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The Future of the Blue Planet

Presented by

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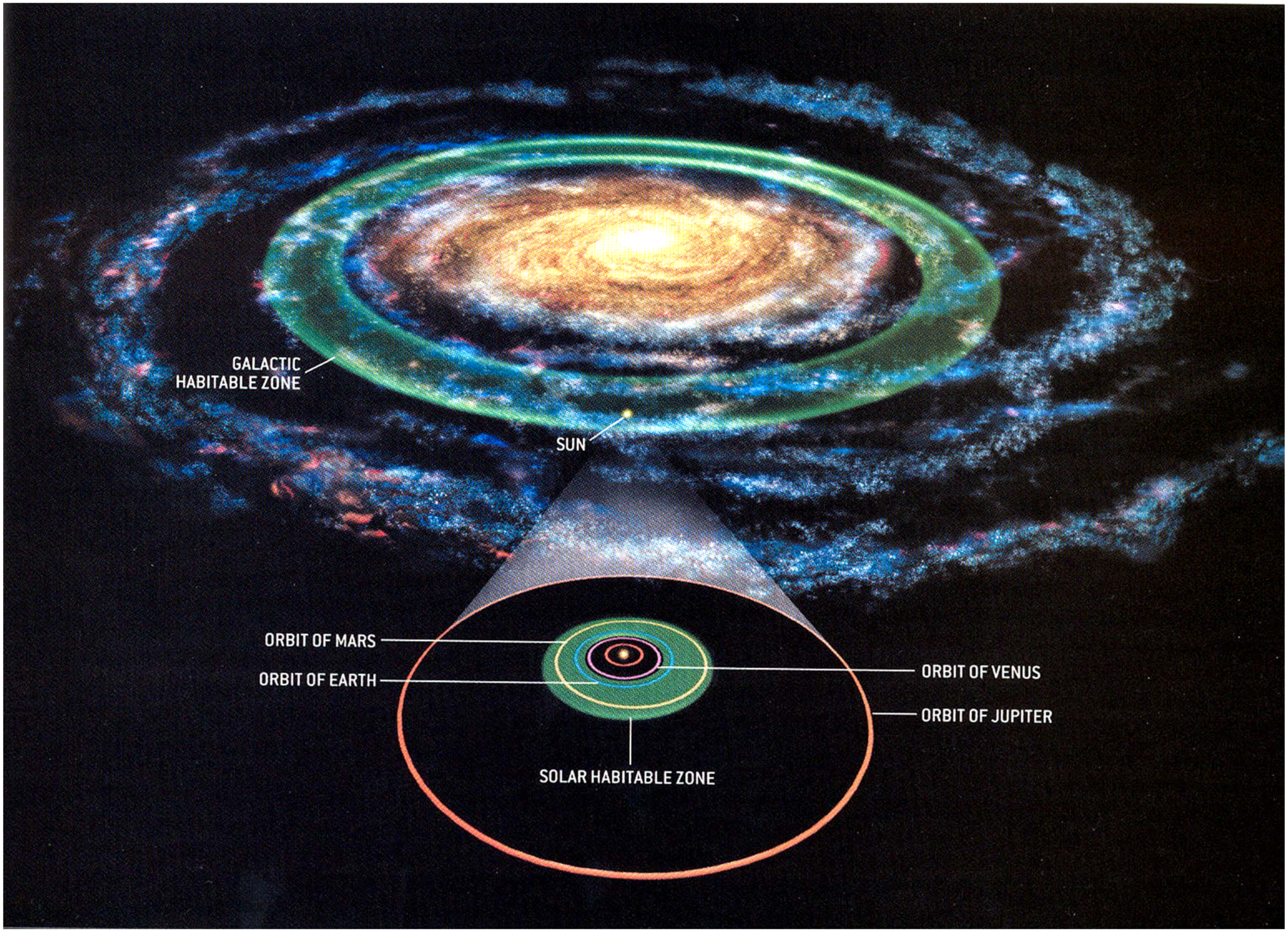
Professor of Electrical Engineering

30 October 2001
Electrical Engineering Writing & Project (EE403)
Penn State University



Habitable regions of our Milkyway galaxy are very limited

Scientific American, pg 63, October 2001.

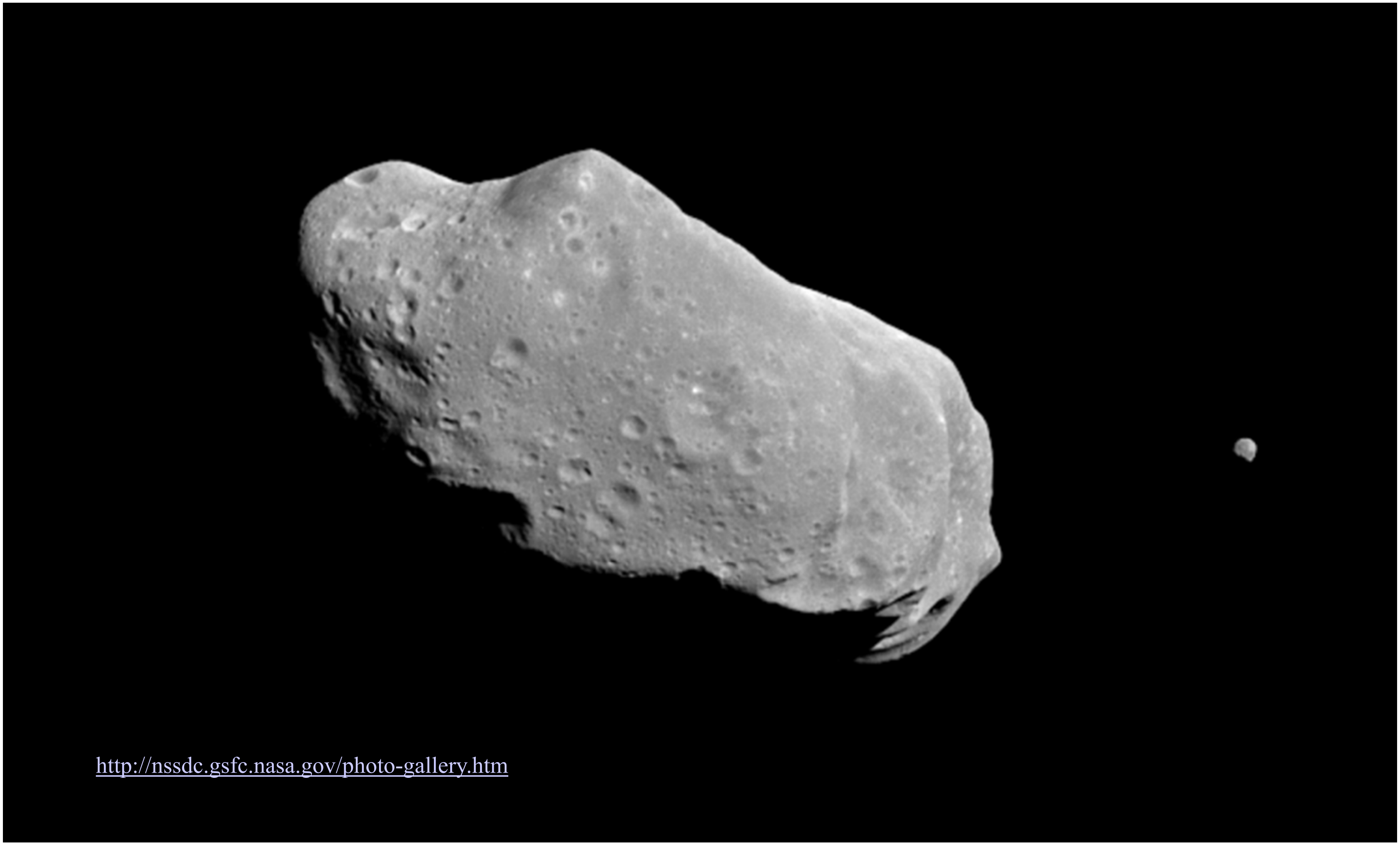

The Earth from Moon
shows a fragile view.
http://nssdc.gsfc.nasa.gov/photo-gallery.htm

We live in a precarious environment –

Solar flares rage through space.

Asteroids wander through our solar system.

Ida (50 km) and its moon (1.5 km)



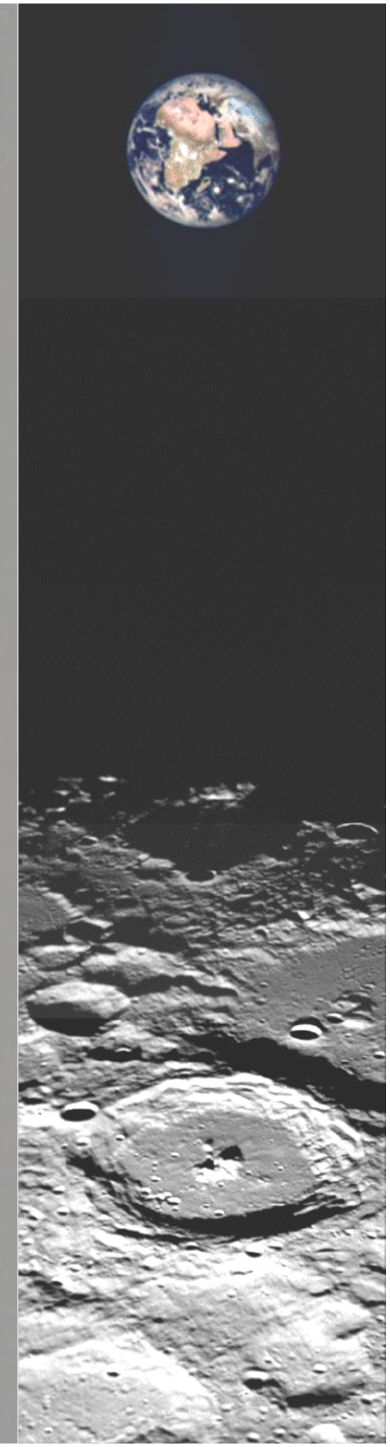
The activities of man are changing the face of our planet. The resources of our planet are stretched. The quality of air, water and earth are deteriorating. Biodiversity is being lost. What is the responsibility of an Engineer in the world today? How can I understand the problems and make a difference?

<u>Major Concerns</u>

Power generation
Anthropogenic fuel for transportation
Chemicals for manufacture
Chemical use in agriculture

***produce* –**

Acid rain – biological stress
Toxic emissions – ozone
Greenhouse gas – climate change
Airborne particulate – health effects & regional haze
Stratospheric ozone depletion
Hazardous waste



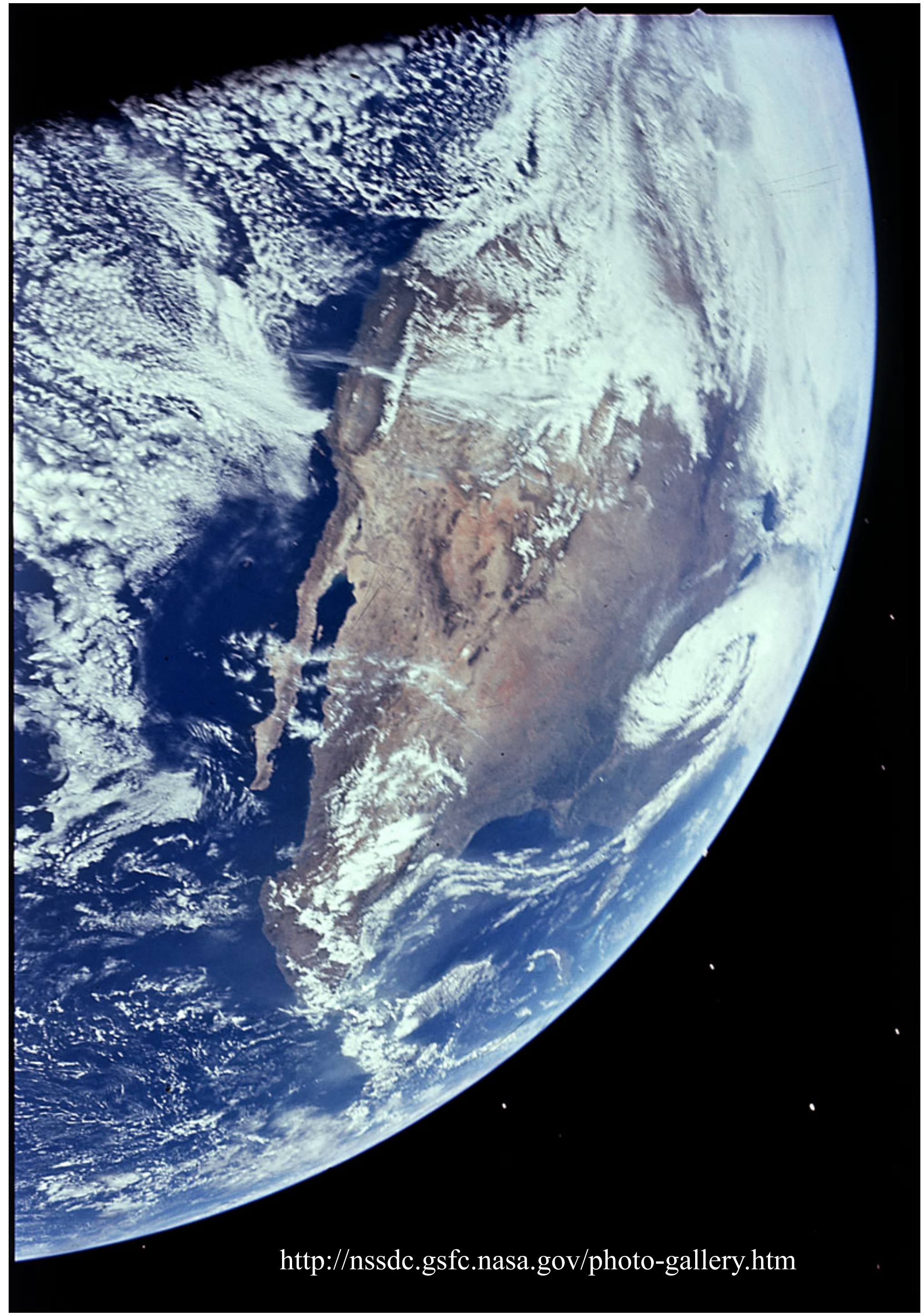
Engineers provide the means to extend the senses, supply the energy, and expand the world interface of individuals --

Eyewitness Encyclopedia
of Space and the Universe –
DK Multimedia, 1996.

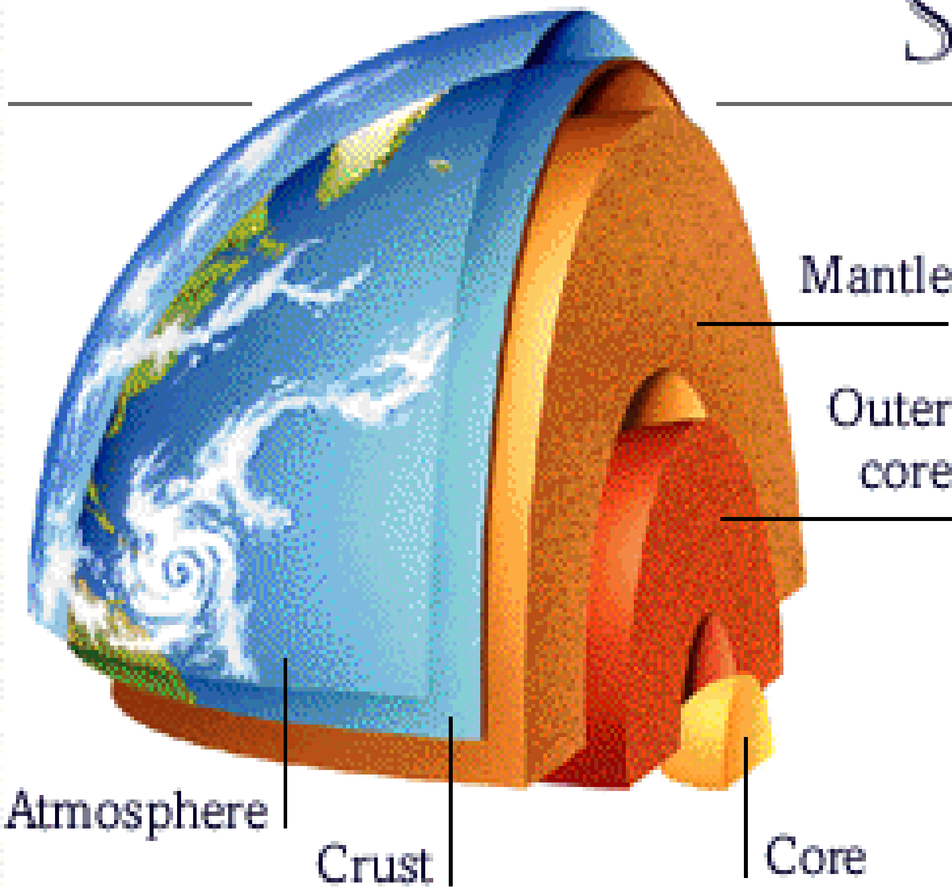
What can you do?

Improve energy resources
Use the computer interface
Paperless environment
Design for conservation
Plan for resource preservation
Practice personal conservation

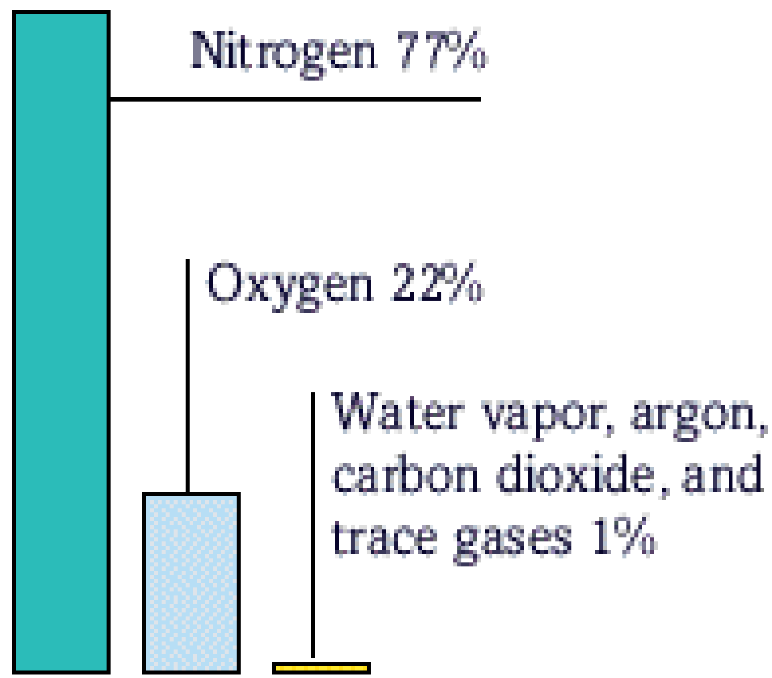
<u>Additional</u>
Practice High Ethics
Develop Technical Competence
(Curious Observer)
Be Efficient Worker
(Project Tools)
Create Environment for Success



STRUCTURE

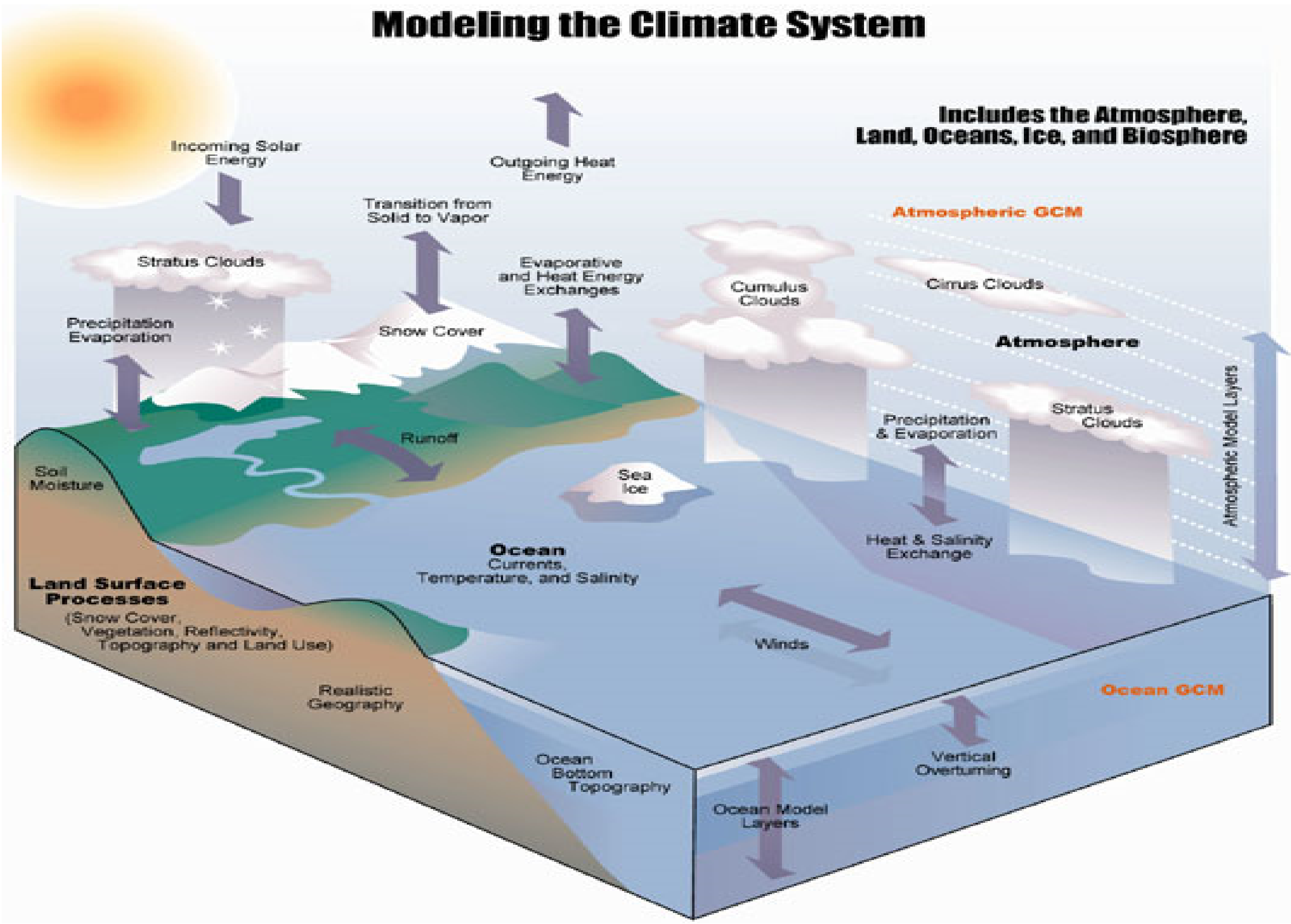


ATMOSPHERIC COMPOSITION

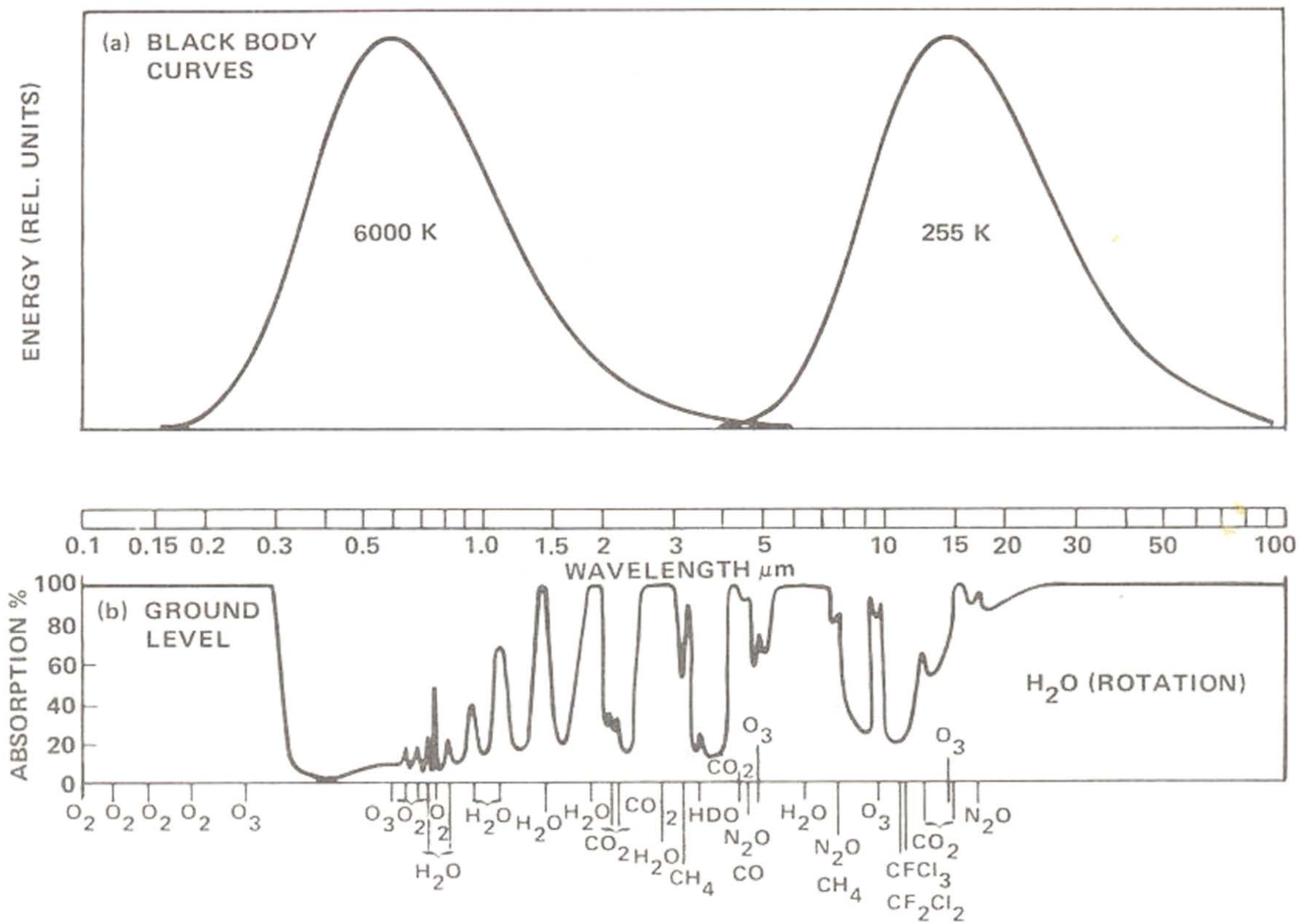


LAYER	THICKNESS	COMPOSITION
Crust	6–40 km (4–25 miles)	Silicate rock
Mantle	2,800 km (1,750 miles)	Mainly solid silicate rock
Outer core	2,300 km (1,430 miles)	Molten iron and nickel
Inner core (radius)	1,200 km (750 miles)	Solid iron and nickel

Eyewitness Encyclopedia of Space and the Universe – DK Multimedia, 1996.

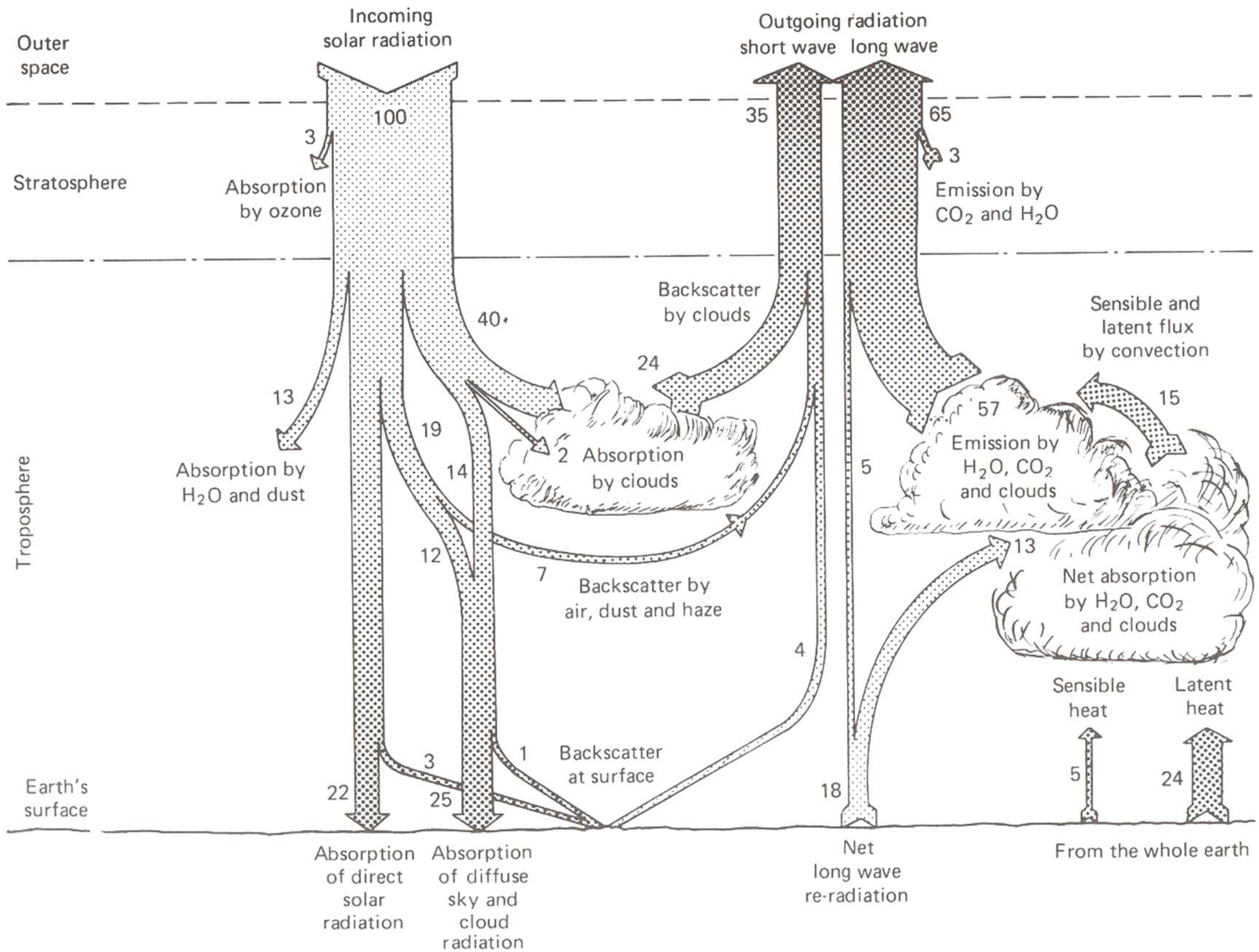

Modeling the Climate System
Includes the Atmosphere, Land, Oceans, Ice, and Biosphere
Incoming Solar Energy
Outgoing Heat Energy
Transition from Solid to Vapor
Atmospheric GCM
Stratus Clouds
Evaporative and Heat Energy Exchanges
Cumulus Clouds
Cirrus Clouds
Precipitation Evaporation
Snow Cover
Atmosphere
Stratus Clouds
Precipitation & Evaporation
Atmospheric Model Layers
Runoff
Soil Moisture
Sea Ice
Heat & Salinity Exchange
Ocean
Currents, Temperature, and Salinity
Land Surface Processes
(Snow Cover, Vegetation, Reflectivity, Topography and Land Use)
Winds
Realistic Geography
Ocean GCM
Ocean Bottom Topography
Vertical Overturning
Ocean Model Layers

Emission Spectrum of Sun and Earth - Infrared Absorption by Molecules



Energy and Climate Change – DOE Multi-Laboratory Committee, Lewis Publishers, 1990. MacCracken and Luther, DOE/ER-0235.

Earth's Radiation Budget



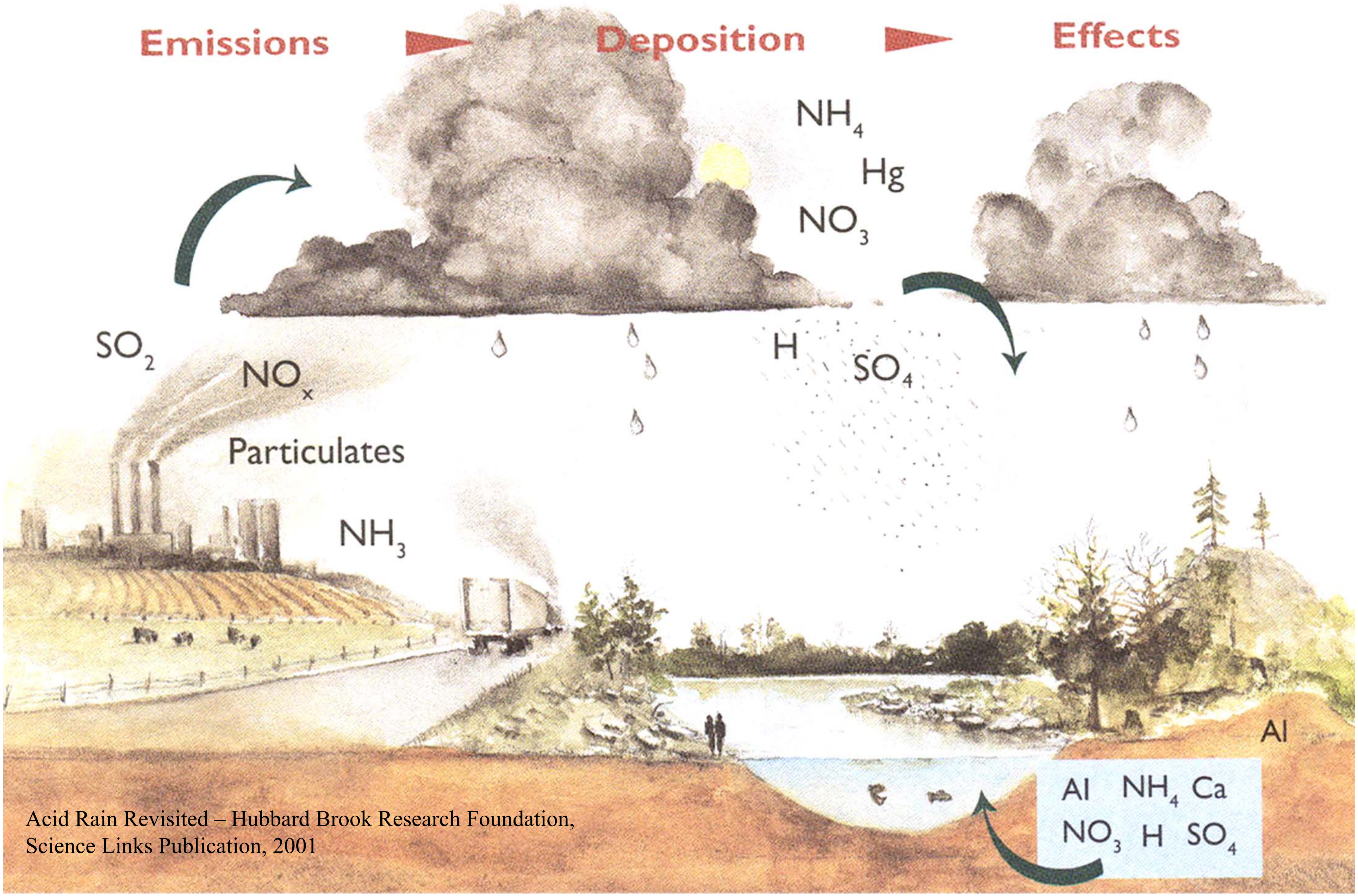
Planet Earth, Cesare Emilliani, Cambridge University Press, 1995.

Airborne Particulate Matter

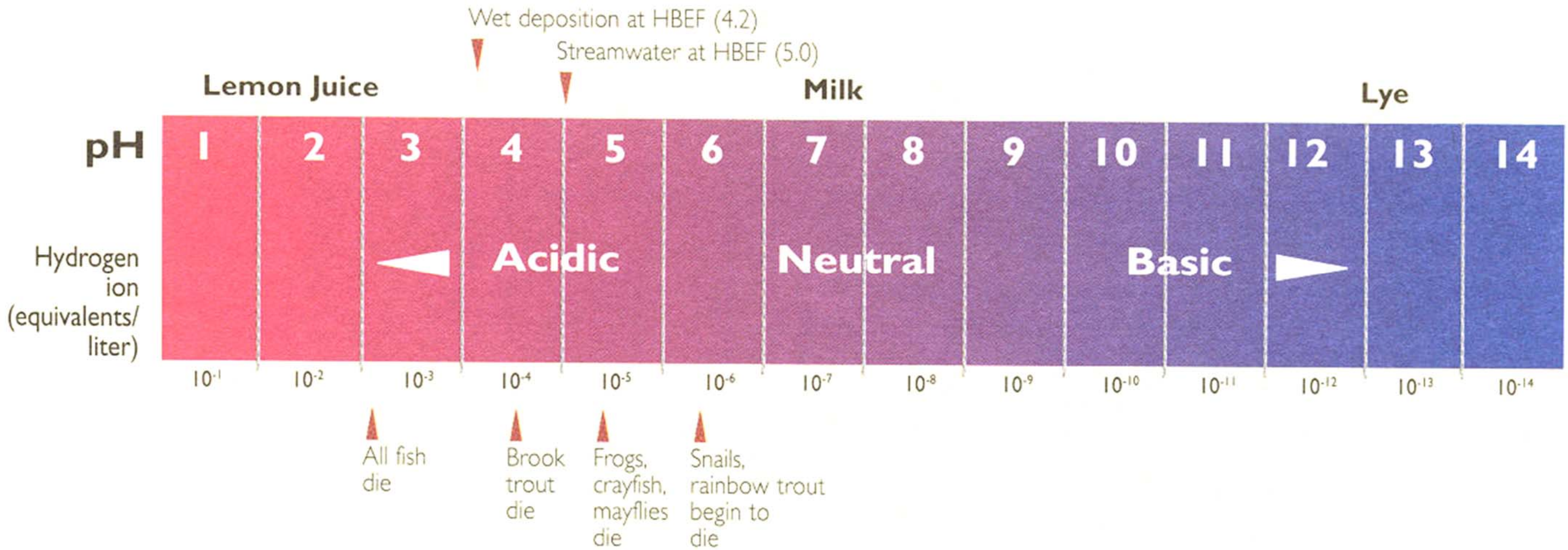
Olympus Photo Deluxe, 2000

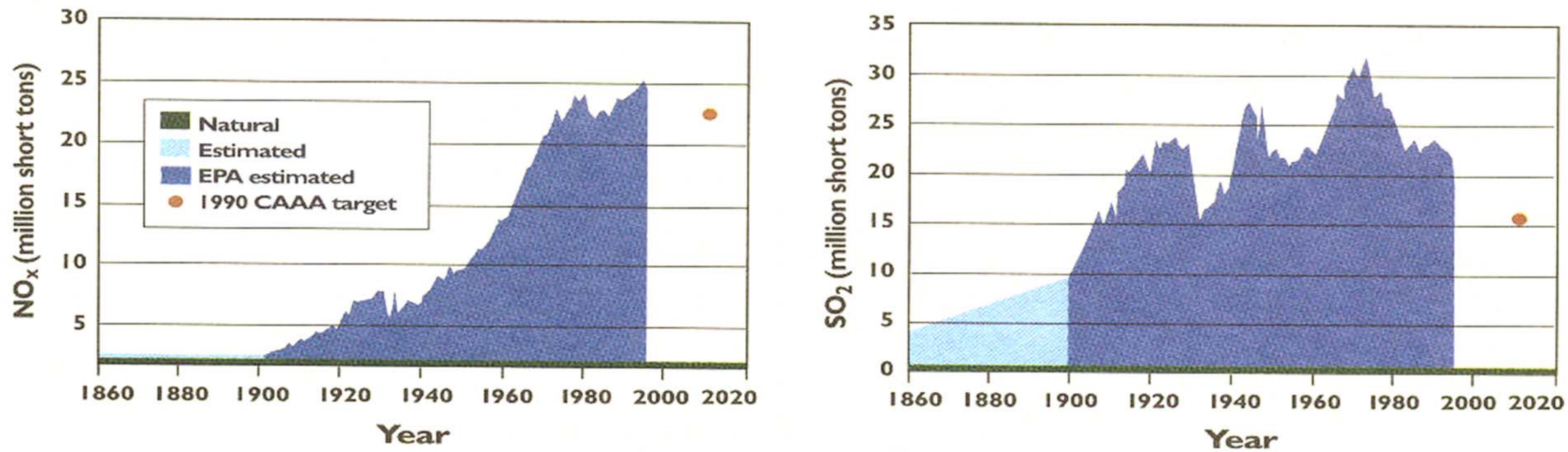
Dust plumes from desert regions can be observed from space –

Acid Rain – SOx and NOx emissions produce acids



Acid Rain Revisited – Hubbard Brook Research Foundation,
Science Links Publication, 2001

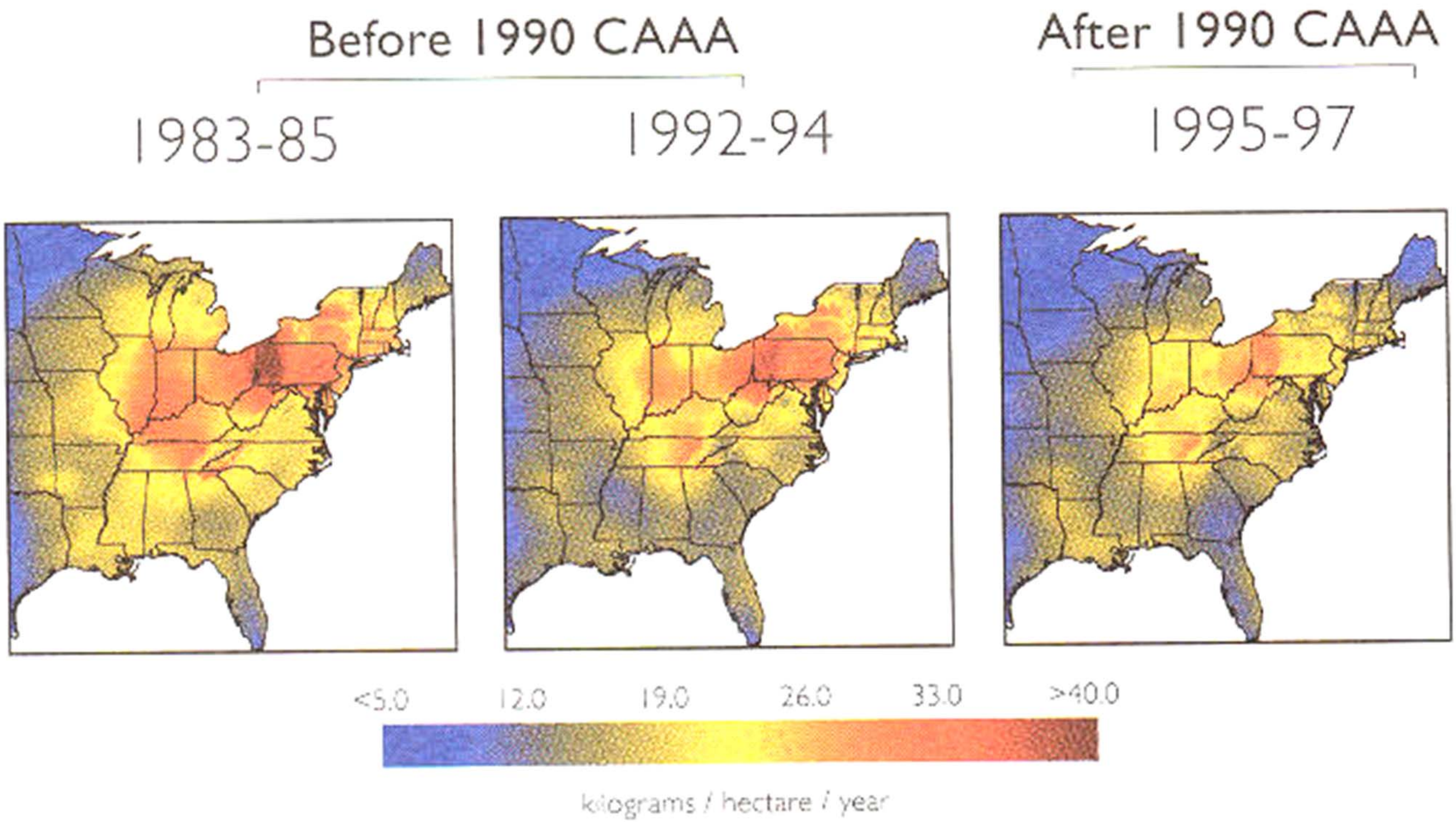




Long-term trends in total sulfur and nitrogen oxide emissions in the United States compared with estimated natural emissions and emission targets estimated based on the 1990 CAAA (after U.S. EPA 2000).

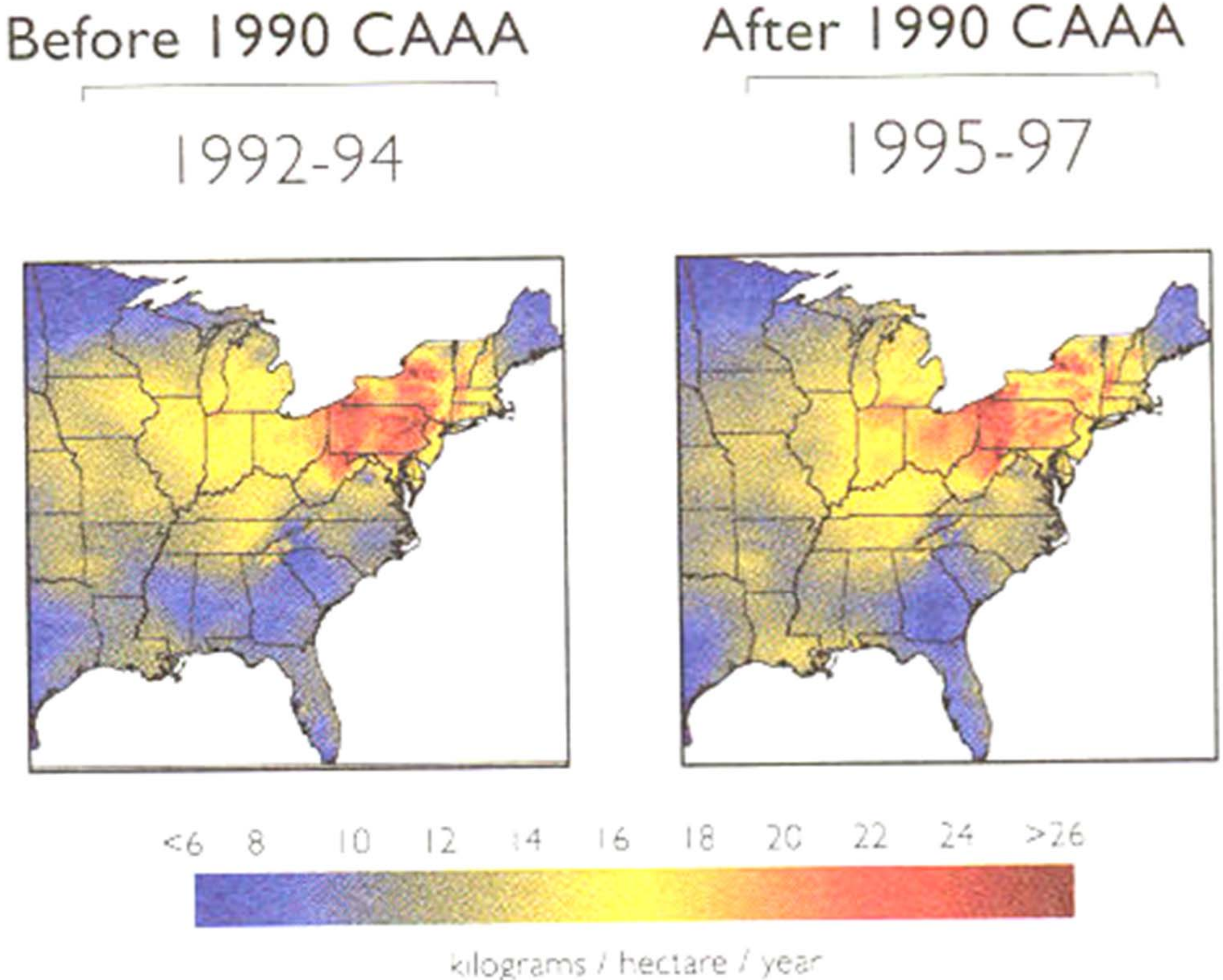
Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001

SULFATE WET DEPOSITION



Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001

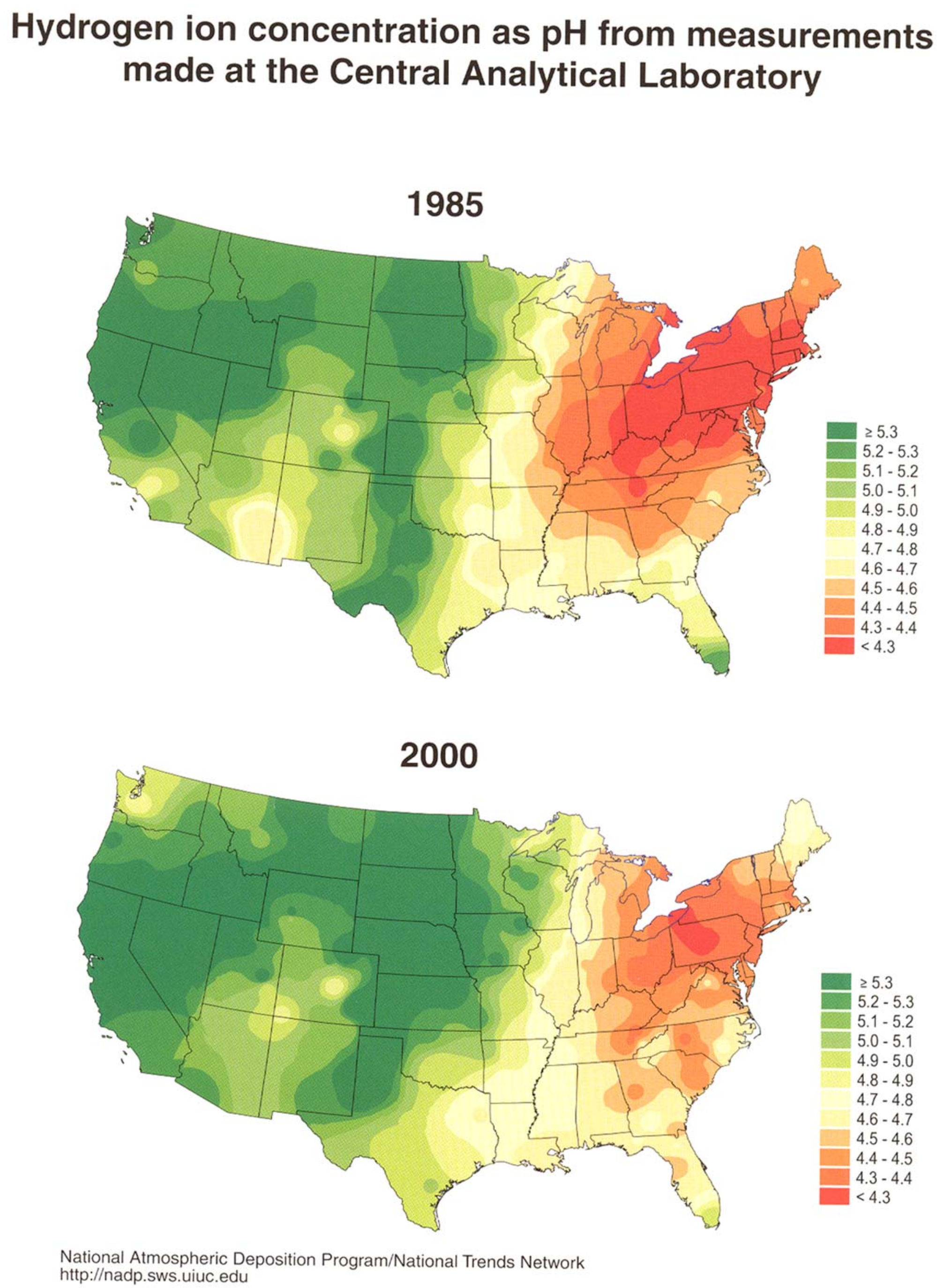
NITRATE WET DEPOSITION



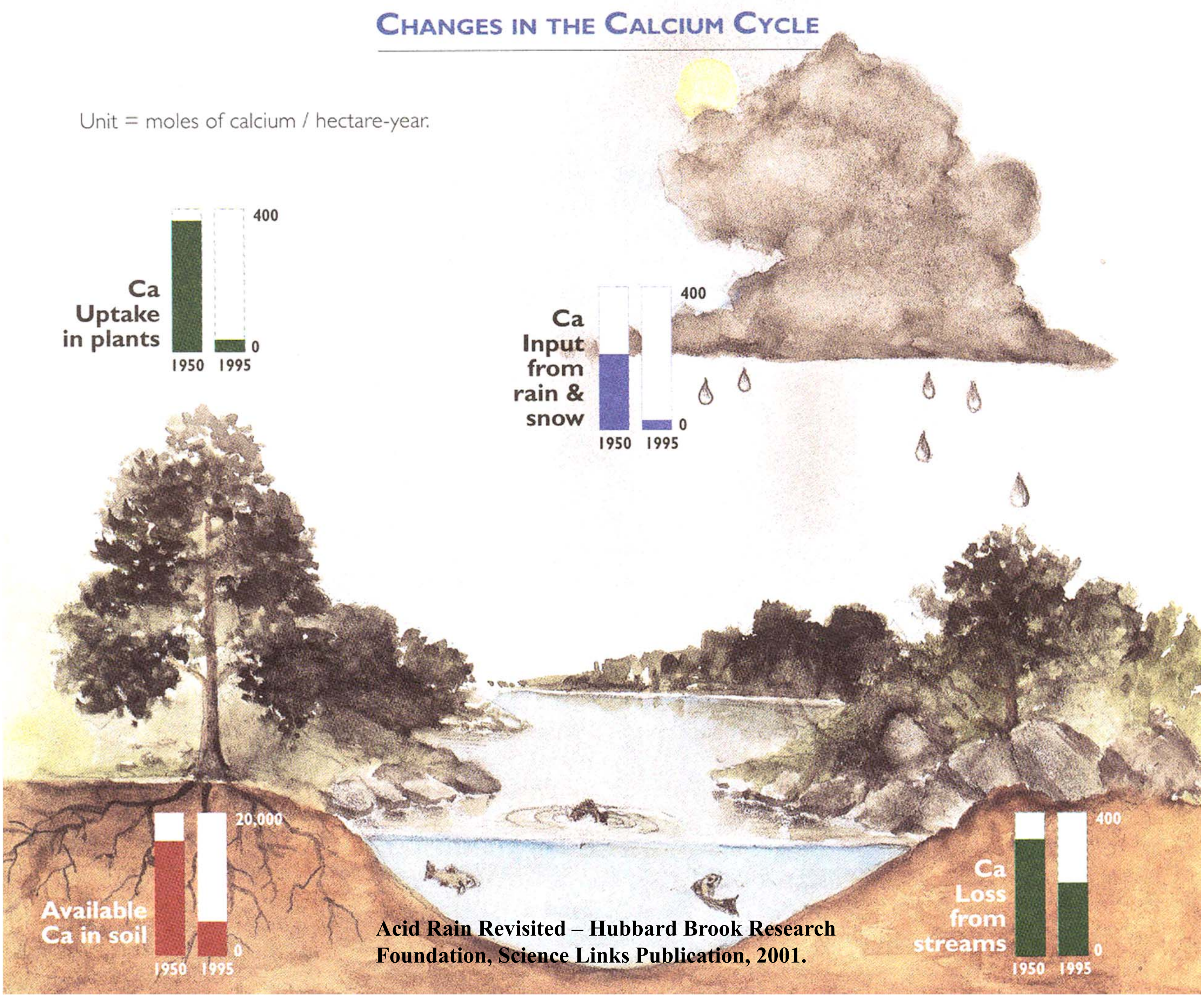
Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001

Acid Rain

While improvements have been made in the acidity, the return of the biological habitat takes decades.

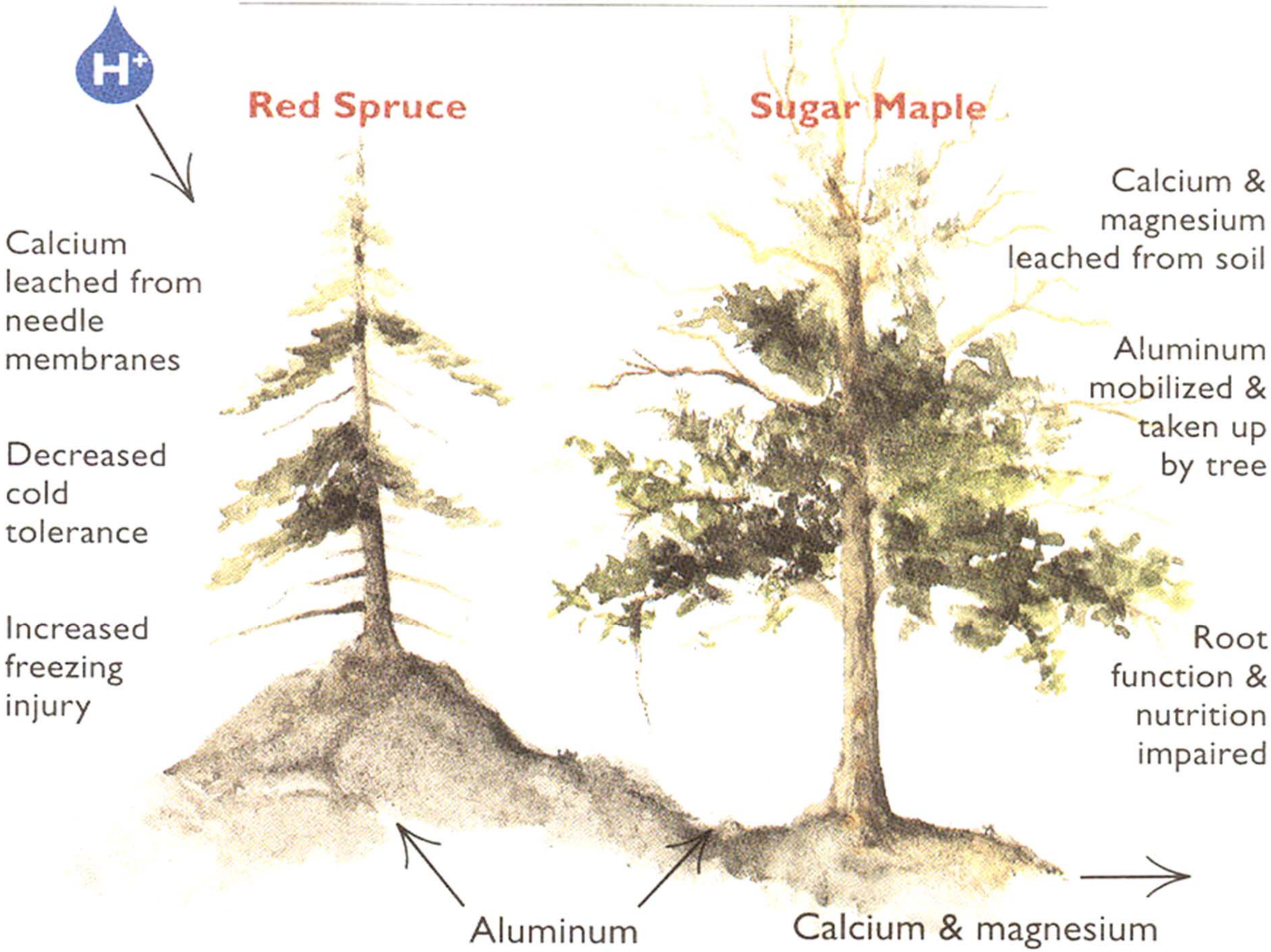


Acid Rain: Are the Problems Solved? –
Center for Environmental Information, 2001.



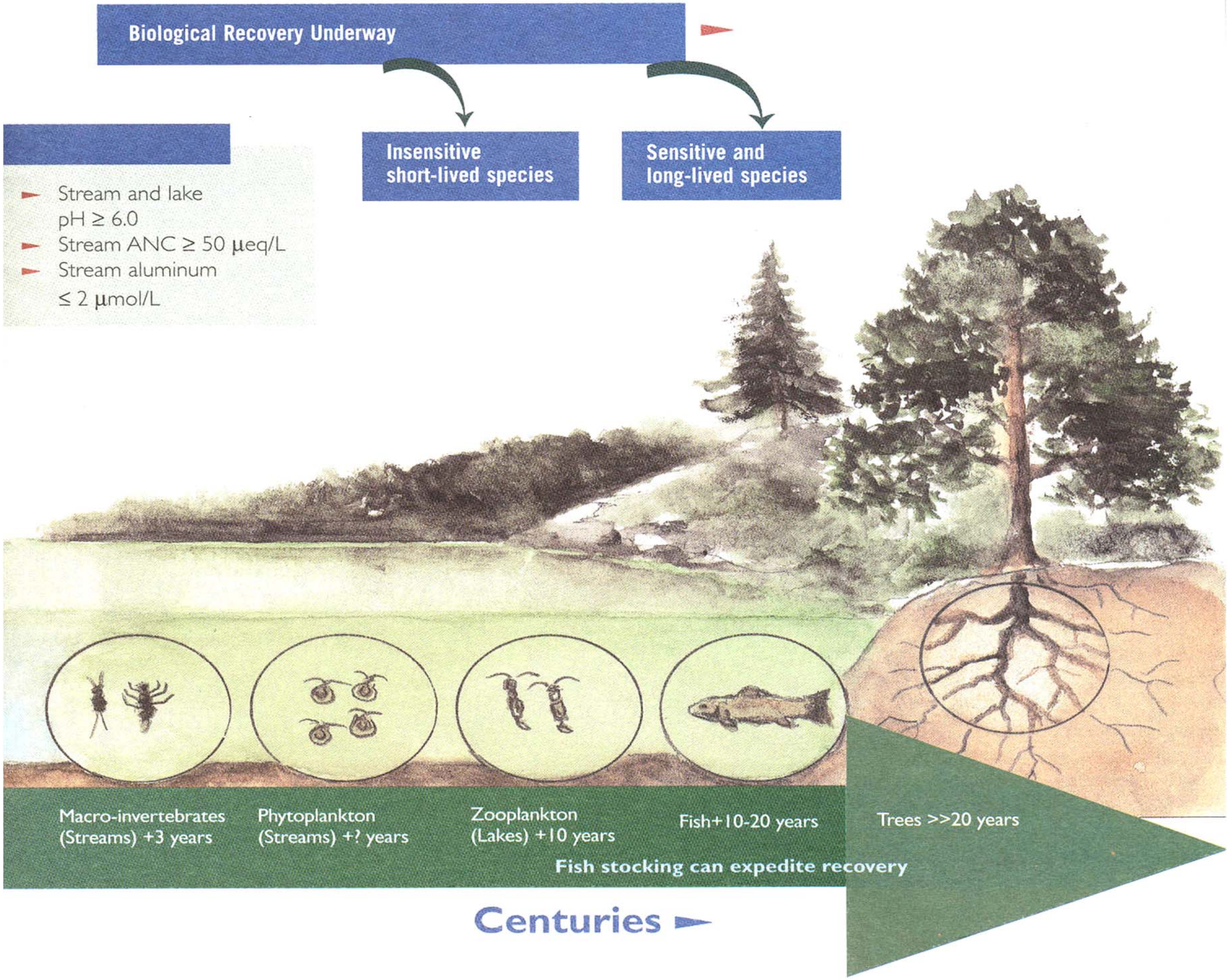
Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001.

ACID DEPOSITION EFFECTS ON TREES



Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001

Olympus Photo Deluxe, 2000



Acid Rain Revisited – Hubbard Brook Research Foundation, Science Links Publication, 2001

Canopy-Buildings

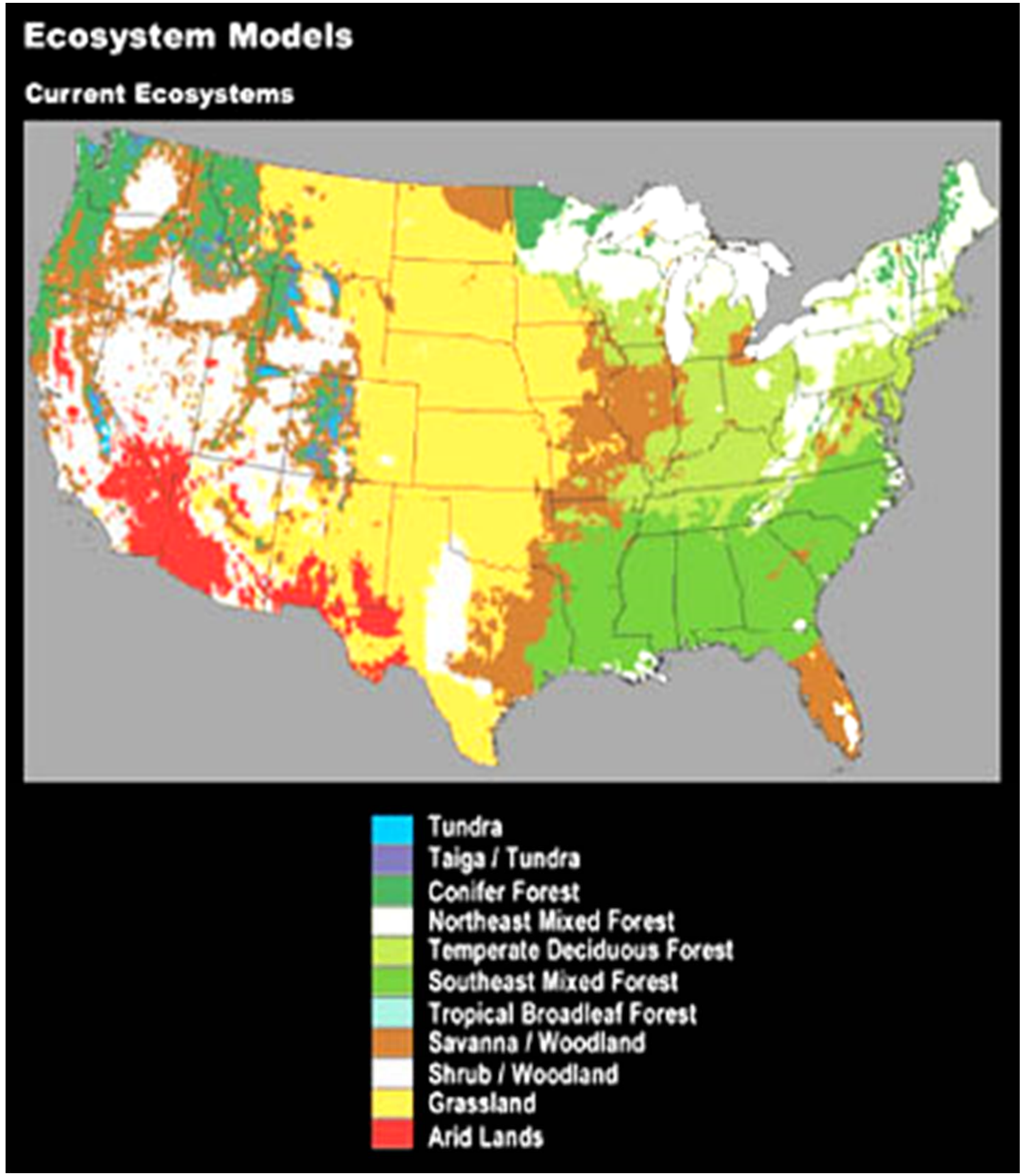
Canopy-Trees

Whichever canopy we choose to live under – we need to practice better conservation of resources.

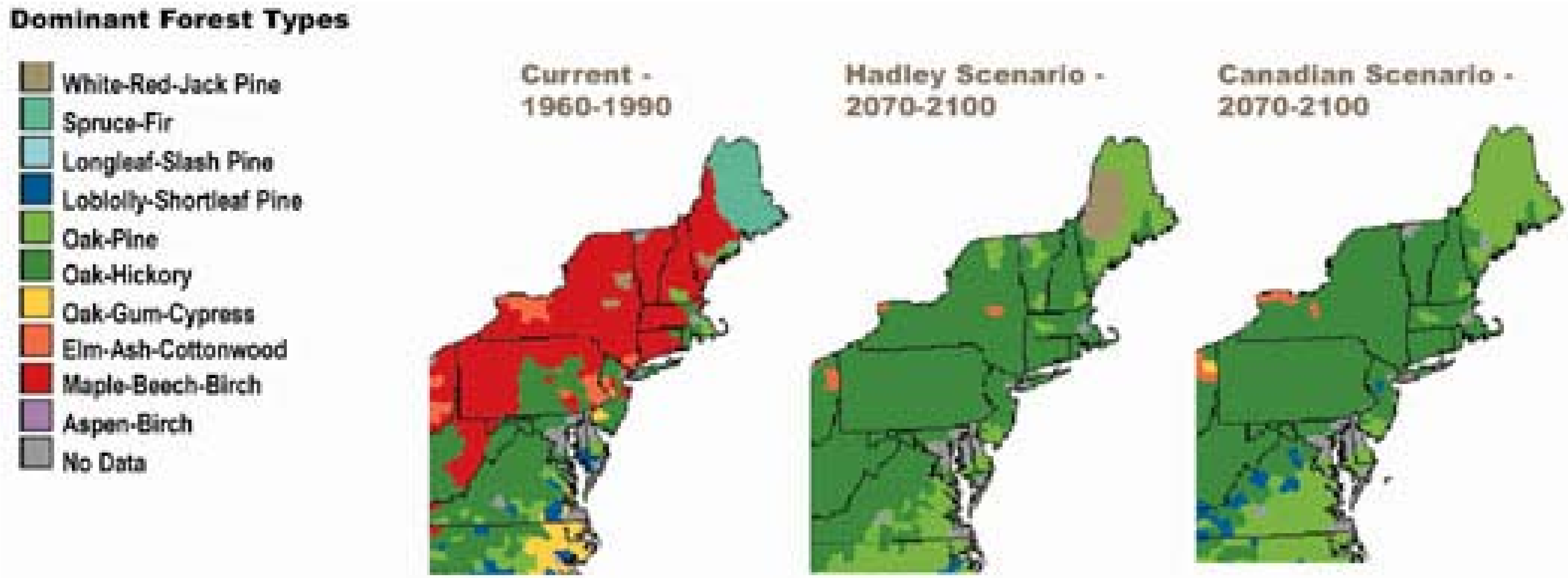
Olympus Photo Deluxe, 2000

Ecosystem

The current ecosystem of the forest is being changed by acid rain, by current use policies, and by climate shifts.



Model Change in Forests due to Climate Change

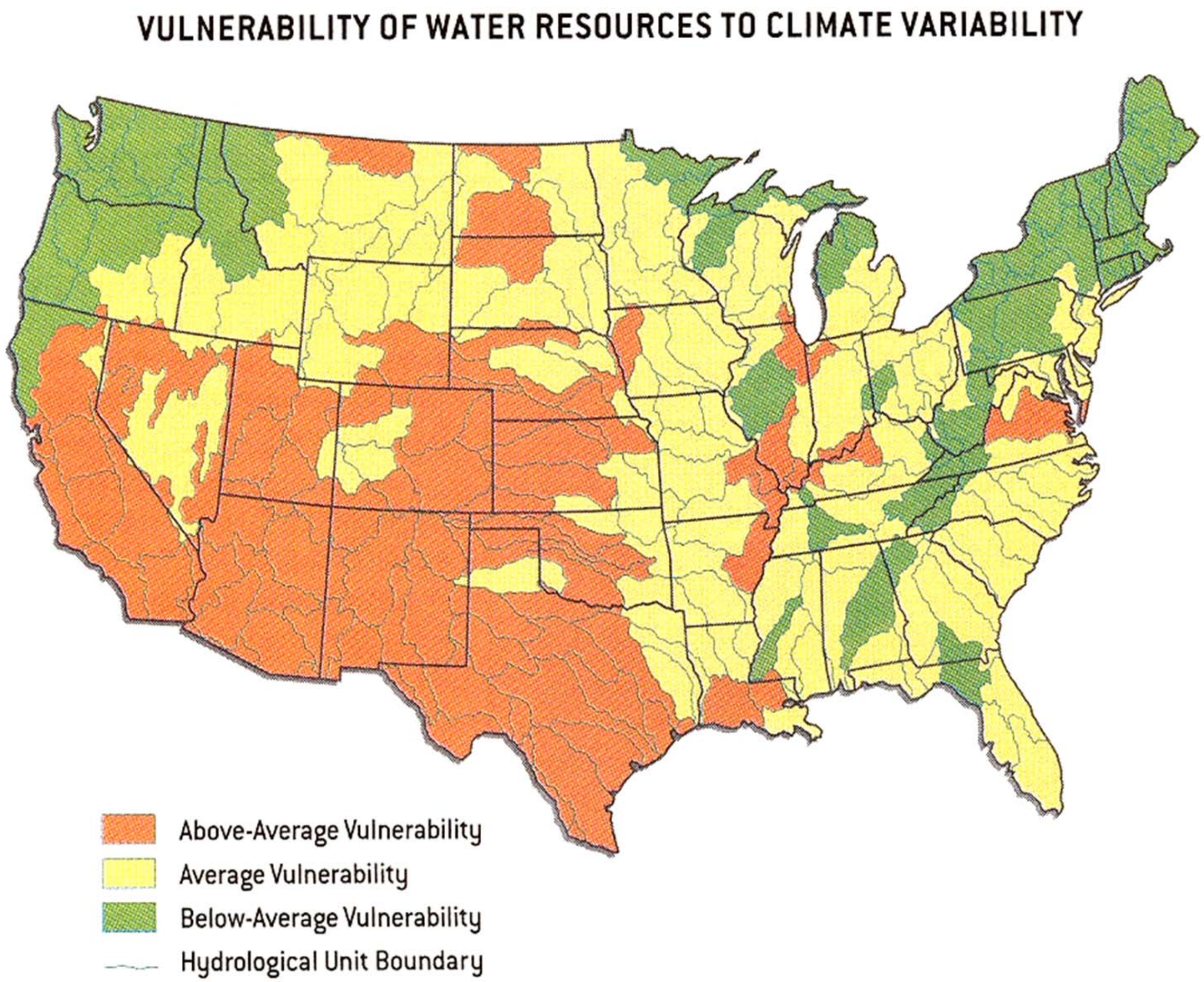


US water use per day

Total - 402 billion gal
surface water 324 b
ground water 78 b
from salt water 15 b

Use

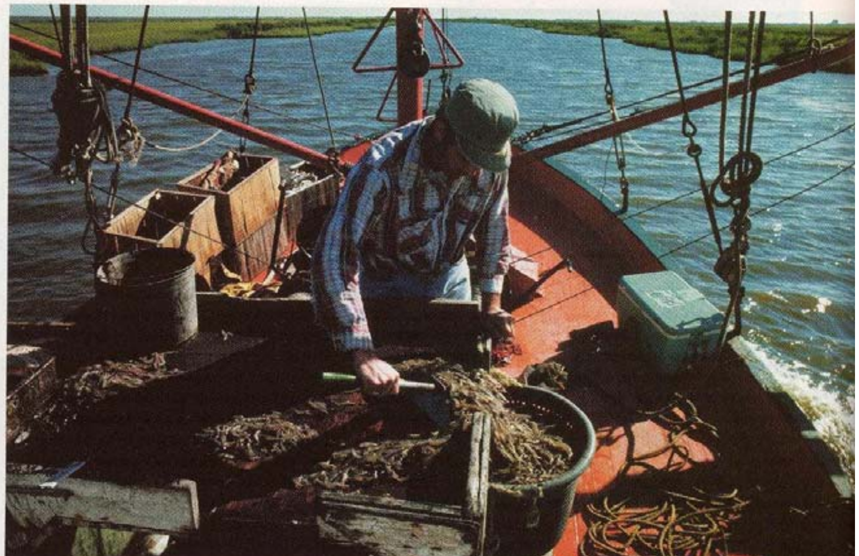
Power generation	47%
Irrigation	33%
Households	11%
Industry	7%
Livestock	1%



Scientific American, pg 30, July 2001.

Shrinking the Dead Zone

POLITICAL UNCERTAINTY COULD STALL A PLAN TO REIN IN DEADLY WATERS IN THE GULF OF MEXICO BY SARAH SIMPSON



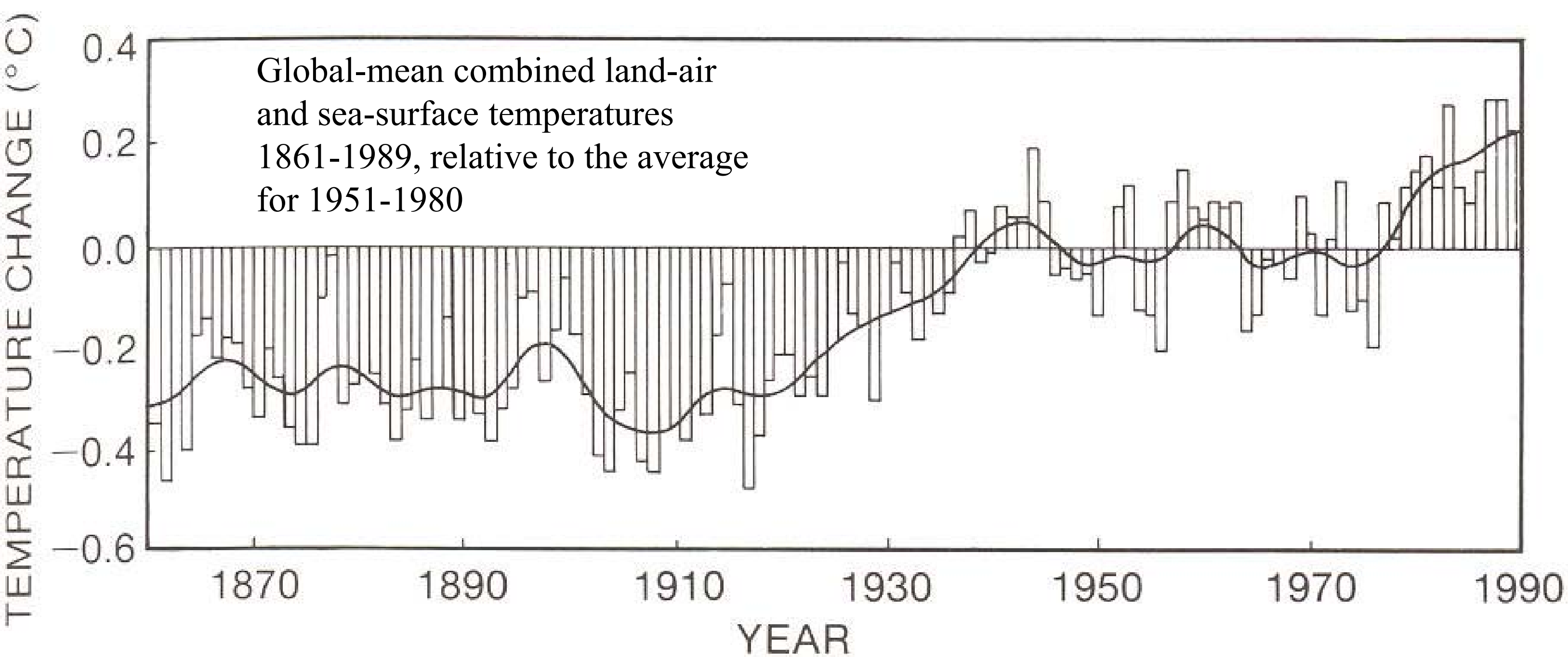
Agricultural application of fertilizers and pesticides leads to major changes in coastal waters.

OUT OF BREATH: Oxygen-starved gulf waters spanned 20,000 square kilometers in 1999.

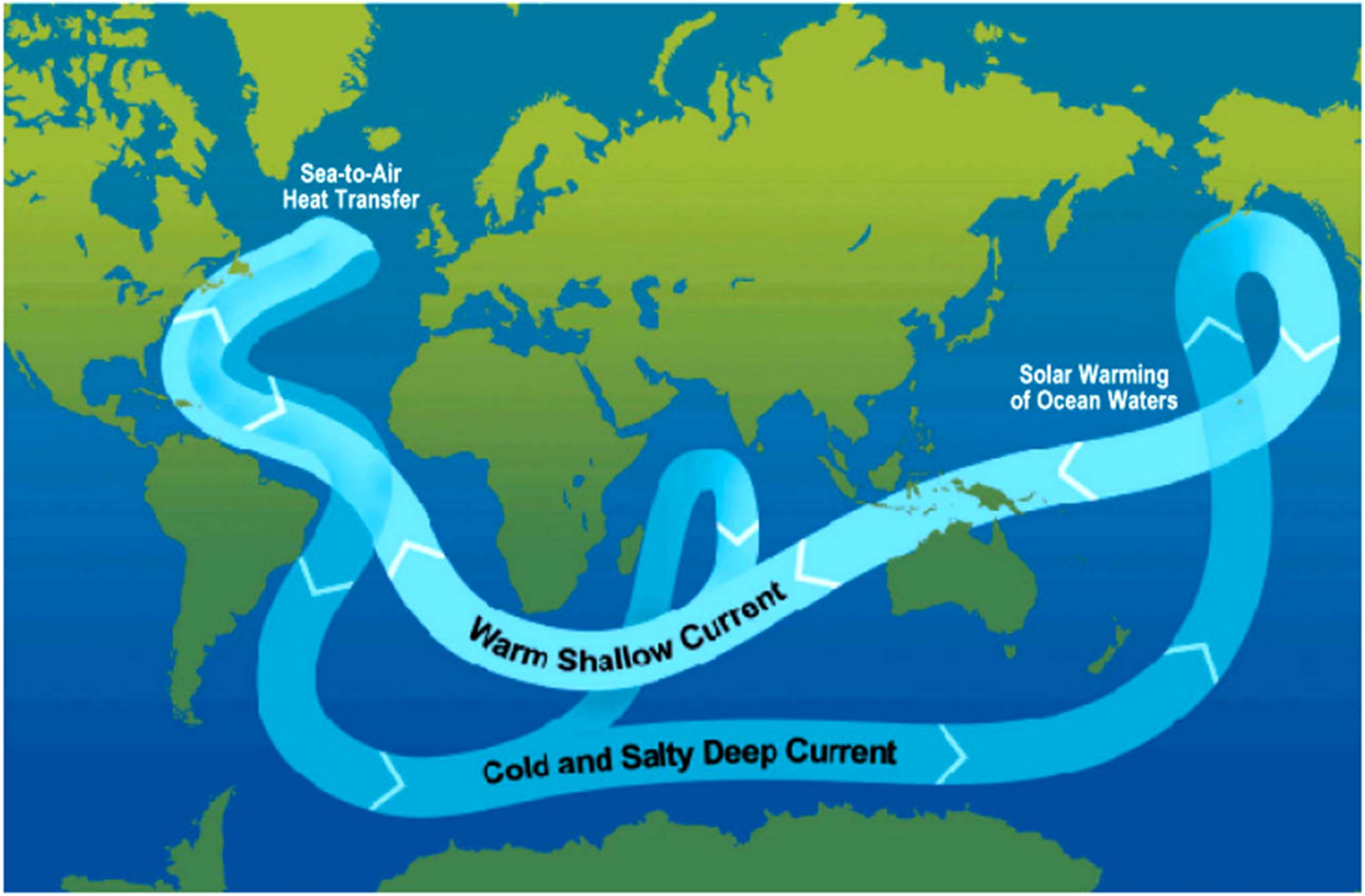
Scientific American, pg 20, July 2001.

Global warming threatens to change the ice caps and glaciers.

Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.

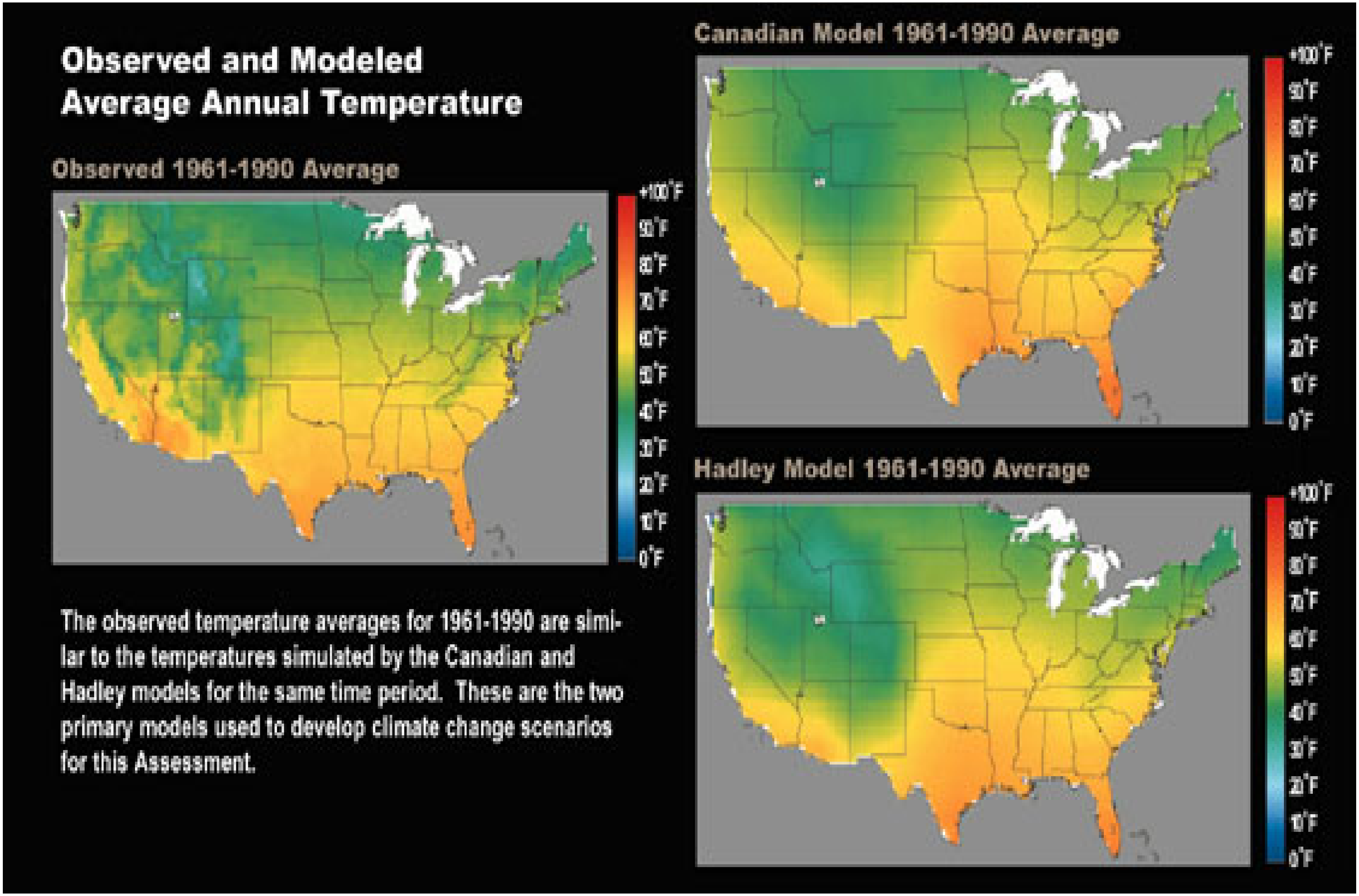


Ocean Circulation Conveyor Belt

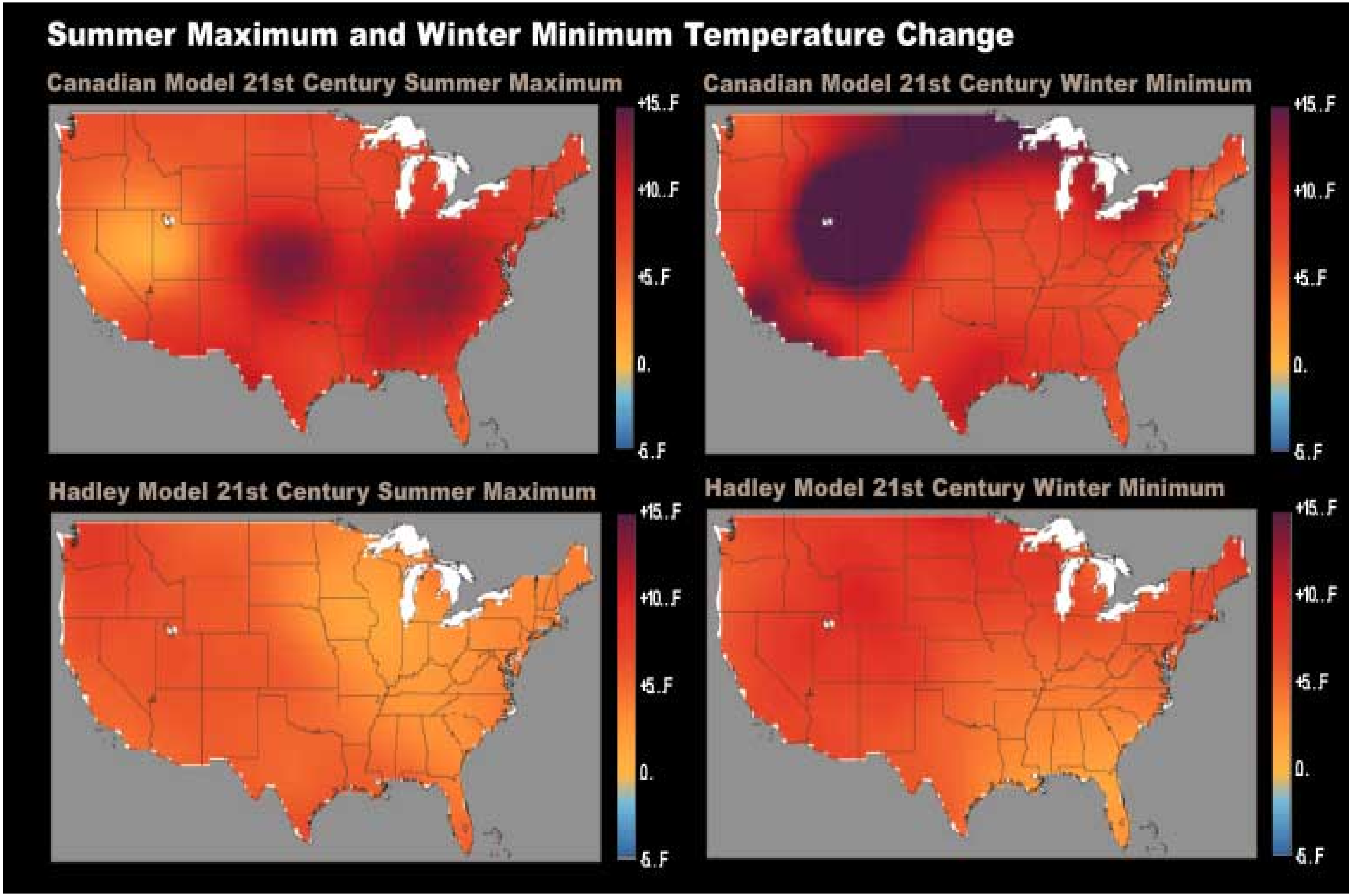


The ocean plays a major role in the distribution of the planet's heat through deep sea circulation. This simplified illustration shows this "conveyor belt" circulation which is driven by differences in heat and salinity. Records of past climate suggest that there is some chance that this circulation could be altered by the changes projected in many climate models, with impacts to climate throughout lands bordering the North Atlantic.

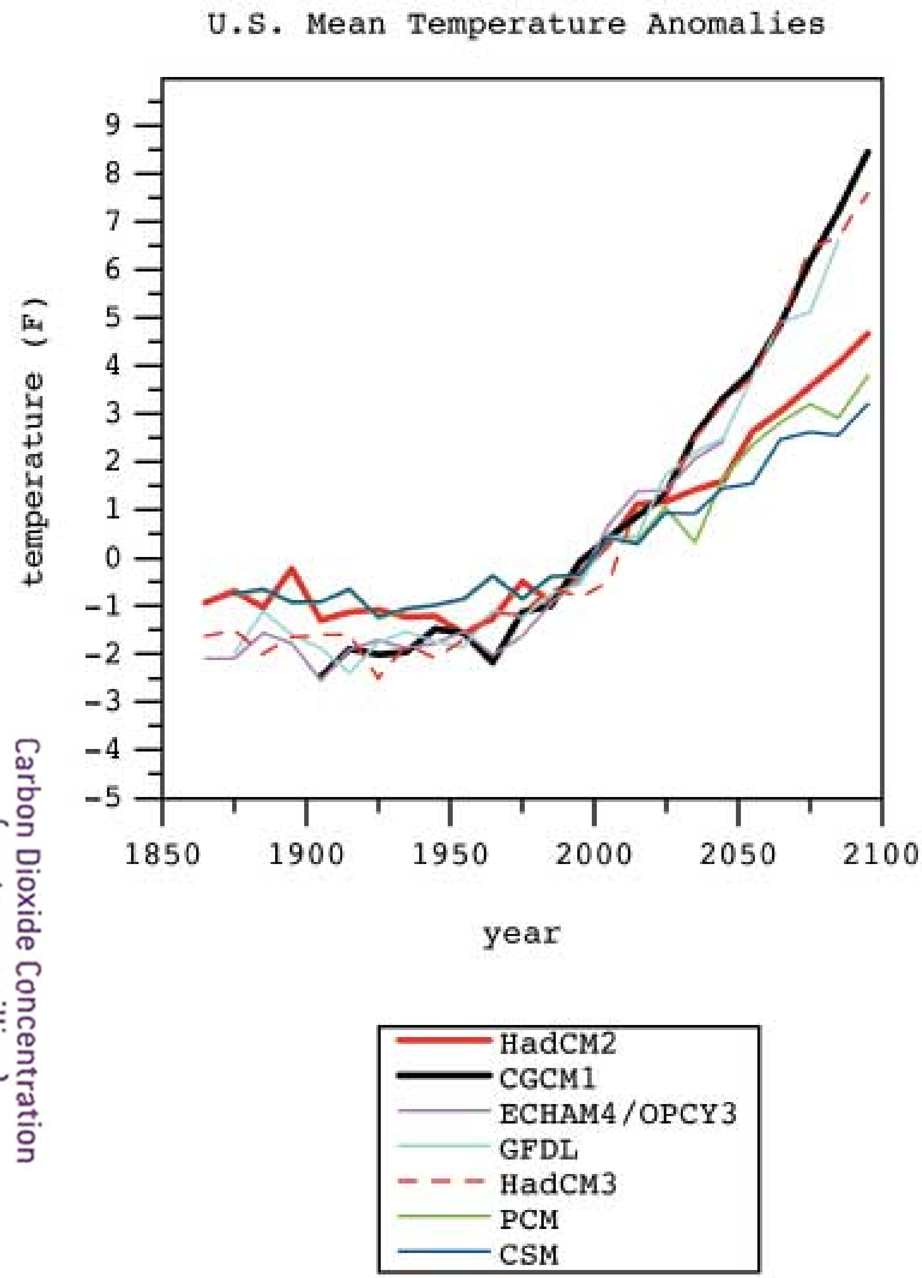
Observed and Modeled Temperature Averages

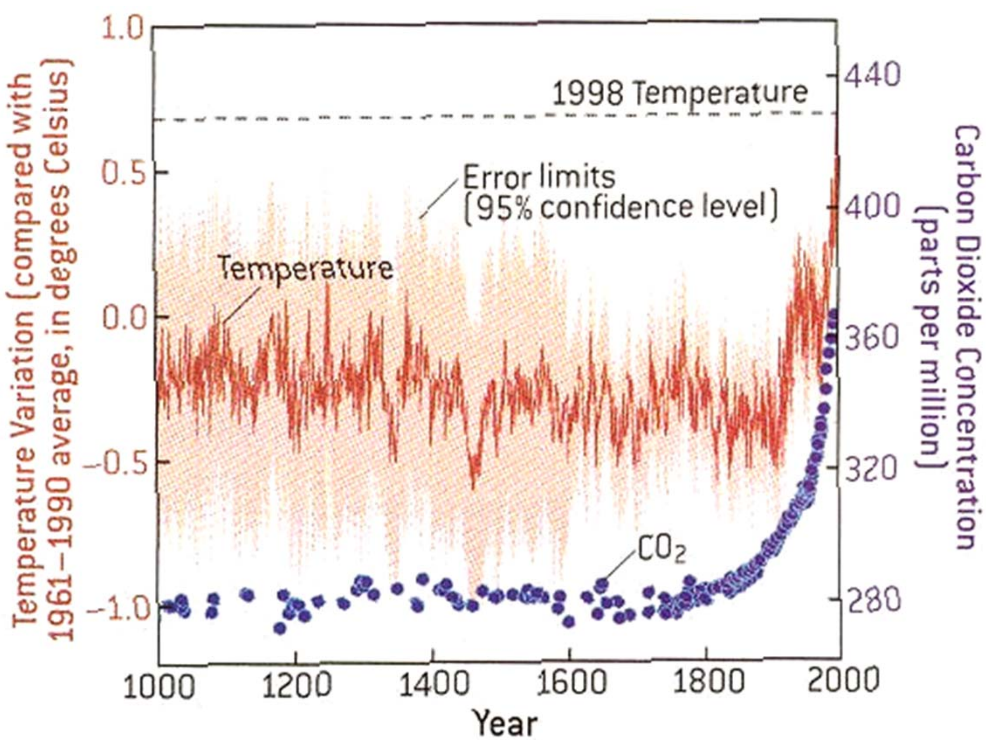


Model of Expected Summer and Winter Changes in 21st Century

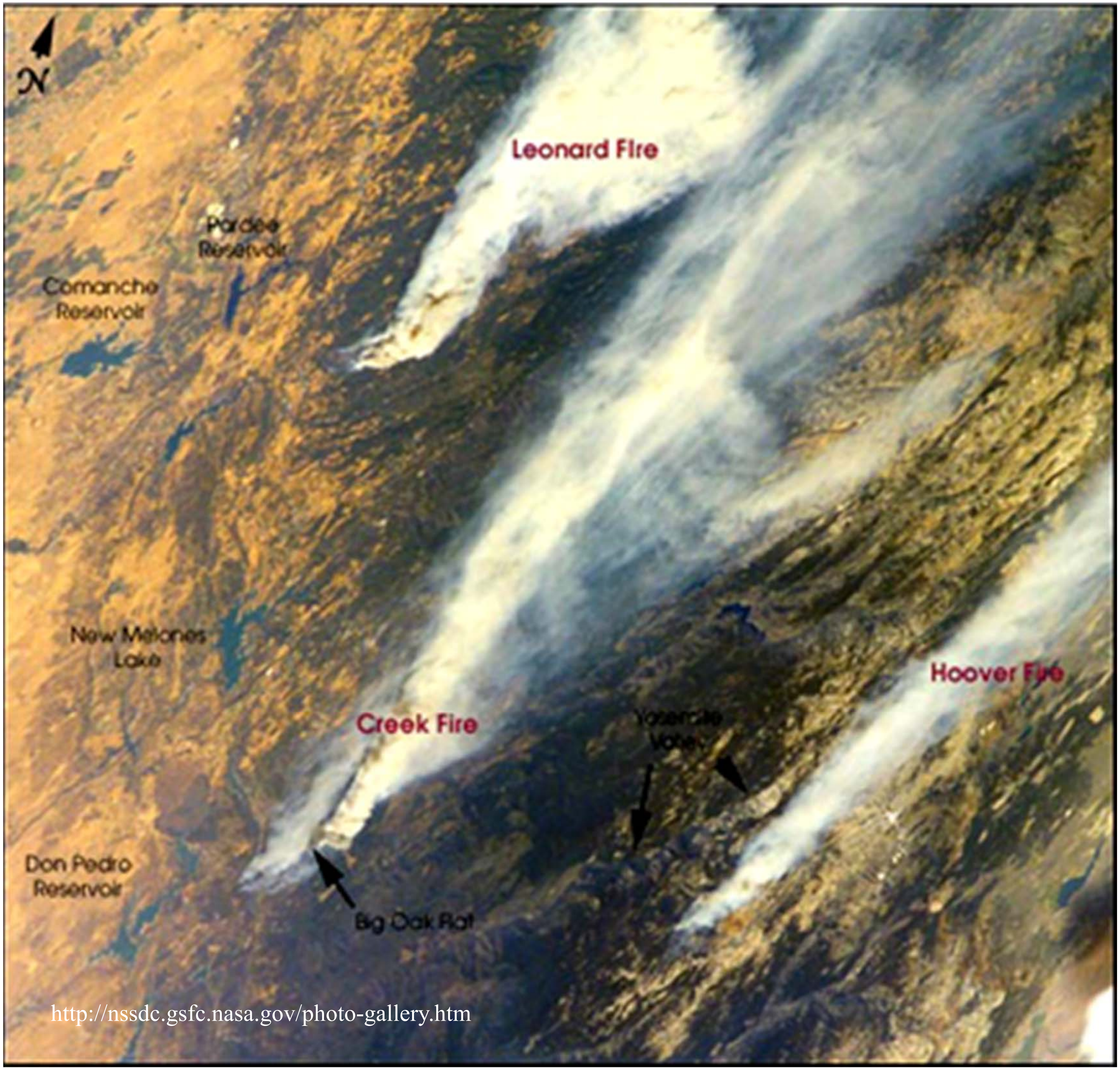


Temperature increase due to global warming based upon different models of several research groups





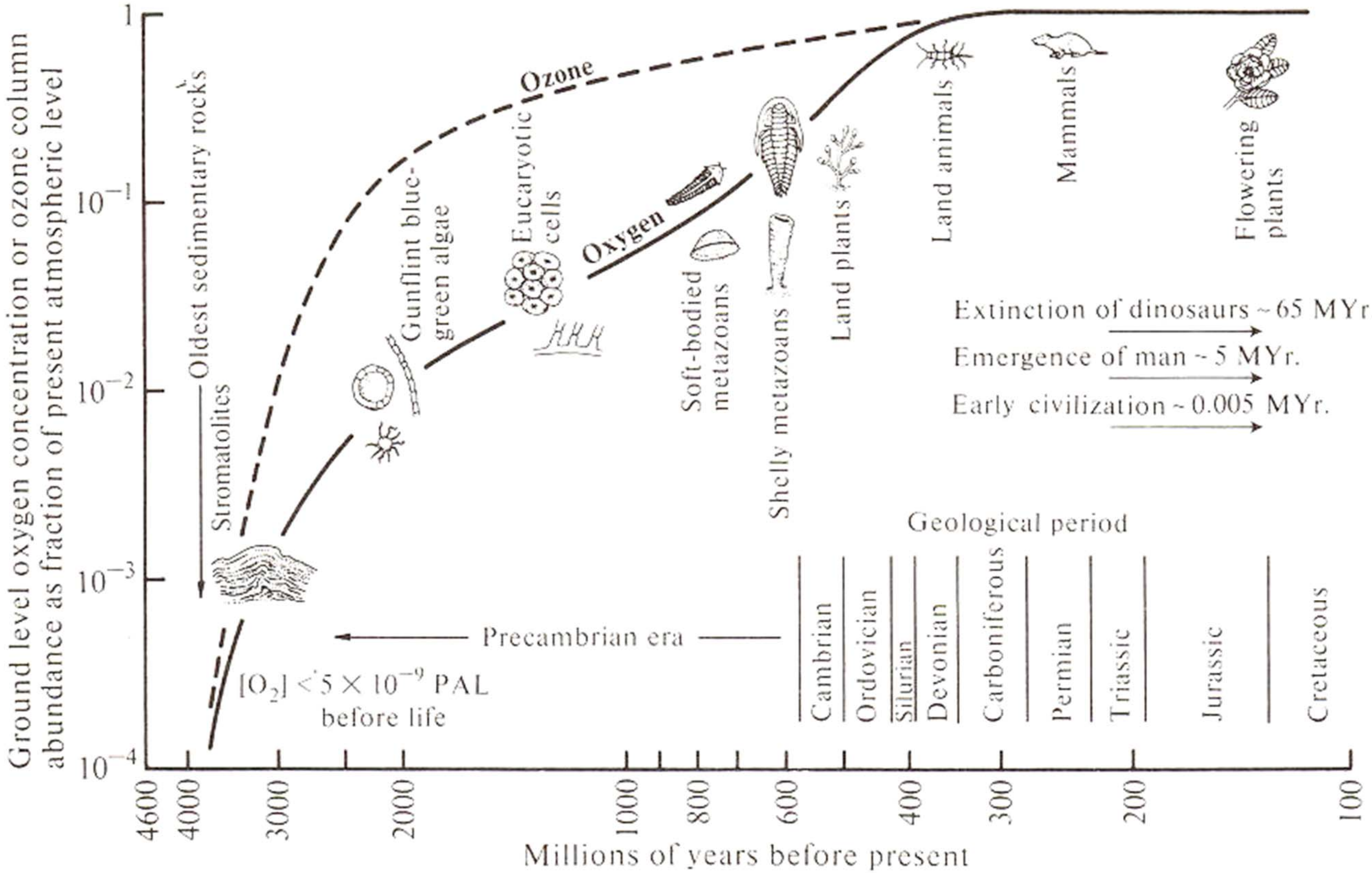
Forest fire observed from space – STS-105 Aug 2001



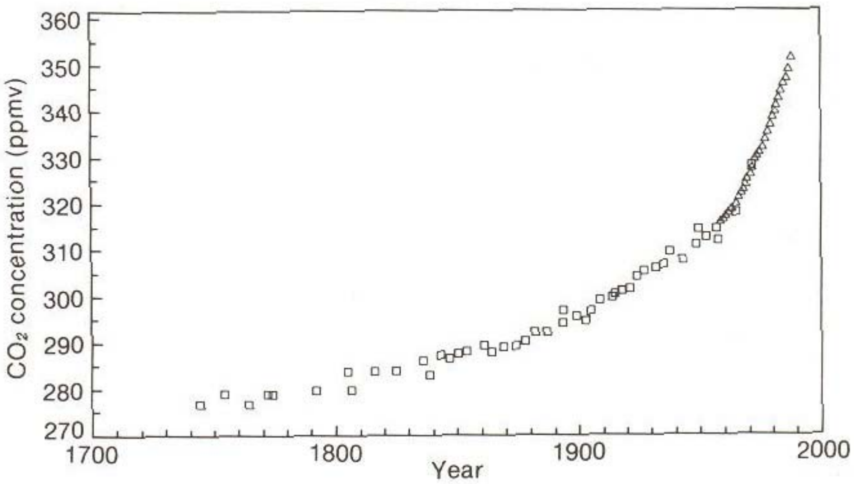
Trans-Amazon Highway being cut through the rain forest near Altamira, Brazil—one example of the deforestation that takes place along with traditional frontier expansion. *Photo courtesy of Nigel J. H. Smith.*

Biodiversity – National Academy Press,1988.

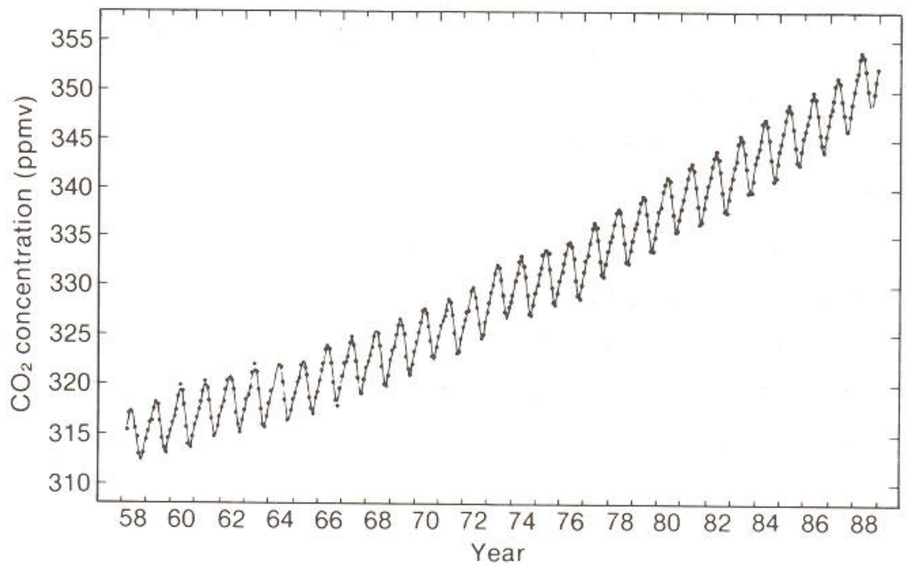
The primordial atmosphere of Earth had no oxygen. The present 21% of O_2 is due to the plant production by photosynthesis which produced oil and coal deposits.



Chemistry of Atmospheres, R.P. Wayne, Oxford Science Publication, 1991.



Atmospheric CO_2 increase in the past 250 years, as indicated by measurements on air trapped in ice from Siple Station, Antarctica (squares; Neftel et al., 1985a; Friedli et al., 1986) and by direct atmospheric measurements at Mauna Loa, Hawaii (triangles; Keeling et al., 1989a).



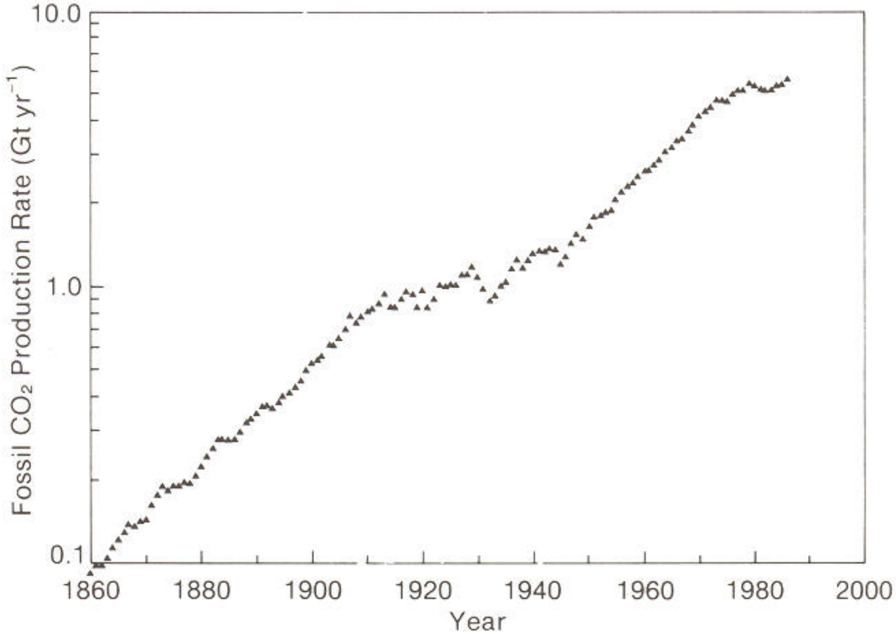
Monthly average CO_2 concentration in parts per million of dry air, observed continuously at Mauna Loa, Hawaii (Keeling et al., 1989a). The seasonal variations are due primarily to the withdrawal and production of CO_2 by the terrestrial biota.

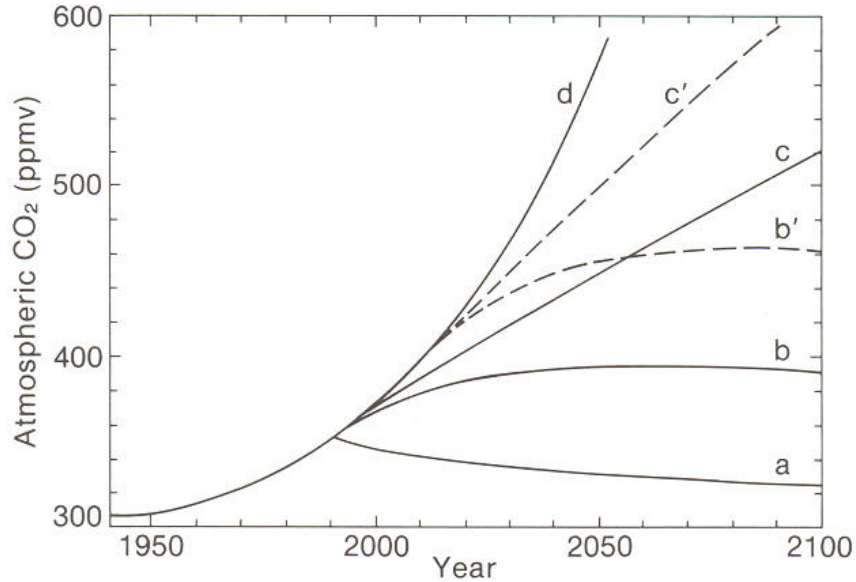
CO_2 is combustion by product of all anthropogenic fuels – it is used by plants in the cycle of photosynthesis to produce oxygen. The increase follows the increase burning of anthropogenic fuels and the oscillation follows the summer/winter conversion of CO_2.

Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.

Forests play a key role in the process of photosynthesis – removal of CO_2 and production of O_2 in our atmosphere

Trees can be saved by making it convenient not to print – better displays



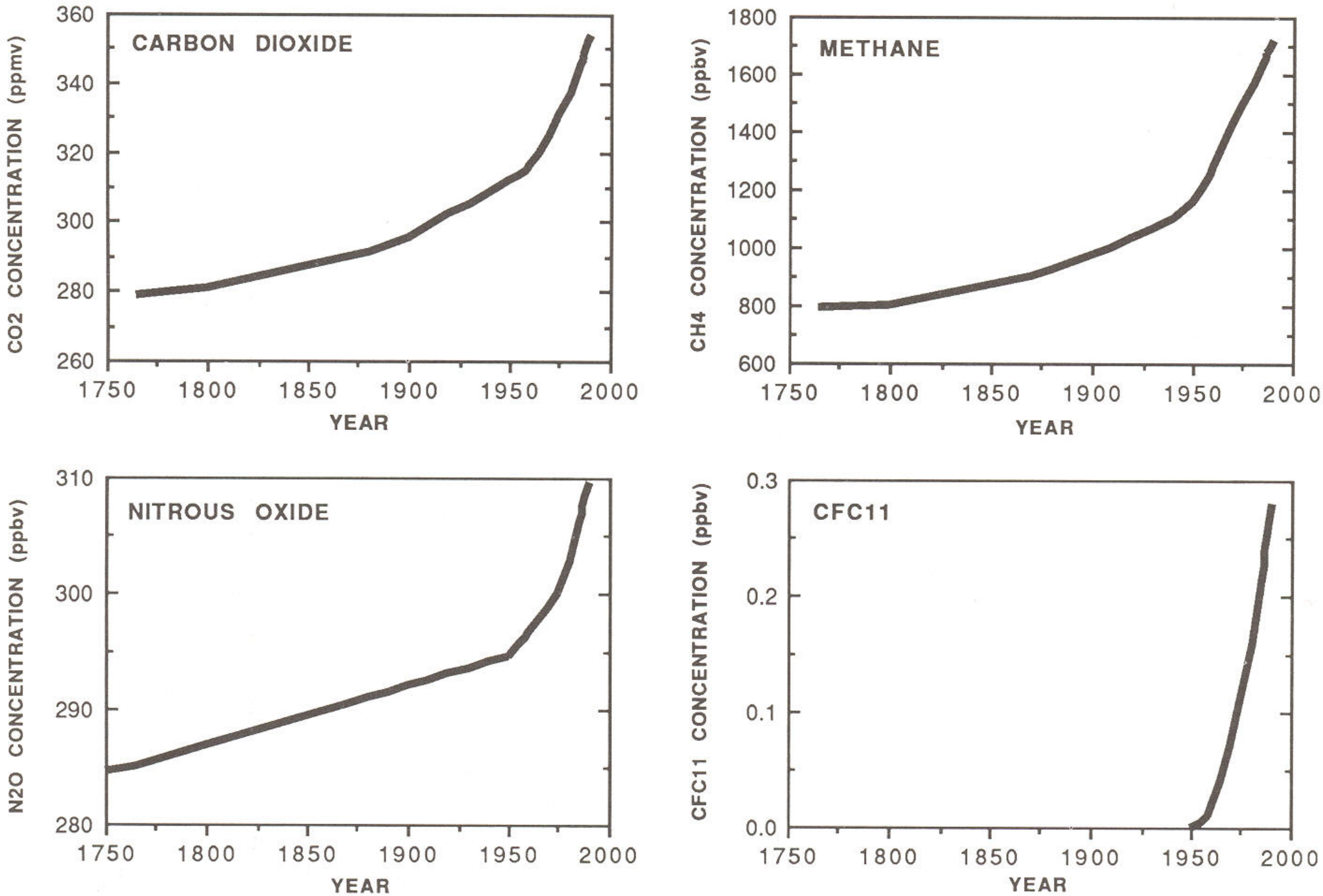


Global annual emissions of CO_2 from fossil fuel combustion and cement manufacturing, expressed in GtC yr^{-1} (Rotty and Marland, 1986; Marland, 1989). The average rate of increase in emissions between 1860 and 1910 and between 1950 and 1970 is about 4% per year.

Future atmospheric CO_2 concentrations as simulated by means of a box-diffusion carbon cycle model (Enting and Pearman, 1982, 1987) for the following scenarios: (a) - (d): anthropogenic CO_2 production rate p prescribed after 1990 as follows: (a) p = 0; (b) p decreasing by 2% per year; (c) p = constant; (d) p increasing at 2% per year. Scenarios (b') and (c'): p grows by 2% per year from 1990-2010, then decreases by 2% per year (b') or is constant (c'). Before 1990, the concentrations are those observed (cf. Figure 1.3), and the production rate was calculated to fit the observed concentrations.

CO_2 production from fossil fuel and the atmospheric composition for various choices by society.

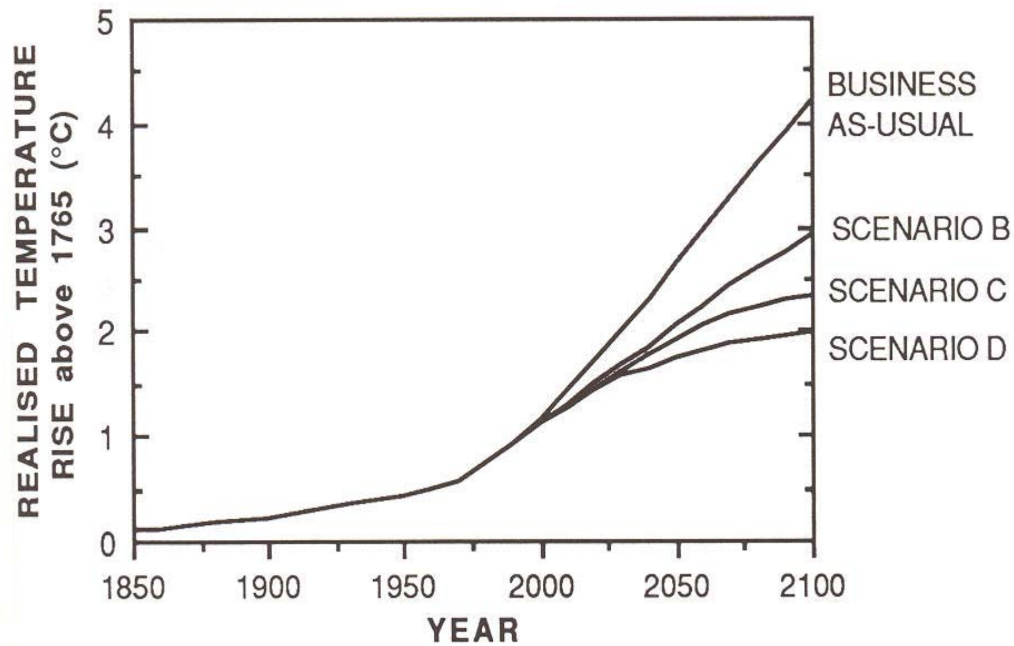
Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.

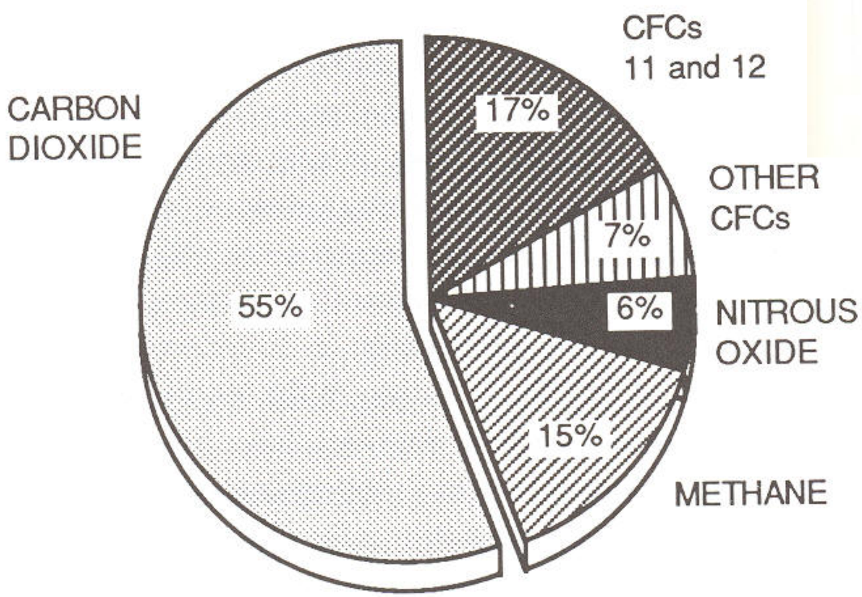


Concentrations of carbon dioxide and methane after remaining relatively constant up to the 18th century, have risen sharply since then due to man's activities. Concentrations of nitrous oxide have increased since the mid-18th century, especially in the last few decades. CFCs were not present in the atmosphere before the 1930s.

Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.

Greenhouse Gases

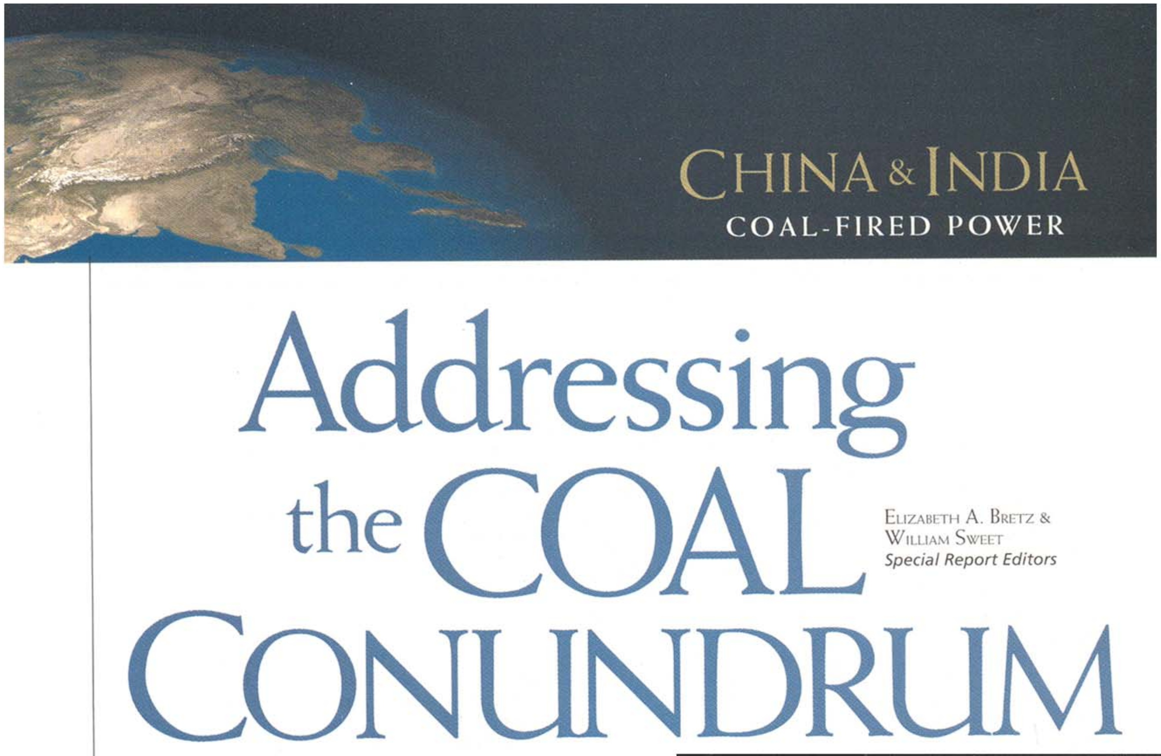




The contribution from each of the human-made greenhouse gases to the change in radiative forcing from 1980 to 1990. The contribution from ozone may also be significant, but cannot be quantified at present.

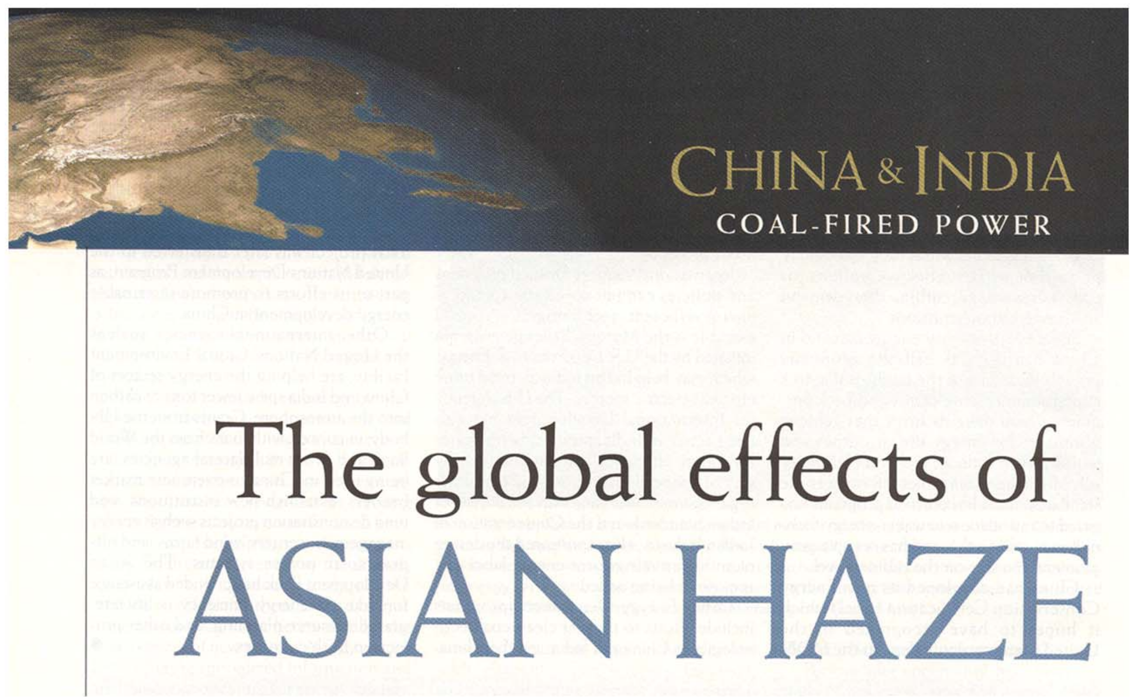
The IR absorption of Earth's radiation into space captures additional heat and causes global average temperature rise.

Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.



In China, between 1990 –1995, there were more deaths due to air pollution than any other cause.

China & India: The Dilemma of Coal-Fired Power - IEEE Spectrum, Nov and Dec 1999



1. Origins and extent of atmospheric pollution

	Long-lived greenhouse gases				Short-lived air pollutants				
Type of pollutant	CO_2	CH_4	N_2O	CFCs [a]	CO	NMHC	NO_x	SO_2	Soot
Sources in 1990s (teragrams per year of carbon or nitrogen or sulfur dioxide)									
Industrial and fossil-fuel related	5500	125	1.3	0.65 (1990)	125	120	25	70	7
Tropical agricultural and biomass burning [b]	1600	275	3	—	400	70	10	2	6
Natural	—	200	7.5	—	160	750	10	20	—
Volume mixing ratios									
Pre-industrial (about 1850)	280 ppm	750 ppb	270 ppb	0	Unknown				
Present (1990s)	360 ppm	1730 ppb	310 ppb	0.8 ppb [a]	50–500 ppb	2–10 ppb	0.05–5 ppb	0.05–5 ppb	1–103 ngC/m^3
Lifetimes and rates of increase									
Atmospheric lifetime	50–200 years	8 years	120 years	50–100 years	2–3 months [c]	Hours-weeks [c]	1–2 days [c]	A few days [c]	Days-weeks [c]
Annual rate of increase in 1990s	0.5%	0.5%	0.2%	0.5%	Regionally variable				

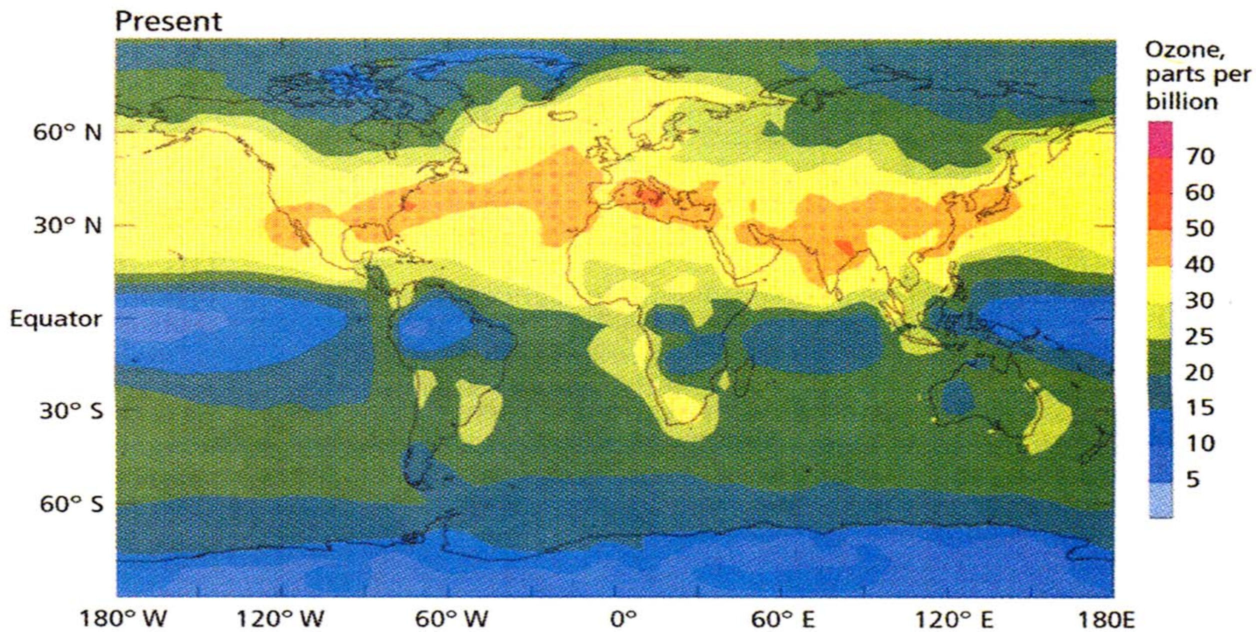
NMHC = non-methane hydrocarbons   Ppm, ppb = parts per million/billion by volume

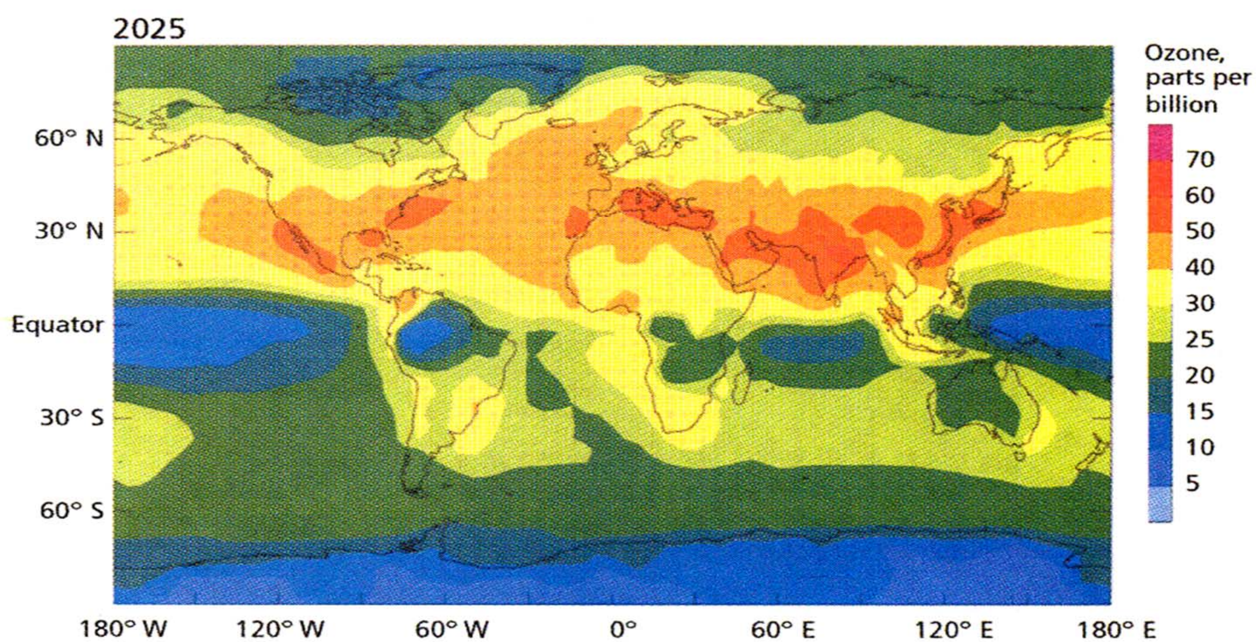
Source: Indoex

[a] These are chlorofluorocarbons CFC-11 and -12, phased out under the Montreal Protocol. The mixing ratio for CFC-11 is declining by 0.3 percent per year, for CFC-12 increasing by 0.7–1 percent per year.
[b] But large-scale fertilization and afforestation may remove 1600 Tg of carbon per year from the atmosphere.
[c] Ranges indicate clean background air to regional pollution.

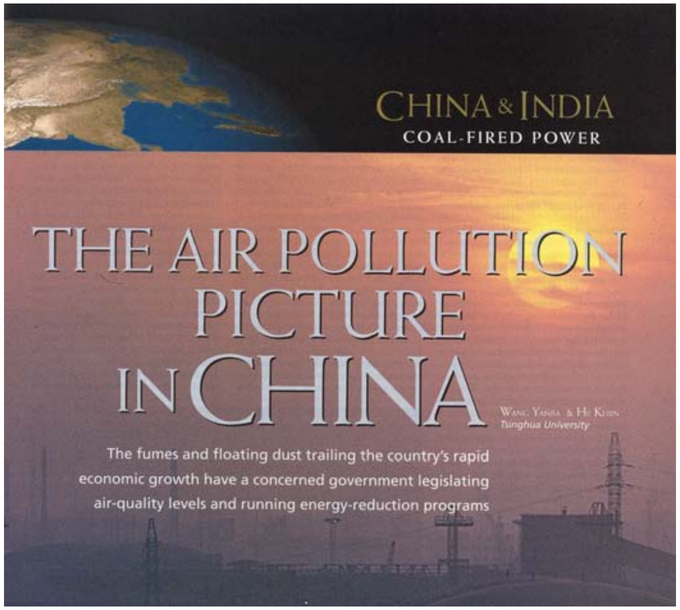
China & India: The Dilemma of Coal-Fired Power - IEEE Spectrum, Nov and Dec 1999

Expected increase in background ozone from fossil fuel combustion





China & India: The Dilemma of Coal-Fired Power - IEEE Spectrum, Nov and Dec 1999



China & India: The Dilemma of Coal-Fired Power - IEEE Spectrum, Nov and Dec 1999

1. Emission of waste gas by industry in 1997

Industry	Volume of waste gas emitted, Gm^3	Percentage of national total	Percentage of waste gases due to combustion[a]
Power[b]	4 148	34%	99%
Iron and steel	2 736	22%	27%
Cement	1 536	12%	15%
Chemical	938	8%	58%
Other	3 012	24%	65%
National total	**12 370**	**100%**	**61%**

Source: China Statistical Yearbook 1998

[a]The remander is due to industrial processes.

[b] Production and supply of electric power, gas and water.

2. Sulfur dioxide and particle emission by industry in 1997

Emissions	SO_2		Dust and soot	
Industry	Volume, kilotons	Percent of total	Volume, kilotons	Percent of total
Power	7 895	56.2	4 025	19.3
Iron and steel	1 664	11.8	1 876	9.0
Cement	796	5.7	6 267	30.0
Chemical	453	3.2	4 749	22.8
Others	3 235	23.1	3 929	18.8
Total	**14 043**	**100.0**	**20 846**	**100.0**

Source: China Statistical Yearbook 1998

3. The main sources of greenhouse gases

Source type	CO_2, megatons of carbon	Methane, megatons
Energy	+546.6–559.6	11.75
Industrial processes	+21.5	N.A.
Agriculture	N.A.	18.23
Changed land use and forestry	-86	N.A.
Landfill and wastewater	N.A.	2.45
Net emission	**+482.1–495.1**	**32.43**

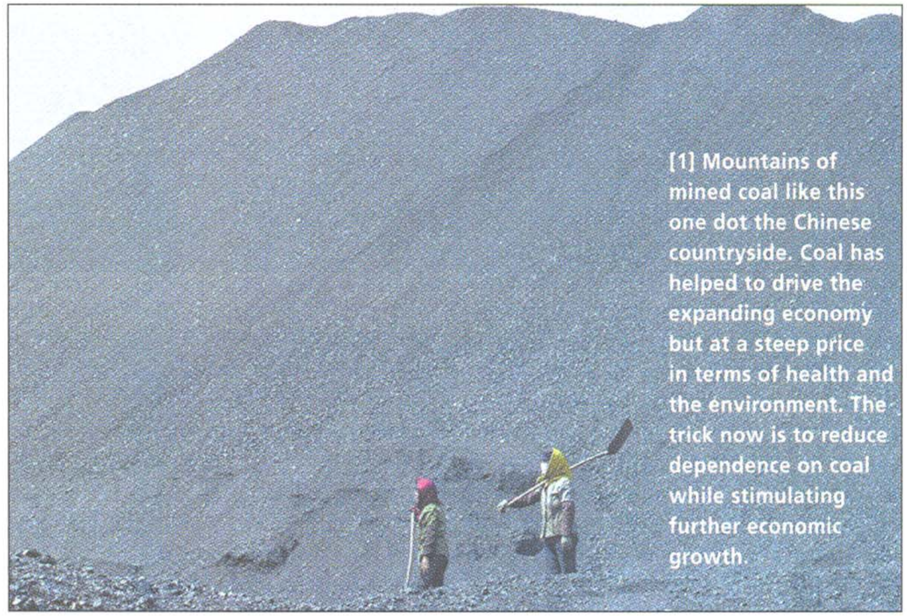
N.A. = not applicable

Source: China Climate Change Country Study, Tsinghua University Press, 1999

4. Likely effect on greenhouse gases of greater energy efficiency

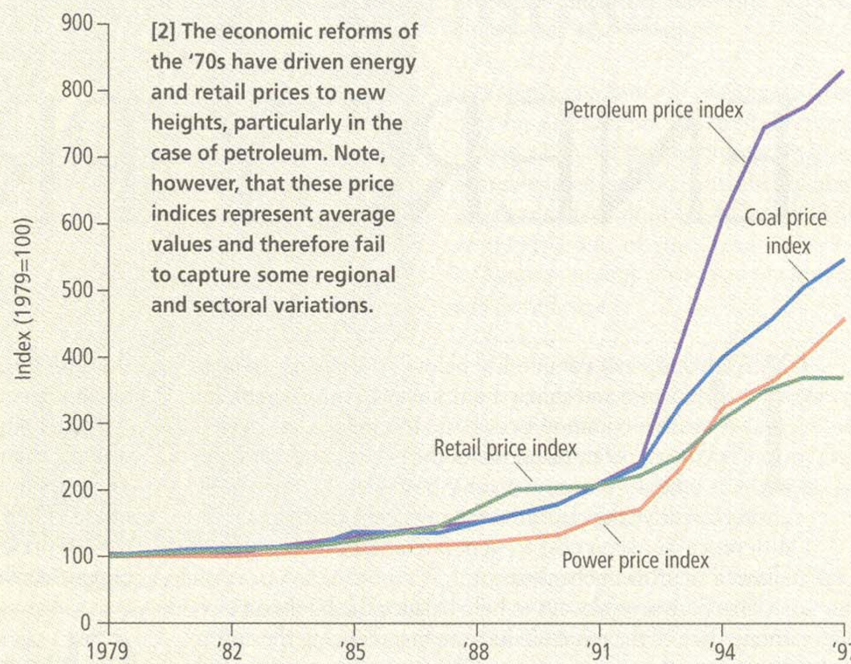
Equipment	Estimated reduction in carbon emissions by 2010
Industrial boilers	62 megatons
Industrial motors	106 megatons
Lighting	68 megatons
Household electric appliances	11 megatons

Source: China Climate Change Country Study, Tsinghua University Press, 1999



[1] Mountains of mined coal like this one dot the Chinese countryside. Coal has helped to drive the expanding economy but at a steep price in terms of health and the environment. The trick now is to reduce dependence on coal while stimulating further economic growth.

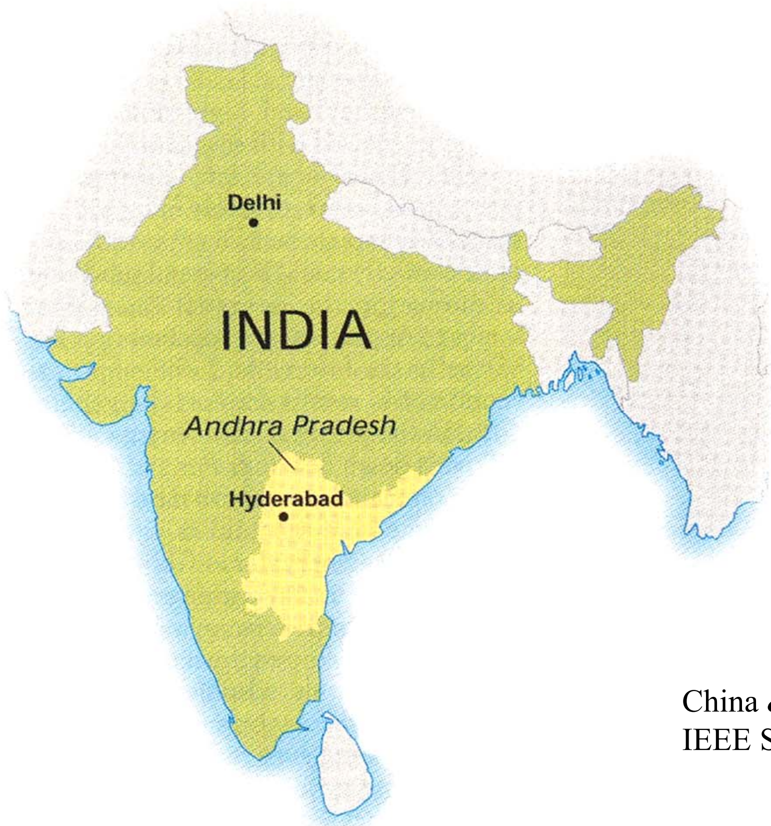
GREG BAKER/ AP/WIDE WORLD PHOTO



[2] The economic reforms of the '70s have driven energy and retail prices to new heights, particularly in the case of petroleum. Note, however, that these price indices represent average values and therefore fail to capture some regional and sectoral variations.

Source: China Statistical Yearbook, 1998.

China & India: The Dilemma of Coal-Fired Power –
IEEE Spectrum, Nov and Dec 1999



1. Energy growth in Andhra Pradesh

Statistic	1959	1998
Peak demand	146 MW	5742 MW
Numbers of consumers served	270 000	10 000 000
Energy moved by grid	686×10^6 kWh	$36\,358 \times 10^6$ kWh
Agricultural pump sets	18 000	1 850 000
Annual revenue	66 million rupees	42 000 million rupees

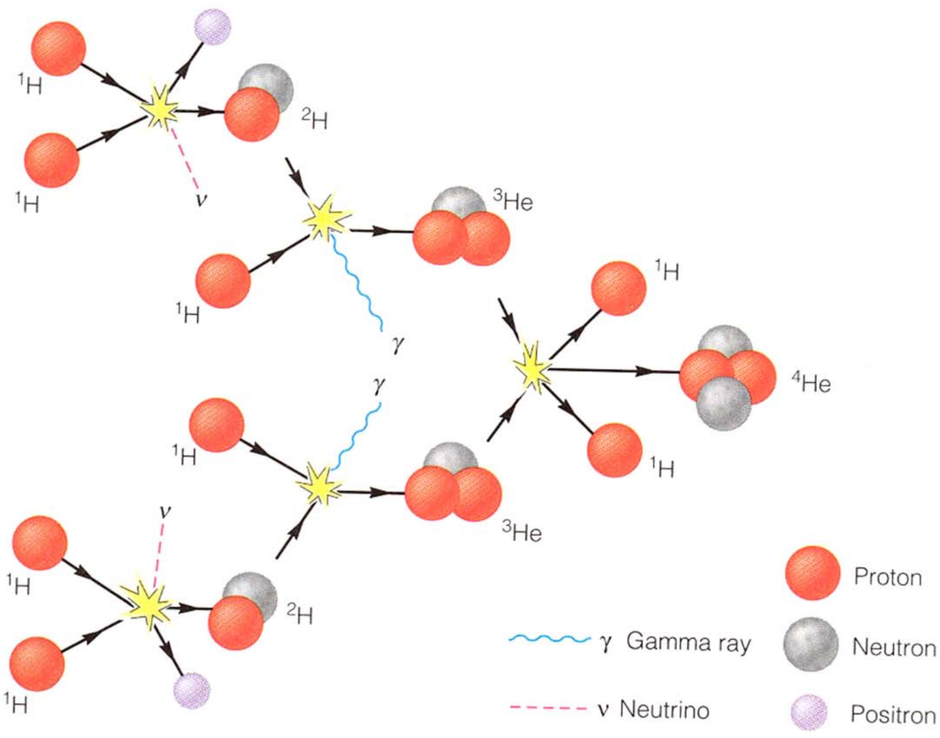
Source: Andhra Pradesh State Electricity Board

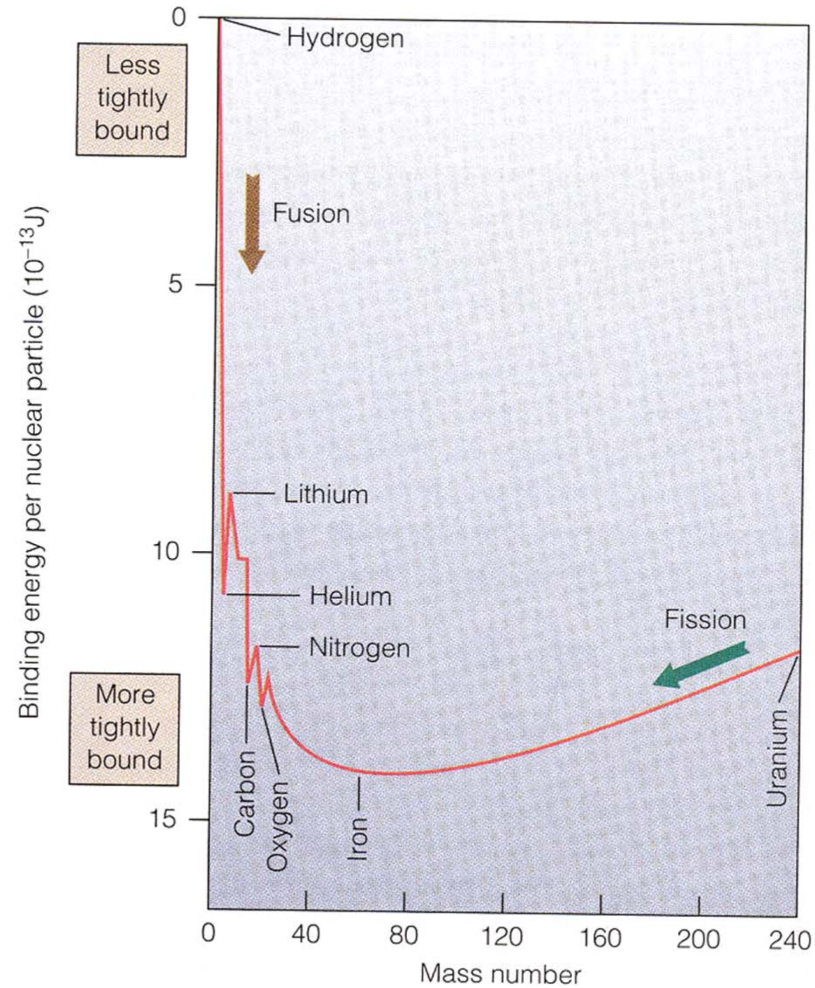
China & India: The Dilemma of Coal-Fired Power –
IEEE Spectrum, Nov and Dec 1999

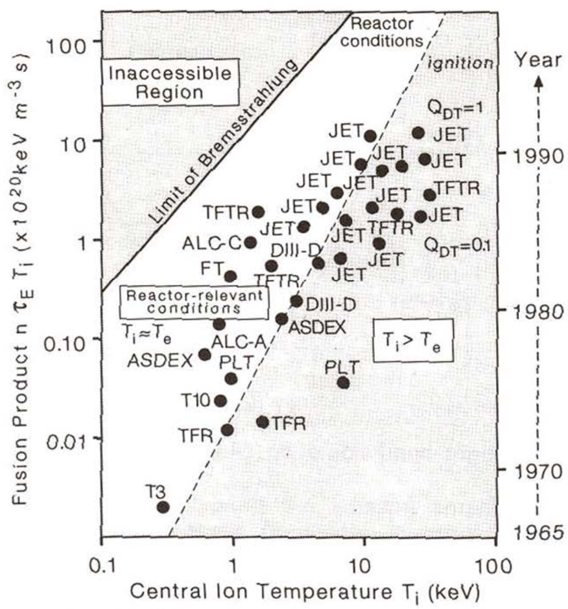
Asian industrial emissions of nitrogen oxides during the next 30 years could triple the acid rain. The source of 10% of nitrogen is natural (from lightning and soil emission), more than 50% from burning fossil fuel, and remainder from industrial and agricultural sources.

(More Acid Rain in East Asia's Future - Science News, p 381, 16 June 2001.)

Nuclear Power Generation -



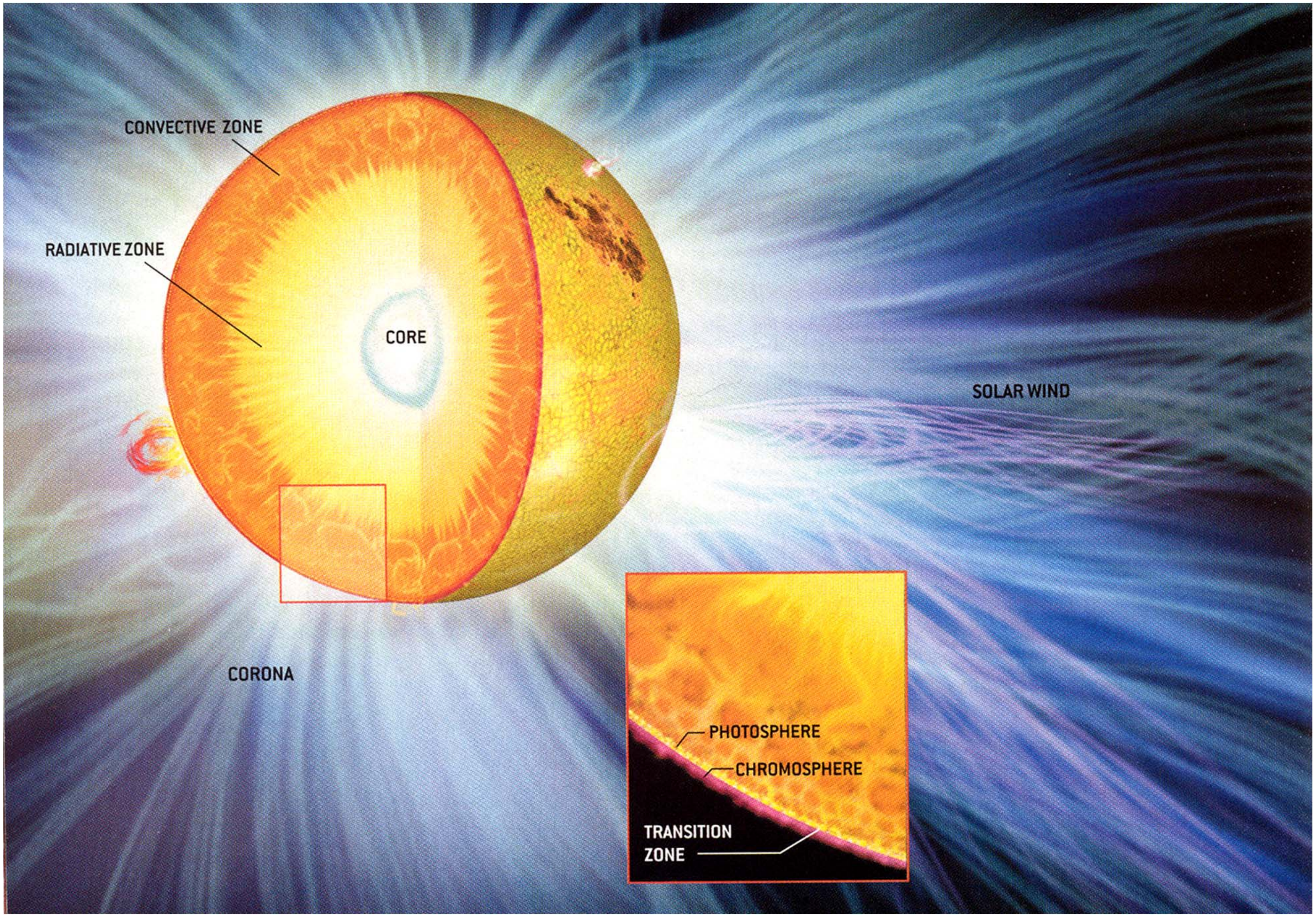




Fusion Reactor

Horizons, Exploring the Universe – MA Seeds, Wadsworth Publishing, 1998.

Environmental Physics, Boeker and Grondelle, John Wiley & Sons, 1995.

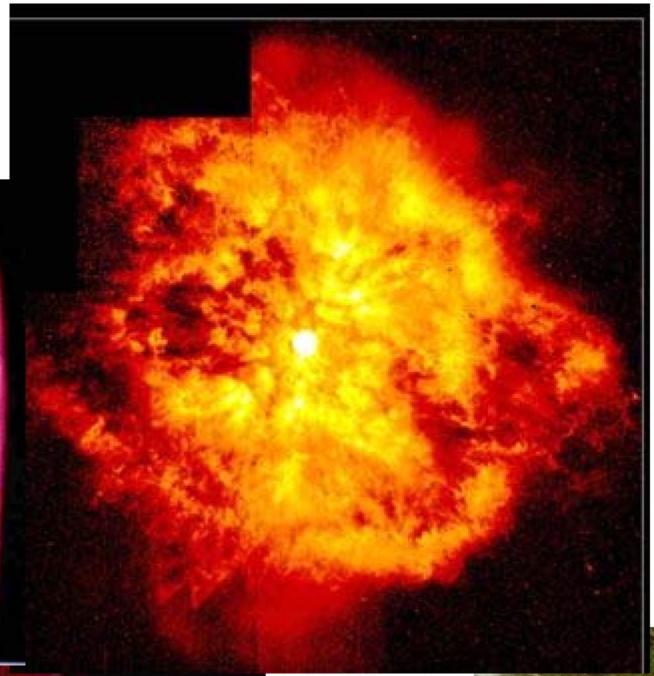


Fusion combines 4 H nuclei to form He and release energy, $E=mc^2$

Scientific American, pg 44, June 2001.

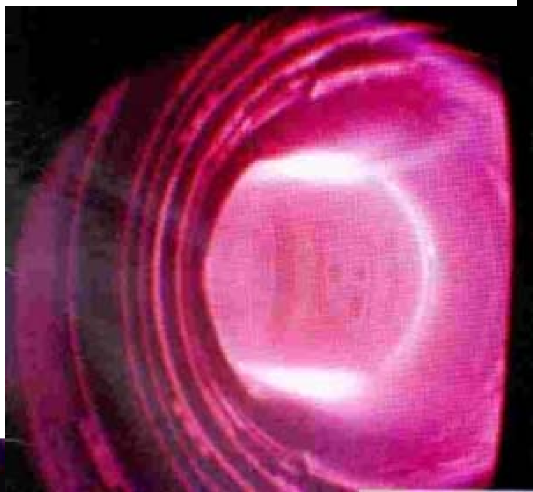
Plasma Fusion

Nebula M1-67

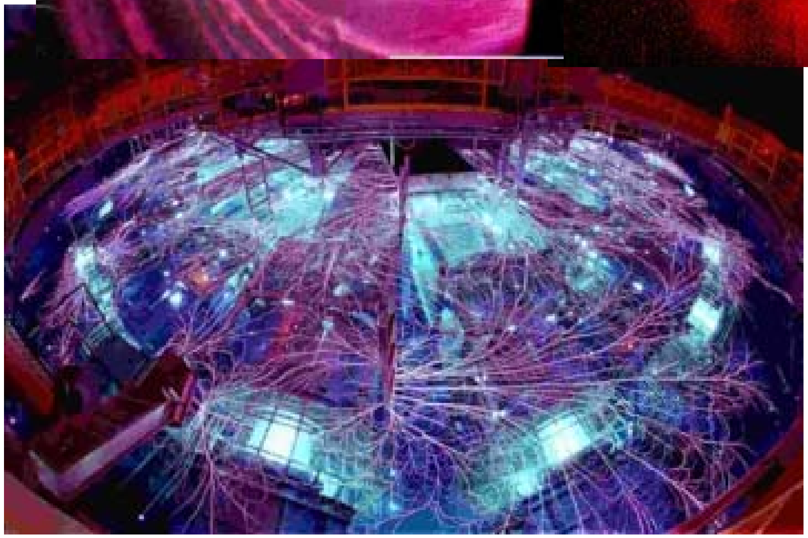


Plasma fusion reactors hold the promise for a long term, relatively clean energy source.

Tokamak Plasma - Princeton

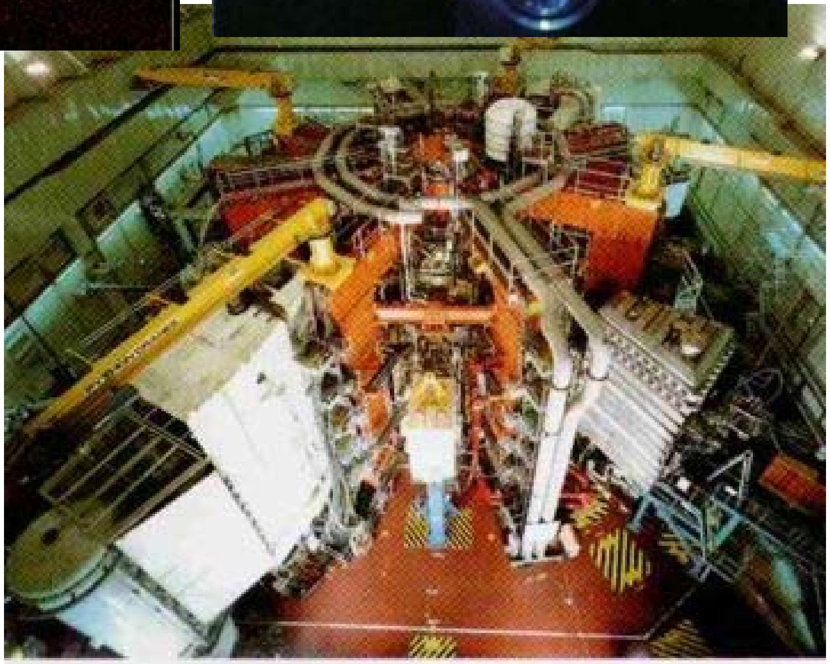


Inertial Confinement – Univ Rochester



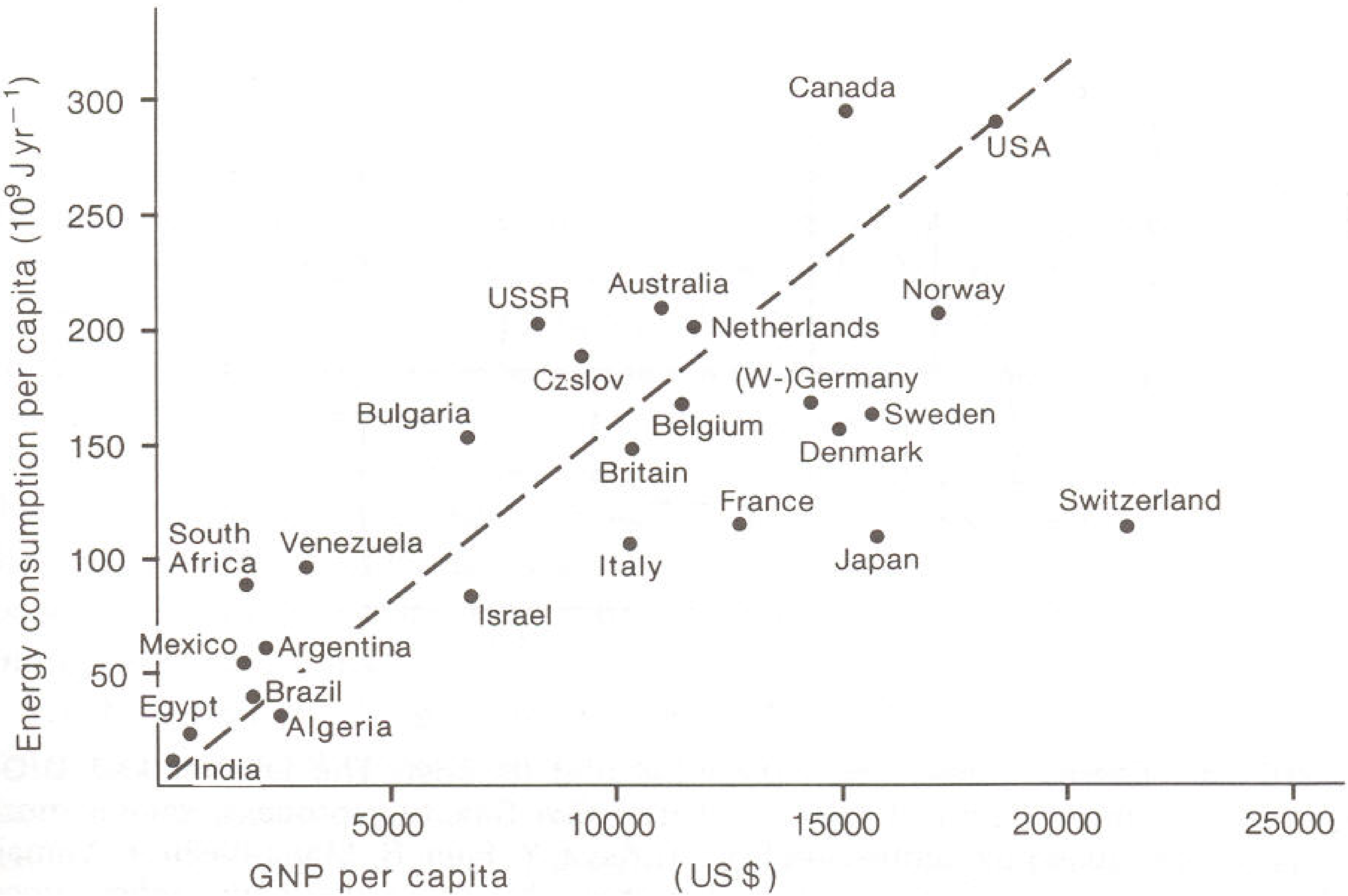
JET-Tokamak
UK Physics

Z-Machine
Sandia



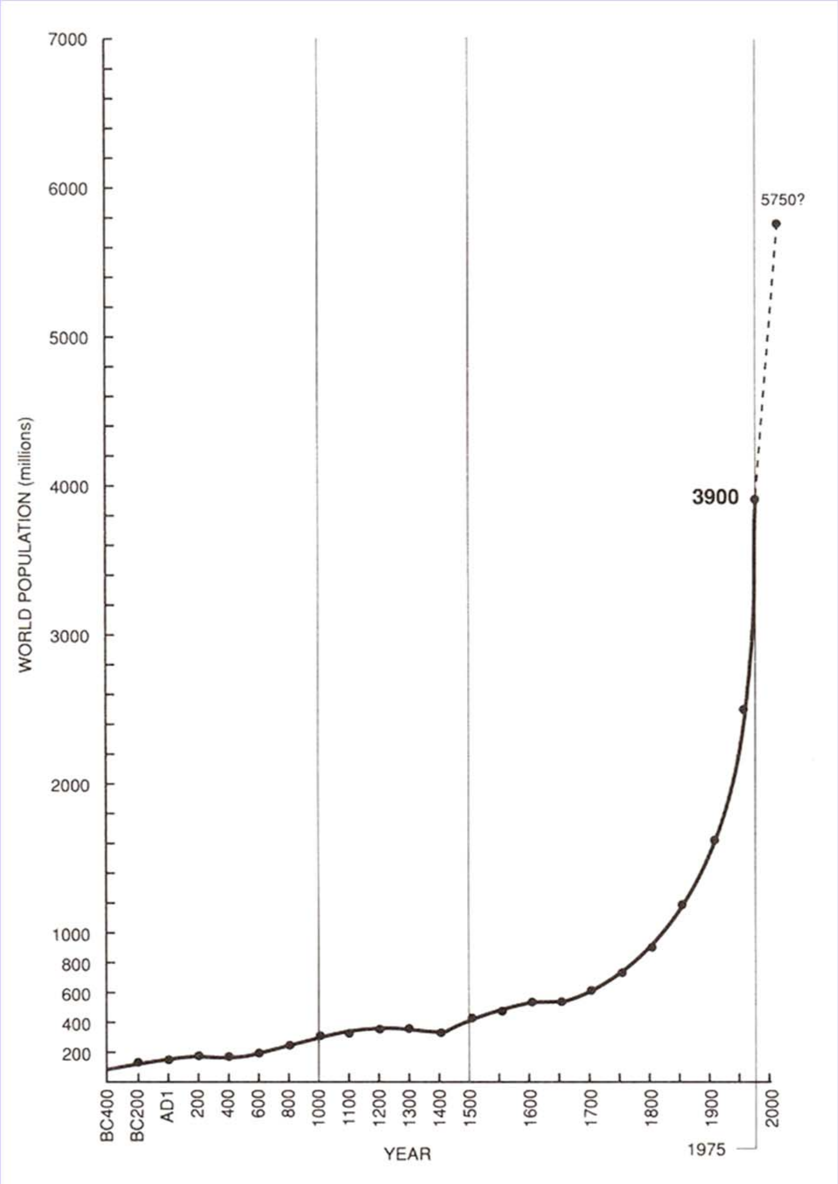
Fusion Plasmas –
http://www.plasma.org/photo-fusion.htm

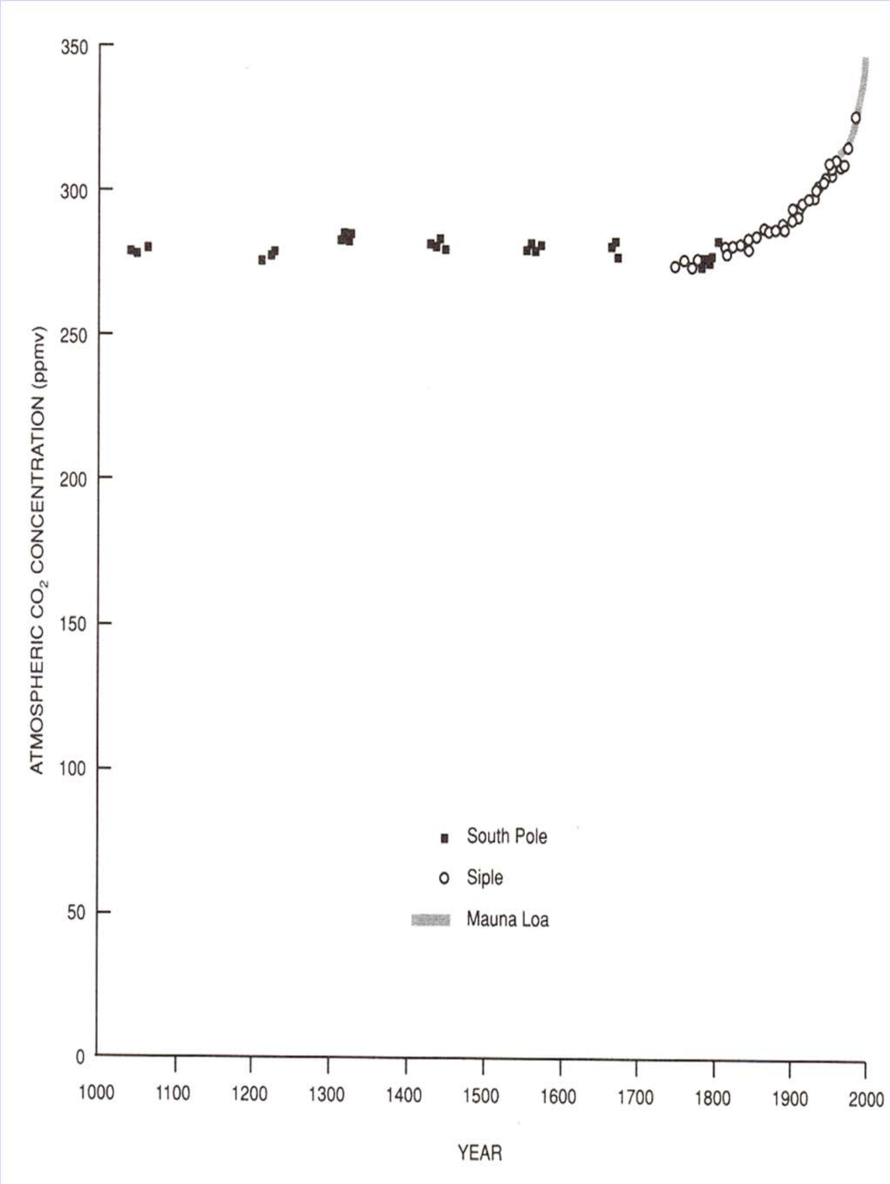
Energy Consumption Compared with Gross National Product



Environmental Physics, Boeker and Grondelle, John Wiley & Sons, 1995.

Population growth and increase in CO_2 from combustion





Policy Implications of Greenhouse Warming – National Academy Press, 1991.

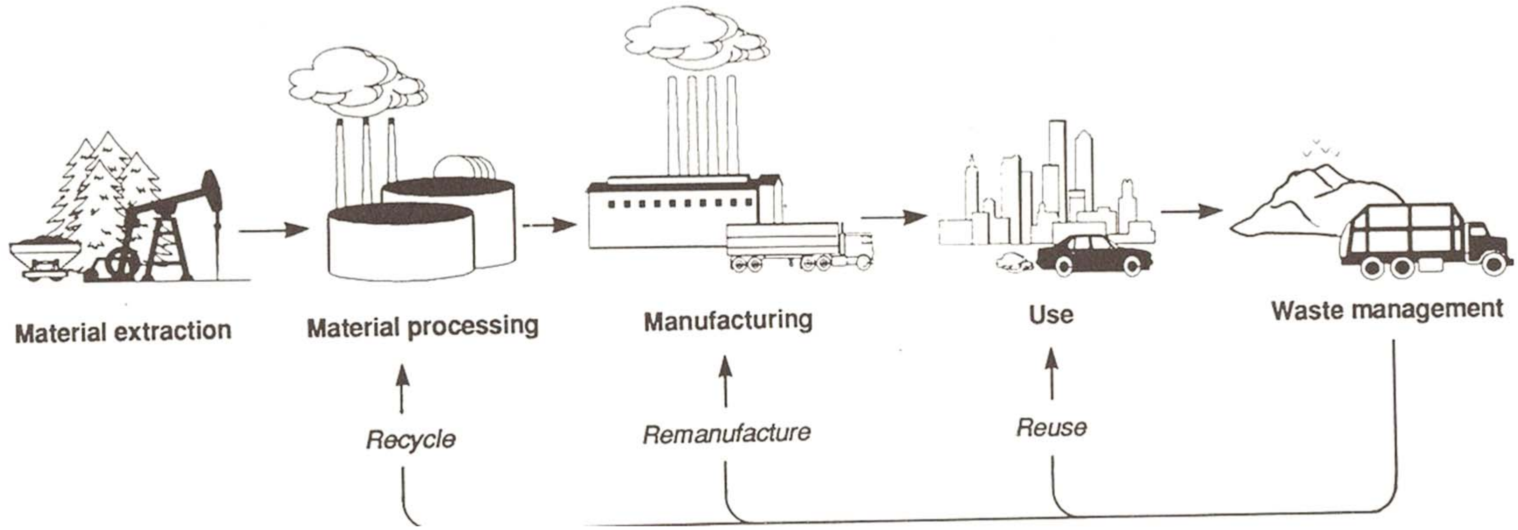
What can I do as an individual to conserve resources?

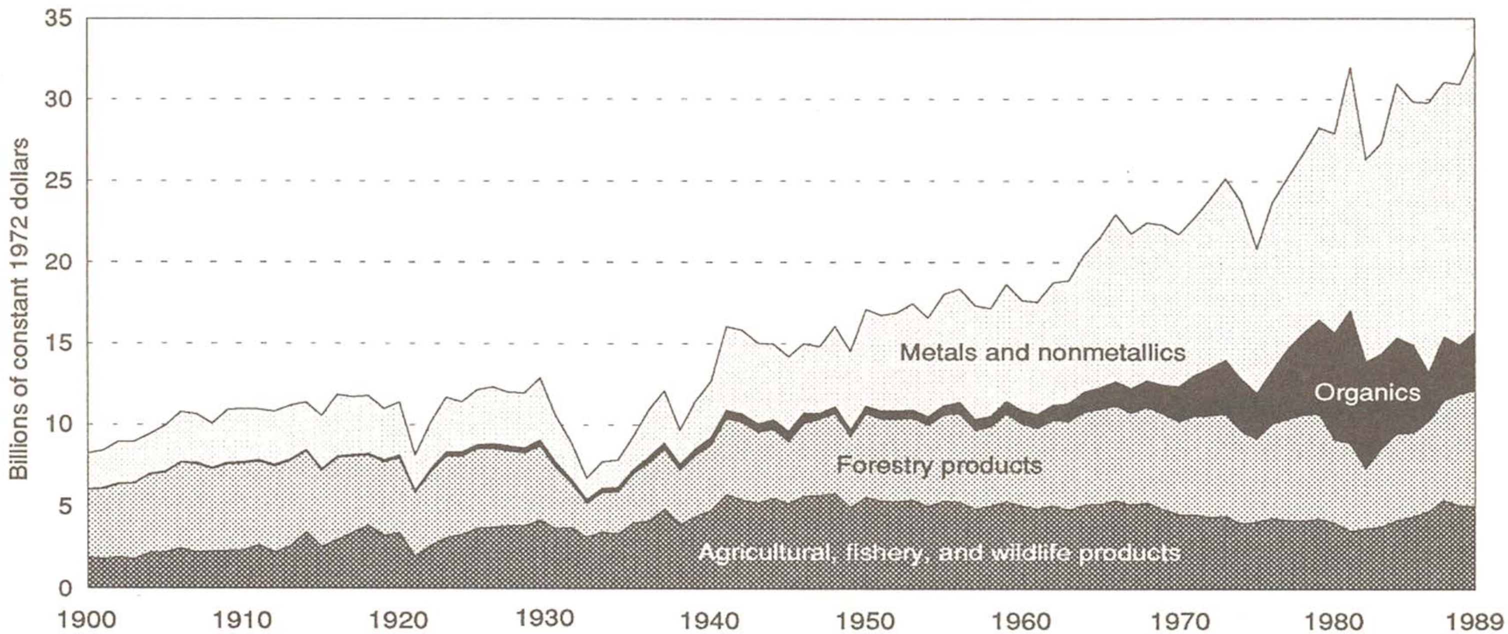
Olympus Photo Deluxe, 2000

- End junk mail
- Use low phosphate detergent
- Use low flow faucet aerator
- Reuse containers
- Use unbleached paper
- Use sponge or cloth to wipe spills
- Use less heating and AC
- Reduce water use in toilet
- Low-flow showerhead
- Shower-soap-shower (30-35%)
- Water flow – brush teeth – water
- Conserve electricity use
- Insulate home
- Reduce travel by car – use public
- Recycle glass, plastic, metal, paper
- Plant a tree (avg use is 7 per year)
- Eat low on food chain
- Teach others to conserve
- Support conservation with your pen

50 Simple Things You Can Do to Save Earth, Earth Works Press, 1991.

Learn and Practice Green Design





Green Products by Design – Congress of the United States, Office of Technology Assessment, 1992.

Perspective –

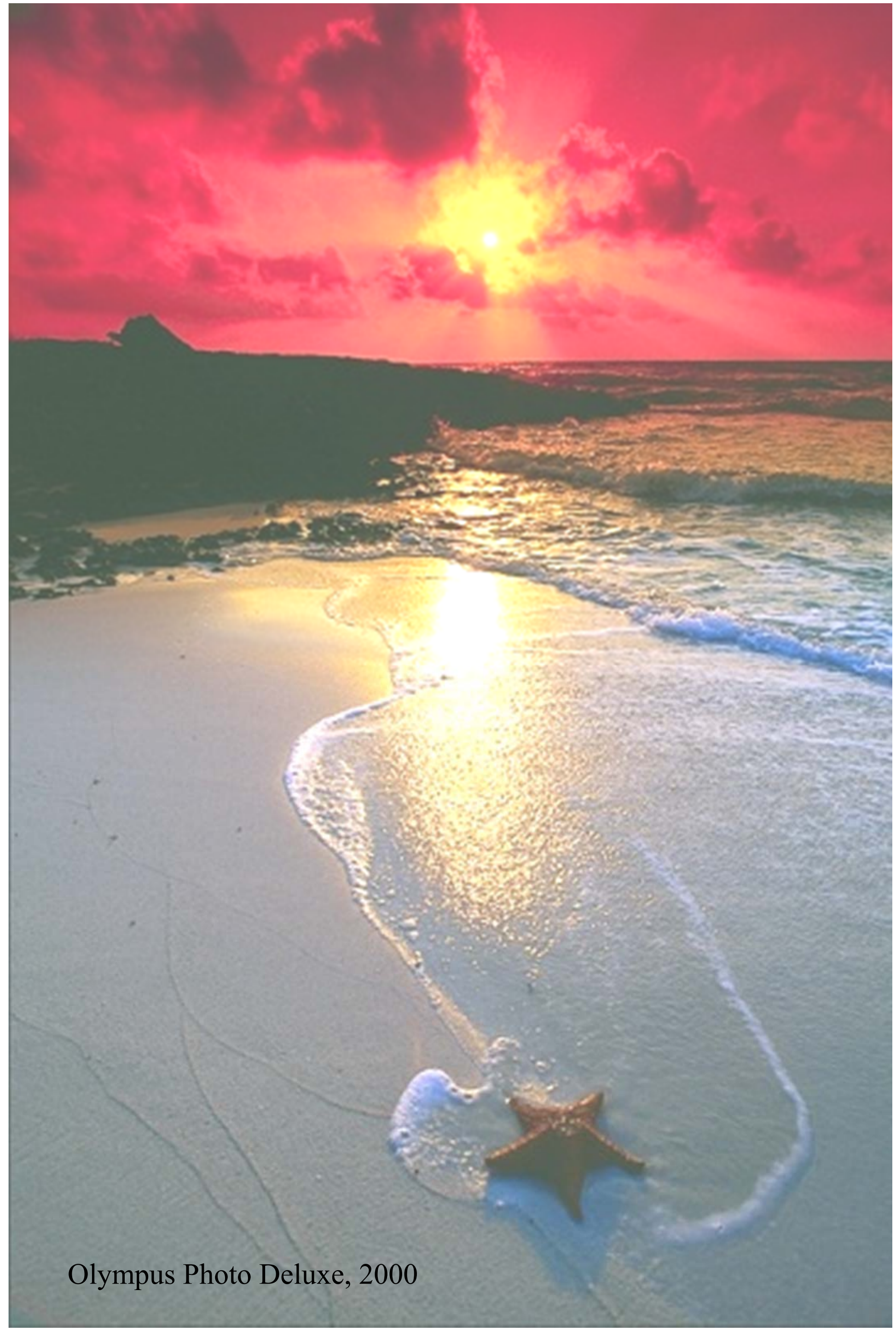
Our universe has been here about 12 billion years,

our solar system formed about 4 billion years ago,

man has been walking this planet about 4 million years,

civilization's roots for modern society are about 2500 years old,

the industrial revolution to produce our goods and services began about 100 years ago.



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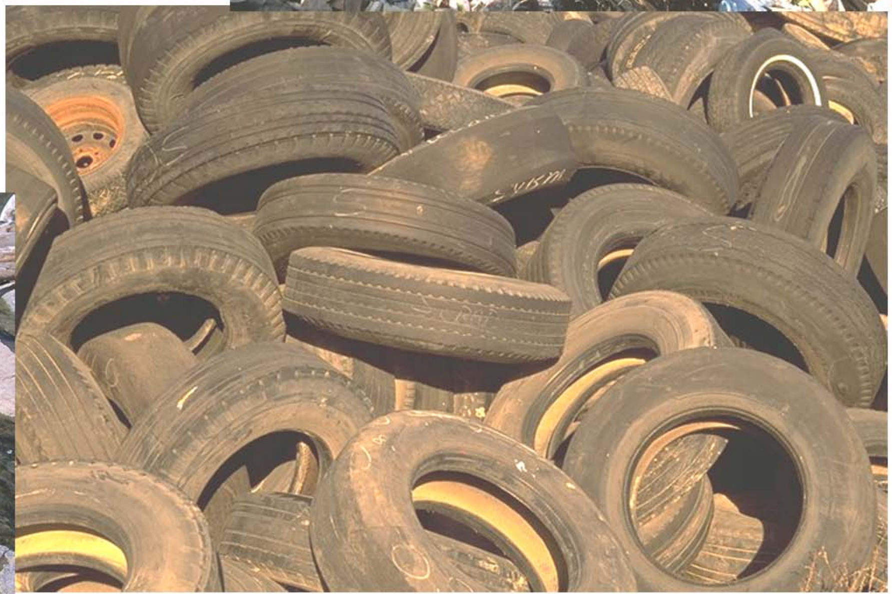
The use of our planets resources produces residual materials and byproducts. How we recycle and dispose of these can cause a burden on our environment.



Olympus Photo Deluxe, 2000

Man's intellect provides solutions for problems, and society's obligation to future generations force us to implement them ---- we need to take responsibility for our industrial development.

Olympus Photo Deluxe, 2000

Man is smart enough to carefully use our resources!

Engineers should take a world view of each new development.

A birth to death view of each new item developed should include analysis of all inputs and outputs.

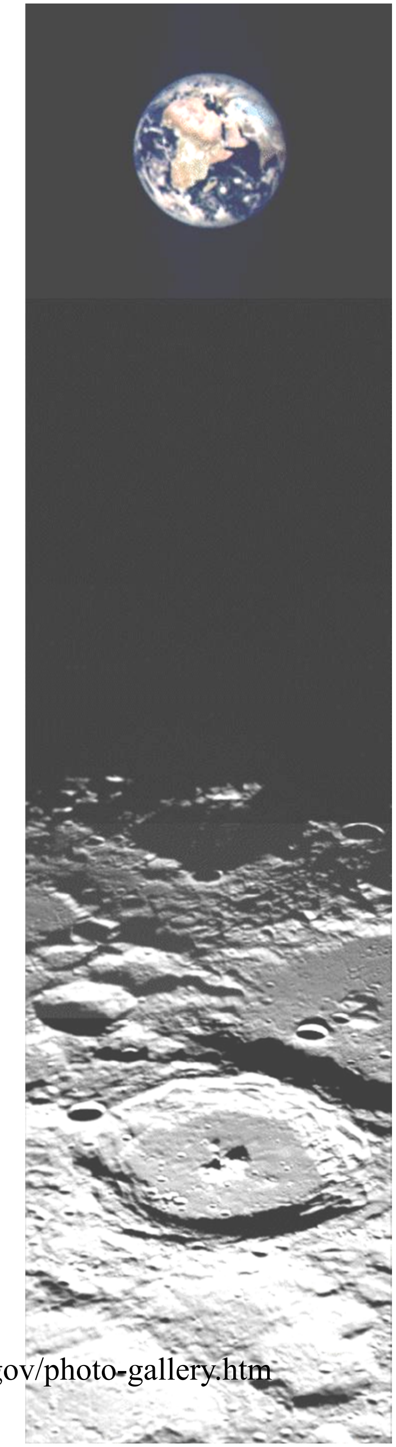
How will the item be disposed?
How can it be recycled?
What is its true lifetime cost?

This is not the alternative that anyone wants!

IBM Advertisement Websphere for Mankind – Back cover Discover Magazine September 2001.

The activities of man are changing the face of our planet. The resources of our planet are stretched. The quality of air, water and earth are deteriorating. Biodiversity is being lost. What is the responsibility of an Engineer in the world today? How can I understand the problems and make a difference?

Population
Energy
Water
Chemicals
Biodiversity



http://nssdc.gsfc.nasa.gov/photo-gallery.htm

World is beautiful place –

You should walk its paths for several decades –

Will you be a preserver

or a disturber of the resources?

Olympus Photo Deluxe, 2000

You are smart –

If you will approach every task with concern for resources and the environment –

If you will encourage that same concern among your co-workers in the future –

YOU CAN MAKE A DIFFERENCE!

Olympus Photo Deluxe, 2000

Our home is becoming more white from space –

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SUMMARY

Each generation must face its own set of problems –

They are not necessarily bigger problems, just different ones,
When I was your age, we faced the balance of world power
based upon mutually assured destruction.
When my father was that age, he faced WWII.
It appears that the problems of your generation will be energy, resource conservation, world population, and terrorists.

You should not feign from the tasks – for the population is becoming smarter, hope is brighter, and opportunities are better.

The basic hopes and goals for most people over the Earth are similar,
for family and friends, ability to work and contribute something of value,
and opportunities to care for and love others.

Remember that in your work, the most important thing is to leave room, and make room, for each of your colleagues to enjoy the feeling of success from their endeavors.

IEEE Code of Ethics

We, the members of the IEEE, in recognition of the importance of our technologies in affecting the quality of life throughout the world, and in accepting a personal obligation to our profession, its members and the communities we serve, do hereby commit ourselves to the highest ethical and professional conduct and agree:

1. to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;
2. to avoid real or perceived conflicts of interest whenever possible, and to disclose them to affected parties when they do exist;
3. to be honest and realistic in stating claims or estimates based on available data;
4. to reject bribery in all its forms;
5. to improve the understanding of technology, its appropriate application, and potential consequences;
6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;
7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
8. to treat fairly all persons regardless of such factors as race, religion, gender, disability, age, or national origin;
9. to avoid injuring others, their property, reputation, or employment by false or malicious action;
10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.