Ecology and Economics: It's Also About Resources, Not Just Jobs and Deficits

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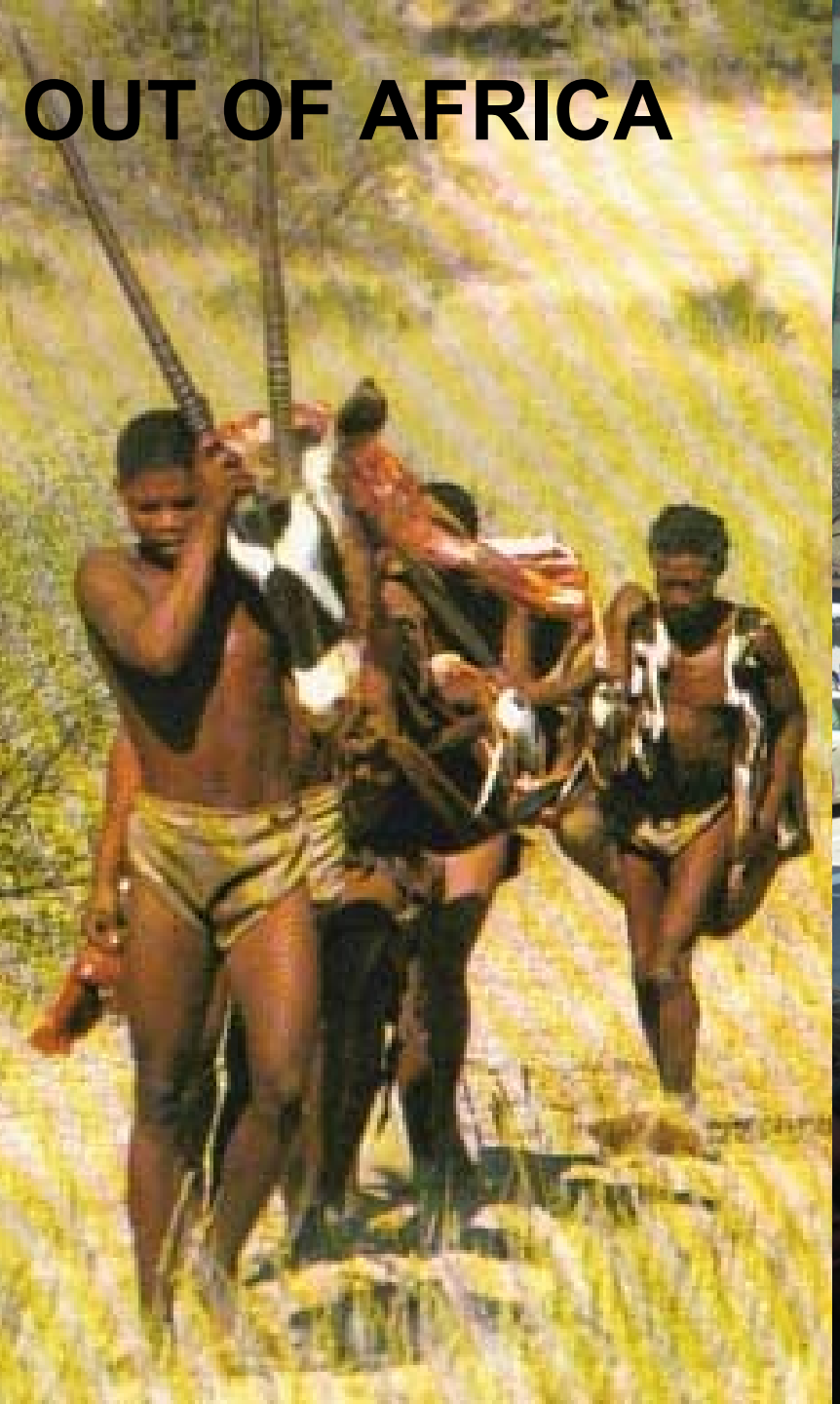
University of New Mexico

Presentation to New Mexicans for Science and Reason
9 May 2012

OUT OF AFRICA



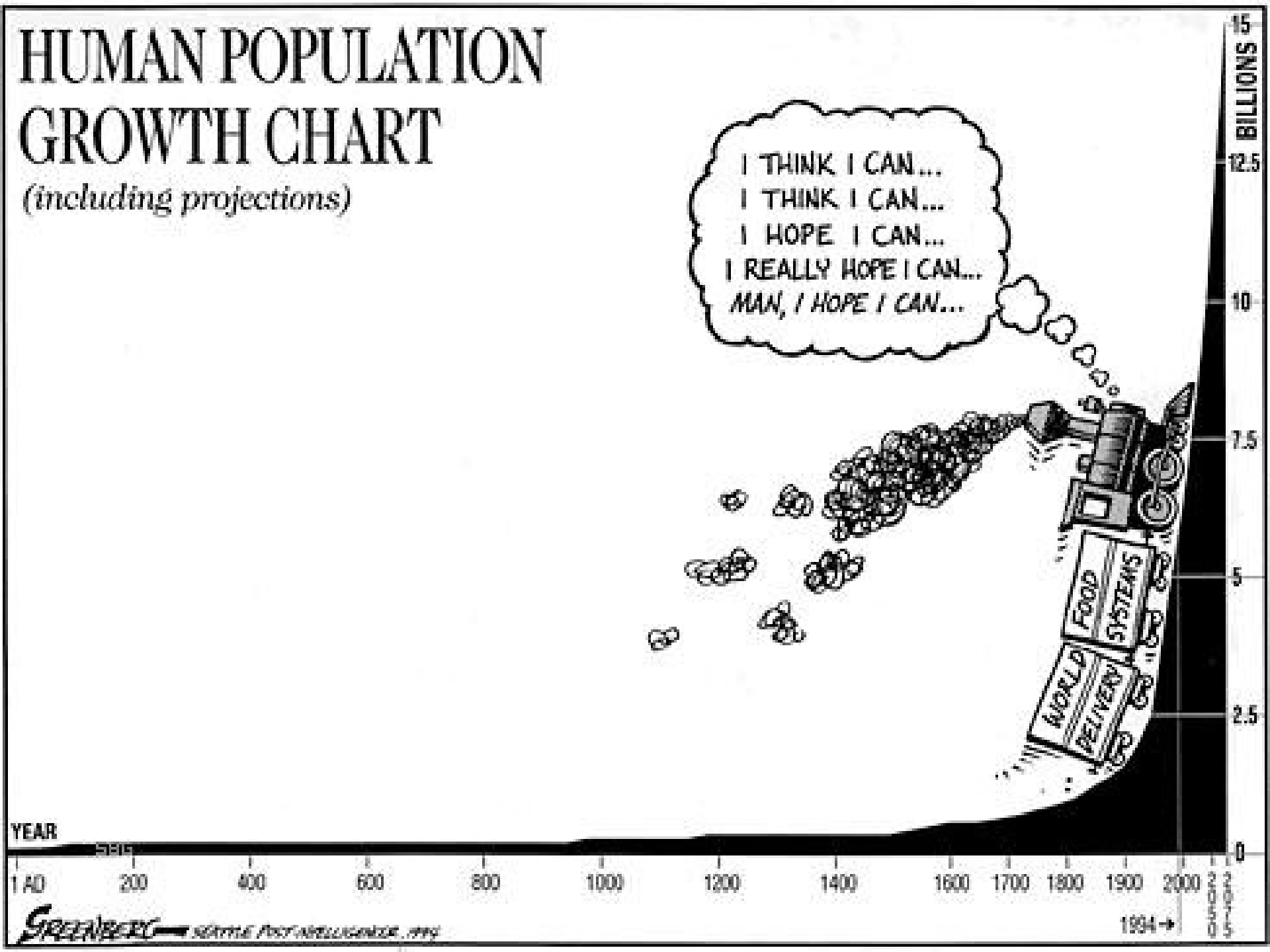
INTO THE 21ST CENTURY

50,000 years of

- Exponential increase in population and resource use
- Global geographic expansion
- Unprecedented ecological dominance

HUMAN POPULATION GROWTH CHART

(including projections)



How much longer can current trajectories of growth and development be maintained?

Optimistic projections for 2050:

- Population: 1-2% per year, 9-10 billion
- Economy: 4% per year, "lift developing countries out of poverty"

These are exponentials which cannot be continued indefinitely in a finite environment

Are "sustainability" and "sustainable development" assumptions, hypotheses, oxymorons?

Icons of sustainability re-examined?

Bristol Bay salmon fishery

"a model of successful natural resource stewardship"

State of Alaska http://www.adfg.alaska.gov

Portland, Oregon

" The most sustainable city in America"

SustainLane (2008) http://www.sustainlane.com/us-city-rankings/overall-rankings

Bristol Bay salmon fishery
"A model of successful natural resource stewardship"

Bristol Bay salmon fishery

70% of wild salmon harvested, sockeye 95% of catch

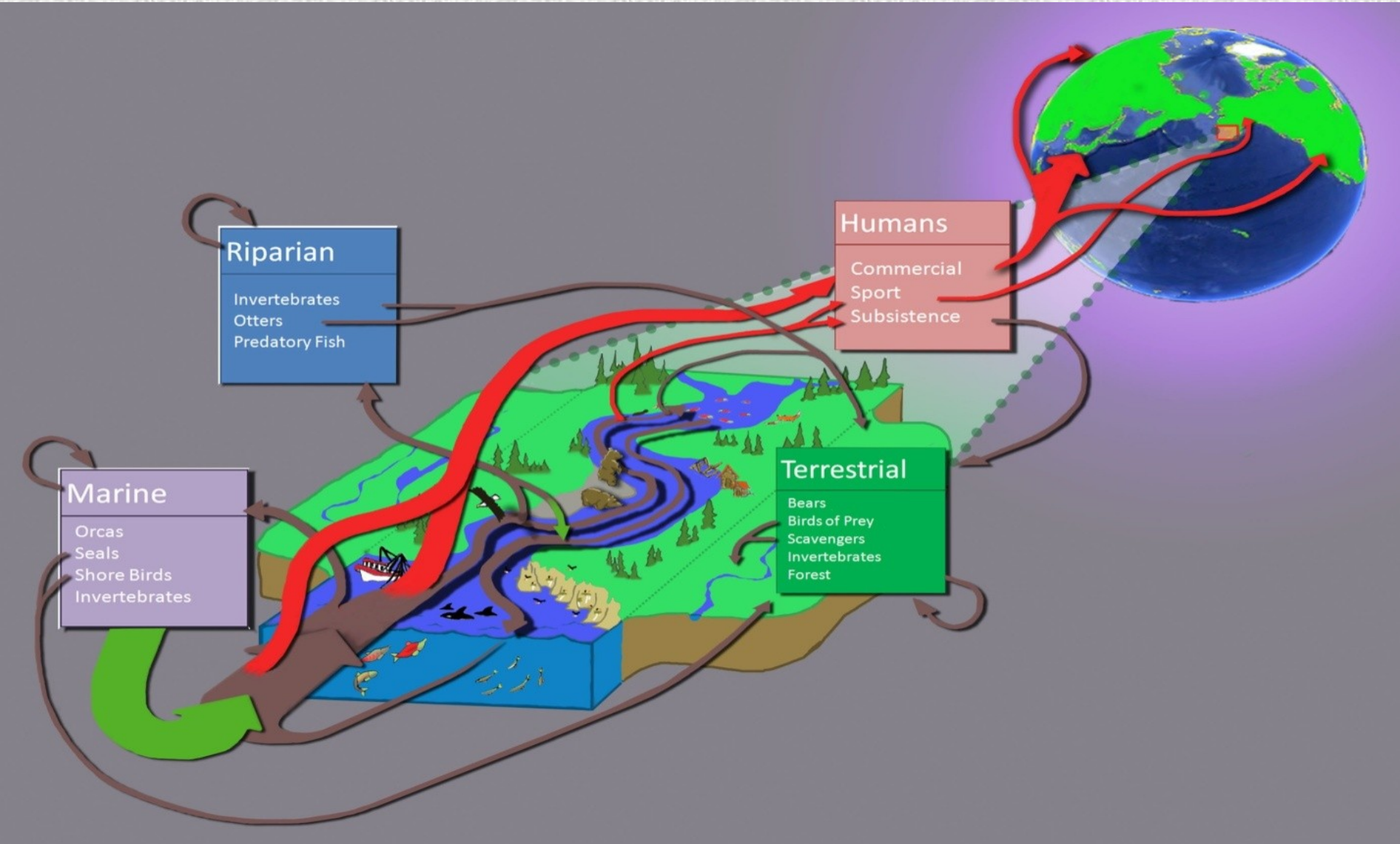
Evidence of sustainability

- **Harvests have been steady 2007-2009**

Causes for concern

- **Export of 83,000 metric tonnes of salmon biomass: 12,000 t Carbon, 2,500 t Nitrogen, 330 t Phosphorus**
- **In Lake Nerka "this loss of MDN (marine derived nutrients) has reduced lake algal productivity to about 1/3 of its level before commercial fishing" Schindler et al. (2005)**
- **Effects on terrestrial and riparian ecosystems, predators, scavengers, subsistence fishers?**

Bristol Bay salmon fishery



Portland, Oregon

“ The most sustainable city in America”

Portland, Oregon

City of Portland and Multnomah County

- **population 715,000, median income $51,000**

Imports/consumes

- **1.25 billion liters of gasoline**
- **28.8 billion megajoules of natural gas**
- **31.1 billion megajoules of electricity**
- **136 billion liters of water**
- **0.5 million tonnes of food**

Exports/releases

- **8.5 million tonnes of carbon as CO_2**
- **99 billion liters of liquid sewage**
- **1 million tonnes of solid waste**

Portland, Oregon

Humans have always used local ecosystems unsustainably

Importing resources

Energy, food, water, minerals

Exporting wastes

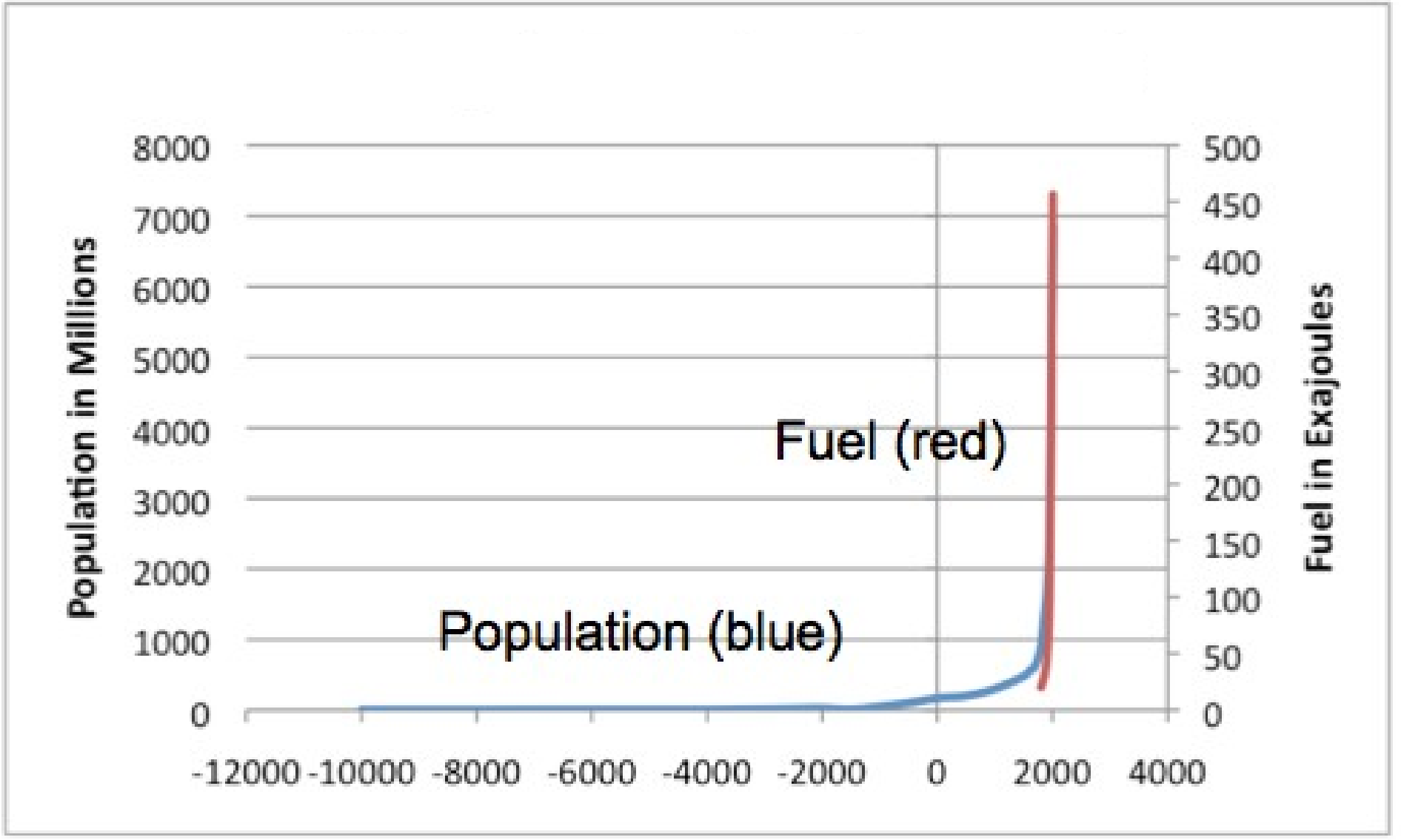
CO2, sewage, chemical

GLOBAL SUSTAINABILITY: ENERGY AND ECONOMICS

Energy and economics

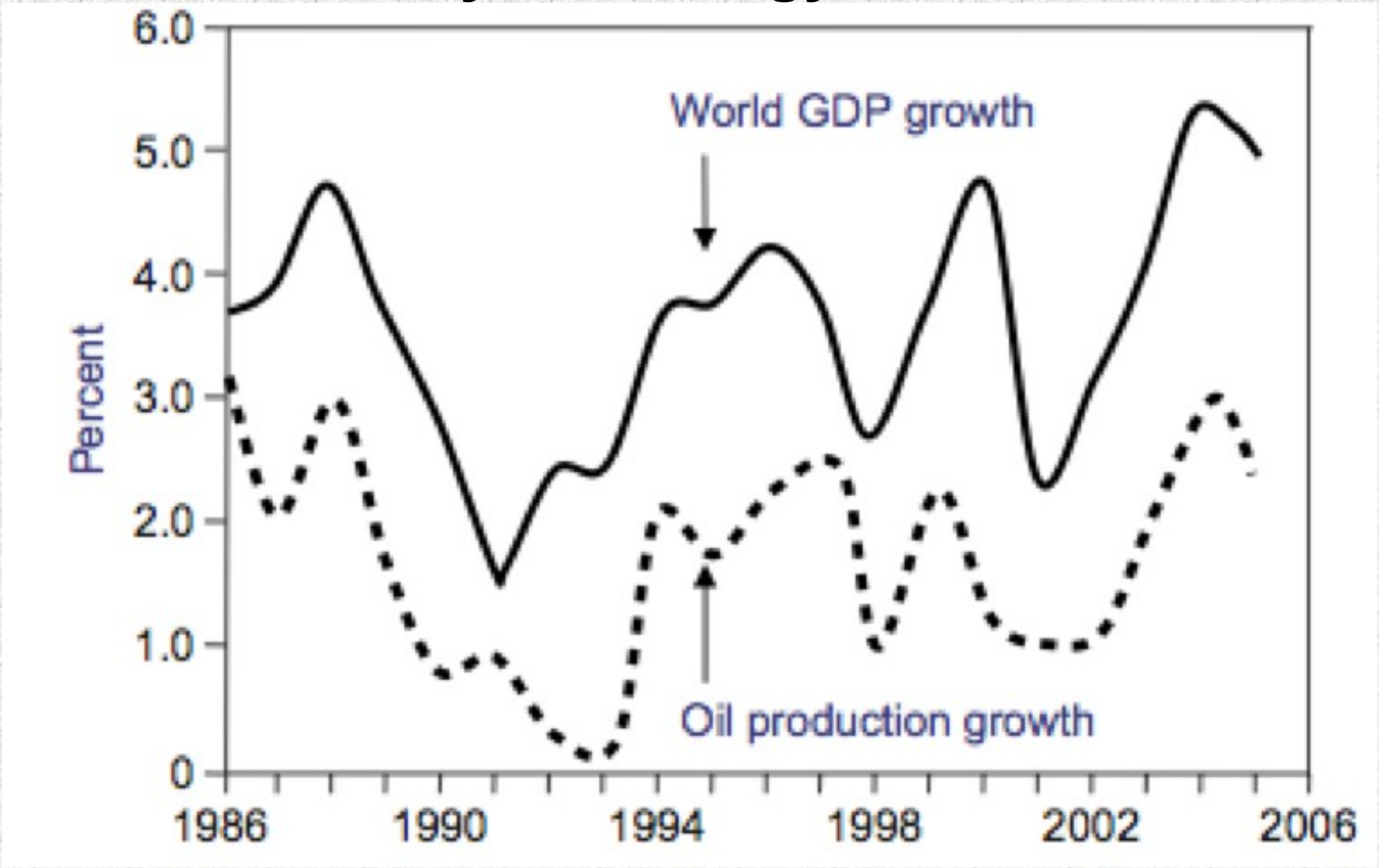
- Energy powers the economy
- GDP tracks per capita energy use across nations and over time
- Most energy comes from fossil fuels
- Implications for economic growth and “sustainable development”

Global population and energy use



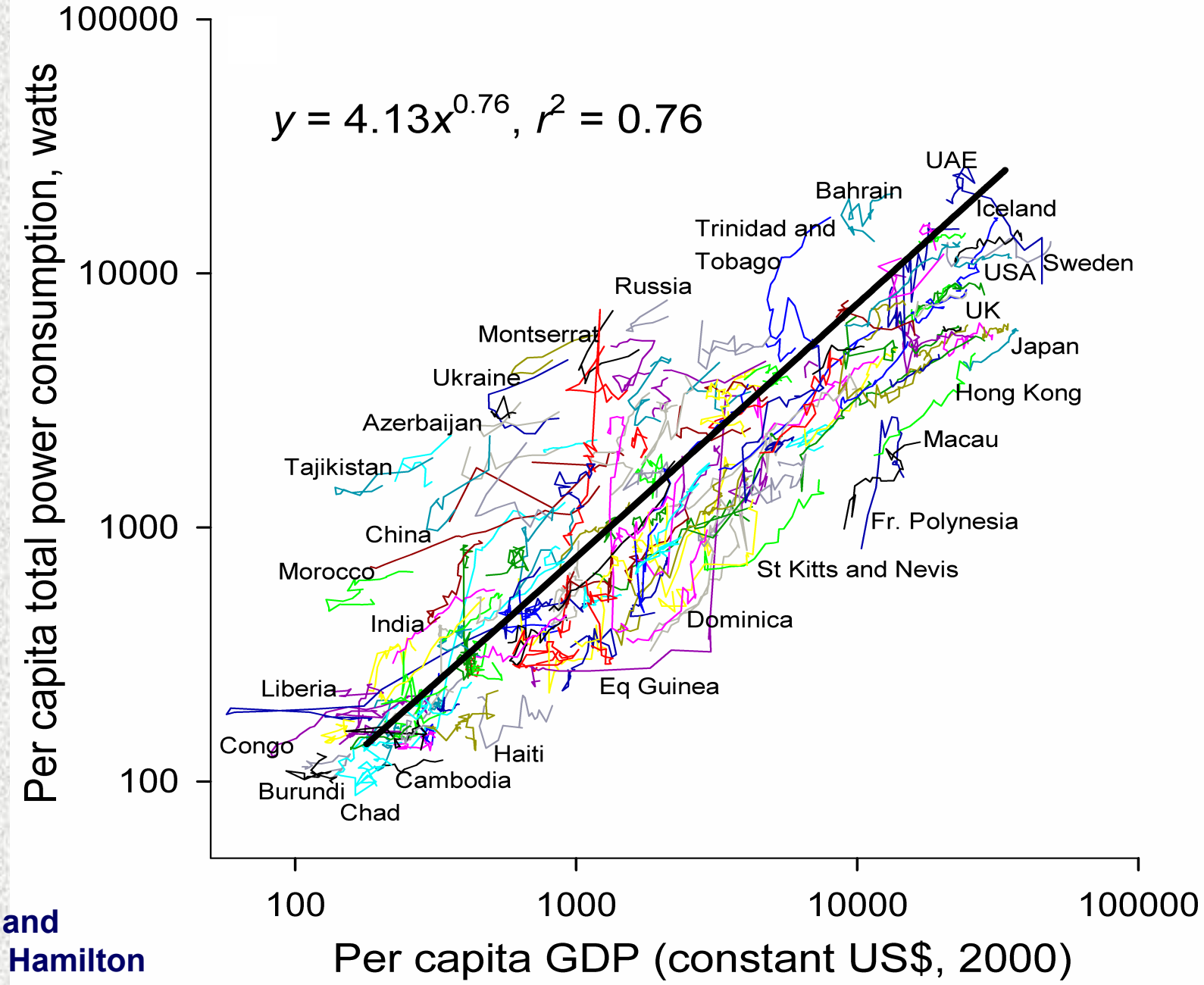
Smil (2010)

Global economy and energy use

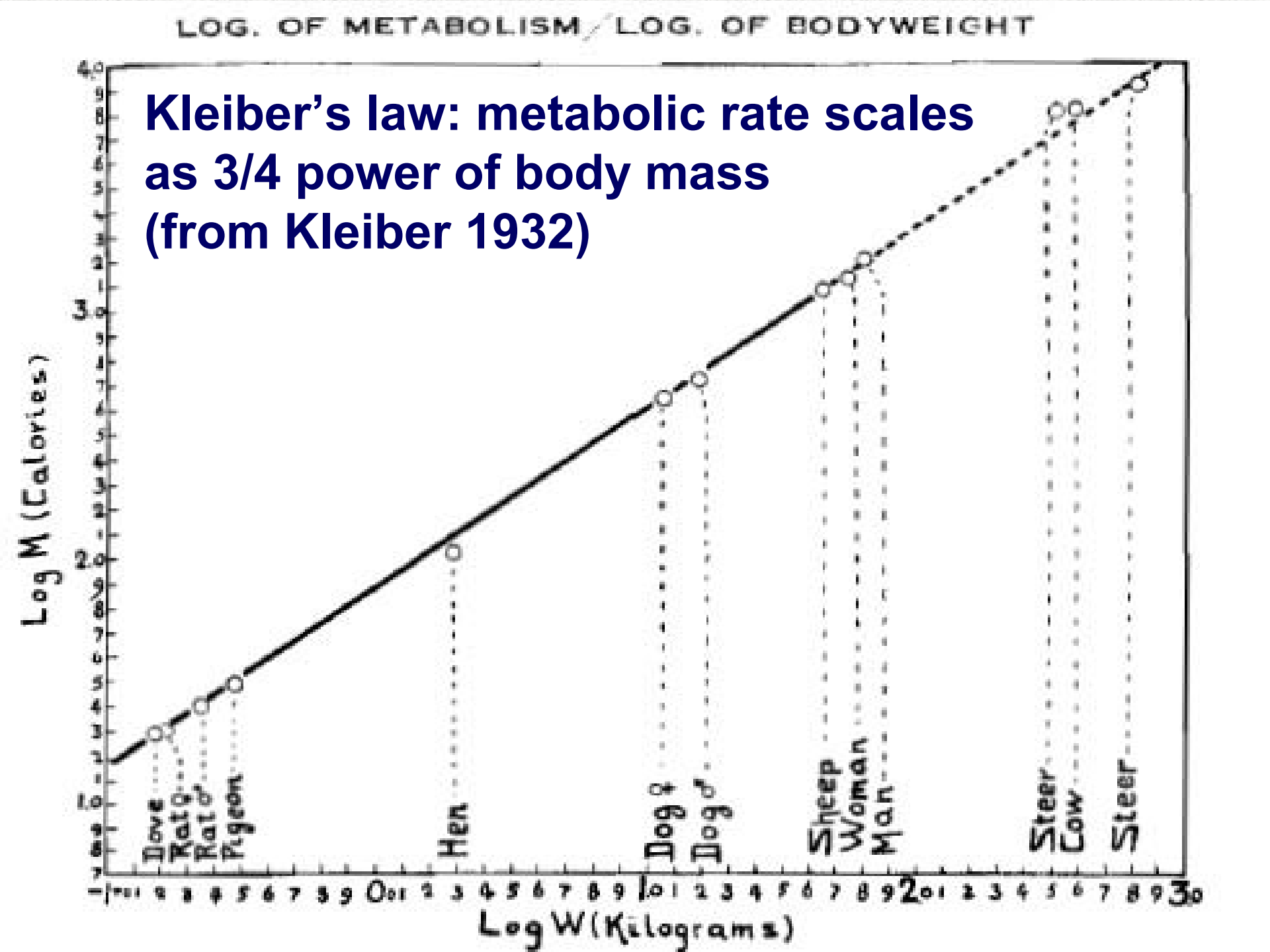


Hirsch (2008)

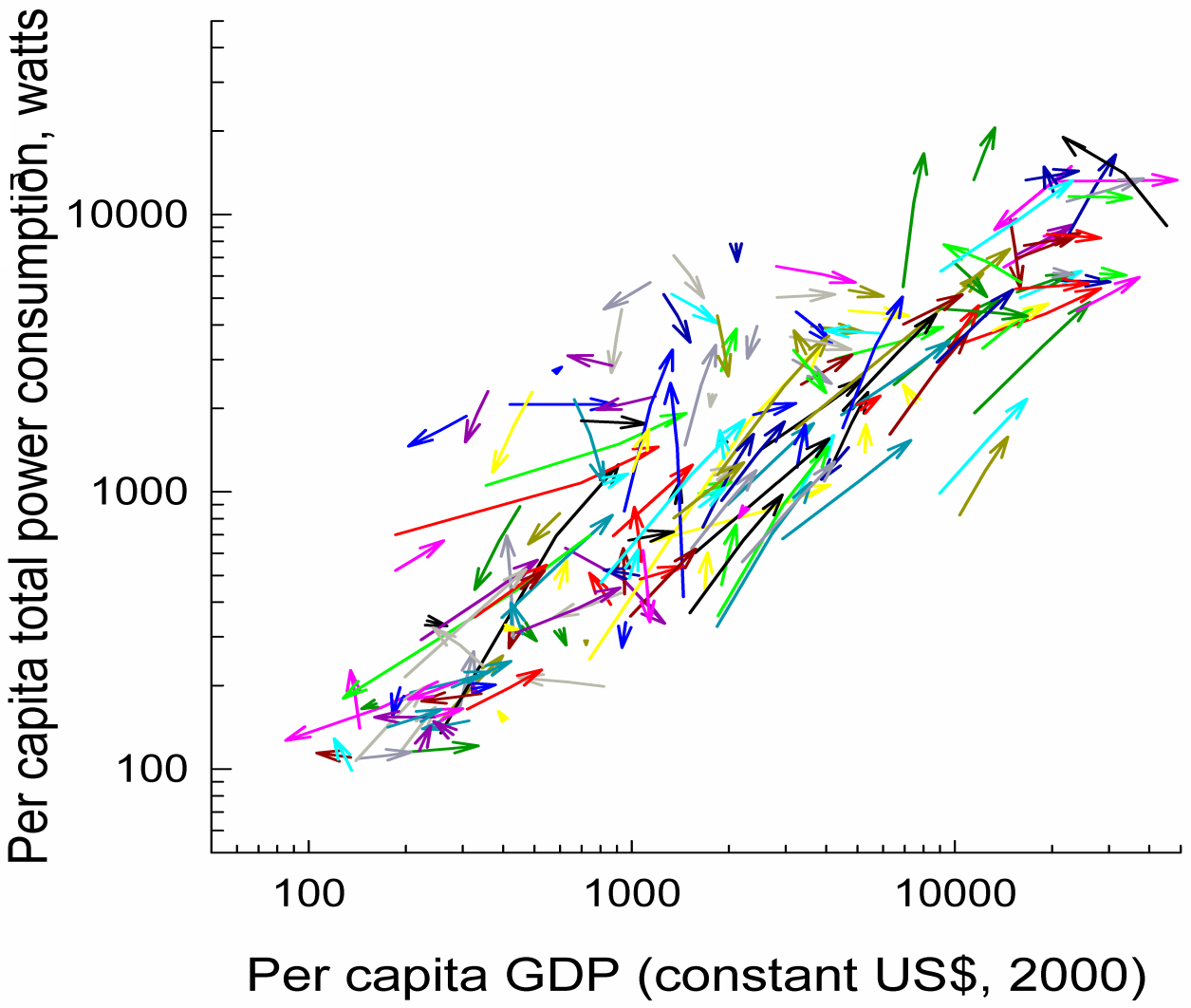
Per-capita energy use vs. per capita GDP



Data compiled and analyzed by M. Hamilton


LOG. OF METABOLISM / LOG. OF BODYWEIGHT
Kleiber's law: metabolic rate scales as 3/4 power of body mass (from Kleiber 1932)
Log M (Calories)
Log W (Kilograms)
Dove
Rat ♀
Rat ♂
Pigeon
Hen
Dog ♀
Dog ♂
Sheep
Woman
Man
Steer
Cow
Steer

Per-capita energy use vs. per capita GDP
25-year trends



Data compiled and analyzed by M. Hamilton

Problem:

1)Massive quantities of energy will be required for projected economic growth and development

Solutions:

1)Increase supply to meet expected demand

2)Reduce demand by reducing population

3) Reduce demand by reducing consumption

Possible solutions

1) Increase supply of energy to meet expected demand

- How much energy will be required?
- Where will it come from?

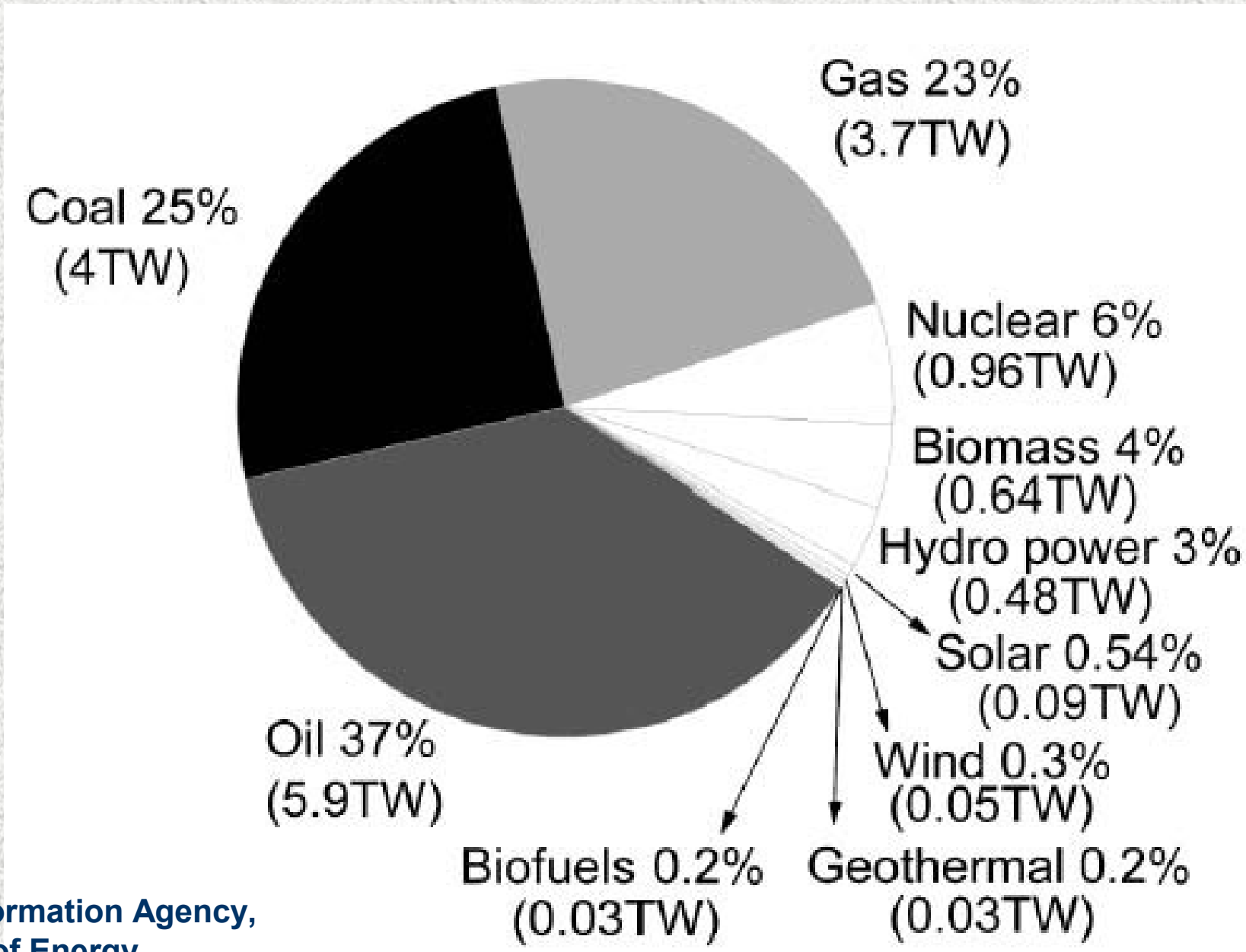
Total annual global energy consumption in different economic scenarios

	EJ	factor
world current	524	1.0
U.S. lifestyle	2440	4.7
Chinese lifestyle	392	0.75
current trends to 2025*	1142	2.2
U.S. lifestyle in 2025*	5409	10.3
Chinese lifestyle in 2025*	848	1.6

*Assumes 2025 world population of 8 billion
(U.S. Census Bureau)
and 3.8% per year increase in global GDP
(World Resources Institute)

Data compiled and analyzed by W. Zuo

Current global energy use



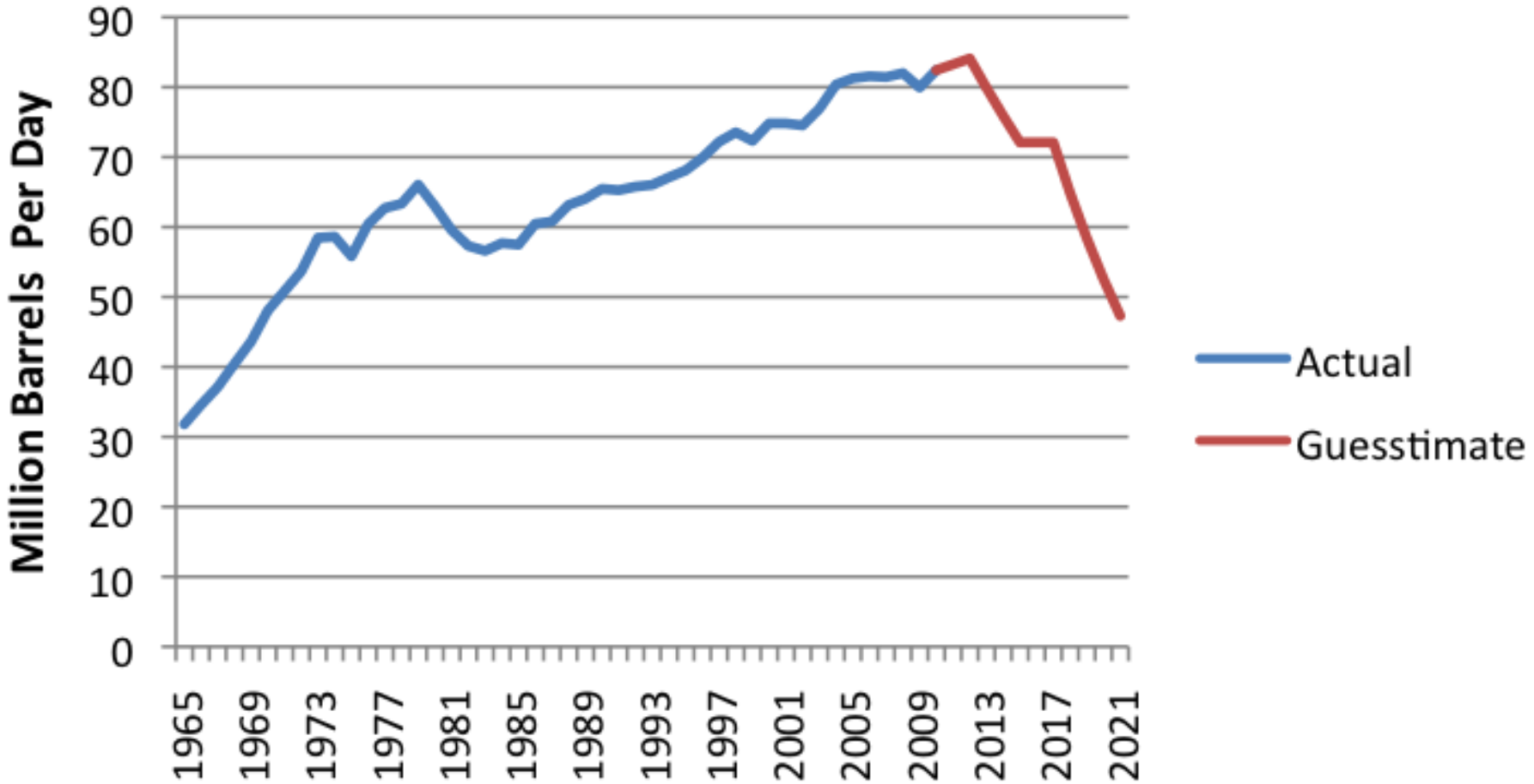
Source:
Energy Information Agency,
U.S. Dept. of Energy

Current global energy use

Fossil fuels (oil, gas, coal)	85%
“Renewables” (solar, wind, geothermal, tidal)	9%
Nuclear	6%

Source: Energy Information Agency, U.S. Dept. of Energy

Past, present and future oil supply



Courtesy of G. Tverberg

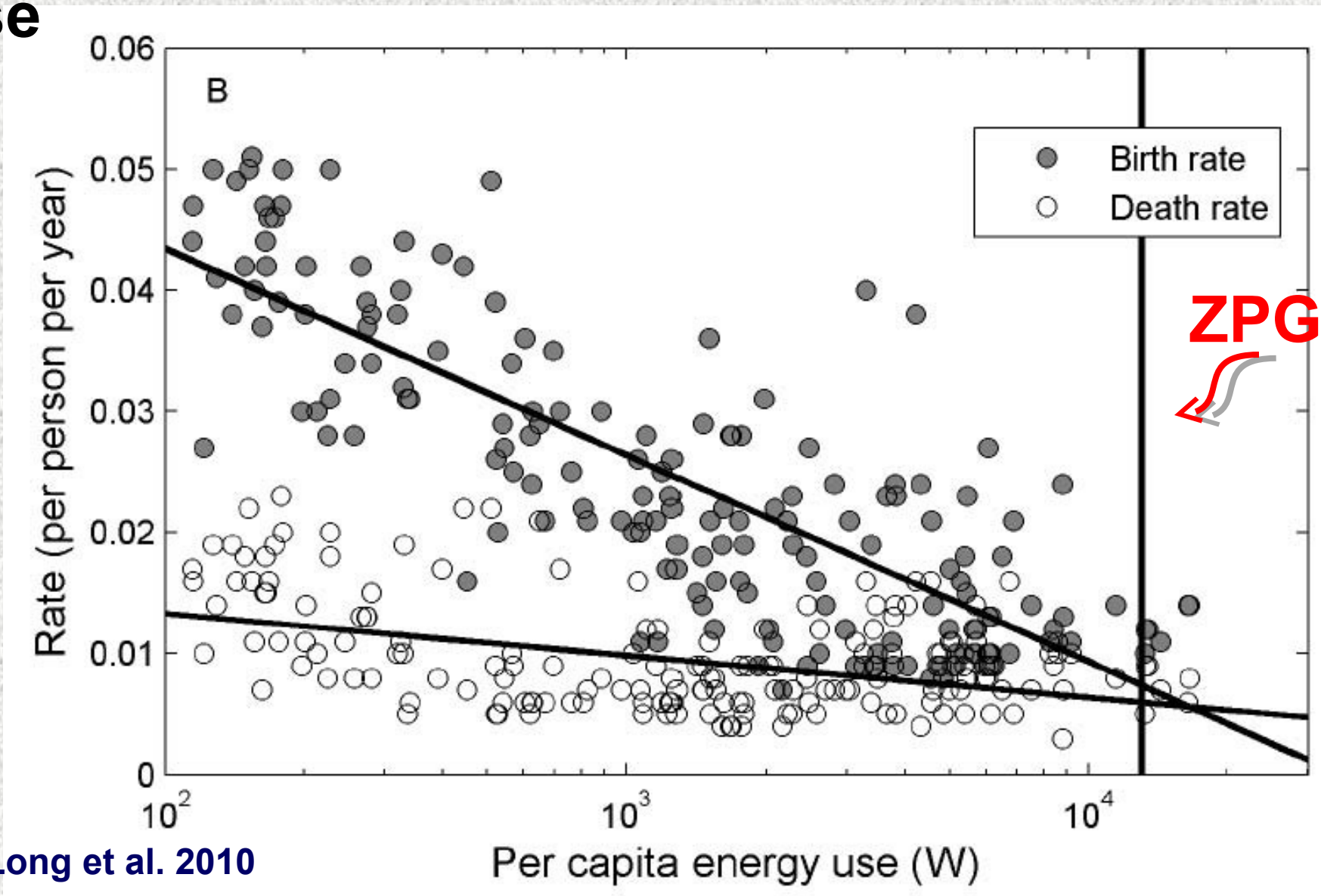
Possible solutions

2) Reduce demand for energy by reducing population

- take advantage of the "demographic transition" (UN model)
  but see DeLong et al. 2010 (PLoS 1)

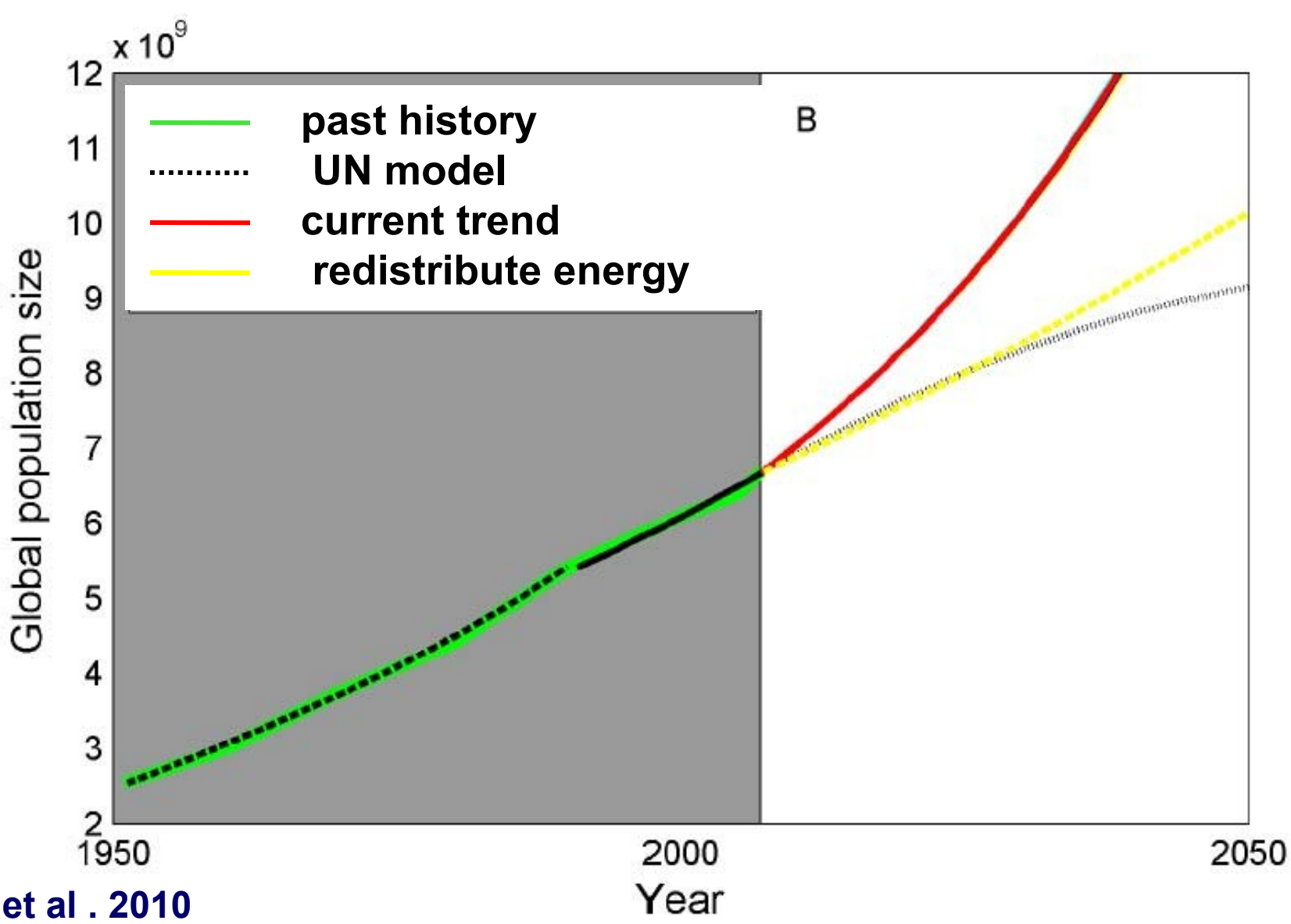
- something more drastic – like China's one child policy?

Stabilizing population growth – achieving the demographic transition by increased energy use



DeLong et al. 2010

Projected population growth



DeLong et al . 2010

Possible solutions

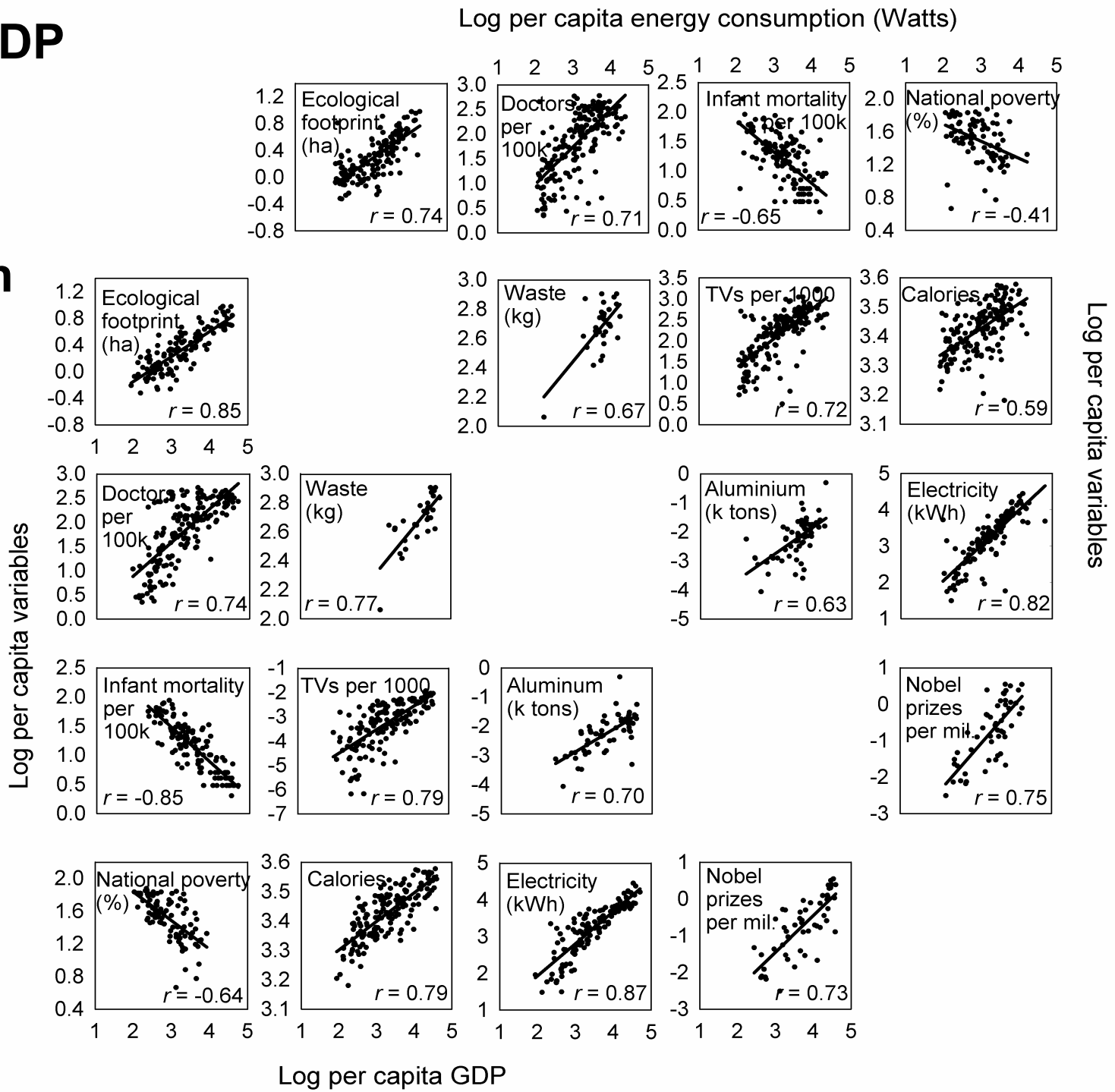
3) Reduce demand for energy by reducing per-capita consumption

- increase efficiency – limited gains and must counter “Jevon’s paradox”
- curtail lifestyle – “there is no such thing as a free lunch”

It is not just GDP

No such thing as a free lunch

Other metrics of quality of life are all correlated with GDP and energy use

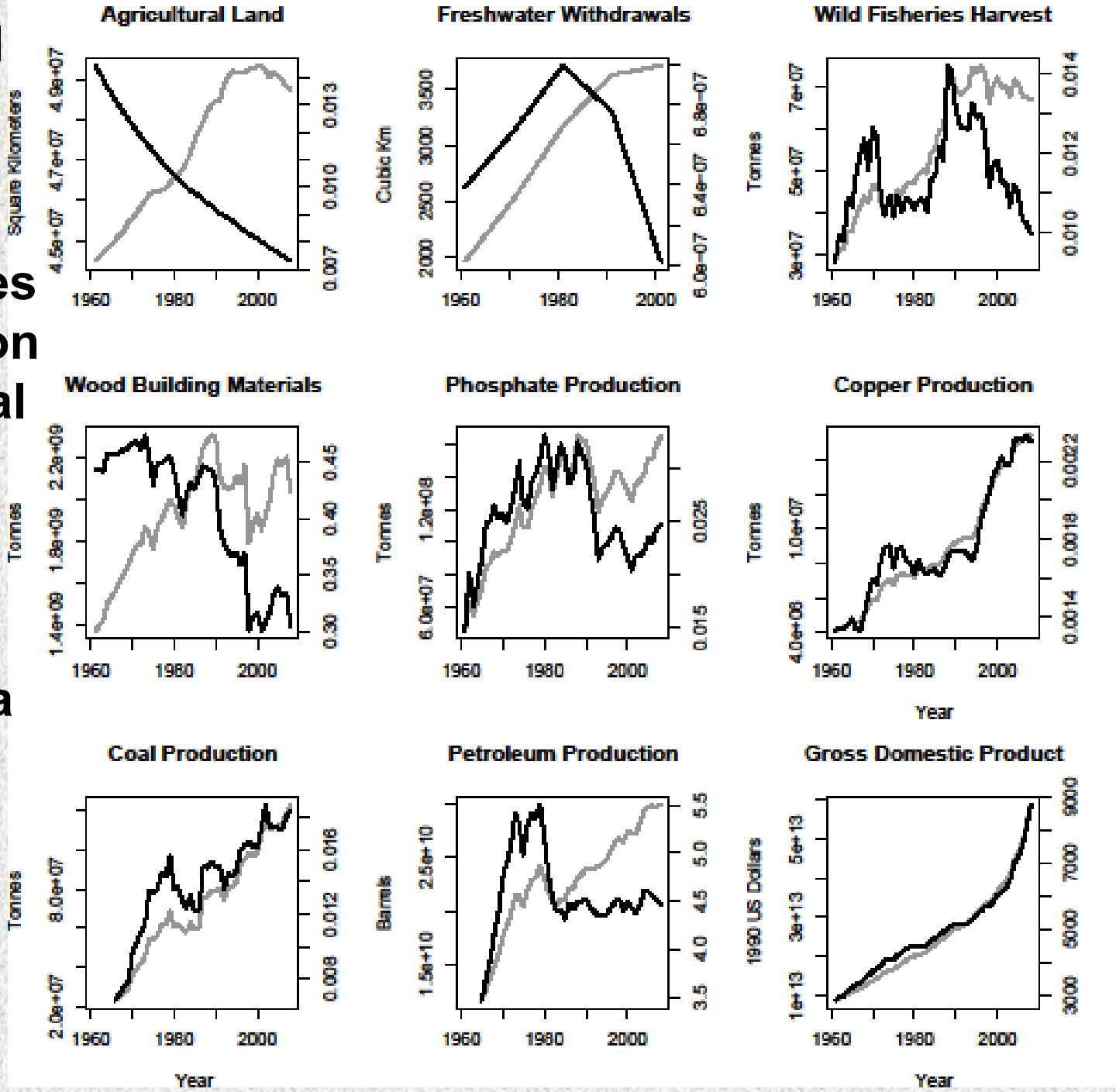


It's not just oil

Per capita rates of consumption of other critical resources are decreasing

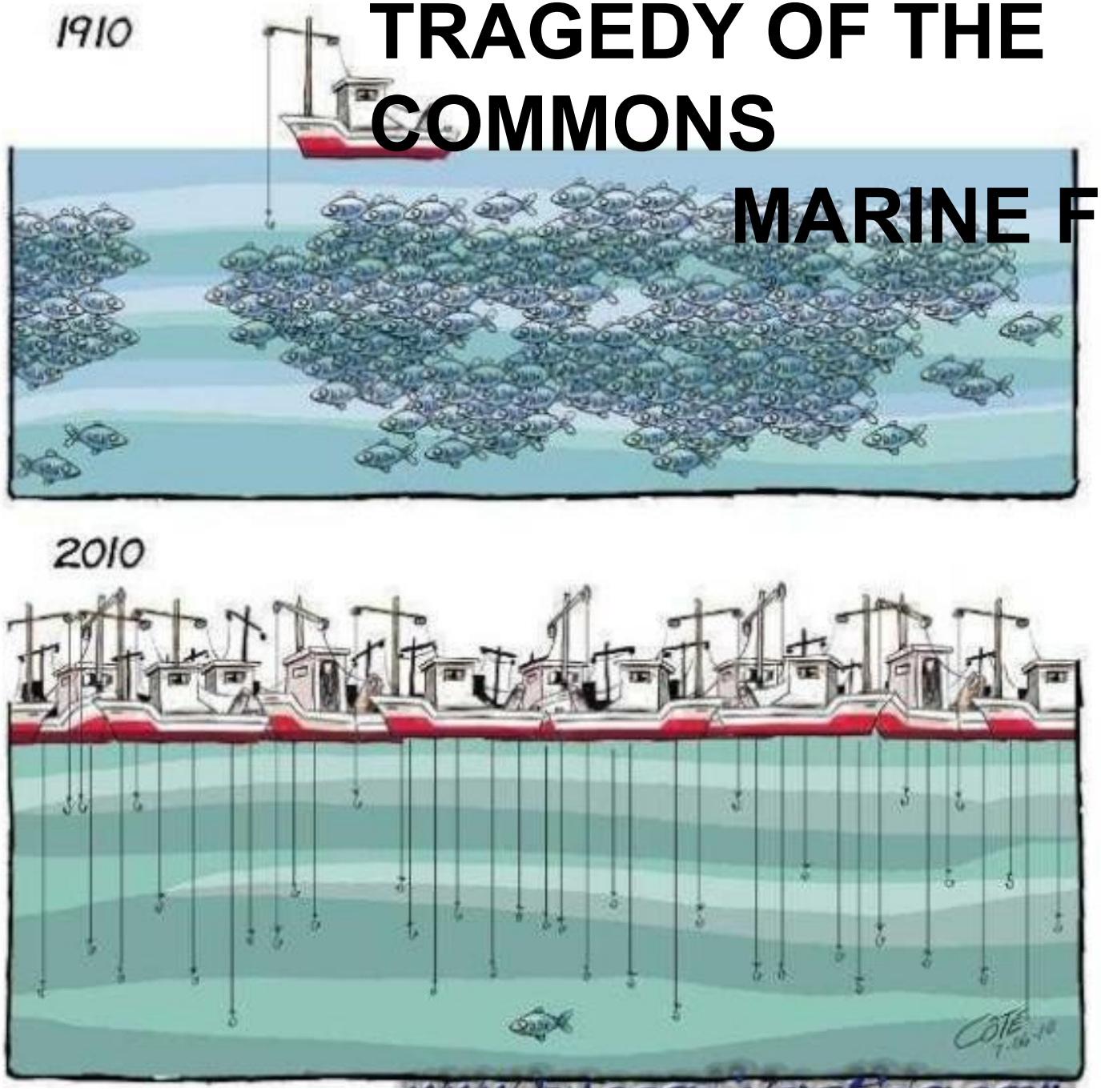
— per capita

— total

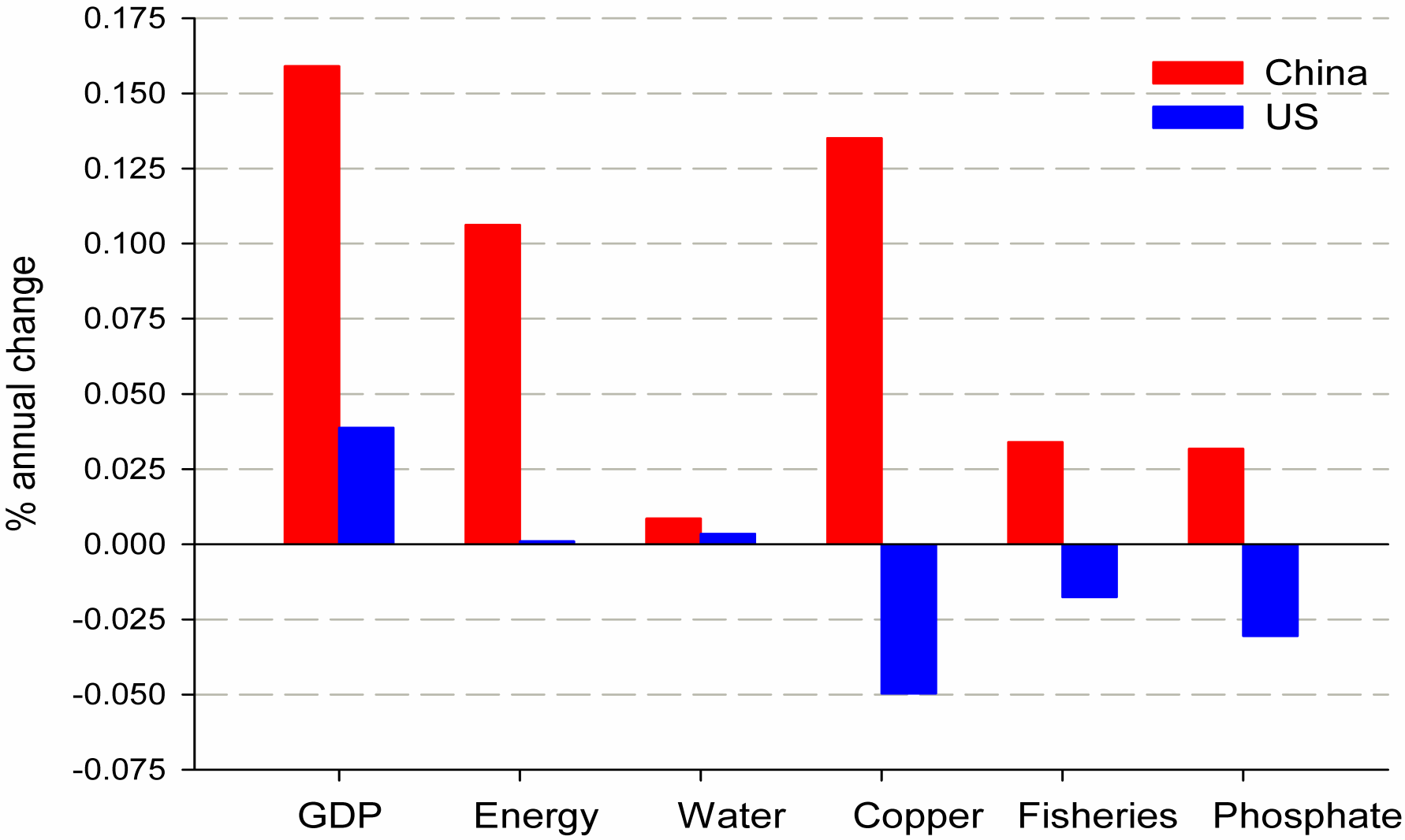


TRAGEDY OF THE COMMONS

MARINE FISHERIES



Resource use and economic growth China and US, 2000-2010



Sustainable development: assumption, hypothesis, oxymoron?

"Sustainable development … meets the needs of the present without compromising the ability of future generations to meet their own needs."

Brundtland Commission Report for the World Commission on Environment and Development (1987)

Sustainable development: assumption, hypothesis, oxymoron?

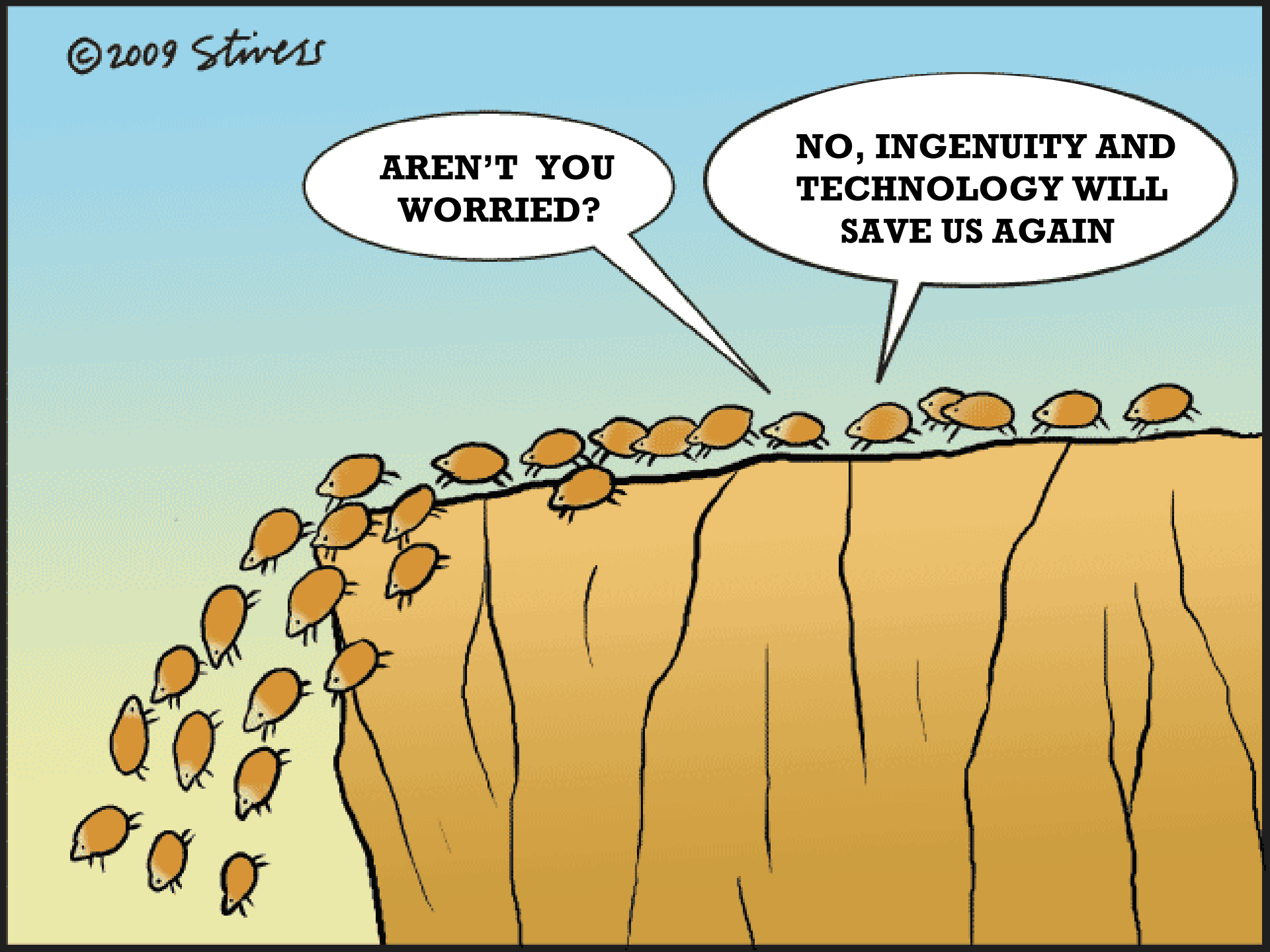
To "get the economy growing again" and "lift developing countries out of poverty" will require enormous quantities of energy

Exponential growth cannot continue indefinitely in a world of finite resources

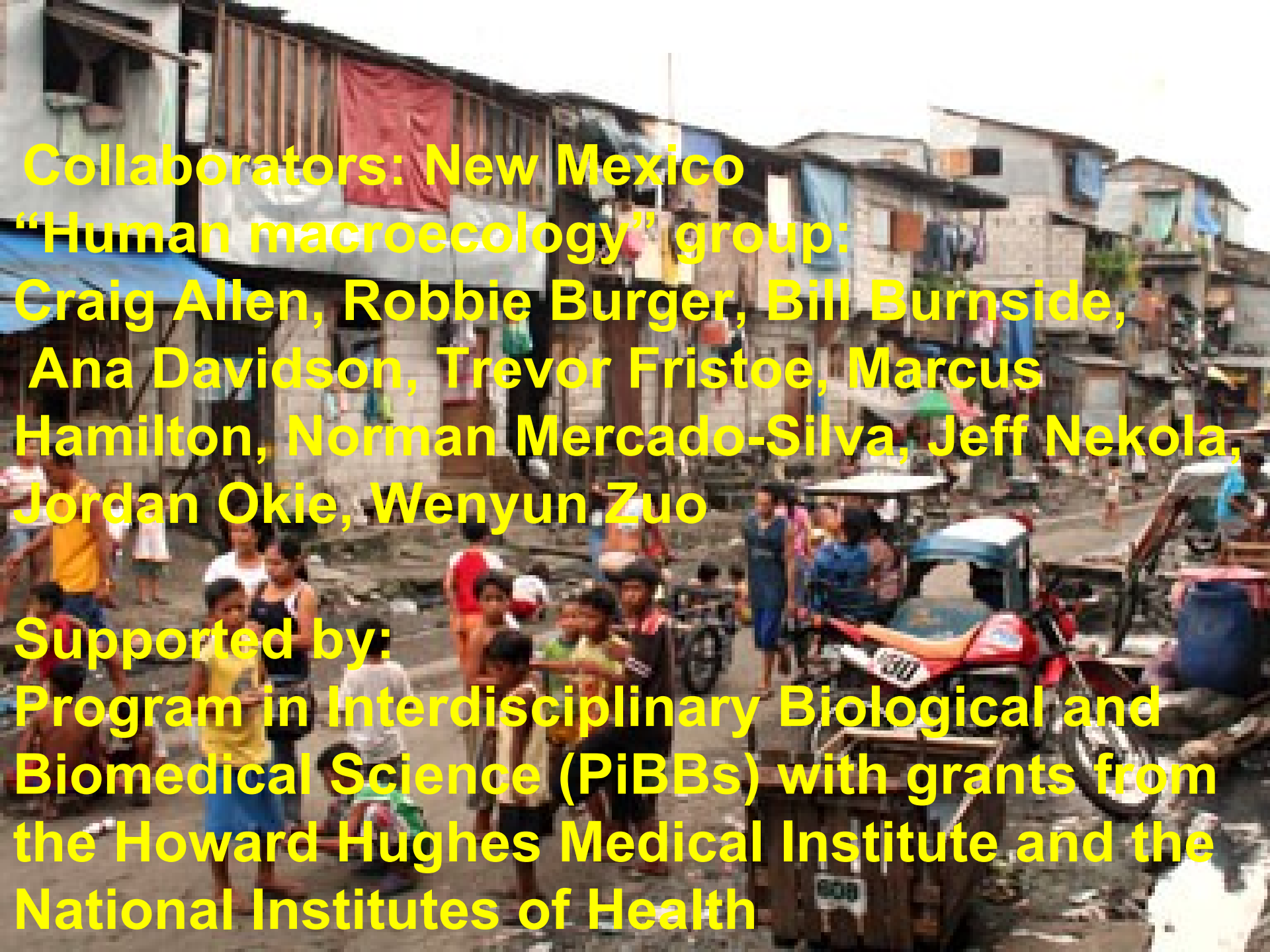
Per capita supplies of many critical resources have been declining since the 1980s

Much of economics is human ecology

The biggest obstacle to sustainability is human nature


©2009 Stivers
AREN'T YOU WORRIED?
NO, INGENUITY AND TECHNOLOGY WILL SAVE US AGAIN

GONE WITH THE WIND
"I can't think about that right now. If I do, I'll go crazy. I'll think about that tomorrow."
Scarlet O'Hara



Collaborators: New Mexico "Human macroecology" group: Craig Allen, Robbie Burger, Bill Burnside, Ana Davidson, Trevor Fristoe, Marcus Hamilton, Norman Mercado-Silva, Jeff Nekola, Jordan Okie, Wenyun Zuo

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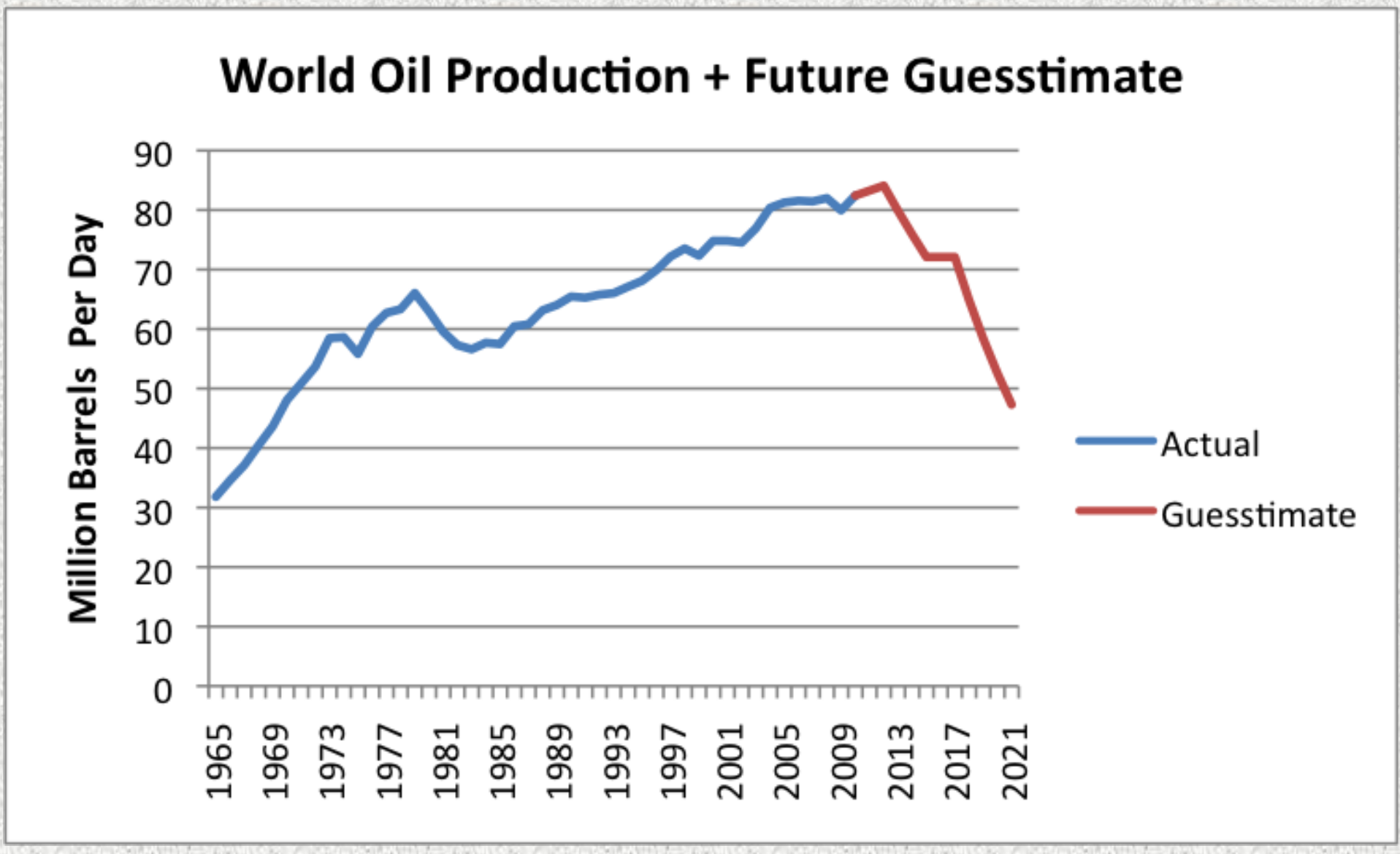


Courtesy of G. Tverberg

Dedicated to my grandchildren

BIRTH RATES IN MODERN NATIONS

↑ developing world

← developed world

POWER AND APPLICATIONS OF HUMAN MACROECOLOGY

- NON-EXPERIMENTAL BUT RIGOROUS AND QUANTITATIVE
- LARGE SCALES OF SPACE AND TIME
- STATISTICAL PATTERNS CALL FOR MECHANISTIC PROCESSES
- DON'T NEED HUMAN SUBJECTS PROTOCOLS

THE DUALITY OF *Homo sapiens*

ON ONE SIDE:

- JUST ONE OF MILLIONS OF SPECIES

- SUBJECT TO THE SCIENTIFIC LAWS
  PHYSICS AND CHEMISTRY:
  CONSERVATION OF
  ENERGY, MASS, STOICHIOMETRY
  BIOLOGY:
  MALTHUSIAN-DARWINIAN DYNAMIC

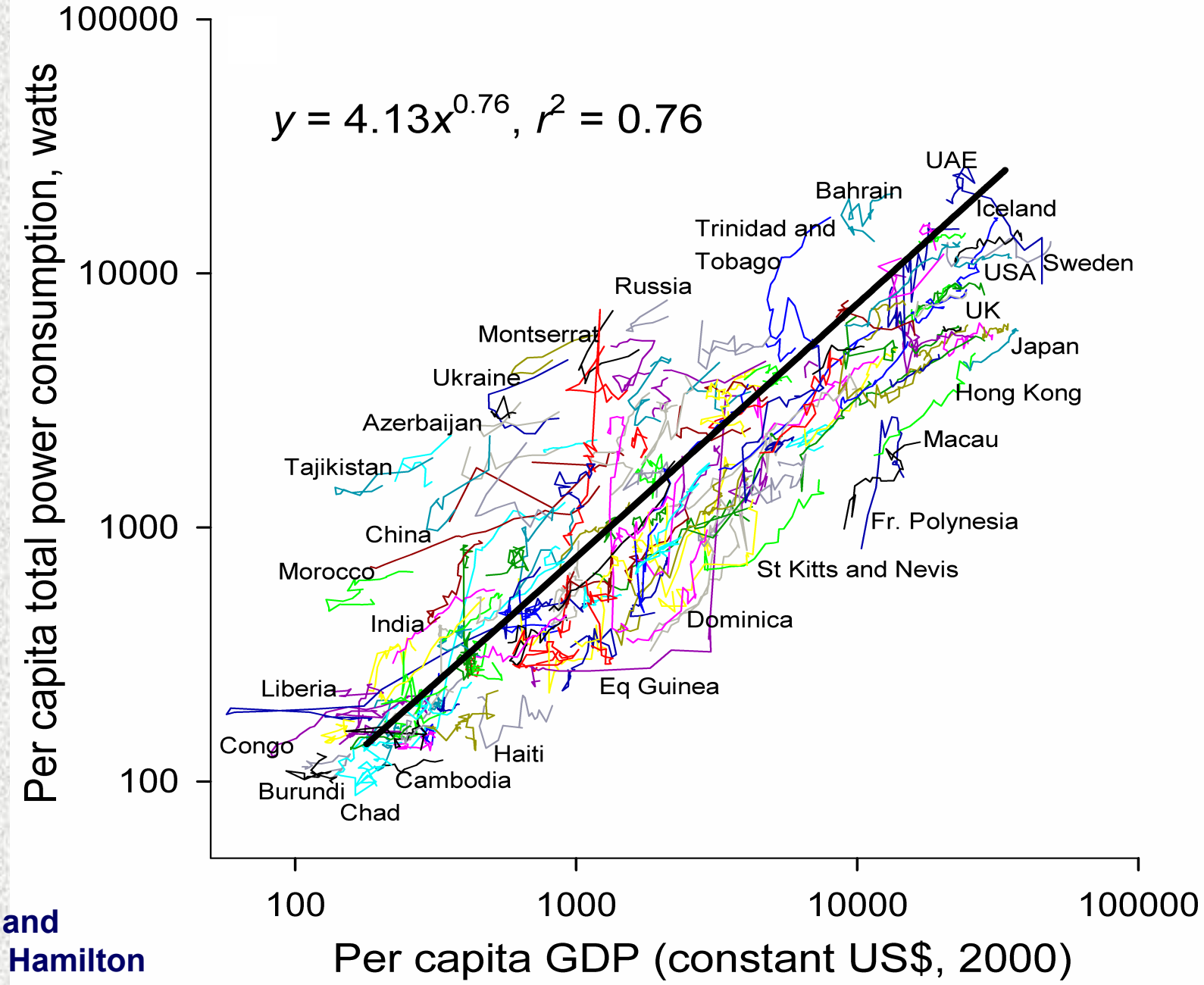
- SUBJECT OF NATURAL SCIENCES
  BIOMEDICINE, ECOLOGY

THE DUALITY OF *Homo sapiens* ON THE OTHER SIDE:

HUMANS ARE UNIQUE

- **BRAIN AND BEHAVIOR,**
- **AGRICULTURAL, INDUSTRIAL, TECHNOLOGICAL ECONOMY**
- **THE ECOLOGICALLY DOMINANT SPECIES**
- **SUBJECT OF SOCIAL SCIENCES PSYCHOLOGY, SOCIOLOGY, ECONOMICS**

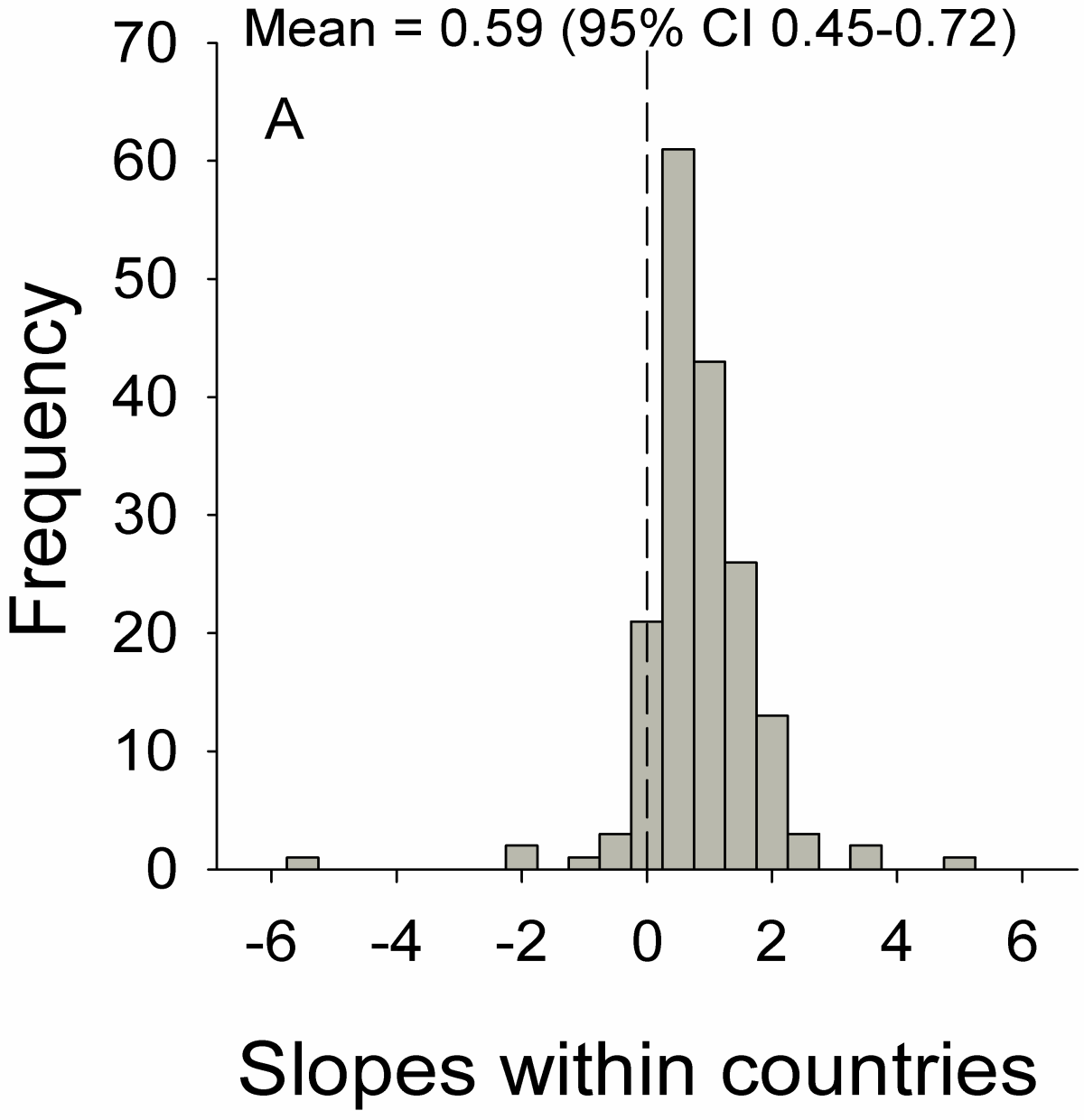
Per-capita energy use vs. per capita GDP



Data compiled and analyzed by M. Hamilton

Per-capita energy use vs. per capita GDP

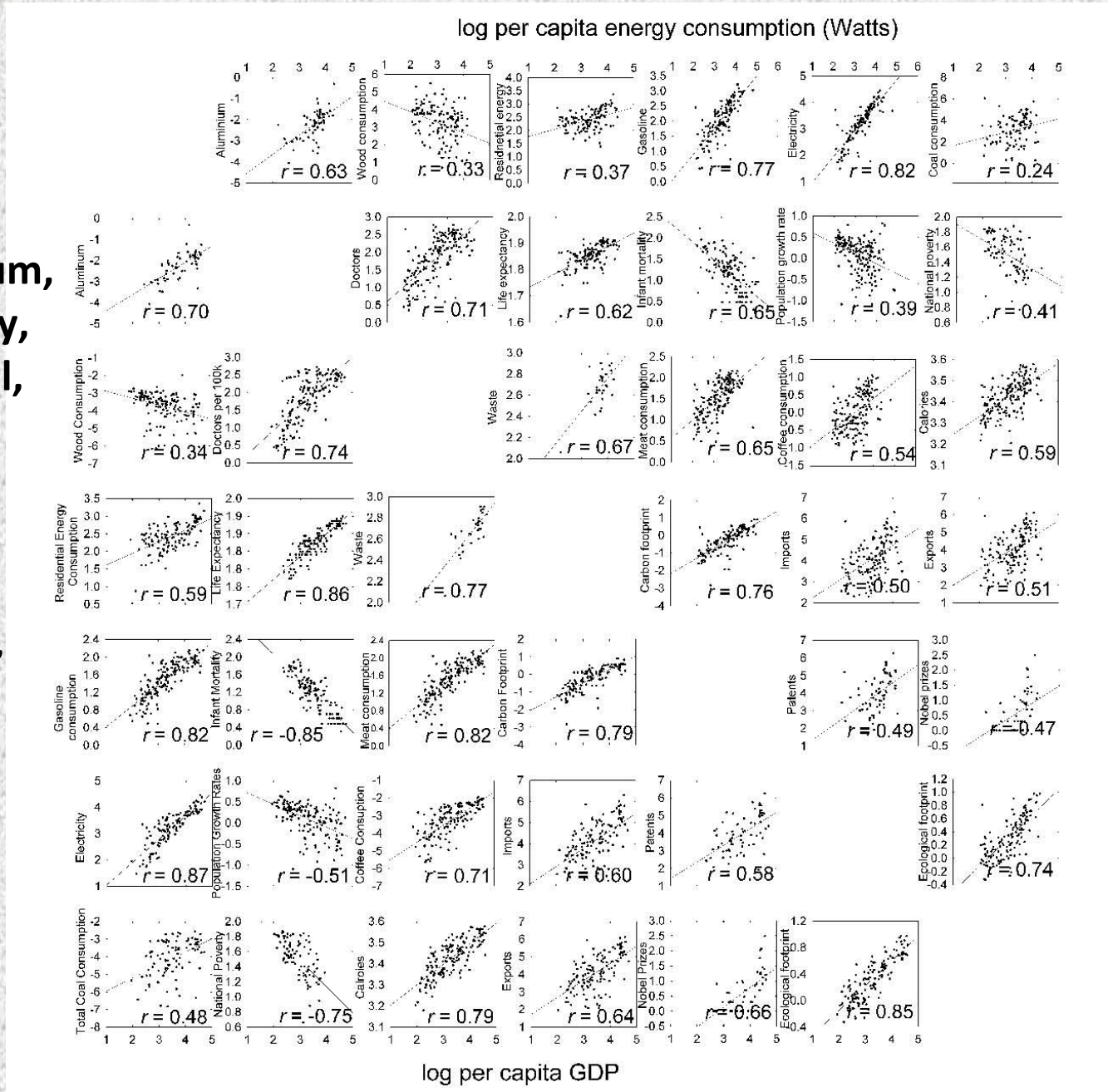
Slopes over 25 years, 1980-2005



Data compiled and analyzed by M. Hamilton

Other metrics are all correlated with GDP and energy use

- consumption of aluminum, wood, residential energy, gasoline, electricity, coal, meat, coffee, calories
- production of waste
- number of doctors, life expectancy, infant mortality, poverty level, population growth rate
- carbon and ecological footprint
- imports, exports
- patents, Nobel Prizes



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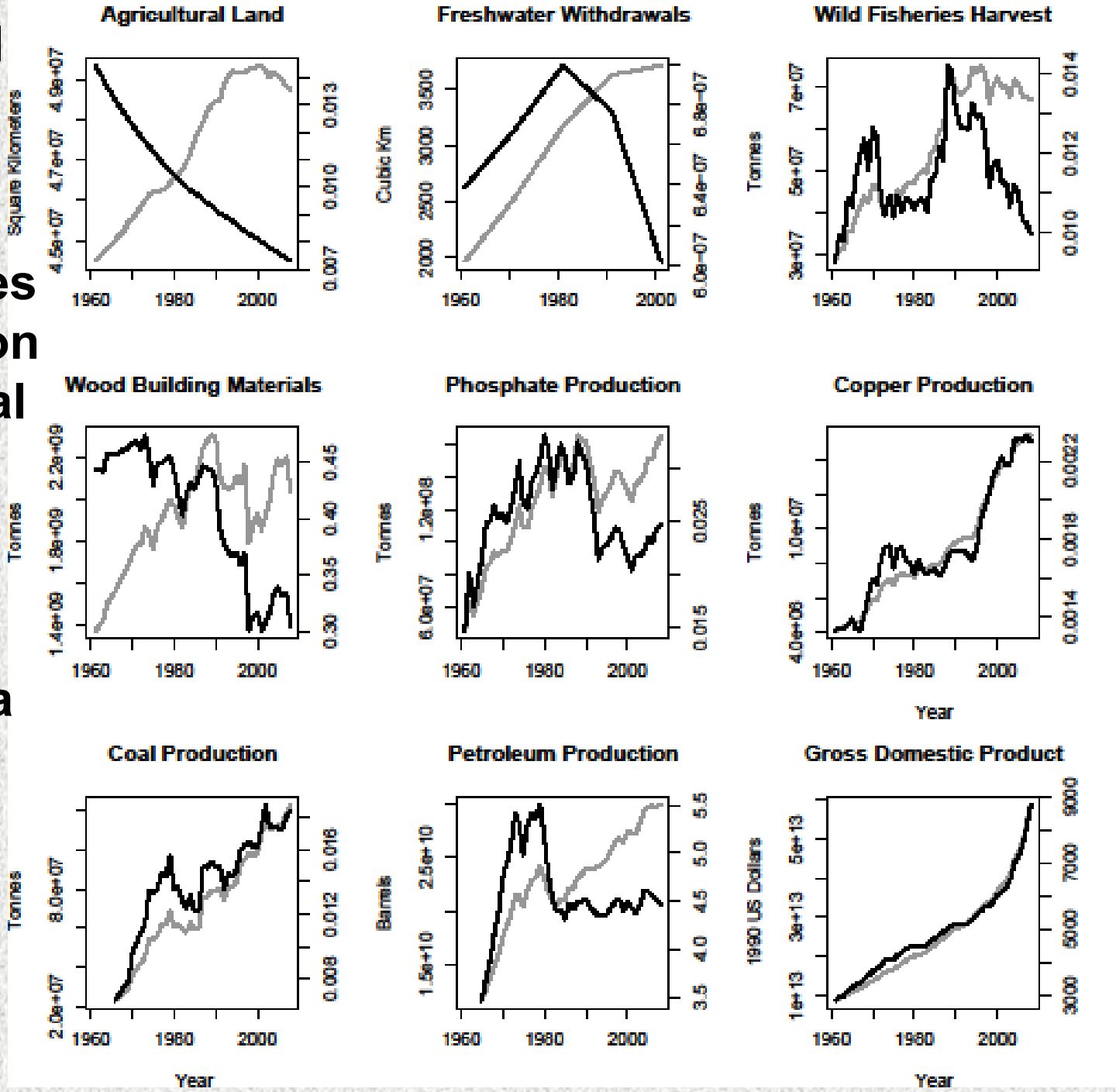
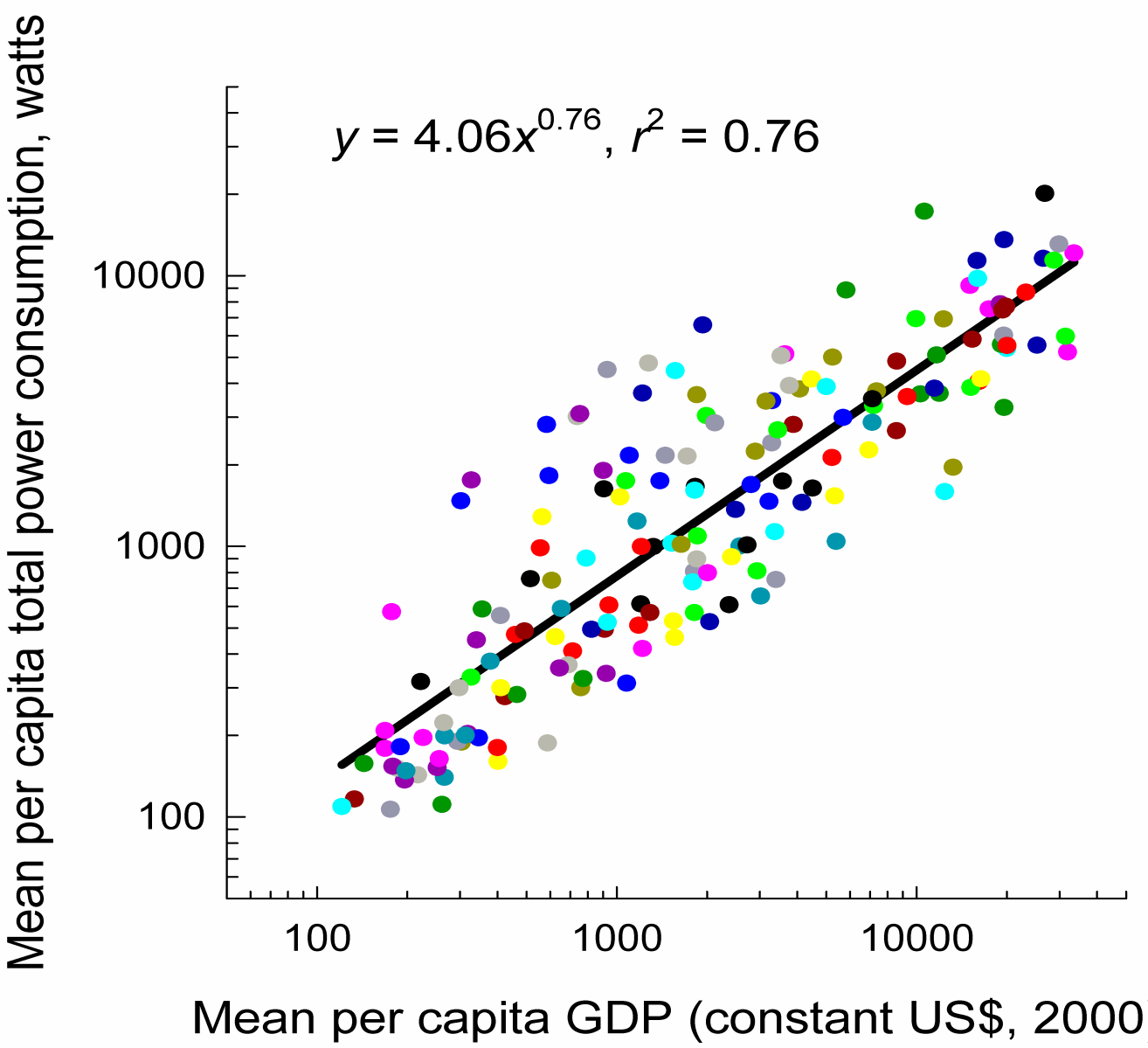


ENERGY AND ECONOMICS:

a macroecological and metabolic perspective

- GDP tracks per capita energy use across nations and over time
- Energy fuels economic growth and development
- All measures of standard of living are correlated with energy use and GDP
- Most energy comes from fossil fuels
- Limited potential to substitute renewable sources
- Implications for
  - "getting the economy growing again"
  - "sustainable development"
    - *Third World must develop or die* (BBC 2/12/09)

Per-capita energy use vs. per capita GDP
25-year averages for alternative scenarios



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NO, INGENUITY AND TECHNOLOGY WILL SAVE US AGAIN
ARE YOU WORRIED?

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UNM/SFI/LANL scaling group:
O. Burger, W. Burnside, H. Davis, M. Hamilton, M. Moses, J. Okie, G. West, W. Woodruff