

*How Climate Change and Oil
Depletion Illustrate the
Limits to Growth*

Presentation by Dennis Meadows
to the
Club of Vienna
Vienna, 5 May 2006

Overview of my Comments

- Thirty-five years of data show our original study results were correct. Many limits will become serious in the next two decades; climate change and oil depletion are illustrations.
- The critics have shifted their claims over time.
- Politics and the market are inherently unsuited to adopt constructive policies.
- Therefore the main policies have not changed, and overshoot has already occurred.
- Overshoot need not lead to collapse, sustainable development is still possible - barely.
- The key changes are psychological, not technical.

The Ideas of *Limits to Growth*

- One does not need a computer model to prove there are physical limits to physical growth on a physically finite planet. That was not our goal, and it was not our main contribution.
- Our contribution was to show that population and industrial growth are inherently exponential; and that exponential growth takes one to any existing limit quickly, whatever its magnitude.
- We showed also that global society will most likely adjust to limits by overshoot and collapse, not by S-shaped growth. But sustainable development is possible, if important changes are made.

We Were Correct

- The scale of human activities has grown to alter the physical characteristics of the globe.
- World population and industry have continued to grow exponentially, and our scenarios for 2000, made in 1972 were accurate.
- The global system has overshoot its limits.
- Steady decline has already shown up in the statistics of over 50 countries.

Human beings and the natural world are on a collision course. **Human activities inflict harsh and often irreversible damage on the environment and on critical resources.** ... many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know. **Fundamental changes are urgent....**

World Scientists' Warning to Humanity signed by more than 1,600 scientists, including 102 Nobel laureates, from 70 countries, 1992.

The Critics Said Don't Worry:

- There are no effective limits.
- Perhaps there are limits, but they are far away.
- Perhaps the limits are near, but technology will avoid any problems.
- Technology apparently does not avoid all problems, but markets will allocate the available goods and services satisfactorily.
- Markets do not always work, but it is too late to avoid the overshoot. We must adapt. In any event, DON'T WORRY

SPECIAL REPORT GLOBAL WARMING

TIME

BE WORRIED. BE **VERY** WORRIED.

Climate change isn't some vague future problem—it's already damaging the planet at an alarming pace. Here's how it affects you, your kids and their kids as well

EARTH AT THE TIPPING POINT
HOW CHINA & INDIA CAN HELP SAVE THE WORLD—OR DESTROY IT
THE CLIMATE CRUSADERS

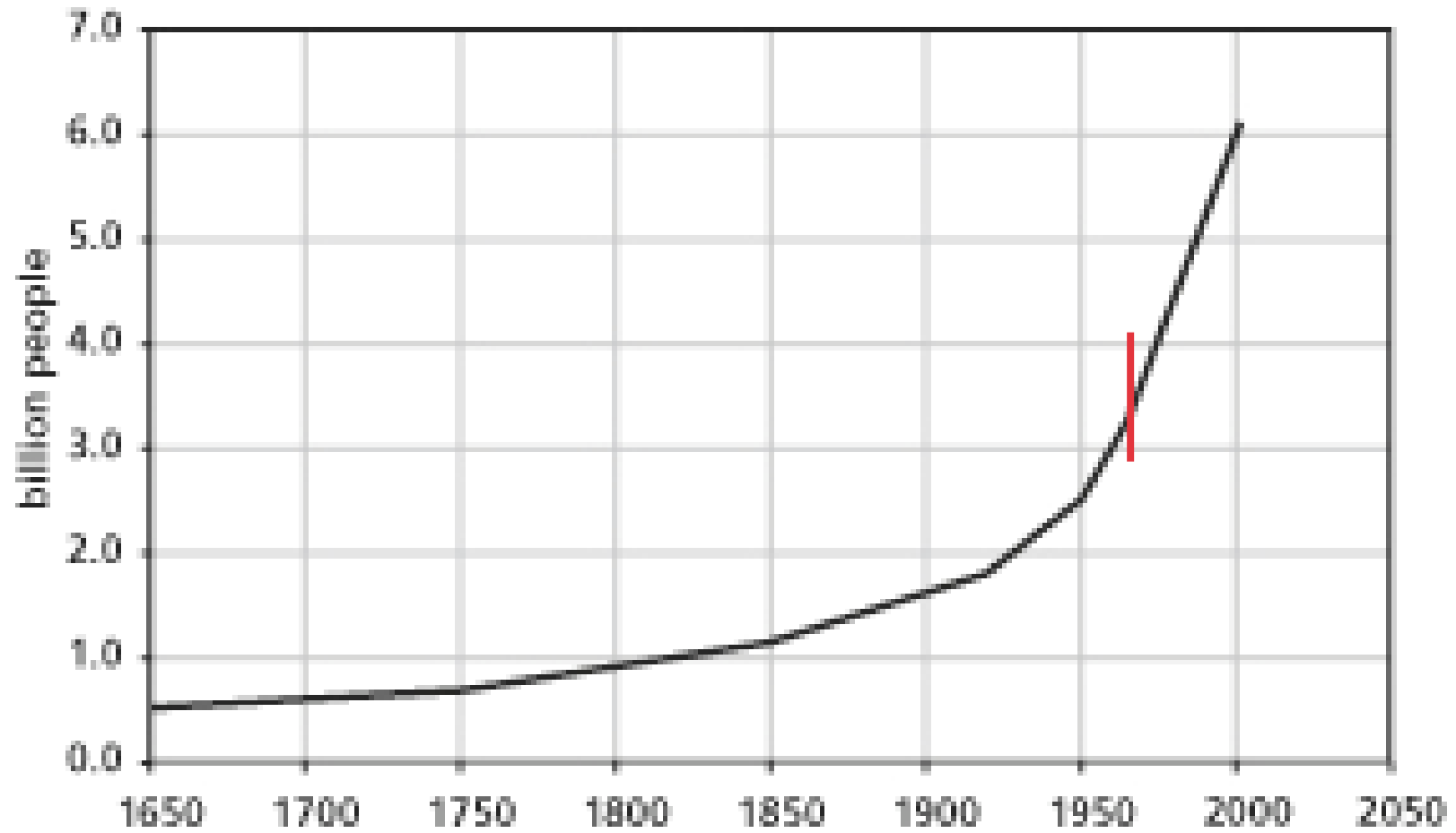


ARGENTINA \$12.00 AUSTRALIA \$12.00 BELGIUM \$12.00 BRAZIL \$17.00 CANADA \$12.00 CHINA \$12.00 CZECH REPUBLIC \$12.00 DENMARK \$12.00 FINLAND \$12.00 FRANCE \$12.00 GERMANY \$12.00 GREECE \$12.00 HONG KONG \$12.00 HUNGARY \$12.00 INDIA \$12.00 ITALY \$12.00 JAPAN \$12.00 KOREA \$12.00 MEXICO \$12.00 NETHERLANDS \$12.00 NEW ZEALAND \$12.00 NORWAY \$12.00 POLAND \$12.00 PORTUGAL \$12.00 ROMANIA \$12.00 RUSSIA \$12.00 SINGAPORE \$12.00 SOUTH AFRICA \$12.00 SPAIN \$12.00 SWEDEN \$12.00 SWITZERLAND \$12.00 TAIWAN \$12.00 THAILAND \$12.00 U.K. \$12.00 U.S. \$12.00 VIETNAM \$12.00



BELIZE \$12.00 COLUMBIA \$14.00 JAMAICA \$12.00 PANAMA \$12.00
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CHILE (include tax) \$12.00 HONG KONG \$12.00 NICARAGUA \$12.00

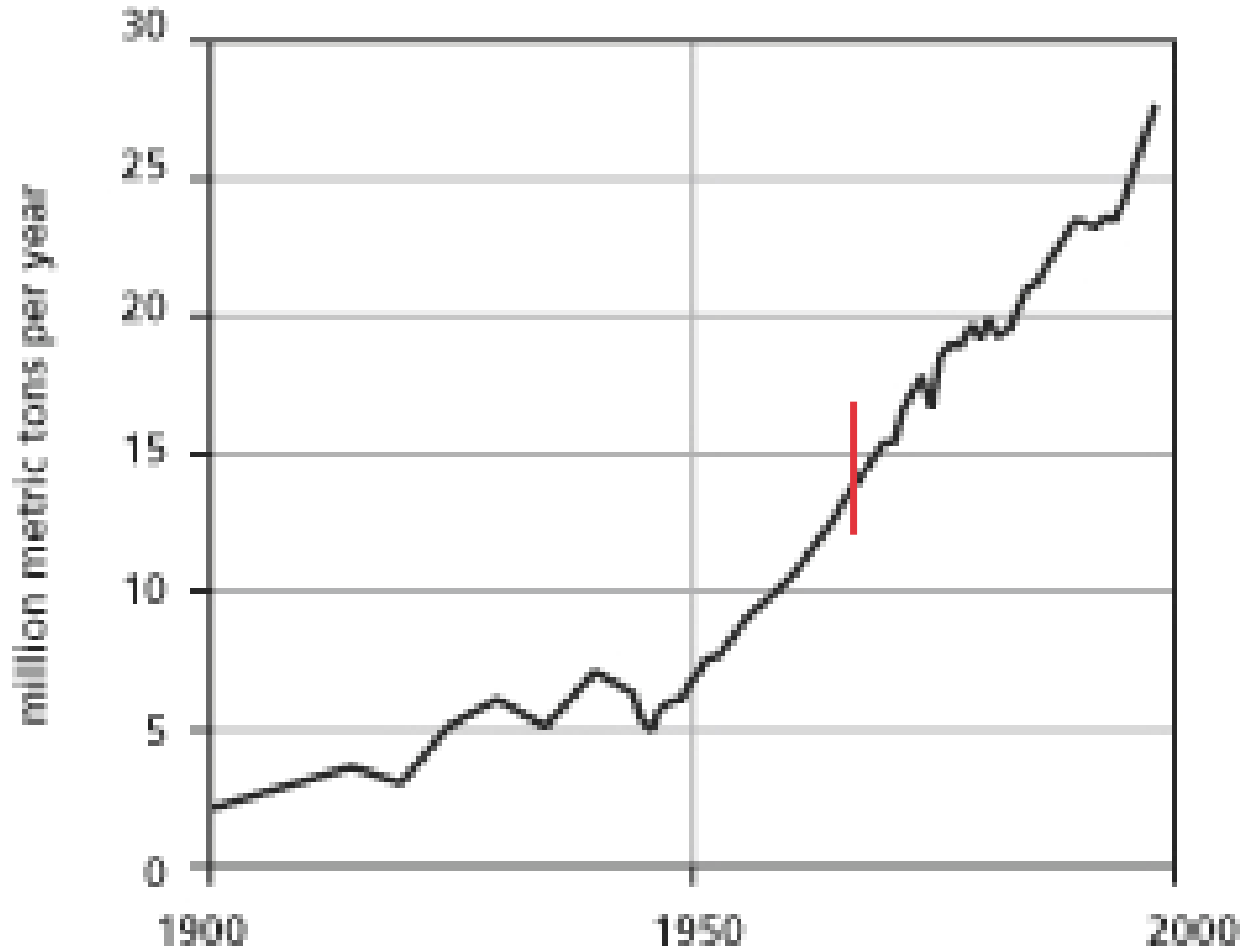
World Population



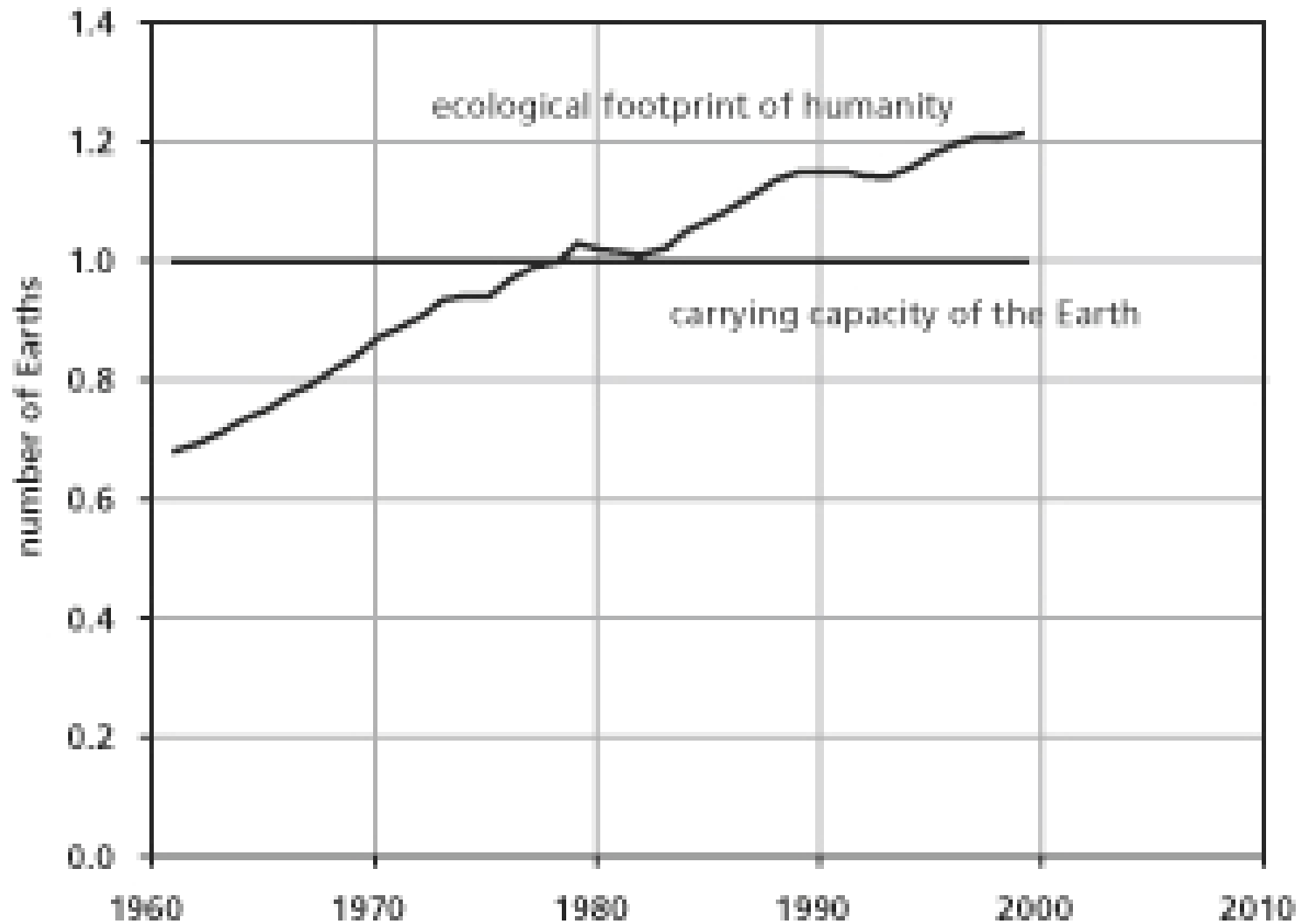
Industrial Production



Index of World Metals Use



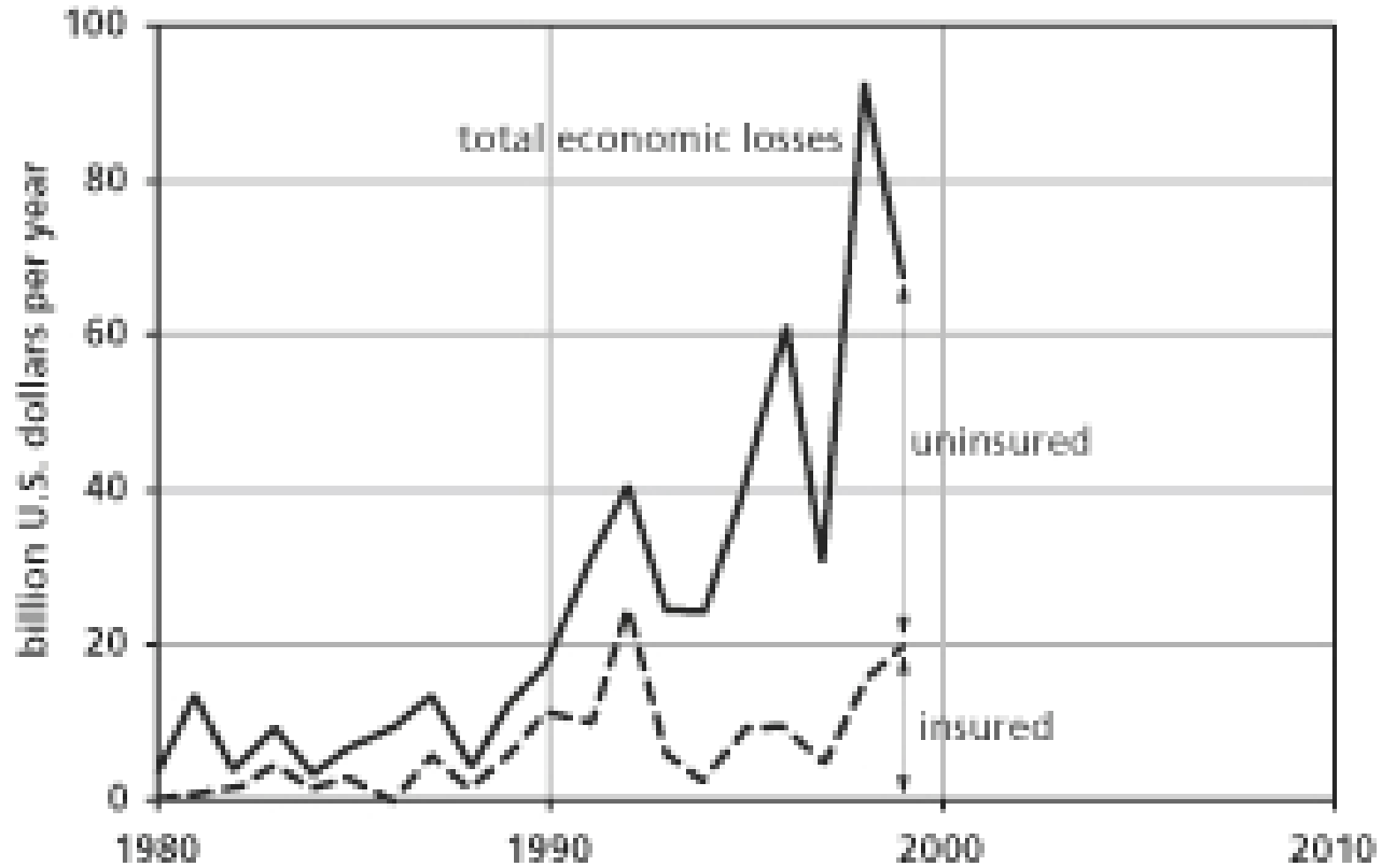
One Indicator of Overshoot



Some Indicators of Overshoot

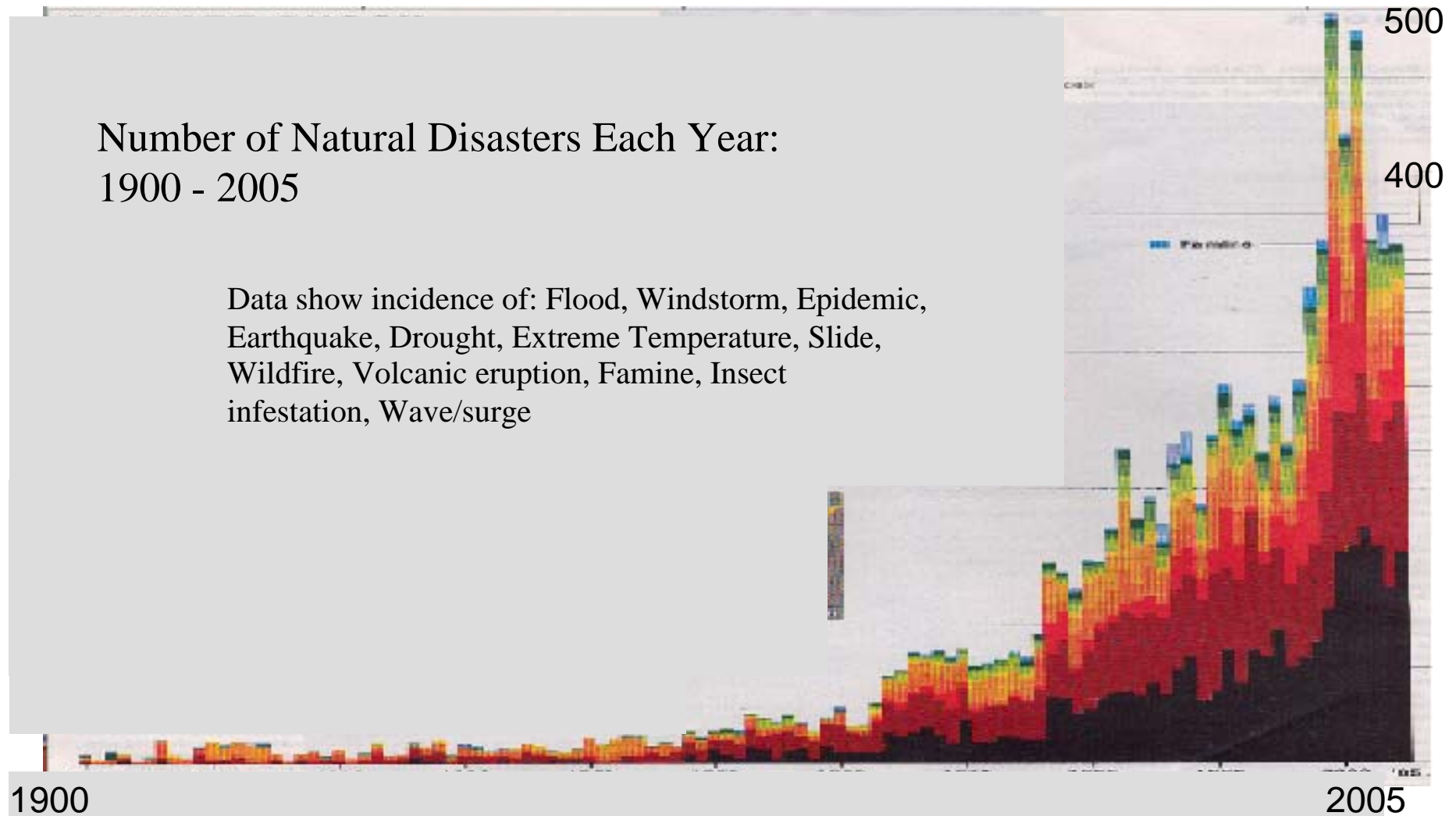
- Deterioration in renewable resources - surface and ground water, forests, fisheries, agricultural land.
- Rising levels of pollution.
- Growing demands for capital, resources, and labor by military and industry to secure, process, and defend resources.
- Investment in human resources (education, shelter, health care) postponed in order to provide immediate consumption and security demands.
- Rising debt; eroding goals for health and environment.
- Growing instability in natural ecosystems.
- Growing gap between rich and poor - between the powerful and the weak. **Meadows, et. al. pp 176-177.**

Insurance Losses

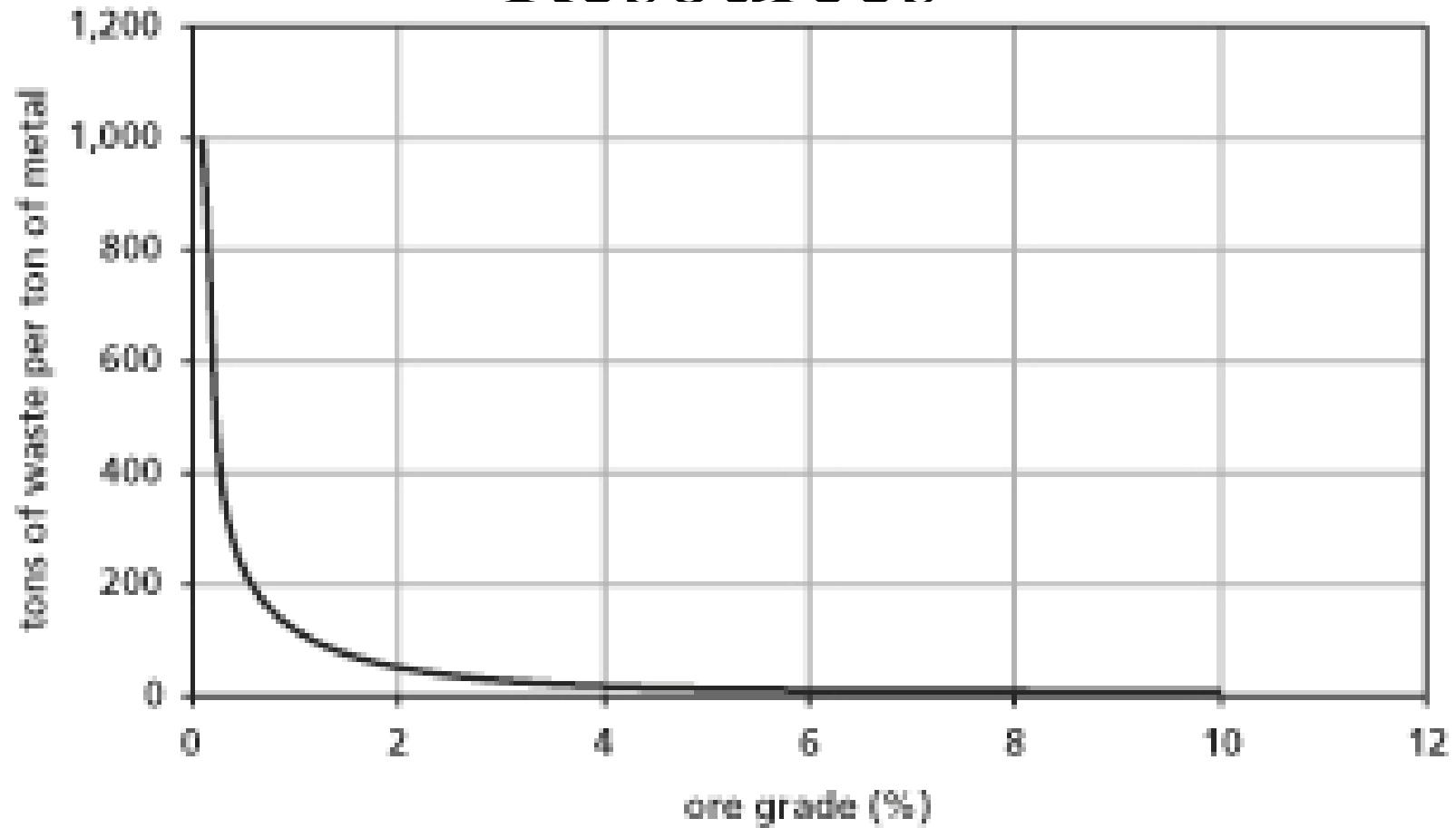


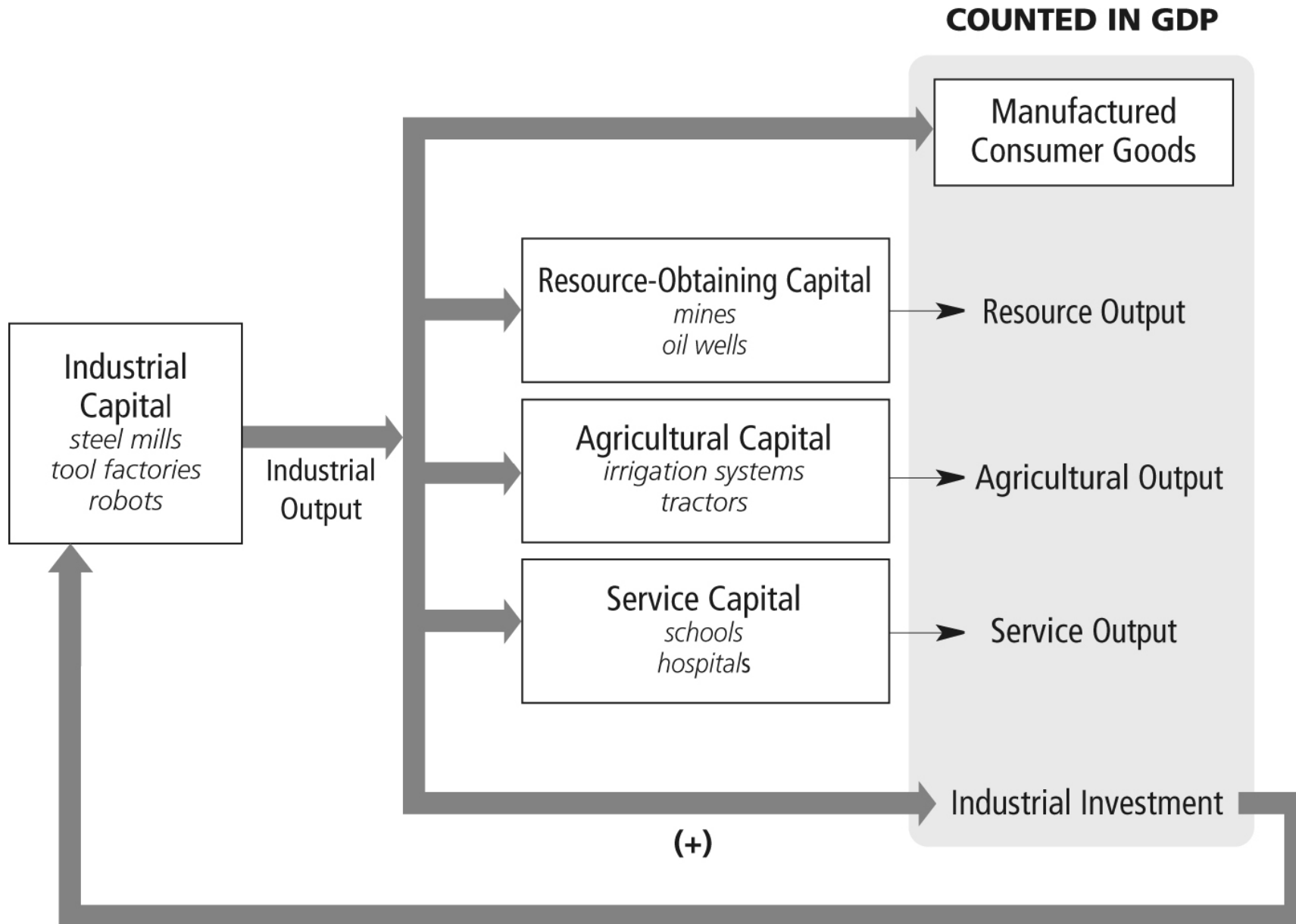
Number of Natural Disasters Each Year: 1900 - 2005

Data show incidence of: Flood, Windstorm, Epidemic,
Earthquake, Drought, Extreme Temperature, Slide,
Wildfire, Volcanic eruption, Famine, Insect
infestation, Wave/surge

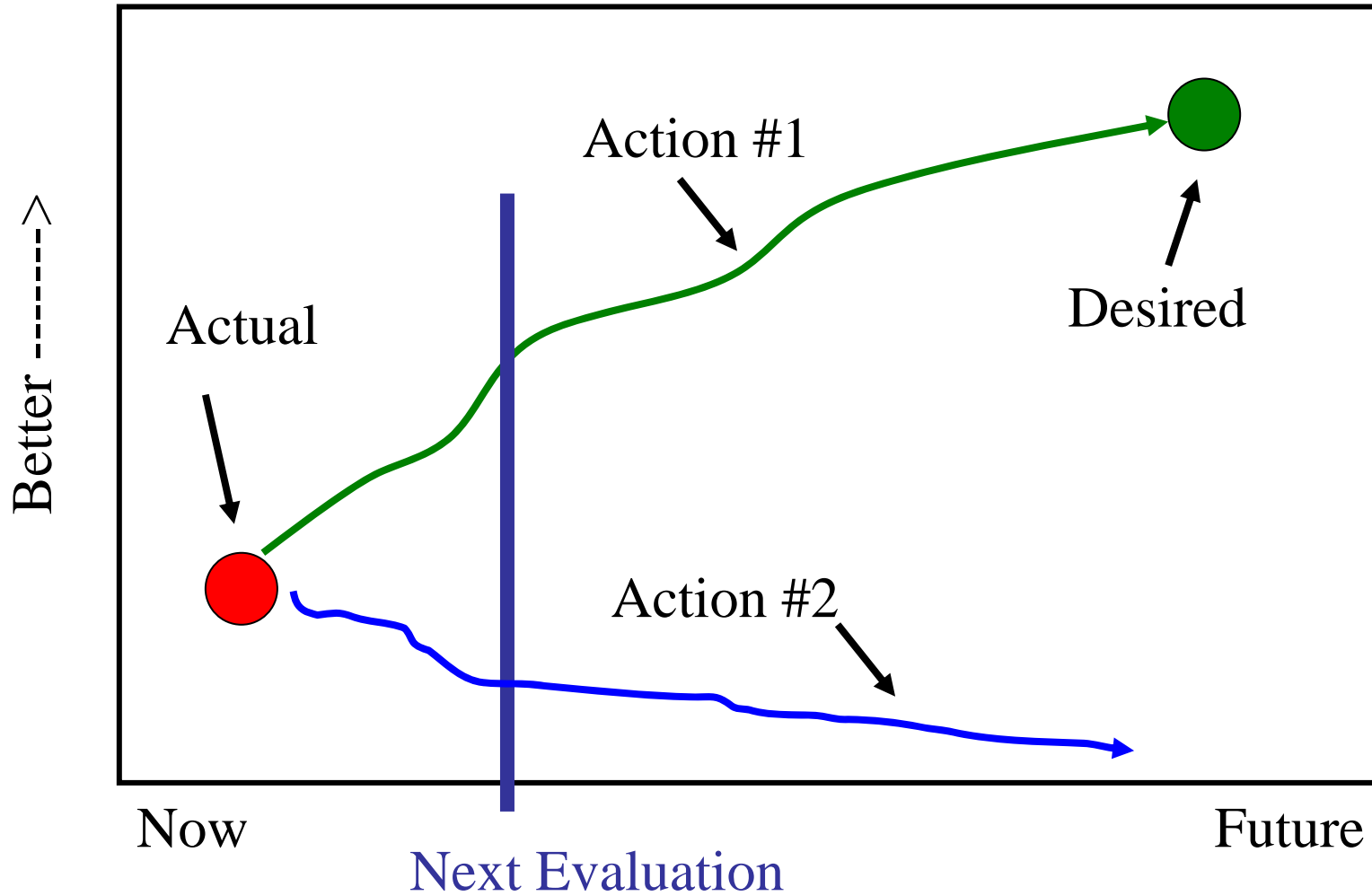


Index of Capital to Obtain Resources

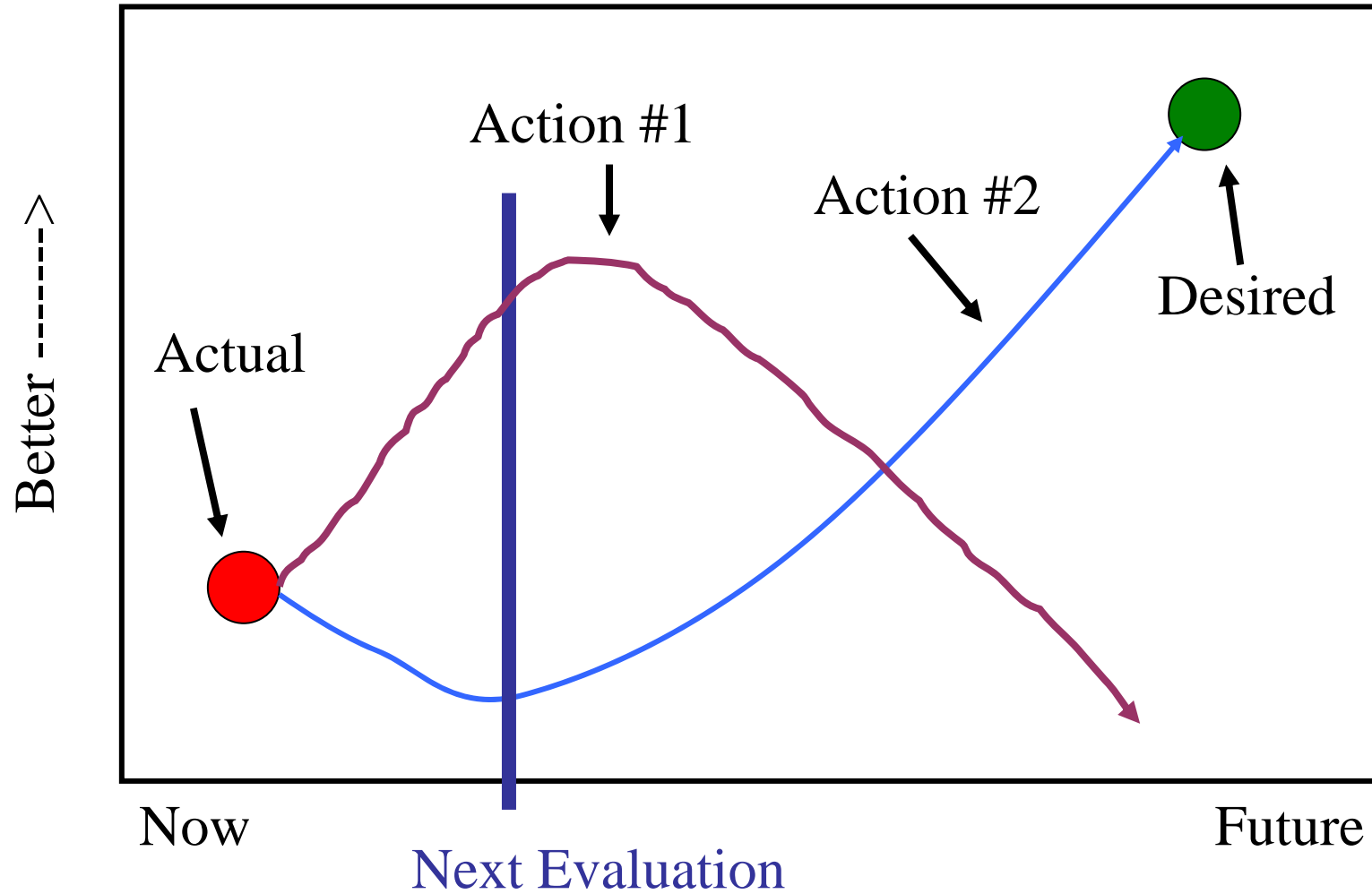




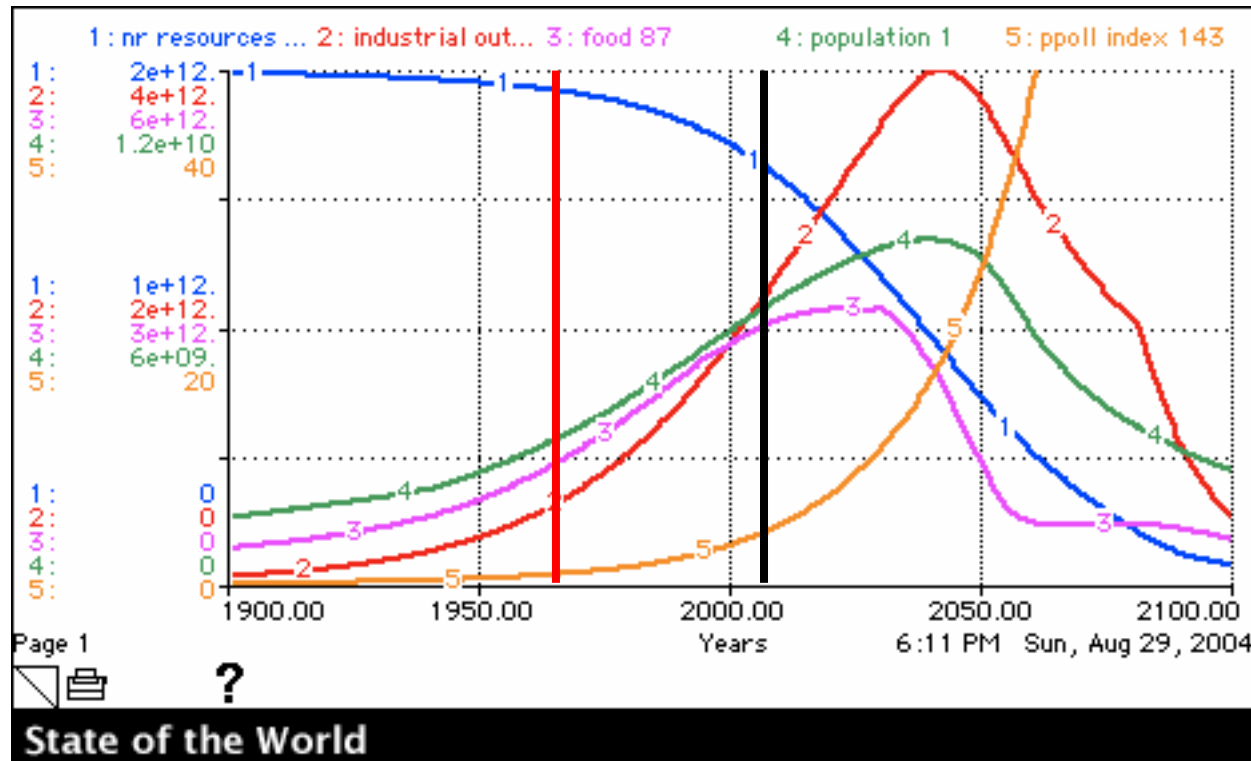
Easy Problems



Hard Problems



The Reference Scenario



Pollution

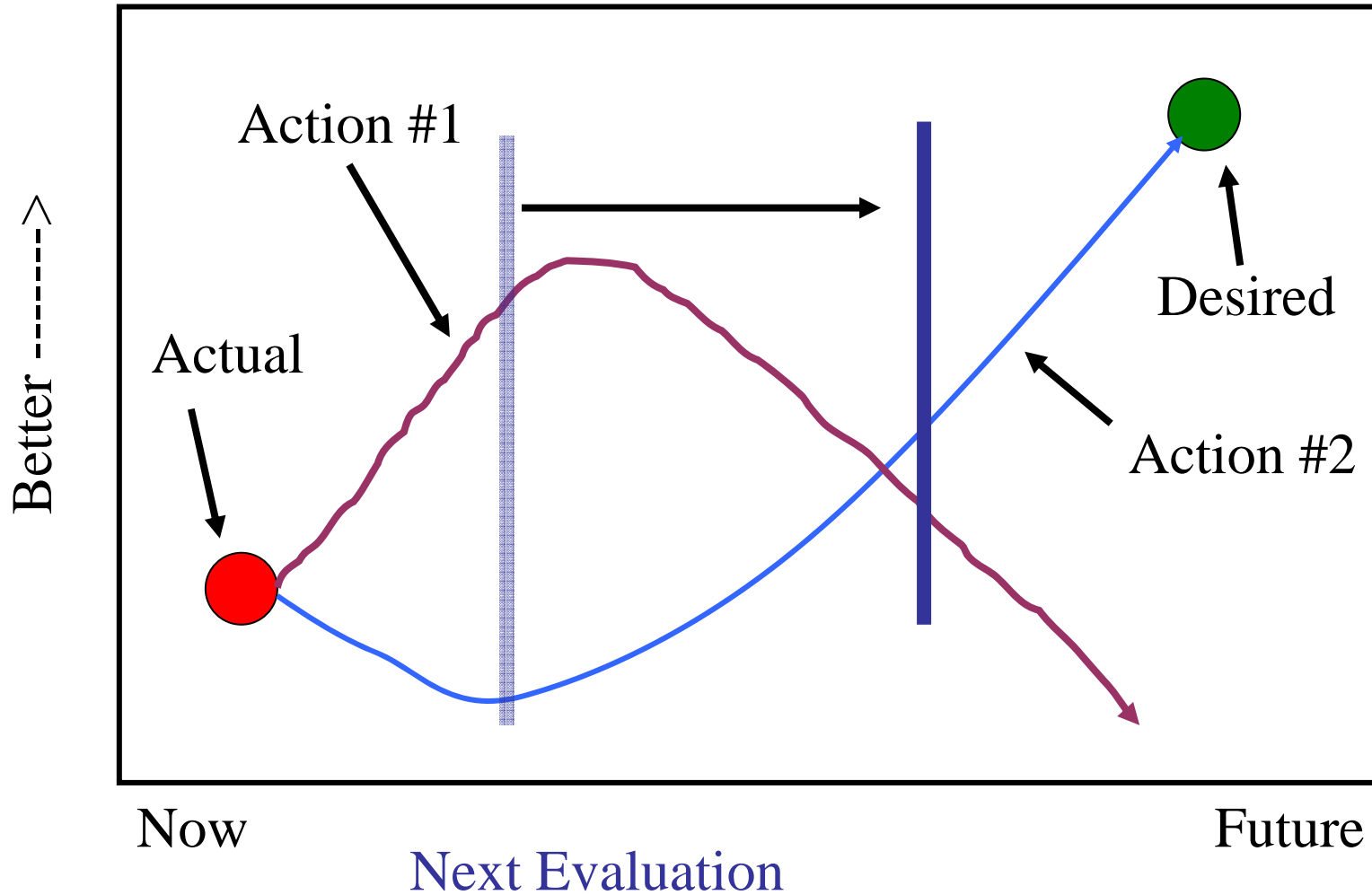
Population

Industrial Output

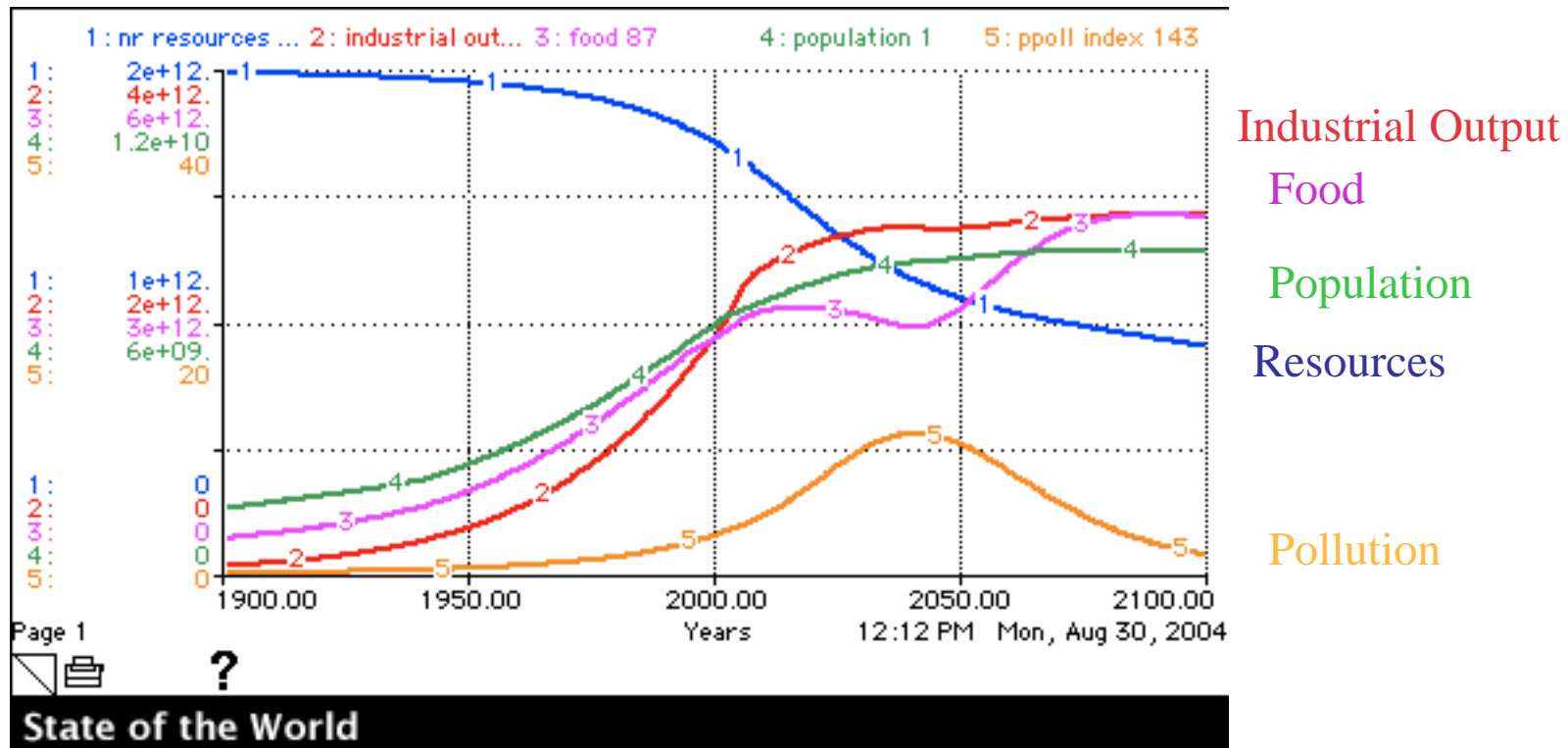
Food

Resources

Hard Problems Become Easy with Greater Time Horizon

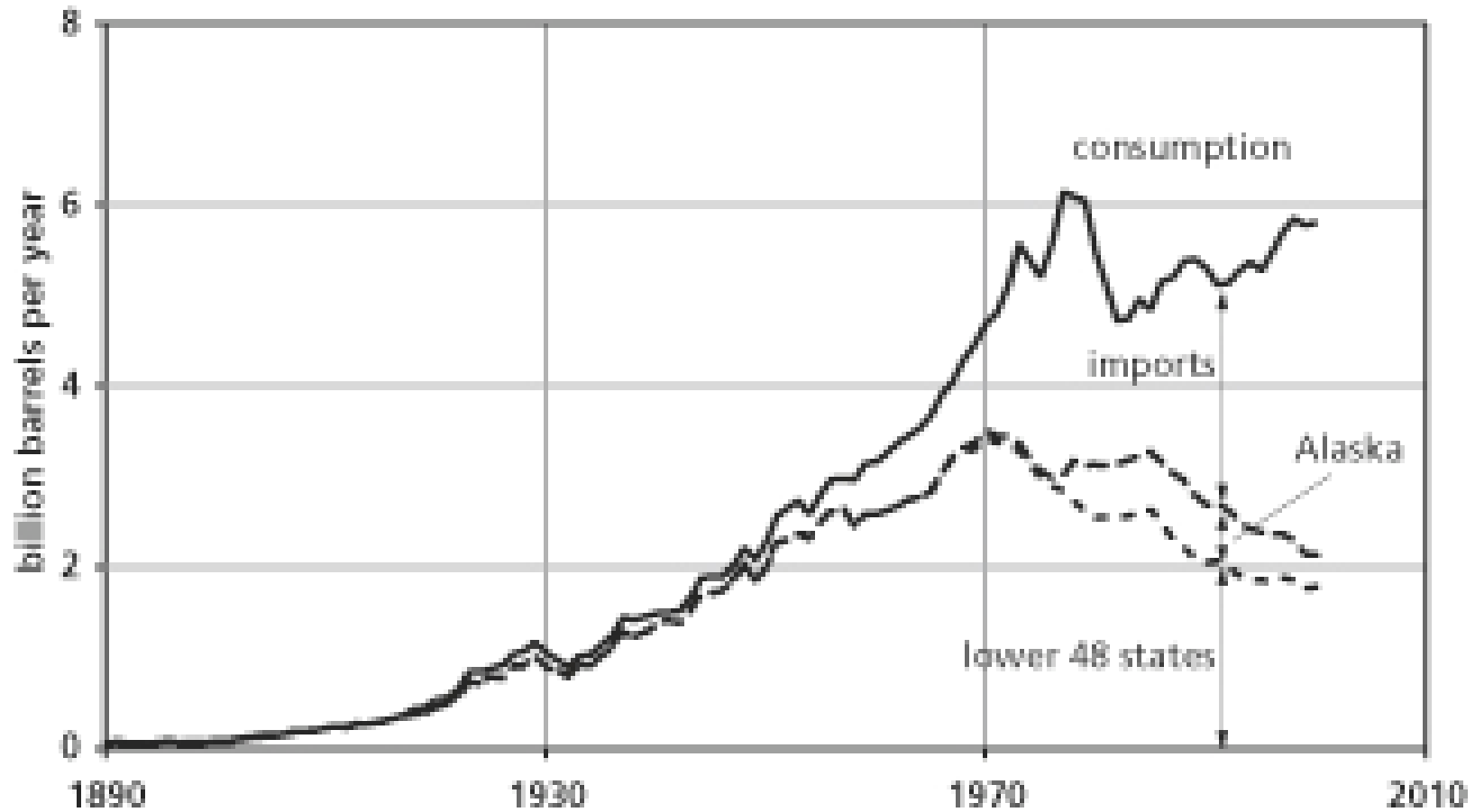


#1 - Sustainable Development

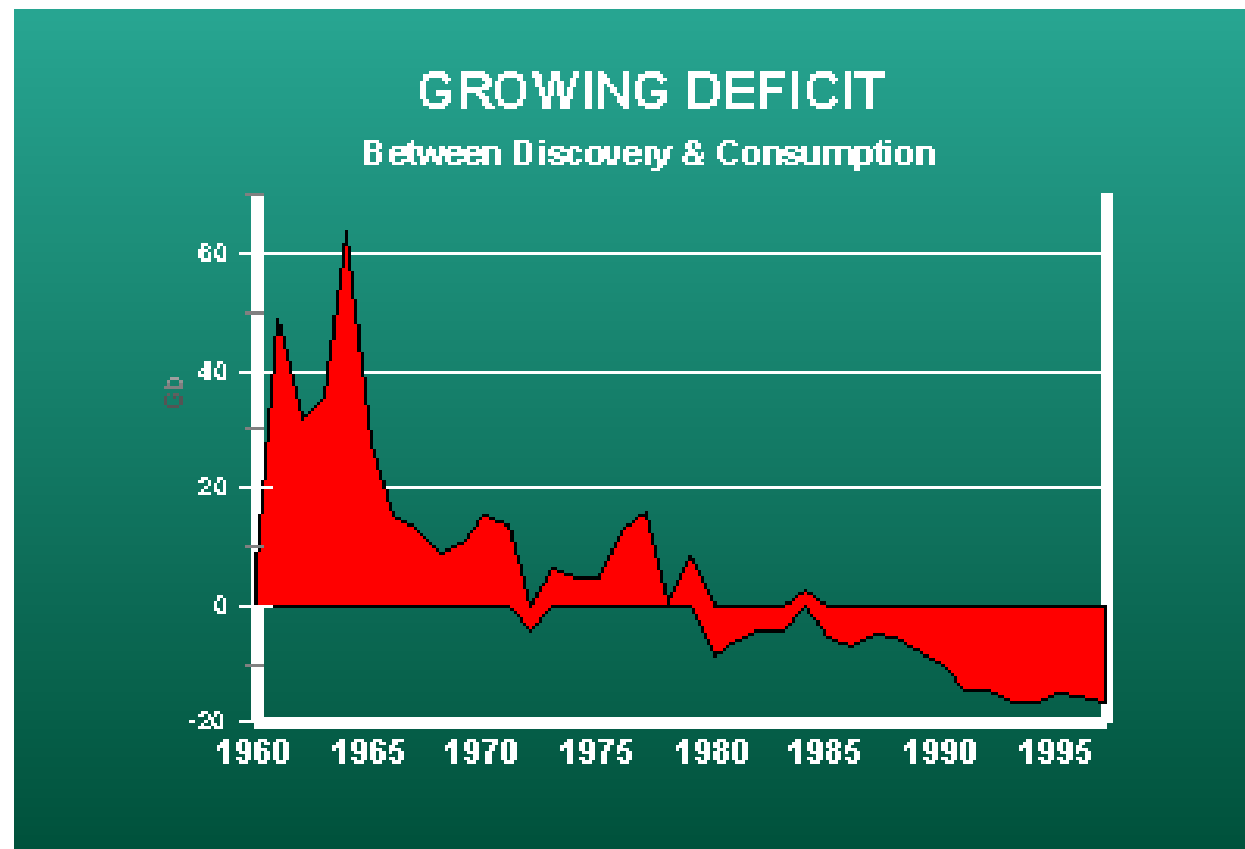


Limit Example #1: Oil Depletion

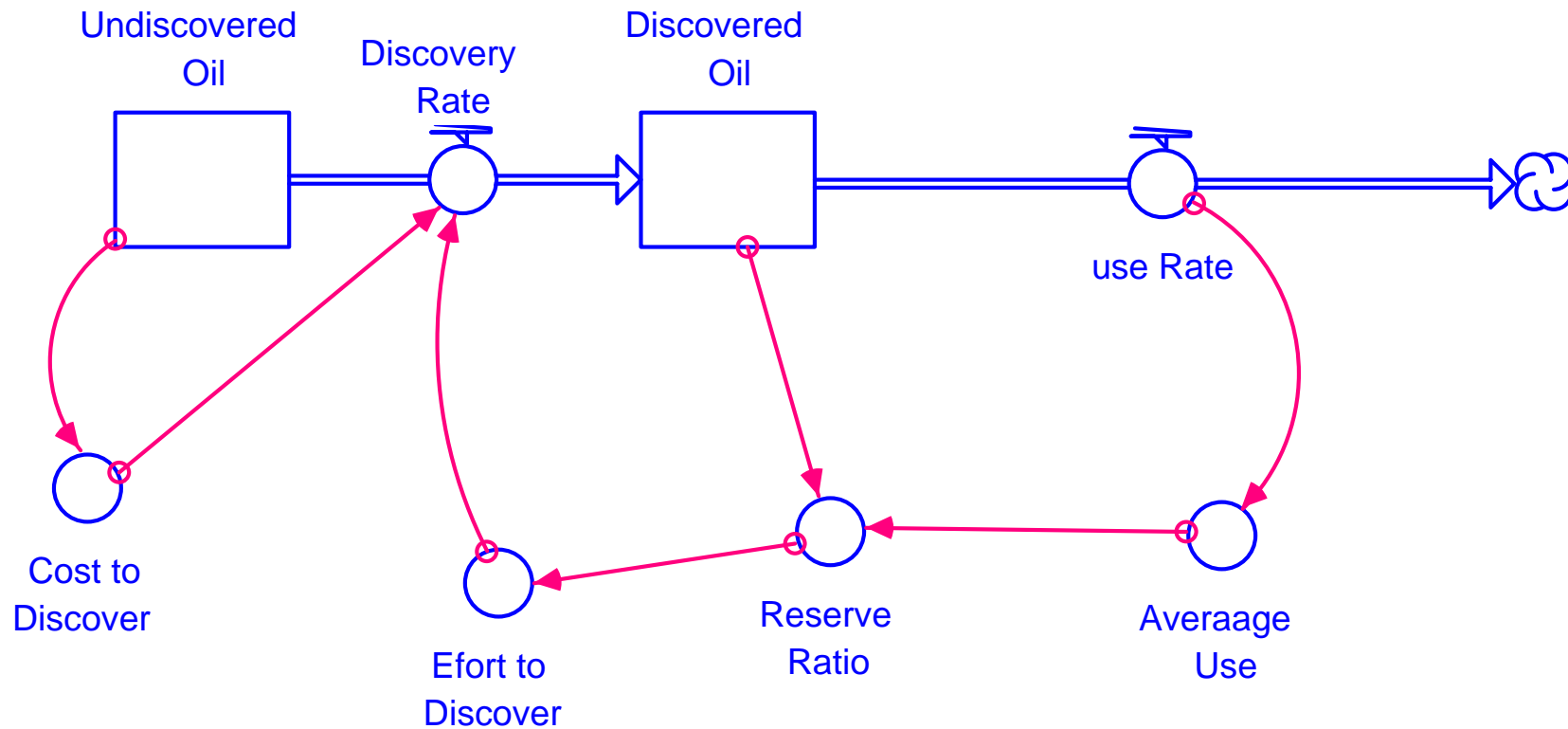
US Production Peaked in 1971



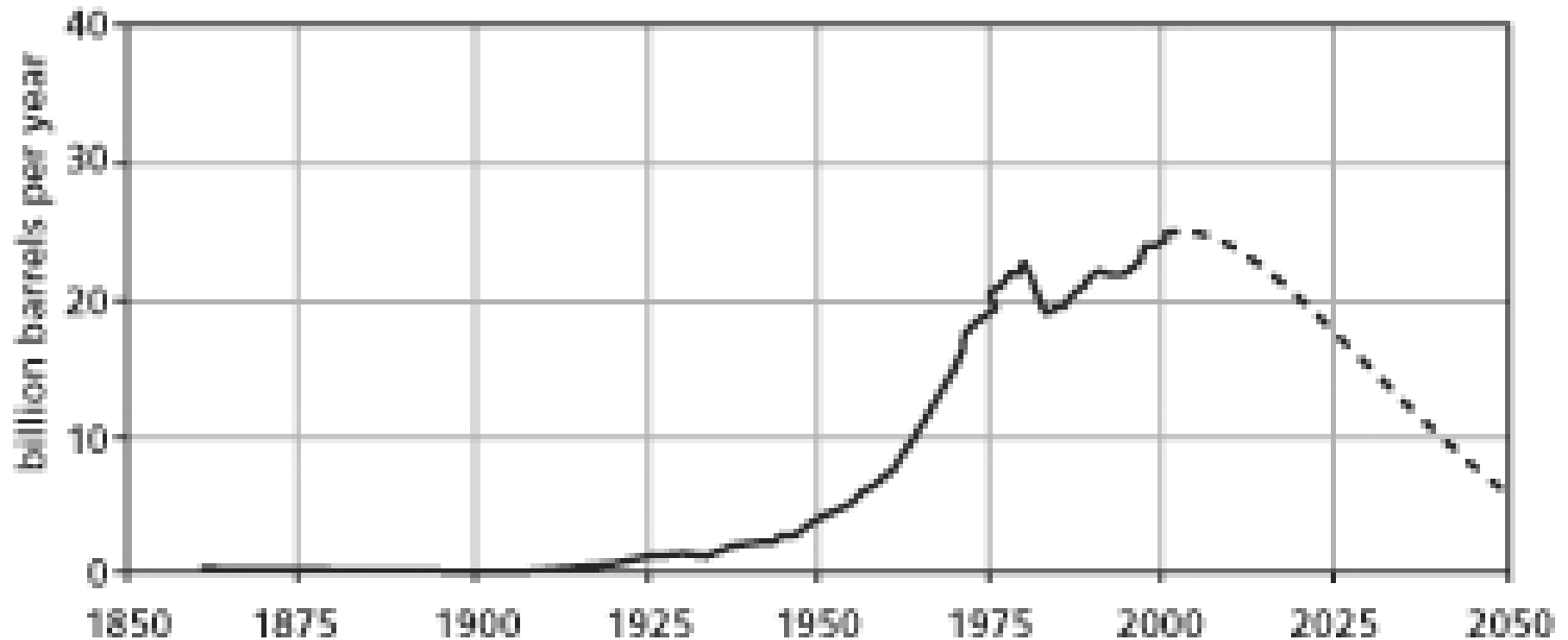
Gap between Discovery and Use



The Oil Depletion System

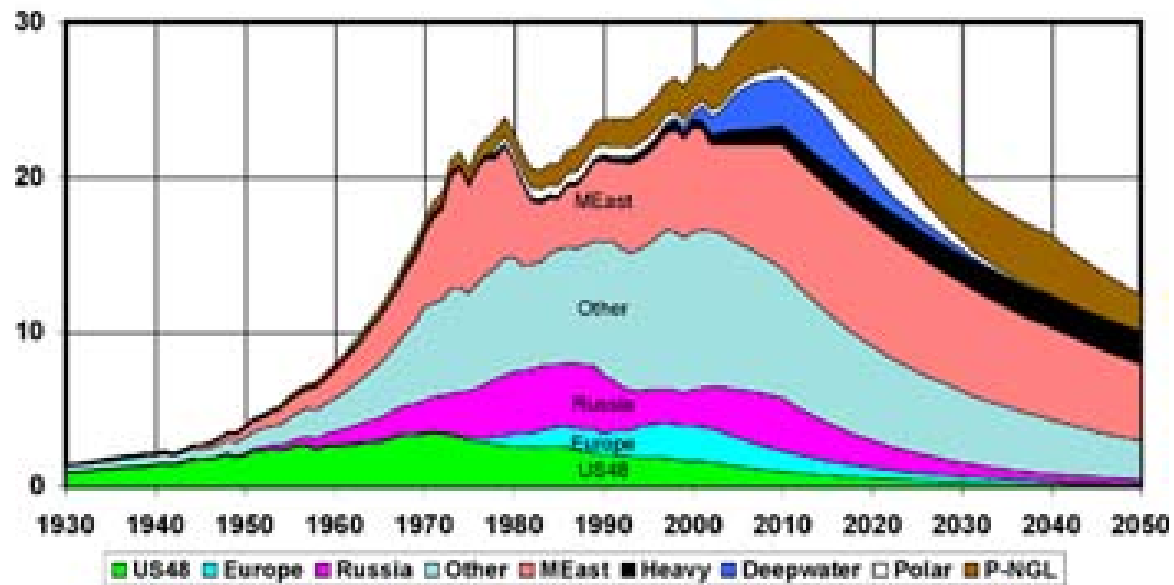


Global Oil Production will Peak Soon



Production Profile

Regular Oil & Natural Gas Liquids
2003 Base Case Scenario



What Are the Facts of Global Energy?

- Oil discoveries peaked out in 1964
- Consumption exceeded discovery in 1980
- Substitutes for conventional oil are more expensive, often dirtier, less easy to transport, and slow to develop
- Industrialized societies are profoundly dependent on cheap energy.

Energy Gap

- Today 13 TW, 2050 projected - 30
- Projected shortfall is 17 - 20 TW
- Building 1 1000 MW nuclear plant/day for 50 years would give 10 TW
- Wind offers 2-4 TW
- Solar offers 20
- Biomass has 7-10 theoretical maximum

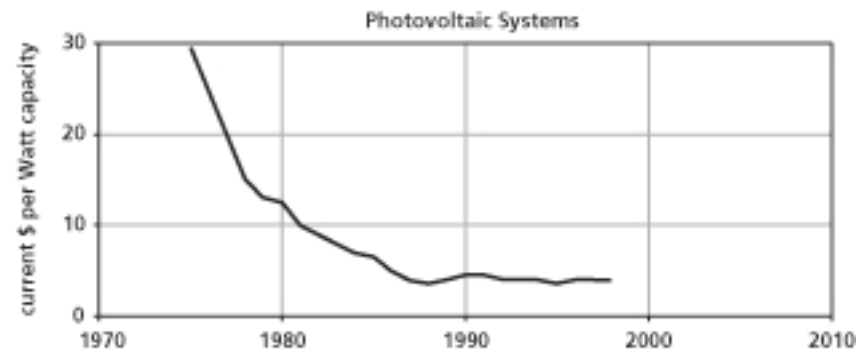
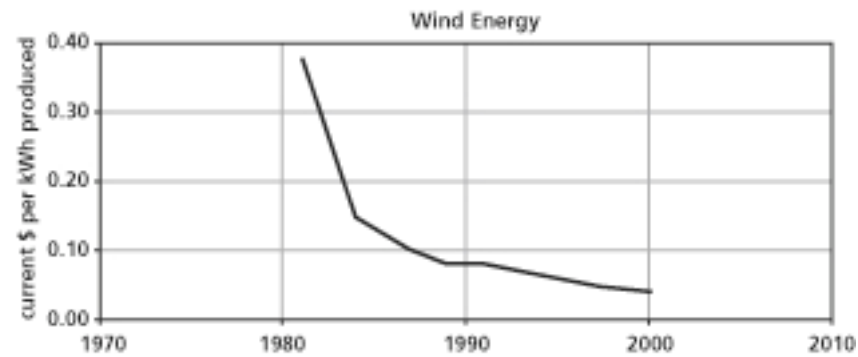
Some Net Energy Yields

- US Oil 1930 - 100; 1970 - 30; 2005 - 15
- Imported Oil - 30
- Coal - 10 - 80
- Nuclear - 10
- Firewood - 25
- Photovoltaics - 15-45
- Oil Sands - 2-3

Capital Investments for US Energy

- 150 oil refineries
- 4000 offshore platforms
- 160,000 miles of oil pipelines
- 10,400 electricity generating plants
- 410 underground gas storage fields
- 1.4 million miles of gas pipelines
- 160,000 miles of high voltage powerlines
- Port facilities to handle 15 million barrels/day of oil

Renewable Costs are Declining



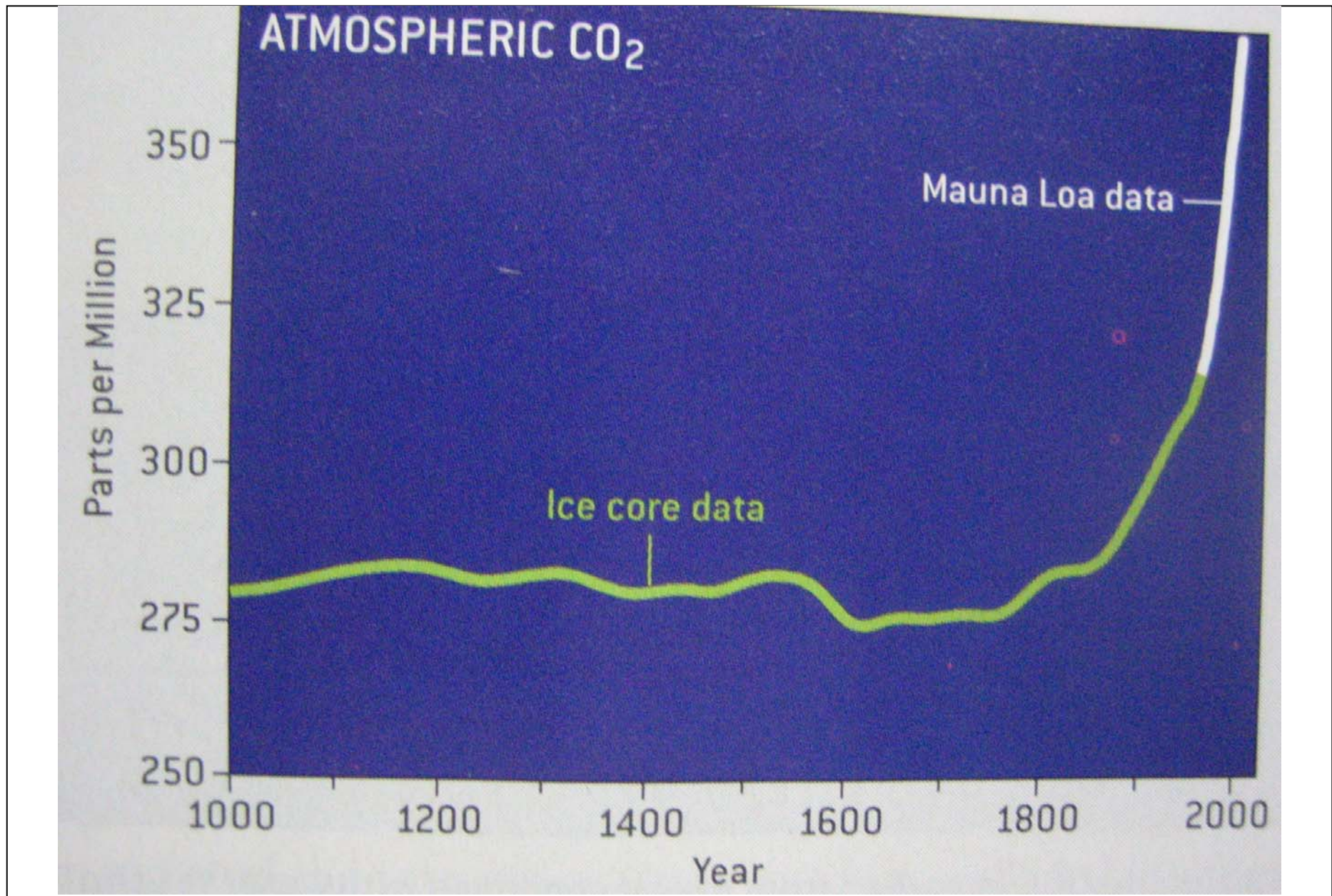
Myths Related to Alternatives

- We can sell oil at high prices, producing it with capital and labor obtained with low prices.
- We can focus only on the energy problem.
- Market adjustments are attractive.
- The adjustment will be fast.

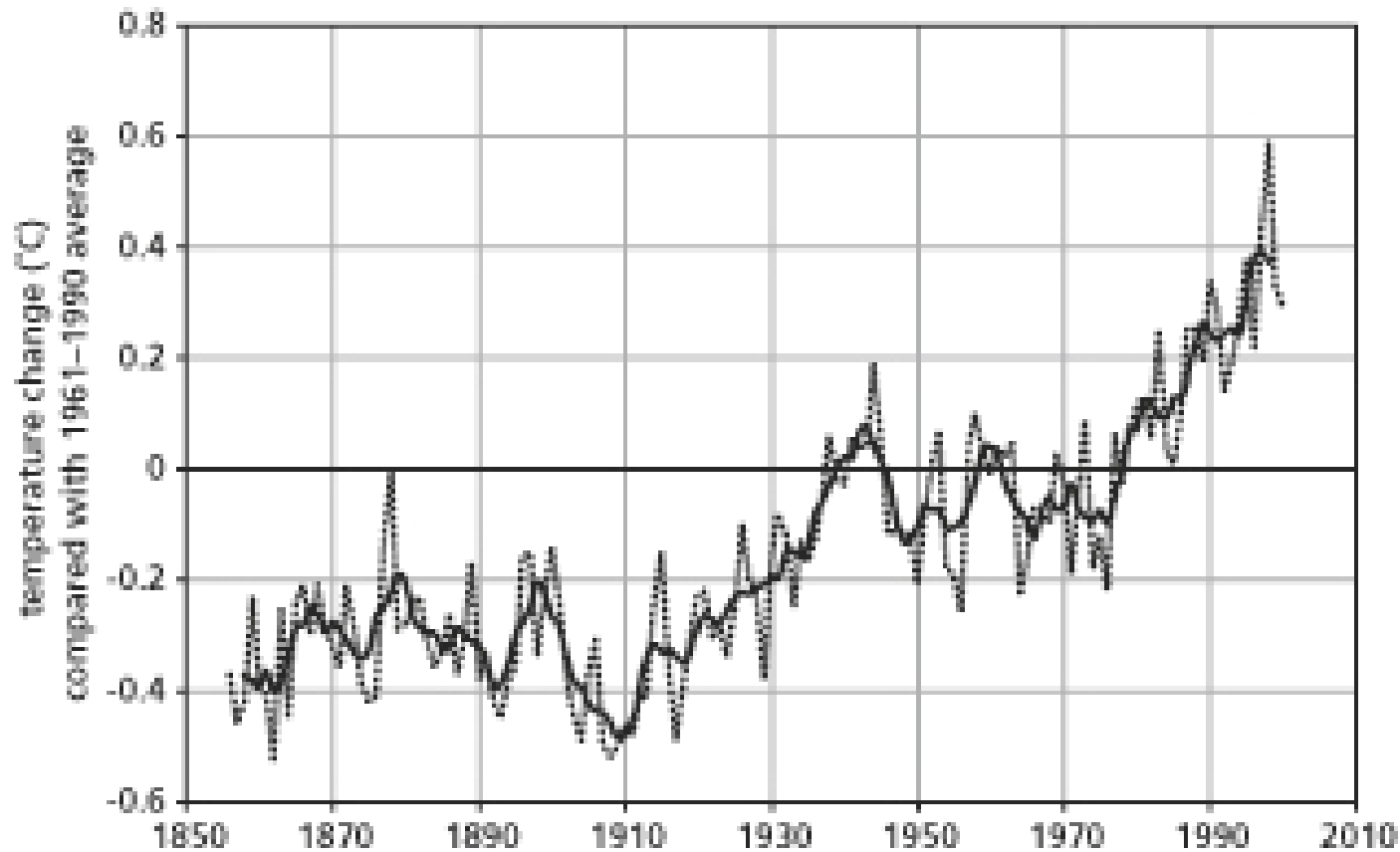
The Challenge of Man's Future

Within a period of time which is very short compared with the total span of human history, supplies of fossil fuels will almost certainly be exhausted. This loss will make man completely dependent upon waterpower, atomic energy, and solar energy for driving his machines. There are no fundamental physical laws which prevent such a transition, and it is quite possible that society will be able to make the change smoothly. But it is a transition that will happen only once during the lifetime of the human species. .. if machine civilization should, because of some catastrophe, stop functioning, it will probably never again come into existence. **Harrison Brown, 1954, p.222**

Limit Example #2: Climate Change



Rising Global Temperature



Facts about Atmospheric CO₂

- Two sources of data:
 - Mauna Loa, HI (50 years)
 - Ice core data (several thousand years)
- Now 30% greater than preindustrial and expected to double or triple by 2100
- CO₂ from fossil fuels is unique, so it is clear the increase comes from combustion
- 40% remains in the atmosphere; the rest goes equally into plants and the sea

Some Facts About Climate Change

- Preindustrial CO₂ concentrations = 270ppm
- Now CO₂ concentrations = 375ppm
- Currently emissions are 7 billions tons C/year, about twice the rate of ecosystem removal.
- If that were maintained, CO₂ would rise to 500ppm over the next 50 years, but current policies will double emissions. Kyoto calls for 10% reduction
- We do not fully understand the dynamics, but history shows that global temperature changes suddenly, not gradually, when thresholds are reached.
- Climate scientists generally agree that climate seems to be changing very much faster than they expected even five years ago.

