Will we be forced to a bread and water diet by climate change?

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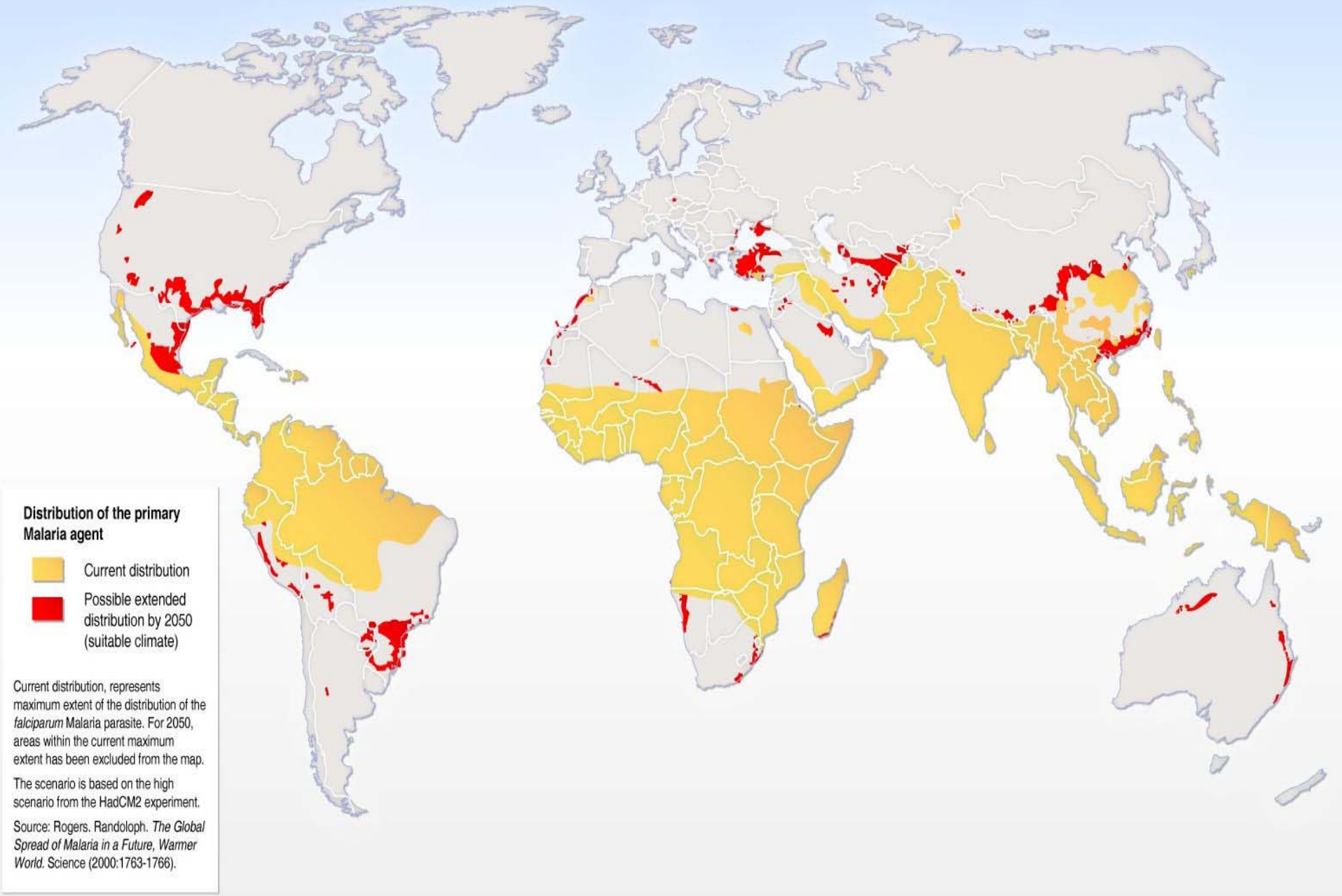
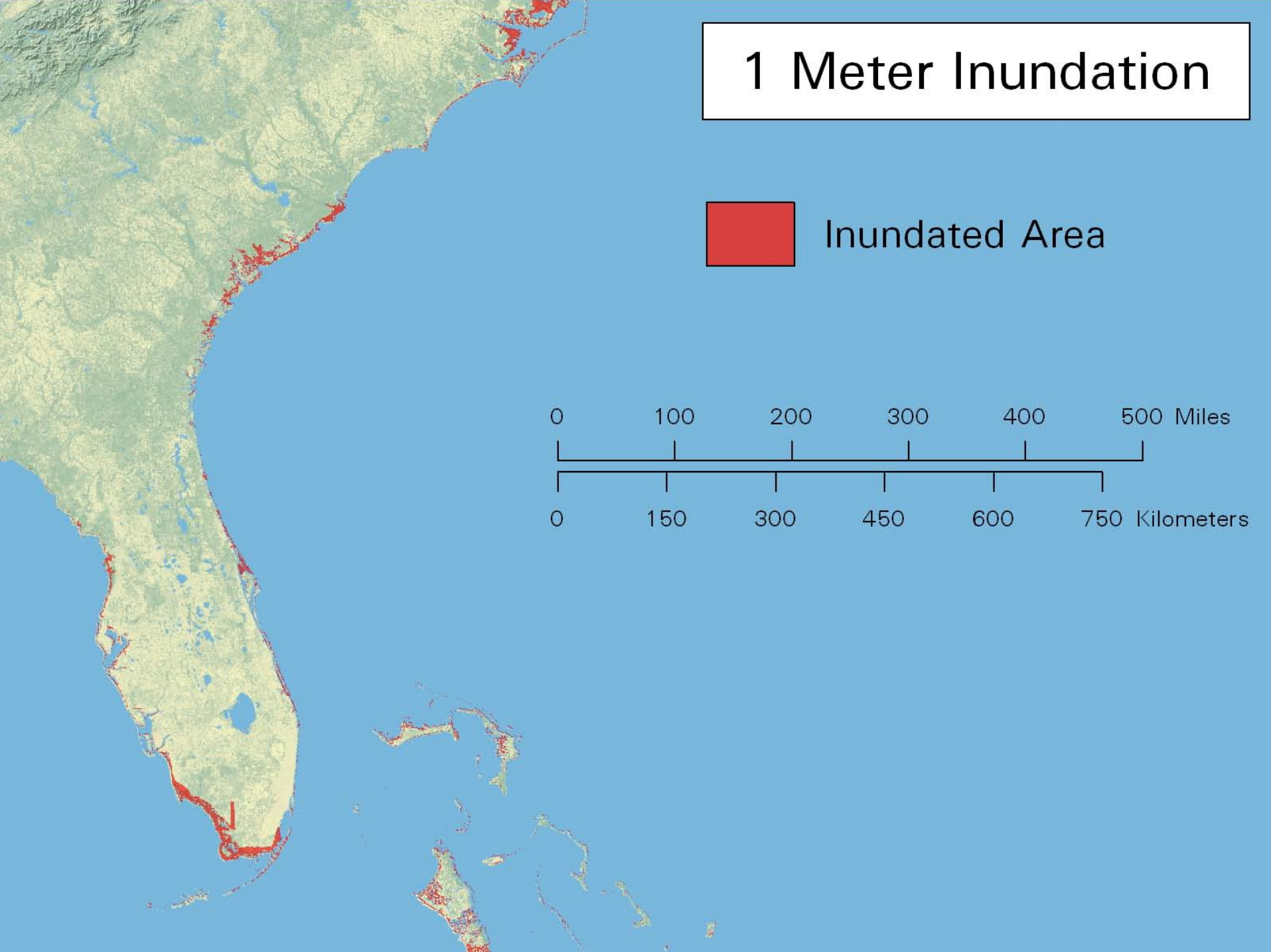
Climate Change and Malaria




1 Meter Inundation
Inundated Area
0 100 200 300 400 500 Miles
0 150 300 450 600 750 Kilometers

Food and Water

World food production has kept pace with demand

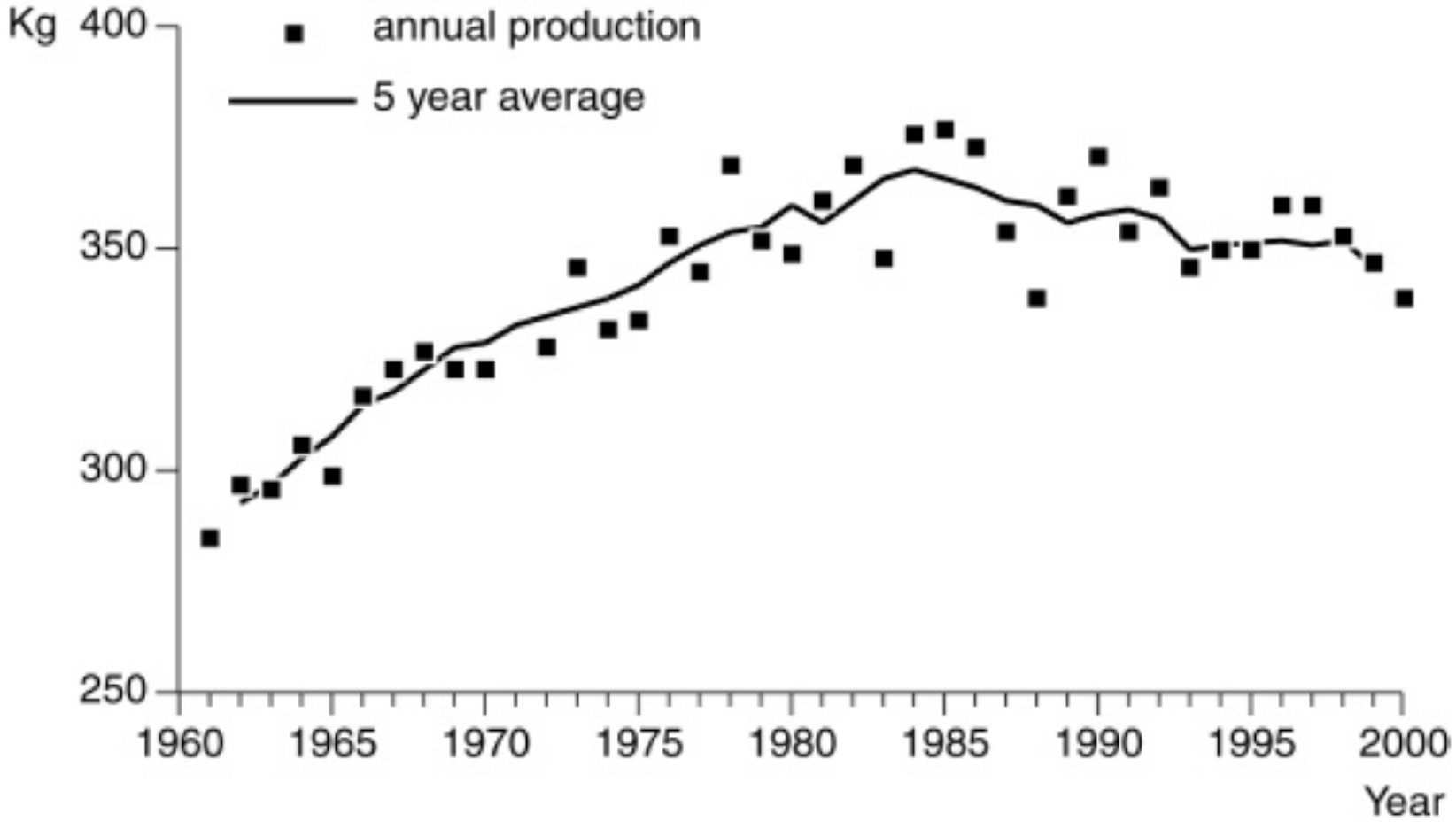
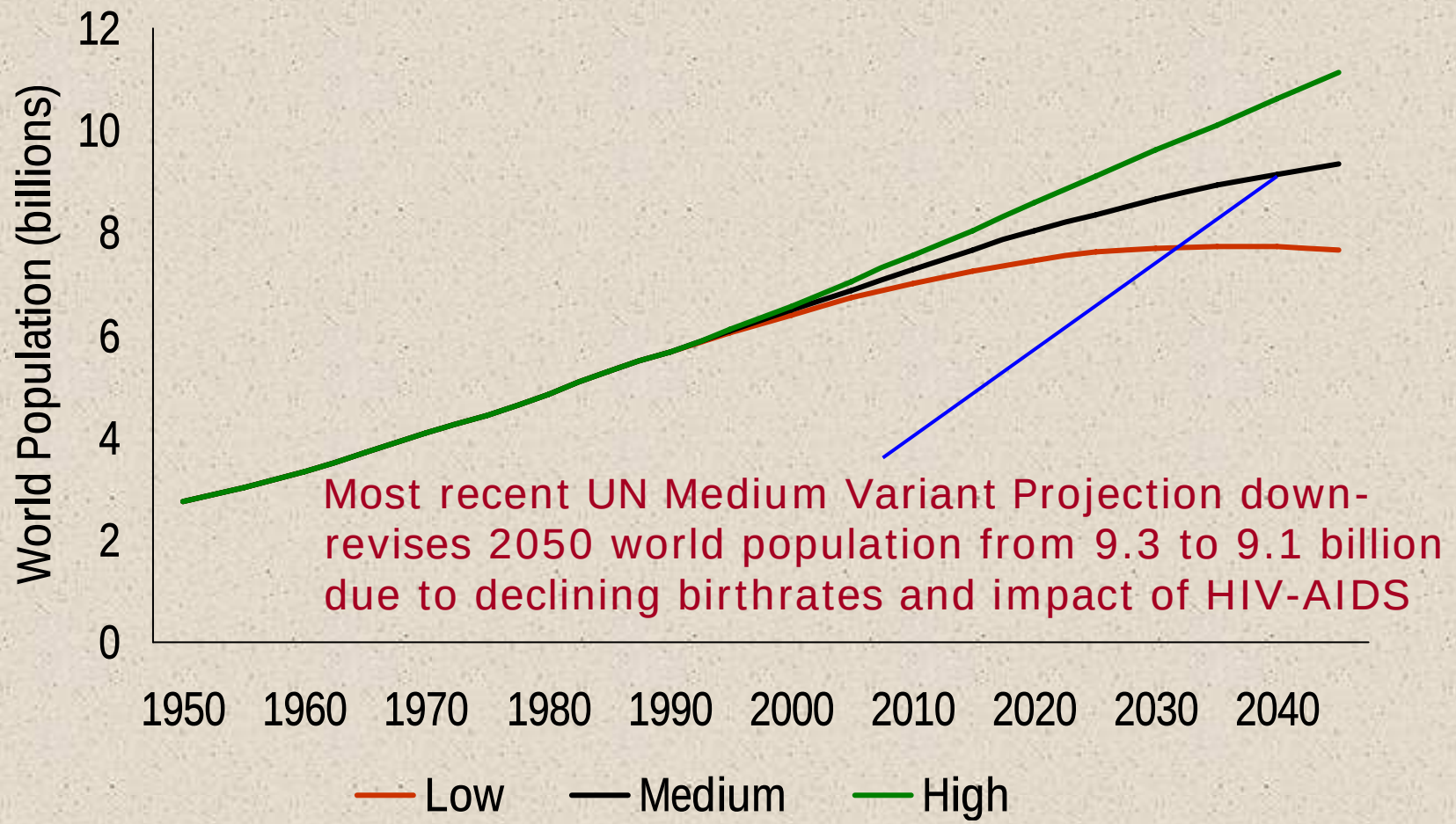


FIGURE 1. World per capita cereal production, 1961–2000

FAO

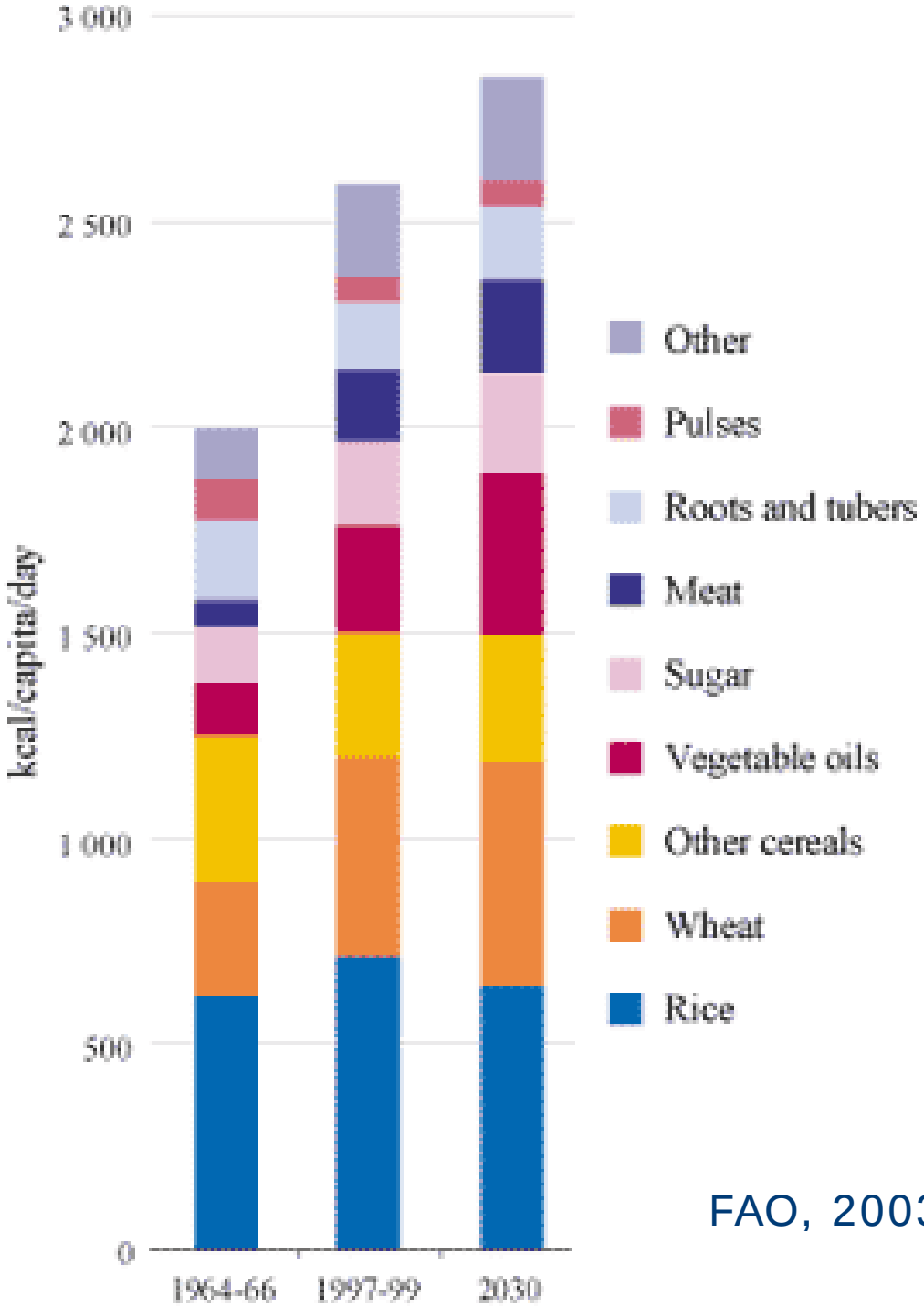
Some future challenges.....

High, Medium, and Low Variant UN Population Projections



Changing Diets

- More meat, sugar, oils, wheat
- Less rice, coarse grains, roots and tubers



FAO, 2003

Why Adaptation is Crucial

Table SPM.3. *Projected global average surface warming and sea level rise at the end of the 21st century. {10.5, 10.6, Table 10.7}*

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a]		Sea Level Rise (m at 2090-2099 relative to 1980-1999)
	Best estimate	*Likely* range	Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:

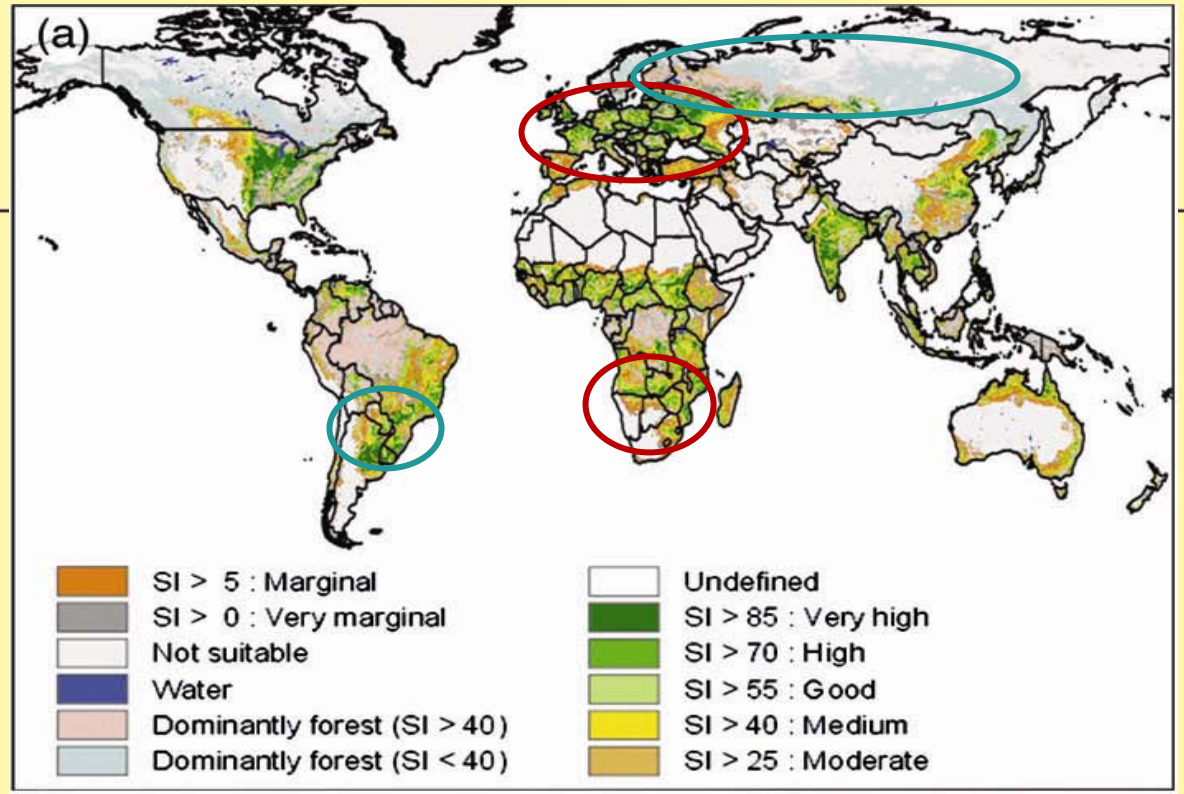
[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).

[b] Year 2000 constant composition is derived from AOGCMs only.

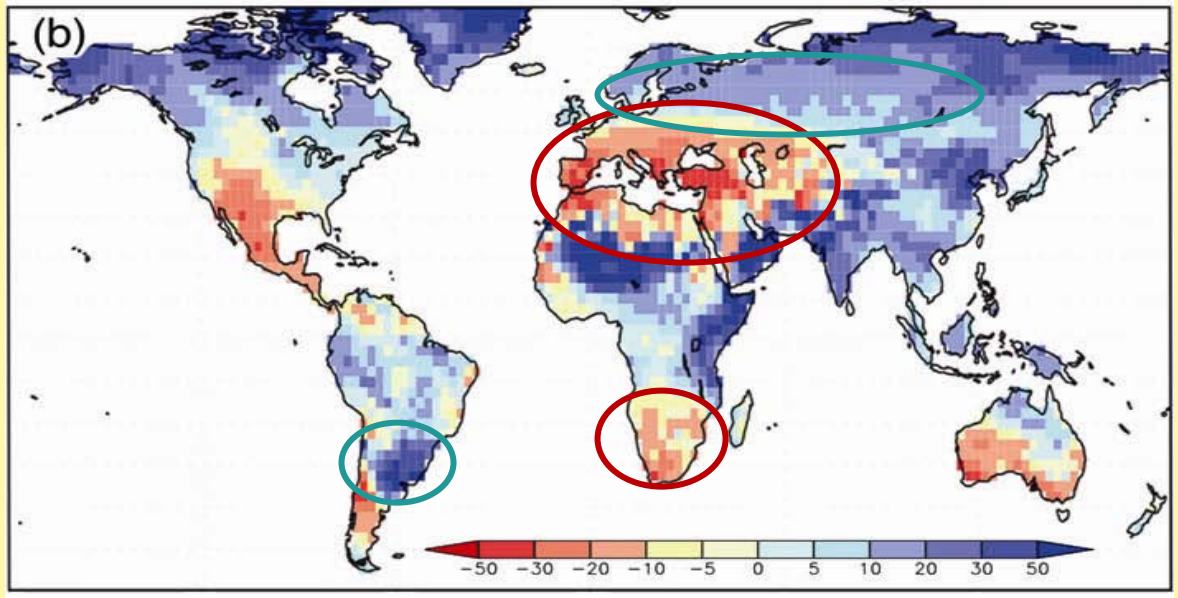
IPCC, 2007

Not only will it get warmer but runoff—a useful marker of water availability to crops—will change

Current Rain-fed Crop Production Potential of the Earth



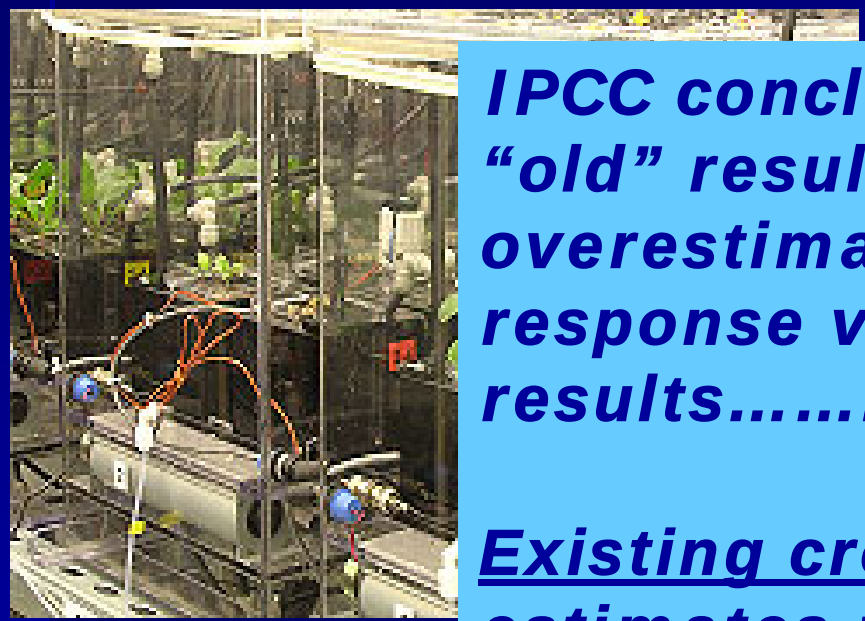
Ensemble mean percentage change of annual runoff between present and 2100



IPCC, 2007

The role of CO_2 "fertilisation" effects—is it overestimated?

CO_2 fertilization: chambers versus Free Air Carbon Enrichment (FACE) rings



IPCC concludes that "old" results do NOT overestimate CO_2 response viz "new" results……..

<u>Existing crop model estimates remain valid!</u>

"Old" Chamber

E Experiments

What do physiologically-based crop simulation models say about the combined effects of CO_2 and climate change on yields globally?

Cereal Yield Response to Warming—Temperate vs. Tropical Regions

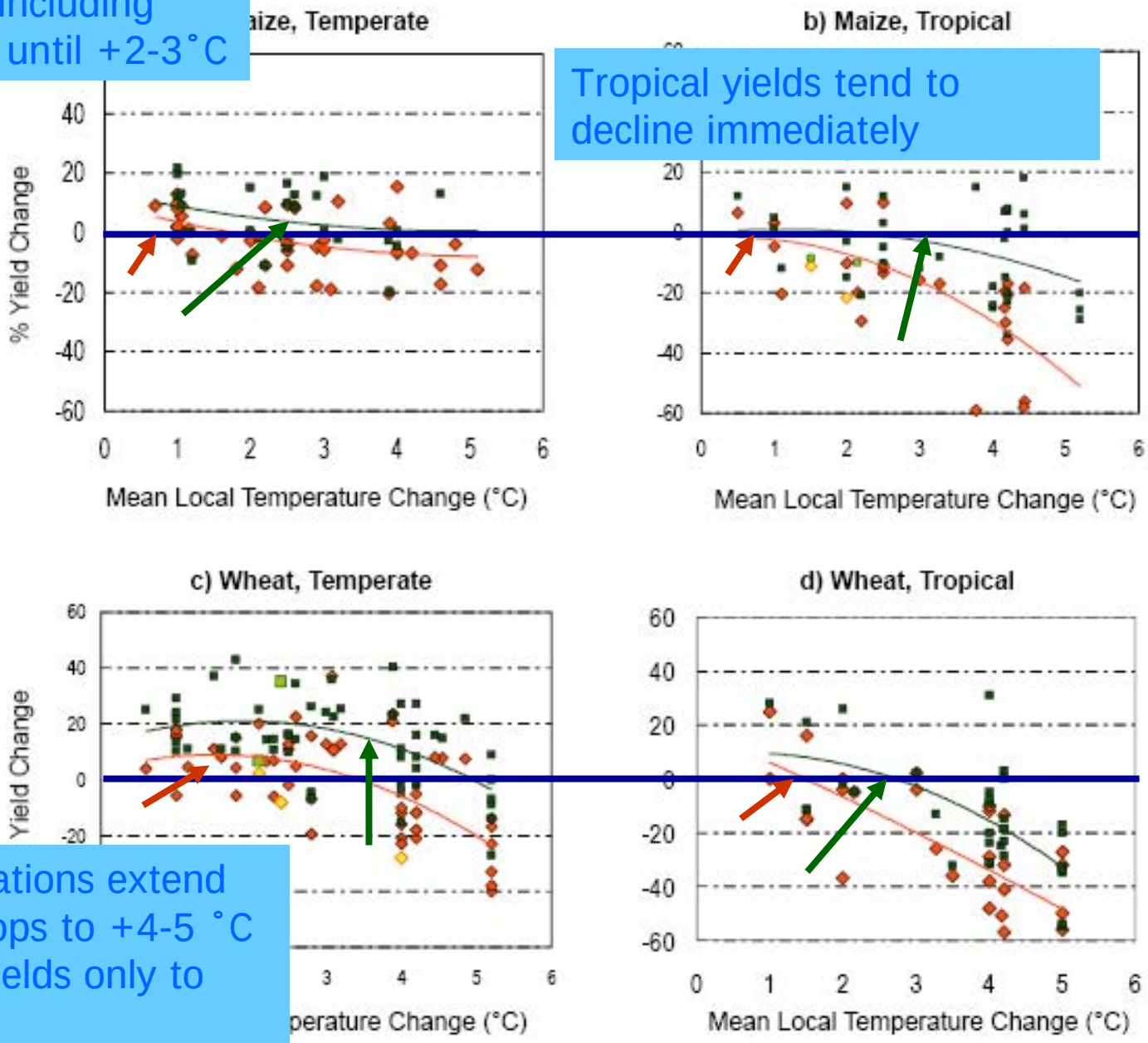
Temperate yields (including U.S) tend to thrive until +2-3˚C

Red = without adaptation

Green = with adaptation

___= reference line for current yields

Simple adaptations extend temperate crops to +4-5 ˚C but tropical yields only to +2-3˚C



Much of the literature would have you think that adaptation to climate will be a radical change from the status quo!

To some extent, adaptation is the status quo!--we have always been adapting to environmental challenges....

Adaptation is fundamental to humanity

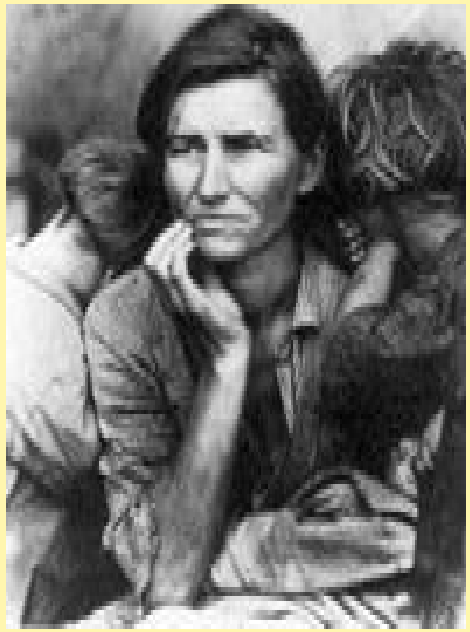
- Pliocene drying in continental interior Africa and expansion of grasslands encourages hominin evolution to upright, two-legged posture, which is more versatile stance than quadra-pedalism

  - Next came larger brain sizes that substituted behavioral adaptation for evolutionary adaptation

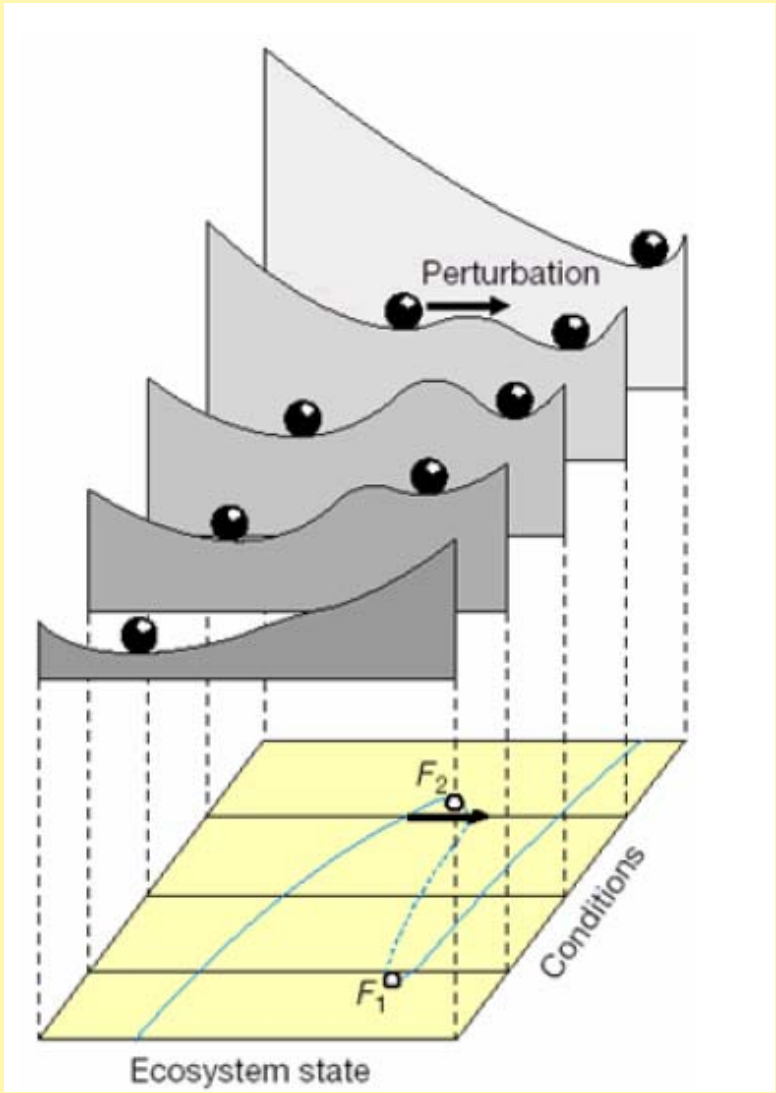
  - But, interestingly, recent thinking of anthropologists is that periods of high climate variability likely correlated with advent of some of the great human adaptive achievements:

    1. Stone tools and control of fire
    2. Migration out of Africa

Dust Bowl Okies—Migration as Adaptation



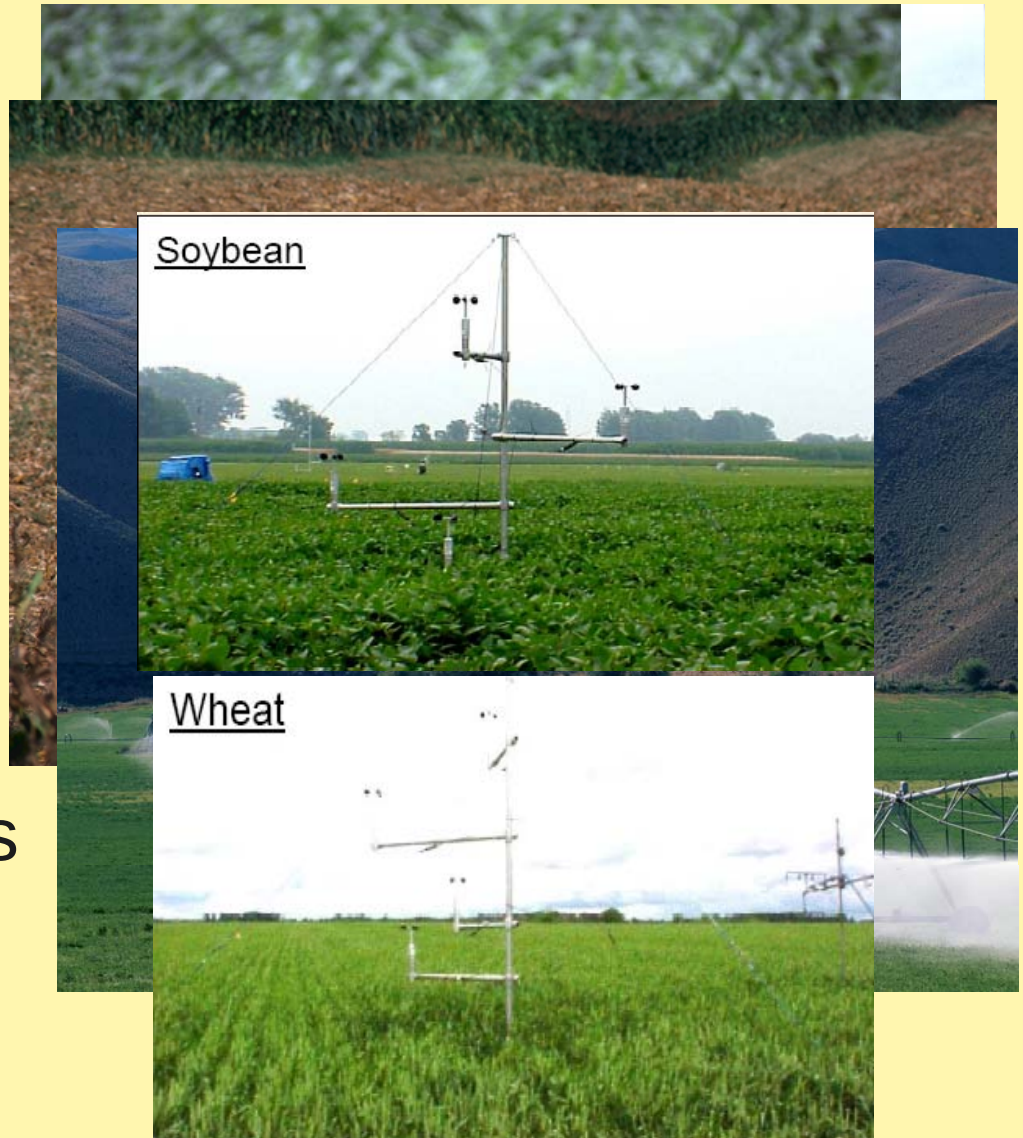
System resiliency vs. system adaptation



Holling, 1994

Autonomous response options to increase resiliency

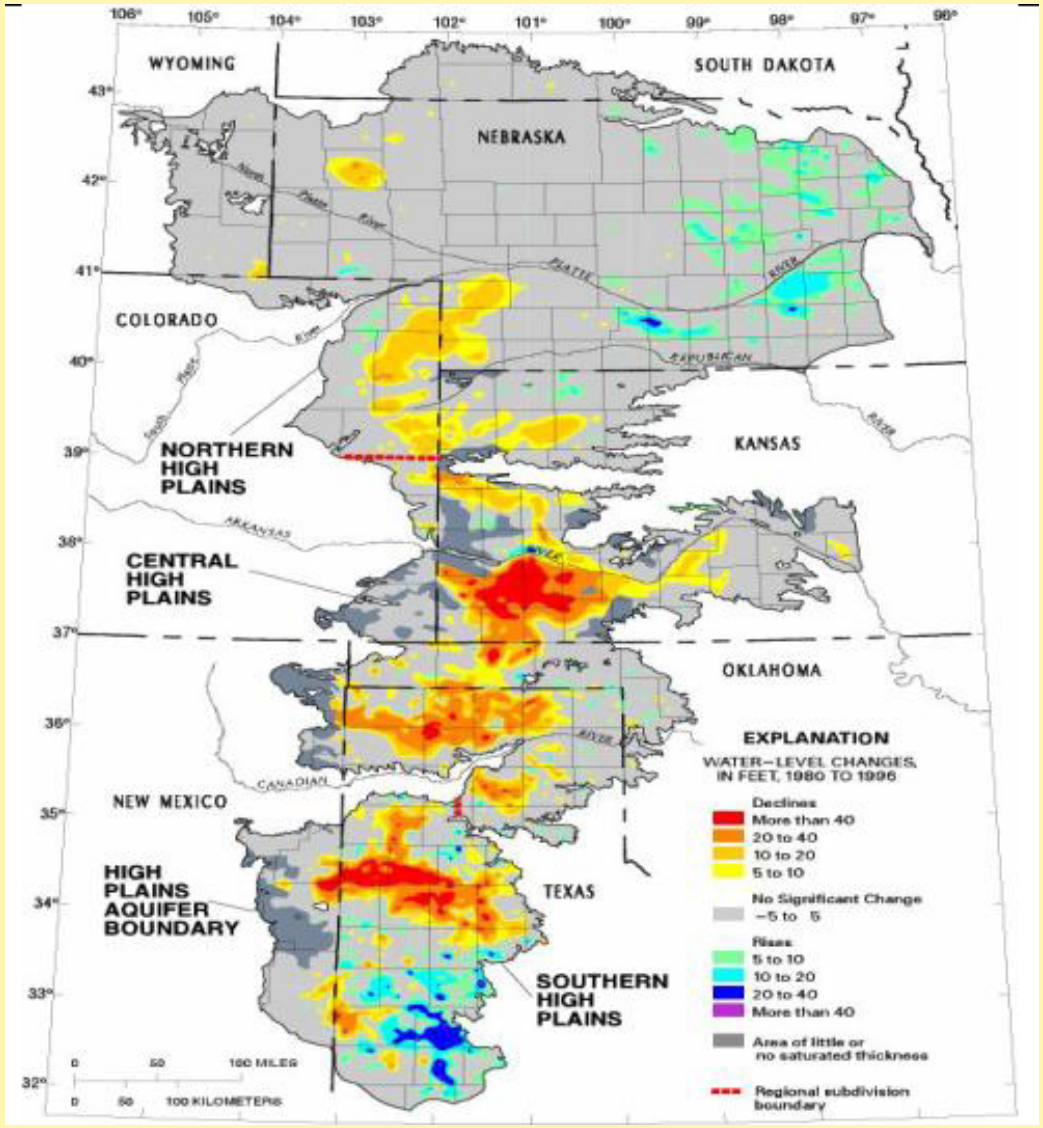
- Planting dates
- Changes in cultivar maturity classes
- Moisture and soil conserving tillage
- Deploying irrigation where economical
- Switching crops and/or crop rotations



What happens when resiliency is exceeded?

Adaptation to Declining Groundwater levels in the High Plains

- Ogallala is fossil water
- Massive conversion to center pivot irrigation after WW II
- Declining saturated thickness forces return to dryland practices



Water will be the linchpin of adaptation to climate change

- **1/6 of humanity has little or no access to clean freshwater**
- **By 2025, that number will rise to 1/3**
- **IPCC says by 2050, annual average river runoff and water availability are projected to increase because of climate change at high latitudes and in some wet tropical areas, and decrease over some dry regions at mid-latitudes and in the dry tropics**
- **Human communities dependent on snow and glacial melt for water are already feeling the effects of warming.**
- **IPCC says, globally, the negative impacts of future climate change on freshwater systems are expected to outweigh the benefits**

Impact of climate change on number of people (millions) living in water-stressed river basins

	Estimated millions of people	
	From Arnell, 2004b	From Alcamo et al., 2007
Baseline (1995)	1,368	1,601
2050: A2 emissions scenario	4,351 to 5,747	6,432 to 6,920
2050: B2 emissions scenario	2,766 to 3,958	4,909 to 5,166

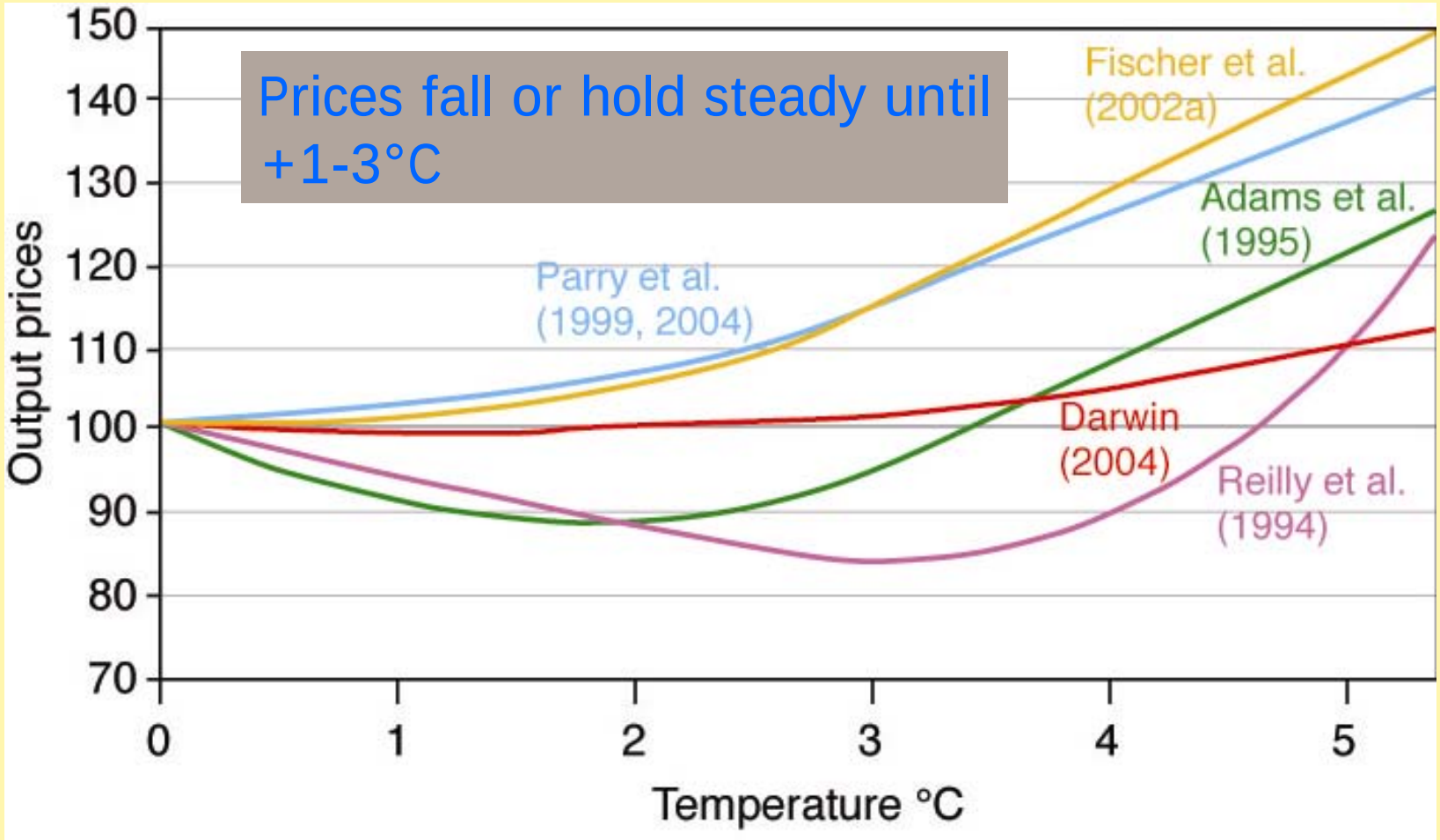
Source: IPCC, 2007

What if adaptation fails?

Real Cereal Prices (% baseline) vs Temperature (interpolated from point estimates for 5 studies)

But remember, incomes are expected to rise across the board!

100 = no change from baseline



Easterling et al. 2007

Millions at risk of hunger 2020-2080—reference case and climate change case (two studies: Tubiello et al—AEZ-BLS; Parry et al DSSAT-BLS)

The climate does not change

The climate changes and CO_2 levels rise

	2020		2050		2080	
	Millions at risk		Millions at risk		Millions at risk	
Reference	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS
A1	663	663	208	208	108	108
A2	782	782	721	721	768	769
B1	749	749	239	240	91	90
B2	630	630	348	348	283	283
CC	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS
A1	666	687	219	210	136	136
A2	777	805	730	722	885	742
B1	739	771	242	242	99	102
B2	640	660	336	358	244	221
CC, no CO_2	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS	AEZ-BLS	DSSAT-BLS
A1	NA	726	NA	308	NA	370
A2	794	845	788	933	950	1320
B1	NA	792	NA	275	NA	125
B2	652	685	356	415	257	384

+26%

Easterling et al, 2007

Summary of where we are:

- CO_2 effects on crops expected to be significant but will not compensate temperature and moisture changes
- Regional imbalances in winners in losers
- Adaptation is not an option
- For most, if not all, of the century, rate of growth in global calories will match rate of growth in food demand, with or without climate change
- Calories will not be evenly distributed regionally, leading to climate-induced increases in people at risk of hunger in Tropics
- Water is critical

So, will we be forced to a bread and water diet?

The bread may be the easy part!

THANK YOU!