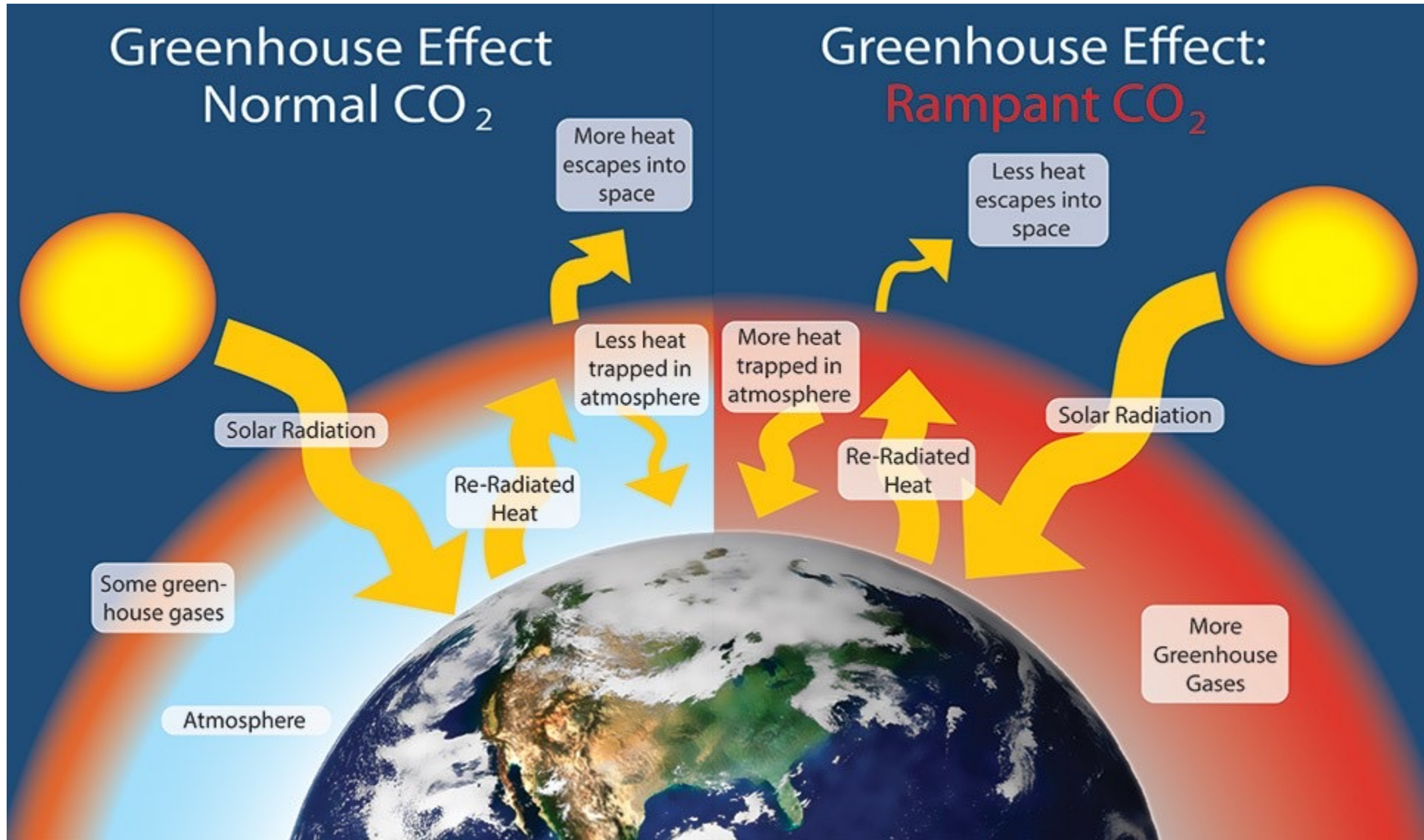


Climate Change and the Food Supply

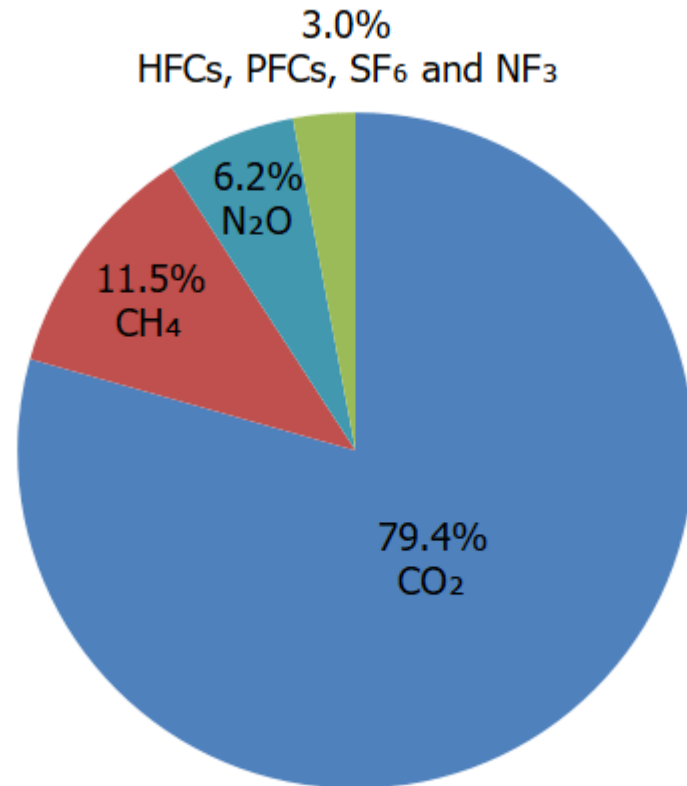
Eric A. Decker

Department of Food Science

UMass, Amherst



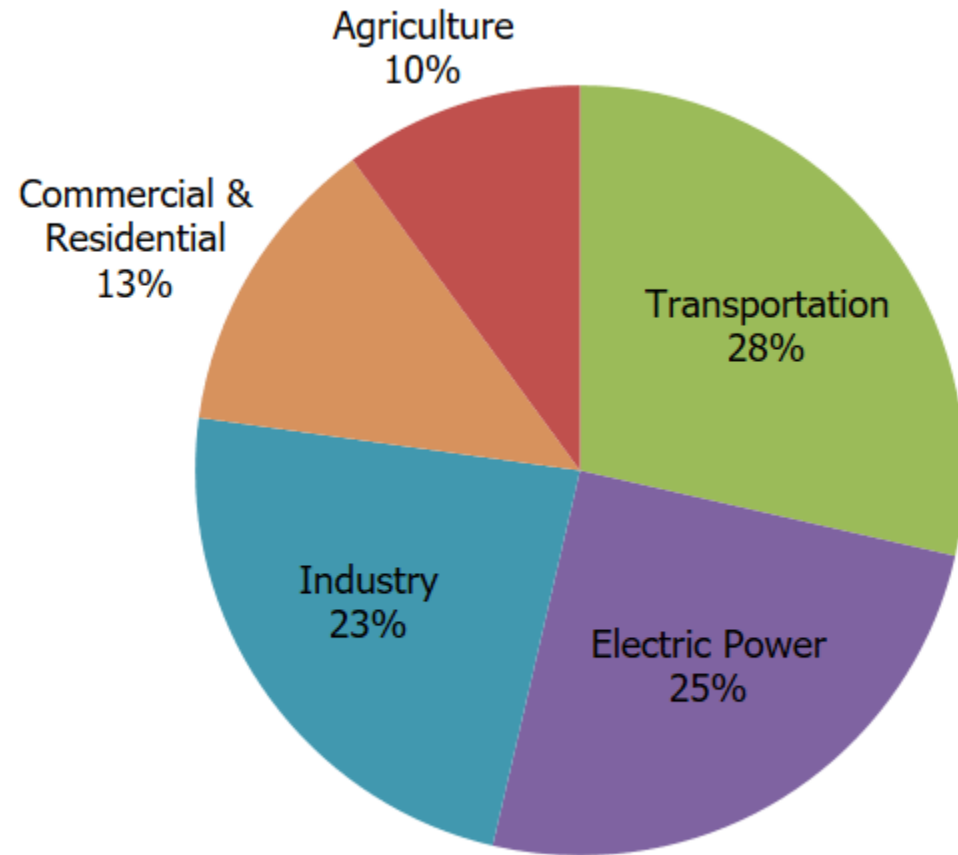
Major Greenhouse Gases



U.S. Environmental Protection Agency (2023). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021

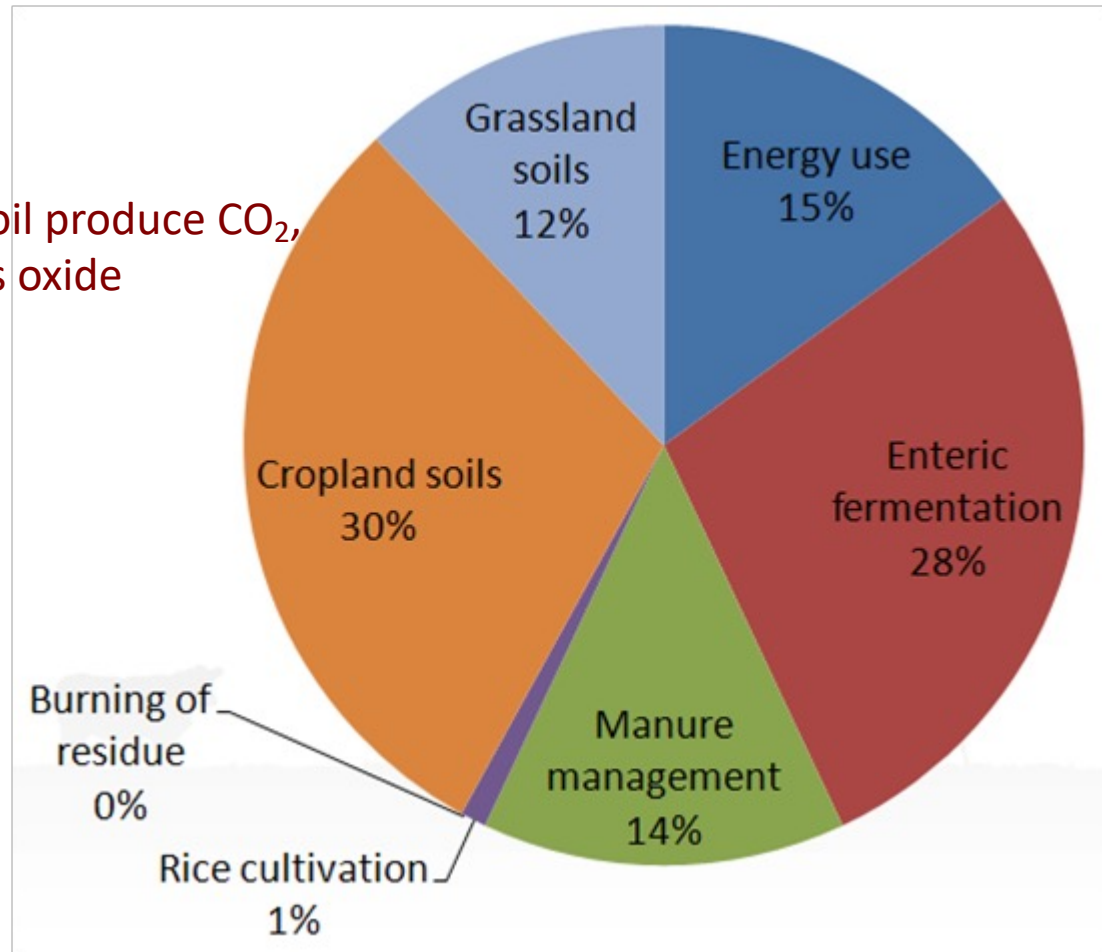


Sources of Greenhouse Gases

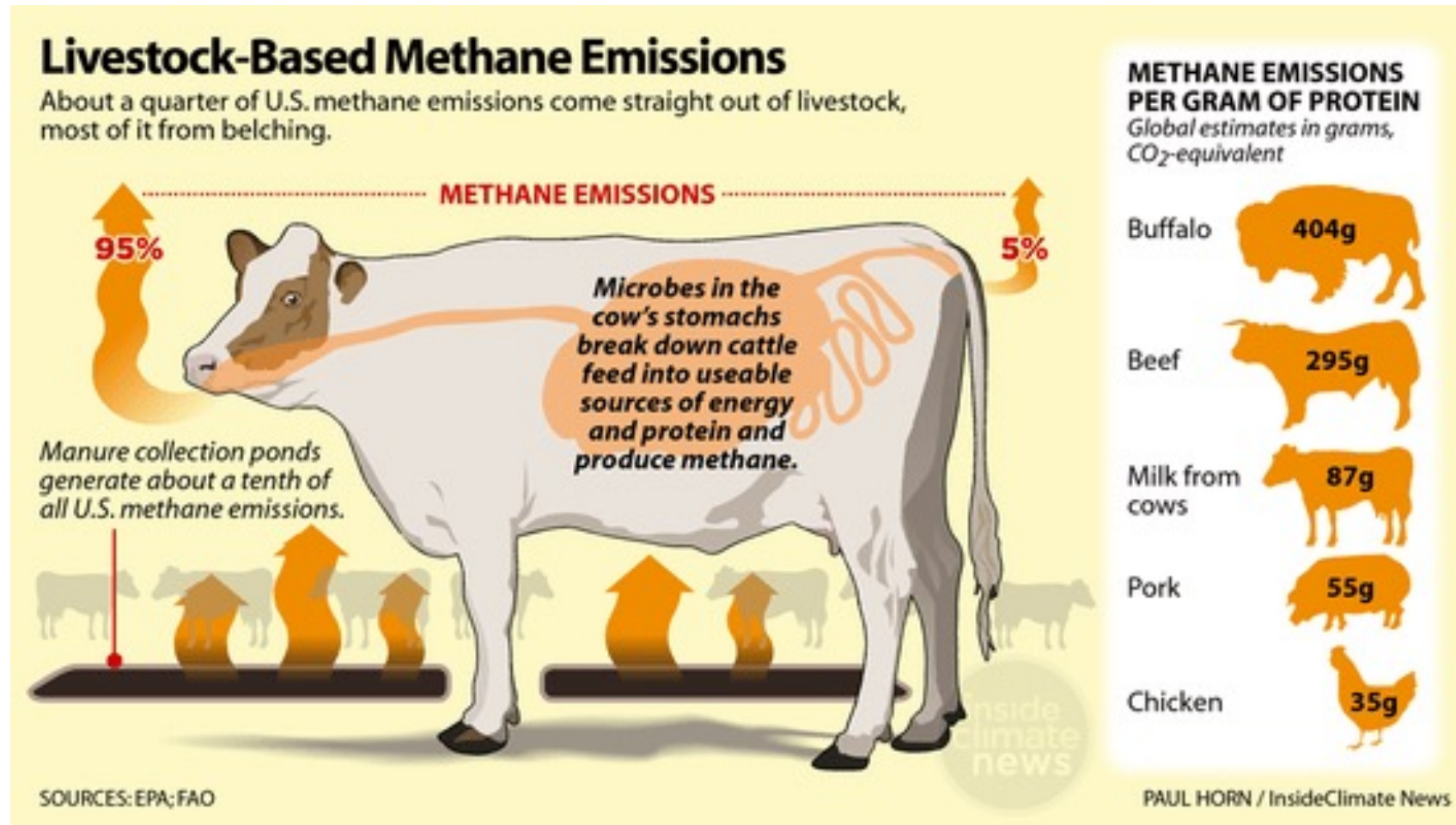


Agricultural Sources of Greenhouse Gases

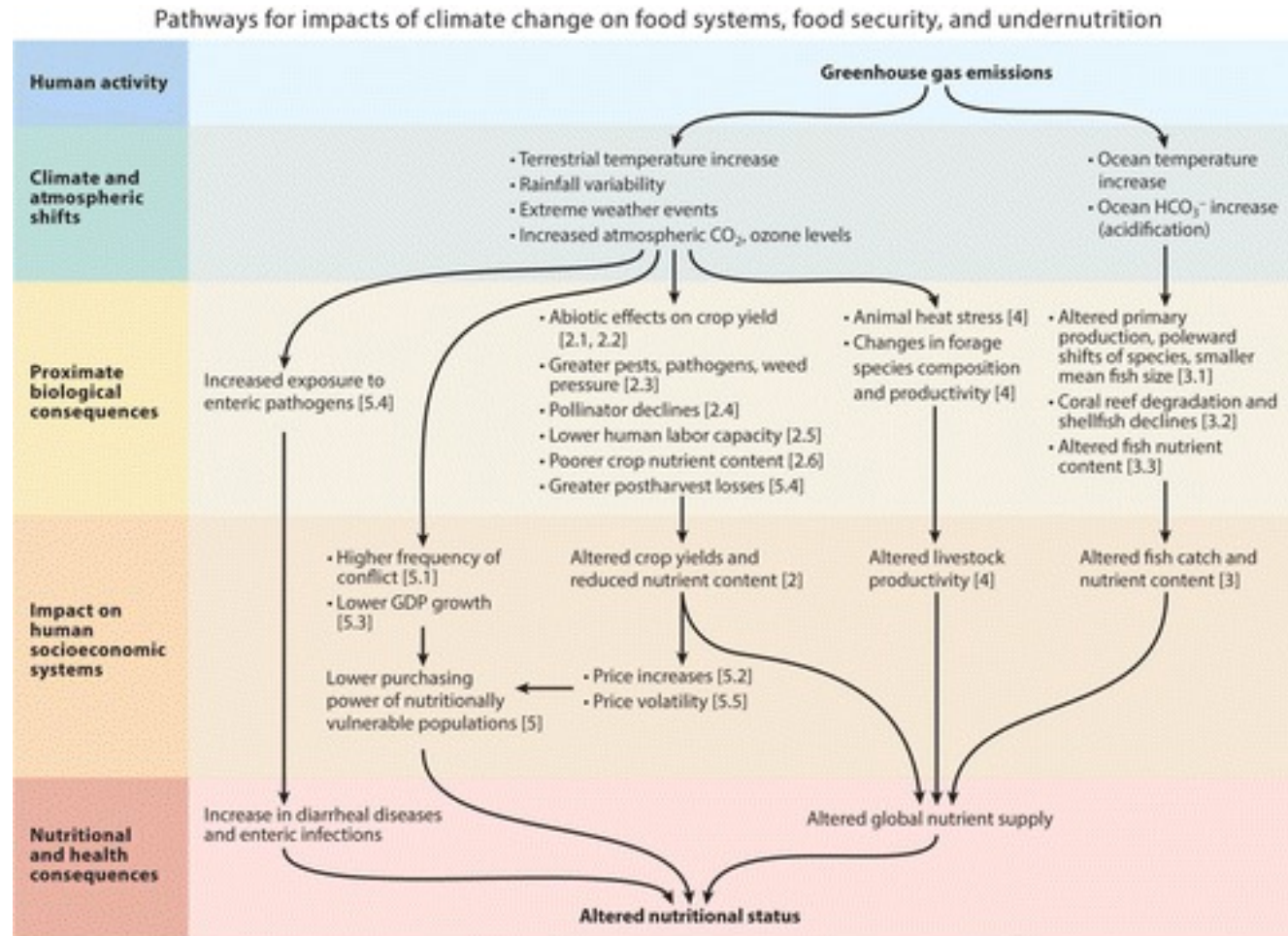
Microorganisms in soil produce CO₂, methane and nitrous oxide



Sheep, Beef and Dairy Cattle Contributions to Greenhouse Gases



Climate Change and Plant Health



Climate Change and Water

- Shifting precipitation patterns
 - Loss of glaciers/earlier snow melt
 - Infusion of salt water into coastal water supplies
 - More severe flooding
 - Droughts
-
- Could require relocation of agricultural production
 - e.g. Dairy in California



Temperature

- Many rain feed crops decrease yield with temp > 86 F
 - Increases water loss by evaporation
- Future: 15-25% decrease in crop yields with increasing temperature especially in tropical areas
- Range of agricultural production can change.
- Wine
 - Expansion of vineyards to areas that traditionally could not grow grapes during to excess moisture or cold temperatures
 - Can also change areas where plants are stressed (e.g. low water) which produces higher quality wines
 - Some growers are now having to deal with over-ripening so need to move vineyards from southern to northern slopes



Wine growing regions , 2100

Selected

Edinburgh,
The Borders
Riesling
Pinot Noir
Pinot Grigio

Hereford &
Worcestershire,
West Midlands,
Shropshire,
Cheshire
Chardonnay
Sauvignon Blanc
Riesling
Pinot Noir

Bristol area,
Somerset
Merlot

London
Merlot
Malbec
Syrah
Tempranillo

West Sussex,
Kent
Merlot

Red wine
White wine

Northamptonshire,
Lincolnshire,
Yorkshire
Chardonnay
Sauvignon Blanc
Riesling
Pinot Noir
Pinot Grigio

Essex
Merlot
Malbec
Syrah
Tempranillo
Chardonnay
Riesling
Sauvignon Blanc

120 km

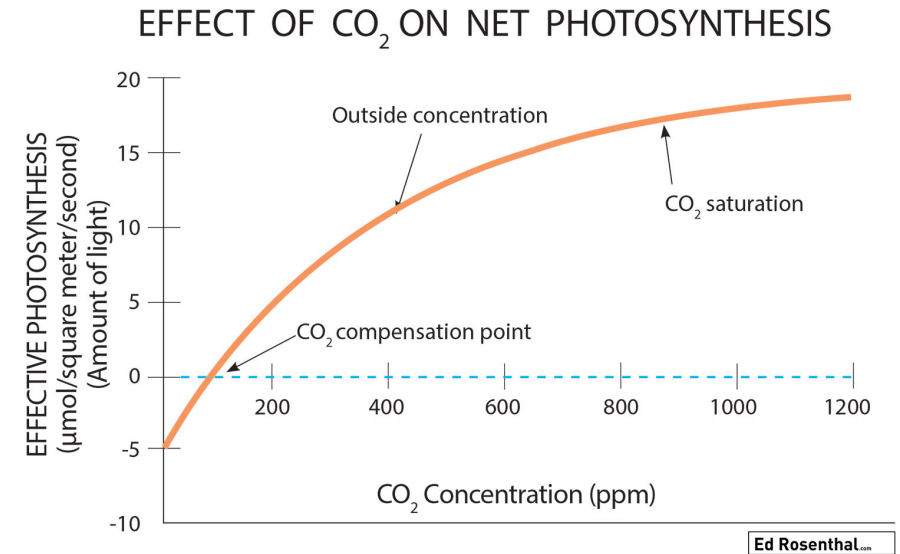
Source: Laitthwaite's Wine



Washington Post and Financial Times

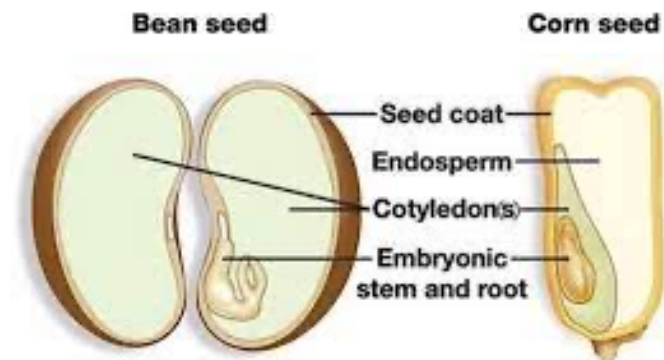
Carbon Dioxide

- Carbon dioxide is food for plants
- Increased carbon dioxide increases water utilization and photosynthesis in plants
 - Wheat, rice and soybeans will grow faster with increasing carbon dioxide
 - Weeds respond better than crops



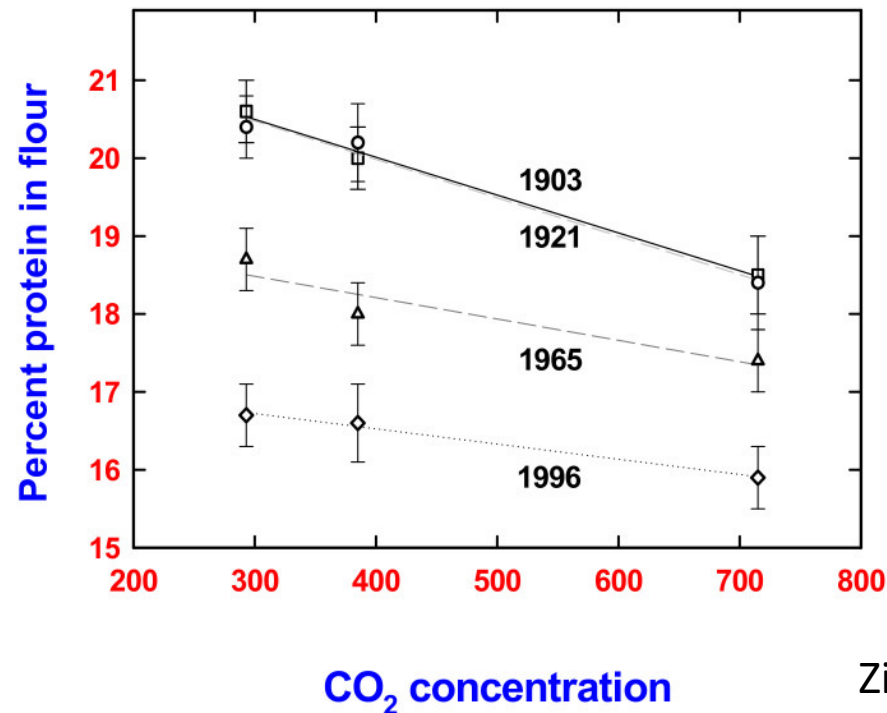
Climate Change and Nutritional Composition of Plants

- Biological systems have adapted to store energy when excess is available
 - Humans = fat
 - Plants = starch
- As starch accumulates, other nutrients are diluted
 - Breeding to increase yield results in lower protein, Ca, P, Fe riboflavin and ascorbic concentrations (Davis et al. 2004)



Climate Change and Nutritional Composition of Plants

- With increased CO₂, rice, wheat, barley, and potatoes experience 7–15% reductions in protein content
- 3–11% decreases of zinc and iron concentrations in cereal grains and legumes



Ziska et al., 2022

Climate change effects vulnerable populations the most

- Vulnerable populations such as Latin American, Southern Asia and Africa receive high amount for calories and proteins from cereal grains
- Because of the large of amounts of grains consumed, they are a major source of protein
 - Rice: 2.7% protein
 - Wheat: 13% protein
 - Corn: 11% protein
- Reduction of protein in grains due to climate change could result in protein deficiencies
 - 200 million people are estimated to not receive recommended protein intakes

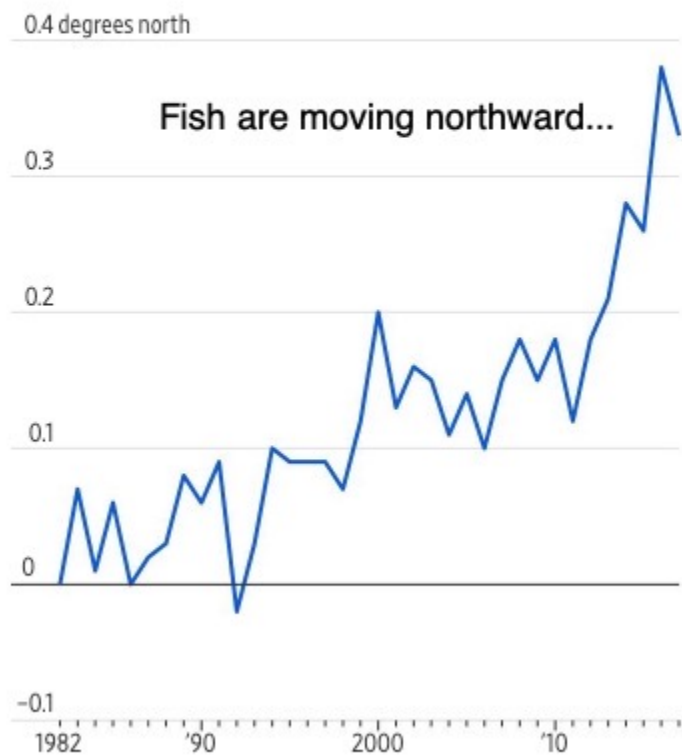
Climate Change and Seafood

- Current crisis is over-fishing
 - 68% of global fish stocks are below sustainable harvest levels
- Climate change impacts oceans by causing
 - Increasing temperature
 - Decreasing oxygen
 - Increasing acidity from carbon dioxide
- Changes food sources (microalgae)
- Net result is a shift in species toward poles to find cooler waters

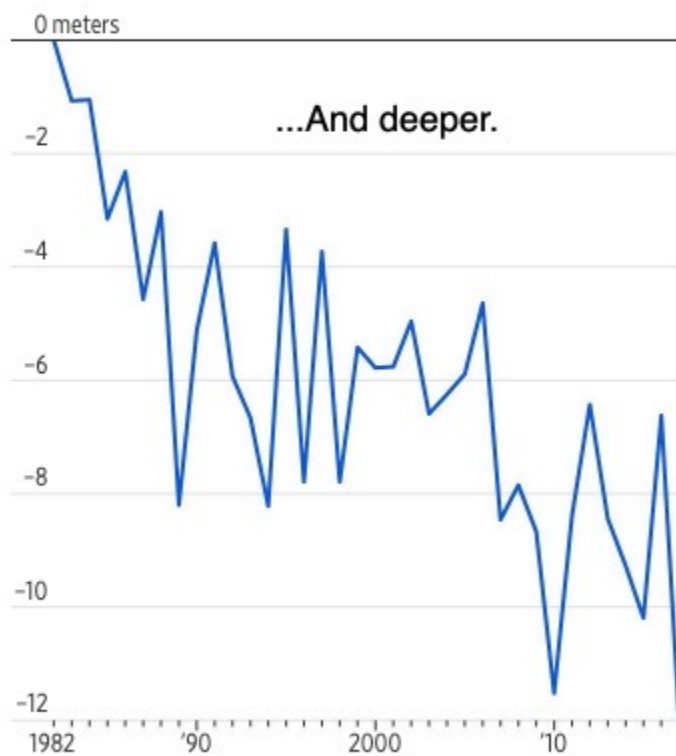


AVERAGE CHANGE IN LATITUDE AND DEPTH FOR 105 MARINE FISH AND INVERTEBRATE CENTERS OF ABUNDANCE IN THE U.S.

LATITUDE



DEPTH



Source: National Oceanic and Atmospheric Administration/OceanAdapt, Rutgers University

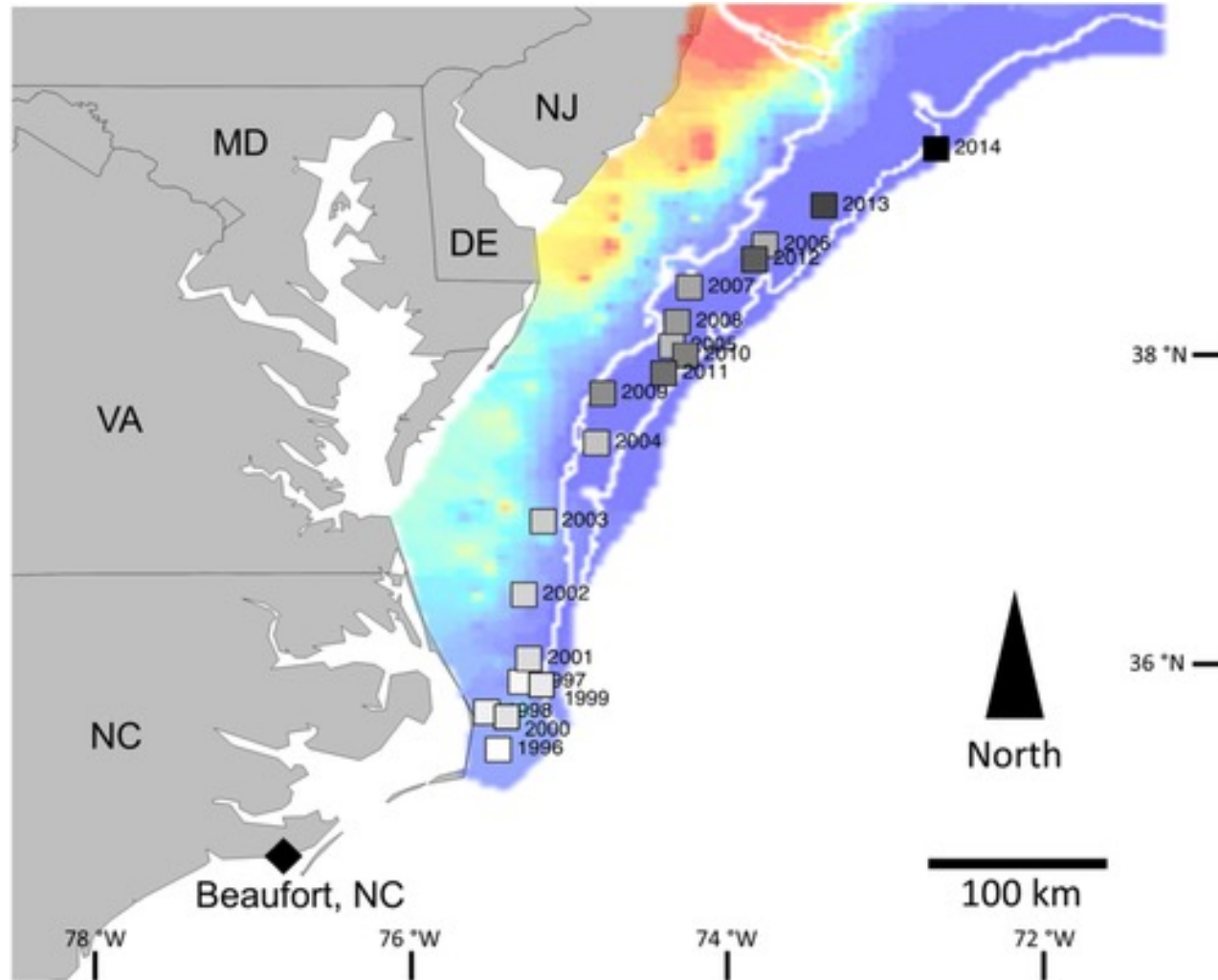
WSJ

Seafood

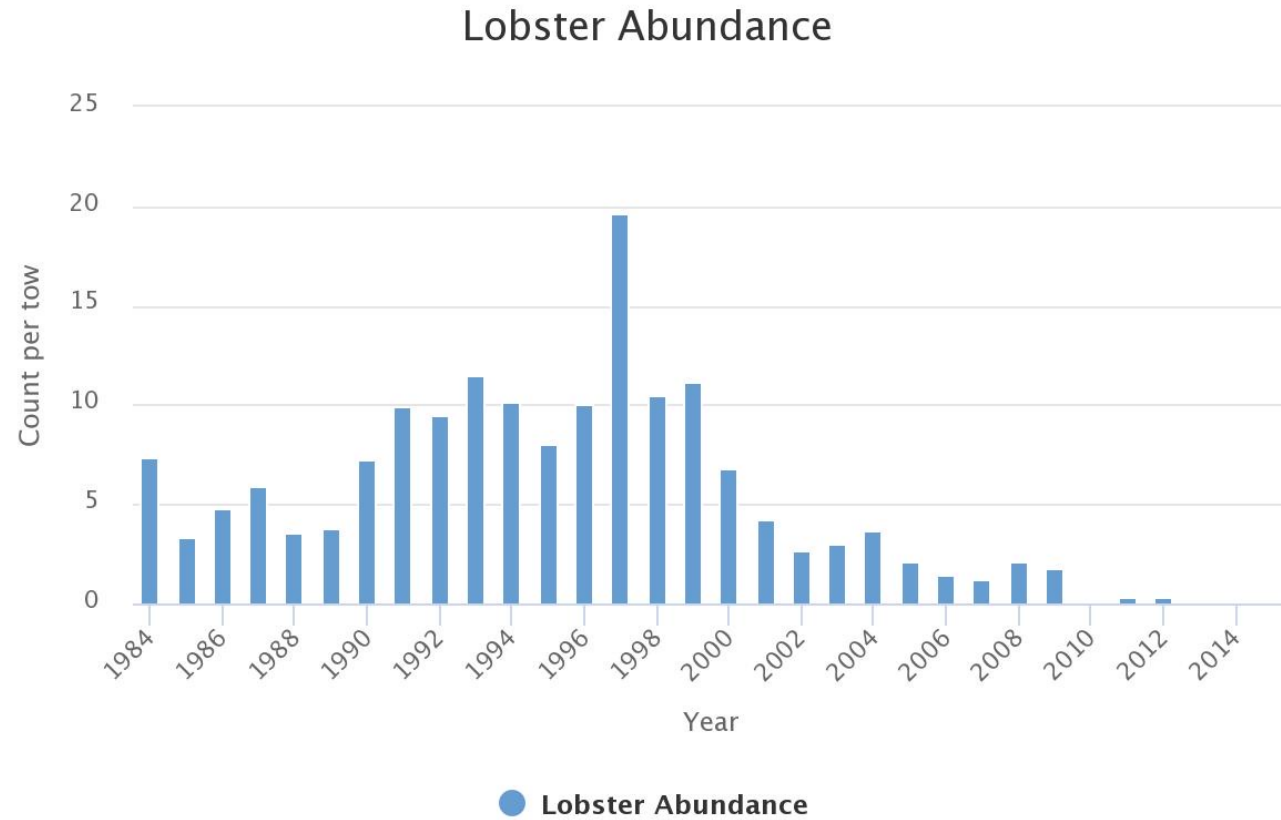
- Migration leads to loss of fishery management regulations
- EU mackerel are now being caught in Iceland
 - Two different fishery regions are now catching this fish population without mutual fishing limits = overfishing



Longer fishing trips, summer flounder fishing ground



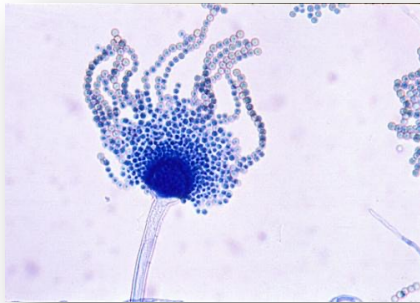
Long Island Sound Lobster Populations



Food Safety

Aflatoxins are highly carcinogenic

- Aflatoxin is produced by *Aspergillus flavus* and *Aspergillus parasiticus*
- Most carcinogenic naturally occurring compound known



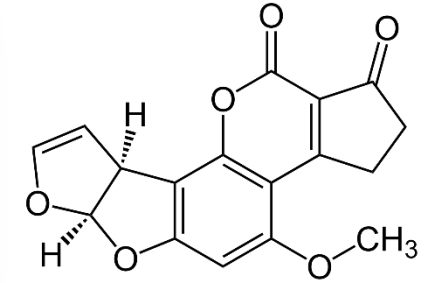
Aspergillus flavus



Maize contaminated
with *A. flavus*



Peanut contaminated
with *A. flavus*

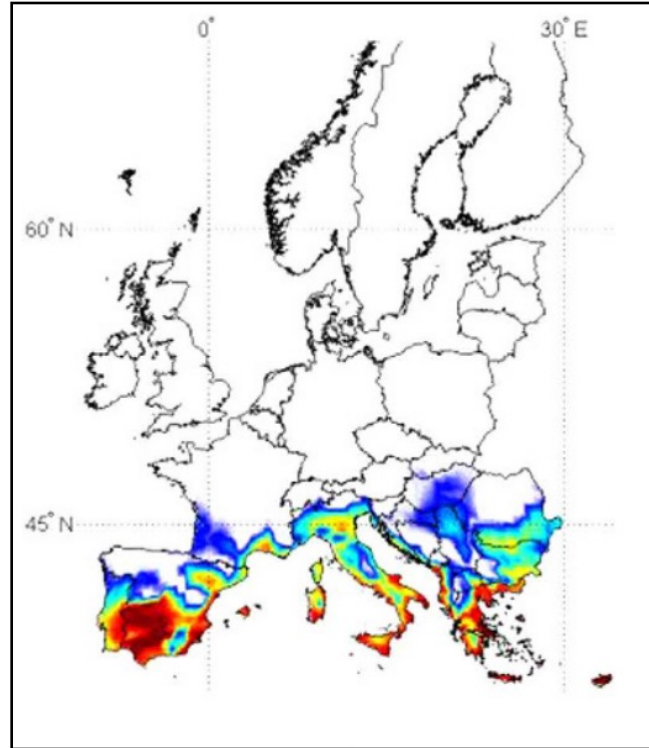


Aflatoxin B1

Aspergillus does not
survive in cold climates

Climate change will increase aflatoxin contamination in maize

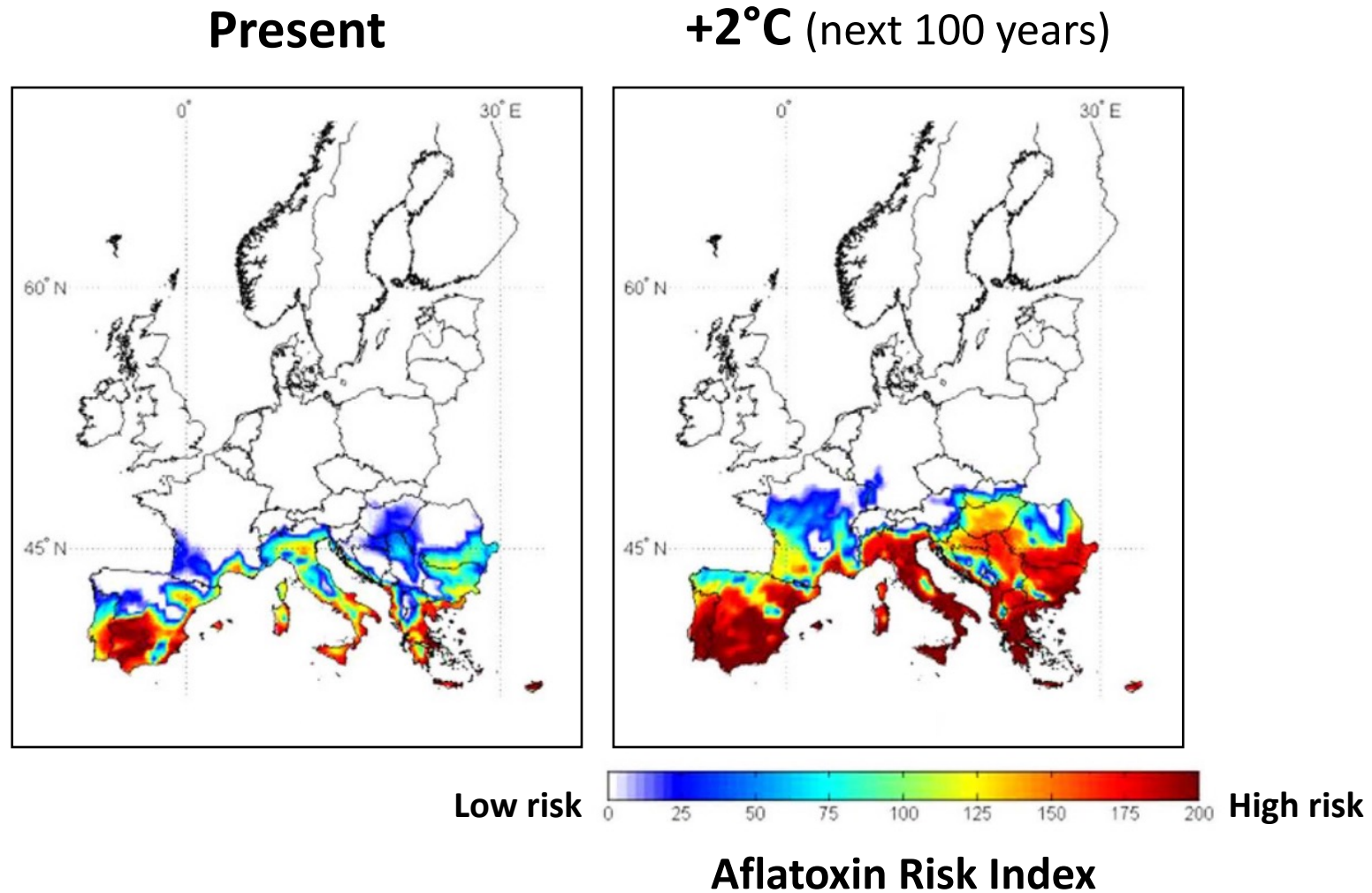
Present



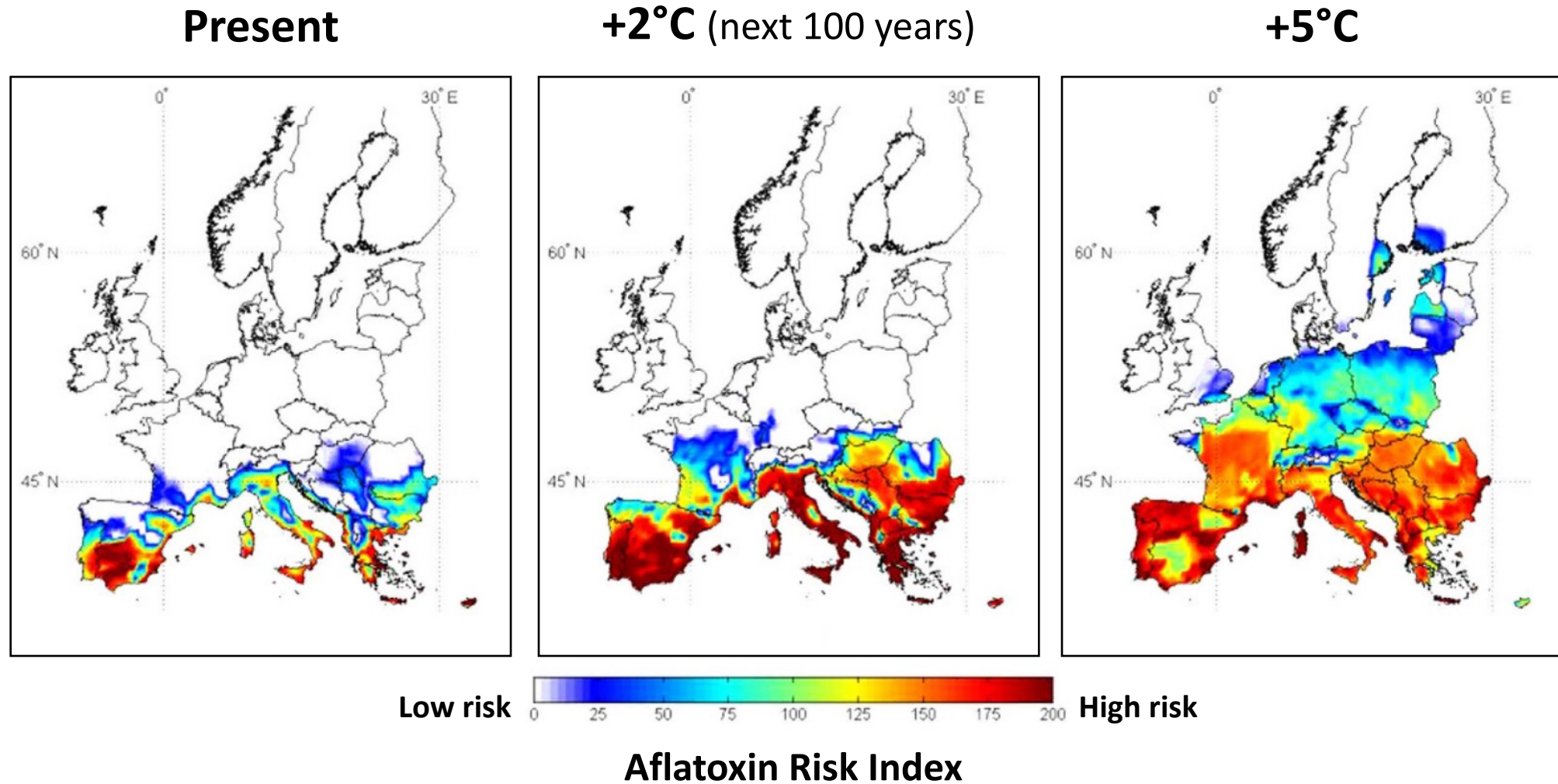
Low risk 0 25 50 75 100 125 150 175 200 High risk

Aflatoxin Risk Index

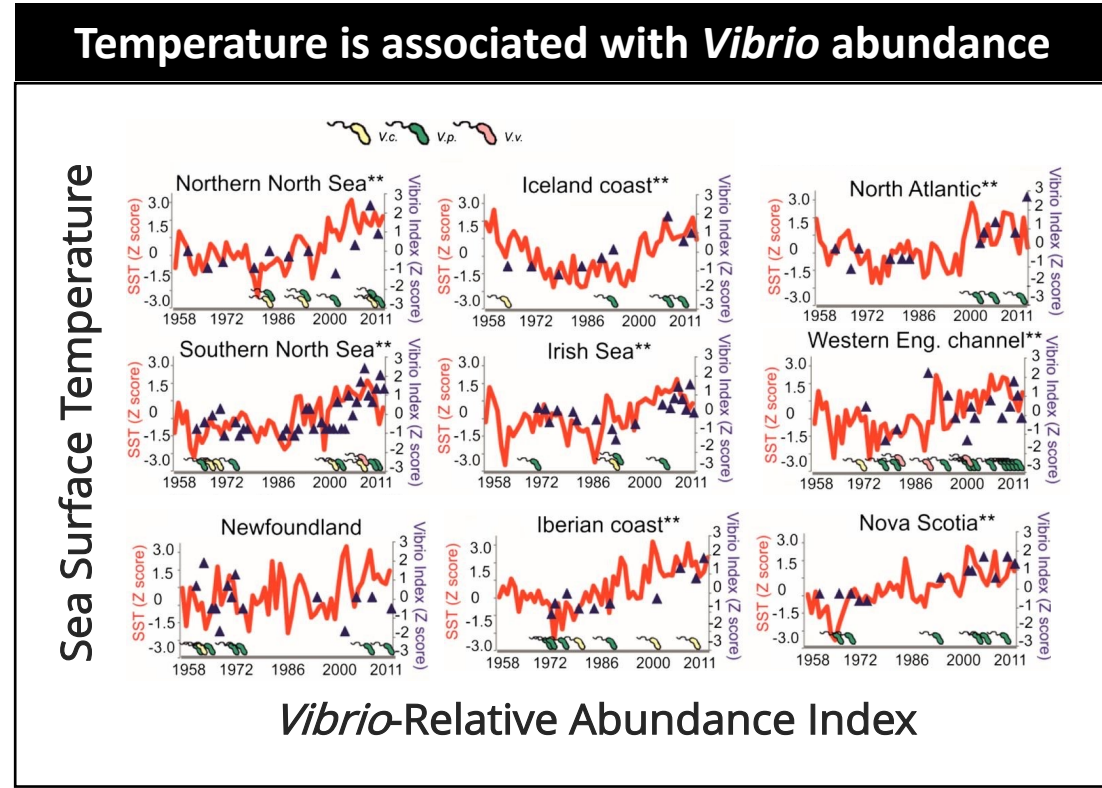
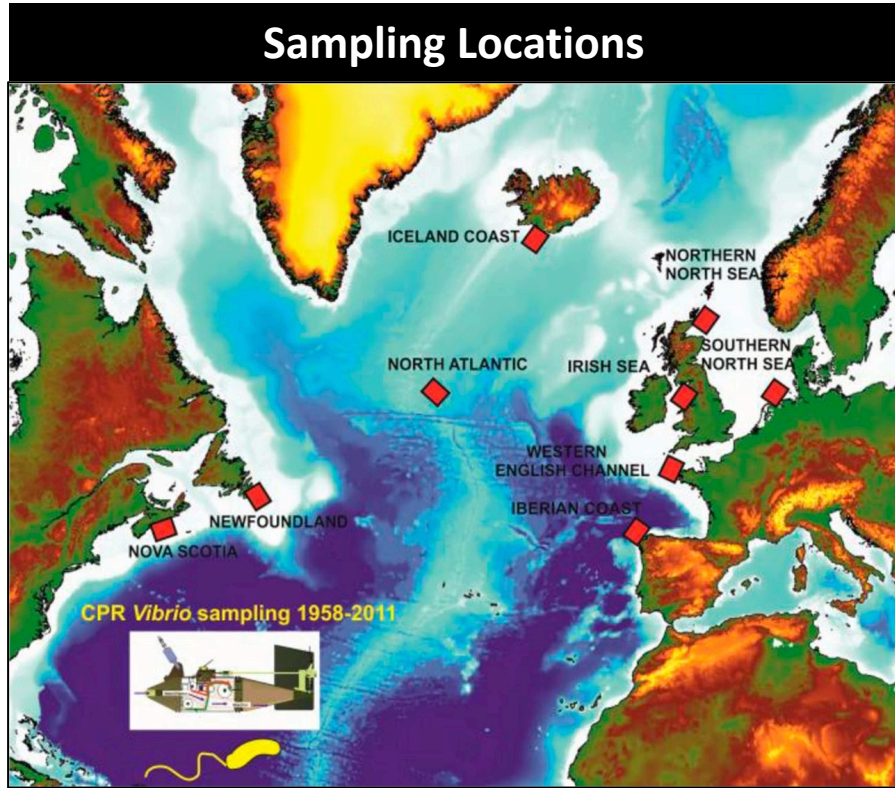
Climate change will increase aflatoxin contamination in maize



Climate change will increase aflatoxin contamination in maize



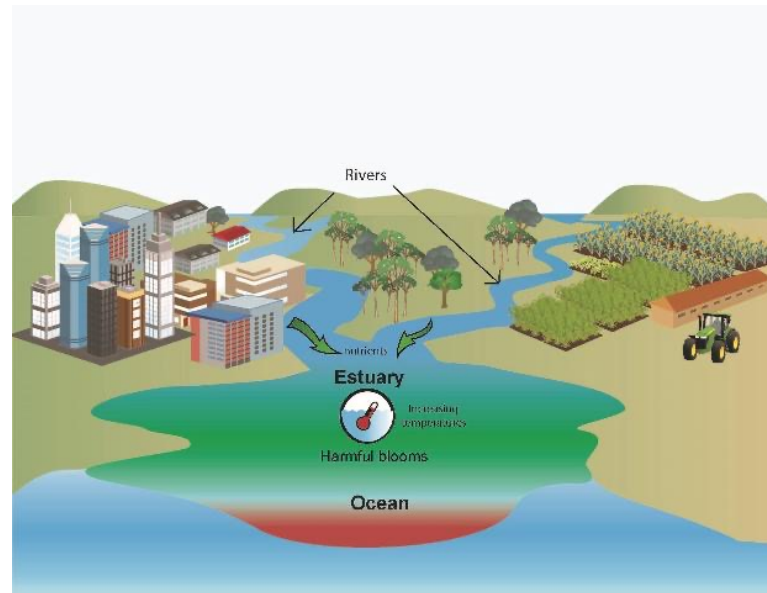
Vibrio causes food poisoning associated with shellfish



- North Atlantic Sea surface temperature (SST) has increased up to 1.5 °C
- **Vibrio abundance is becoming more prevalent in northern waters**

Red Tide

- Red tide is caused by algal blooms
- Algal blooms increase with increasing temperature and nutrient sources
 - Nutrient sources can be due to excessive rain fall that washes fertilizers into the ocean



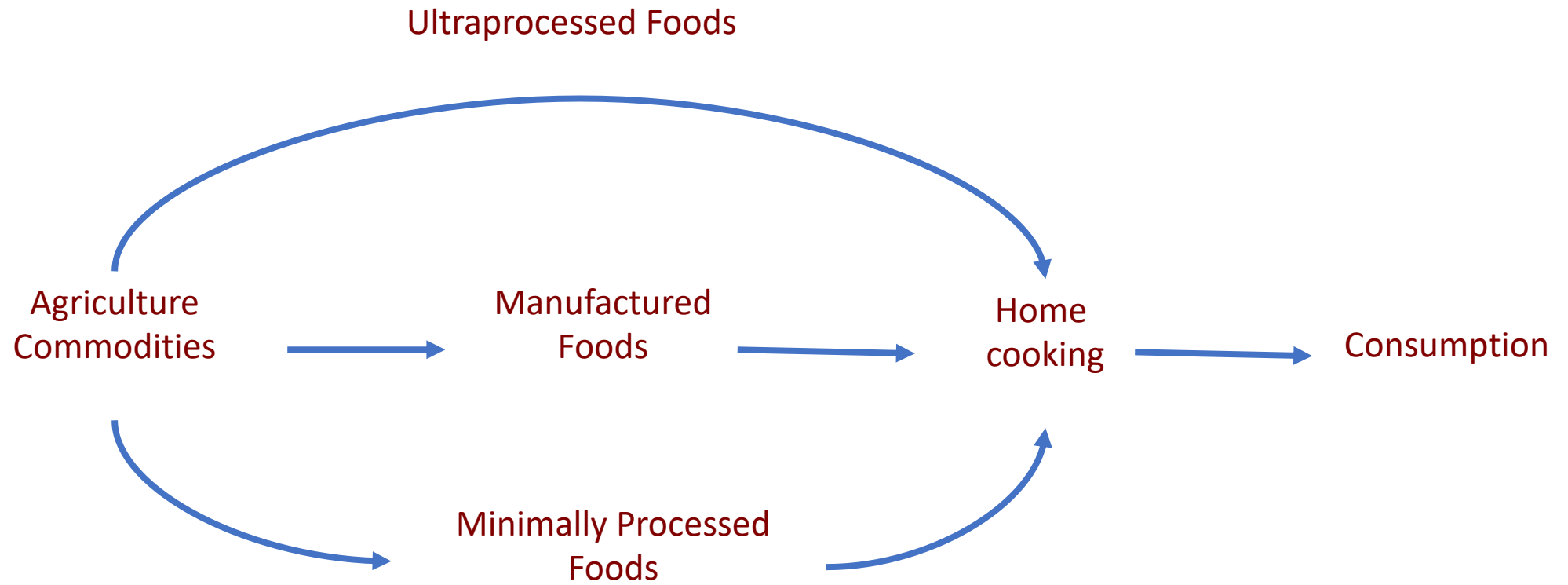
Red tide

- Red tide is toxic to marine life and humans
 - At low levels, red tide toxins can accumulate in shellfish and cause paralytic shellfish poisoning
 - Results in closure of shellfish harvesting
- Also kills marine life
 - A red tide outbreak in Florida earlier this year killed 20 tons of marine life.



What can we do?

Economics of Cooking from Scratch



Cooking at Home Decreases Sustainability

- Home Cooking < Food Service < Industrial Food Production
 - Water
 - Energy
 - Food waste



Food Manufacturing at Scale is Critical for Producing Affordable Foods

- Buy raw materials in large quantities
- Use energy efficient processing steps
 - 6.6 MJ/kg product in industry
 - 22.8 MJ/kg product for home cooking
- Maximize yield to decrease waste
- Utilize food waste products to offset processing costs
- Utilize food processing operations, packaging technologies and food ingredients to maximize shelf-life



Homemade tomato paste = \$9.90+/pound
Industrial tomato paste = \$2.00/pound

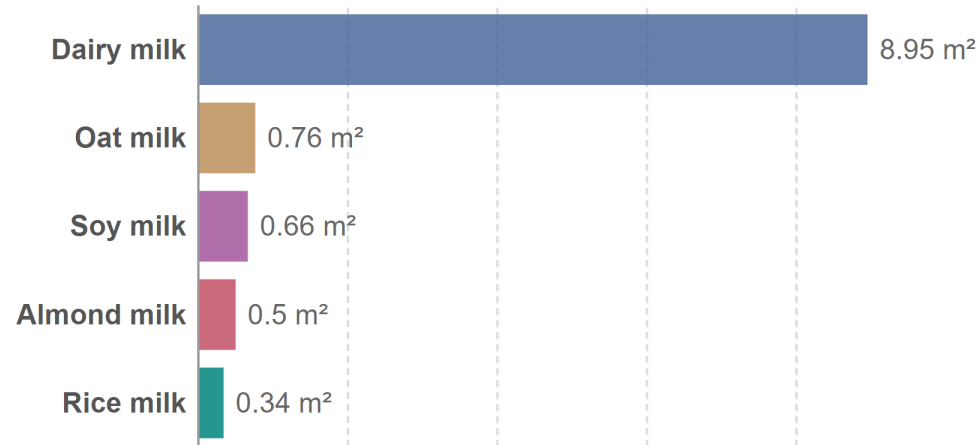
Sustainability

- Home Cooking < Food Service < Industrial Food Production
 - Water
 - Energy
 - Food waste
- Plant based animal food alternatives
 - Beef > pork > poultry > fish
 - Milk vs nut milks

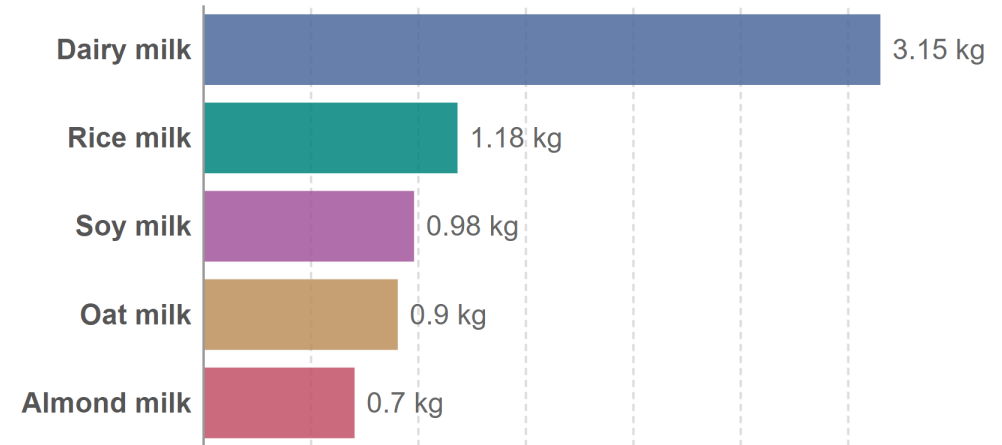
Environmental footprints of dairy and plant-based milks

Impacts are measured per liter of milk. These are based on a meta-analysis of food system impact studies across the supply chain which includes land use change, on-farm production, processing, transport, and packaging.

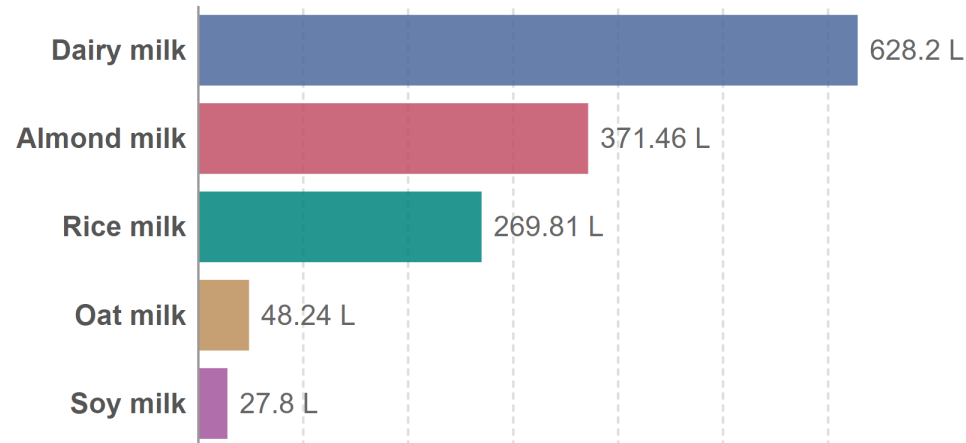
Land use



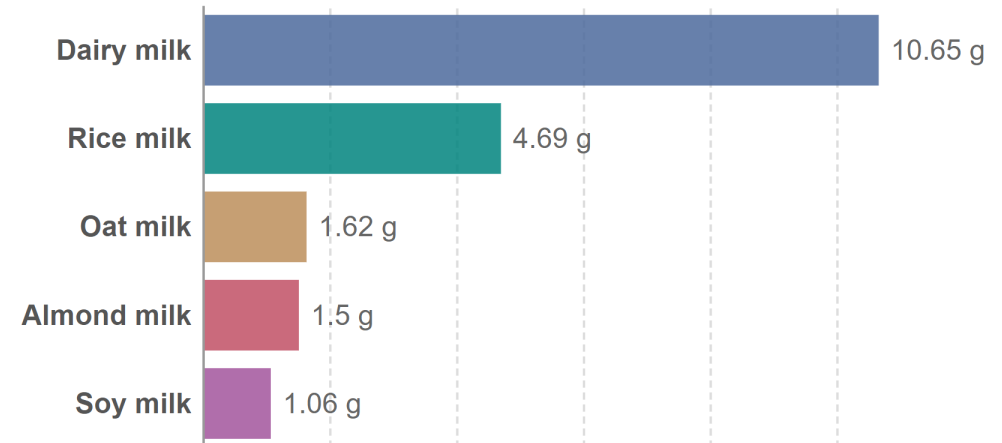
Greenhouse gas emissions



Freshwater use



Nutrient Runoff



Sustainability Challenges

- Livestock Production Costs
 - Producing 1 lb meat costs
 - Beef = 5-20 lb feed
 - Pork = 3 lb feed
 - Chicken = 2 lb feed
 - Fish = 1.2 ?

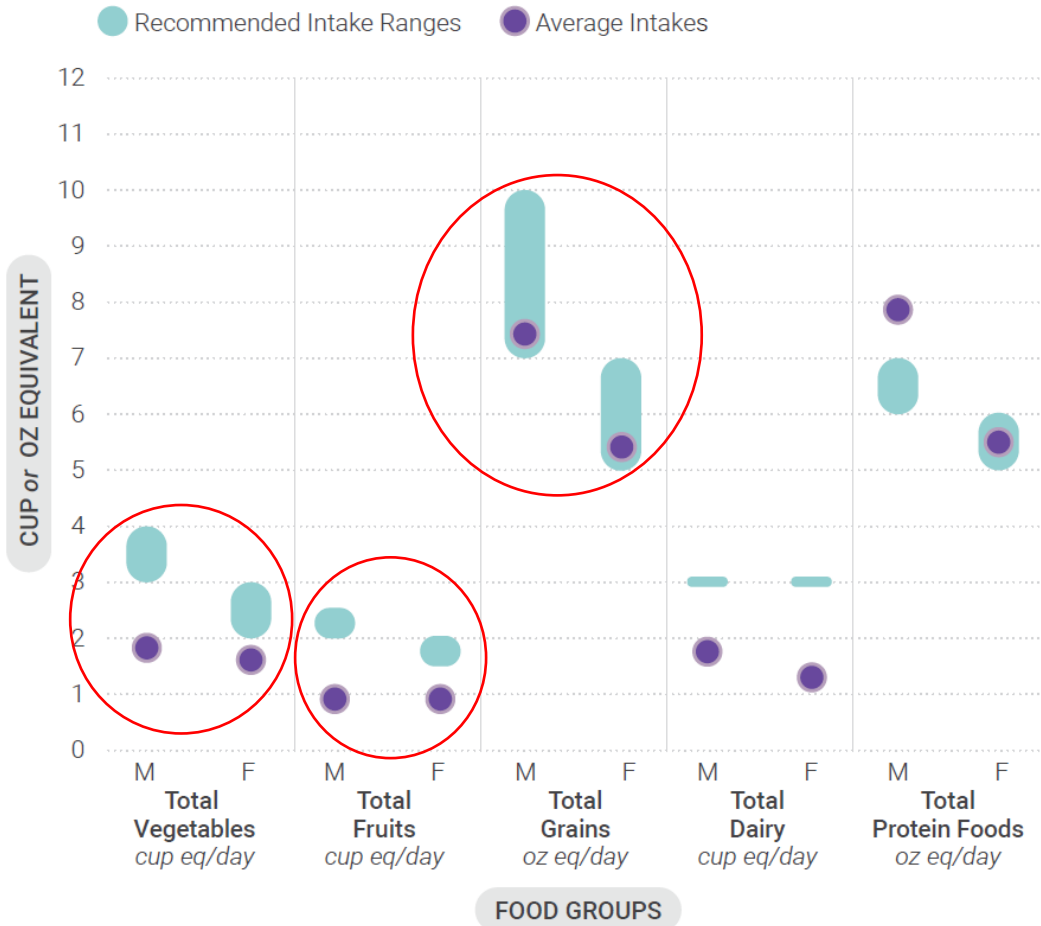


Sustainability

- Home Cooking < Food Service < Industrial Food Production
 - Water
 - Energy
 - Food waste
- Plant based animal food alternatives
 - Beef > pork > poultry > fish
 - Milk vs nut milks
- Not nutritionally equivalent
 - Calcium, iron, zinc and omega-3 fatty acids

Eat more fruits, veggies and whole grains

Average Daily Food Group Intakes Compared to Recommended Intake Ranges



What can be done to increase fruit, veggie and whole grain consumption?

- Change government subsidies
- Genetics
 - Flavor, flatulence, ripening, functionality
- Culinary solutions that don't add calories
 - Off-flavor masking
 - Flavor enhancement – umami and acid
 - Low fat frying
 - Optimize texture -calcium
- Stealth
 - Blended products
 - Meat patties
 - Baked goods and fruit purees
 - Dishes with small amounts of proteins and mostly veggies

