Climate Change and Our Food System

Dr. Vern Grubinger
Extension Professor, University of Vermont
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The University of Vermont Extension

www.uvm.edu/vtvegandberry

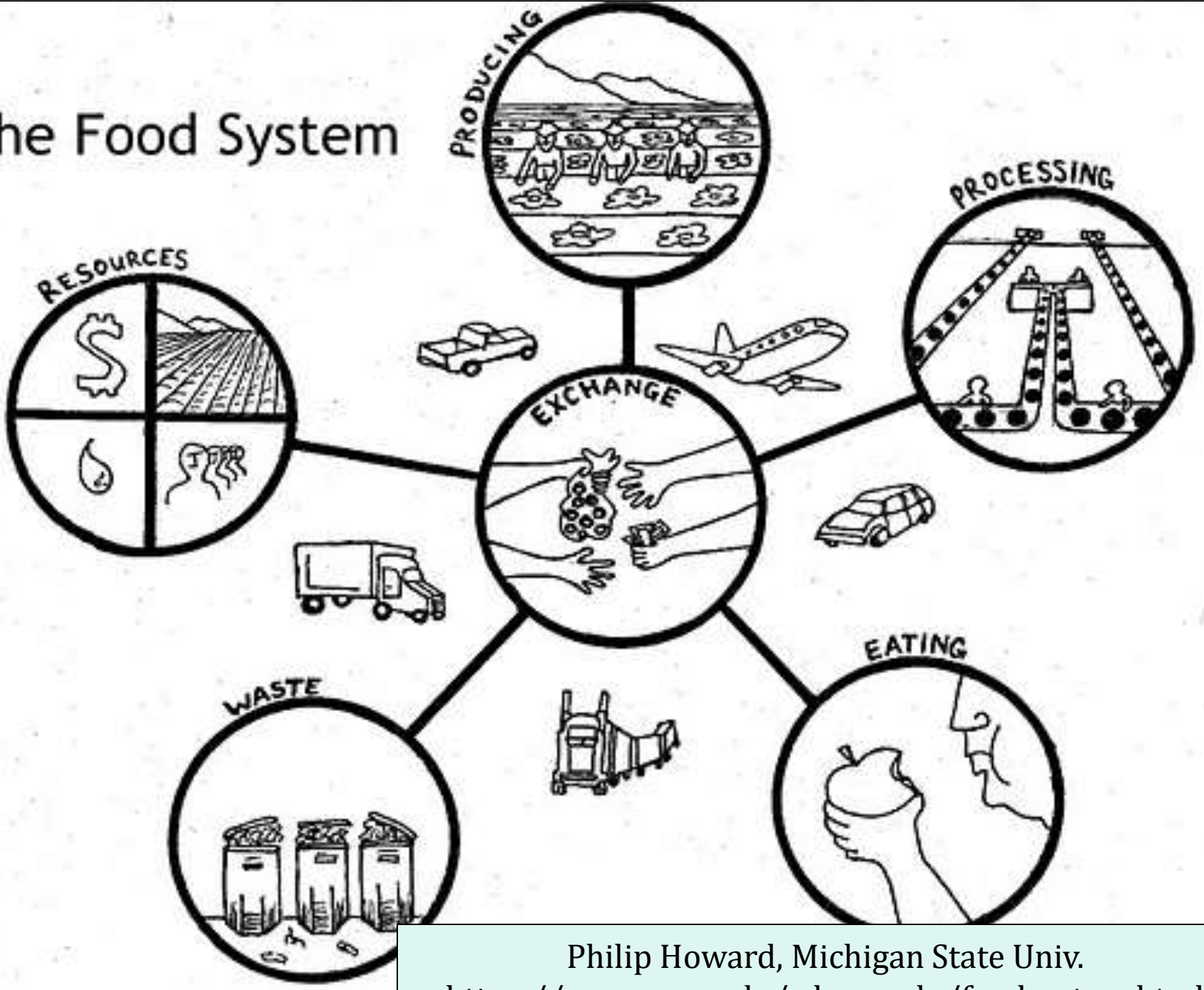
Northeast SARE
Sustainable Agriculture Research & Education

www.nesare.org

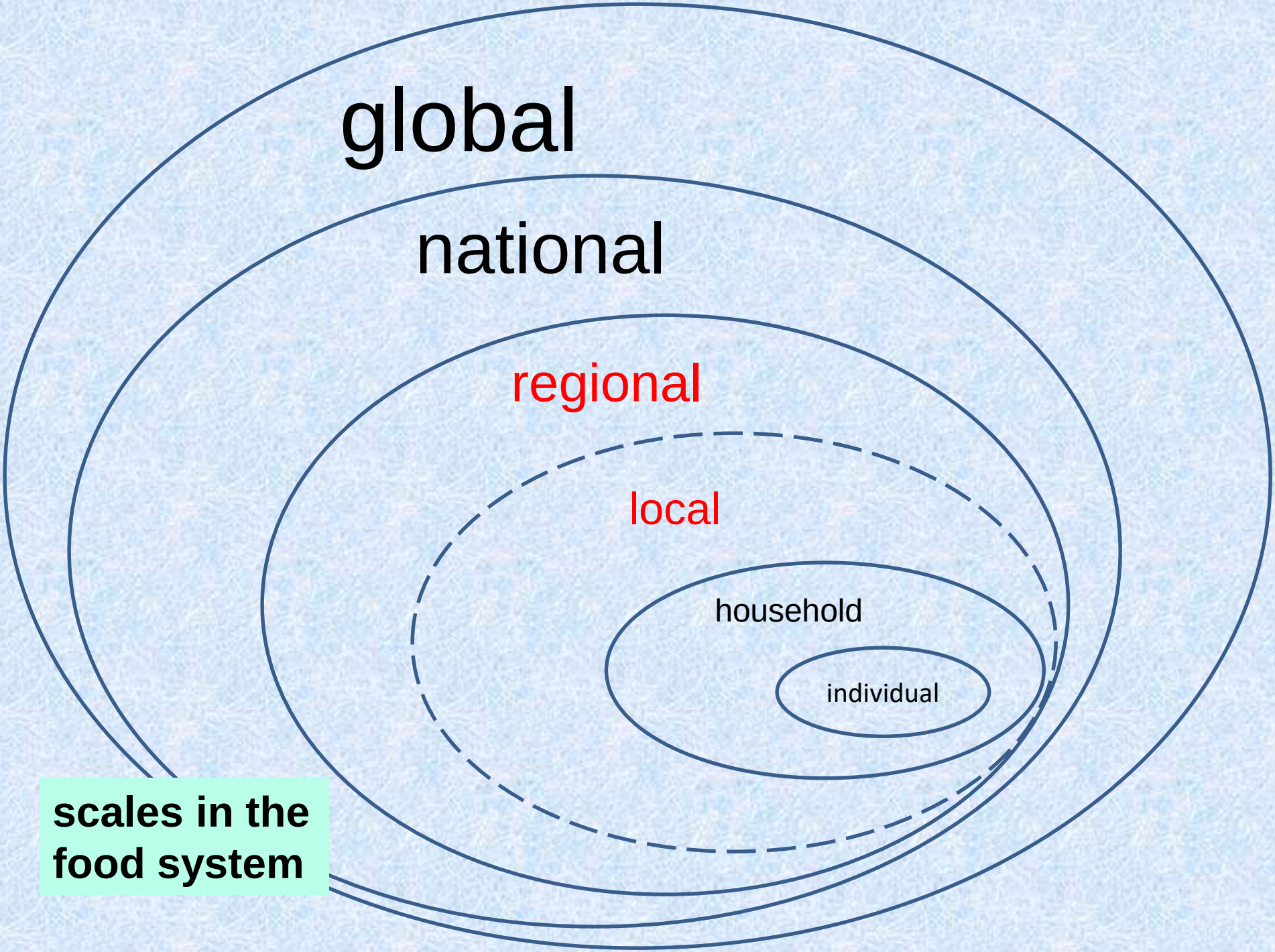
tonight

- Food systems thinking
- Climate change overview
  - global and Northeast
- Agriculture and greenhouse gases
- Communication challenges
- Practical steps for farmers
- Practical steps for ‘consumers’

The Food System

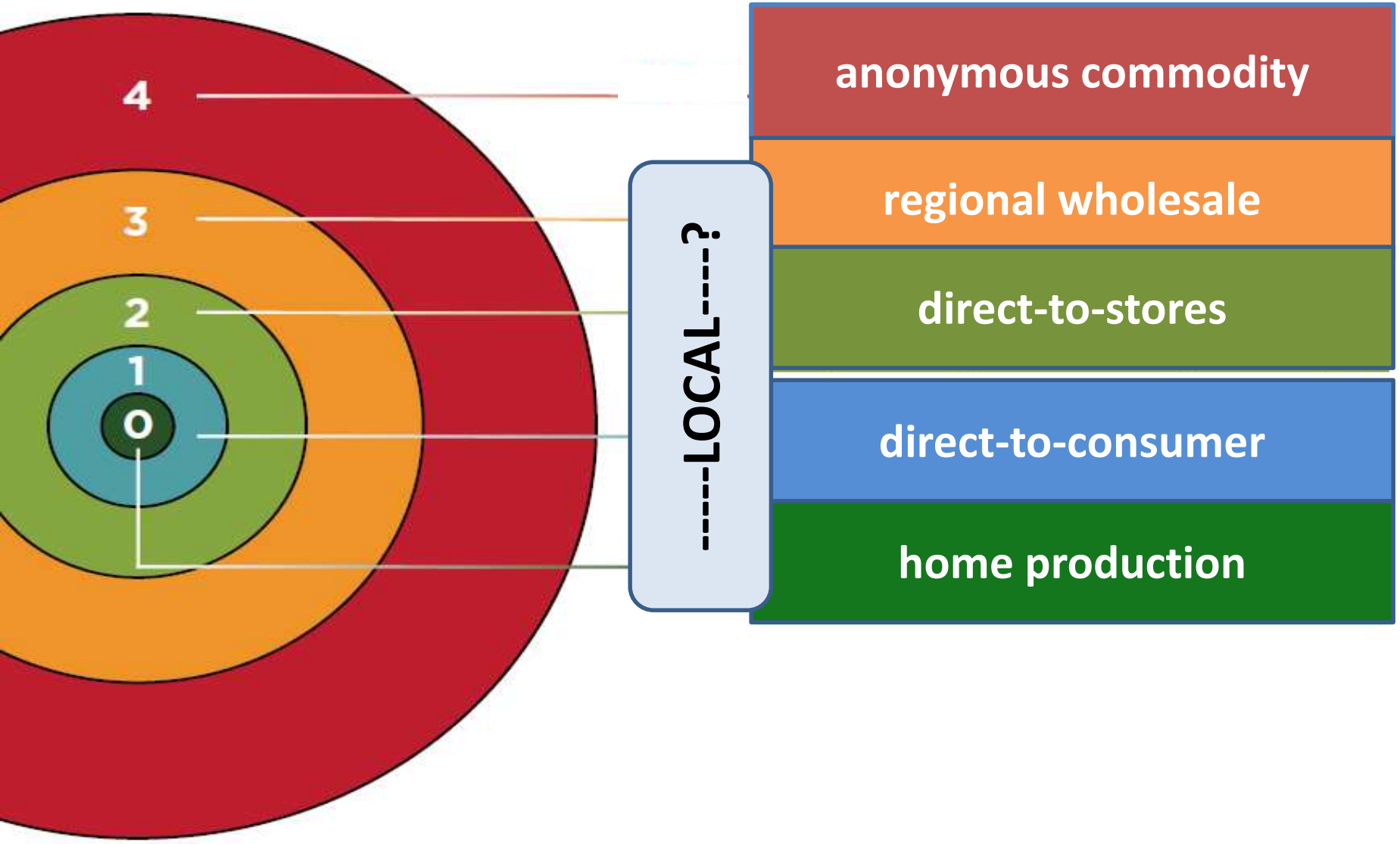


Philip Howard, Michigan State Univ.
https://www.msu.edu/~howardp/foodsystem.html



scales in the food system

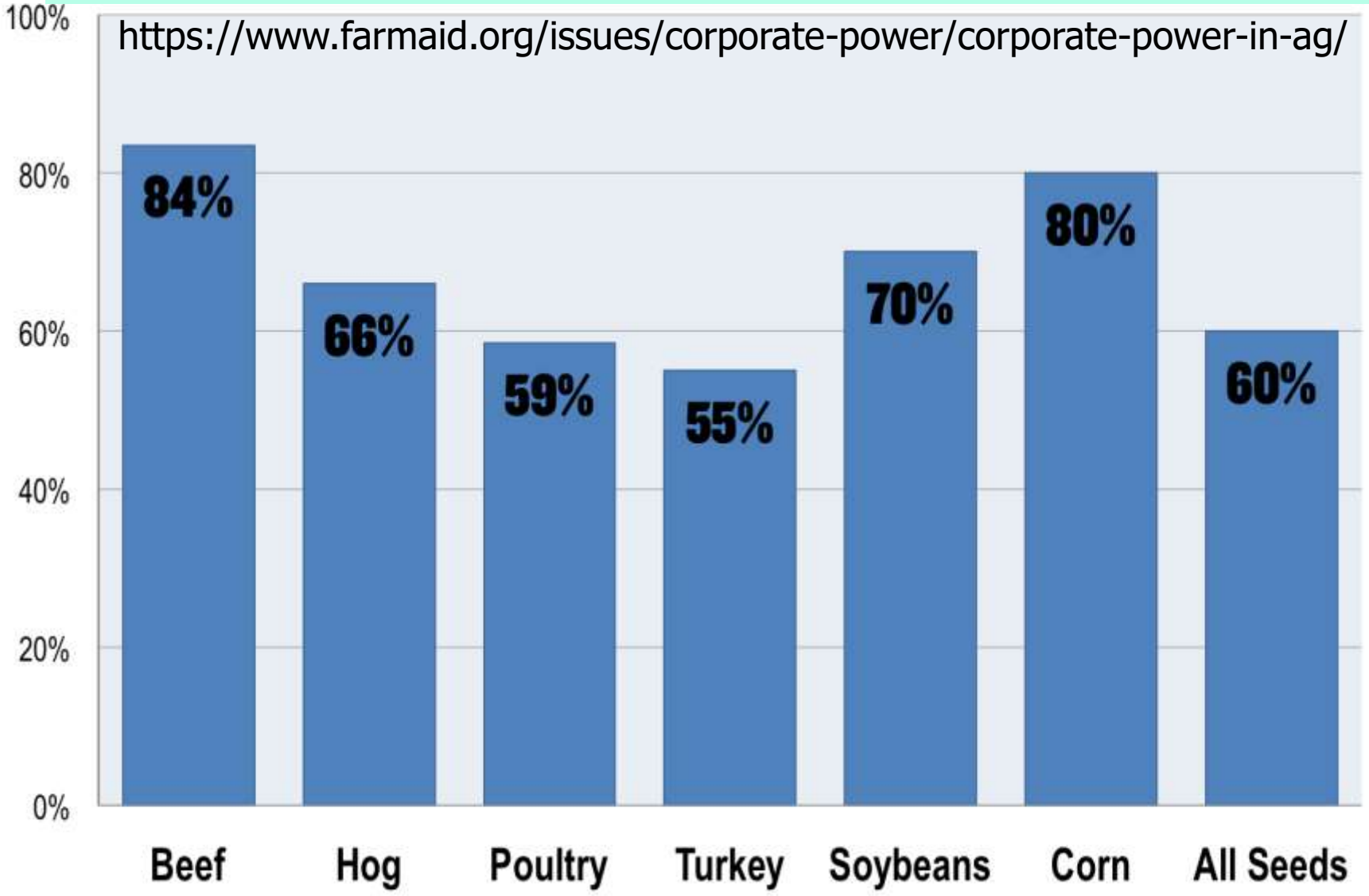
market levels of the food system



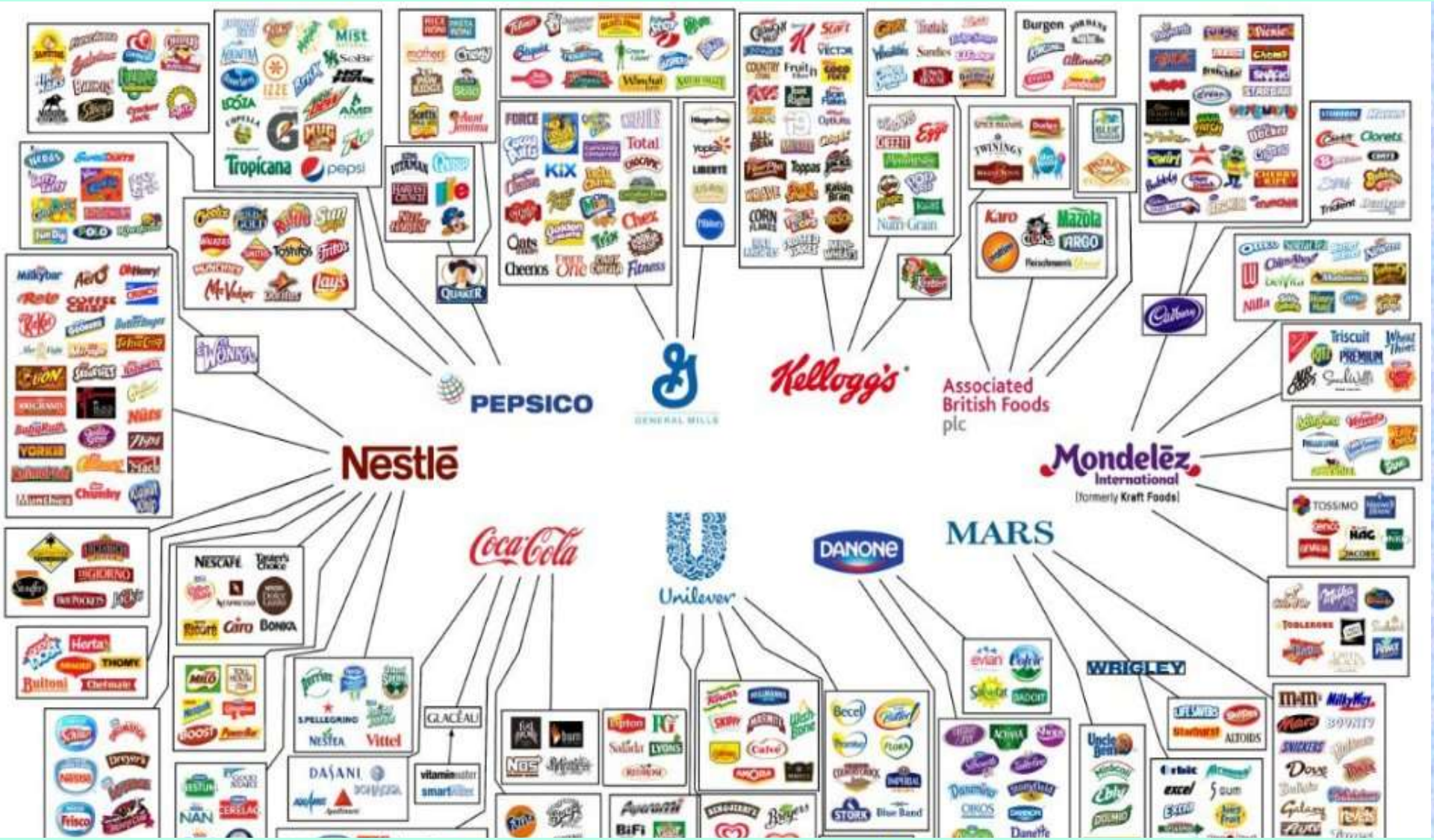
The ‘first world’ food system is highly consolidated.

In 2012 only 4% of all U.S. farms produced 66% of $395 billion in total agricultural products

Food processing is also highly consolidated:
Top 4 companies share of 'commodity' processing



food distribution and retailing is also consolidated



10 corporations account for half of all U.S. food sales

2,000+ brands

in 189 countries

$90 billion annual sales

33% GHG reduction per ton of product since 2007

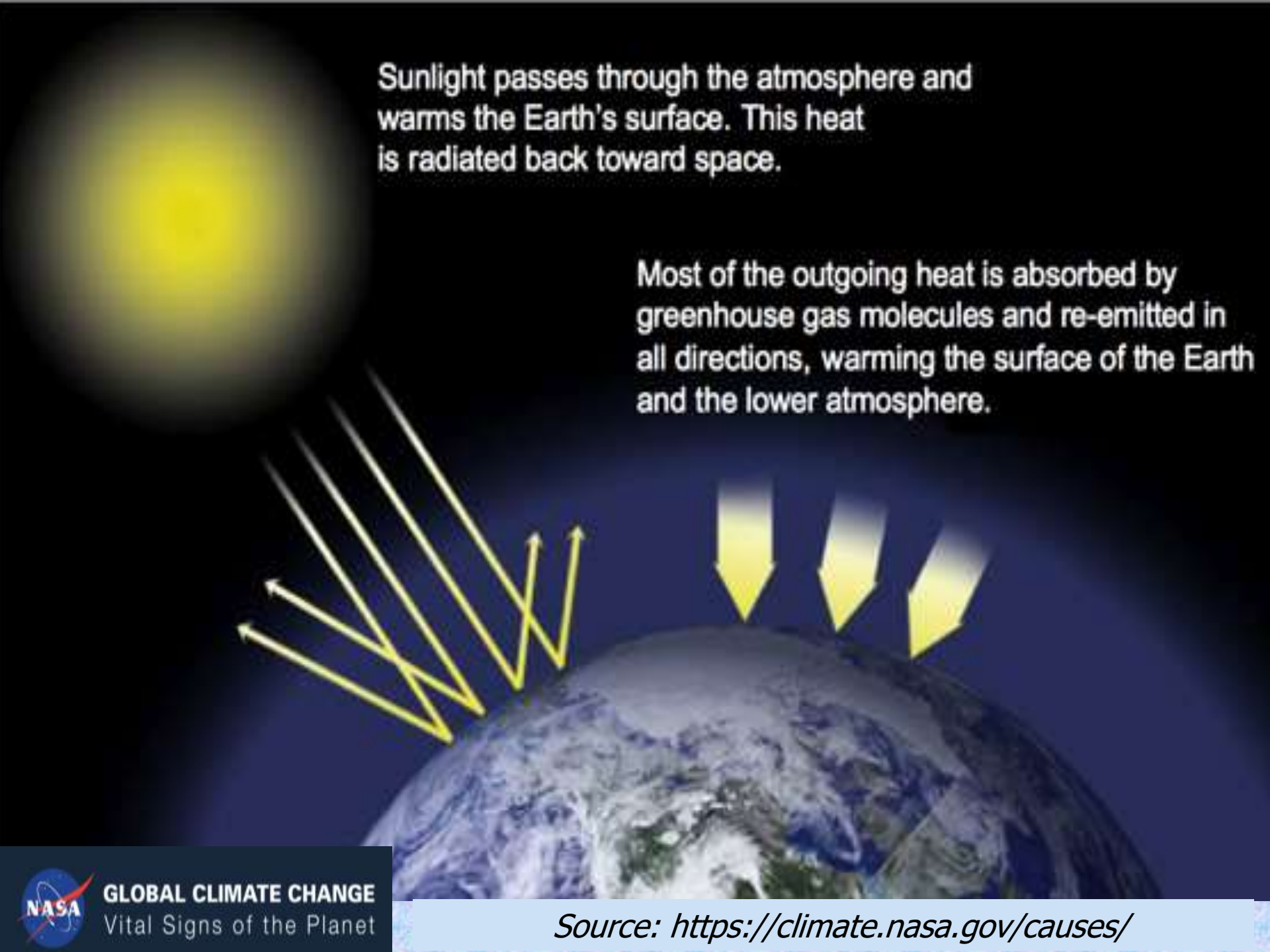
"Climate change is a major global challenge…our size and scale means we can show real leadership on climate change…We have set ambitious targets to reduce GHGs, in line with the Paris Agreement on climate change."

-Nestle 2017 Annual Review

https://www.nestle.com/asset-library/documents/library/documents/annual_reports/2017-annual-review-en.pdf

The food system can be improved, at all scales

The Farm Between, Jeffersonville, VT



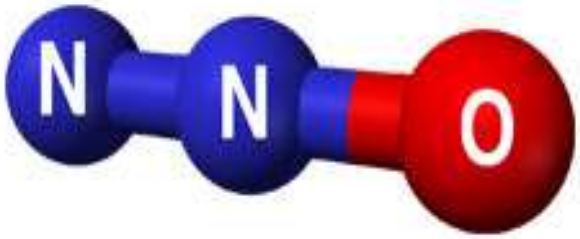
Source: https://climate.nasa.gov/causes/

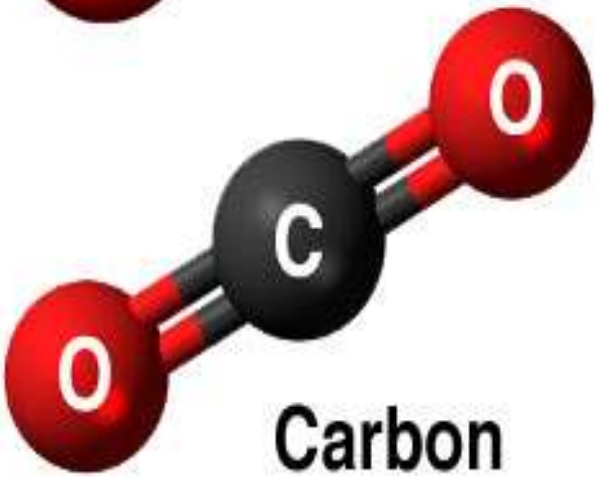
Water vapor (H_2O)

GWP=N/A

Nitrous oxide (N_2O)

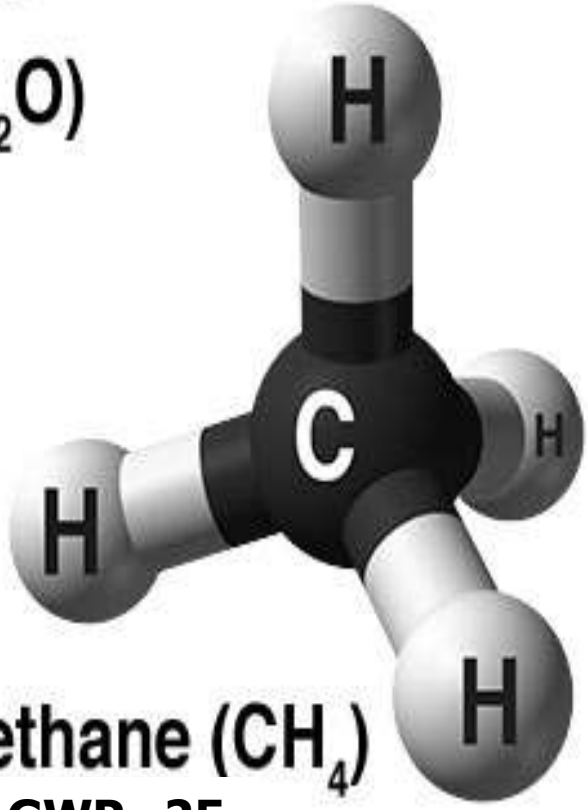
GWP=298





Carbon dioxide (CO_2)

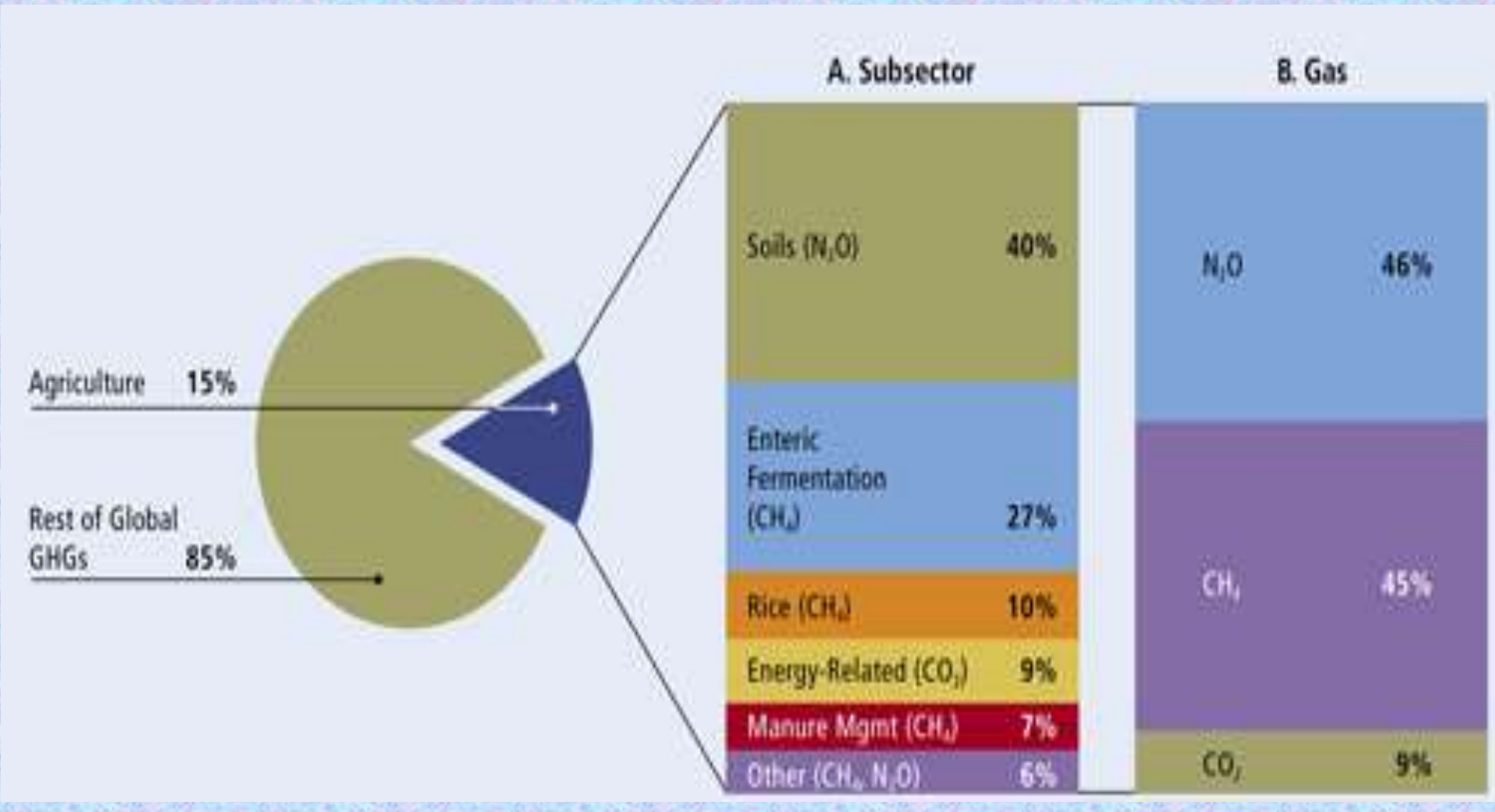
GWP=1



Methane (CH_4)

GWP=25

"CO2 equivalents" important to agriculture



https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=92

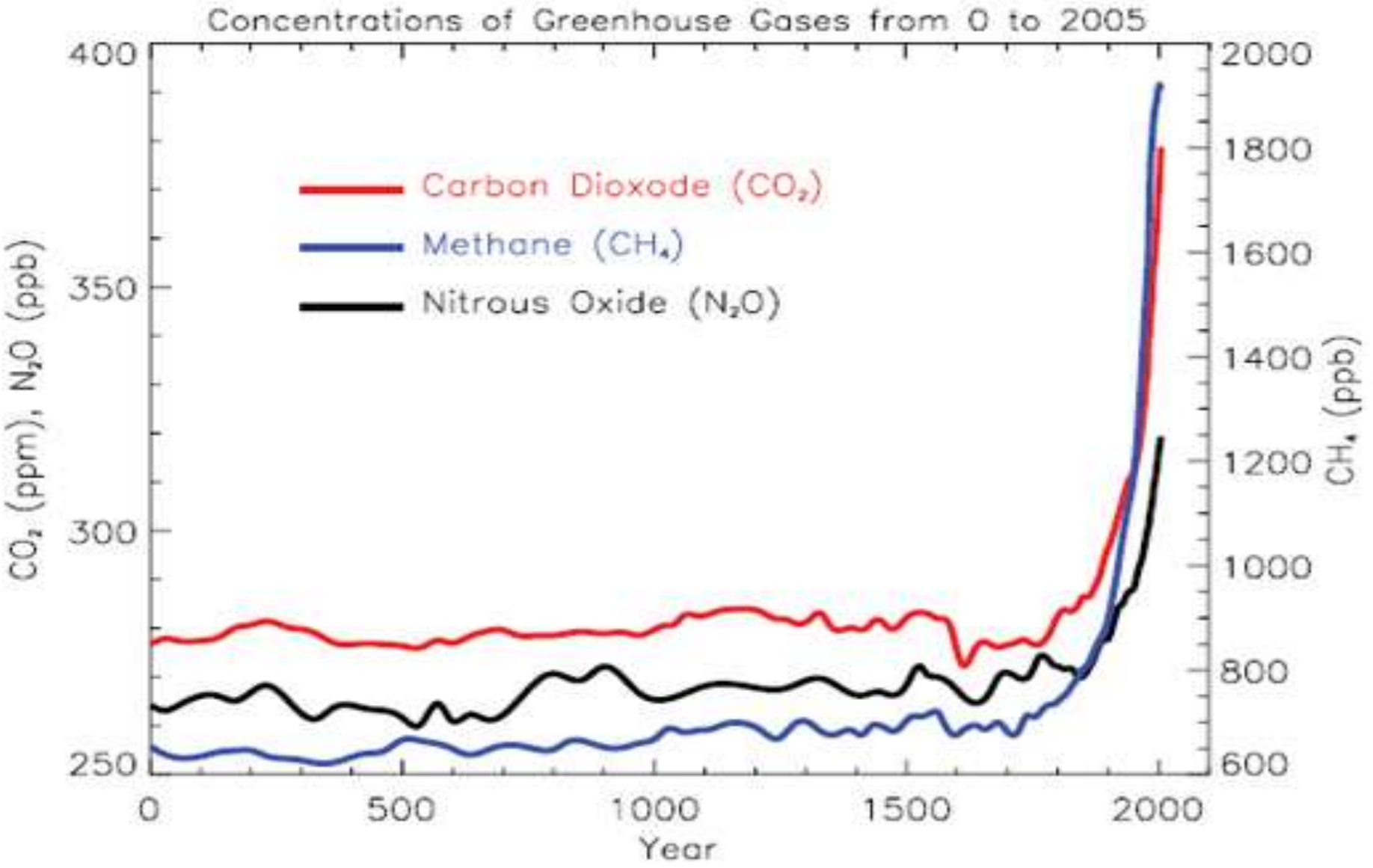
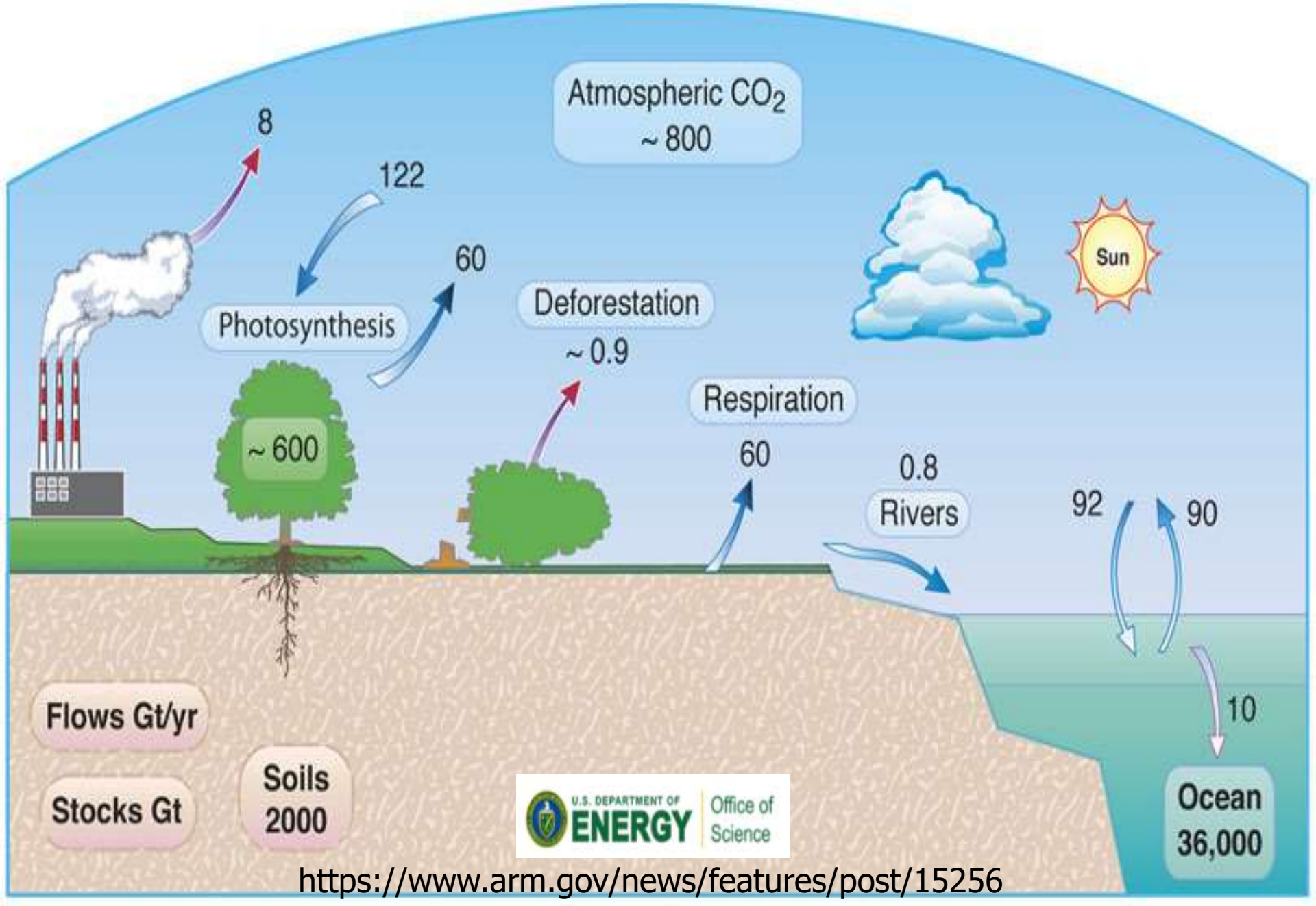


Figure 1. Atmospheric concentrations of important long-lived greenhouse gases over the last 2,000 years. Increases since about 1750 are attributed to human activities in the industrial era. Concentration units are parts per million (ppm) or parts per billion (ppb), indicating the number of molecules of the greenhouse gas per million or billion air molecules, respectively, in an atmospheric sample.

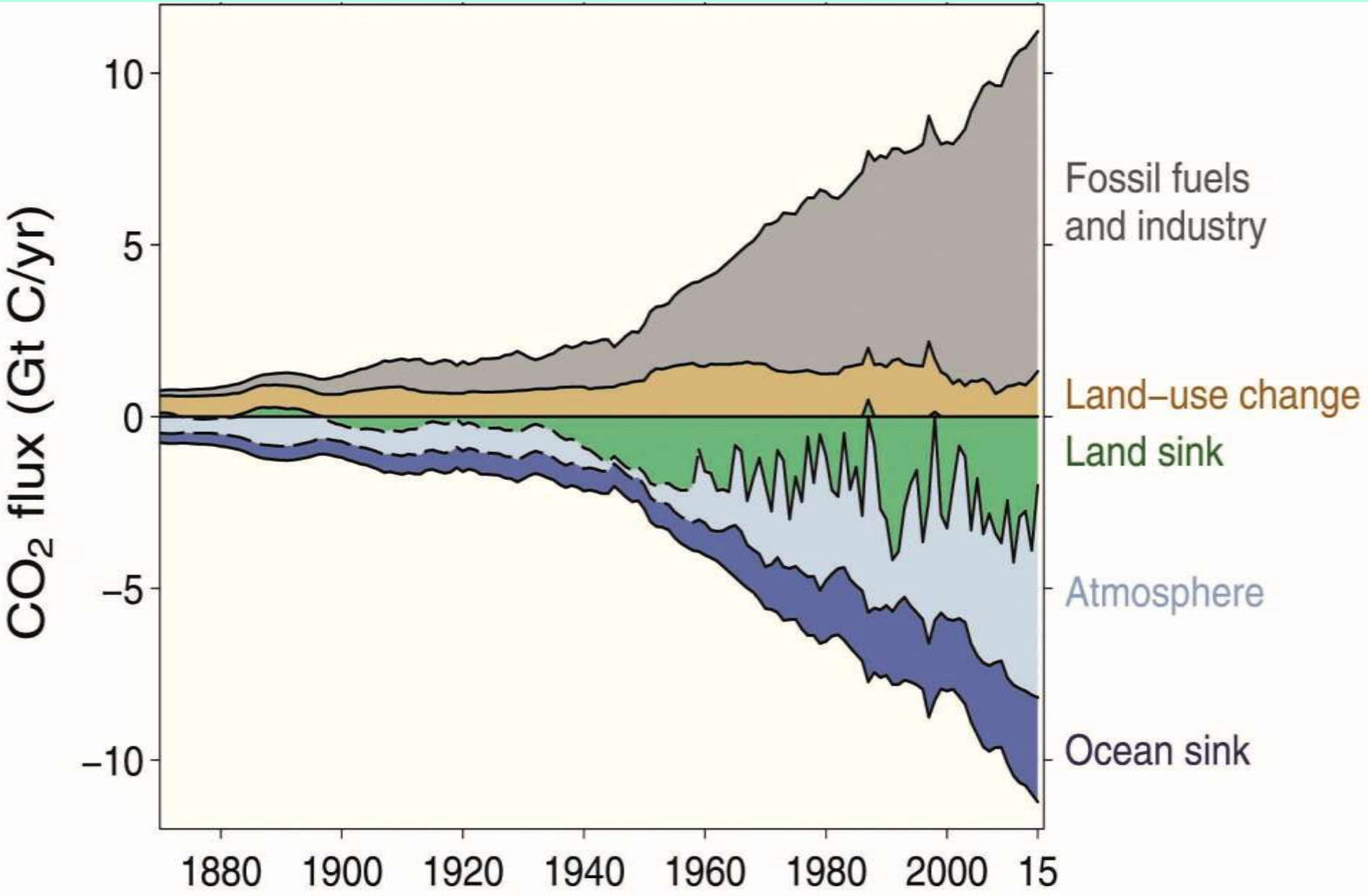
IPCC AR4 FAQ

The global carbon cycle – sources and sinks

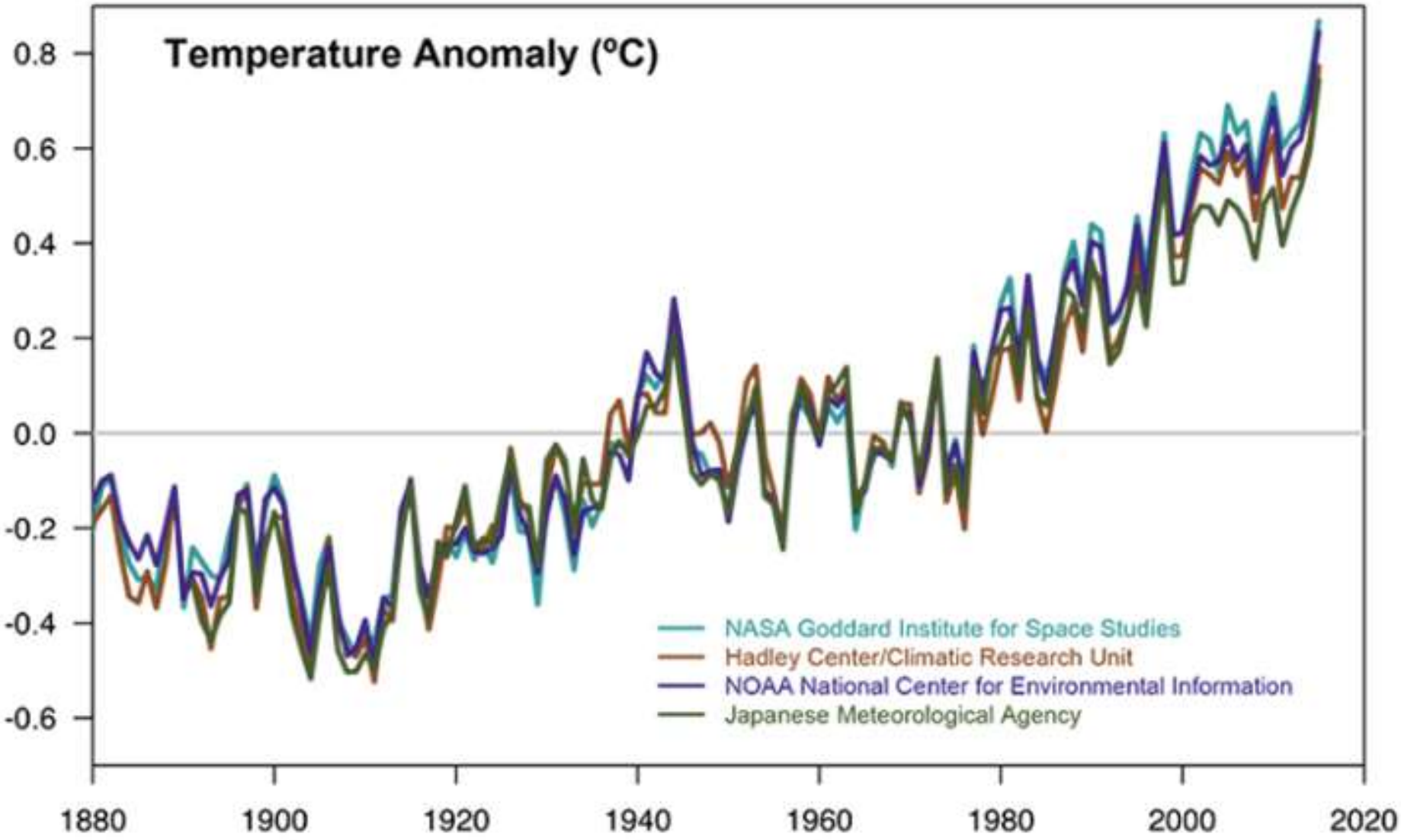


https://www.arm.gov/news/features/post/15256

global carbon flux over time



https://public.wmo.int/en/resources/bulletin/annual-global-carbon-budget



Temperature data from four international science institutions. All show rapid warming in the past few decades and that the last decade has been the warmest on record. Data sources: NASA's Goddard Institute for Space Studies, NOAA National Climatic Data Center, Met Office Hadley Centre/Climatic Research Unit and the Japanese Meteorological Agency.

Global impacts of climate change

Temperature rise. Planet's average surface temperature has risen 2.0 degrees F since the late 19th century.

Warming oceans. The top 2,300 feet of oceans warmed 0.3 degrees F since 1969.

Shrinking ice sheets. Greenland lost 36-60 cubic miles of ice per year between 2002 and 2006, while Antarctica lost about 36 cubic miles of ice.

Glacial retreat. Glaciers are retreating almost everywhere around the world — in the Alps, Himalayas, Andes, Rockies, Alaska and Africa.

Decreased snow cover. Amount of spring snow cover in the Northern Hemisphere has decreased over the past five decades and the snow is melting earlier.

Sea level rise. Global sea level rose 8 inches in the last century. The rate in the last two decades is nearly double that of the last century.

Extreme events. Record high temperature events in the US increasing, record low temperature events decreasing, intense rainfall events increasing.

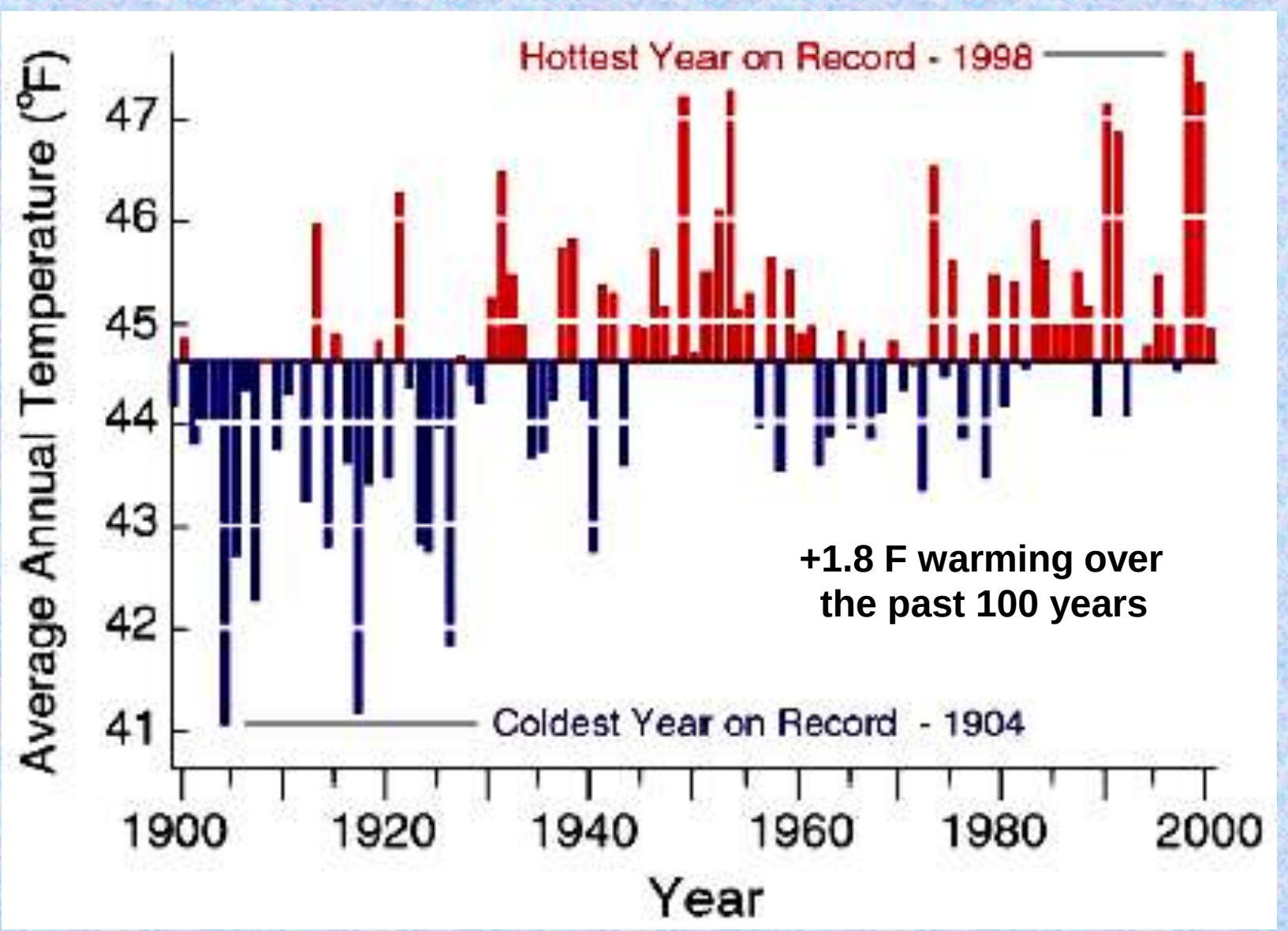
Ocean acidification. Since the Industrial Revolution, acidity of surface increased by 30% and CO_2 absorbed increased by 2 billion tons per year.

https://climate.nasa.gov/evidence/

Climate change is well documented in the Northeast

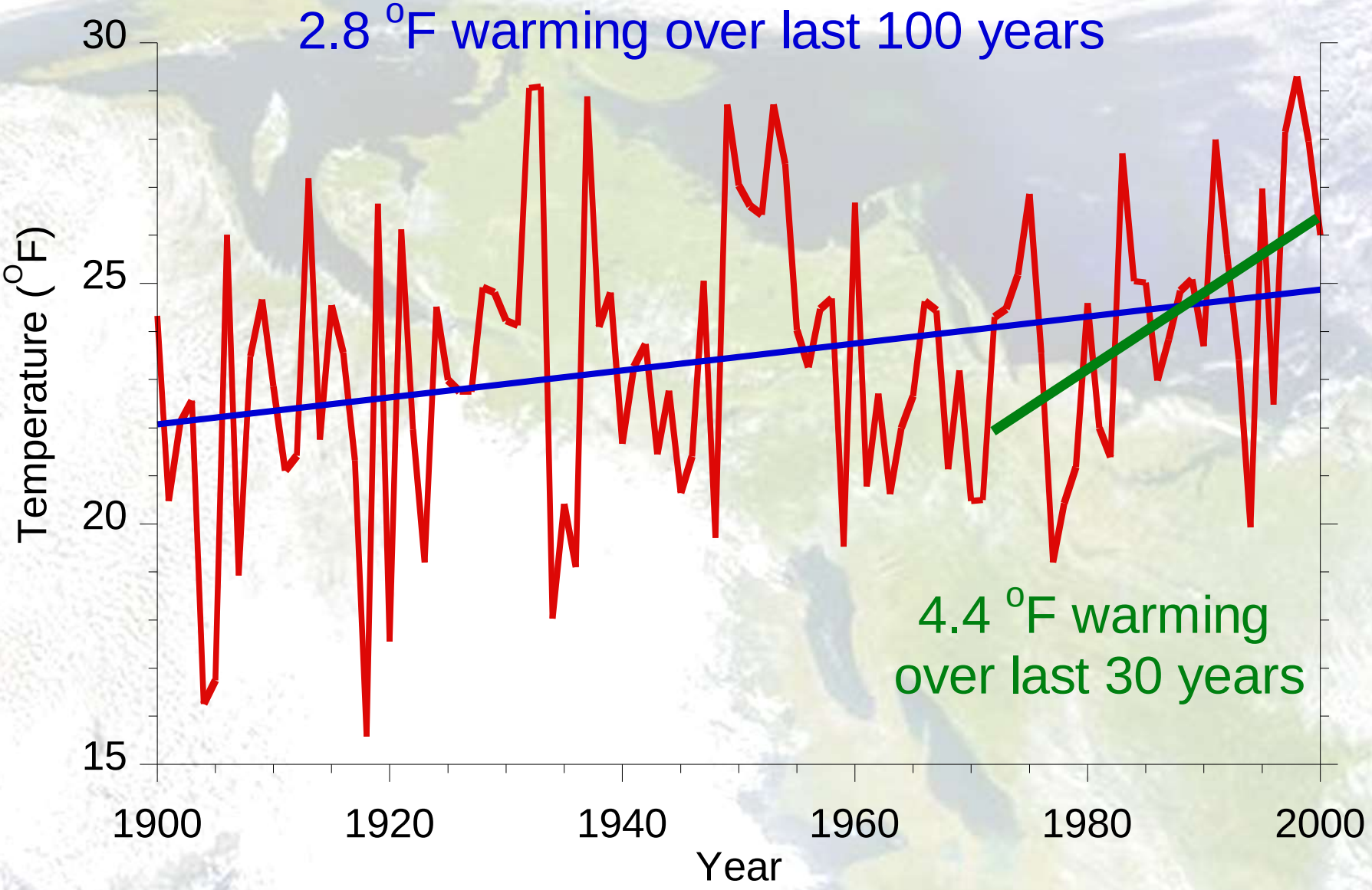
- warmer temperatures
- longer growing season
- increased / more extreme precipitation
- less snow cover

Northeast Average Temperatures

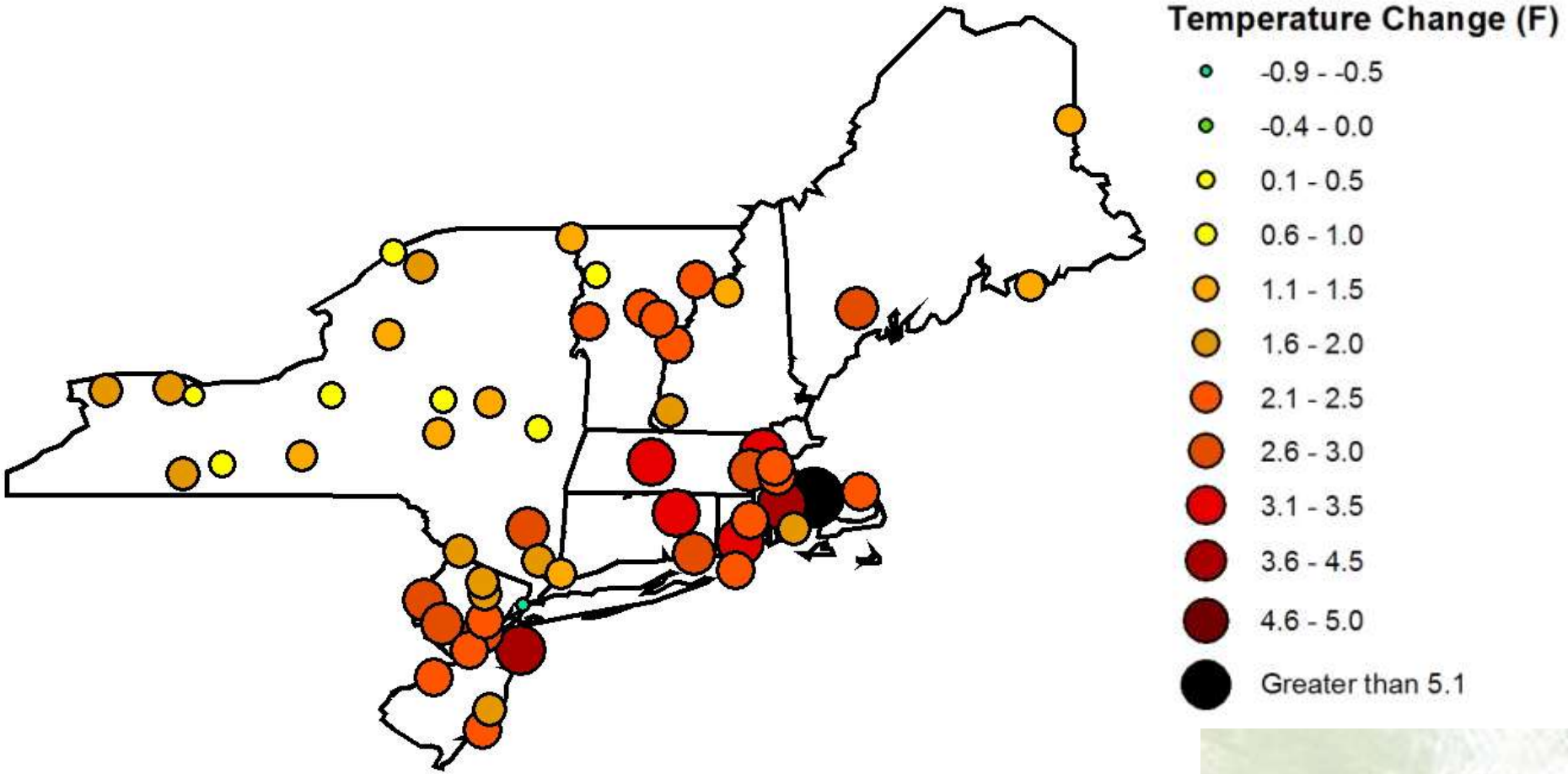


Source: Wake, C. 2005. Indicators of Climate Change in the Northeast. Climate Change Research Center, Univ. of New Hampshire.

Average Winter Temperature in the Northeast 1899-2000

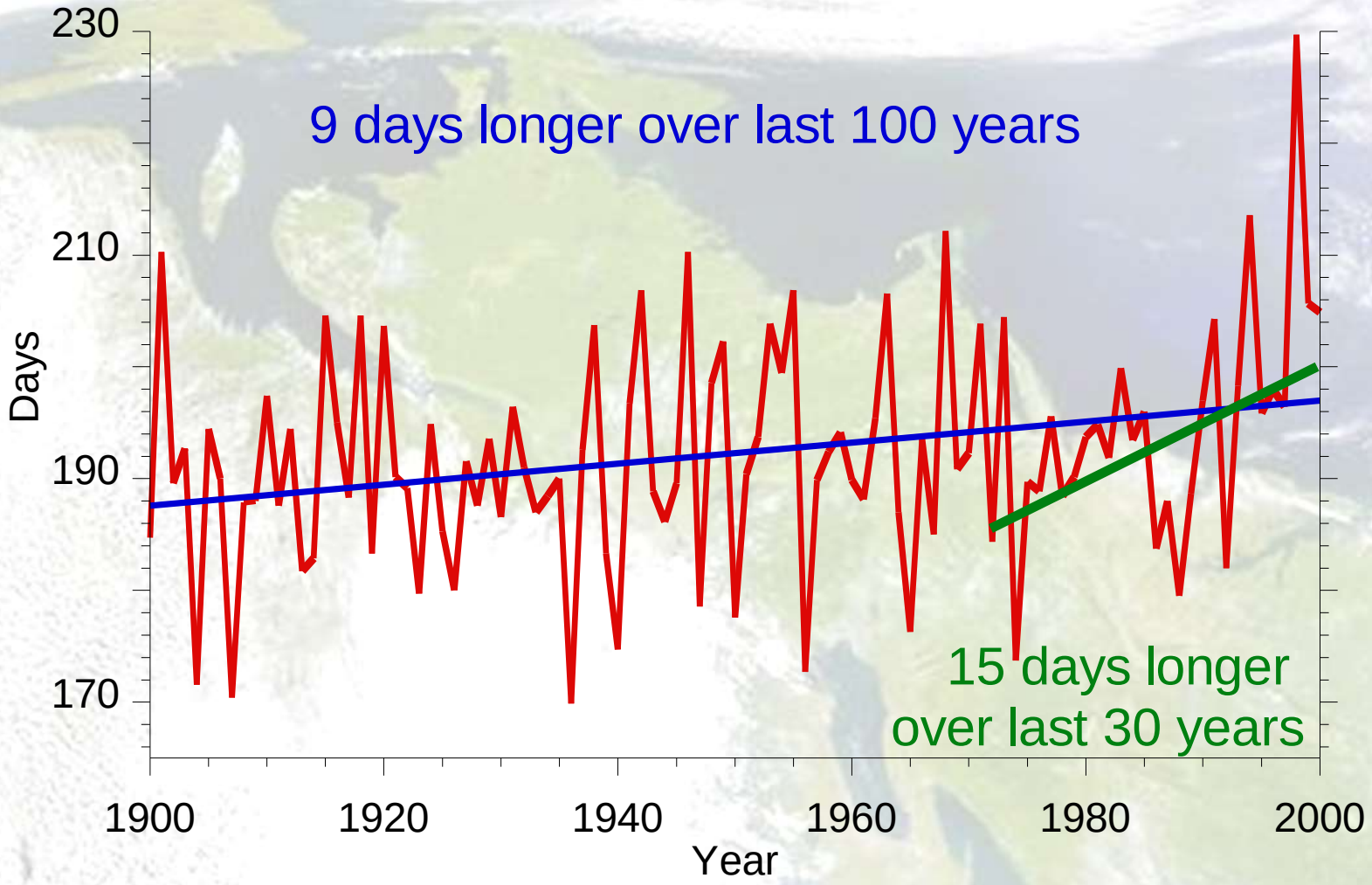


Spatial Variation of Linear Temperature (°F) Trend 1899-2000



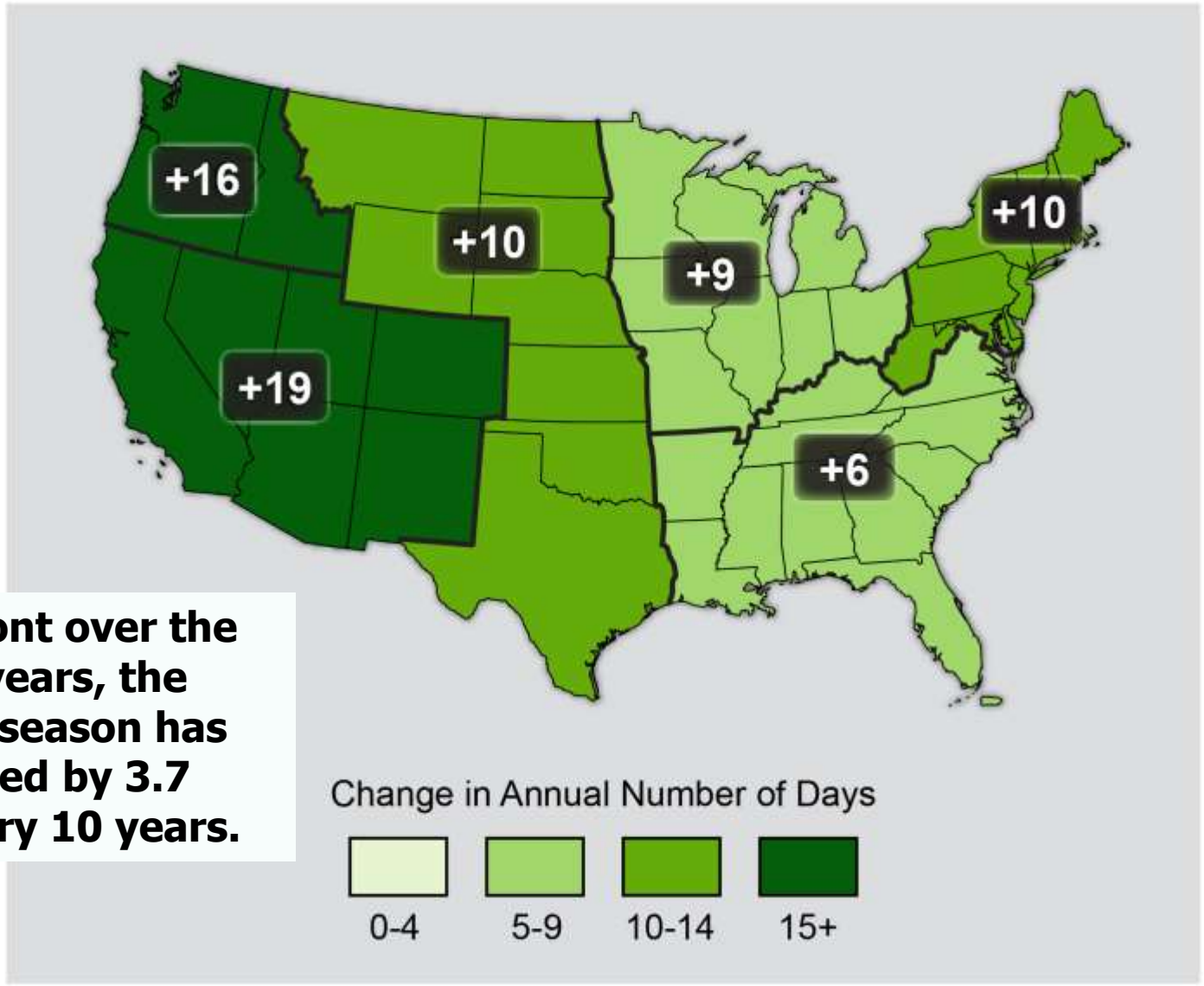
Linear trend in annual temperature (°F) from 1899-2000 for the Northeast. The change was estimated from a linear regression of annual average temperature for each station.

Average Growing Season (32ºF) in New England (6 stations)



Stations: Gardiner, ME; Blue Hill, Framingham, Tauton, MA; Chelsea, Enosburg Falls, VT

Increase in Frost-Free Season Length 1991-2012 relative to 1901-1960



In Vermont over the past 40 years, the growing season has lengthened by 3.7 days every 10 years.

(Walsh et al. 2014, National Climate Assessment)

Average annual precipitation at 79 Northeast locations

Increase of 3.3 inches from 1900-2000

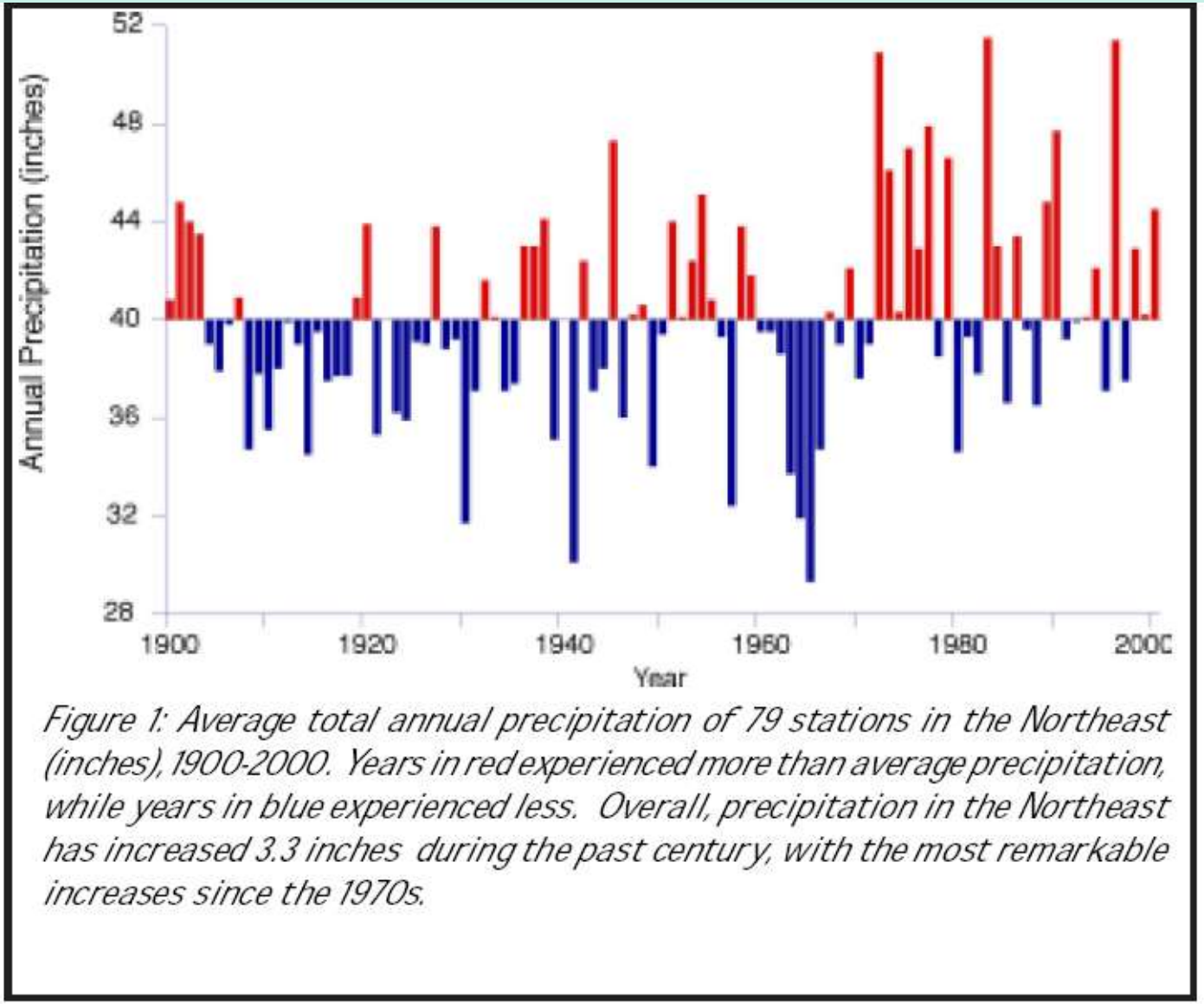
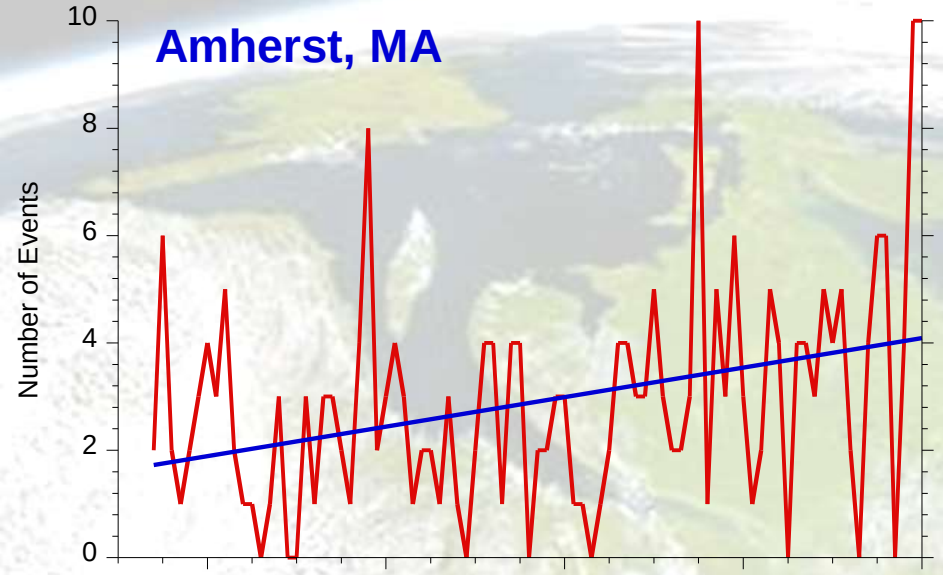
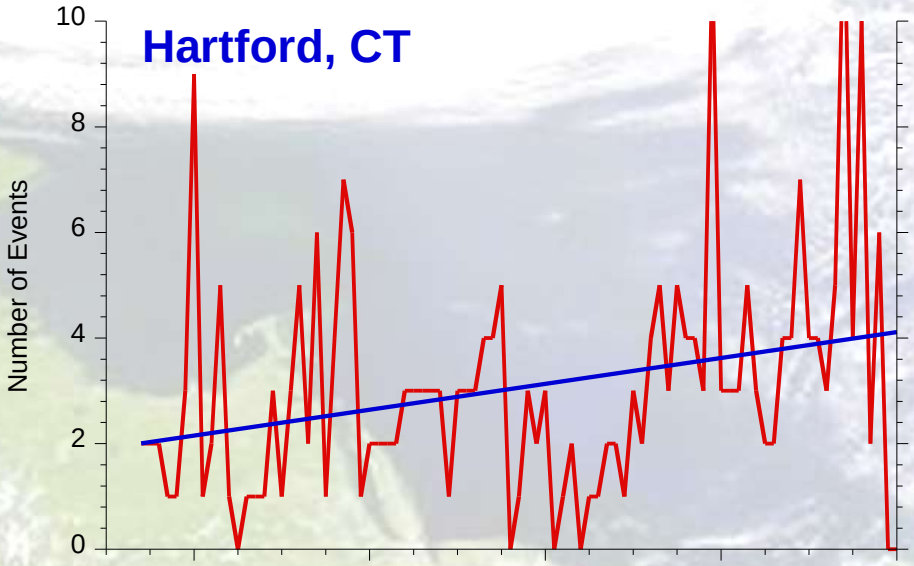


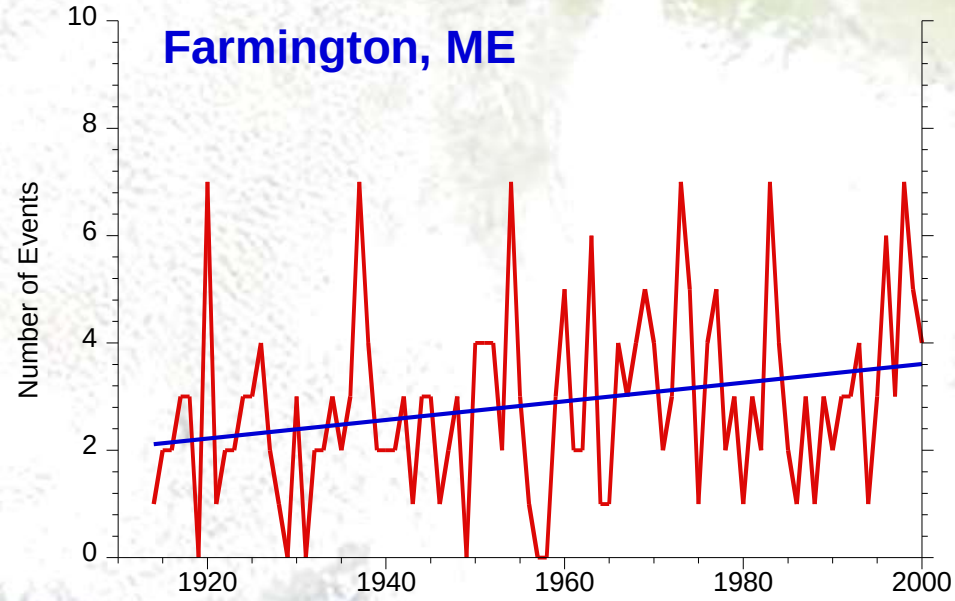
Figure 1: Average total annual precipitation of 79 stations in the Northeast (inches), 1900-2000. Years in red experienced more than average precipitation, while years in blue experienced less. Overall, precipitation in the Northeast has increased 3.3 inches during the past century, with the most remarkable increases since the 1970s.

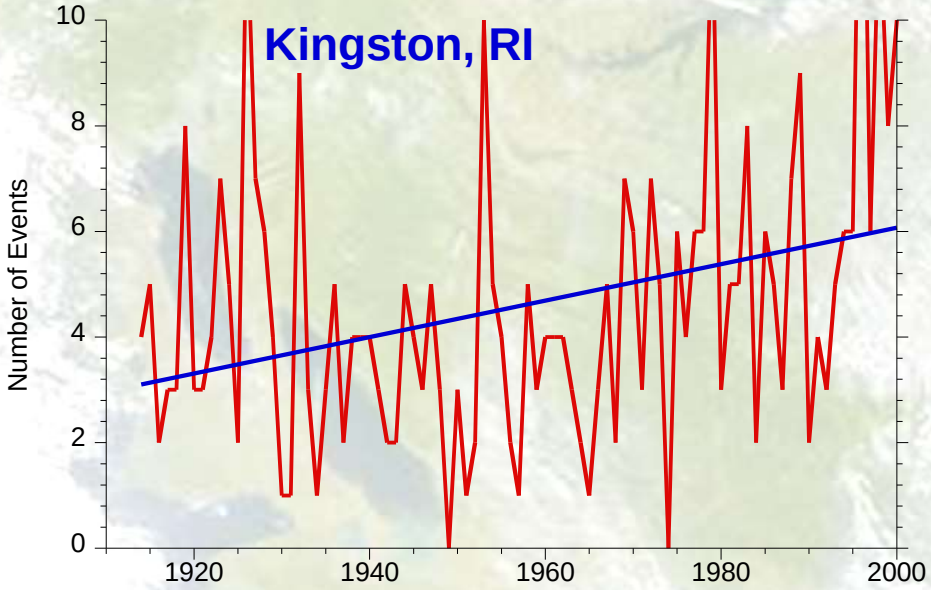
Source: Indicators of Climate Change in the Northeast 2005. C. Wake, UNH

Extreme Precipitation Events (>2” over 48 hrs)

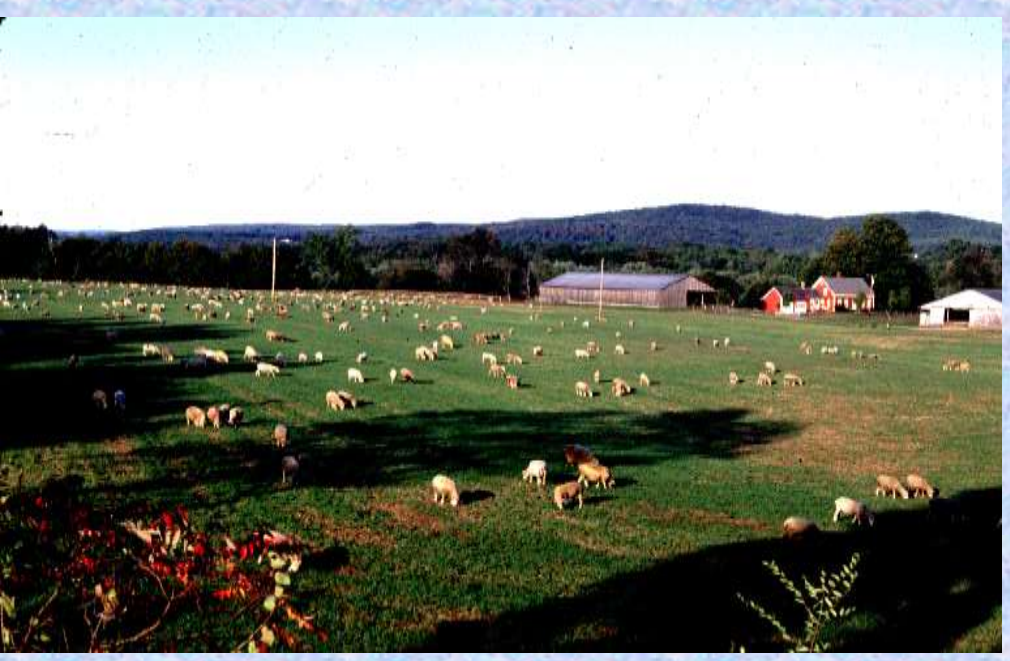








How will crops, livestock, pests respond to climate change?



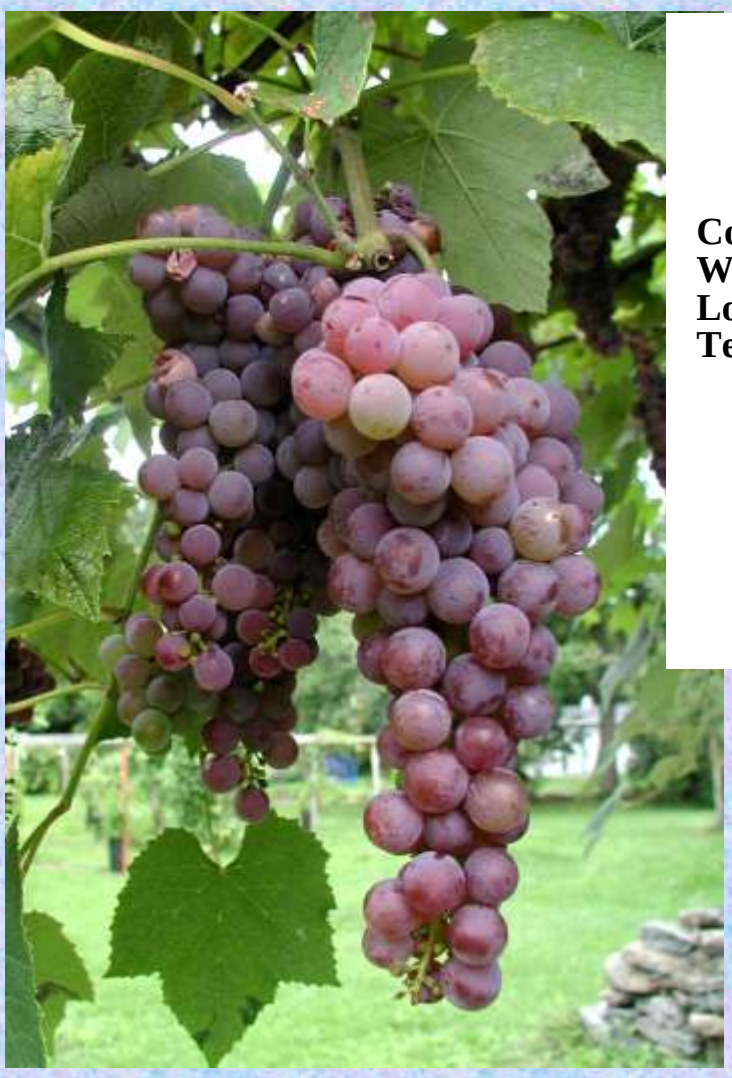
Potential positive effects in the Northeast

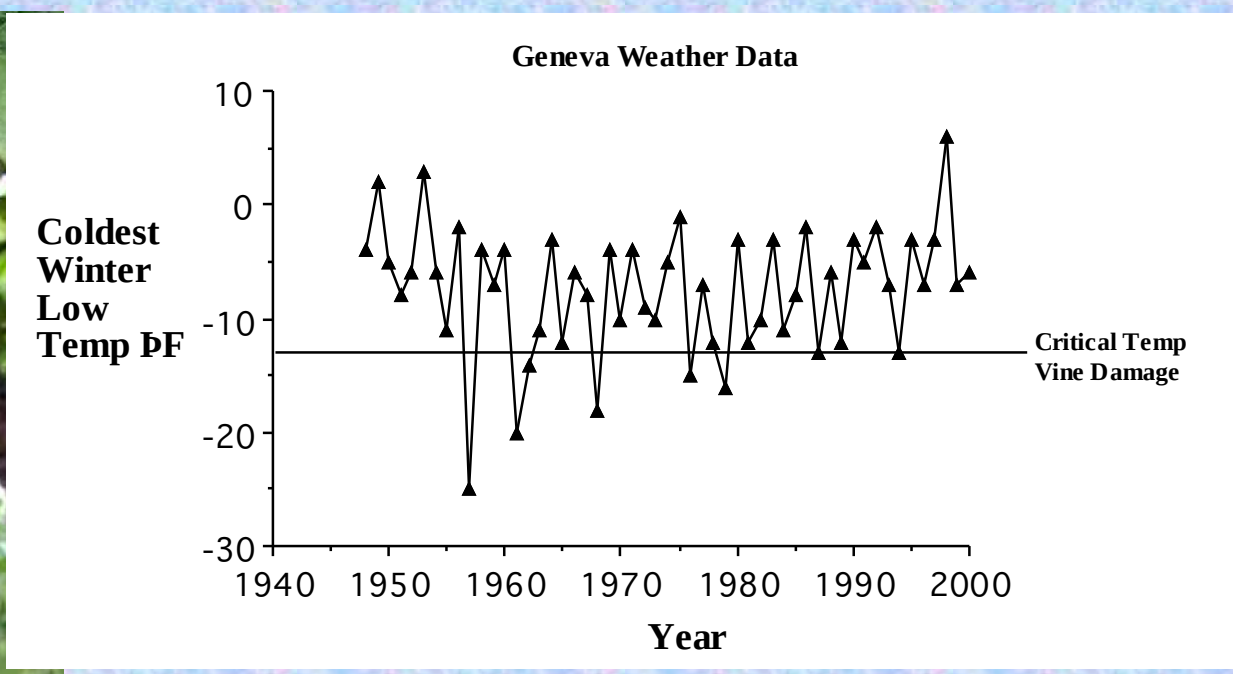
- warmer, longer growing season
- increased photosynthesis/ plant growth
- more rainfall to meet water needs
- less winter stress to livestock, crops

Potential negative effects in the Northeast

- more floods and droughts
- new insect, disease, and weed problems
- invasive plant species prosper
- poor growth of cool-season crops
- heat stress in livestock

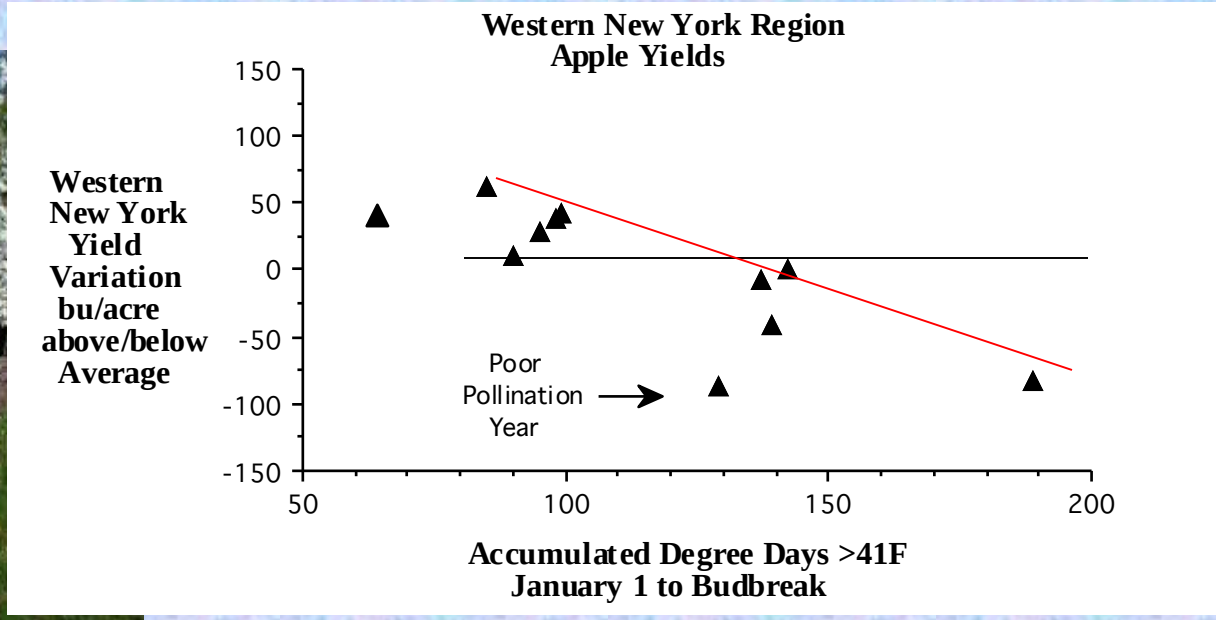
Warmer winters may benefit European wine grapes (V. vinifera) by reducing winter damage to roots and vines





Source: A. Lakso, Cornell

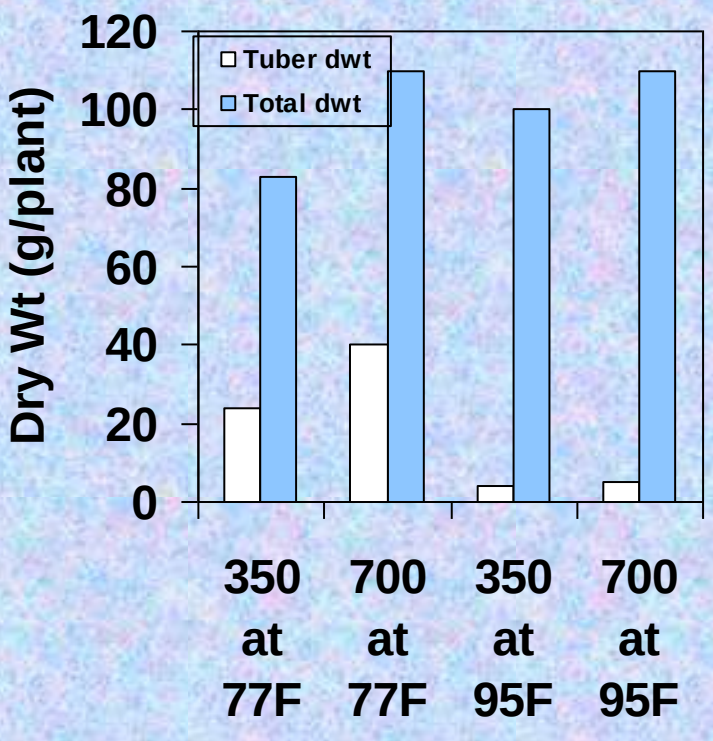
Apple fruit set and yield may be negatively affected by warmer winters and early springs



Source: A. Lakso, Cornell

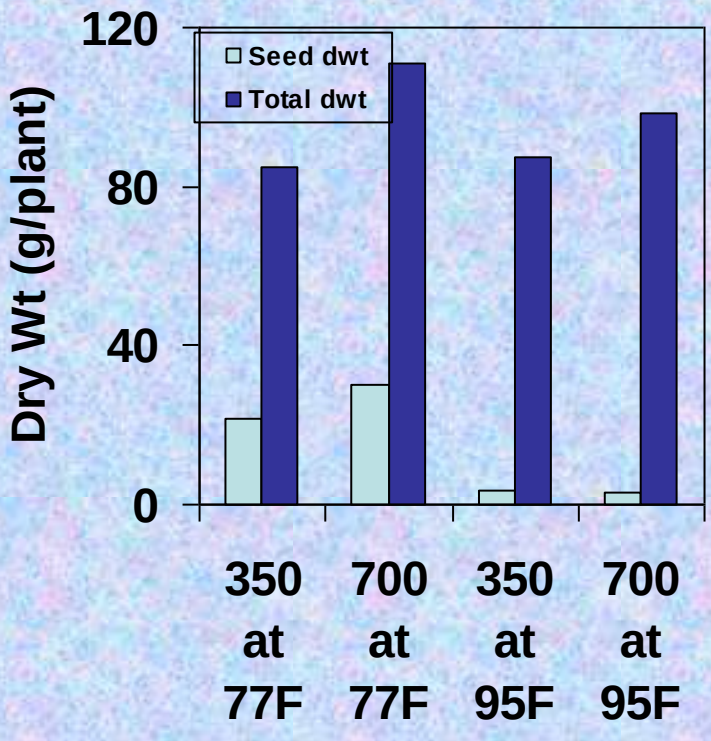
Will higher CO_2 increase crop yields?

Potato Response



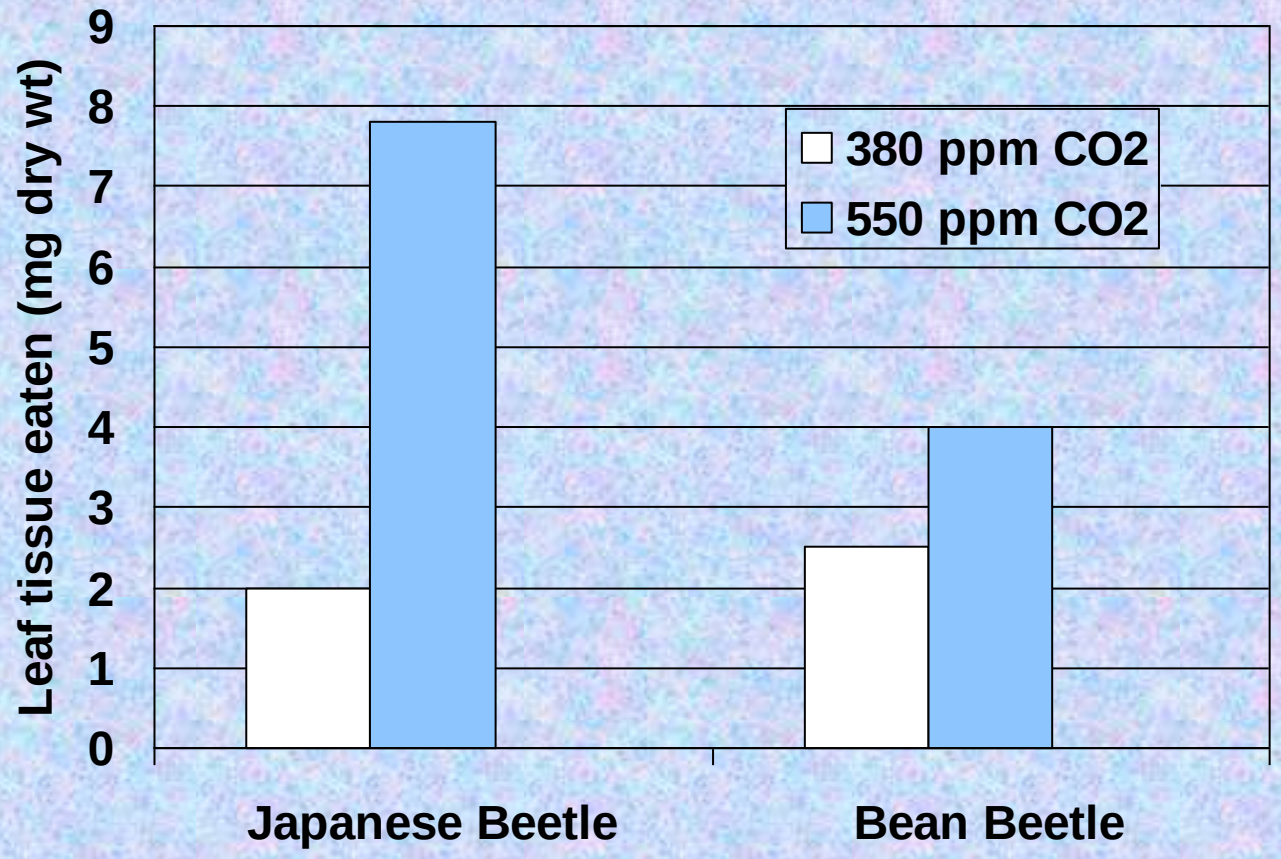
Peet and Wolfe, 2000, In: KR Reddy (ed.) *Climate Change and Global Crop Productivity*

Dry Bean Response



Jifon and Wolfe, 2005, *J Amer Soc Hort Sci* 130(4):515-520

Leaf-feeding insects may do more damage in a high CO2 world



Data are from soybean field experiments.
Source: Hamilton et al. 2005 Environ. Entomology 34:479-485

CO_2 level may affect herbicide use

350 ppm - ambient CO_2 **500 ppm – future CO_2**

Increasing CO_2 reduces glyphosate efficacy

See: Ziska et al. in *Weed Science* 2004

Corn Earworm
– overwintering?

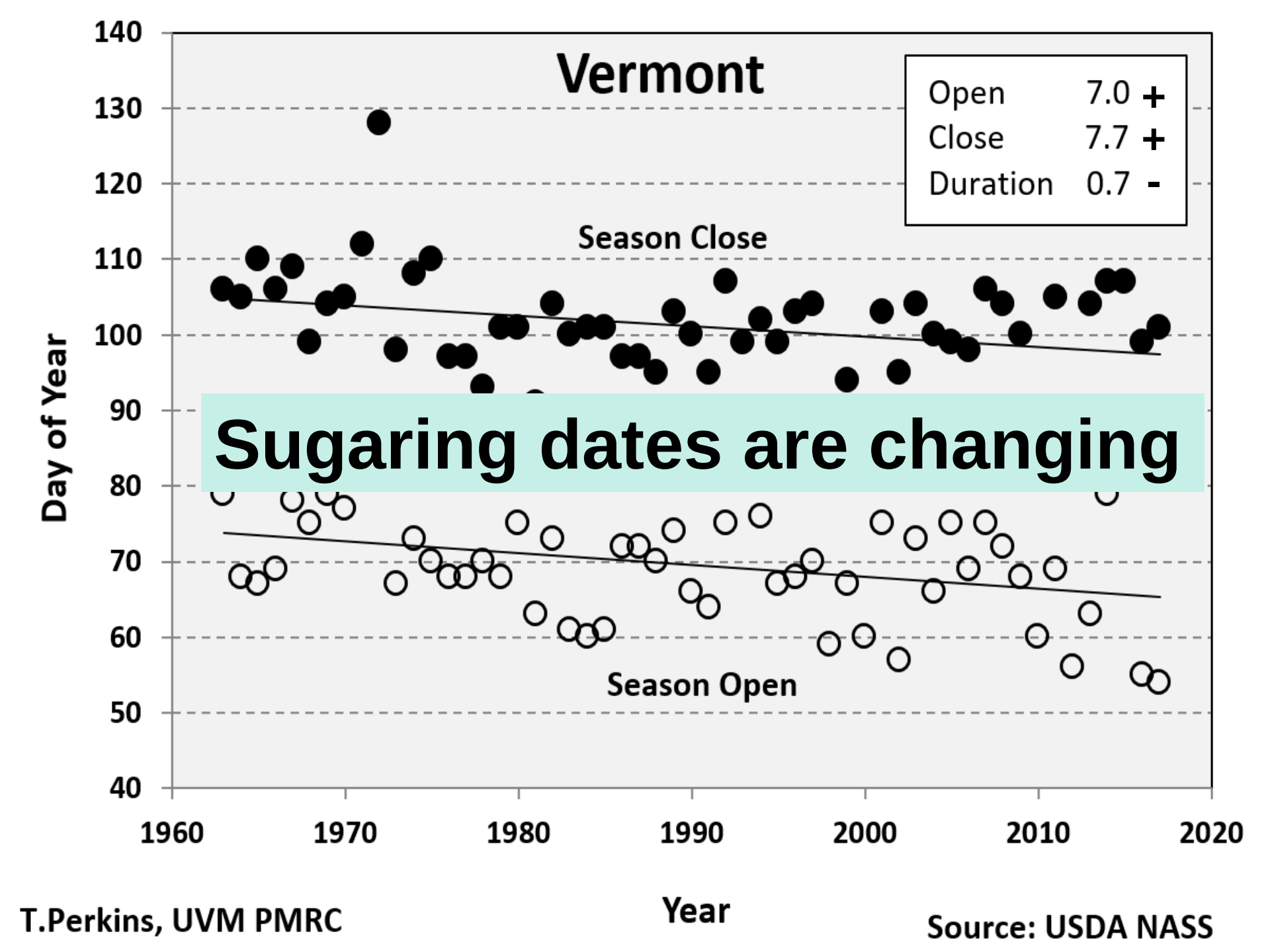
Insect pests are changing

Potato Leafhopper
– more frequent?

Stewart's wilt – more winter survival of flea beetle vector?

Disease patterns are changing

Phytophthora root rot – more frequent with wetter soils?


Vermont
Open 7.0 +
Close 7.7 +
Duration 0.7 -
Season Close
Season Open
Sugaring dates are changing
Day of Year
Year
140
130
120
110
100
90
80
70
60
50
40
1960
1970
1980
1990
2000
2010
2020
T.Perkins, UVM PMRC
Source: USDA NASS

Warmer winters may shorten winter ban on manure spreading, less use of open manure lagoons = less methane generated


A longer grazing season benefits grass-based livestock production,
but milder winters may enhance year-to-year parasite survival.

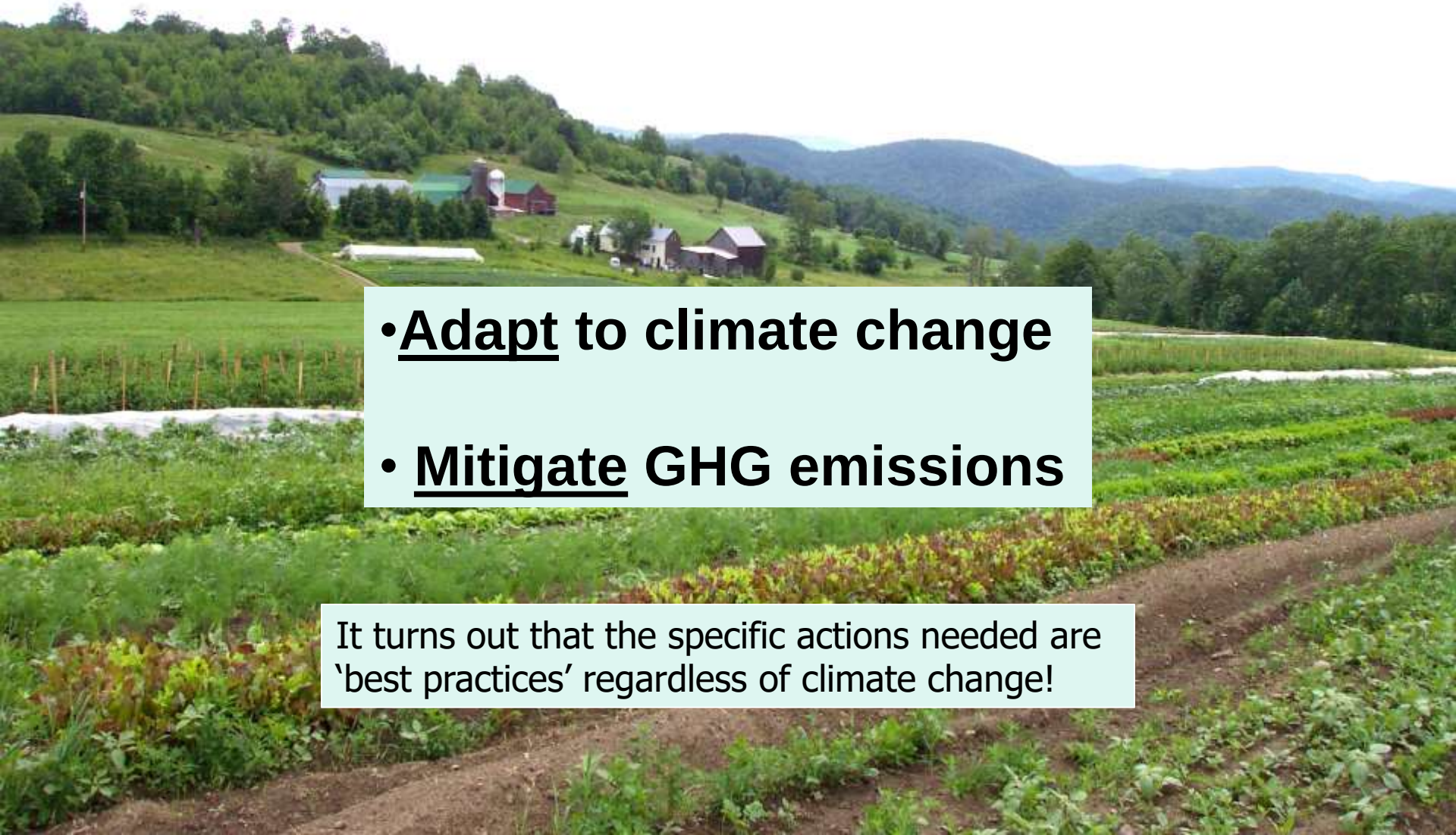
Heat + humidity (THI) stresses dairy cows

Annual economic impact of heat stress on livestock

state	loss, million $	% of total loss from dairy
New York	24.9	98
Pennsylvania	50.8	88
Vermont	5.4	98
Maryland	8.75	86

From: St-Pierre et. al., 2003

What can farmers do?



- **<u>Adapt</u> to climate change**
- **<u>Mitigate</u> GHG emissions**

It turns out that the specific actions needed are 'best practices' regardless of climate change!

“What we got here is a failure to communicate”

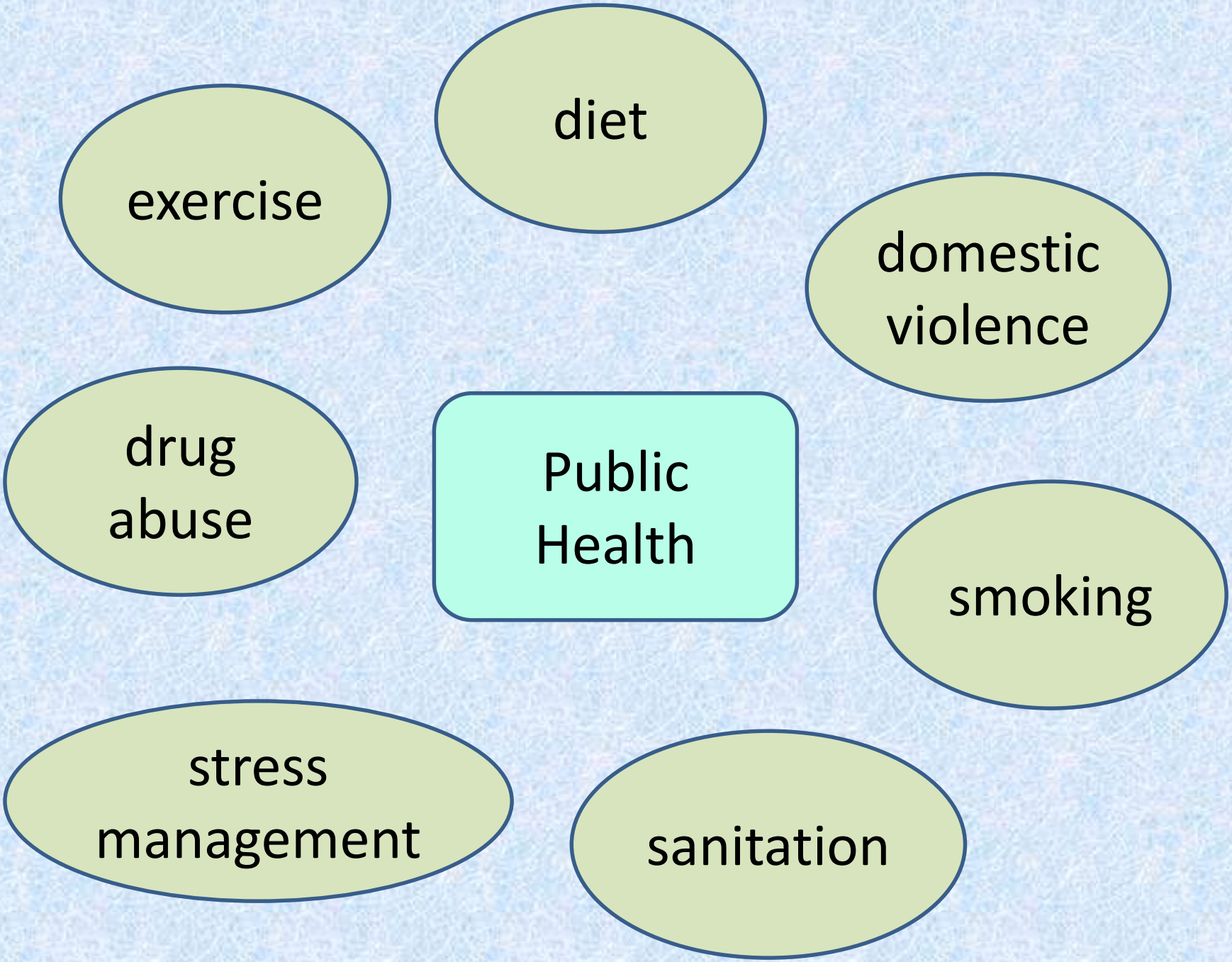
- Cool Hand Luke, 1967

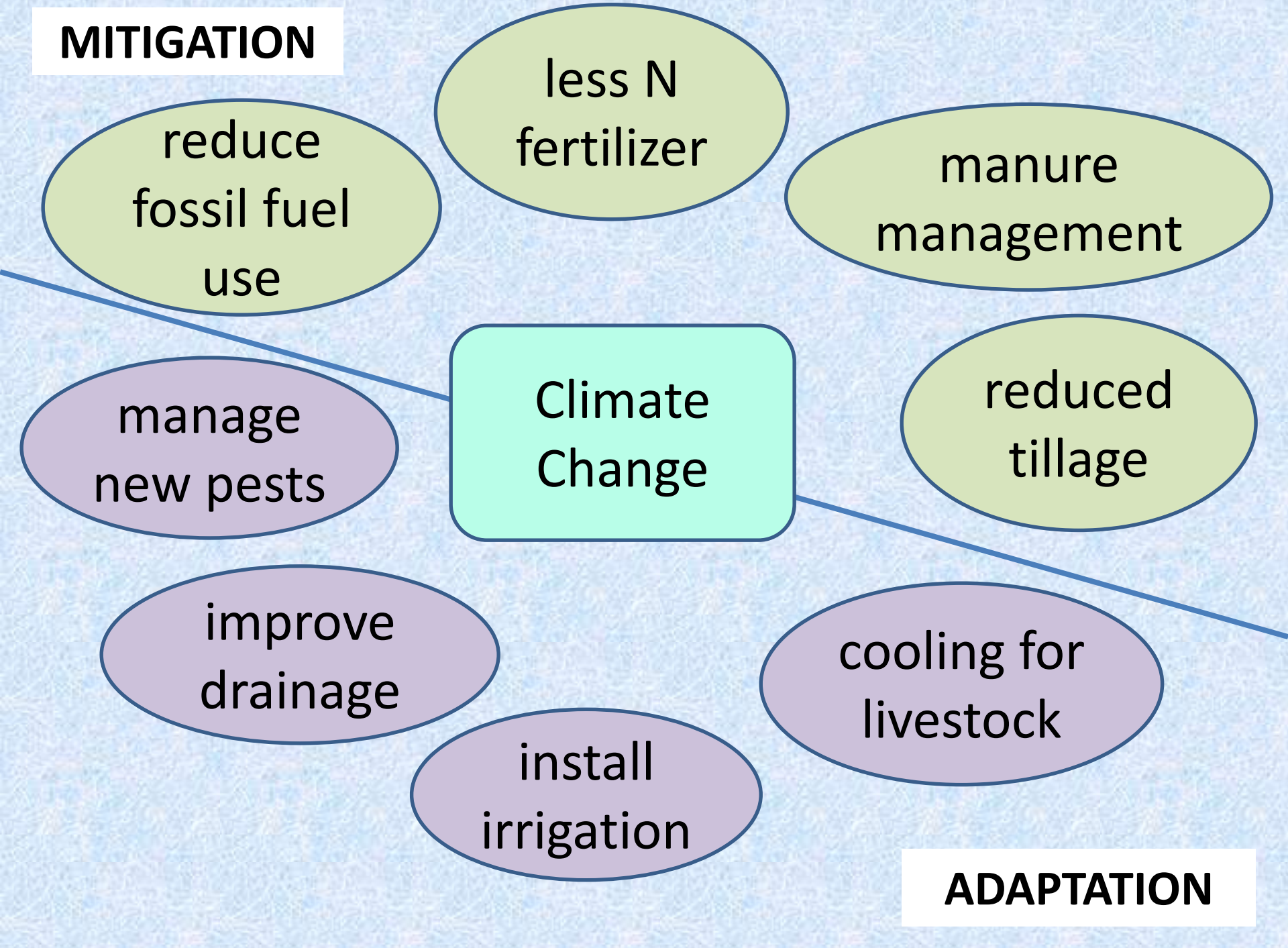
My proposition

Climate change by itself is not an actionable issue for most people.

It's too overwhelming, scientifically complex, and politically charged to motivate behavior change.

Many people can be motivated to act on specific issues that address climate change, through a mixture of examples, information and incentives.


exercise
diet
domestic violence
drug abuse
Public Health
smoking
stress management
sanitation


MITIGATION
less N fertilizer
reduce fossil fuel use
manure management
Climate Change
manage new pests
reduced tillage
improve drainage
cooling for livestock
install irrigation
ADAPTATION

My recommendations

Focus on what people can do, and how to do it.

Less on climate science, projections, models.

Describe multiple benefits of specific actions.

Establish targets for adoption.

Improve estimates of GHG impacts so that ‘best practices’ can be prioritized (and monetized).

Climate adaptation strategies for farmers (and gardeners)

barns designed to passively keep livestock cool


trees and water in pasture for shade and cooling

irrigation for consistent crop yields

Drainage of excess water improves crop yields

Raised beds on heavy soils can promote drainage

Monitoring and scouting are key to detecting new pests or unusually high populations


New tools are needed to cope with new pests

Cover crops improve soil structure which aids water infiltration, retention, and drainage

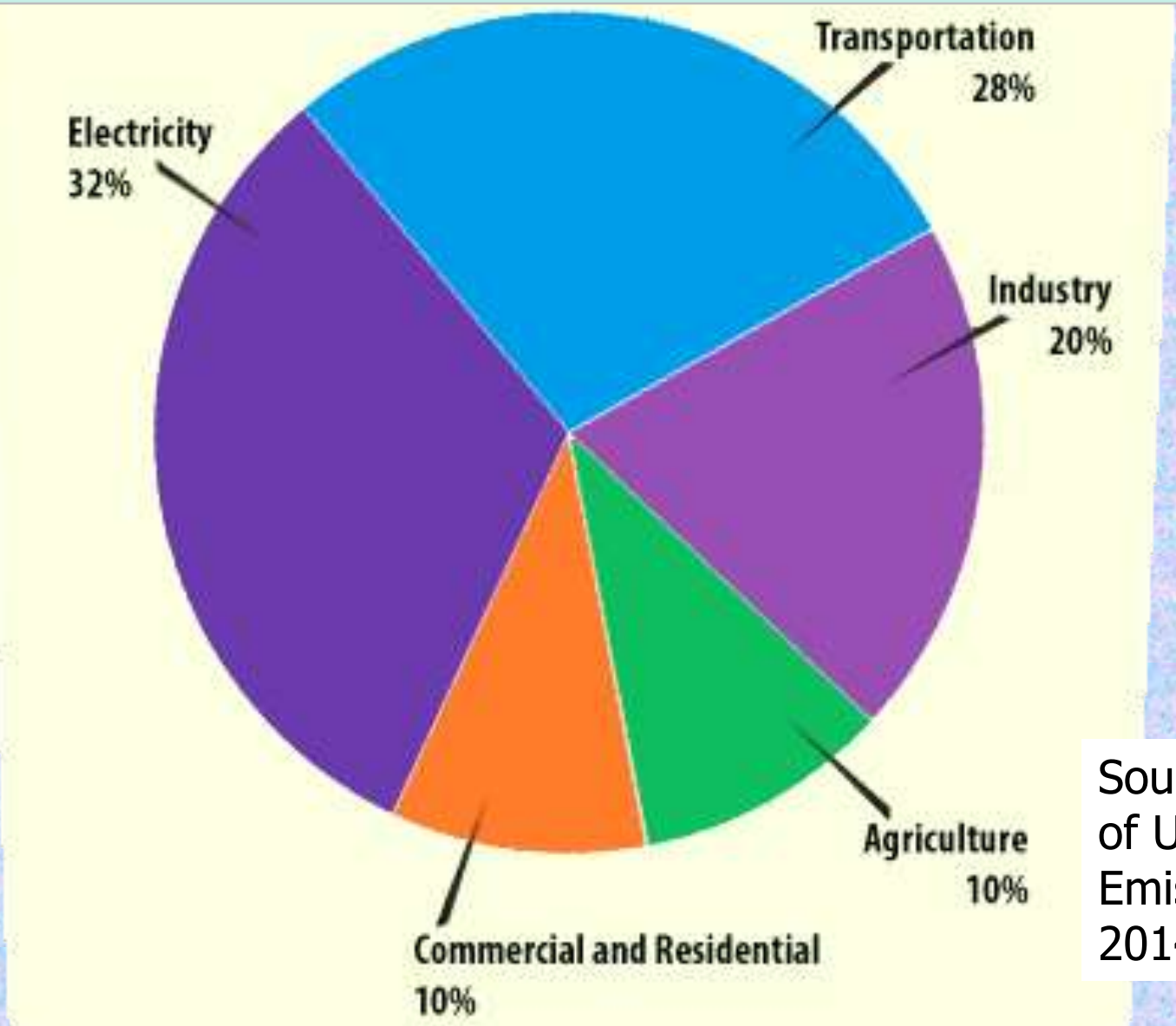

high tunnels and greenhouses
can reduce weather-related losses

Climate mitigation strategies for farmers (and gardeners)

Reducing greenhouse gases

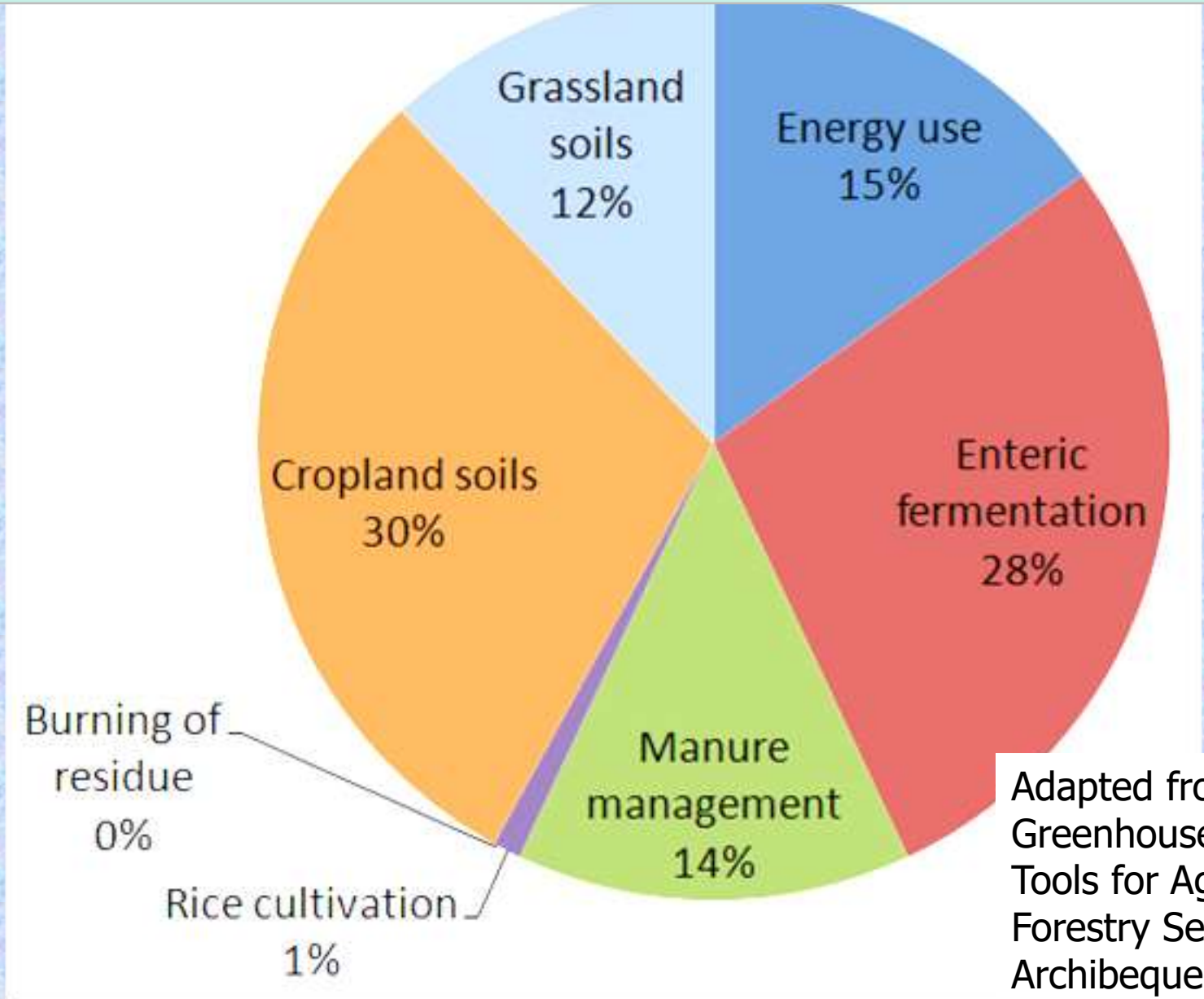
- Use less nitrogen fertilizer
- Improve manure management
- Reduce tillage
- Grow plants everywhere possible
- Use on-farm renewable energy
- Avoid packaging, transport, storage

Agriculture accounts for ~10% U.S. GHG Emissions



Source: EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks, 2014

Most ag. emissions come from soil and livestock



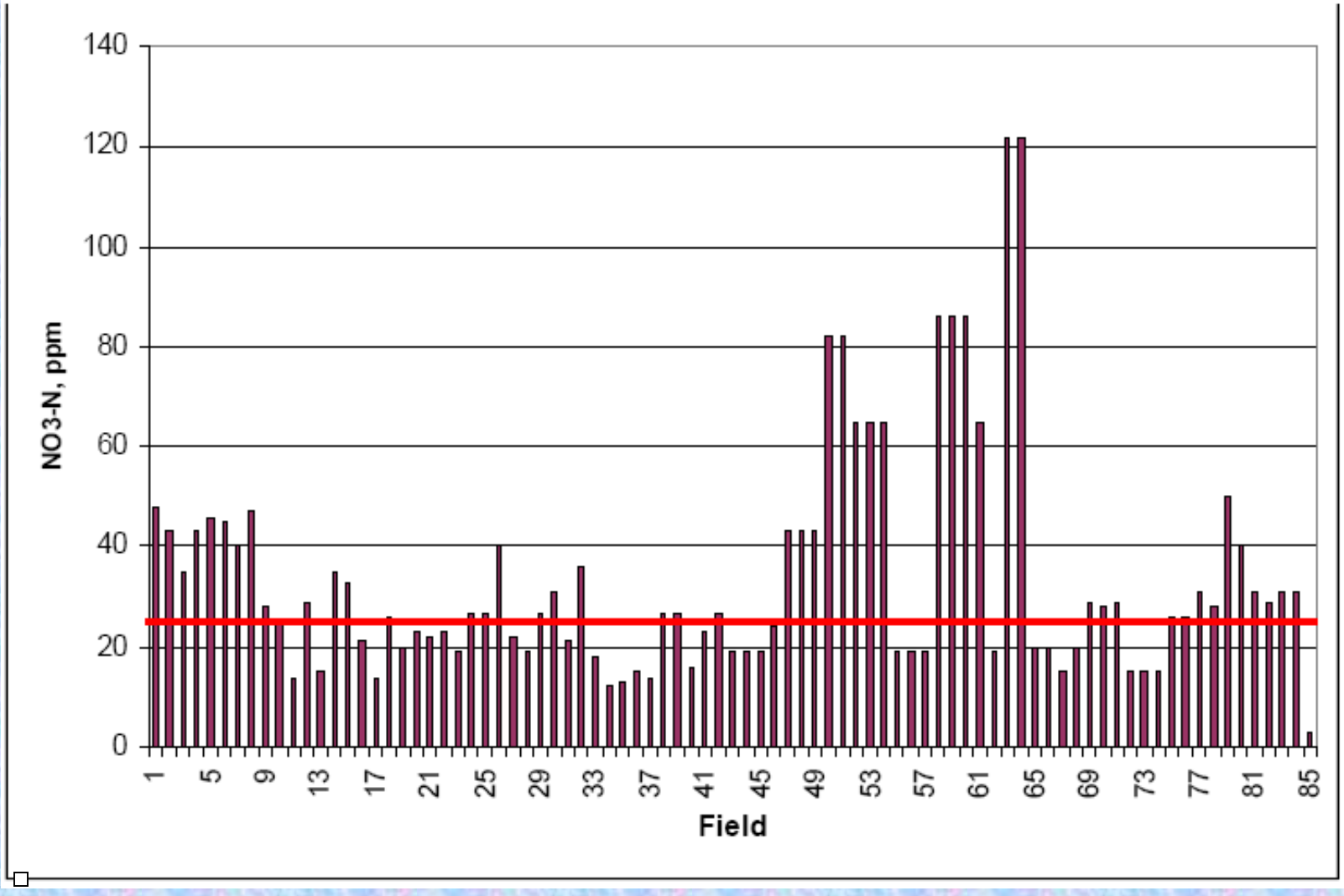
Adapted from: Report of Greenhouse Gas Accounting Tools for Agriculture and Forestry Sectors. Archibeque, S. et al., 2012

Intensive pasture management sequesters C, captures nutrients, protects soil

Winter cover crops after annual cash crops

Optimize fertilizer N use

Results of pre-sidedress nitrate test ($8) on Vermont dairy farms show many fields above 25 ppm = no more N needed



From: http://pss.uvm.edu/vtcrops/vdfsp/VDFSP_WebPpt_0606.pdf

Legume N instead of fertilizer N

Killdeer Farm, Norwich


Reduced tillage keeps carbon in the soil and protects against erosion
Lincoln Farm, Randolph Center

variety of reduced tillage systems

soil spader

no-till

mulches

Manure management: water and air quality can be in tension


Manure injection

Manure stacking

Energy efficiency: milk pre-cooler (heat exchanger) using cold well water

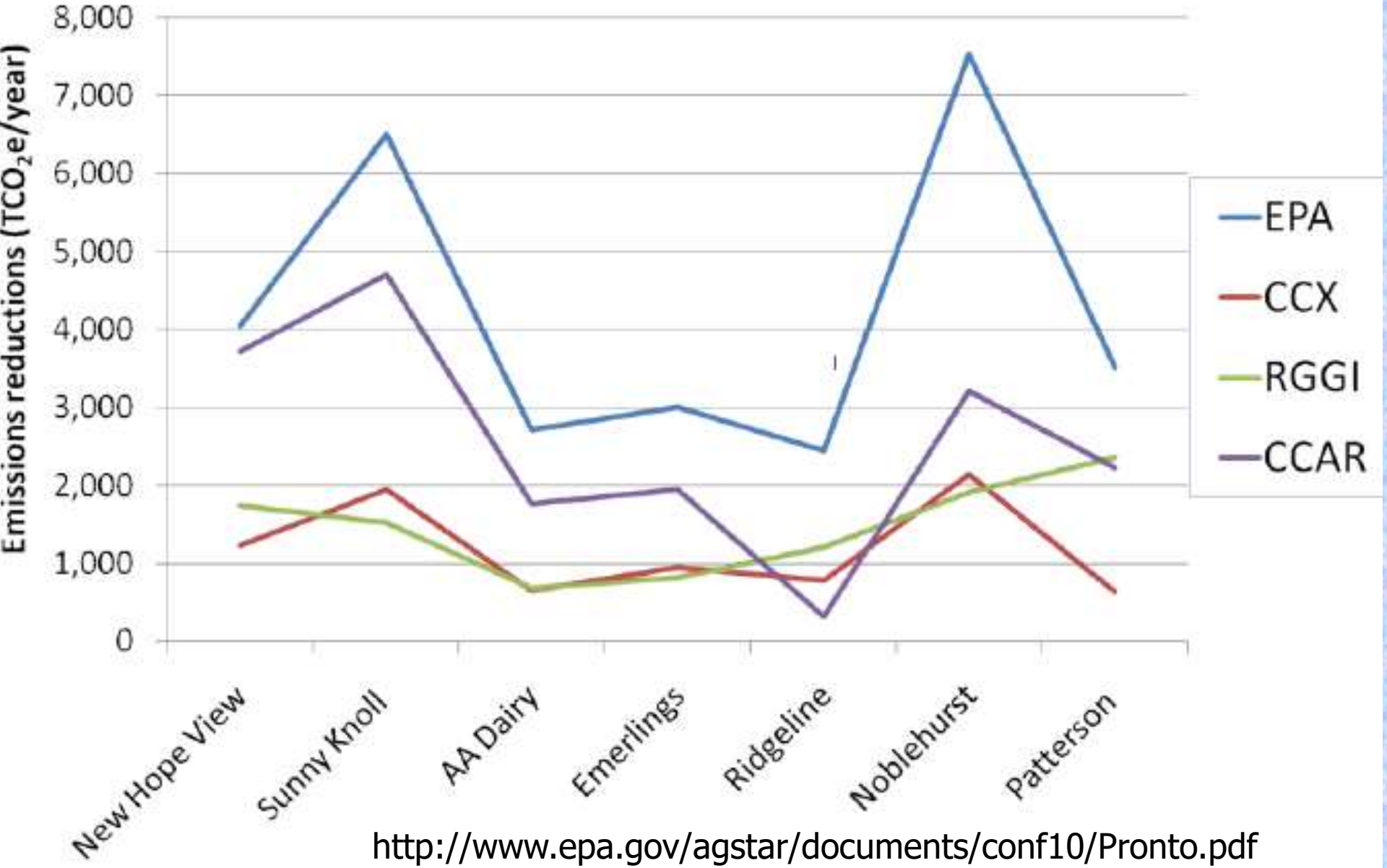
Can save a 400 cow dairy 29% of total electricity use = 22,500 kWh/yr

Anaerobic digesters: water quality and renewable energy benefits

Blue Spruce Farm, Bridport


CAT

Emission reductions over 7 NYS dairy farms following 4 different methodologies



http://www.epa.gov/agstar/documents/conf10/Pronto.pdf

Biomass fuels
(to reduce 'below ground' carbon use)

- Manure…to methane..to electricity

- Wood: logs, chips, pellets
- Hay, grass, willow etc. pellets
- Corn grain

- Vegetable oils: used or virgin
- Ethanol


Gorham Farm, W. Rutland

Grass or wood pellets for heating

Wood pellet/shell corn furnace

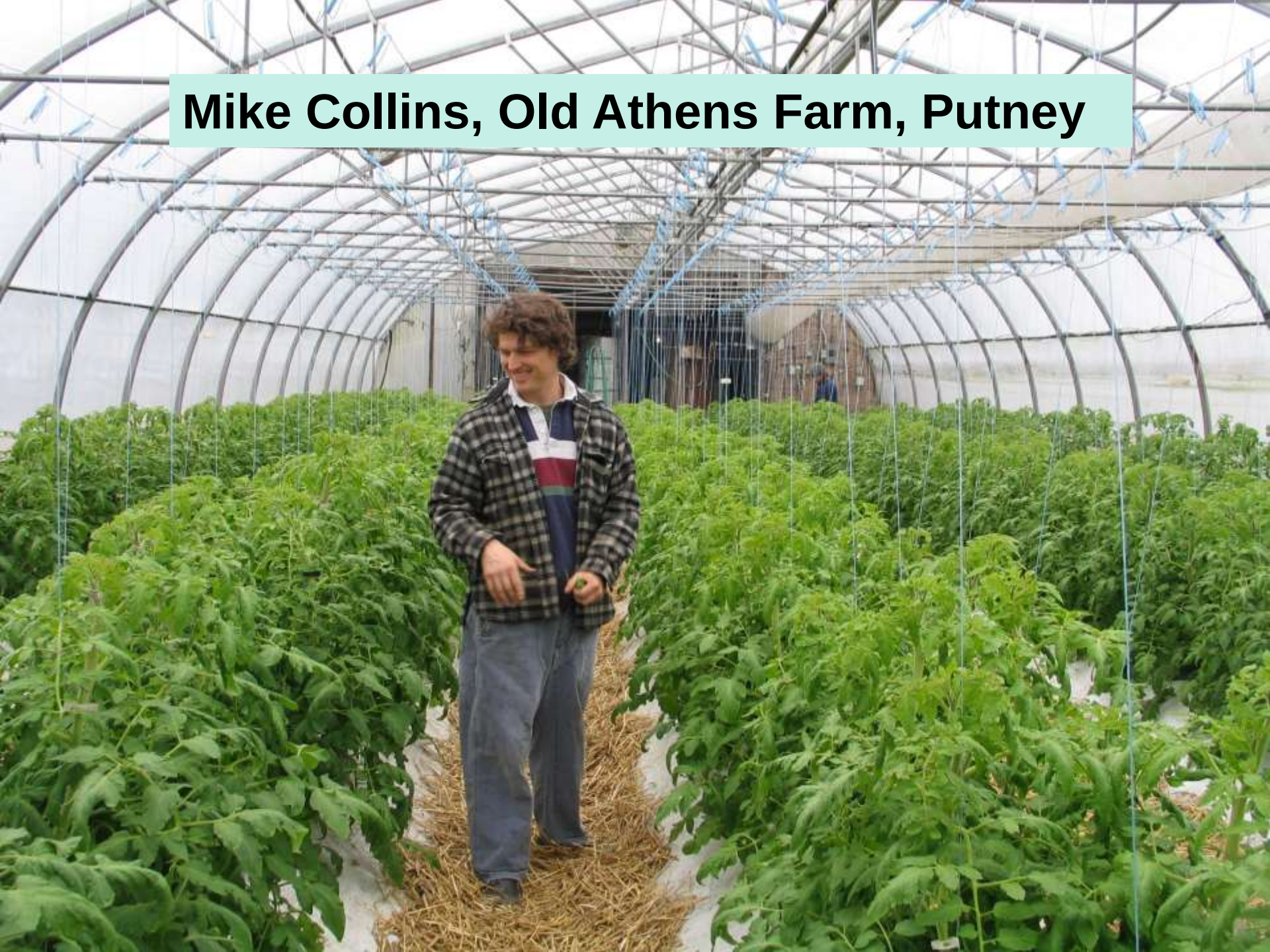
Intervale Community Farm Burlington

24 biofuel heating systems in VT saved $439,000 in fuel over 6 years, avoiding 890 tons of CO_2 emissions (~1.8 million car miles)

Shell corn for heating

Mazza's Farm, Colchester

Used vegetable oil


Mike Collins, Old Athens Farm, Putney

On-farm biodiesel from local crops

Liquid fuels have higher value than solid fuels


Sunflowers on August 1
Stateline Farm, Shaftsbury

Sunflowers on October 2

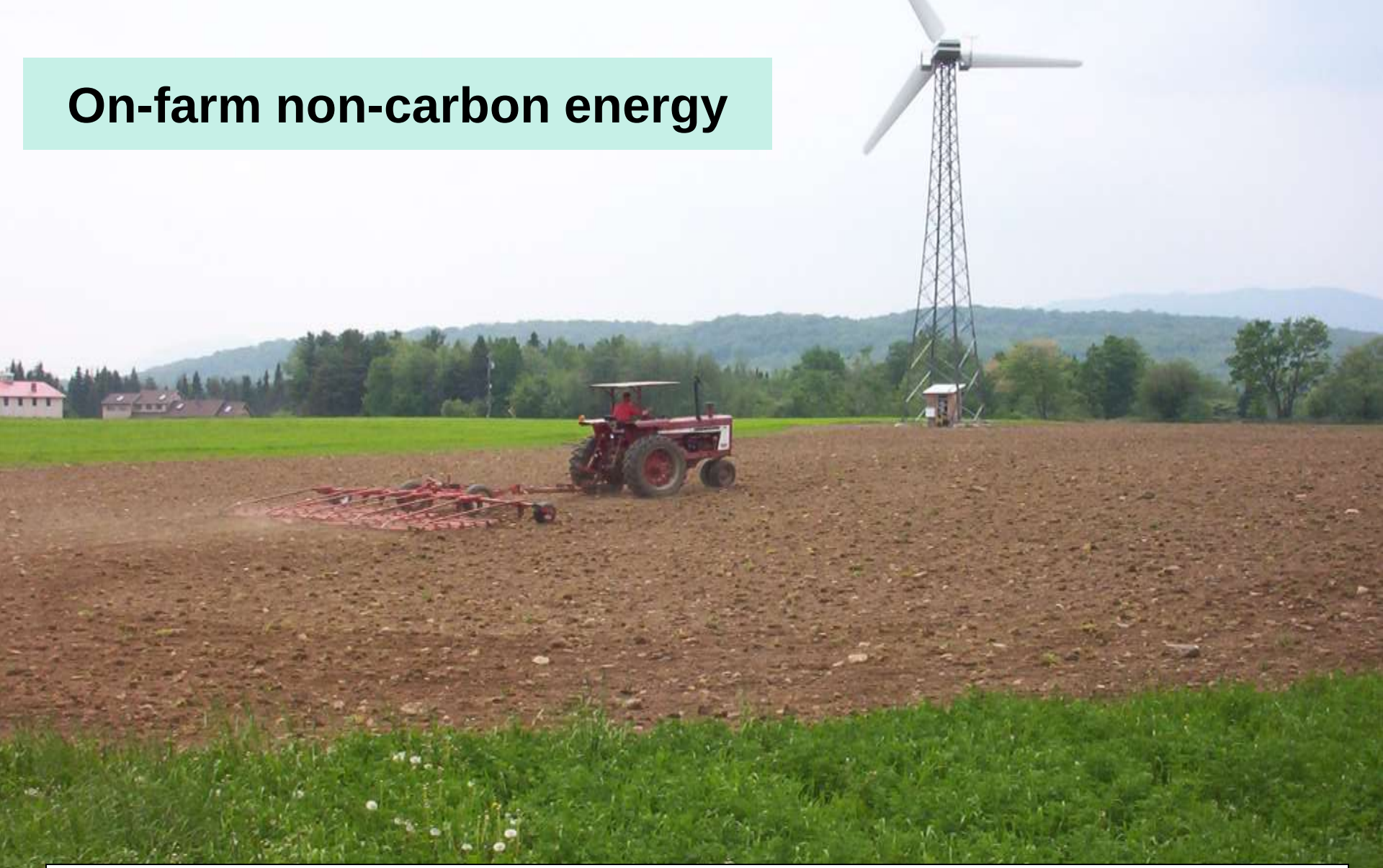

Canola on July 1


Canola on August 1


MASSEY · HARRIS


SEEDS
AGRICULTURE QUALITY SEED

On-farm non-carbon energy



Butterworks Farm, Westfield
35 kW generator produces 3,000-3,500 kW / month in winter
(60% of farm's electricity, 15% in summer)

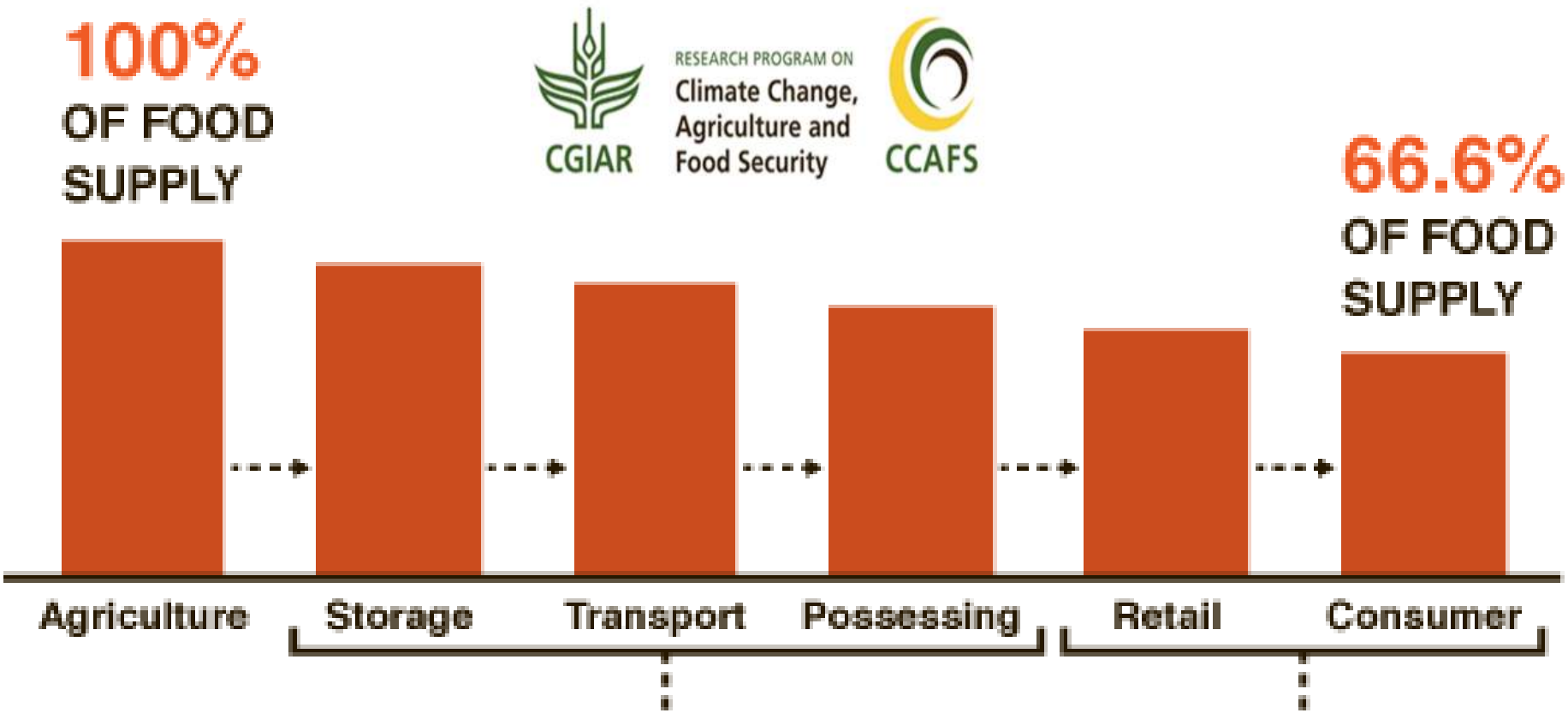

Solar panels on barns or marginal land
Amazing Planet Farm, Newfane


Cate Farm, Plainfield

What “consumers” can do

- reduce food waste
- buy less processed, packaged food
- consume less (industrial) meat
- favor grass-fed livestock products
- buy local: fewer food miles (?), less storage, less waste …more resilience
- support “working land” uses vs. pavement

About a third of all food produced is lost in the food supply chain.

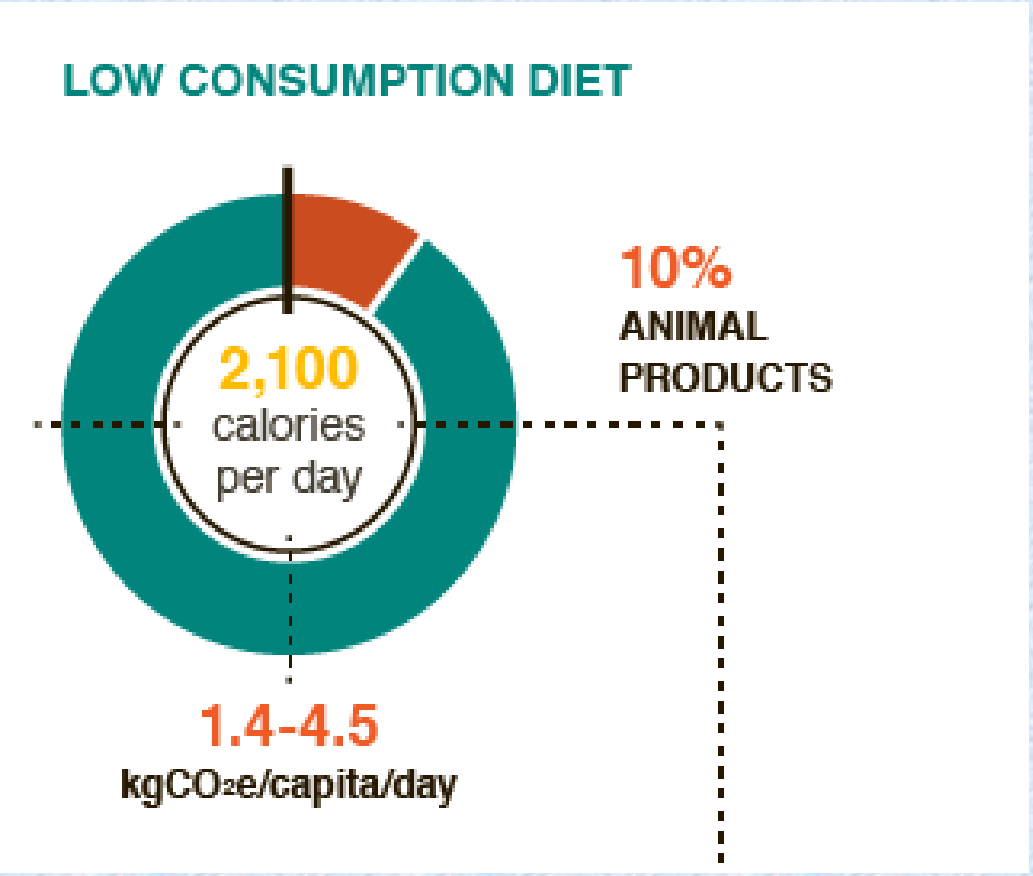


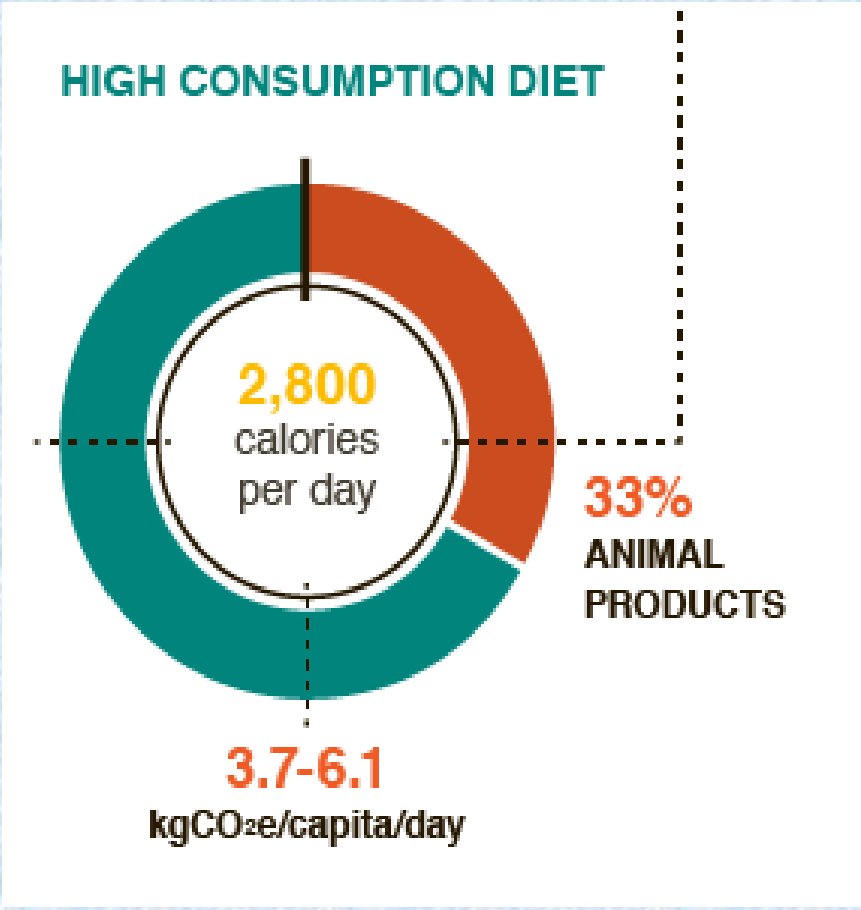
Most food losses in low-income countries occur at storage, transport and processing levels.

Most food losses in high-income countries occur at retail and consumer levels.

Food “date” labeling is part of the problem

Dietary choices affect GHG emissions

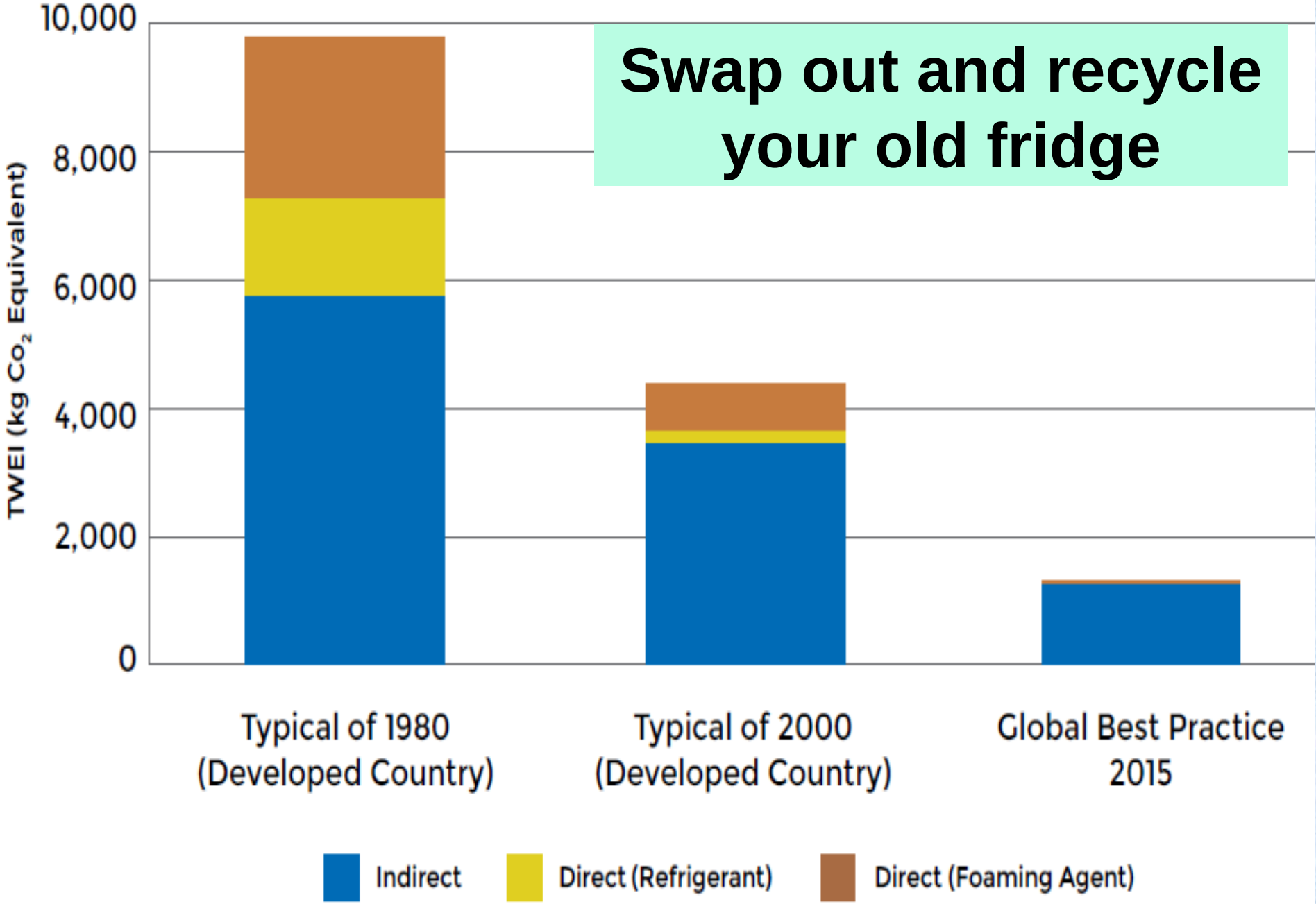




CGIAR RESEARCH PROGRAM ON Climate Change, Agriculture and Food Security CCAFS

Local food from CSAs, farm stands, farmers' markets, etc. may reduce packaging, storage energy, food waste, transportation energy

Swap out and recycle your old fridge



http://united4efficiency.org/wp-content/uploads/2017/06/U4E-RefrigerationGuide-201705-Final-R1.pdf

Thanks for listening...your thoughts?