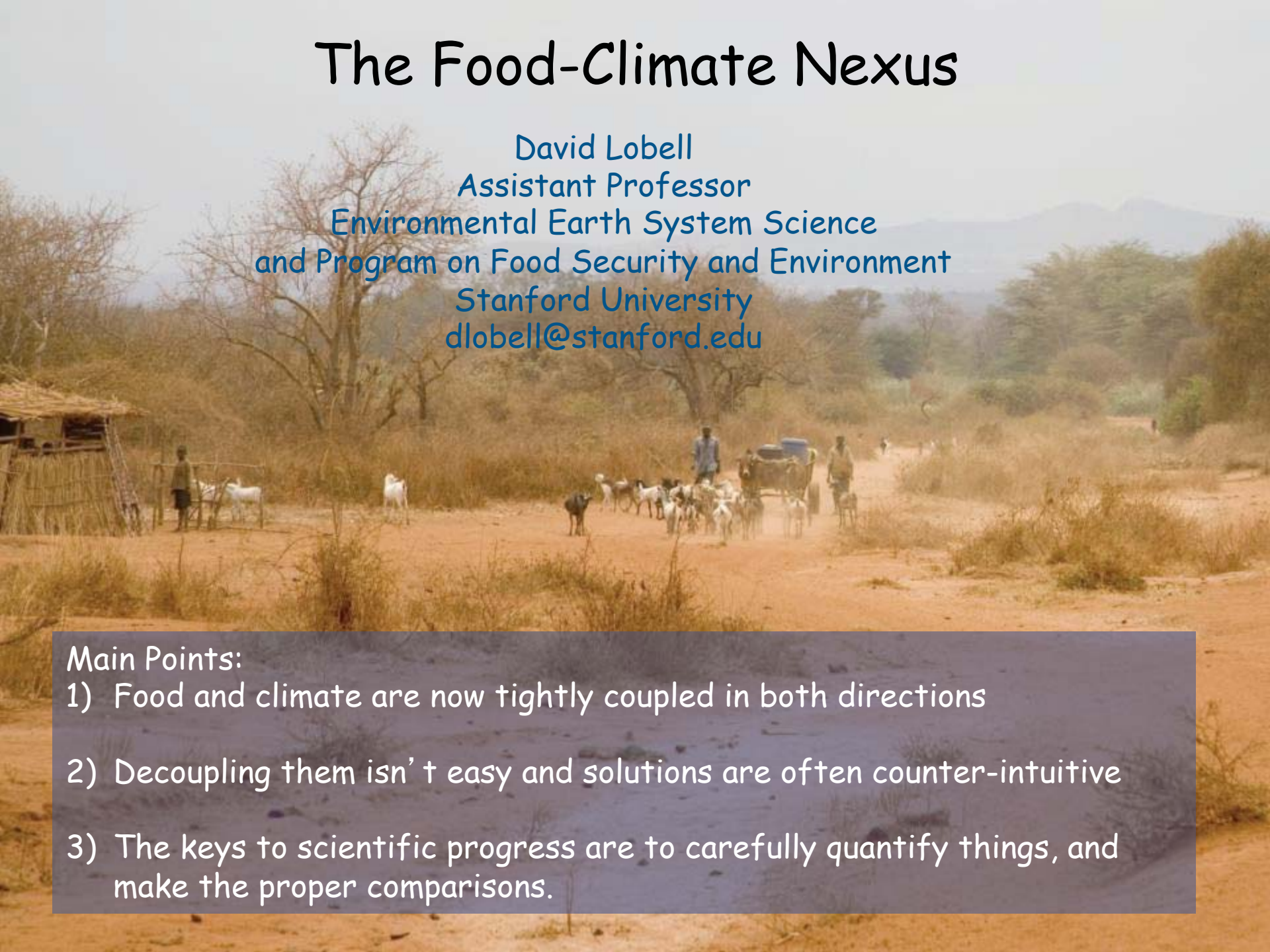
The Food-Climate Nexus

David Lobell
Assistant Professor
Environmental Earth System Science
and Program on Food Security and Environment
Stanford University
dlobell@stanford.edu



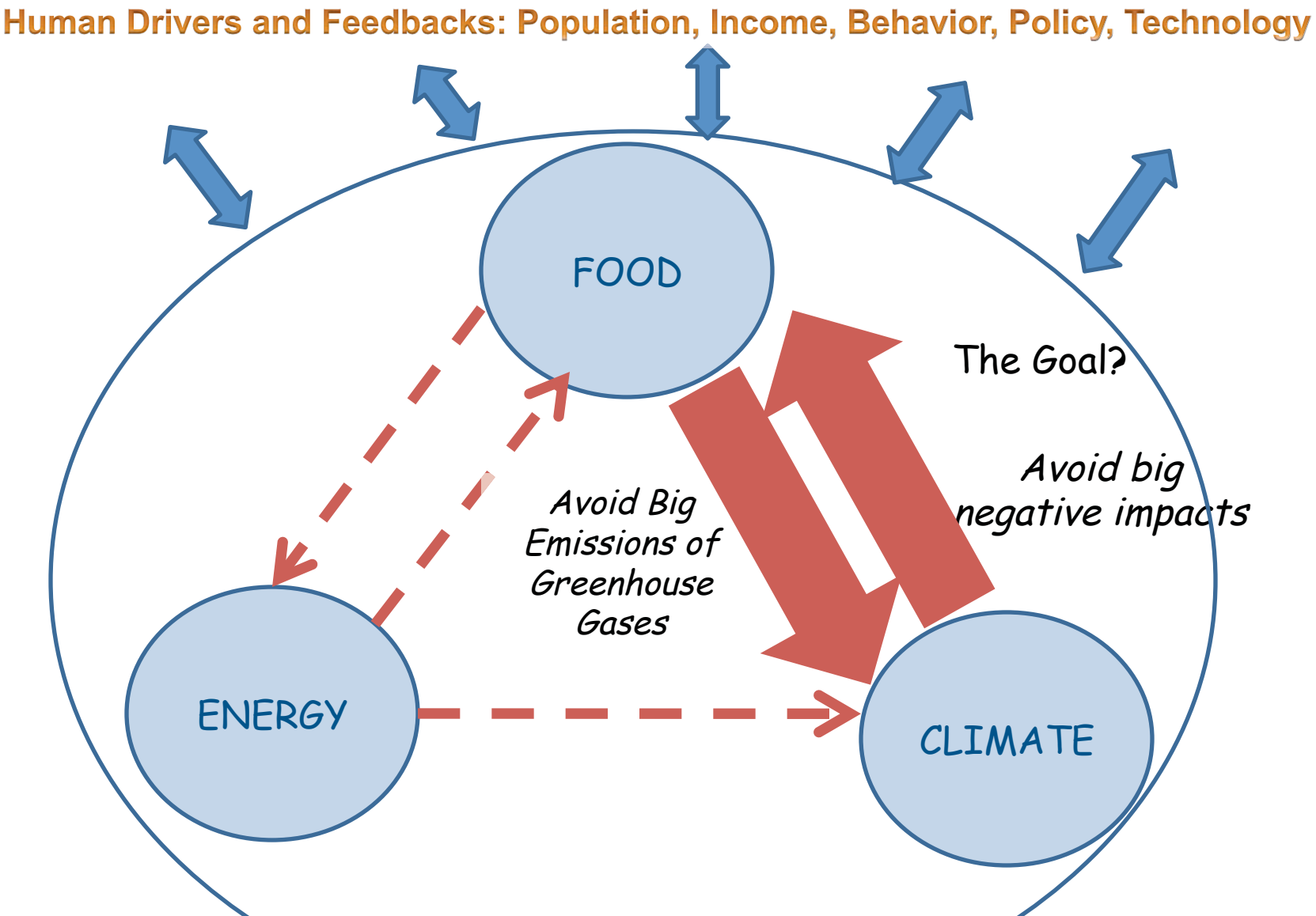
Main Points:

1) Food and climate are now tightly coupled in both directions

2) Decoupling them isn't easy and solutions are often counter-intuitive

3) The keys to scientific progress are to carefully quantify things, and make the proper comparisons.

The Food-Climate Nexus



Answers are not obvious, because…

1) Many of the relationships between food and climate are still poorly quantified

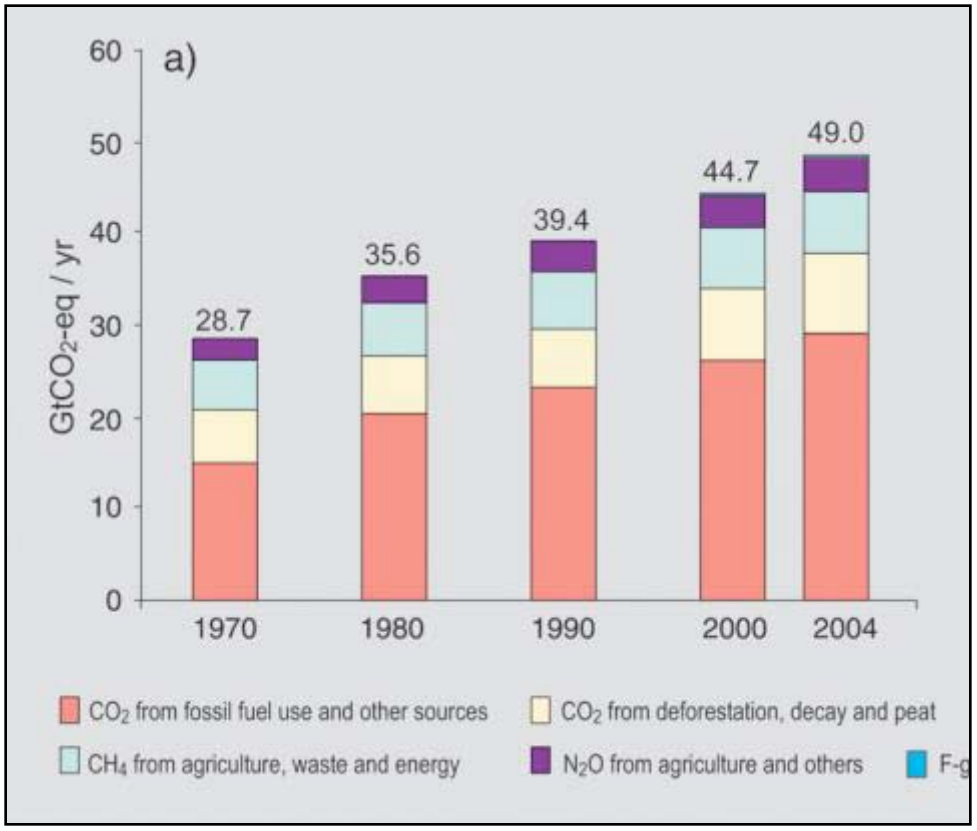
2) Humans are constantly responding to biophysical constraints (at least those reflected in prices), and so provide an important feedback

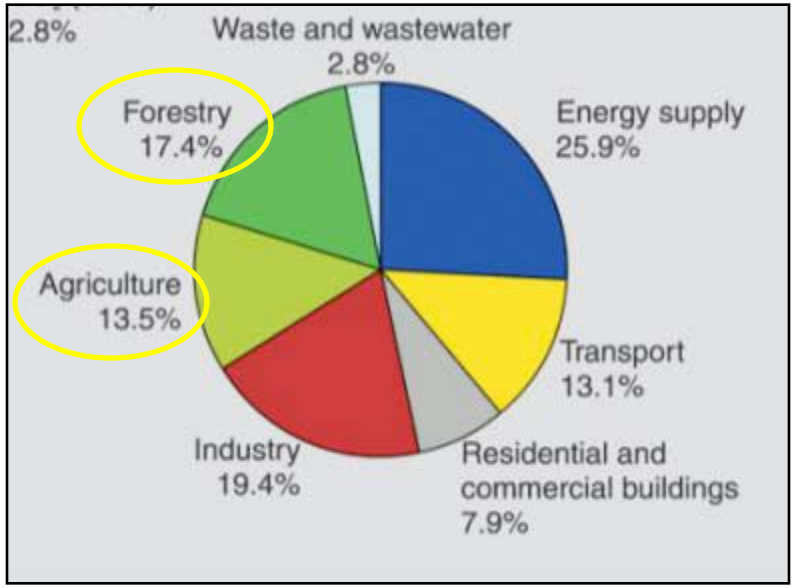
3) Many studies measure things as "with" vs. "without" some action. The right comparison is "choice 1" vs. "choice 2"

   -For example, does it make sense to say that modern agriculture is responsible for 15% of greenhouse gas emissions?

It is true that modern practices involve emissions

Also true that the sum total of these are ~15% of total greenhouse gas emissions





IPCC, AR4 -- Synthesis Report (2007).

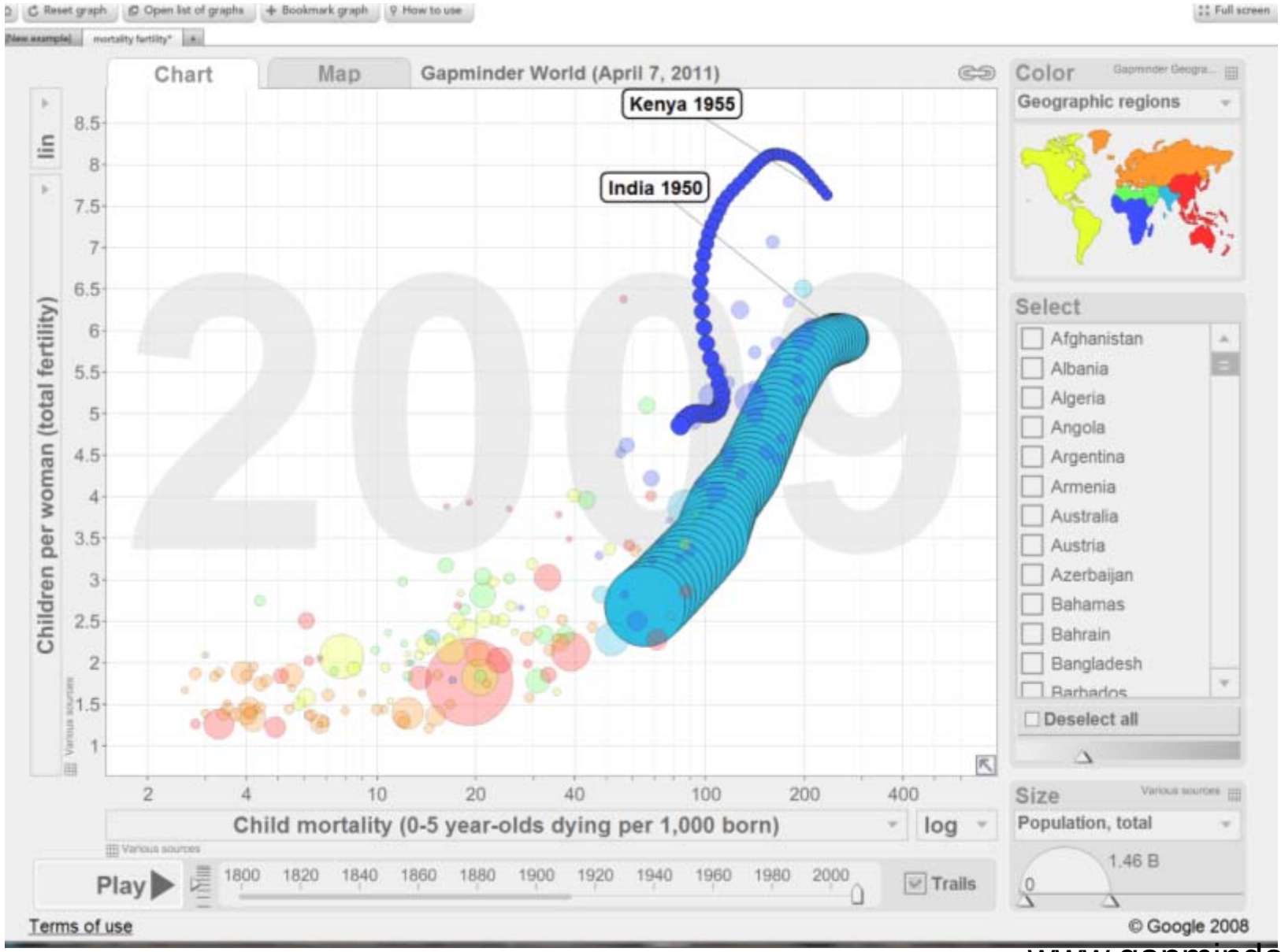
How much does modern agriculture contribute to greenhouse gas emissions?

To answer this, have to propose an alternative for comparison, such as:

A) All Organic
B) All Local
C) Use "traditional" technologies

Let's consider for now what would have happened if we stopped intensifying in 1960

With less food, wouldn't population slow?

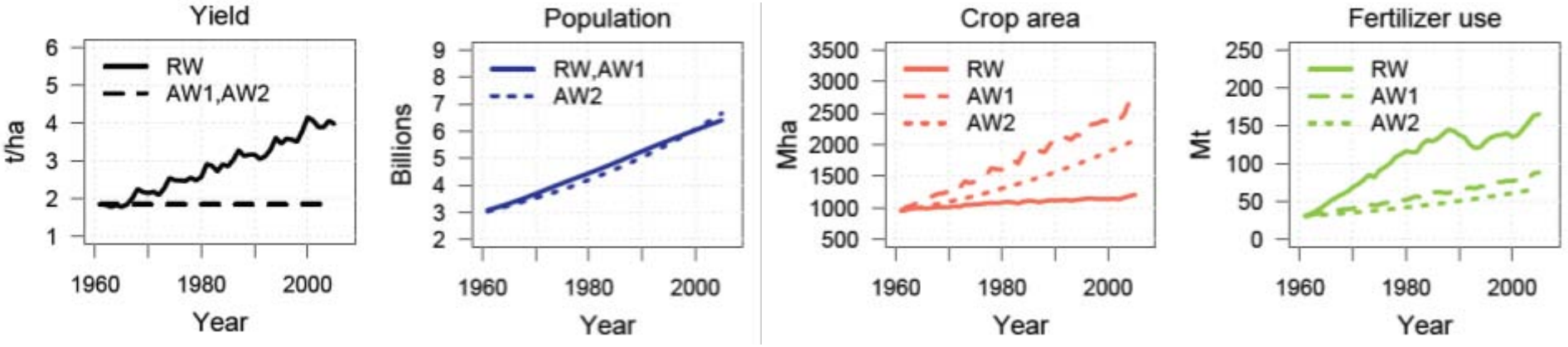


www.gapminder.org

With less food, wouldn't population slow?

www.gapminder.org

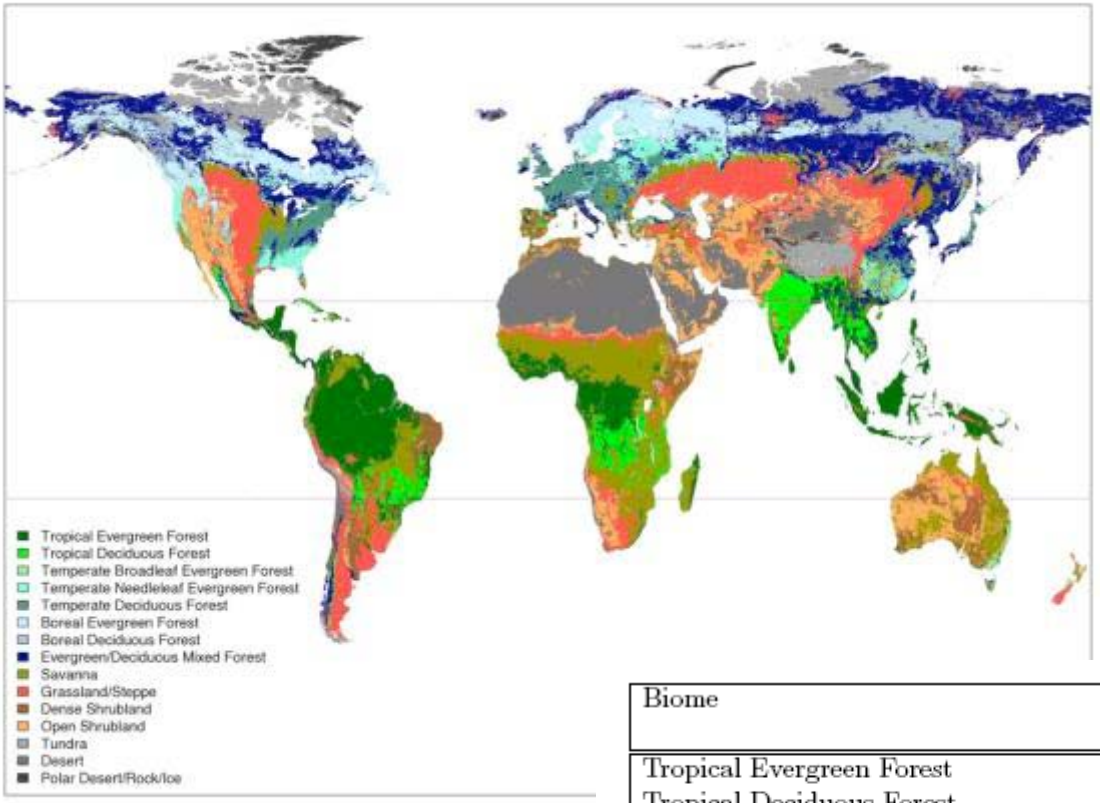
If we stopped intensifying in 1960, additional demand would be met by more expansion



RW = real world
AW1 = no yield gain, but historical trends in population and living standards
AW2 = no yield gain, constant fertility rates and living standard since 1961

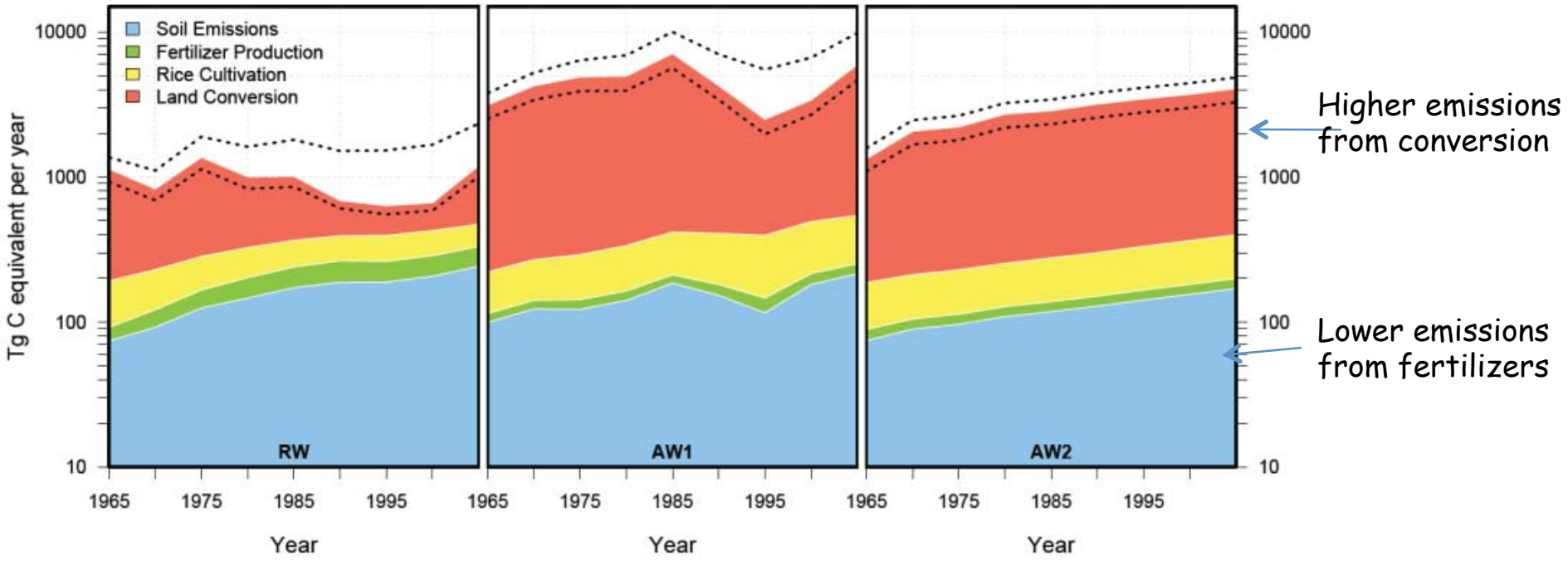
Burney et al. PNAS 2010

Cropland Expansion Causes GHG Emission



Biome	Biomass Carbon [t/ha]	Soil Organic Carbon [t/ha]	Source
Tropical Evergreen Forest	210	72	Gibbs
Tropical Deciduous Forest	132	72	Gibbs
Temperate Broadleaf Evergreen Forest	100	101	Houghton
Temperate Needleleaf Evergreen Forest	160	101	Houghton
Temperate Deciduous Forest	135	101	Houghton
Boreal Evergreen Forest	90	155	Houghton
Boreal Deciduous Forest	90	155	Houghton
Evergreen/Deciduous Mixed Forest	145	101	Houghton (Est.)
Savanna	43	55	Gibbs
Grassland/Steppe	8	59	Gibbs
Dense Shrubland	69	59	Gibbs
Open Shrubland	31	59	Gibbs
Tundra	1	1	Est.
Desert	1	1	Est.
Polar Desert/Rock/Ice	1	1	Est.

Total GHG Emission from real and alternate worlds



RW = real world
AW1 = no yield gain, but historical trends in population and living standards
AW2 = no yield gain, constant fertility rates and living standard since 1961

Burney et al. PNAS 2010

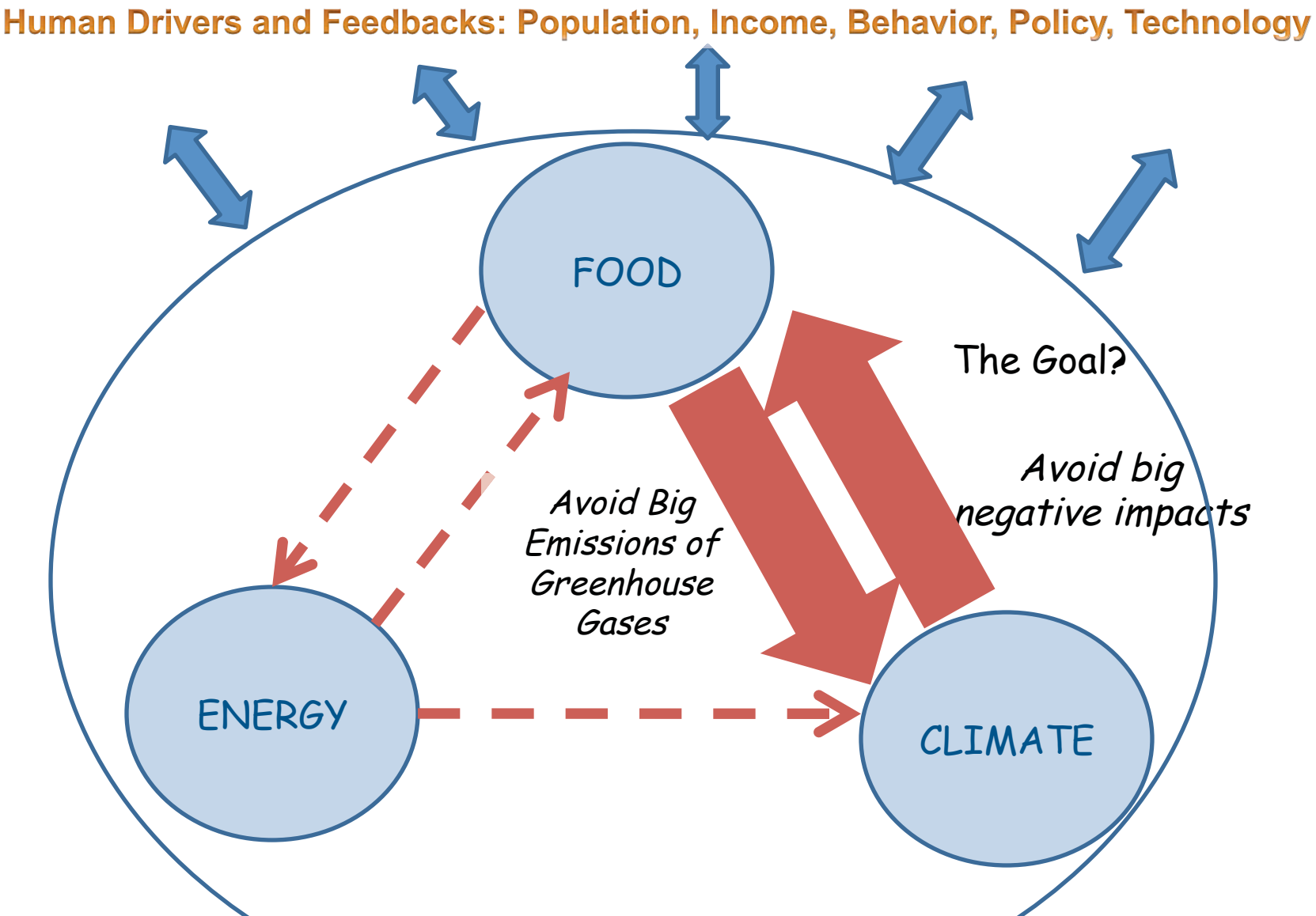
How much does modern agriculture contribute to greenhouse gas emissions?

- So intensification has actually resulted in a net decrease in emissions compared to a low intensity alternative

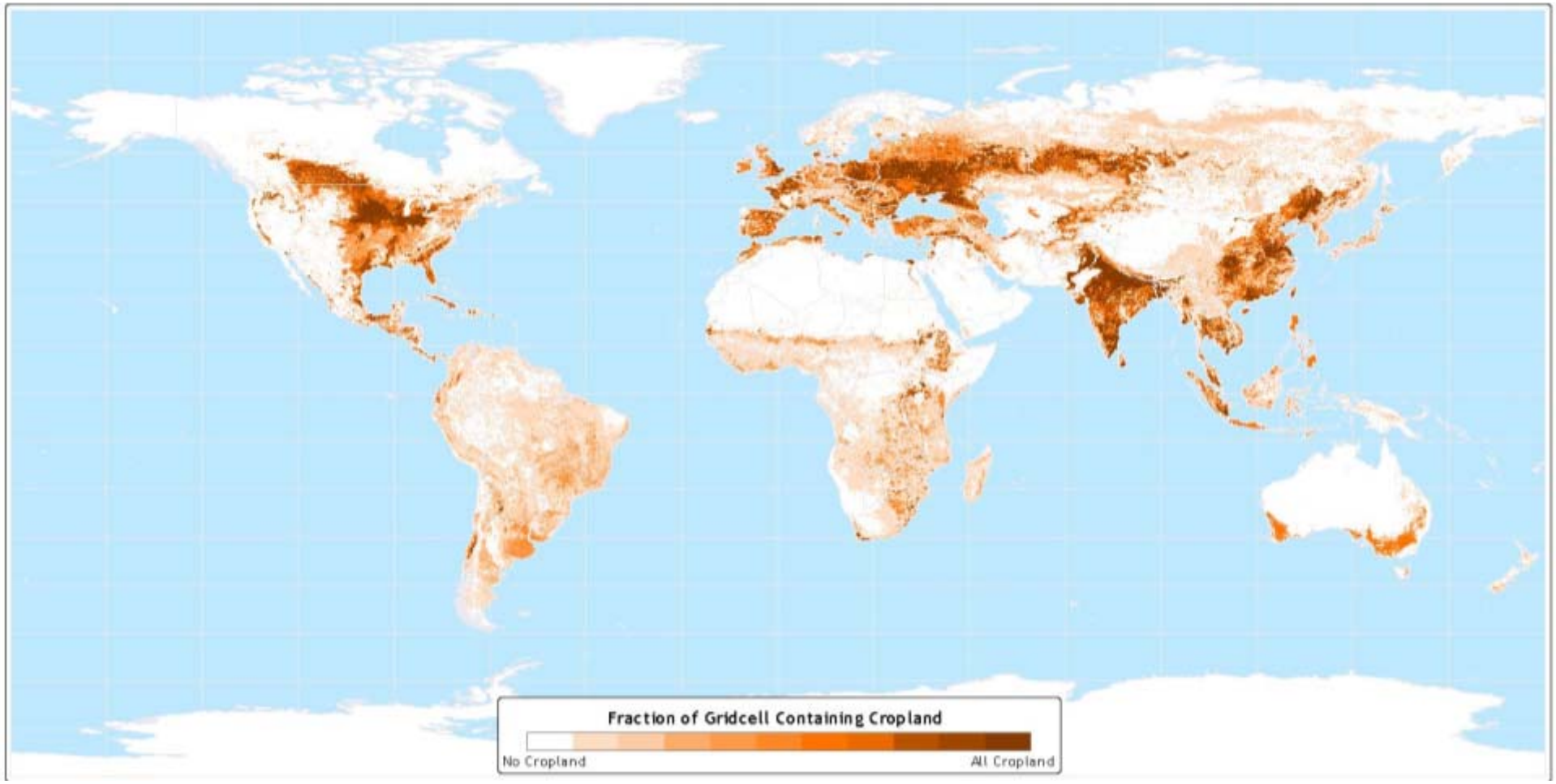
- This is mainly because
  (1) people need to eat
  (2) poorer populations grow faster, even with higher death rates
  (3) clearing of land has a large climate effect

- The carbon savings were actually a bargain (about \$10/ton CO_2)

What do we know about climate → food?



We know that climate is one of several factors that determine where we grow food

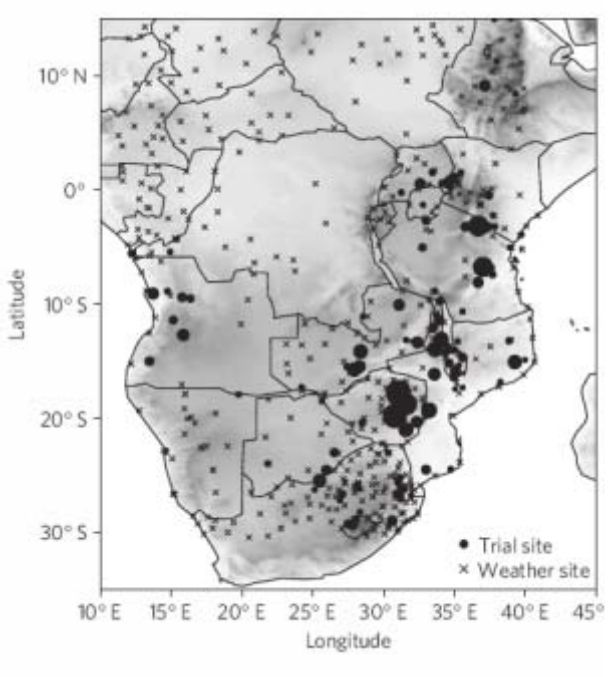


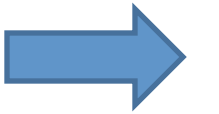
Map from http://www.sage.wisc.edu/atlas/

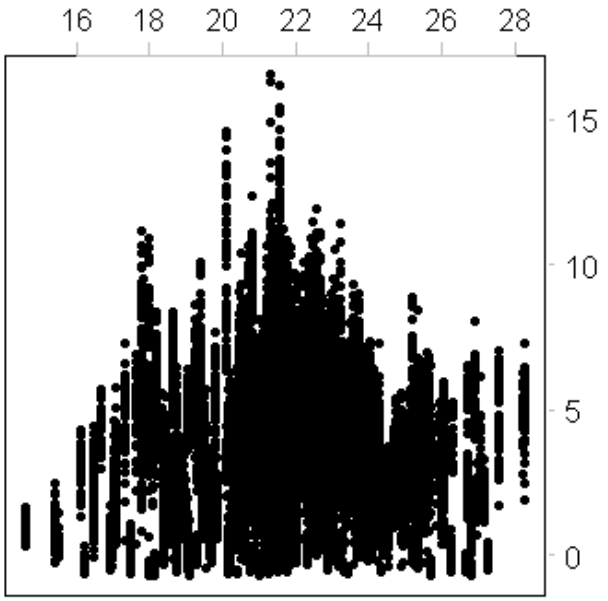
But the key question is *how much* does it matter if climate changes (is it a 1% or 20% problem)

By looking at how well crops do in different places or years, we can measure how important climate is:

Field trials

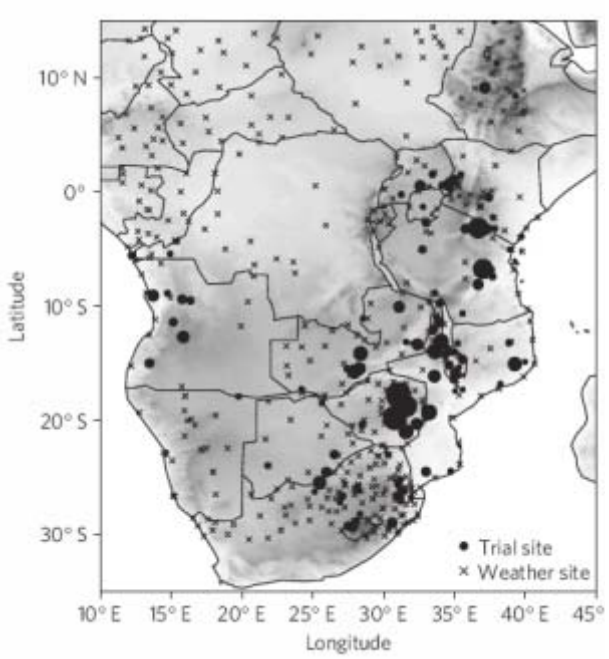




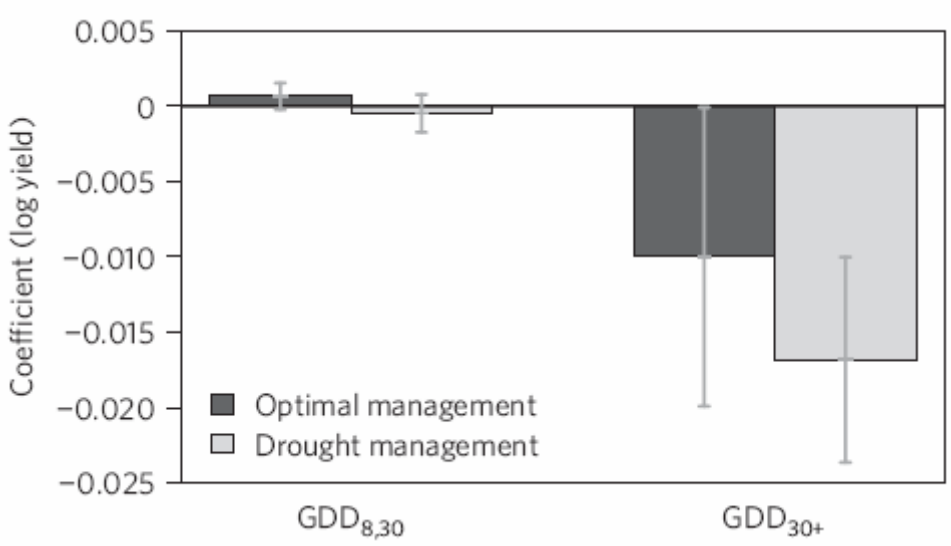


Overall, temperatures are surprisingly important for crop yields

Field trials

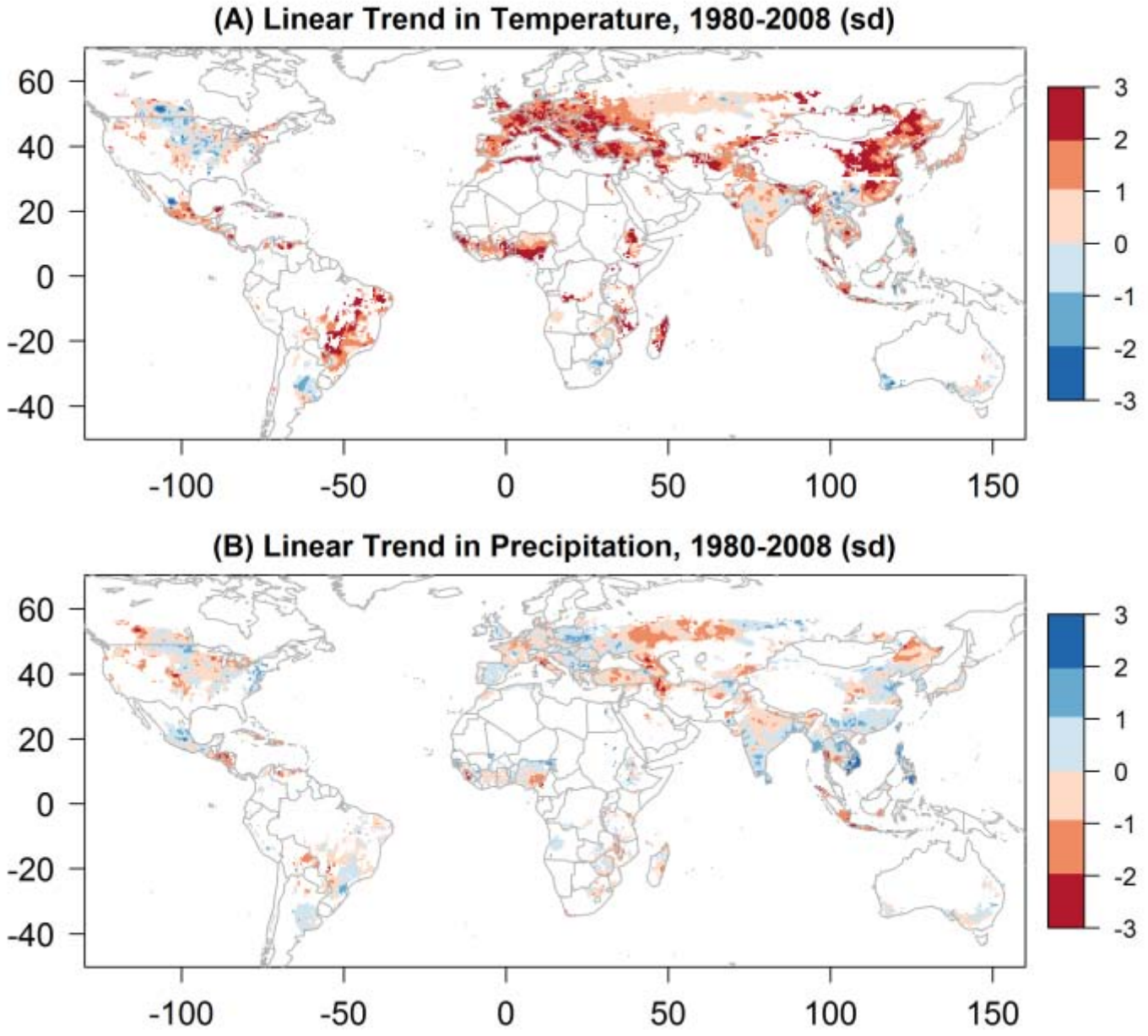


- Rapid yield loss for T>30°C (~1%/day)
- Strong dependence on moisture



Lobell et al. Nature Climate Change, 2011

We already see lots of changes occurring, and impacts ~$50B/yr



Lobell et al. 2011

A big remaining question is how people adapt