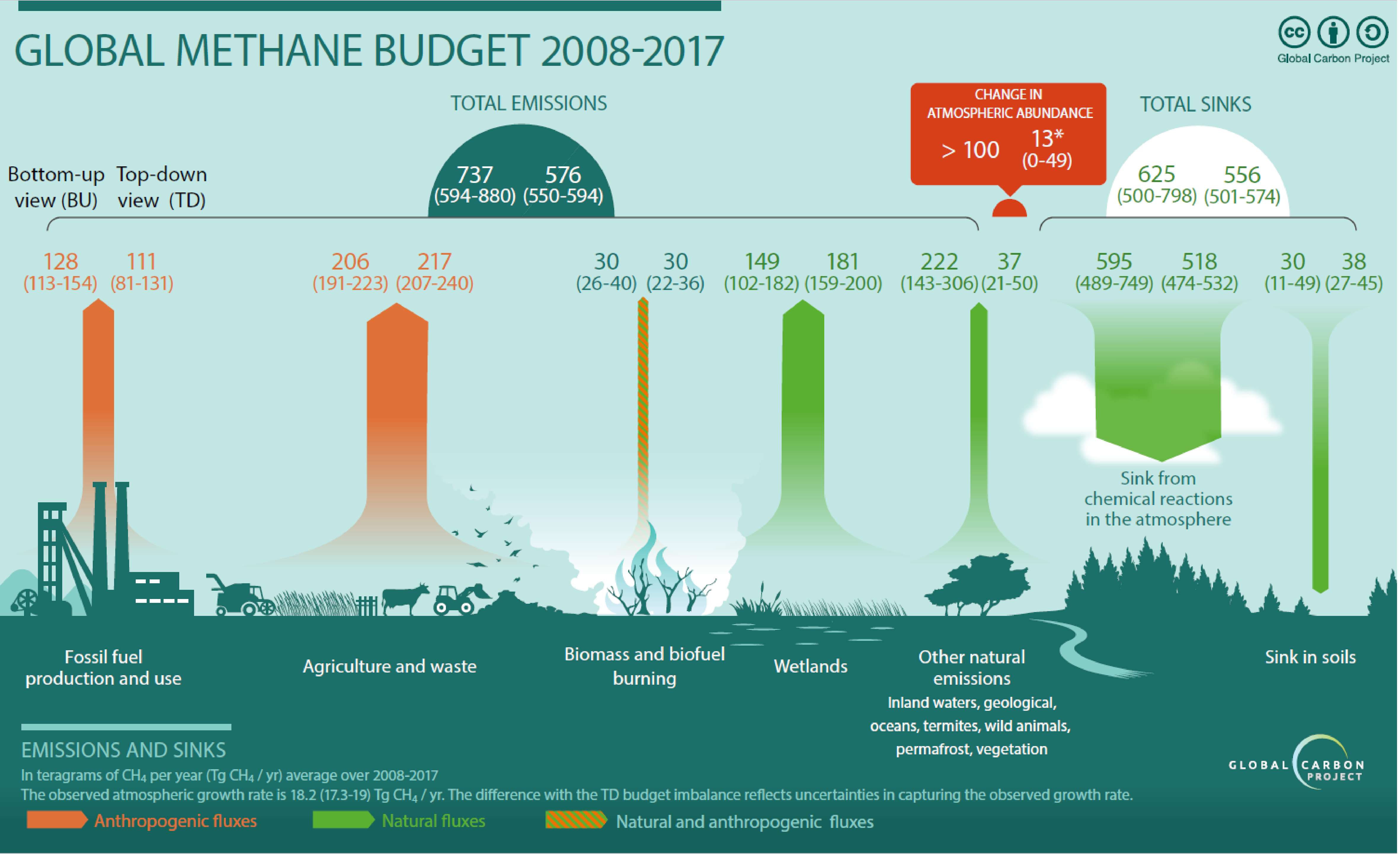
Source: Vaclav Smil (2017), Energy Transitions: Global and National Perspective & BP Statistical Review of World Energy
OurWorldInData.org/fossil-fuels/ • CCBY

Available at: https://ourworldindata.org/fossil-fuels

Methane (CH4) is the second most important anthropogenic GHG and has also increased atmospheric concentrations since the Industrial Revolution (up 150% since 1750)



Available at: https://www.globalcarbonproject.org/methanebudget/20/presentation.htm


GLOBAL METHANE BUDGET 2008-2017
Global Carbon Project
TOTAL EMISSIONS
737 (594-880)
576 (550-594)
Bottom-up view (BU)
Top-down view (TD)
CHANGE IN ATMOSPHERIC ABUNDANCE
> 100
13* (0-49)
TOTAL SINKS
625 (500-798)
556 (501-574)
128 (113-154)
111 (81-131)
206 (191-223)
217 (207-240)
30 (26-40)
30 (22-36)
149 (102-182)
181 (159-200)
222 (143-306)
37 (21-50)
595 (489-749)
518 (474-532)
30 (11-49)
38 (27-45)
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) average over 2008-2017
The observed atmospheric growth rate is 18.2 (17.3-19) Tg CH4 / yr. The difference with the TD budget imbalance reflects uncertainties in capturing the observed growth rate.
Anthropogenic fluxes
Natural fluxes
Natural and anthropogenic fluxes
GLOBAL CARBON PROJECT

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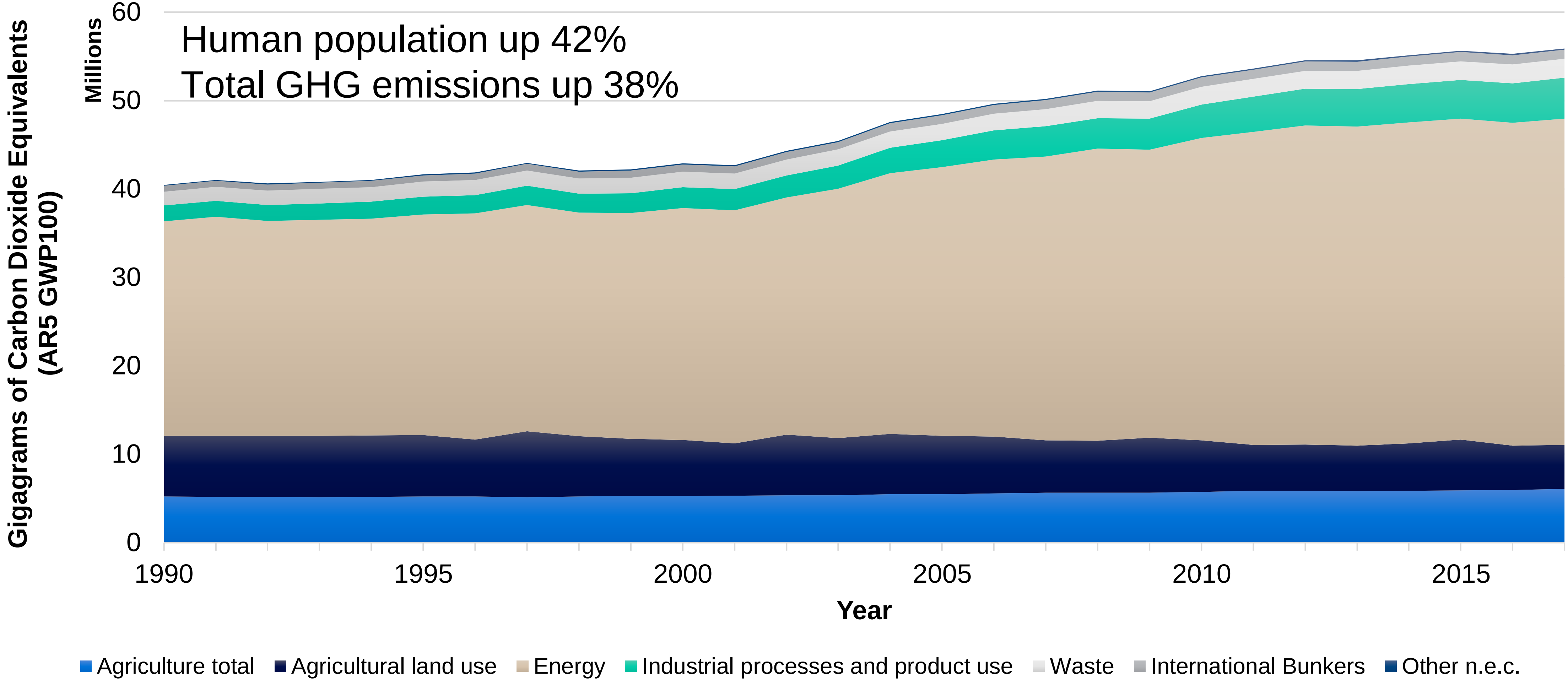
Greenhouse Gas Emissions in Context

Global Greenhouse Gas Emissions Trends, 1990 - 2017



Source: UN FAOSTAT database; http://www.fao.org/faostat/en/#data

Geographic variation in GHG emissions intensity for beef production is substantial

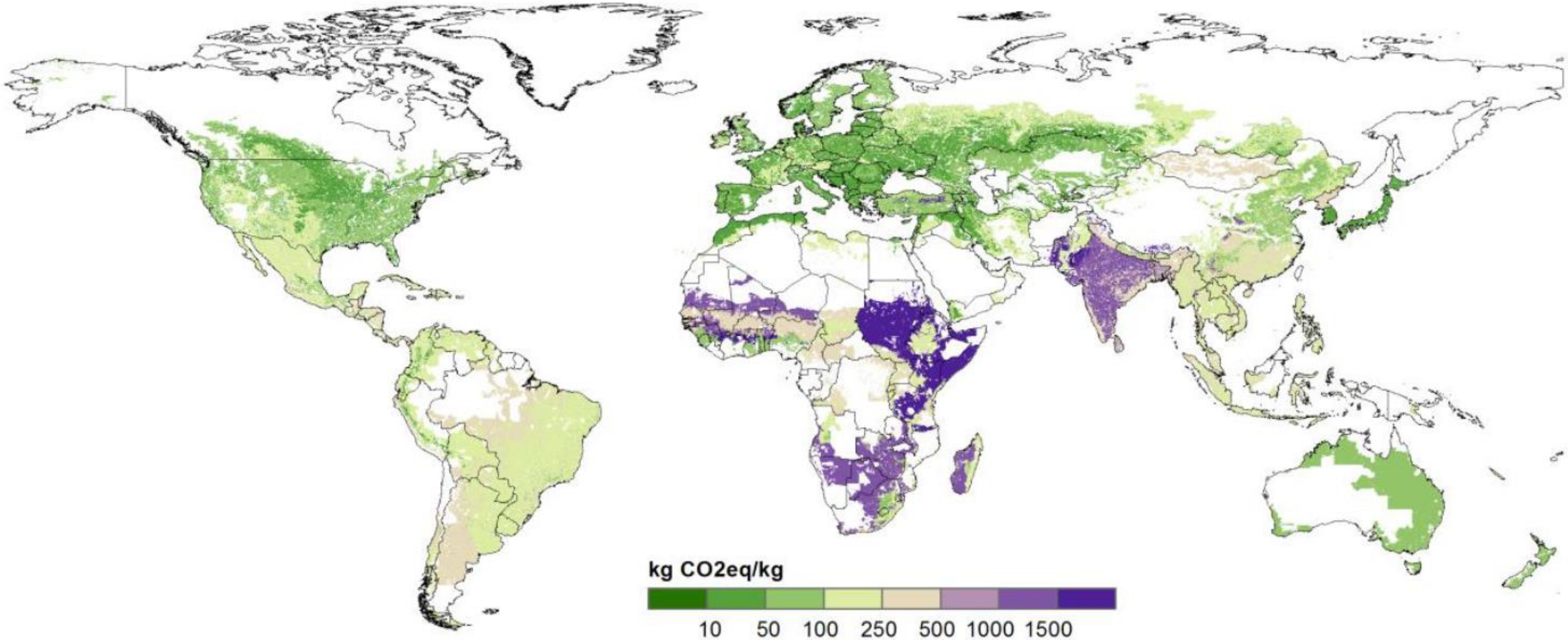
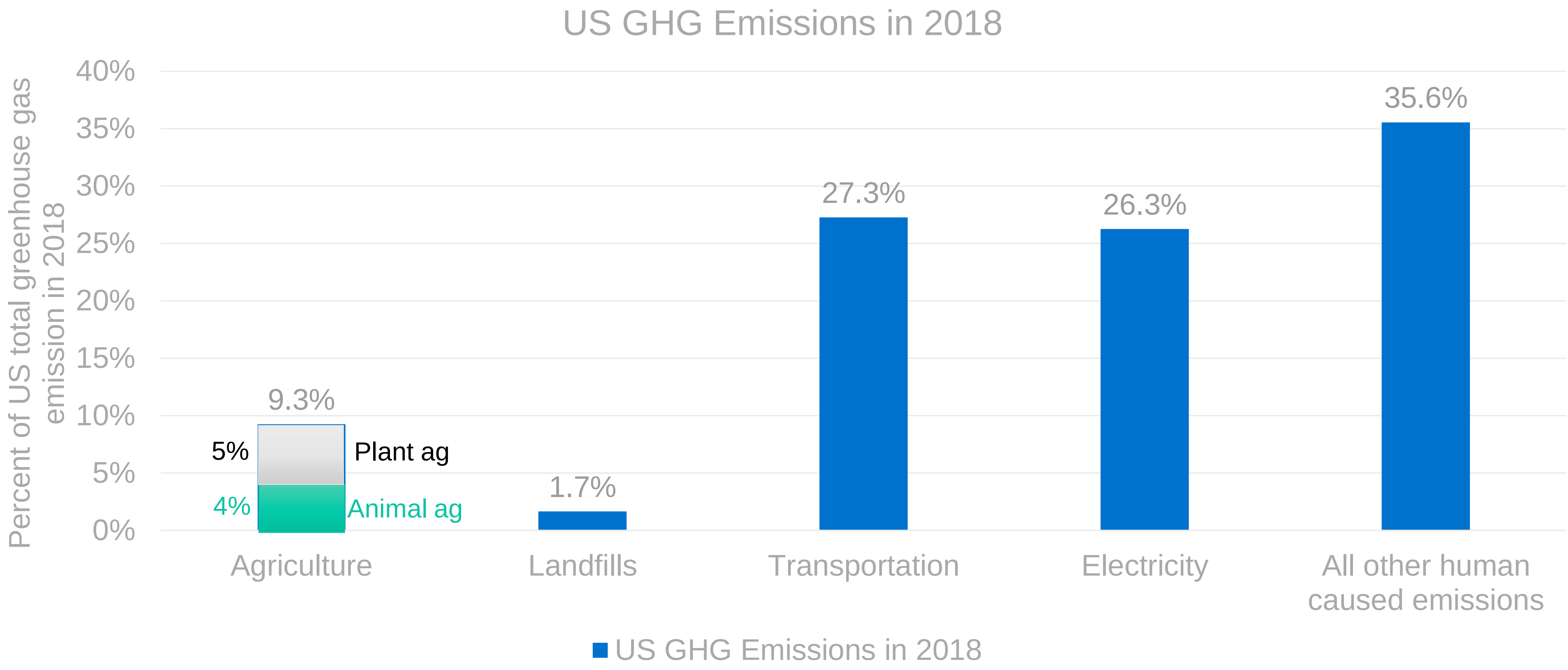


Figure S 47. GHG efficiency of bovine meat production (expressed in kg CO_2eq/g protein) in the year 2000

Source: Herrero et al., 2013. *Proc. Natl. Aca. Sci.* 110: 20888-20893

Animal Agriculture is Responsible for About 4% of U.S. Greenhouse Gas Emissions



US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2018. 2020. available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018

The Climate Balance Sheet for US Beef Cattle Production

~3.7% of US GHG emissions

EMISSIONS SOURCES (% OF TOTAL[1]):

Enteric methane emissions (56%)

- Cow-calf production = 77% of enteric methane emissions
- Opportunities: improved production efficiency, reduced mortality, increased digestibility of feedstuffs, new innovations to inhibit methane

Feed/soil emissions (24%)

- Mostly soil nitrous oxide
- Opportunities: improvements in crop yields, optimized fertilizer use, integration of cattle & crops

Fossil fuel & input emissions (17%)

- Equipment, fertilizer, electricity, lime
- Opportunities: energy efficiency, optimized fertilizer use

Manure emissions (3%)

- Manure nitrous oxide & methane
- Opportunities: Manure management strategies and innovations customized to operations (e.g., composting, anaerobic digestion where relevant)

[1]Rotz, CA, Asem-Hiablie, S, Place, S, Thoma, G. Environmental Footprints of Beef Cattle Production in the United States. Agricultural Systems [Internet]. 2019 Feb [cited 2020 Aug 13]. 169:1-13. https://www.sciencedirect.com/science/article/pii/S0308521X18305675

CARBON SEQUESTRATION:

Pasture and rangelands

- Opportunities: Maintain soil C stores, increase soil where possible via management & re-establishment on degraded/highly erodible croplands

Row crops fed to cattle

- Opportunities: increase no-till/reduced tillage, cover crops, integration with cattle & other livestock

REDUCE EMISSIONS

\+

MAINTAIN & ENHANCE SINKS

=

NET ZERO CLIMATE IMPACT

US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2018. 2020. available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018

Accounting for short-lived GHG emissions separately better ties emissions to climate impacts

OXFORD MARTIN SCHOOL

UNIVERSITY OF OXFORD

Net zero for agriculture

Oxford Martin Programme on Climate Pollutants

August 2019

To design effective policies to stop global warming, we need to know the impact of different measures on temperature. This has long been a challenge for action involving short-lived climate pollutants such as methane. CO_2-warming-equivalent (CO_2-we) emissions provide a simple but accurate way of assessing the glob temperature outcomes of different mitigation options, avoiding well-known problems arising from the use of conventional CO_2-equivalent (CO_2-e) emissions.

Article | Open Access | Published: 04 September 2019

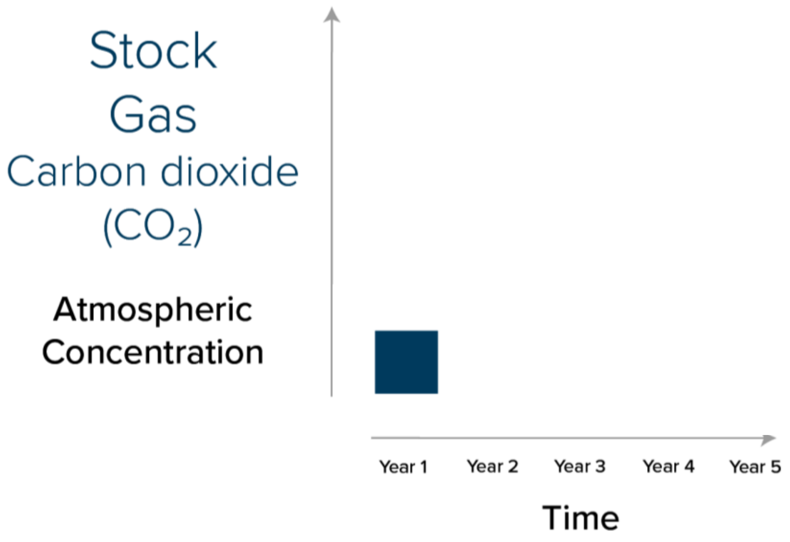
Improved calculation of warming-equivalent emissions for short-lived climate pollutants

Michelle Cain, John Lynch, Myles R. Allen, Jan S. Fuglestvedt, David J. Frame & Adrian H Macey

npj Climate and Atmospheric Science **2**, Article number: 29 (2019) | Cite this article

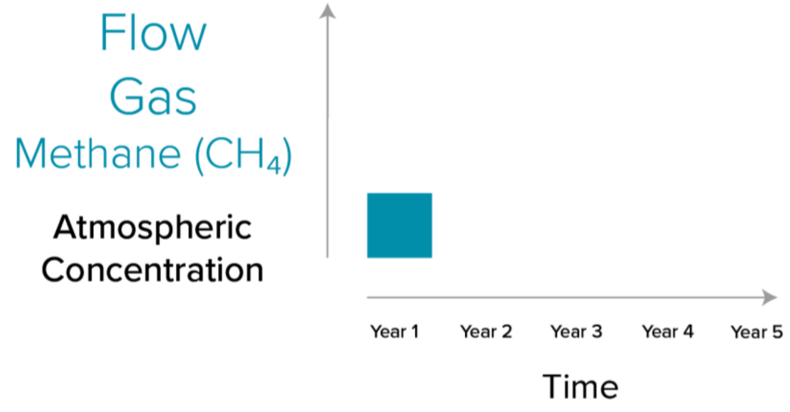
= Pulse of CO_2

= Pulse of CH_4



Stock gases will accumulate over time, because they stay in the environment.

If emissions and sinks are in balance



Flow gases will stay stagnant, as they are destroyed at the same rate of emission.

Based on research by Myles R. Allen, Keith P. Shine, Jan S. Fuglestvedt, Richard J. Millar, Michelle Cain, David J. Frame & Adrian H. Macey.
Read more here: https://rdcu.be/b1t7S

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The "So-what" of New Climate Metrics for Short-lived Gases

Better reflects reality of how emissions impact temperature

- This is what we actually care about

Highlights that methane emissions do not have to be zero to reach "climate neutrality"

- Climate neutrality defined here as not contributing to additional warming or achieving net zero warming

Important for beef/cattle as methane is the largest GHG in profile

- But, it's not the only GHG associated with beef cattle production!

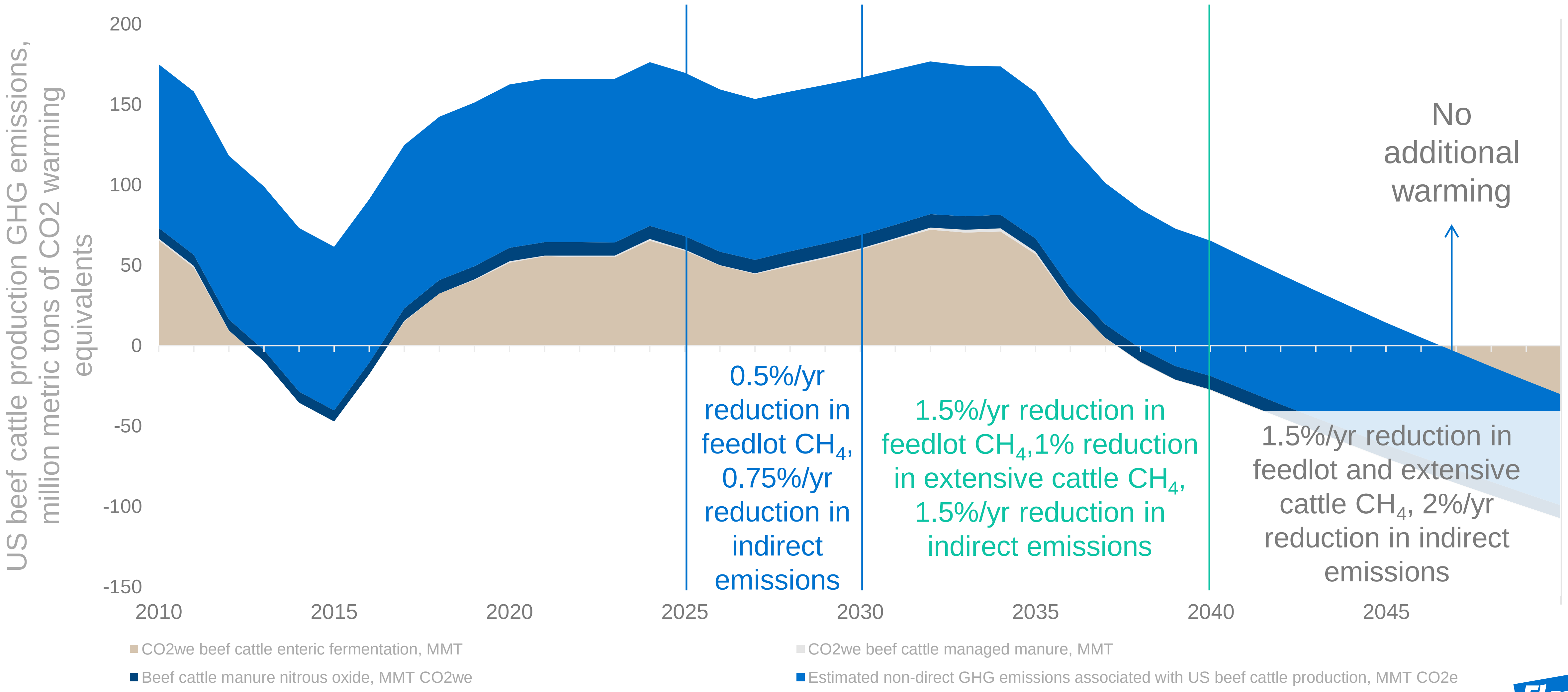
If the Goal is Climate Neutrality for US Beef,
What Could that Look Like?

Assumptions In Scenario to Reach Climate Neutrality

Item	2020	2050	% change from 2020
Cattle, Jan. 1	**93,793,300**	**93,594,500**	**-0.2%**
Beef production, billion lbs.	**27.1**	**31.2**	**+15%**
Beef cattle enteric CH_4, kt	5,163	3,976	-23%
Feedlot cattle enteric CH_4/d, g/hd	127	91	-28%
Beef cow enteric CH_4/d, g/d	262	204	-22%
Indirect GHG emissions, Tg CO_2e[1]	101.7	68.8	-32%
Carbon footprint, kg CO_2e/kg beef carcass[1]	21.04	13.57	-35%
Total GHG emissions, Tg CO_2e[1]	258	192	-26%

[1]Carbon dioxide equivalents (CO_2e) using GWP100 values of 34 and 298 for methane and nitrous oxide, respectively

Climate Neutrality for US Beef Cattle Production by 2047



What Would Be Needed To Reach Climate Neutrality While Maintaining Herd and Production Growth

Need to reduce emissions per head, not just per lb. of beef

Enteric methane is a major "lever" to pull:

- Genetics (feed intake, methane directly)
- Feed additives, feeding strategies
  - Challenge how to deliver to grazing cattle where ~82% of the methane emissions come from?
- Other innovations (e.g., vaccine?)

What Would Be Needed To Reach Climate Neutrality While Maintaining Herd and Production Growth

Unlikely reducing enteric methane will get beef cattle production to climate neutrality alone, so need other reductions and/or increase C sinks

Other reduction examples:

- Reducing feed emissions (e.g., soil N_2O emissions)
- Reducing energy/fuel emissions

Carbon sequestration

- Potential to increase is likely highly dependent upon climate & land’s prior use
- **Consideration: if carbon sold as an offset to buyers outside supply chain, can beef claim as well??**

Bottom Line

Climate neutrality for beef cattle production in the USA is likely possible and technically feasible

- But, it requires new innovations

We cannot lose focus of other aspects of sustainability

- First and foremost, need economic viability
- Cattle production is critical source of nutrition & ruminant benefits to sustainability are substantial (optimum land use, upcycling, wildfire suppression, etc.)

Bottom line

- Cattle products are sustainable
  - Continuous improvement is key
- Cattle provide nutrient rich food
- Cattle provide more than just food
- Animal agriculture directly contributes ~4% of US GHG emissions[1]
- Improved animal health & well-being is a key contributor to sustainability
- Reducing methane emissions is a key opportunity for livestock production, especially ruminant ag

Safe, nutritious, high quality food production while balancing economic viability, environmental stewardship, and social responsibility

Environment

Economic

Social

[1]US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2018. 2020. available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018

EM-US-20-0161

Thank You