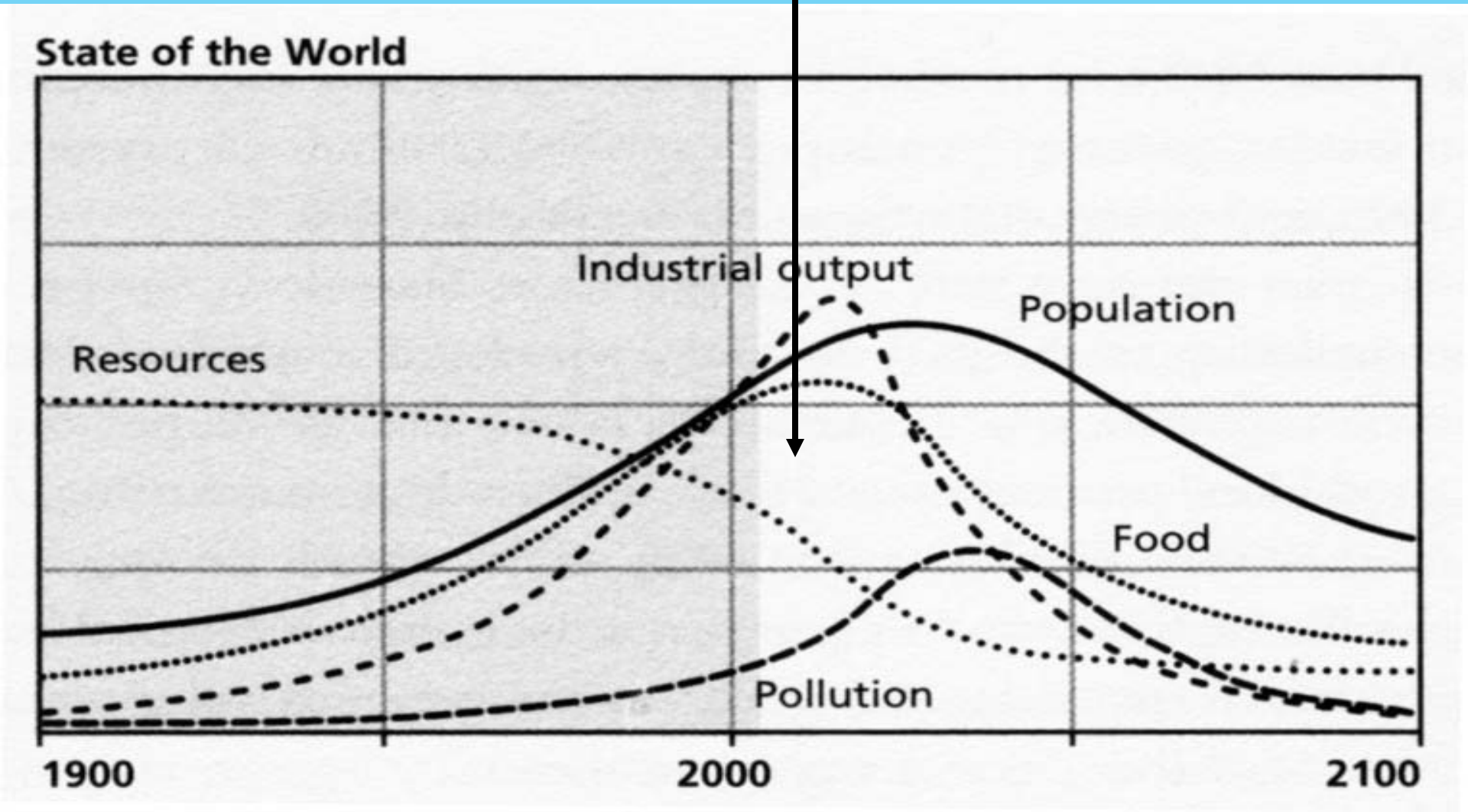
ARE WE REACHING LIMITS TO BIOSPHERIC PRIMARY PRODUCTION?

Prof. Steven Running
University of Montana, USA

IGBP Symposium Planet Under Pressure
Stockholm, Sweden

24 September 2009

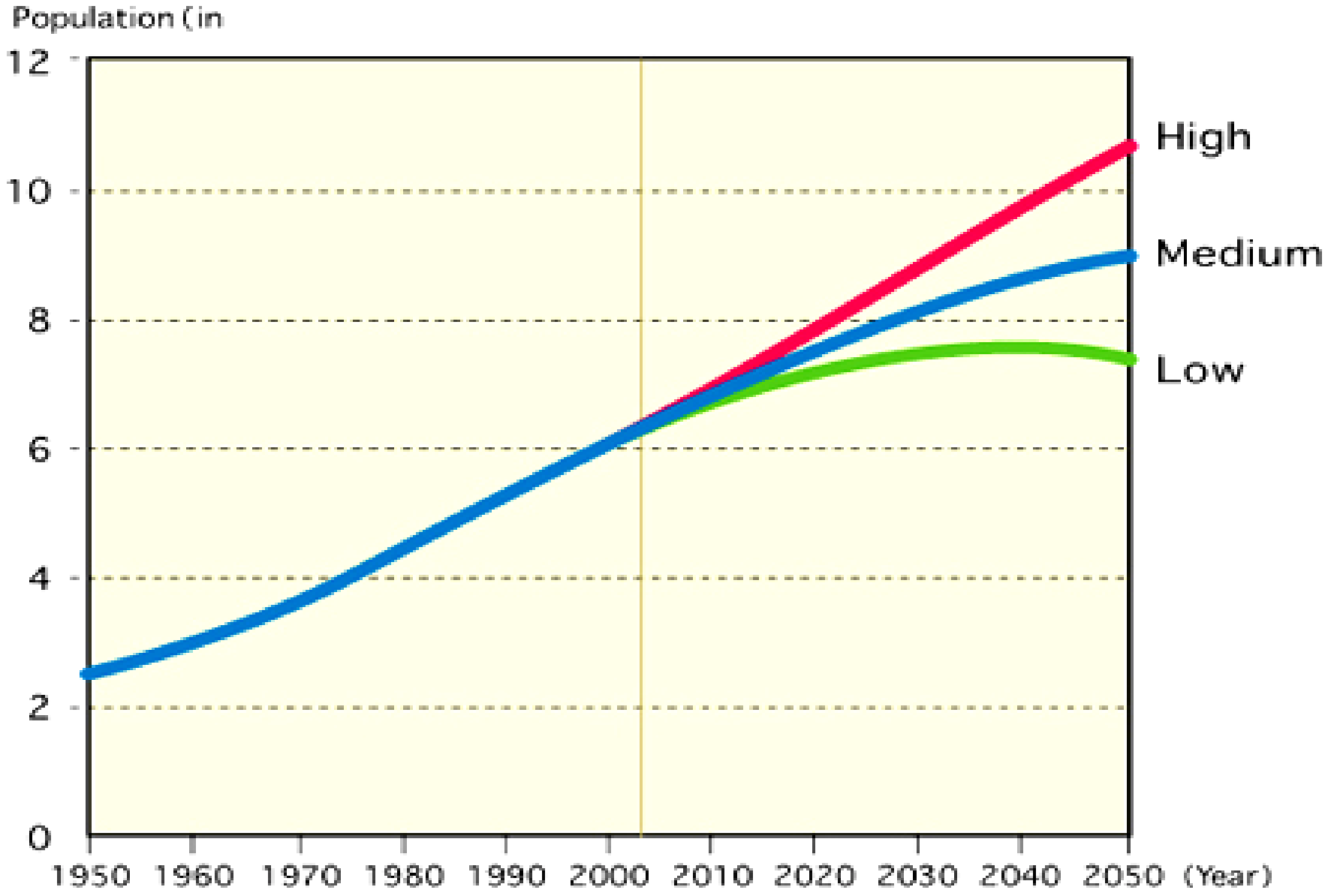
“Limits to Growth” Scenario in 1972 for 2009



From G. Turner, Global Env Change 18:397-411. 2008

Figure 1 United Nations World Population Projections, 1950-2050

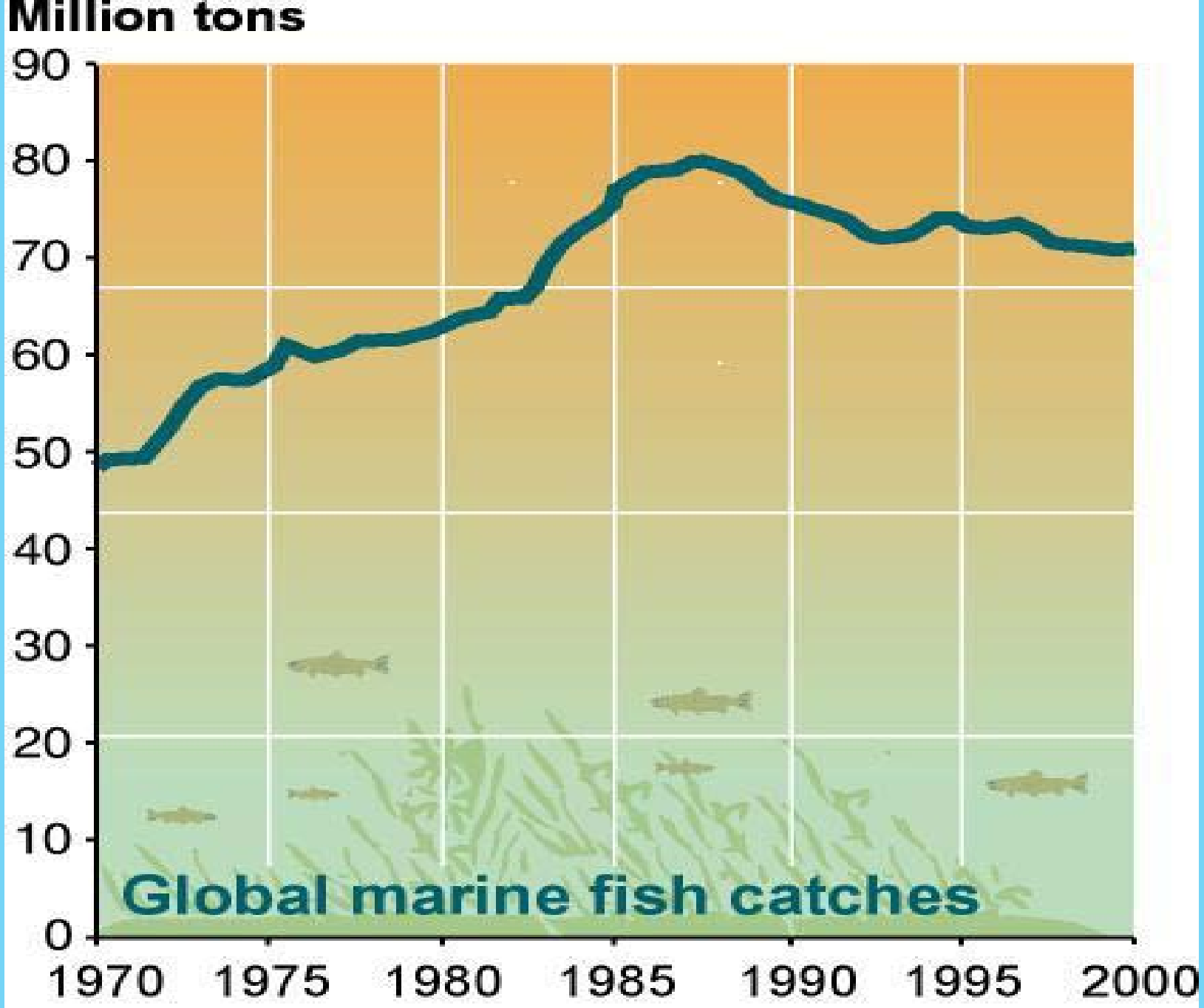
Source: World Population Prospects



How will Biospheric Production meet a population increase of 40% *and* multiple demands from 2009 - 2050?

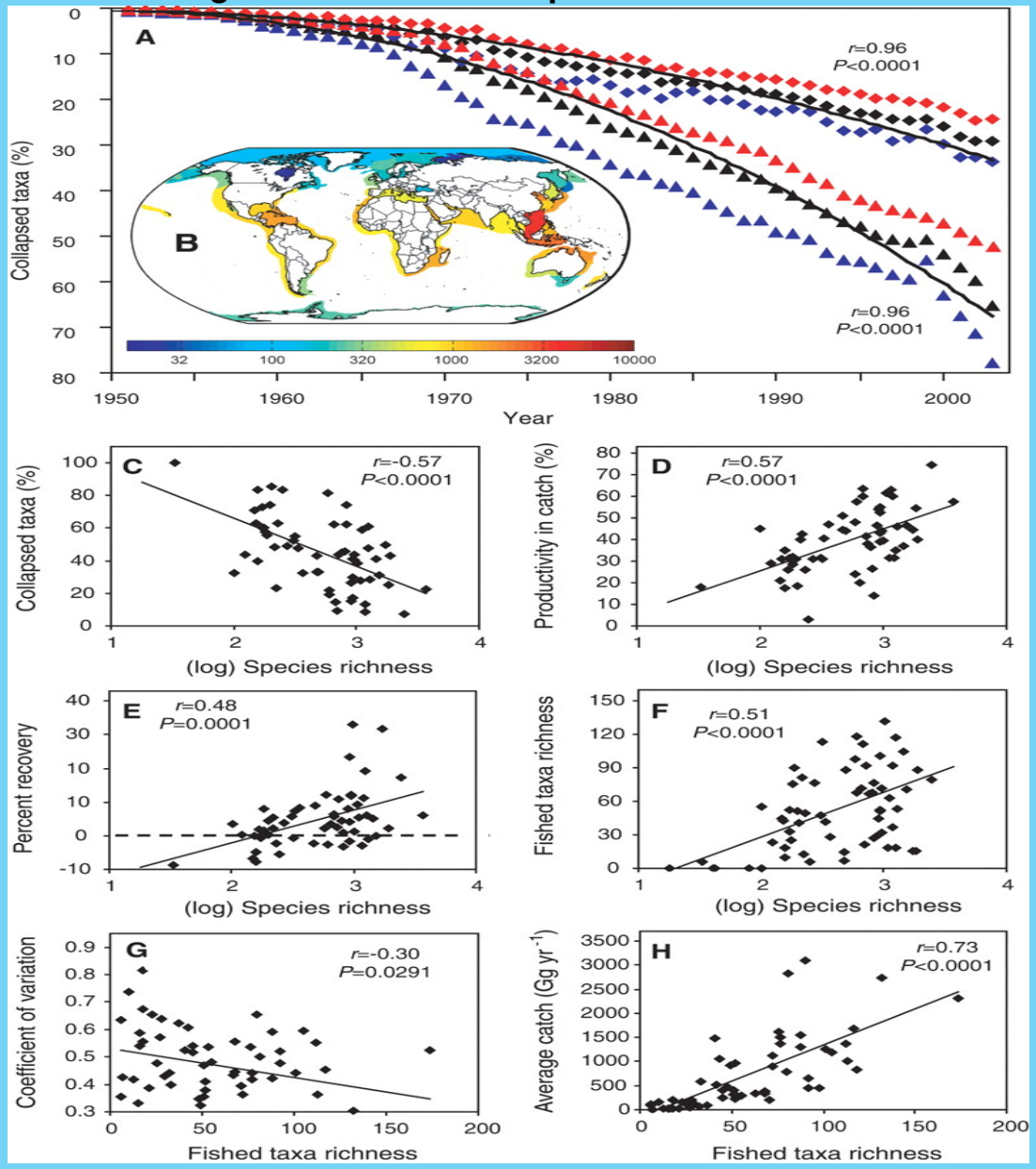
Primary (Vegetation) Production is normally increased by:

- Engaging more land
- Irrigation/fertilization
- Genetic improvements



Source: Millennium Ecosystem Assessment

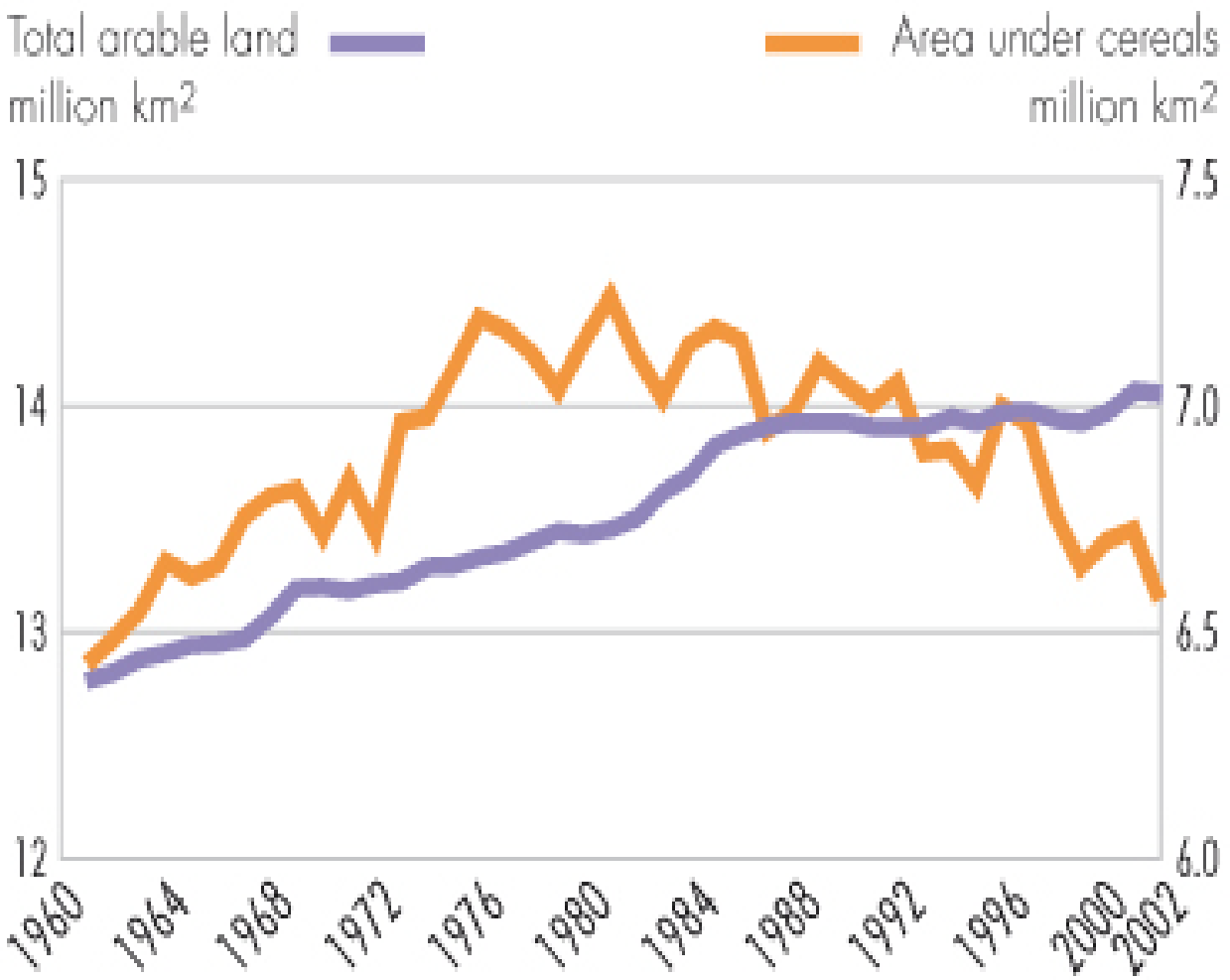
Fig. 3. Global loss of species from LMEs



B. Worm et al., Science 314, 787 -790 (2006)

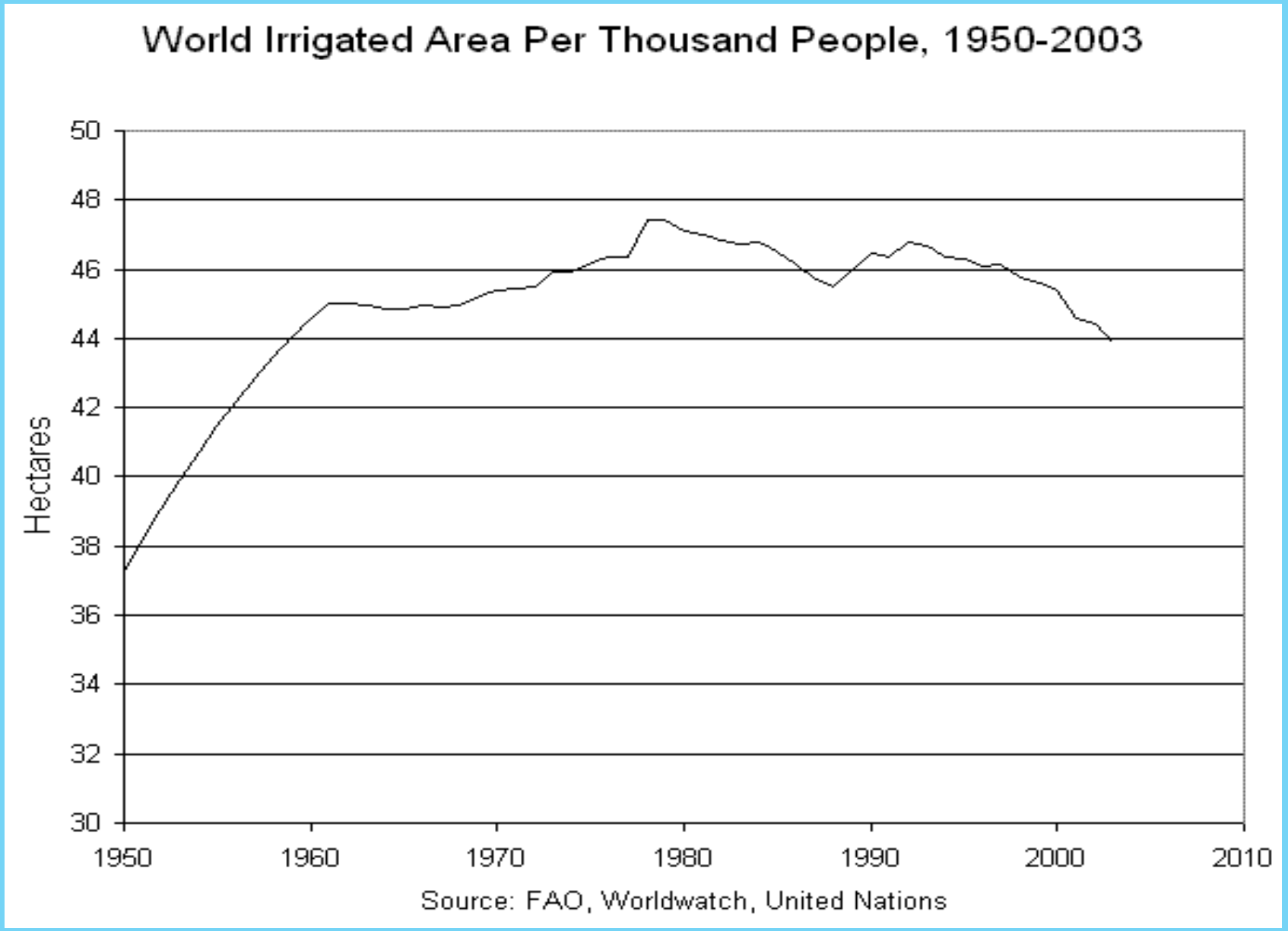
Land area is NOT increasing

Figure 3.11 Arable land and area under cereals



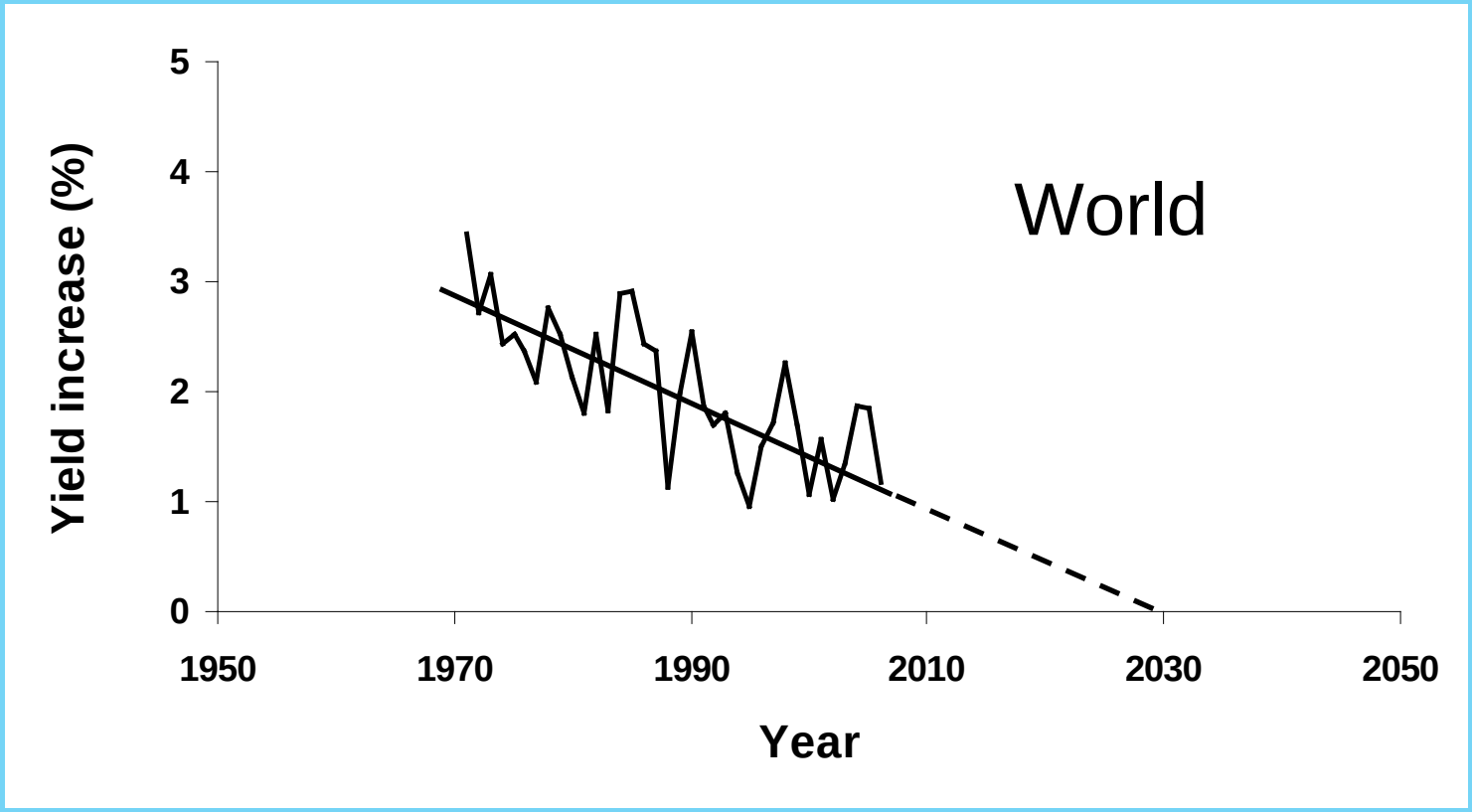
Source: FAOSTAT 2006

Irrigated Land Area is NOT Increasing



Lester Brown Plan 3.0, 2008

Food security: yield growth rate declining

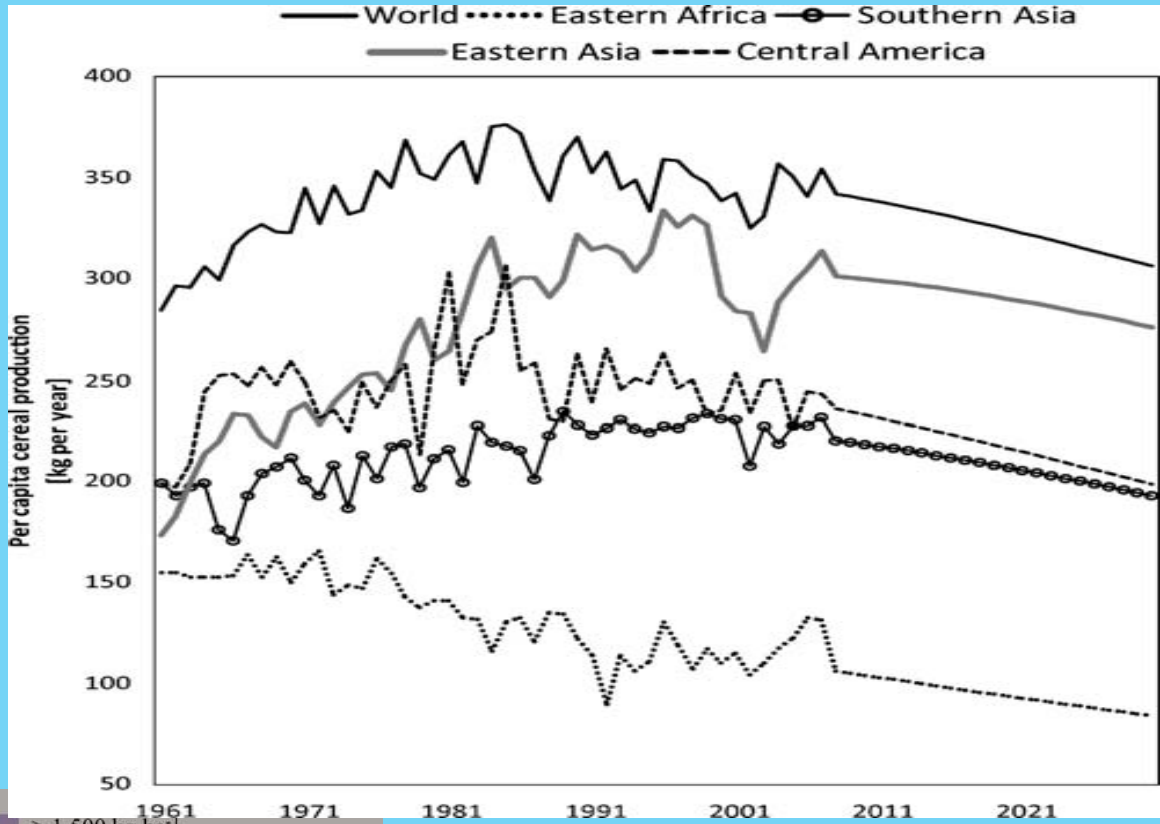


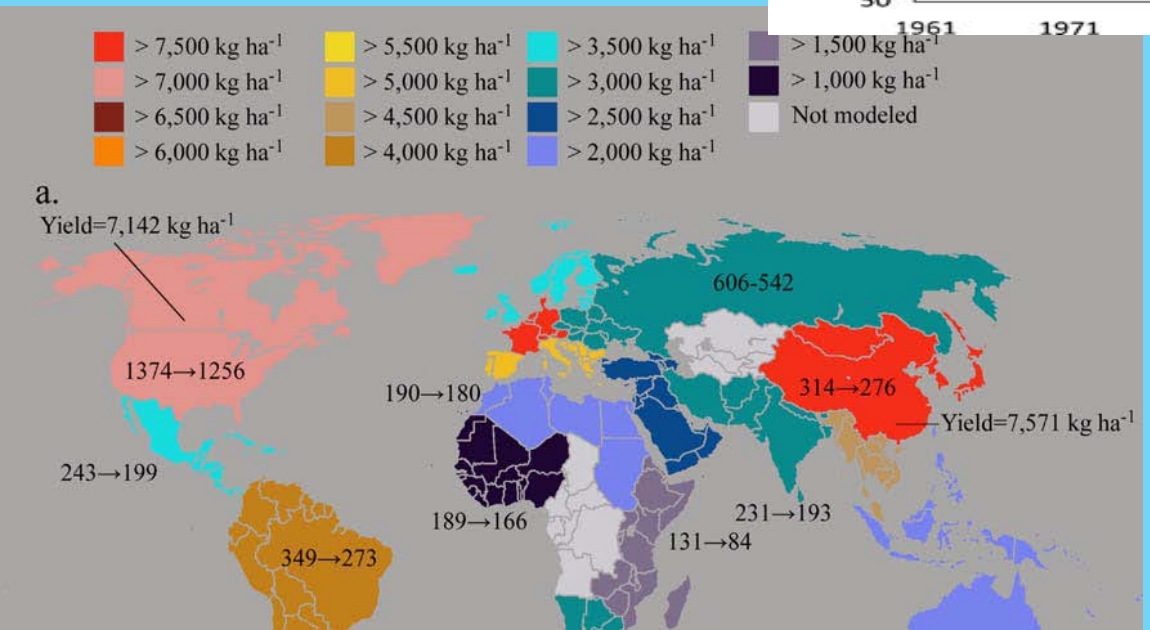
FAO wheat yield data: Analysis

From Mark Howden, CSIRO (2009)

Per Capita Agricultural Production trends.

Global 14% Per capita reduction projected by 2030



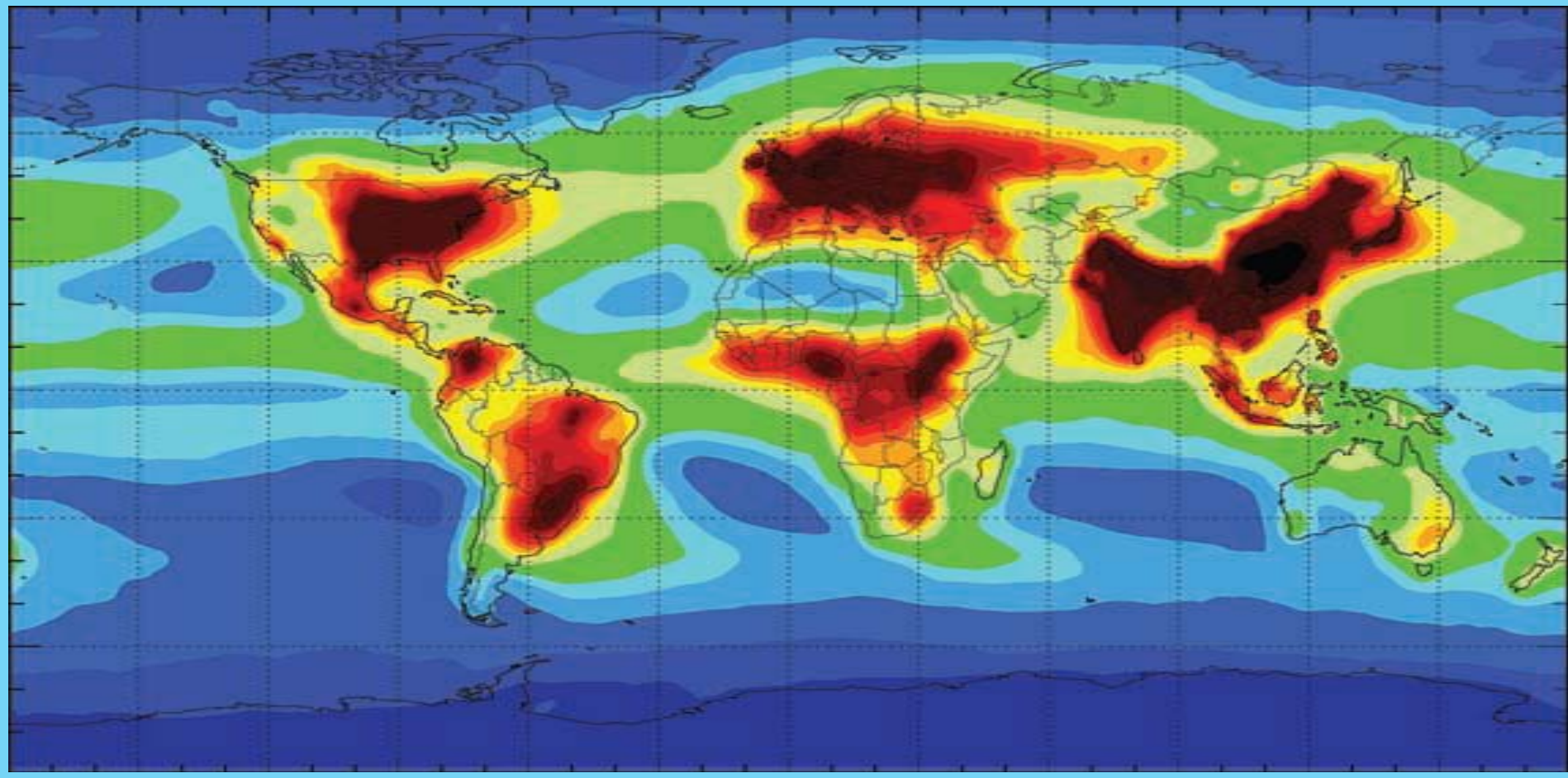


Observed 2007 – Projected 2030

Funk and Brown (2009)

Nitrogen Loading is already damaging the biosphere

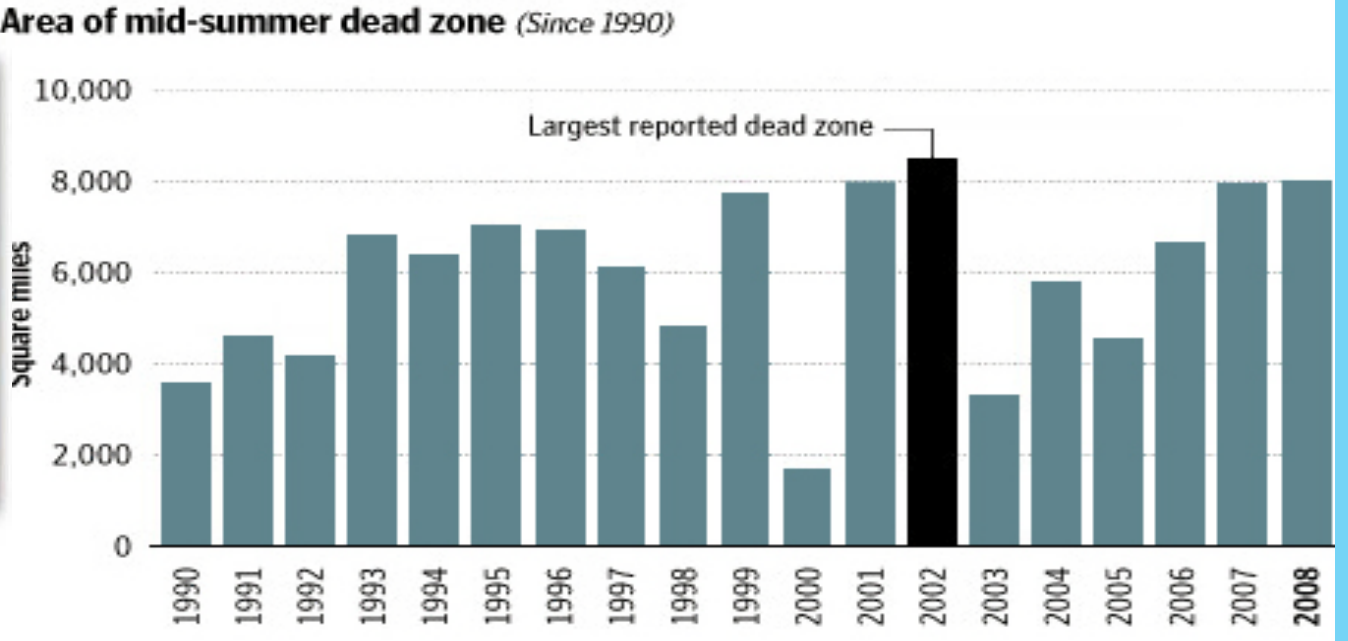
N Deposition rates (0 – 60kg/ha/yr)



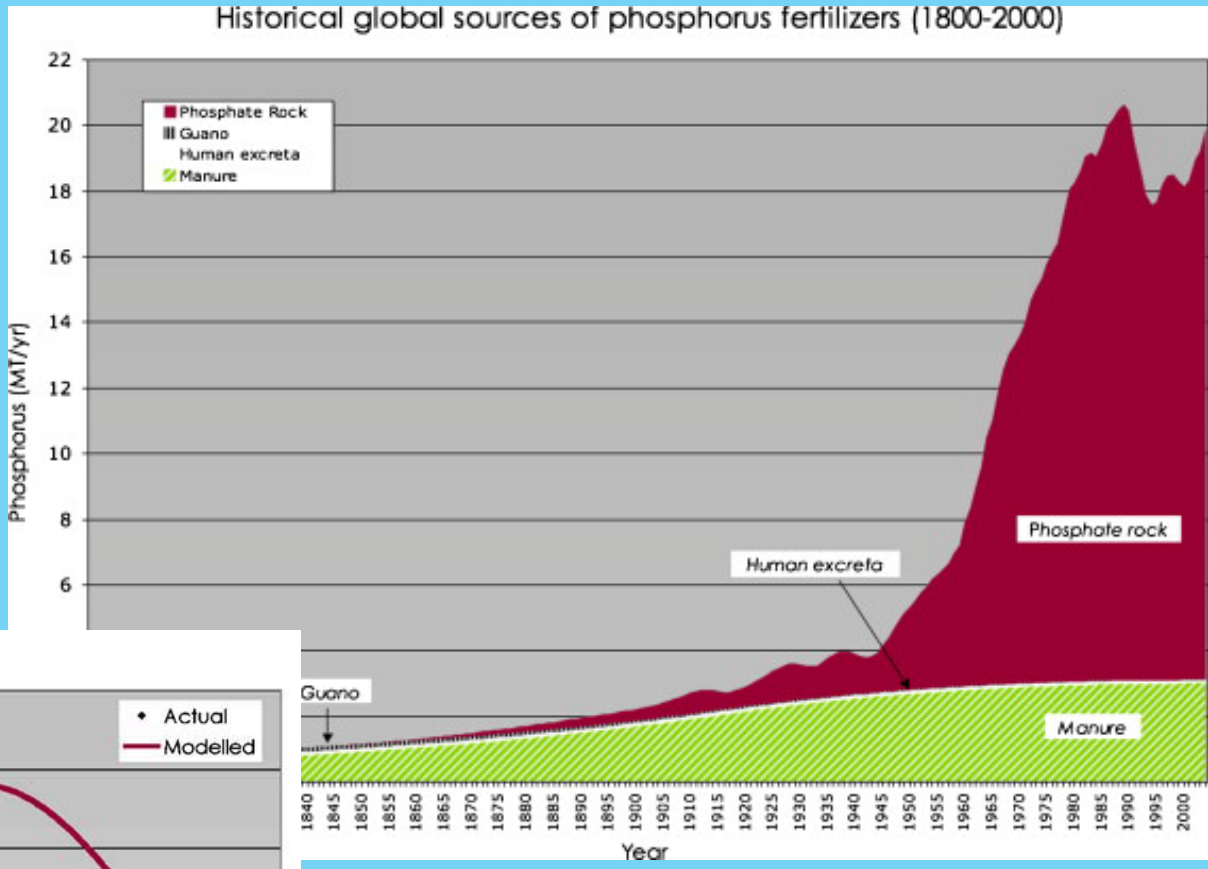
Galloway et al Science 2008

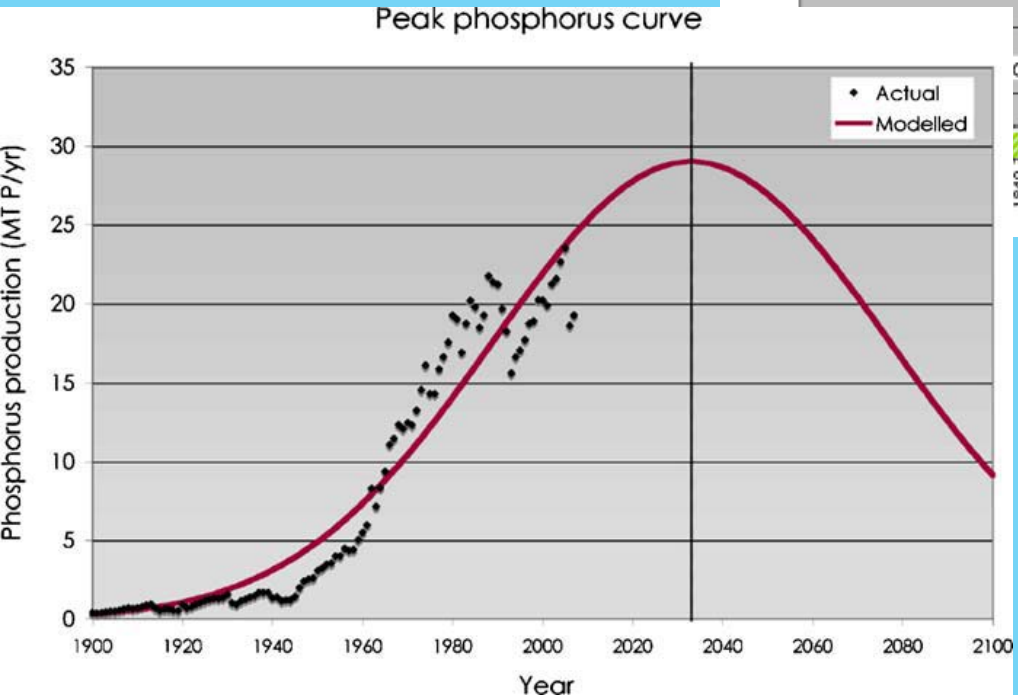
Gulf of Mexico Dead Zone

Photo: Nancy Rabalais, Louisiana Universities Marine Consortium



Future Phosphorus Limitations ?

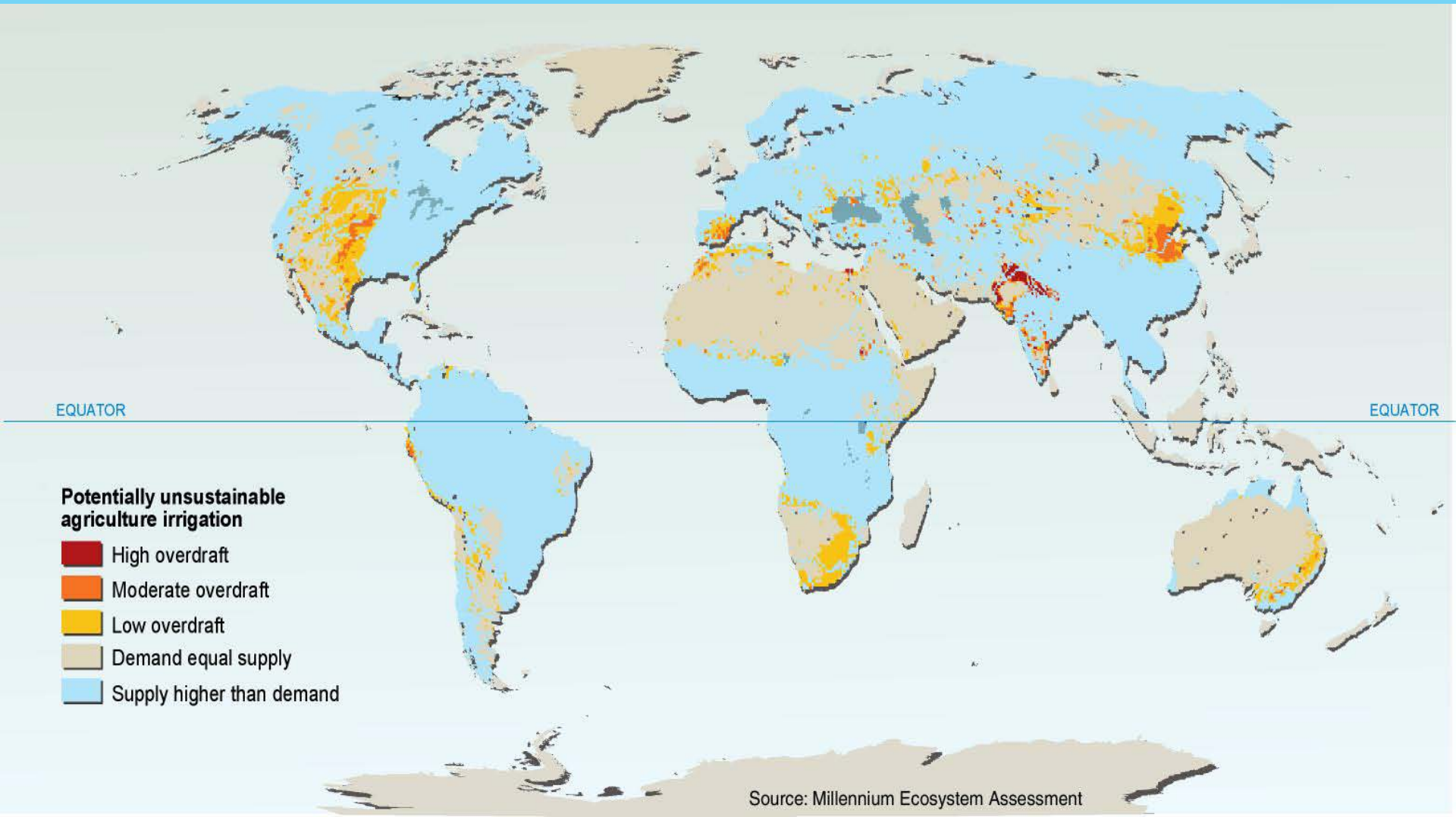




Cordell et al 2009.
Global Env Change 19: 292-305

Water

- 5 to possibly 25% of global freshwater use exceeds long-term accessible supplies (*low to medium certainty)*
- 15 - 35% of irrigation withdrawals exceed supply rates and are therefore unsustainable (*low to medium certainty)*



Unsustainable groundwater withdrawal

Depletion rate 4cm/yr

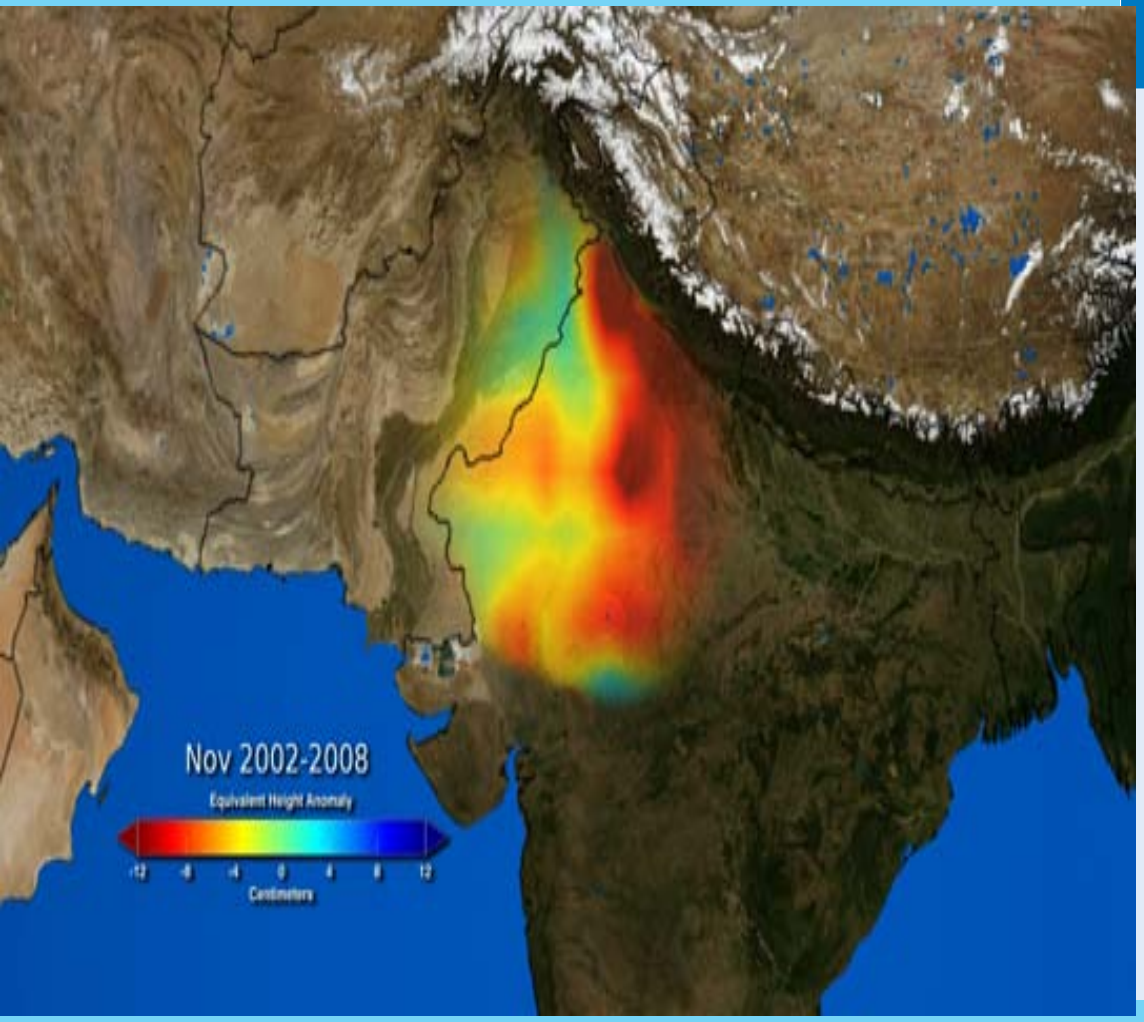
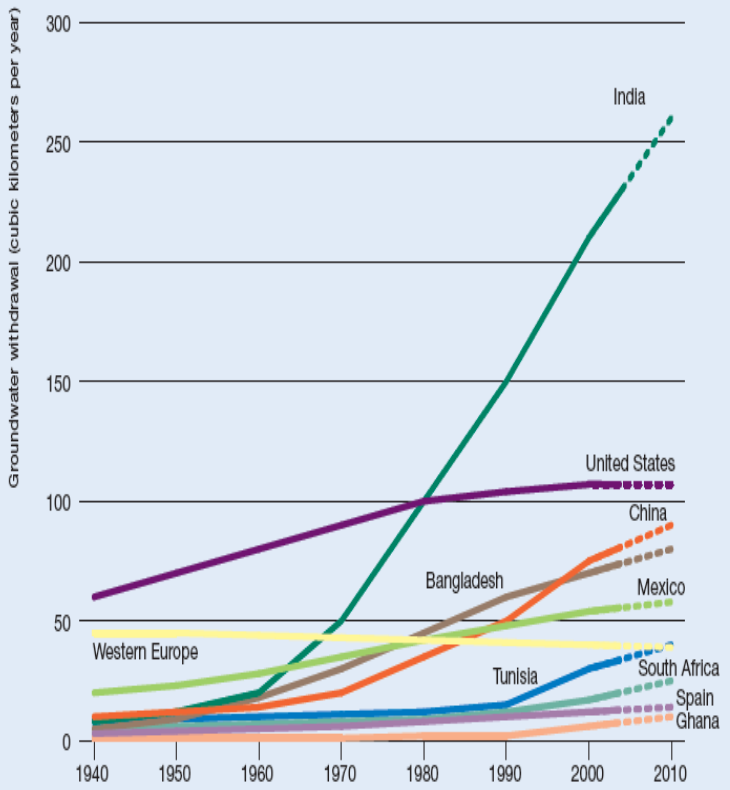


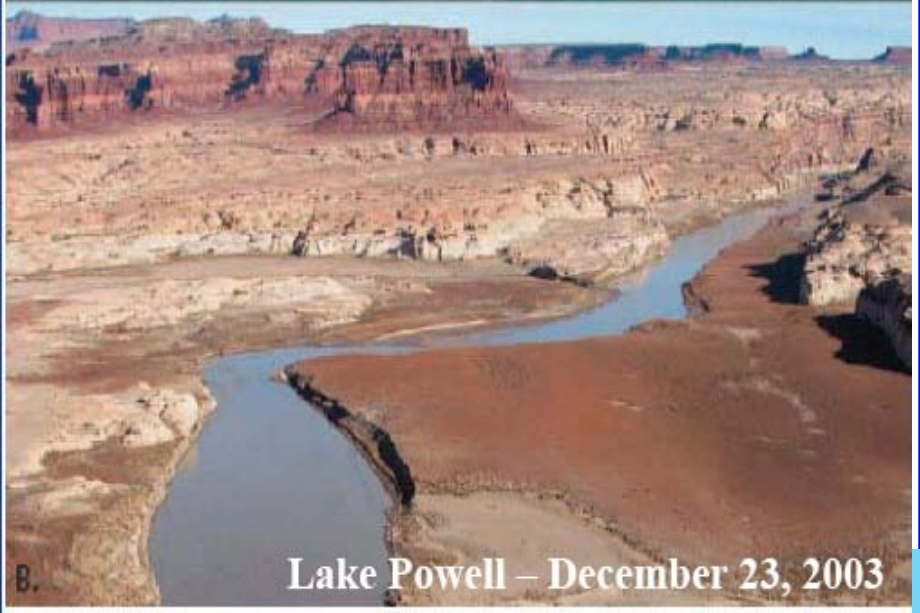
figure 10.1 **Development in groundwater withdrawal in selected countries**

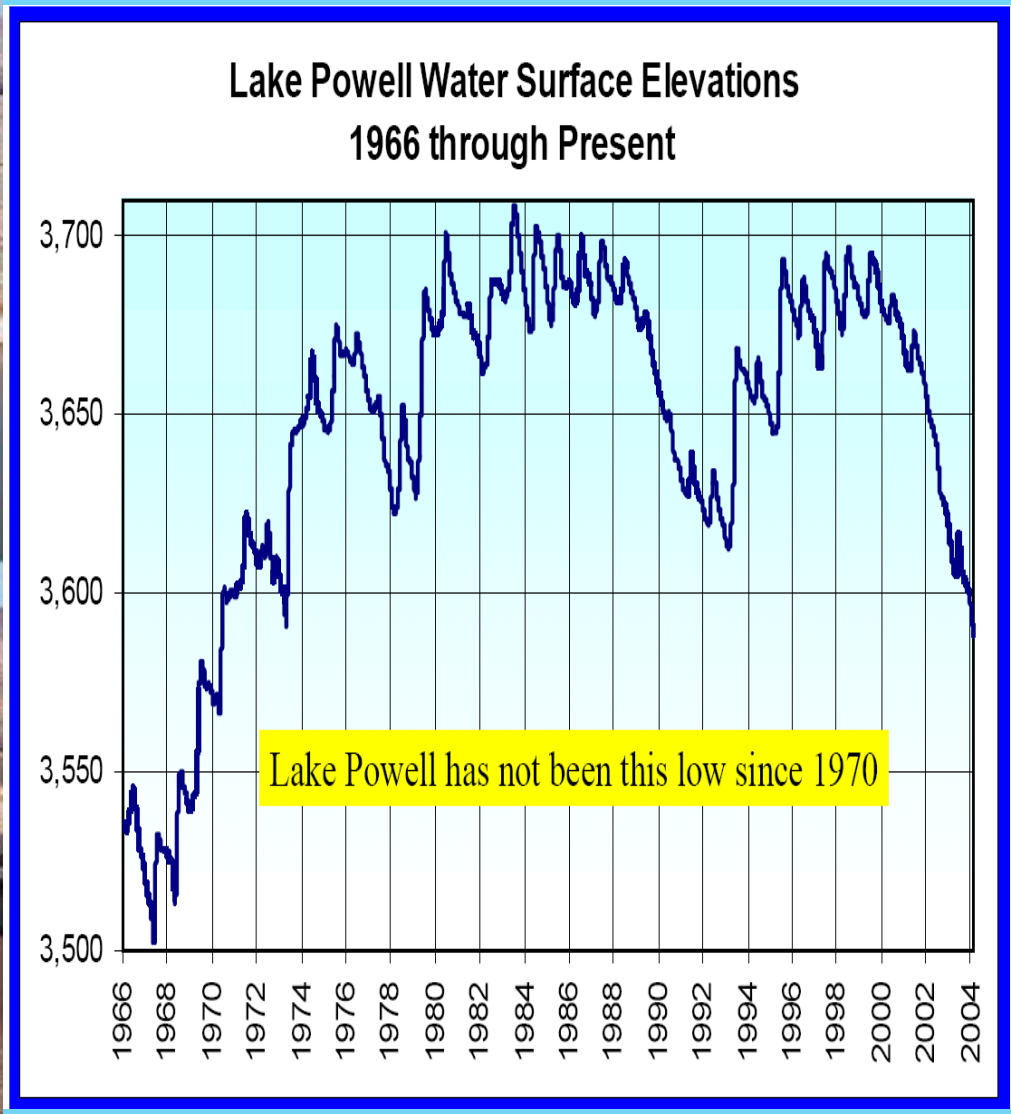


Source: Shah 2005.

Groundwater withdrawals as % of recharge, 2002-2008.
Rodell et al Nature 2009

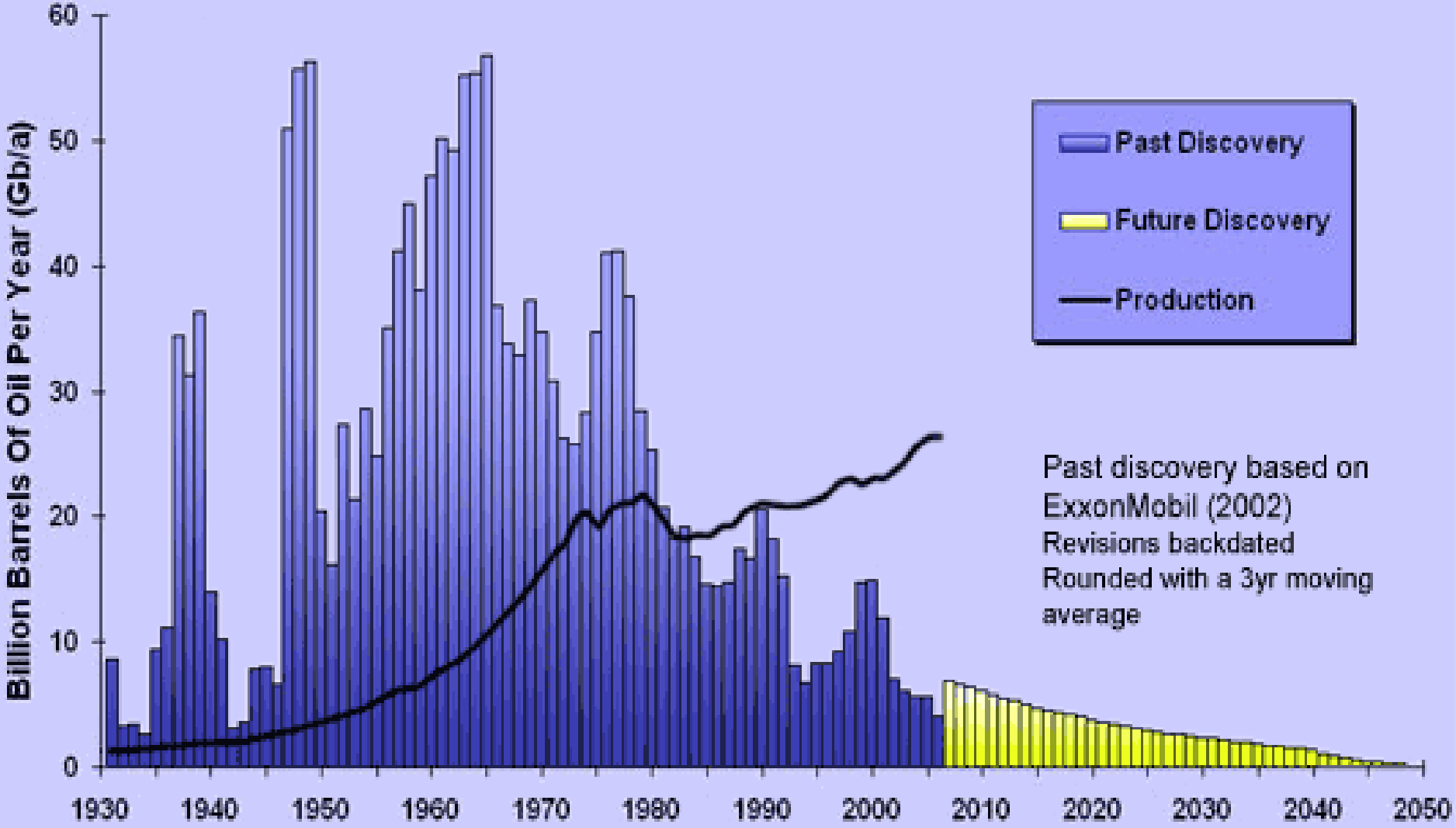
Lake Powell, AZ
Colorado River Basin



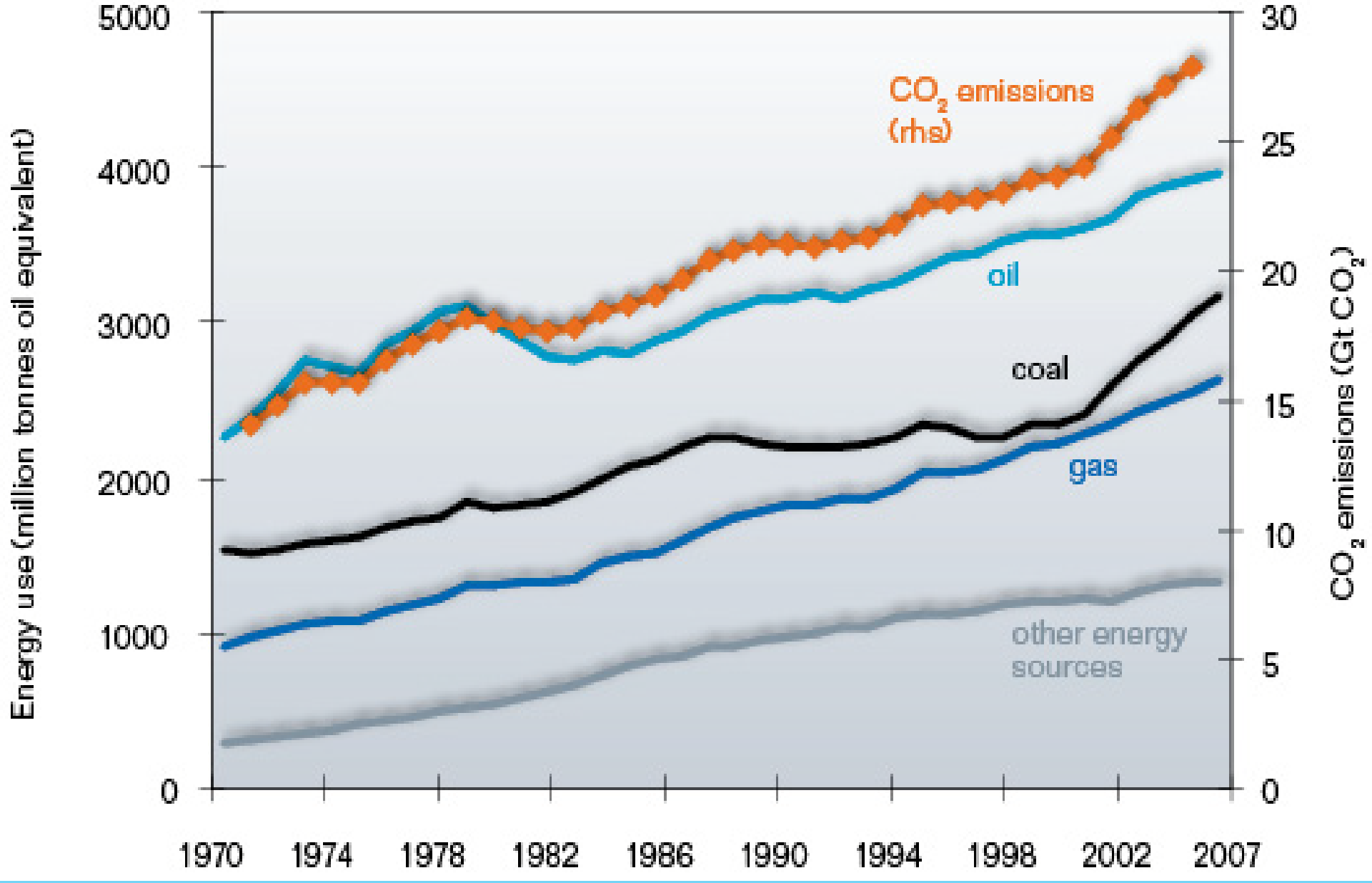


THE GROWING GAP

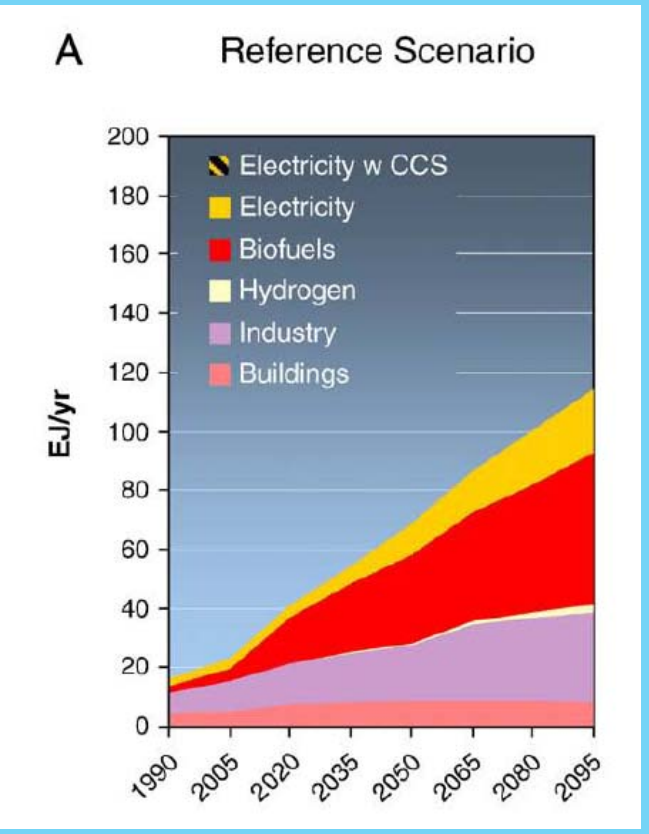
Regular Conventional Oil: Discovery & Production

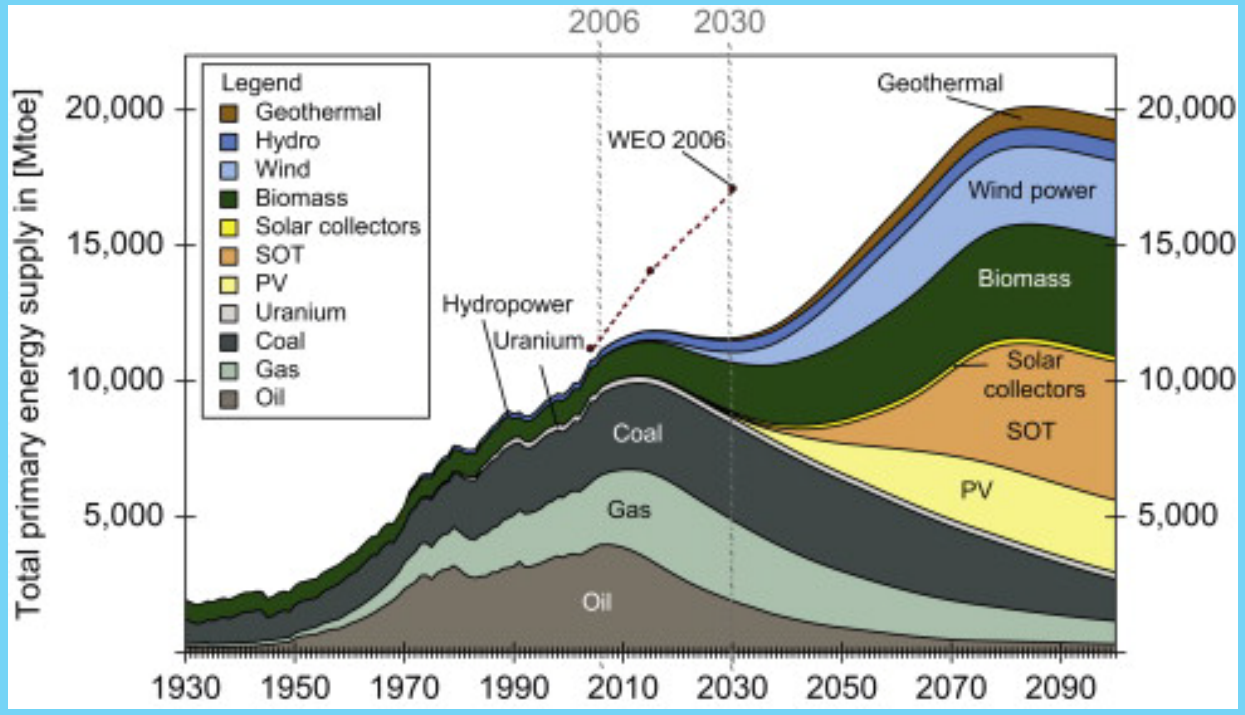


Global Energy Consumption



Aggressive Biofuel Projections by energy and economics sectors

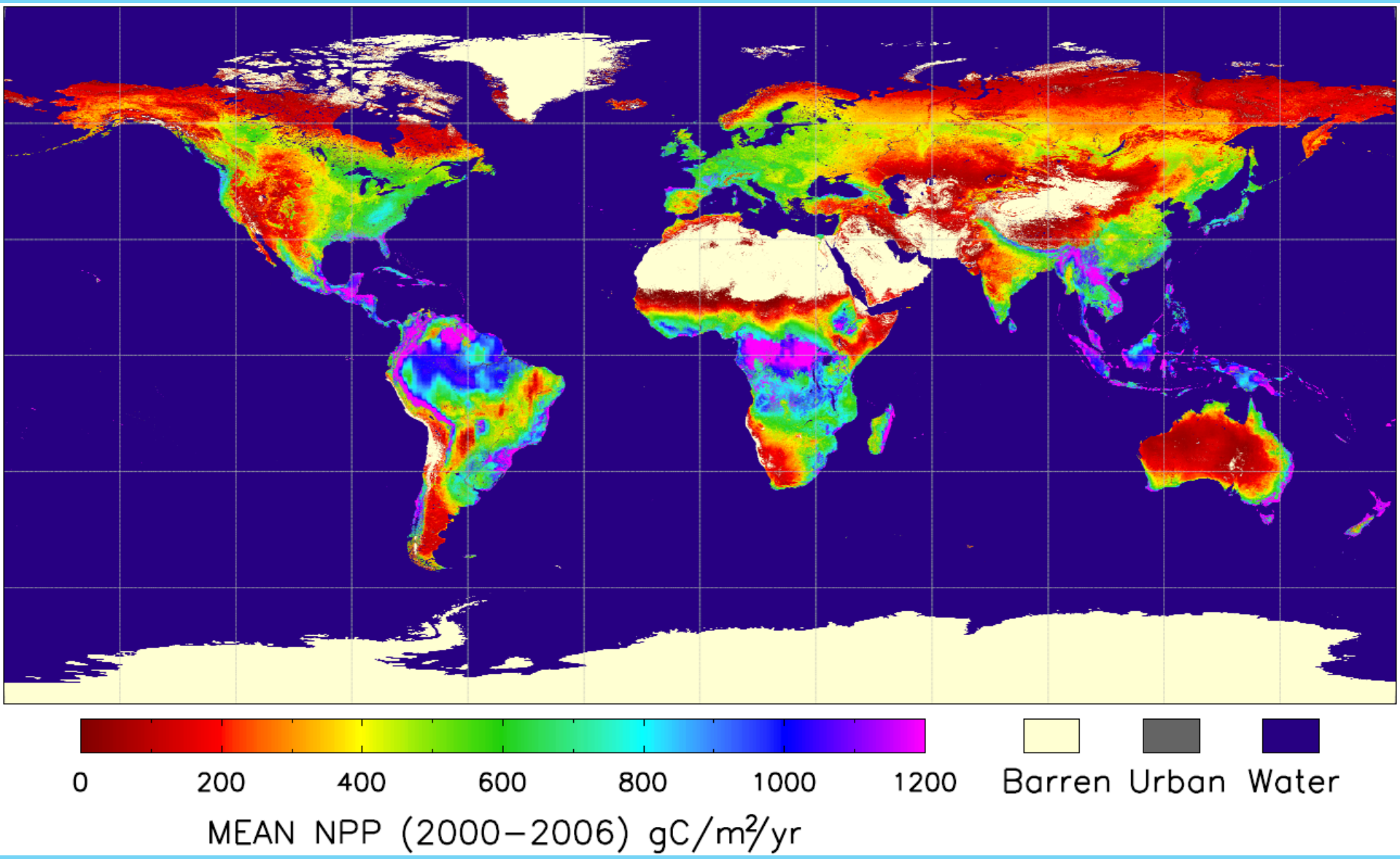




Zerta et al 2008

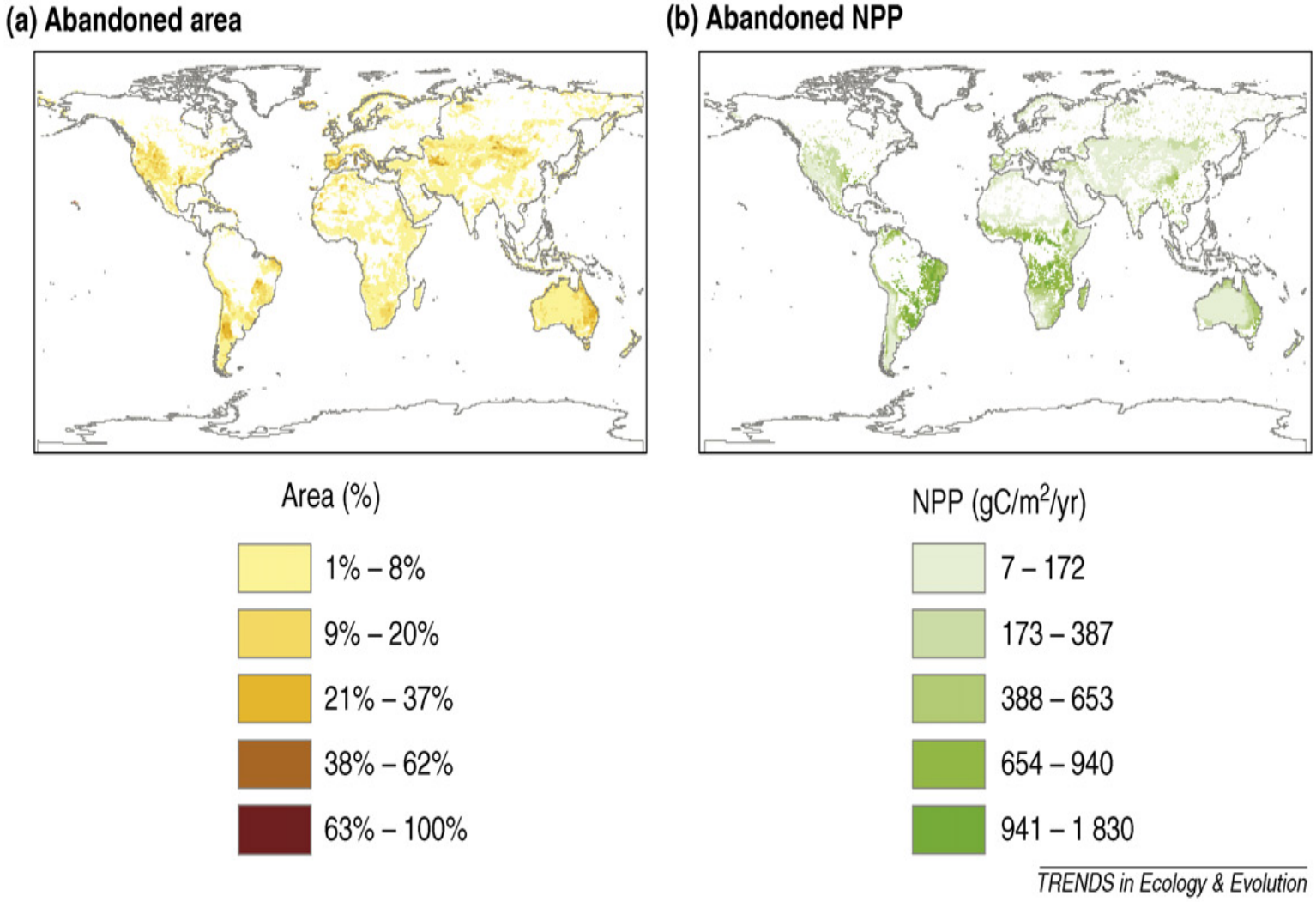
Calvin et al Energy Economics (2009)

Bioenergy Potential needs to be based on more explicit biophysical potentials for NPP



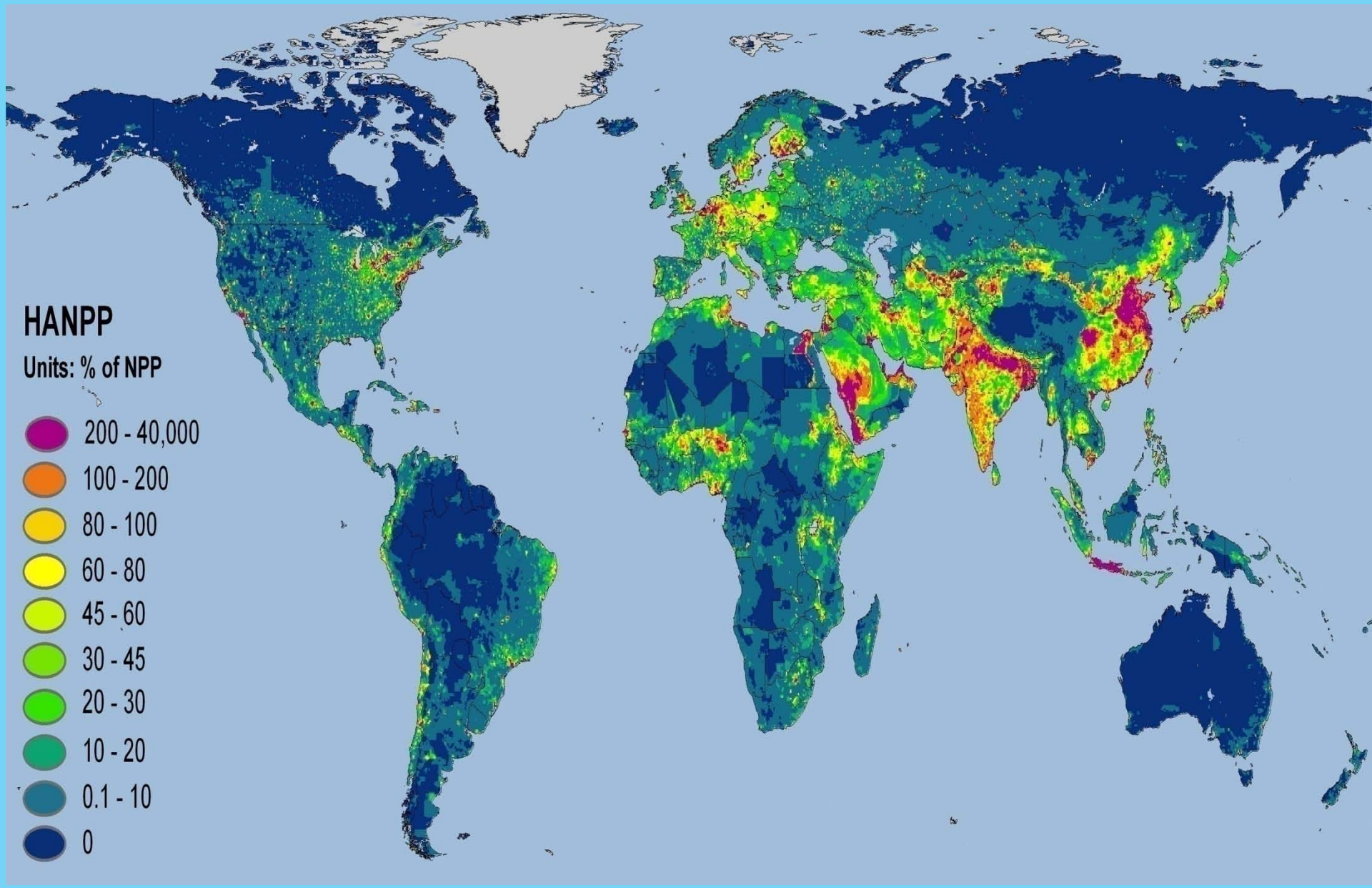
Bioenergy Potential from "Abandoned Area"

(5% of 2006 global energy)



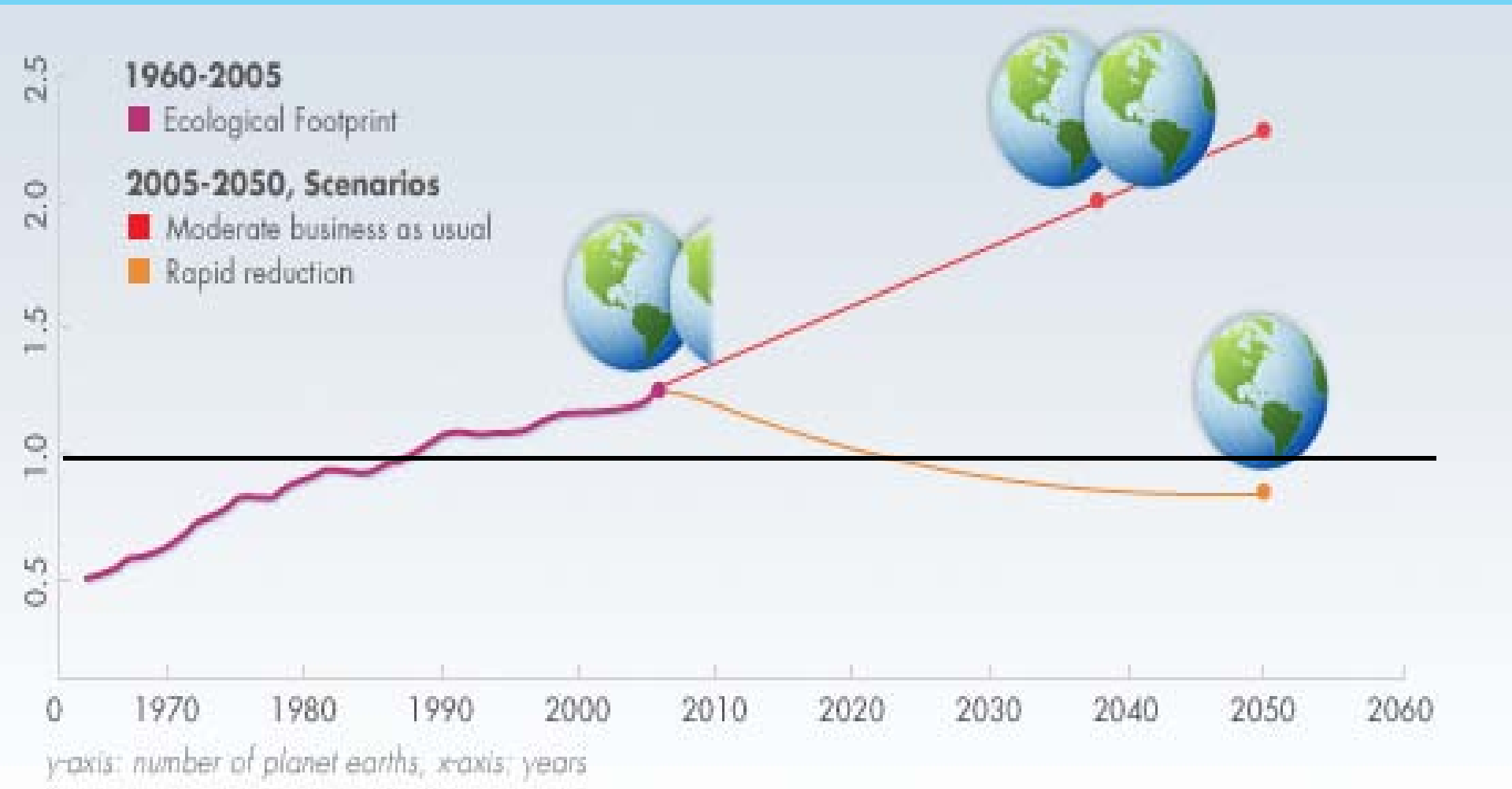
C. Field et al Trends in Ecology and Evolution2008

HUMAN APPROPRIATION OF NET PRIMARY PRODUCTION



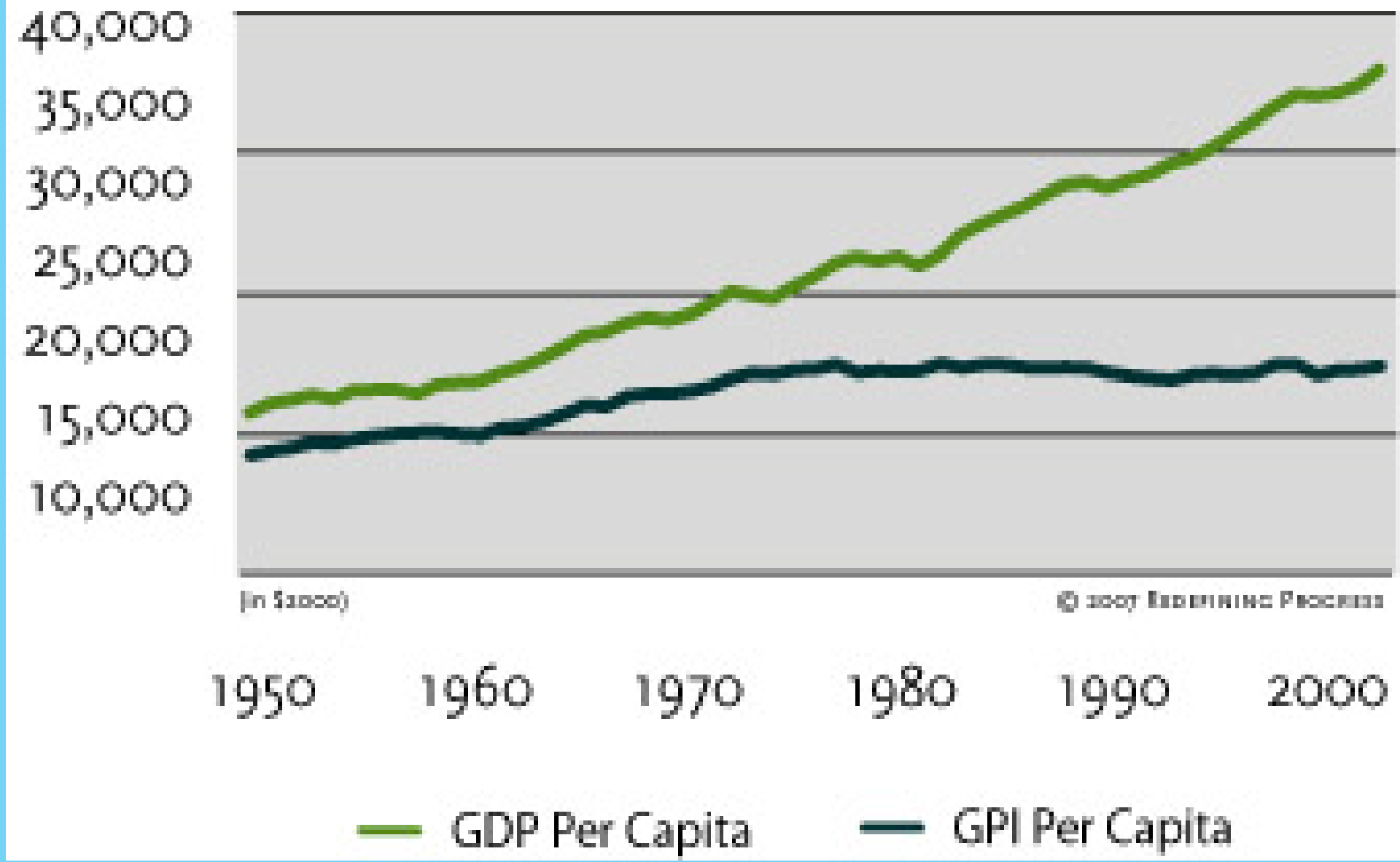
NASA Visible Earth, Imhoff et al 2004

Human Ecological Footprint



For all humans to live like Americans would take 7 Earths

Gross Production vs. Genuine Progress, 1950-2004



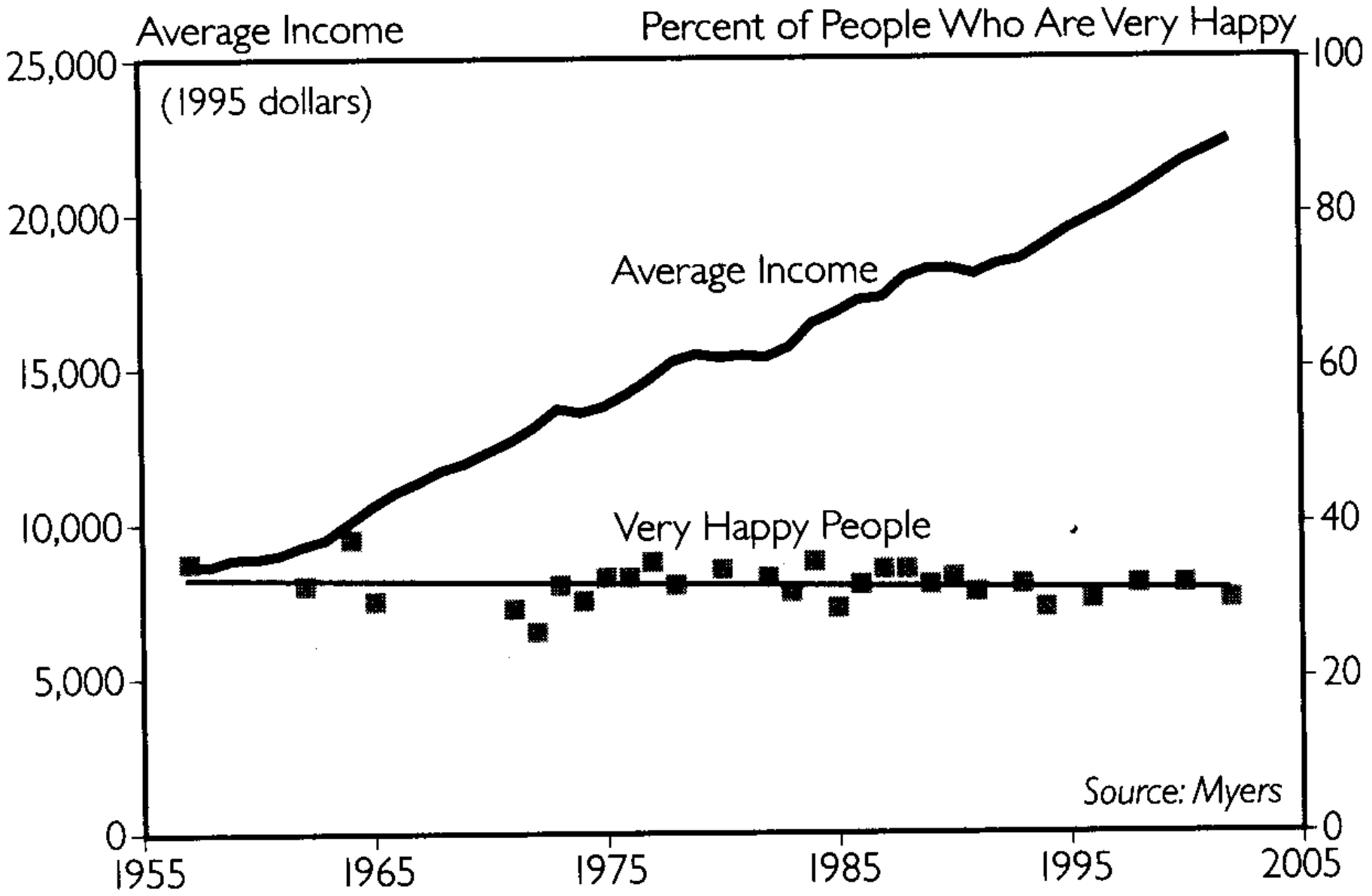
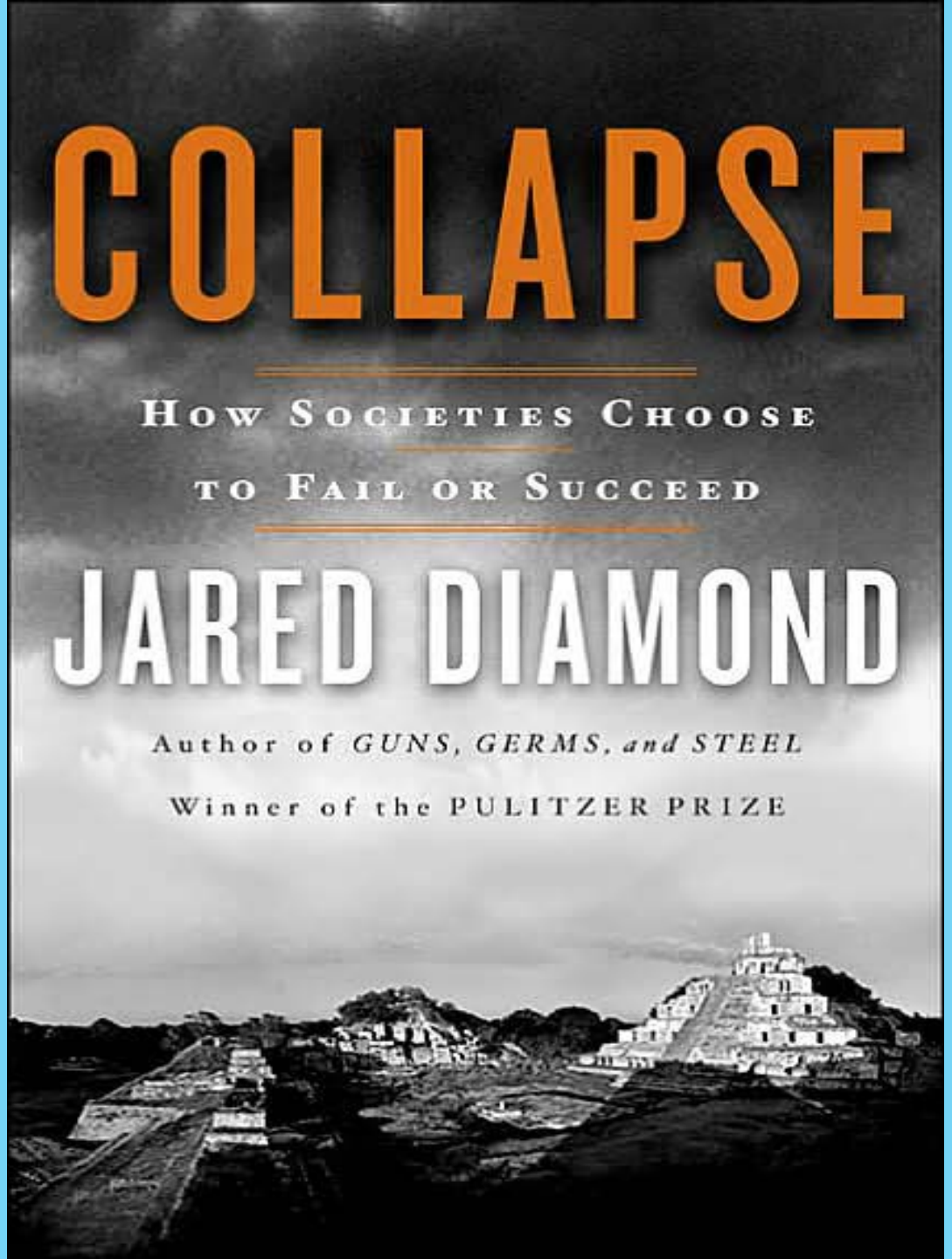


Figure 8–1. Average Income and Happiness in the United States, 1957–2002



Major changes in trends of biospheric consumption must occur in the next 30 years.

Will this be our fate?

Earth from 1 billion km away

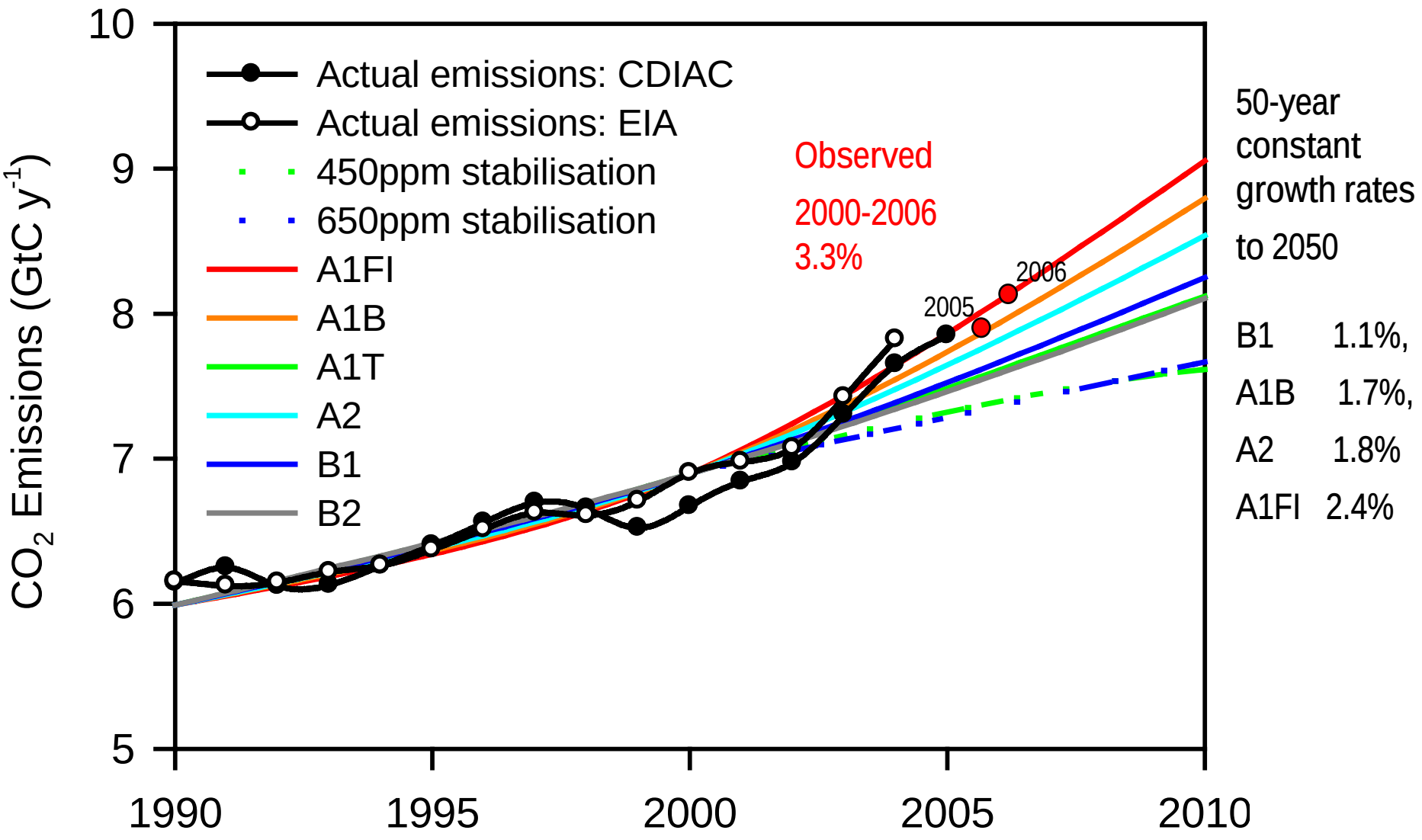
(most remote picture of Earth ever taken)

Cassini spacecraft, Sept 15 2006

Earth

From NASA Earth Observatory

Trajectory of Global Fossil Fuel Emissions



Raupach et al. 2007, PNAS

Fate of Anthropogenic CO_2 Emissions (2000-2007)

1.5 Pg C y^{-1}

+

7.5 Pg C y^{-1}

4.2 Pg y^{-1}
Atmosphere
46%

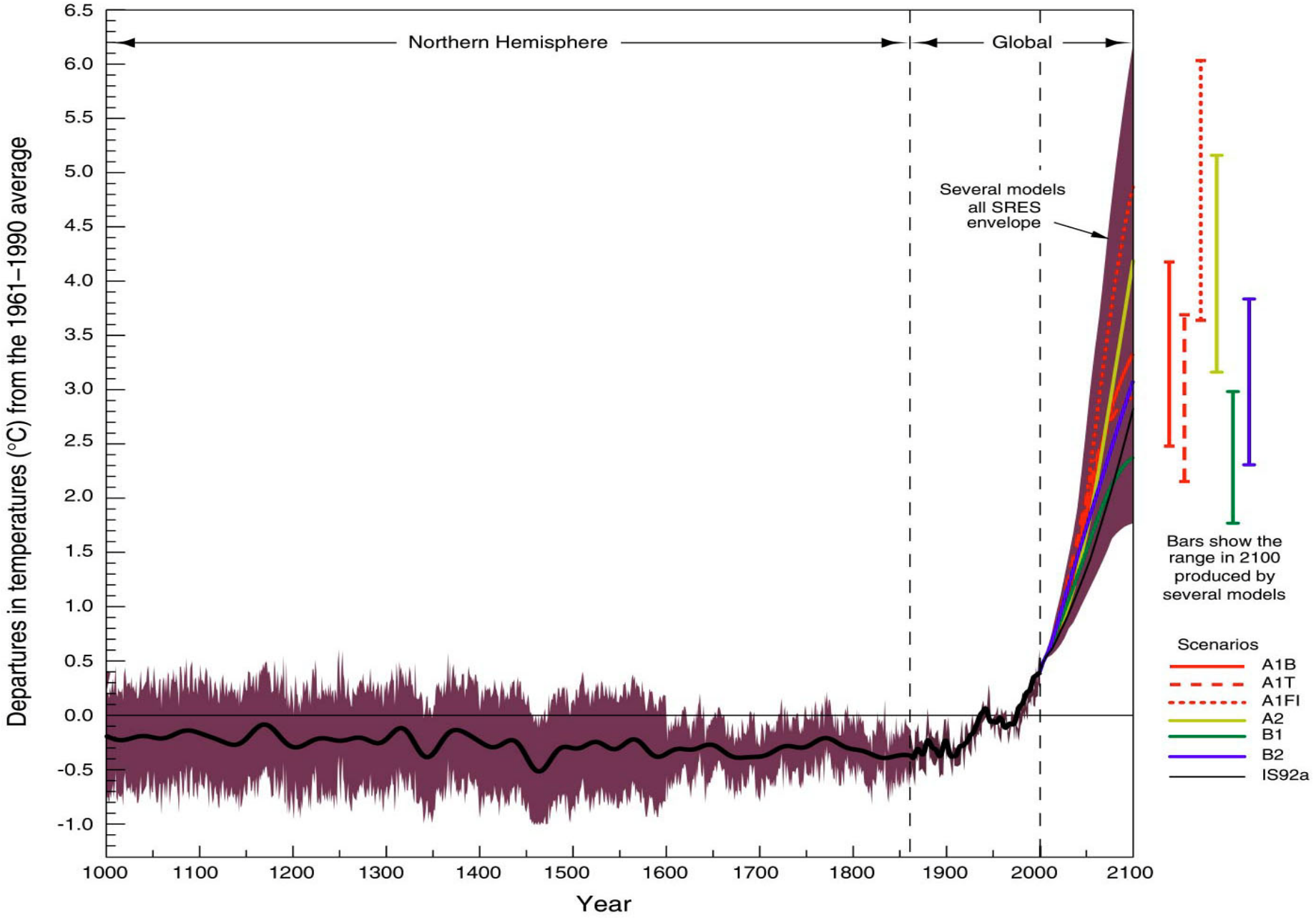
2.6 Pg y^{-1}
Land
29%

2.3 Pg y^{-1}
Oceans
26%

Canadell et al. 2007, PNAS (updated)

Variations of the Earth's surface temperature; 1000 to 2100

1000 to 1861, N.Hemisphere, proxy data; 1861 to 2000 Global, instrumental; 2000 to 2100, SRES projections



PNW Temperature Change