PENNSTATE

1855

PERSPECTIVES FOR A MODERN ENGINEER: Engineering in the 21st Century

Presented by

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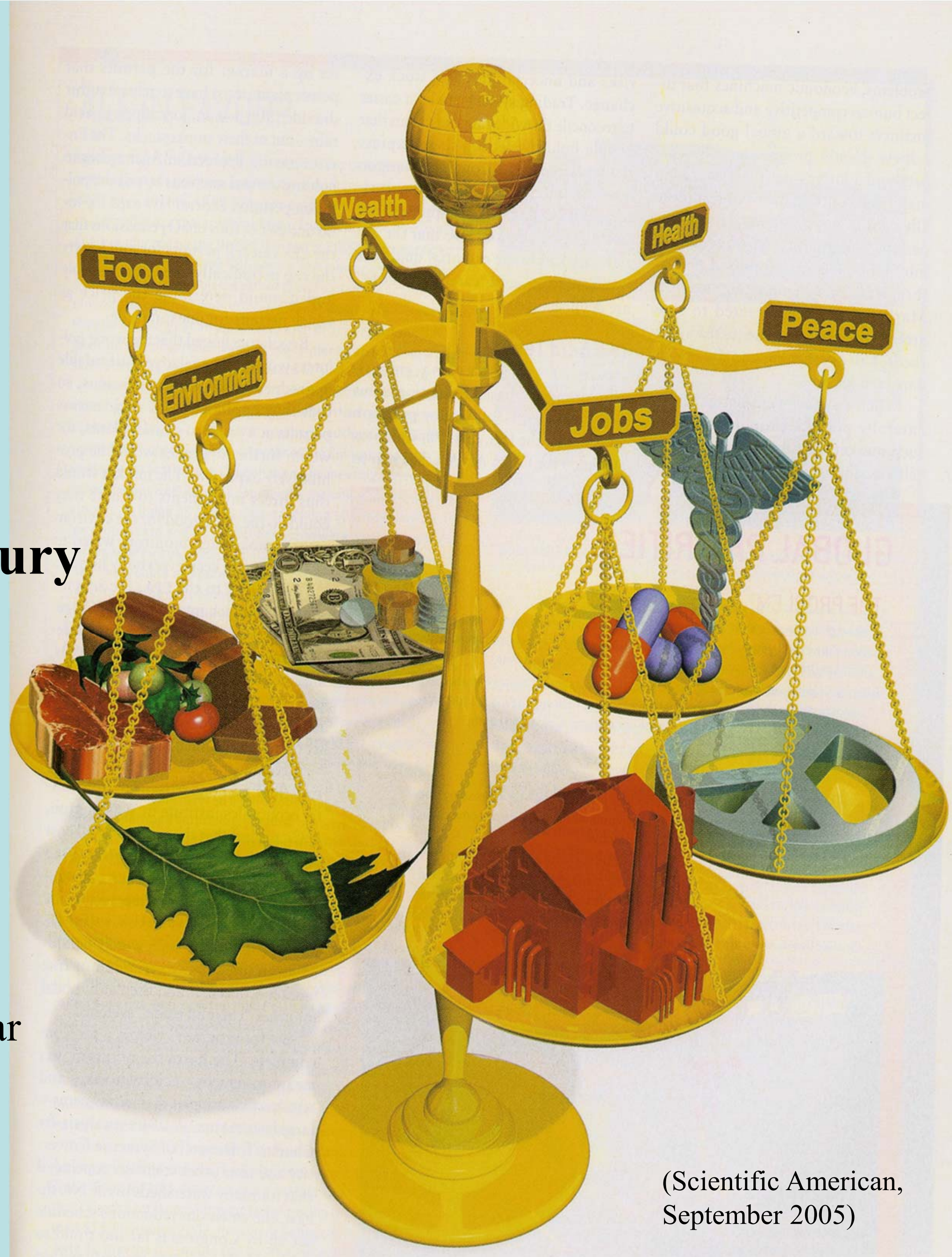
Electrical Engineering Graduate Seminar
Penn State University
1 December 2005



(Scientific American, September 2005)

OUTLINE

Is there any doubt –

- that man is changing the environment of the planet?
- that fossil fuel will eventually run out?
- that fresh water is becoming less available?
- that we are wasting many natural resources?

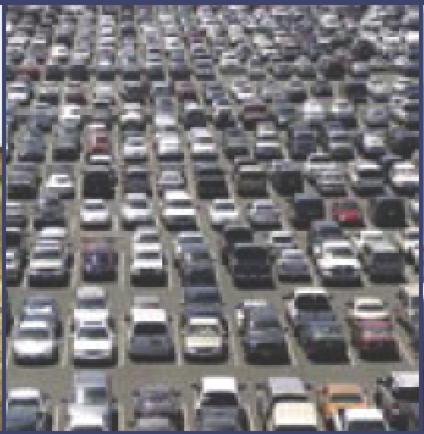
The issues are:

Population
Air
Water
Land – Agriculture – Chemicals
Biodiversity
Energy

Our resources are:

Brains – imagination, planning
Individuals – creative ideas, responsibility, vision
Collective action – issues, government regulation,
global cooperation

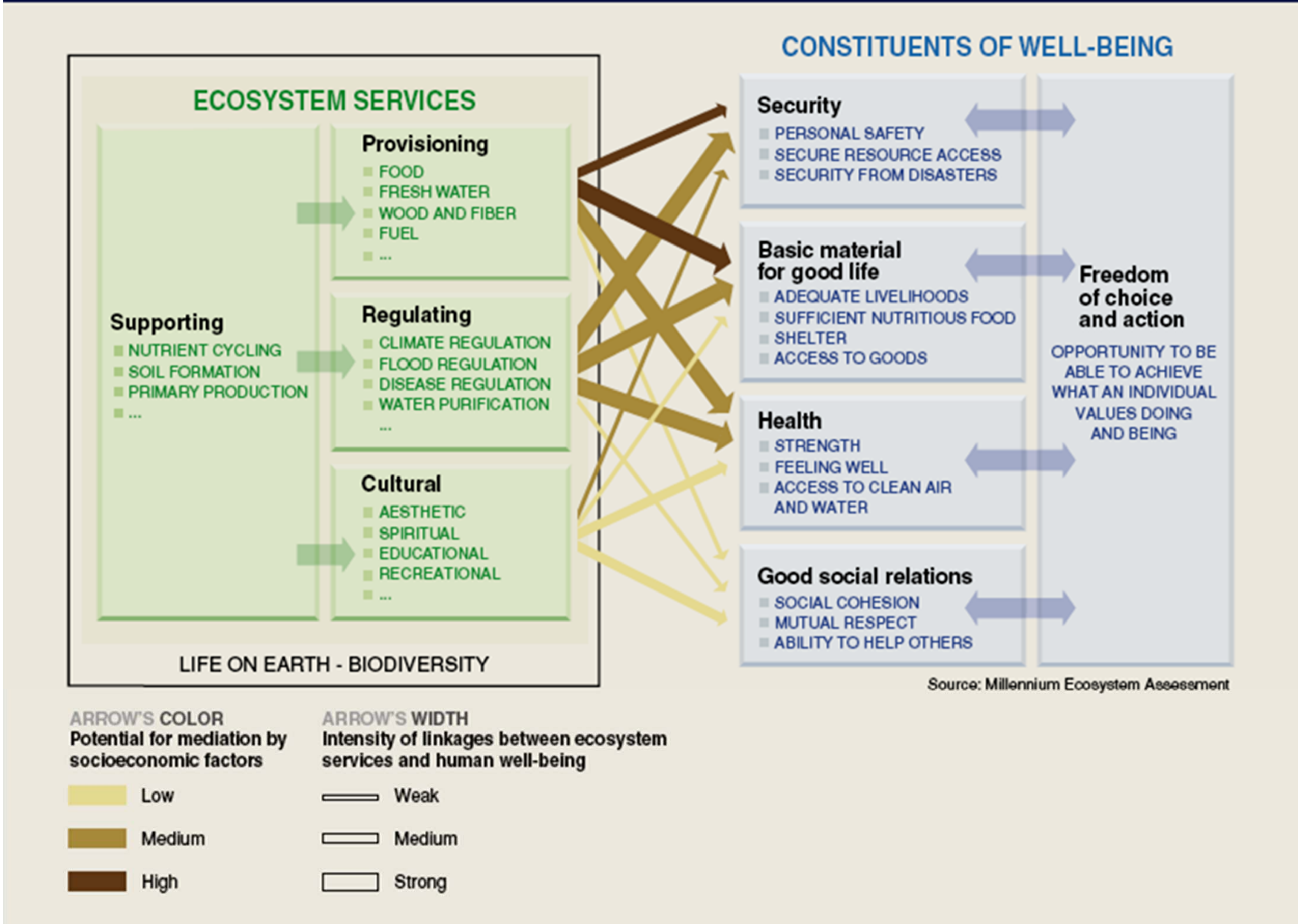
Living Beyond Our Means

http://www.millenniumassessment.org/en/index.aspx
Crossroads for Planet Earth, Scientific American, September 2005

MILLENNIUM ECOSYSTEM ASSESSMENT

Linkages between Ecosystem Services and Human Well-being

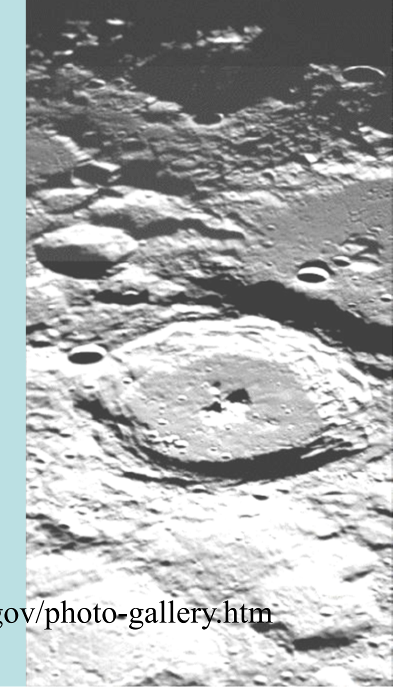


Source: Millennium Ecosystem Assessment

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?

A fragile view of Earth

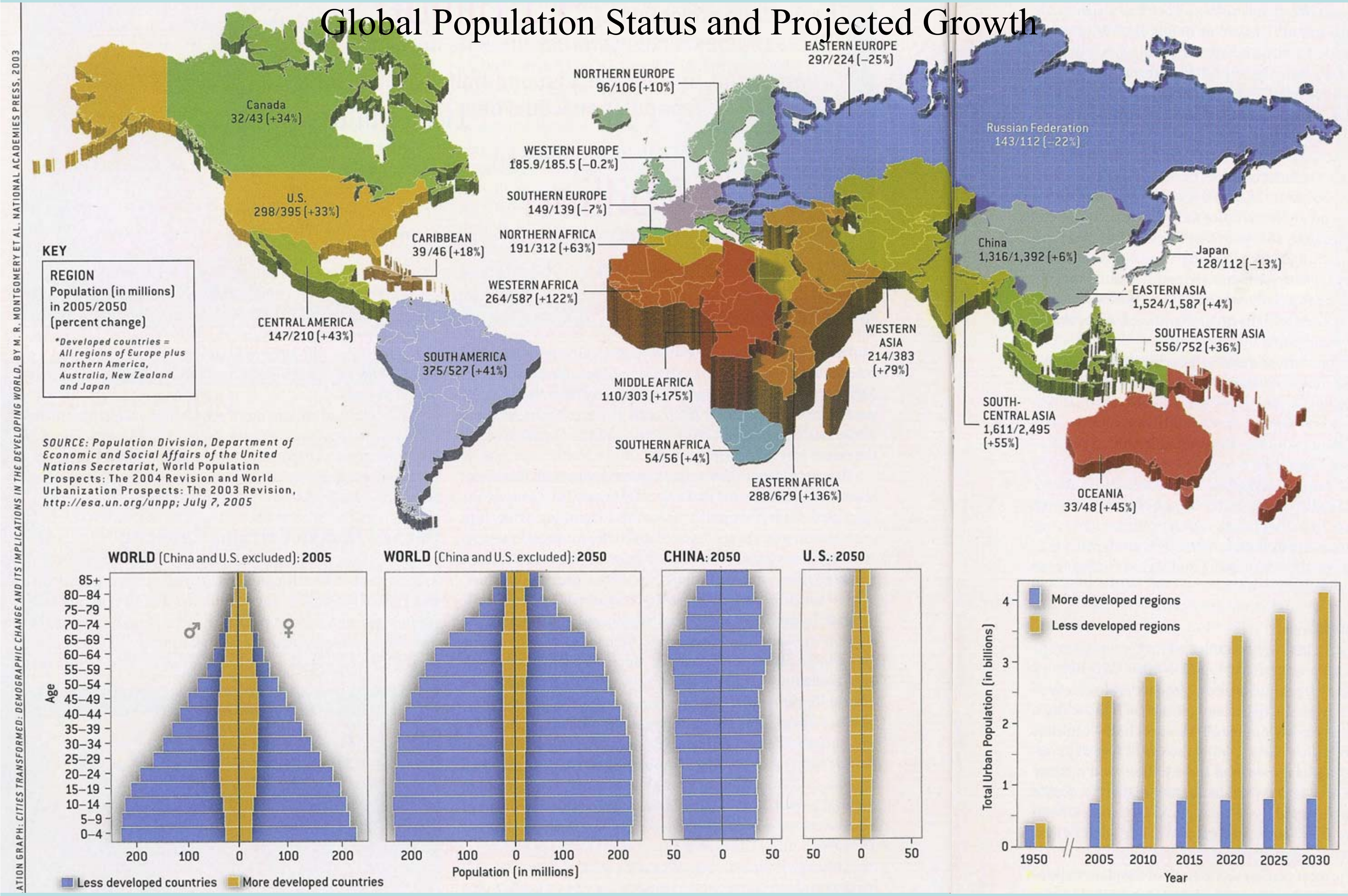
Population
Air
Water
Land
Biodiversity
Energy



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

Population

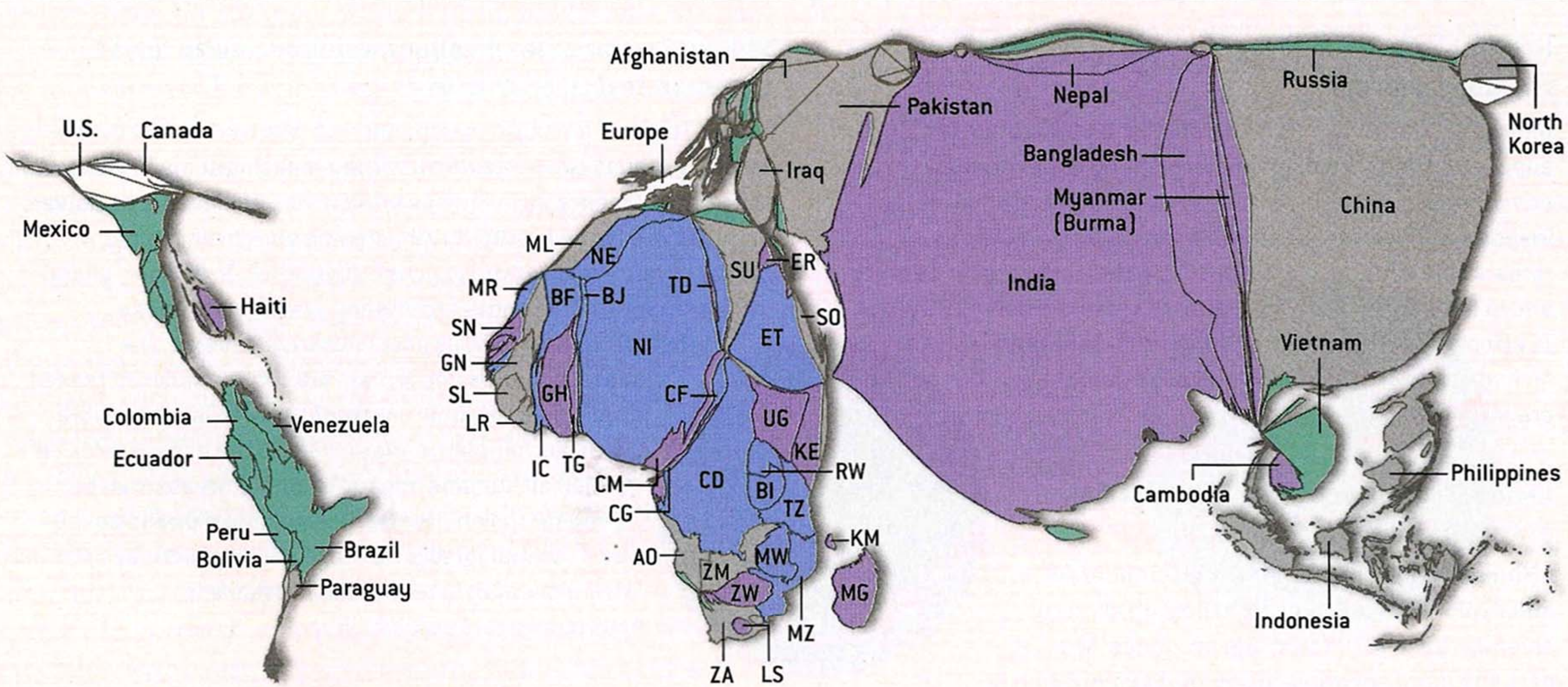
Global Population Status and Projected Growth



(Scientific American, September 2005)

CHRONIC POVERTY: RICH WORLD, POOR PEOPLE

Although chronically poor people live in all regions of the world, they are concentrated in certain places. According to many studies, the problem of extreme poverty (those living on less than $1 a day) is least tractable in sub-Saharan Africa, the Andean and Central American highlands, and the landlocked nations of Central Asia. In the map below, produced by the Chronic Poverty Research Center, country size scales to the number of chronically poor people it harbors, and color indicates the income level of most impoverished inhabitants of each country. When sufficient official data were unavailable, the researchers estimated national poverty rates and numbers.



- Desperately poor
- Very poor
- Relatively nonpoor
- Insufficient data
- Industrial nations

Abbr.	Country Name	Abbr.	Country Name	Abbr.	Country Name	Abbr.	Country Name
AO	Angola	ET	Ethiopia	MW	Malawi	SO	Somalia
BF	Burkina Faso	GH	Ghana	ML	Mali	SU	Sudan
BI	Burundi	GN	Guinea	MR	Mauritania	TD	Chad
BJ	Benin	IC	Ivory Coast	MZ	Mozambique	TG	Togo
CD	Democratic Republic of the Congo	KE	Kenya	NE	Niger	TZ	Tanzania
CF	Central African Republic	KM	Comoros	NI	Nigeria	UG	Uganda
CG	Congo (Brazzaville)	LR	Liberia	RW	Rwanda	ZA	South Africa
CM	Cameroon	LS	Lesotho	SL	Sierra Leone	ZM	Zambia
ER	Eritrea	MG	Madagascar	SN	Senegal	ZW	Zimbabwe

(Scientific American, September 2005)

Status of Poverty and Ecosystem Services

In 2001, more than 1 billion people survive on less than $1 per day – 70% are in rural areas and depend on agriculture, grazing or hunting.

Inequality in income and human life quality increased during past decade.

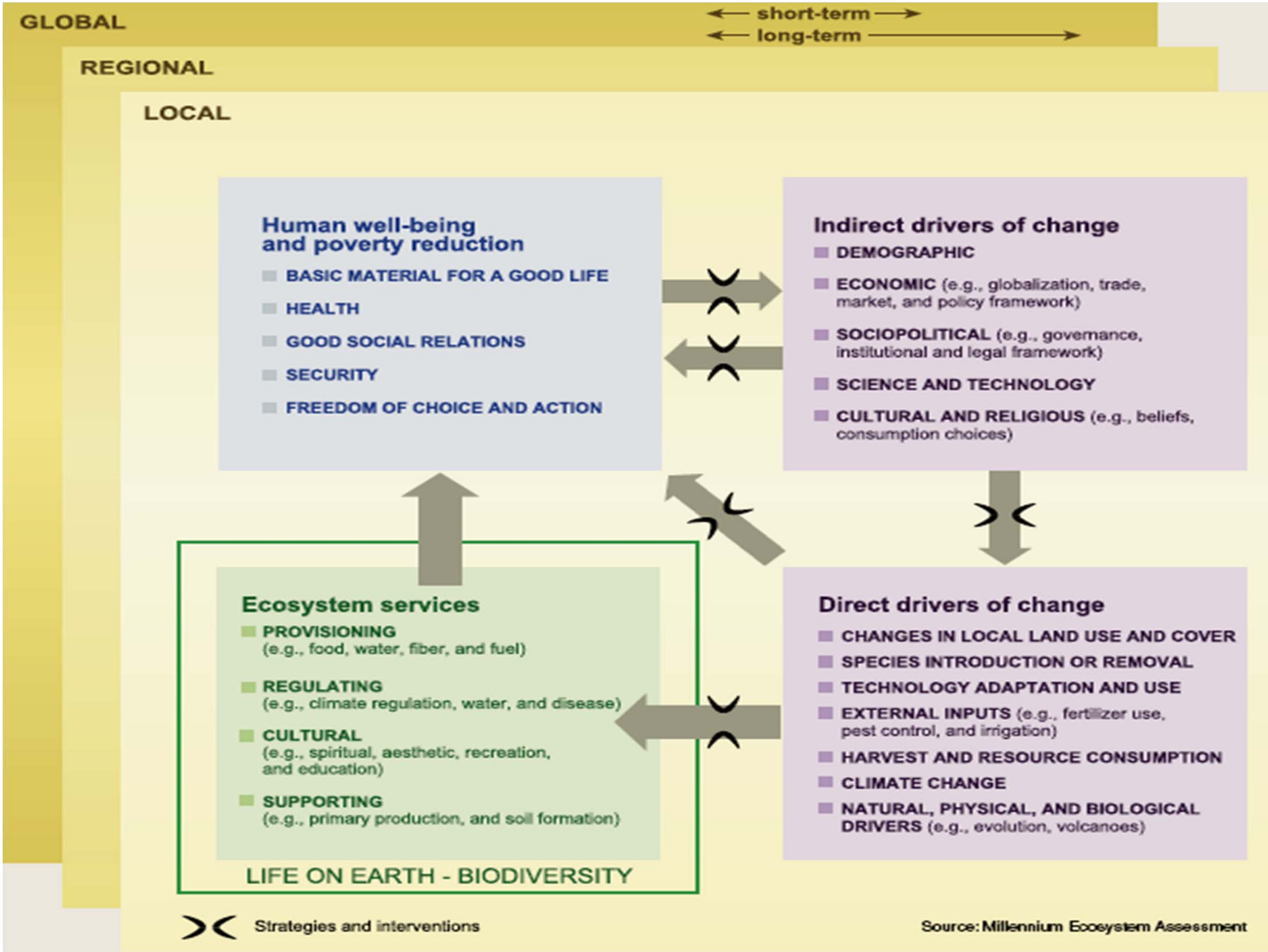
A child in sub-Saharan Africa is 20 times more likely to die before age five, compared with a child in an industrial country.

During past decade, 21 countries declined in their Human Development Index, 14 of these countries are in sub-Saharan Africa.

Per capita food production has increased in the last four decades, but 852 million people were undernourished in 2000-2002.

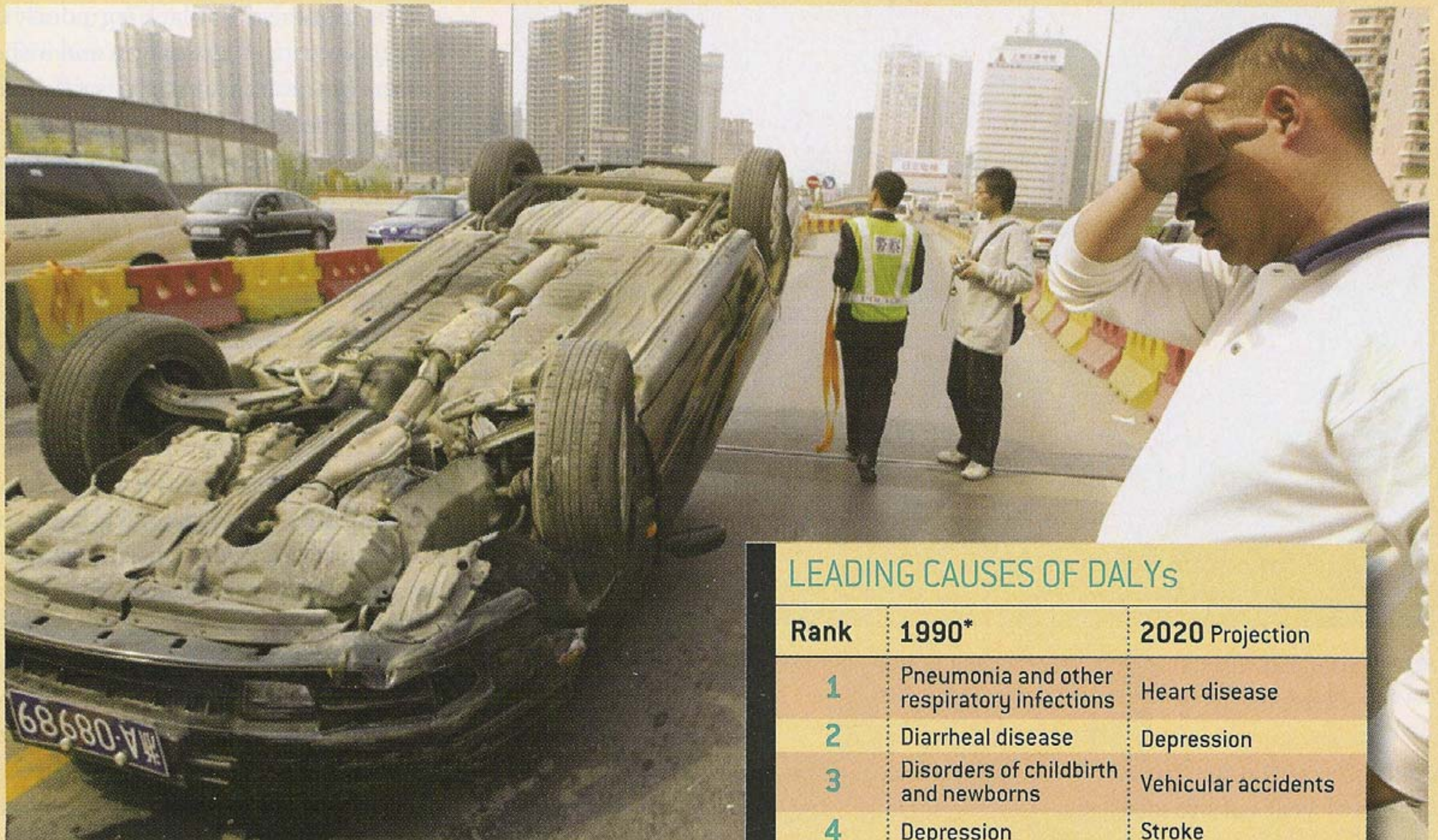
Since 1960, water use ratio to supply has increased 20% per decade. More than 1 billion people do not have access to an adequate water supply.

More than 2.6 billion people do not have access to improved sanitation.



GLOBAL
short-term
long-term
REGIONAL
LOCAL
Human well-being and poverty reduction
BASIC MATERIAL FOR A GOOD LIFE
HEALTH
GOOD SOCIAL RELATIONS
SECURITY
FREEDOM OF CHOICE AND ACTION
Indirect drivers of change
DEMOGRAPHIC
ECONOMIC (e.g., globalization, trade, market, and policy framework)
SOCIOPOLITICAL (e.g., governance, institutional and legal framework)
SCIENCE AND TECHNOLOGY
CULTURAL AND RELIGIOUS (e.g., beliefs, consumption choices)
Ecosystem services
PROVISIONING (e.g., food, water, fiber, and fuel)
REGULATING (e.g., climate regulation, water, and disease)
CULTURAL (e.g., spiritual, aesthetic, recreation, and education)
SUPPORTING (e.g., primary production, and soil formation)
LIFE ON EARTH - BIODIVERSITY
Direct drivers of change
CHANGES IN LOCAL LAND USE AND COVER
SPECIES INTRODUCTION OR REMOVAL
TECHNOLOGY ADAPTATION AND USE
EXTERNAL INPUTS (e.g., fertilizer use, pest control, and irrigation)
HARVEST AND RESOURCE CONSUMPTION
CLIMATE CHANGE
NATURAL, PHYSICAL, AND BIOLOGICAL DRIVERS (e.g., evolution, volcanoes)
Strategies and interventions
Source: Millennium Ecosystem Assessment

CHANGING PATTERNS OF GLOBAL HEALTH



LEADING CAUSES OF DALYs

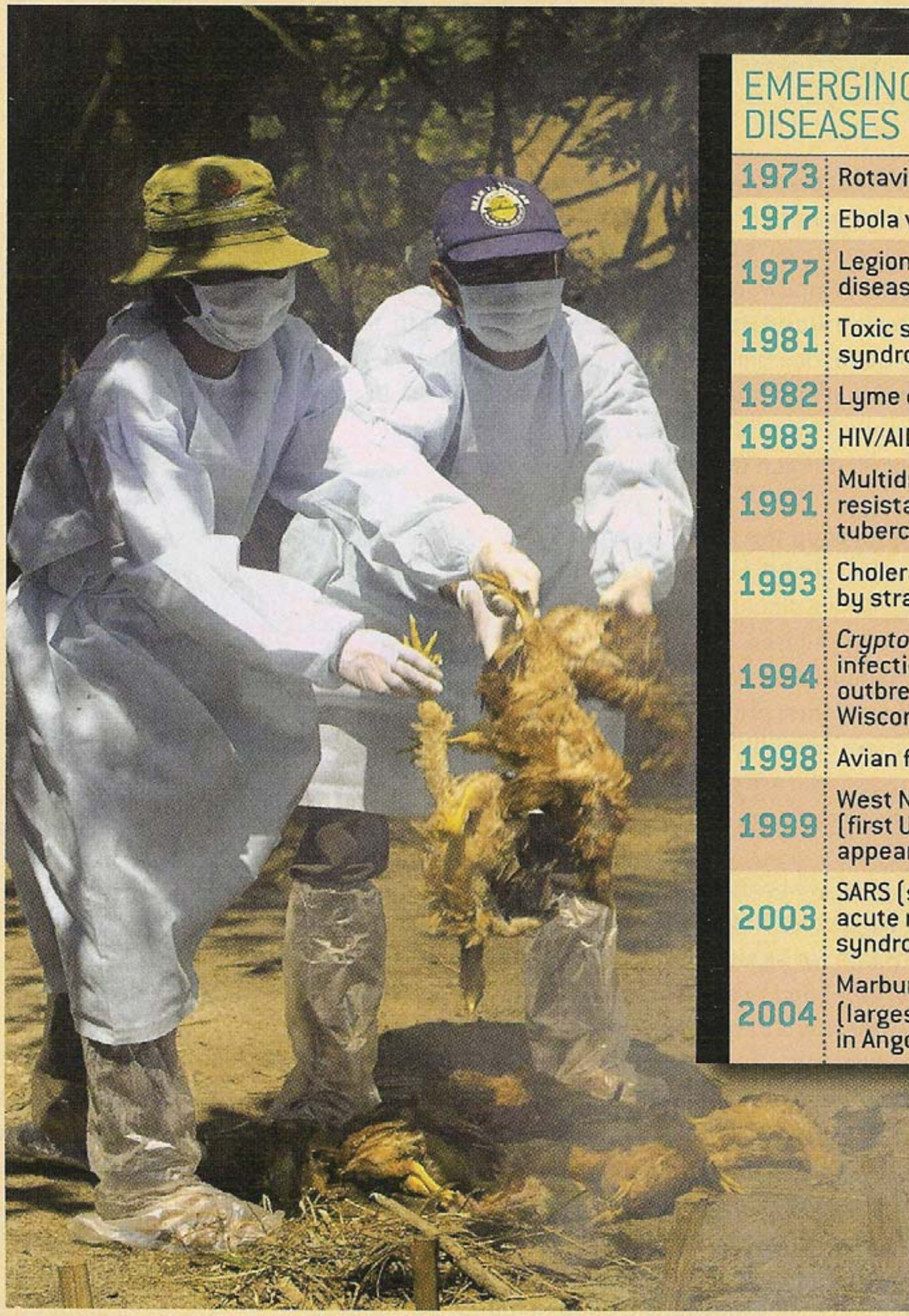
Rank	1990*	2020 Projection
1	Pneumonia and other respiratory infections	Heart disease
2	Diarrheal disease	Depression
3	Disorders of childbirth and newborns	Vehicular accidents
4	Depression	Stroke
5	Heart disease	Emphysema and bronchitis
6	Stroke	Pneumonia and other respiratory infections
7	Tuberculosis	Tuberculosis
8	Measles	War
9	Vehicular accidents	Diarrheal disease
10	Congenital defects	HIV

*Based on 1990 data later reanalyzed as DALYs

PRIME SOURCES OF DALYs (disability-adjusted life-years)—healthy years lost to injury, illness or premature death worldwide—are changing (*table*). They are shifting from acute infections to other influences, including conditions related to aging and behavioral choices. By 2020 heart disease, depression and vehicular accidents are expected to become the top three sources of DALYs. The accident in the photograph occurred in Hangzhou, China, earlier this year.

(Scientific American, September 2005)

NO PLACE TO HIDE



EMERGING DISEASES

1973	Rotavirus
1977	Ebola virus
1977	Legionnaire's disease
1981	Toxic shock syndrome
1982	Lyme disease
1983	HIV/AIDS
1991	Multidrug-resistant tuberculosis
1993	Cholera caused by strain 0139
1994	*Cryptosporidium* infection* (large outbreak in Wisconsin)
1998	Avian flu
1999	West Nile virus* (first U.S. appearance)
2003	SARS (severe acute respiratory syndrome)
2004	Marburg virus* (largest outbreak, in Angola)

(Scientific American, September 2005)

AIR

Airborne Particulate Matter

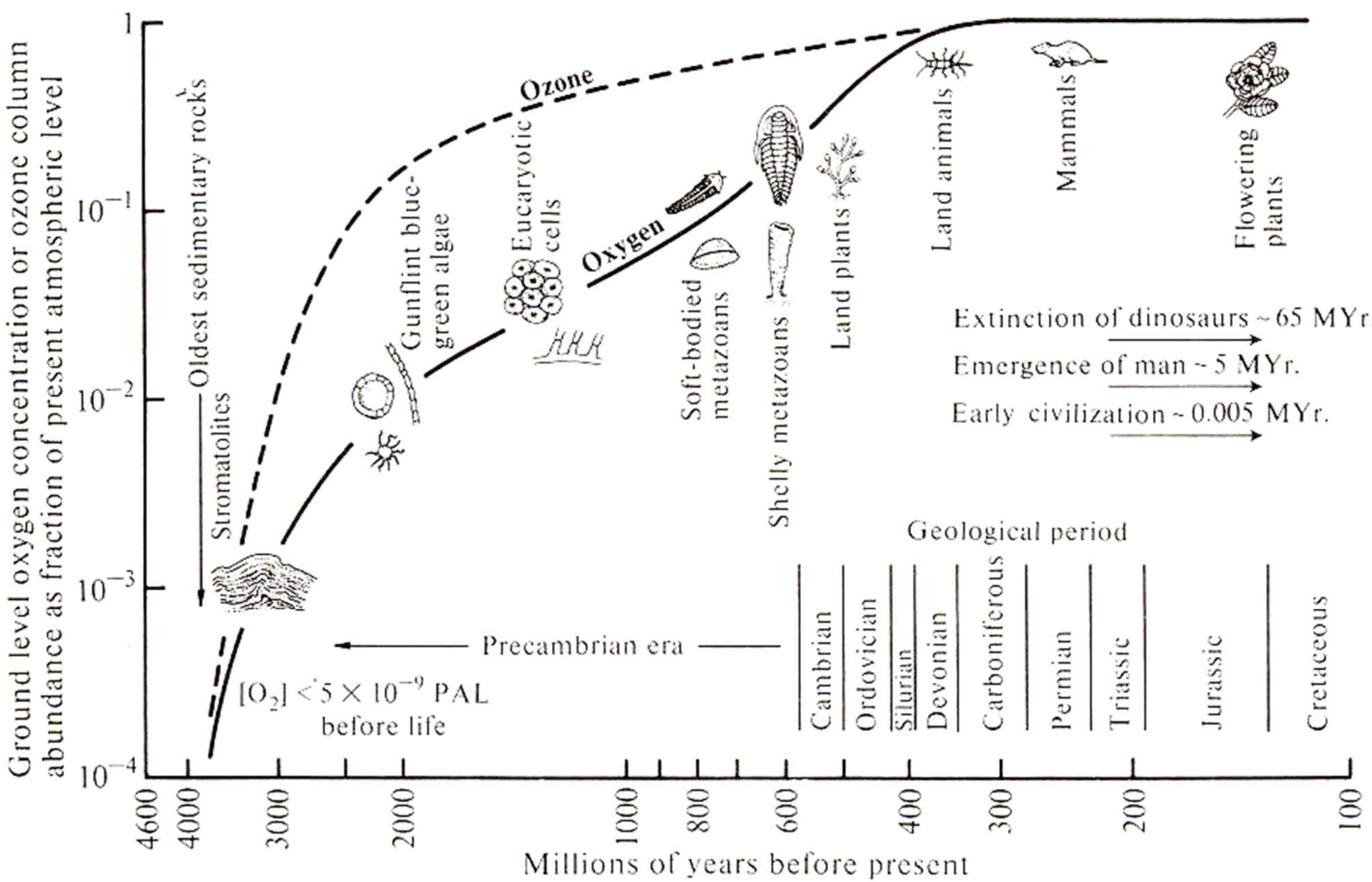
Incineration

Agriculture

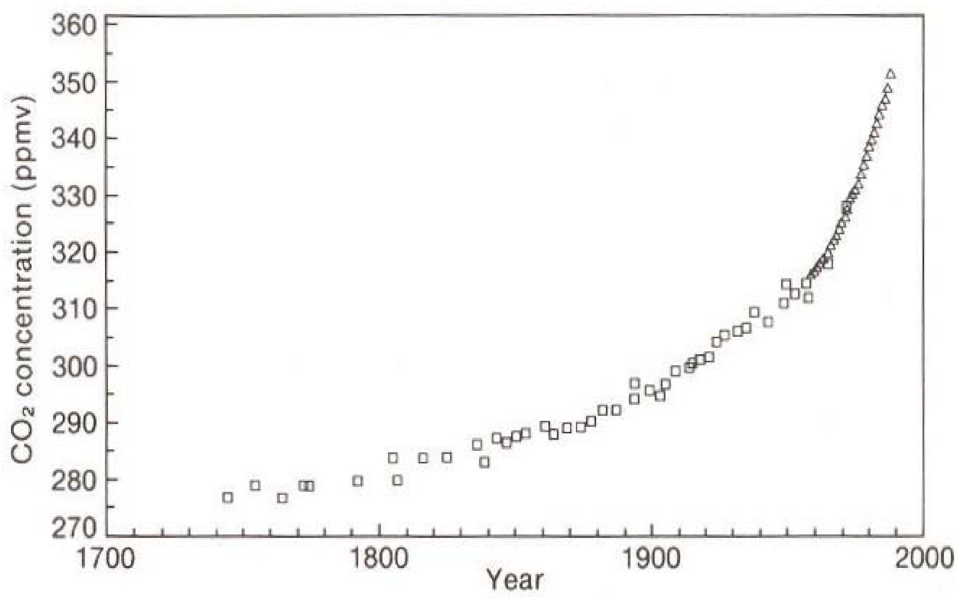
Fossil Fuel Combustion

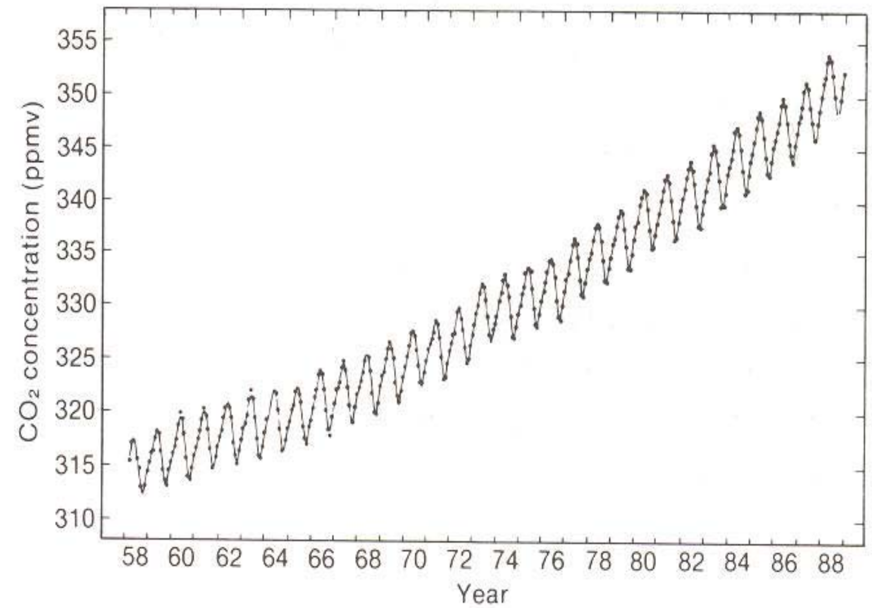
Olympus Photo Deluxe, 2000

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.



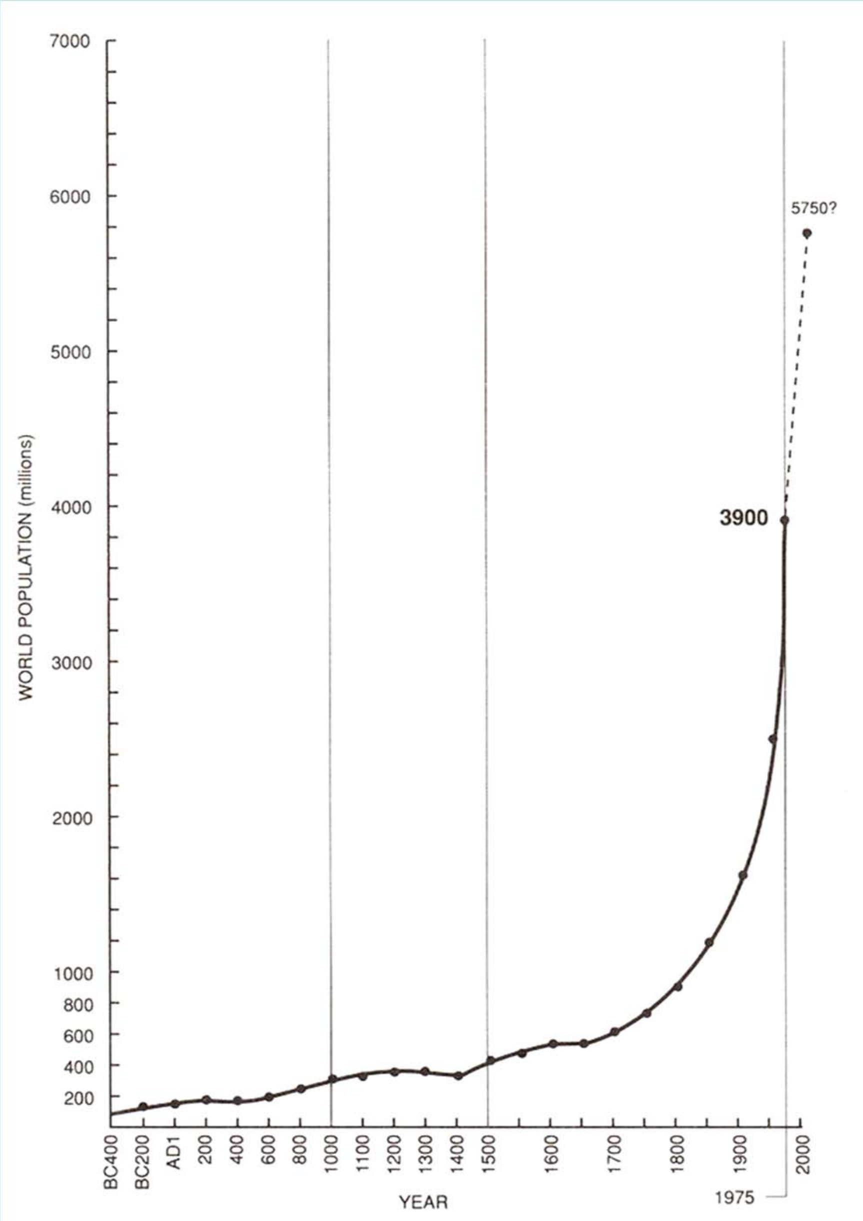


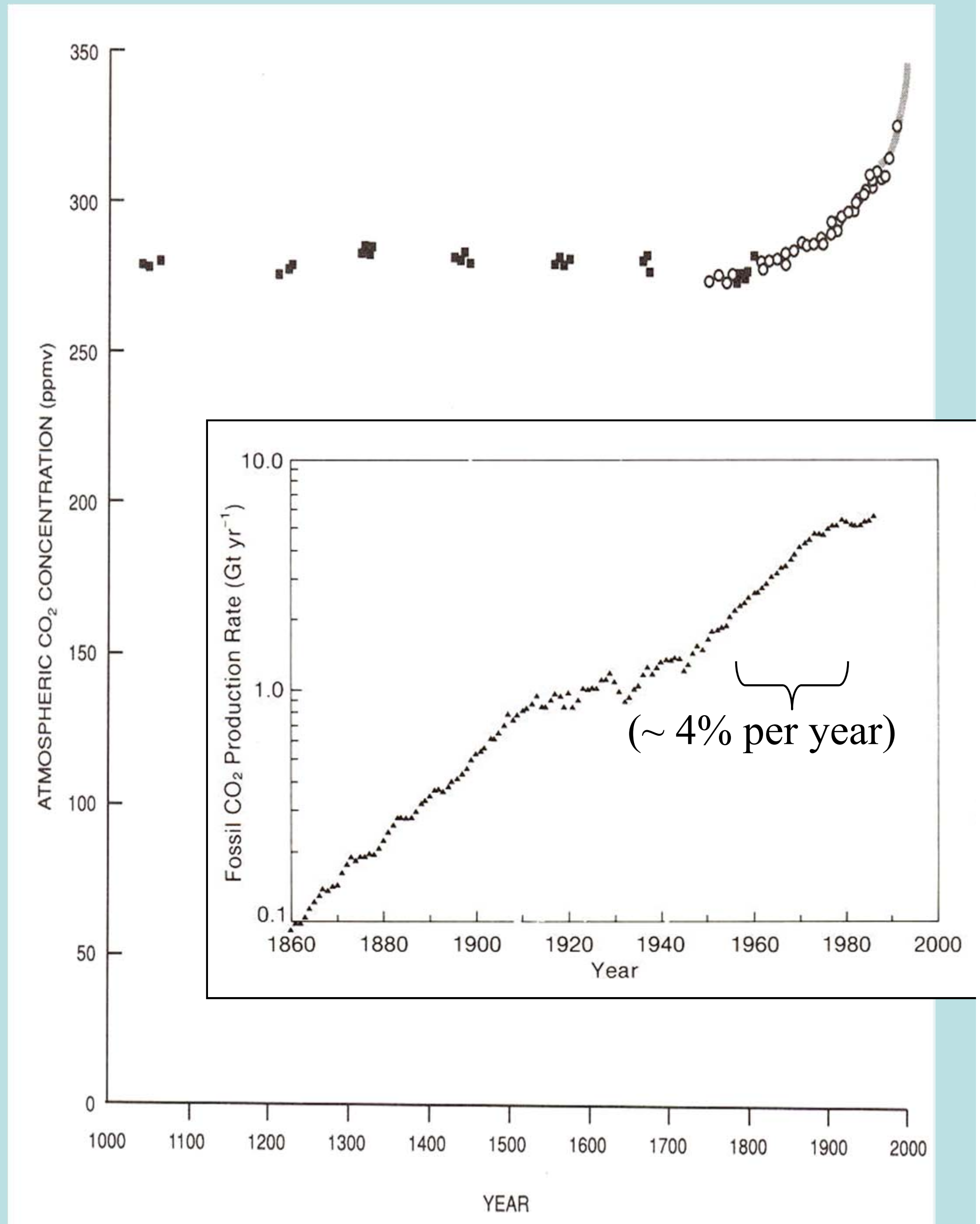
CO_2 Increase

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.

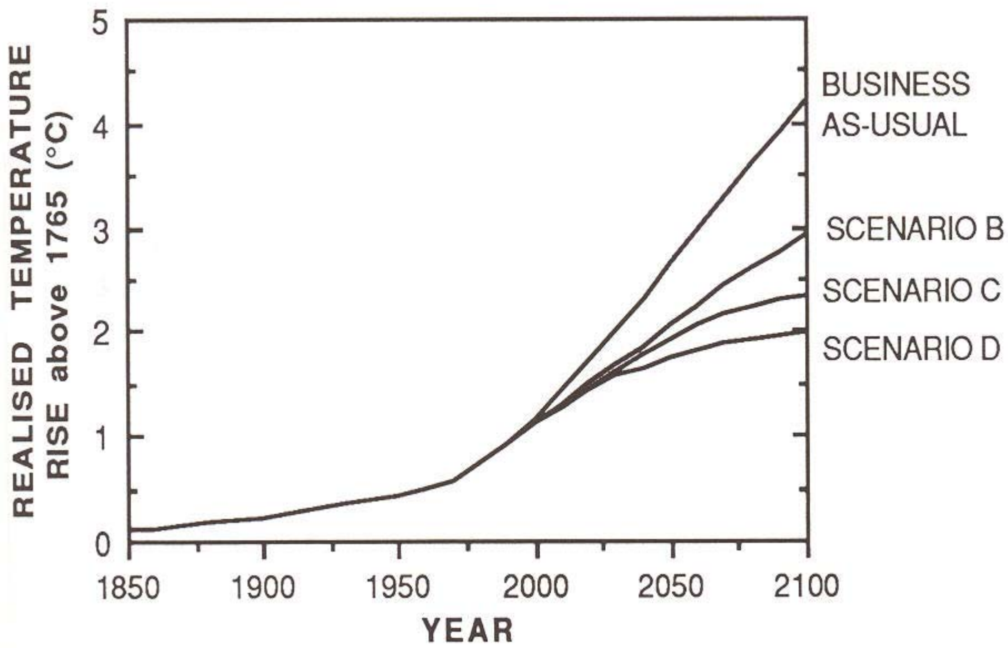
Population growth and increase in CO_2 from combustion

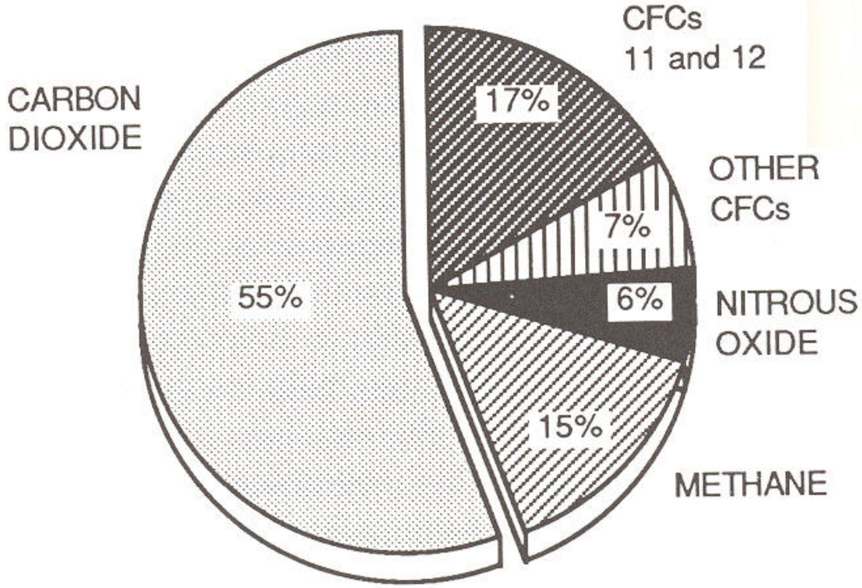




Policy Implications of Greenhouse Warming – National Academy Press, 1991.

Greenhouse Gases



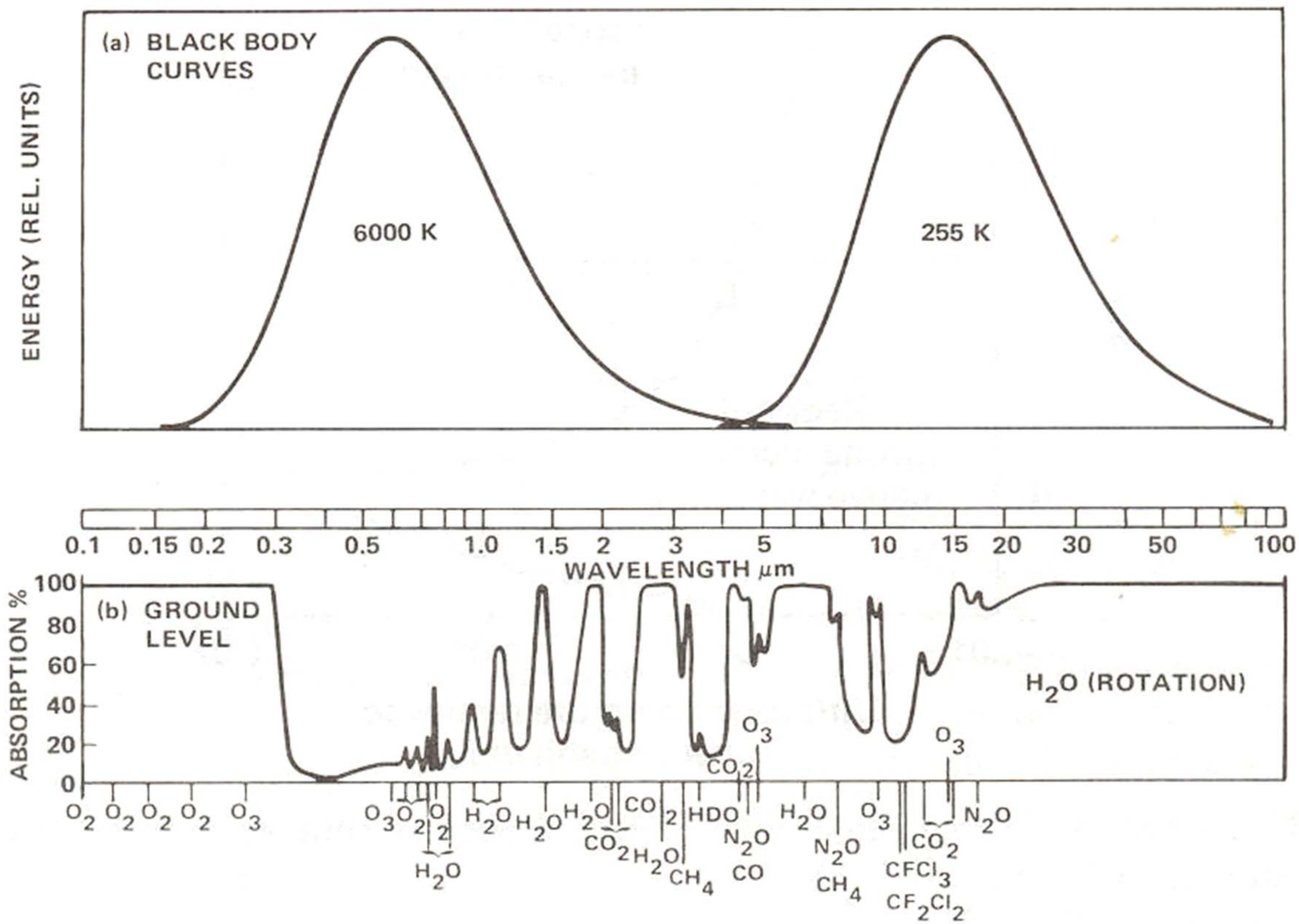


The contribution from each of the human-made greenhouse gases to the change in radiative forcing from 1980 to 1990. The contribution from ozone may also be significant, but cannot be quantified at present.

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.

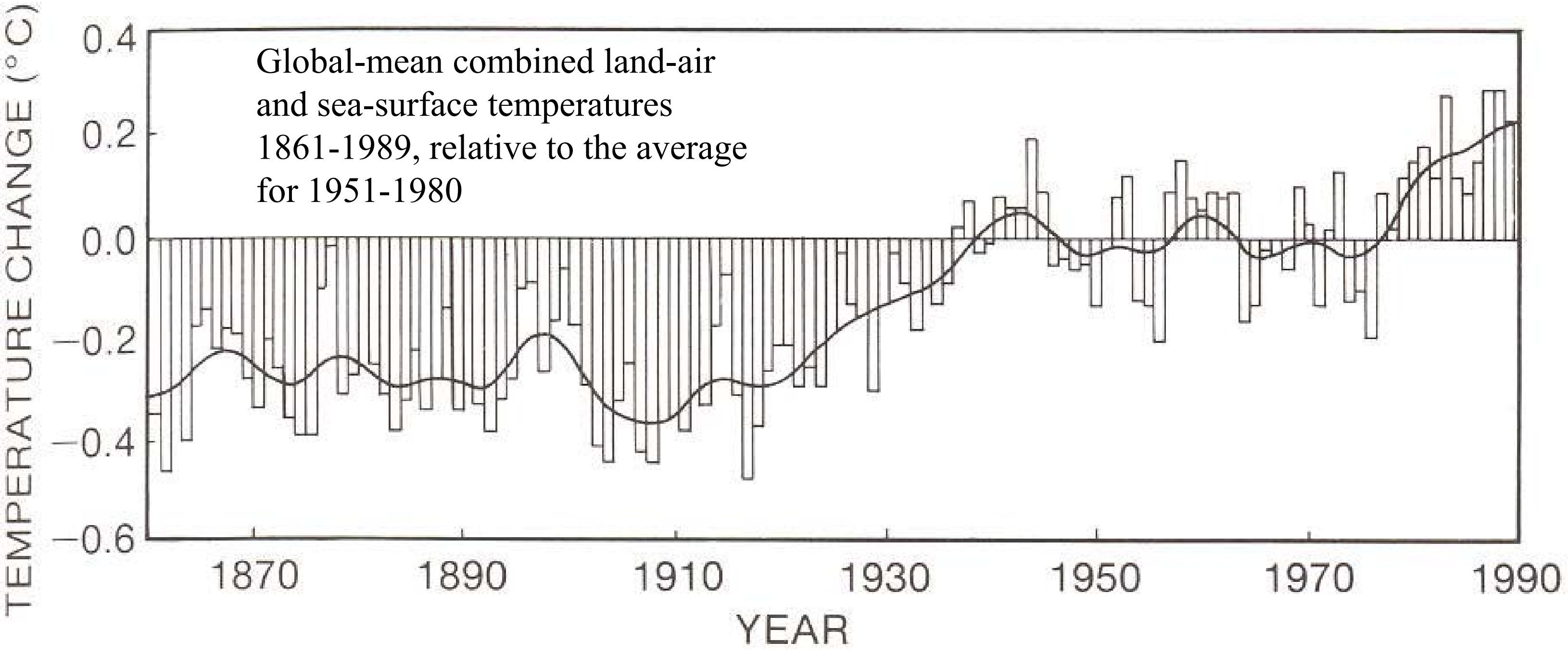
Emission Spectrum of Sun and Earth - Infrared Absorption by Molecules



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

Global warming threatens to change the ice caps and glaciers.

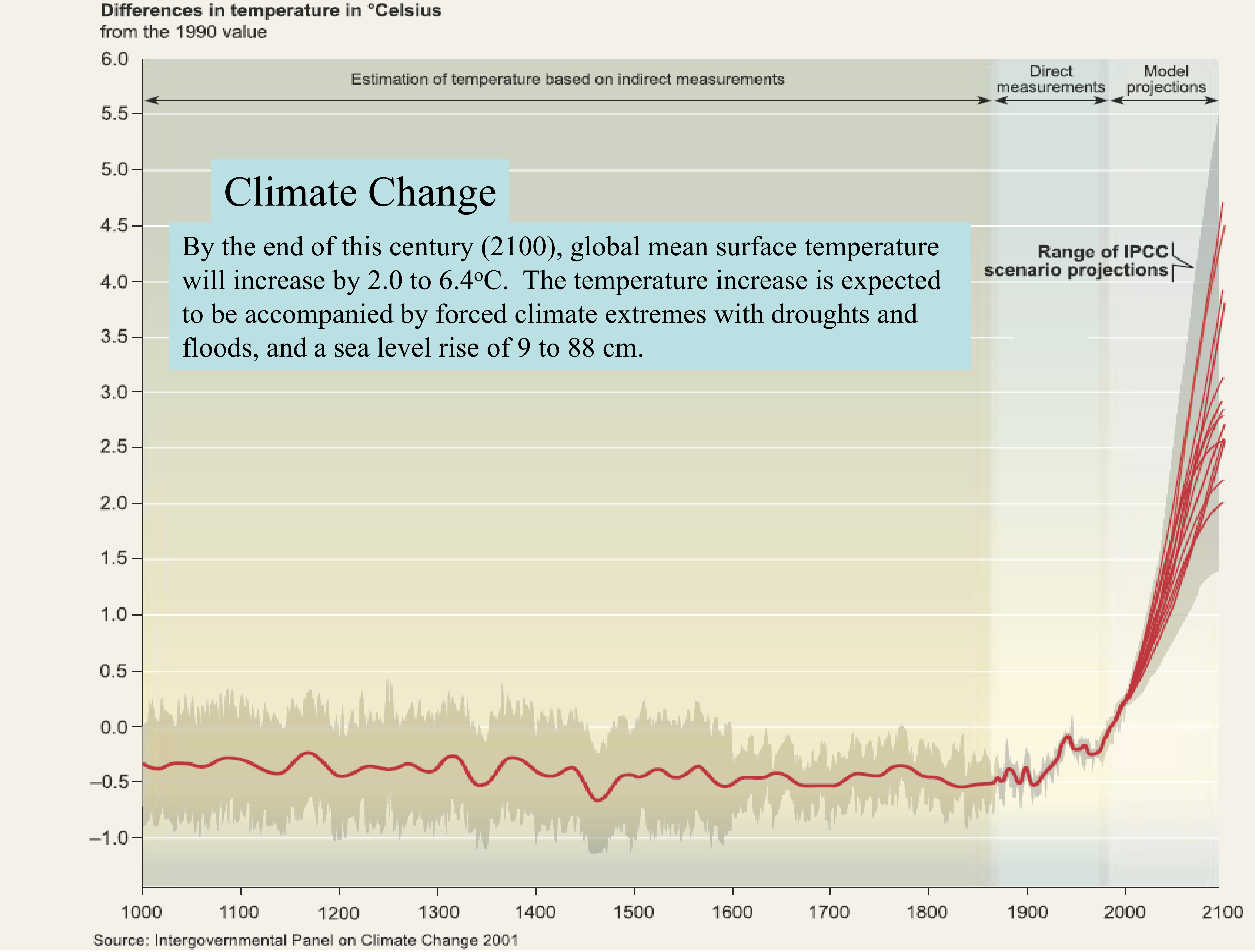
Climate Change: The IPCC Scientific Assessment – World Meteorological Organization, Cambridge University Press, 1990.



Global-mean combined land-air and sea-surface temperatures 1861-1989, relative to the average for 1951-1980

Climate Change

By the end of this century (2100), global mean surface temperature will increase by 2.0 to 6.4^{o}C. The temperature increase is expected to be accompanied by forced climate extremes with droughts and floods, and a sea level rise of 9 to 88 cm.



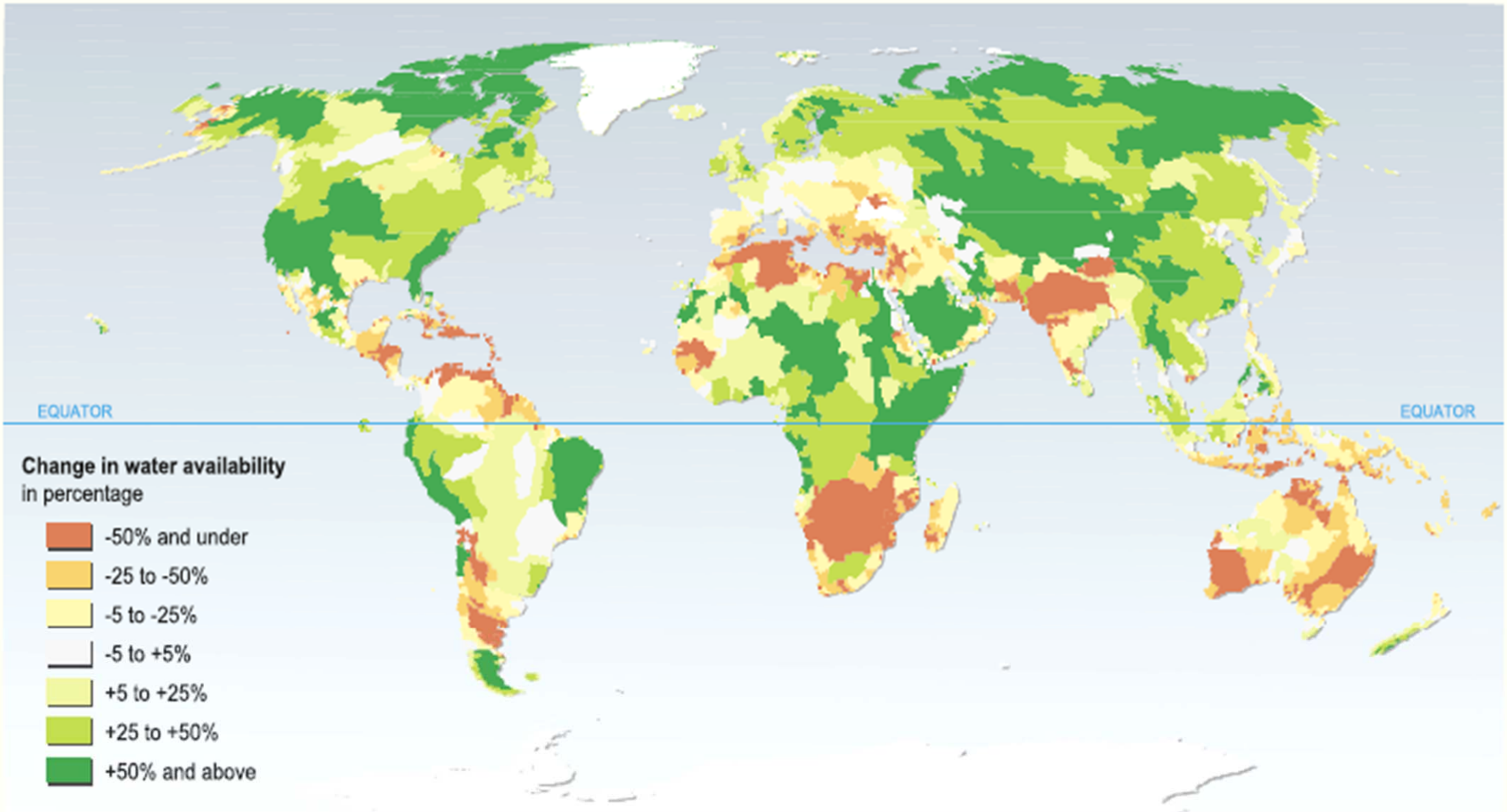
This is not an acceptable alternative!

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

Water

Figure 4.6. CHANGES IN ANNUAL WATER AVAILABILITY IN GLOBAL ORCHESTRATION SCENARIO BY 2100 (S9)

Shades from gray through red indicate regions that are drying.



Source: Millennium Ecosystem Assessment

Fresh Water

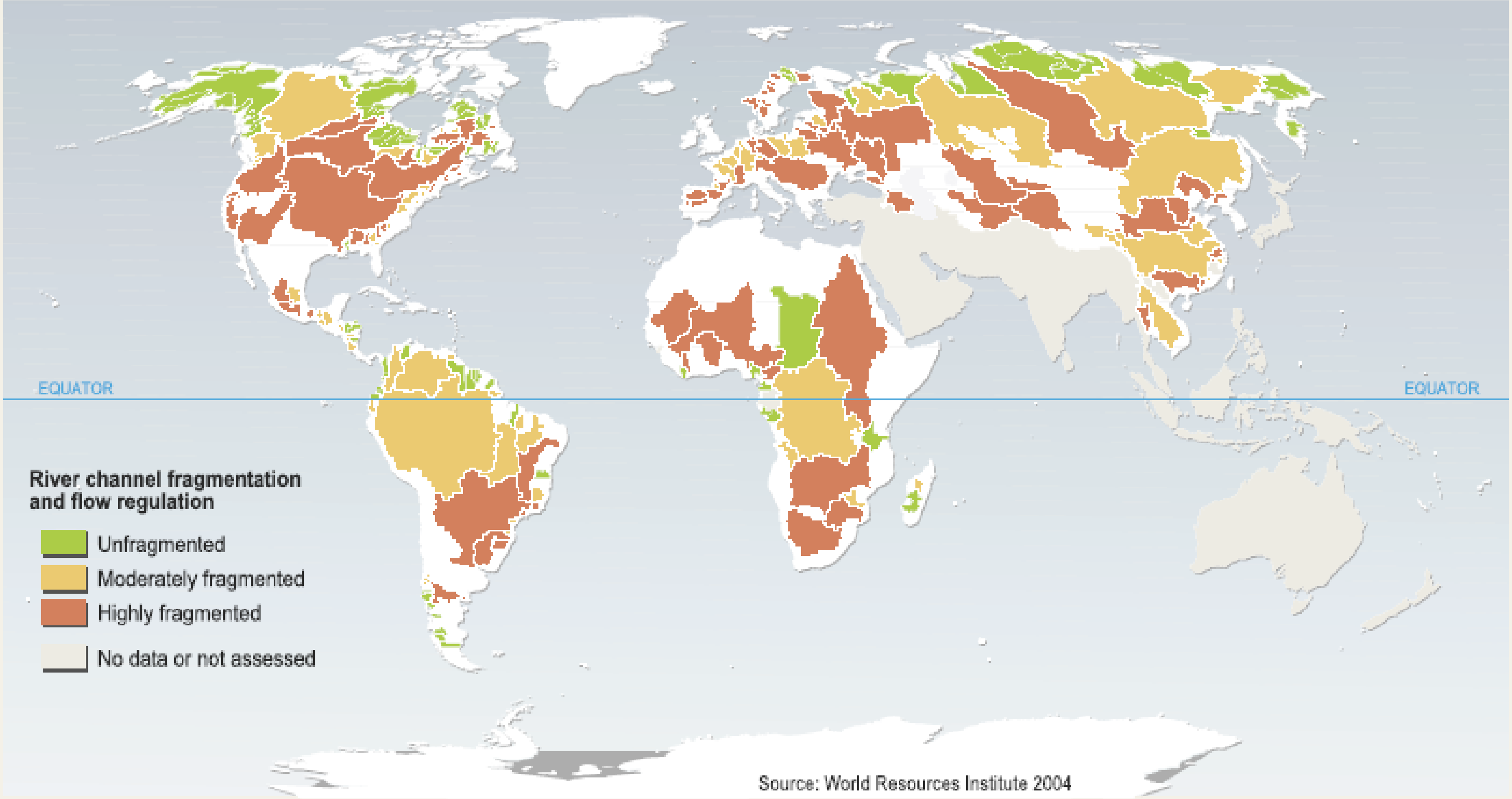
Fresh water use exceeds sustainable supply by 5 to 20% in some regions. That difference is taken from ground water. In large areas, 15-35% of irrigation is unsustainable.

Industrial use of water doubled in past 40 years.

Humans now use 40-50% of the fresh water runoff.

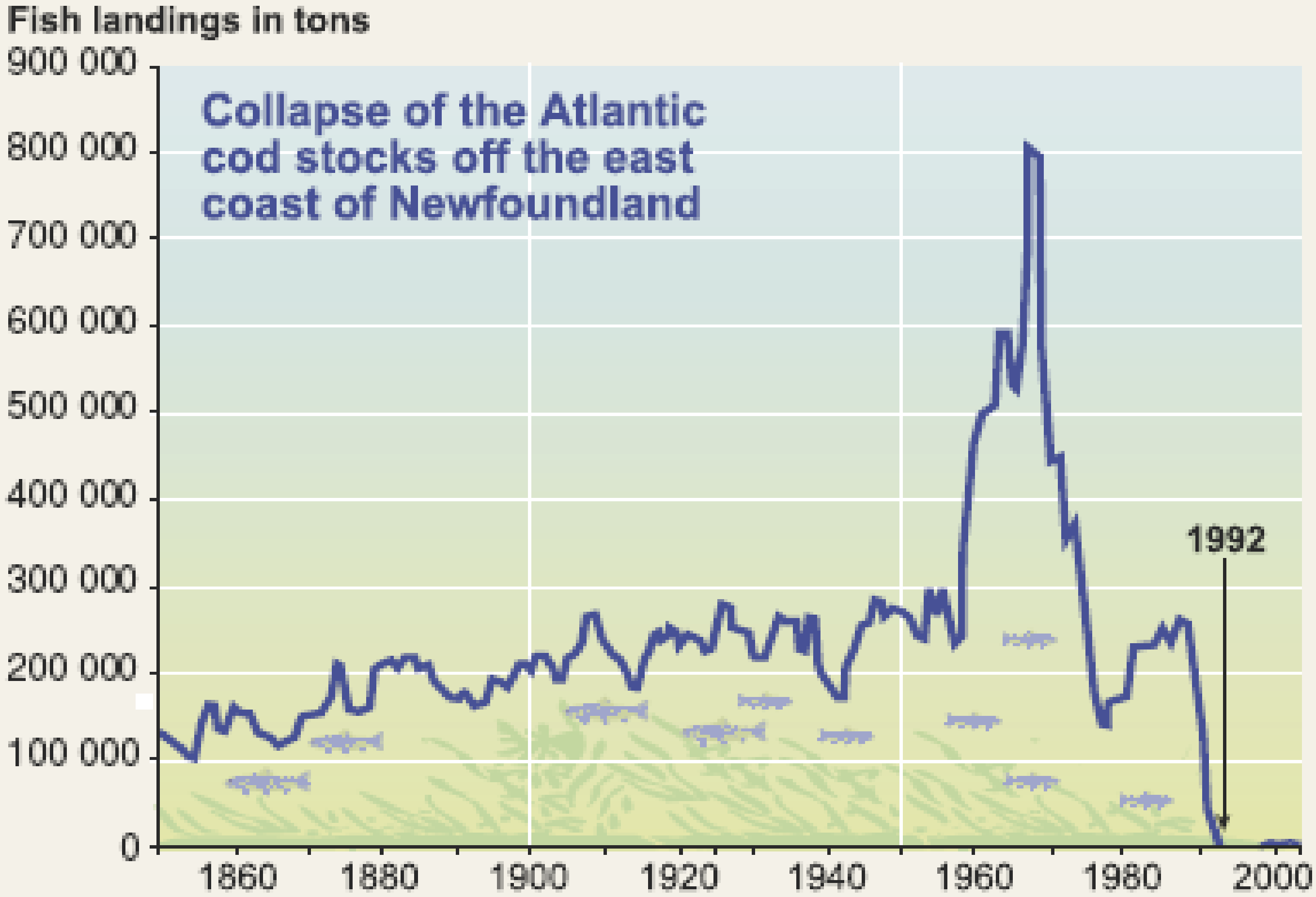
The amount of water held behind dams exceeds the amount in natural rivers and streams by a factor of six.

Figure 3.16. FRAGMENTATION AND FLOW IN MAJOR RIVERS (C20)



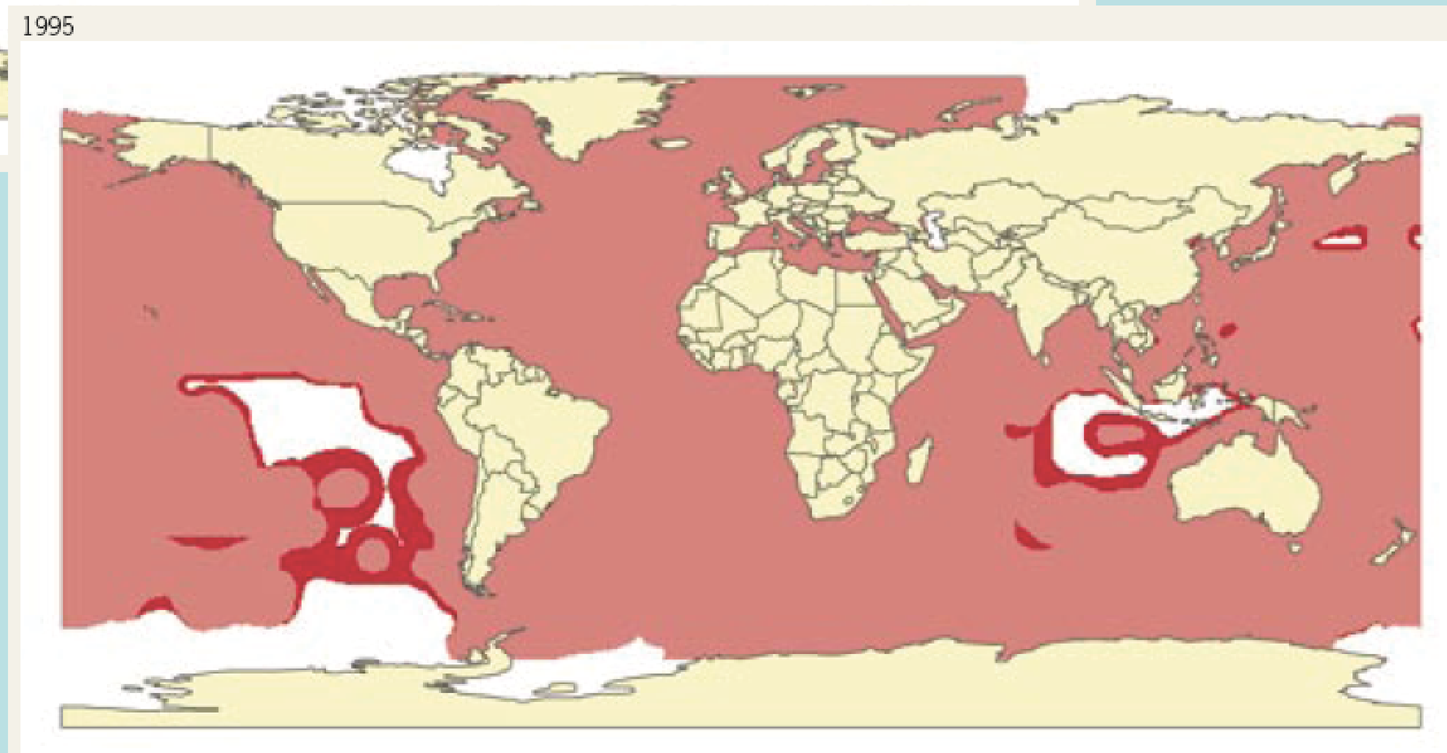
Marine Fisheries

The dramatic collapse of cod stocks off Newfoundland illustrates how quickly the services of an ecosystem can disappear when its resources are overexploited.

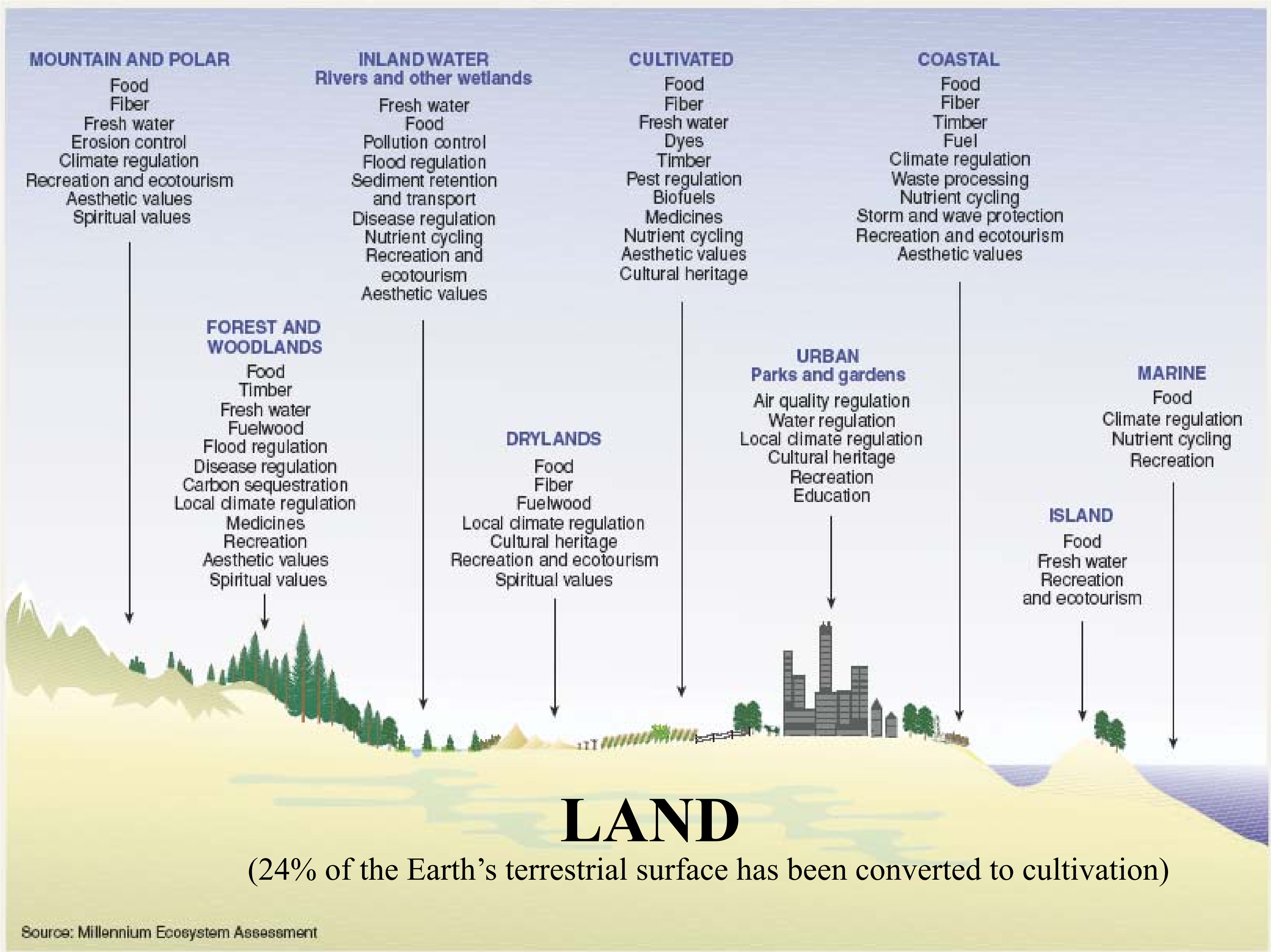


Source: Millennium Ecosystem Assessment

Fishery Catch Locations



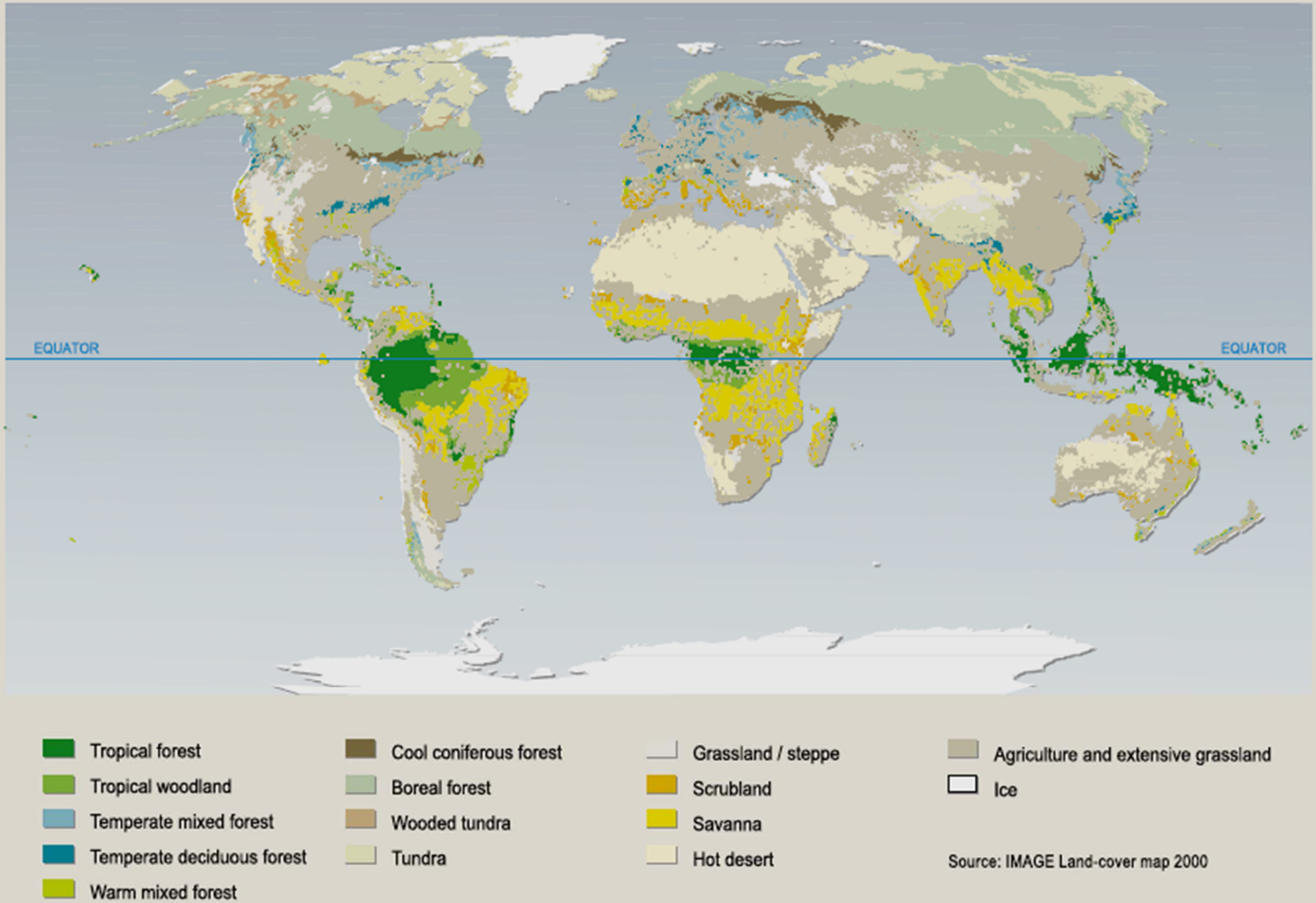
Geographical shift in catch locations reflects depletion of areas closer to shore.



LAND

(24% of the Earth's terrestrial surface has been converted to cultivation)

Figure 4.3. IMAGE Land-cover Map for the Year 2000 (S6)



Source: IMAGE Land-cover map 2000

Forest Changes 1980-2000 (national reports and remote sensing)

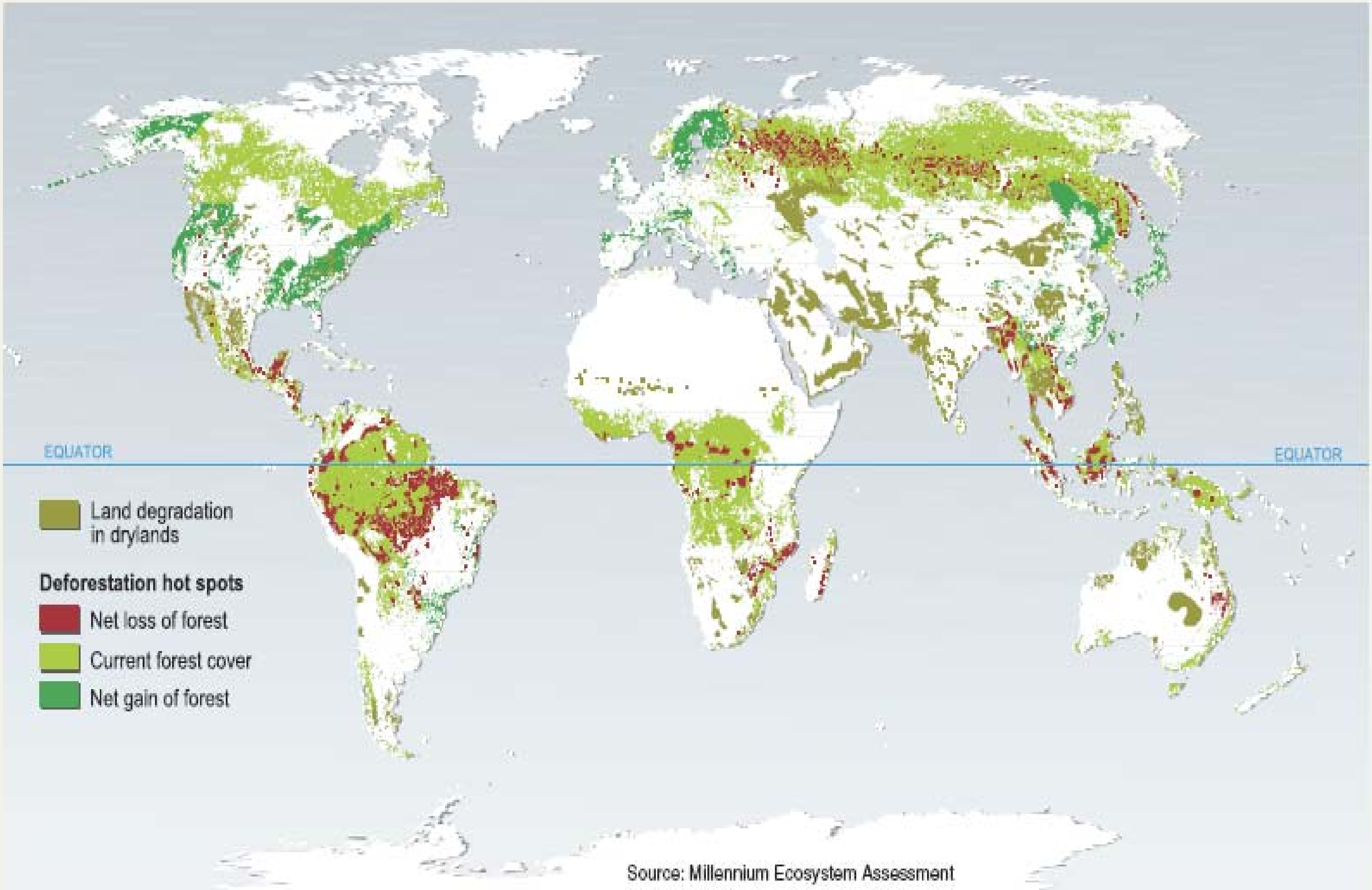
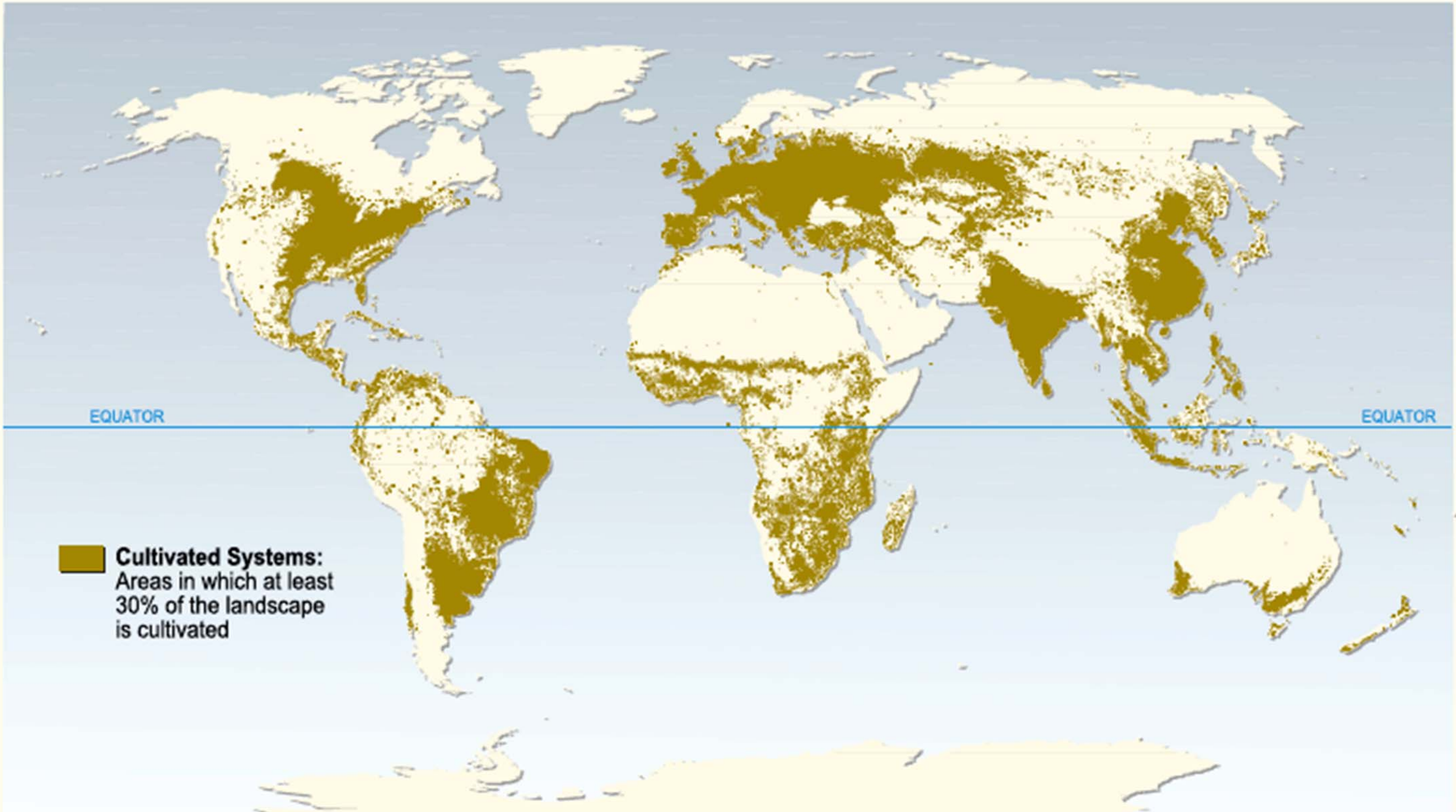


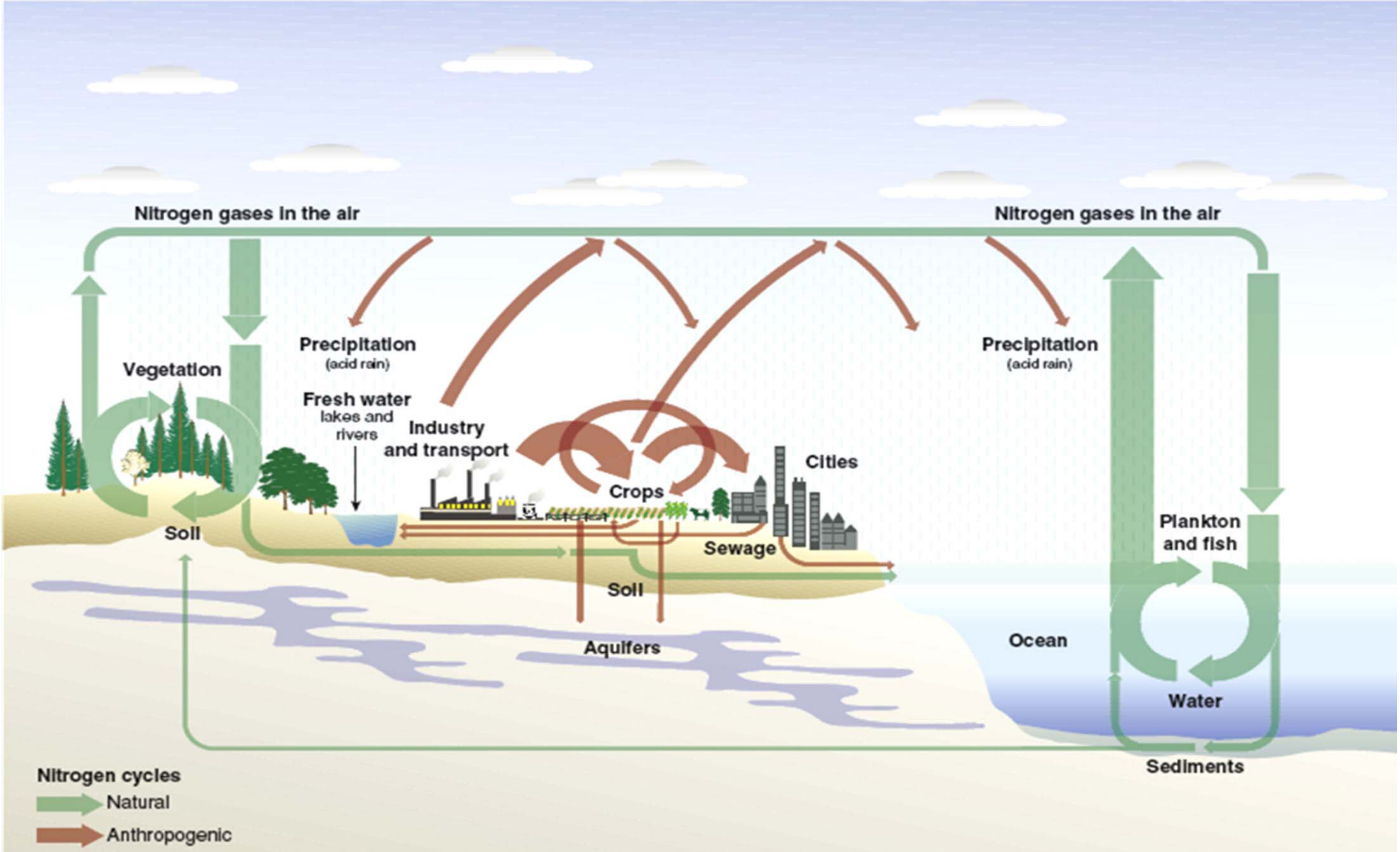
Figure 3.12. Extent of Cultivated Systems, 2000 (C26)



Source: Millennium Ecosystem Assessment

The Nitrogen Cycle.

Human activities, including farming and industry, have greatly increased the cycle of nitrogen through soils, water courses, and the atmosphere. By accumulating more nitrogen in a form that can be taken up by plants, the balance of ecosystems can be seriously upset.

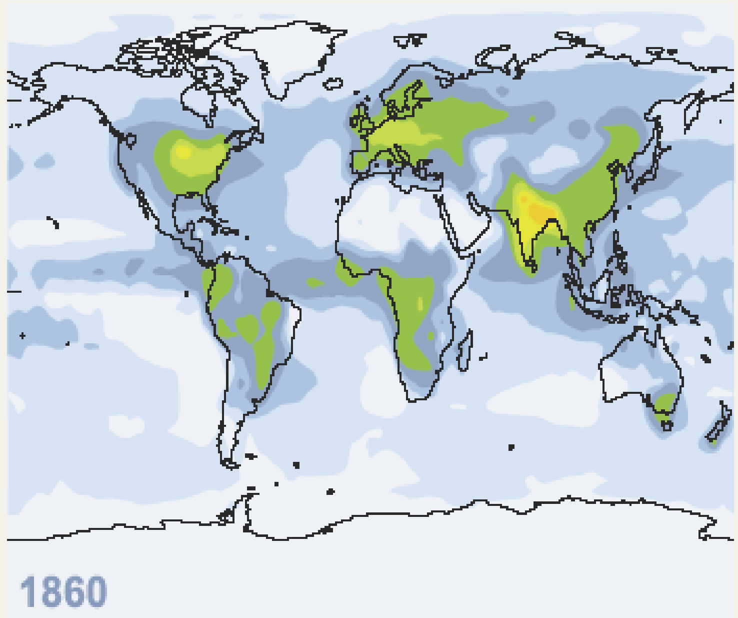


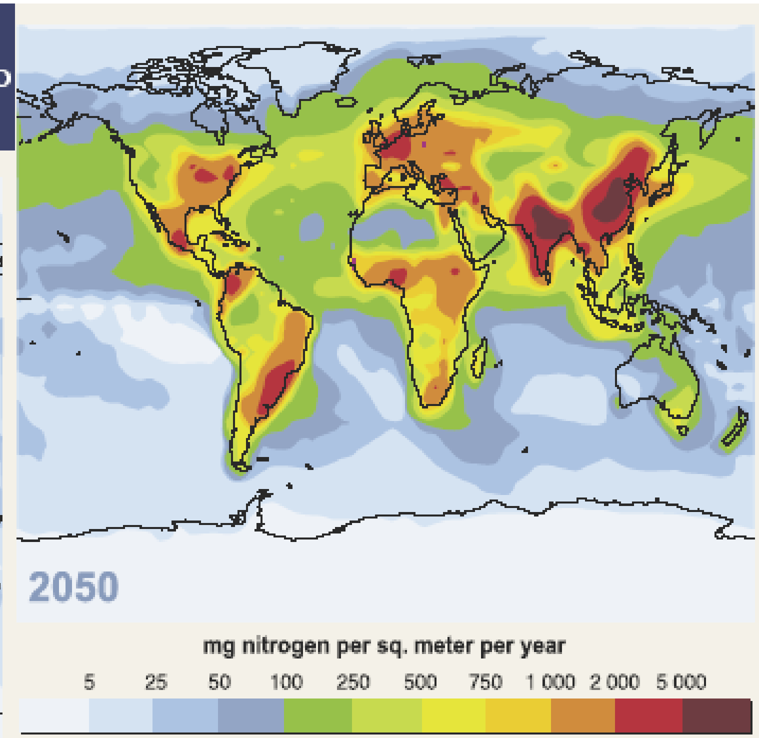
NB: Arrows are proportional to the importance of nitrogen flux.

Source: Millennium Ecosystem Assessment

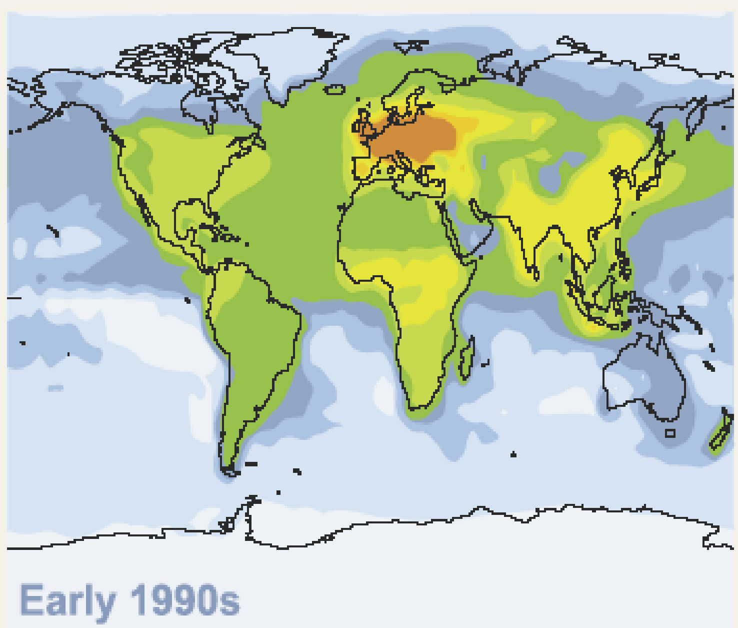
Figure 3.19. Estimated Total Reactive Nitrogen Deposition from the Atmosphere (Wet and Dry) in 1860, Early 1990s, and Projected for 2050 (milligrams of nitrogen per square meter per year) (R9 Fig 9.2)

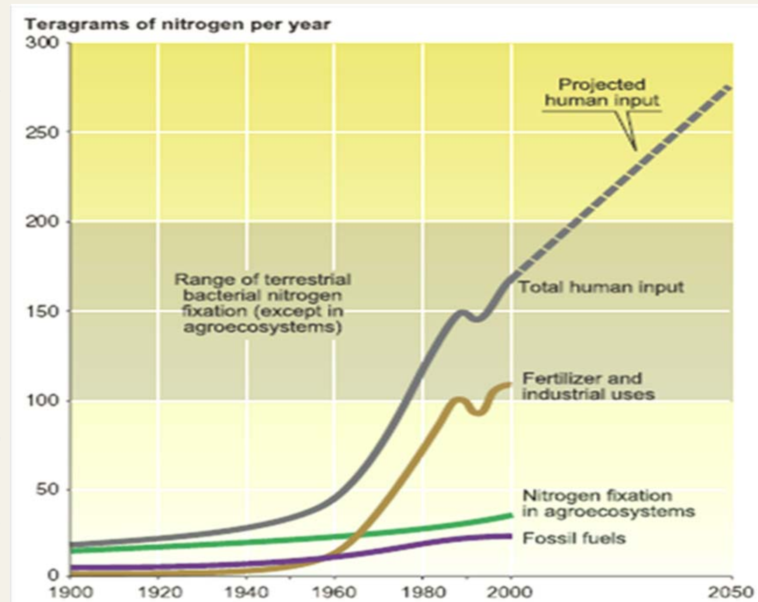
Atmospheric deposition currently accounts for roughly 12% of the reactive nitrogen entering terrestrial and coastal marine ecosystems globally, although in some regions, atmospheric deposition accounts for a higher percentage (about 33% in the United States). (Note: the projection was included in the original study and is not based on MA scenarios.)



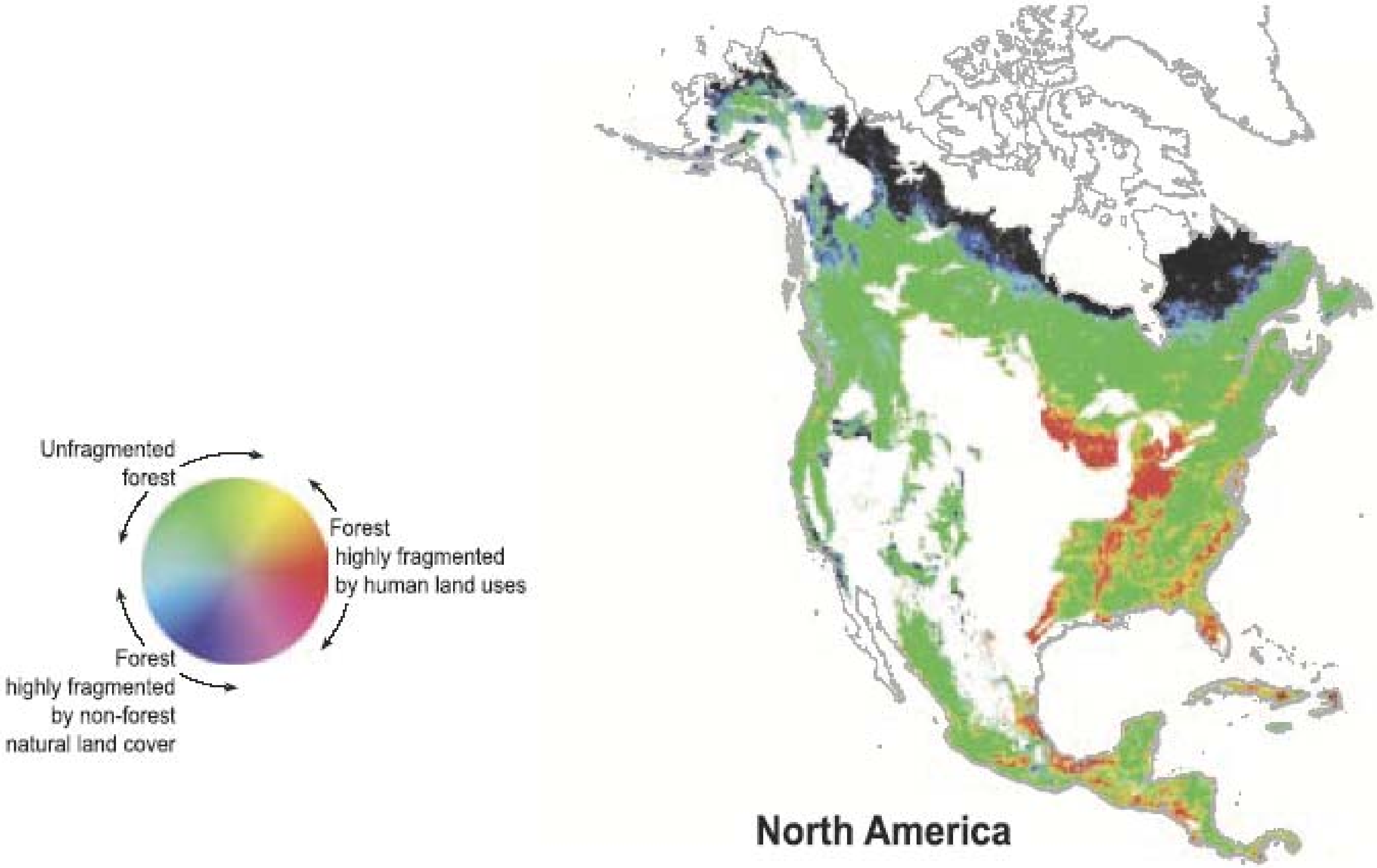


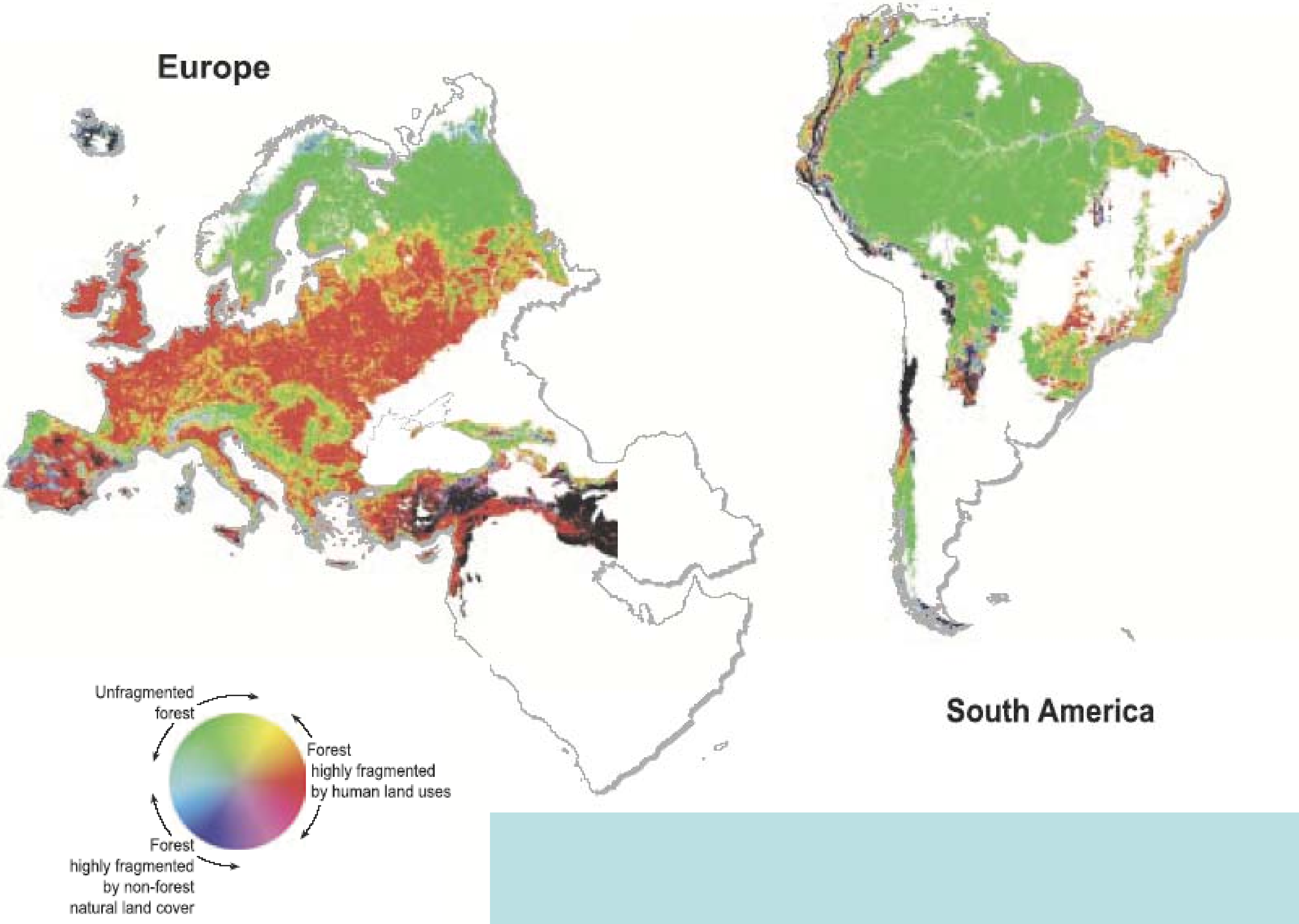
Source: Galloway et al. 2004

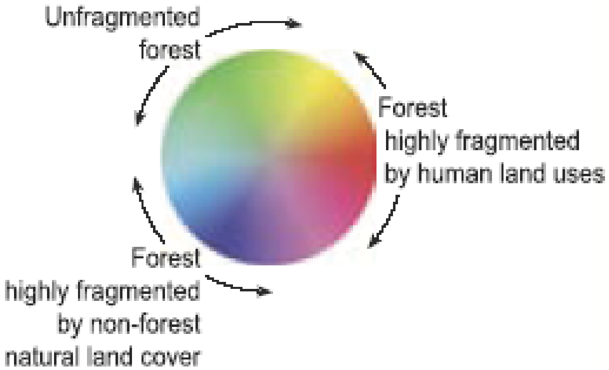


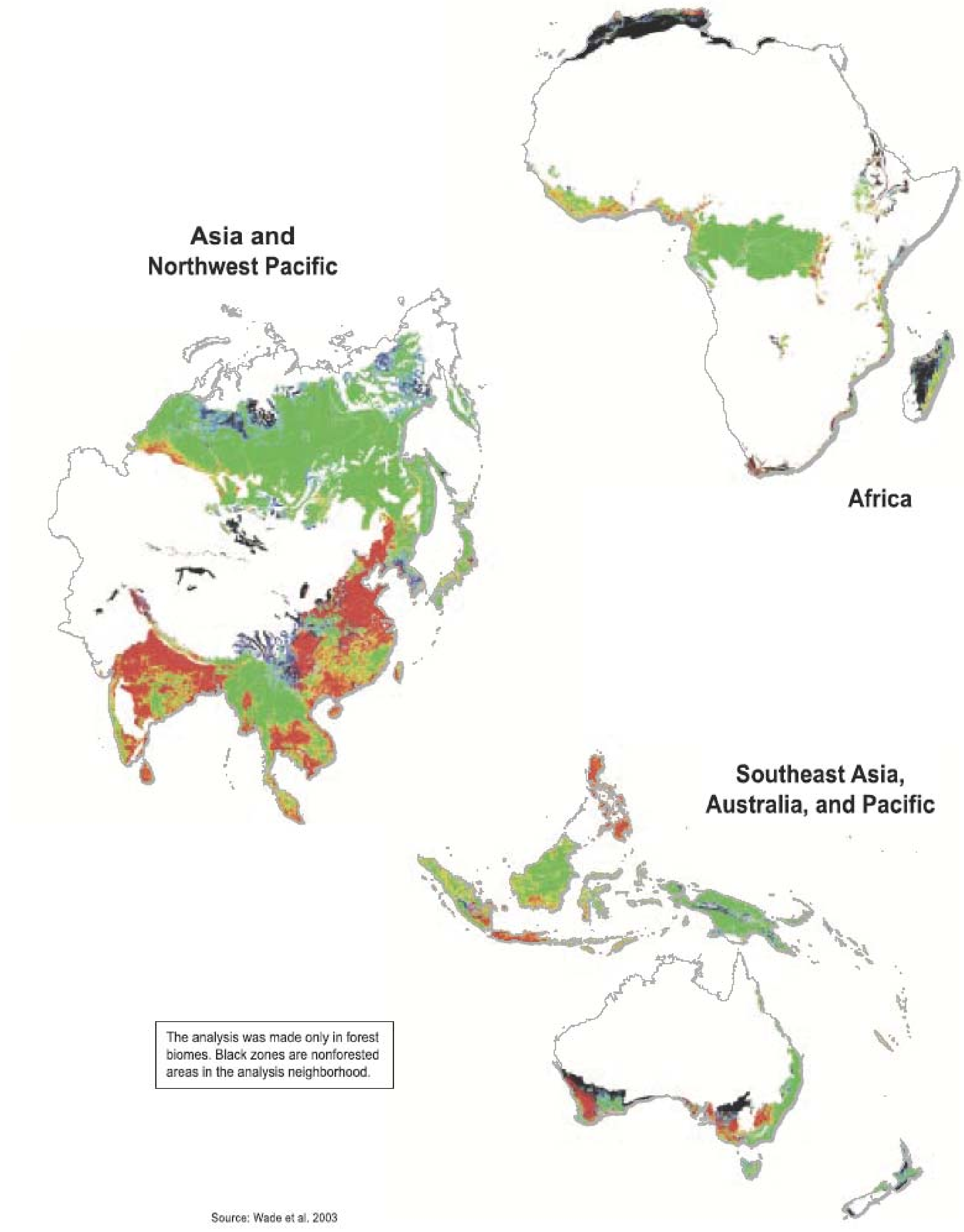


Source: Millennium Ecosystem Assessment


Unfragmented forest
Forest highly fragmented by human land uses
Forest highly fragmented by non-forest natural land cover
North America


Europe
South America
Unfragmented forest
Forest highly fragmented by human land uses
Forest highly fragmented by non-forest natural land cover



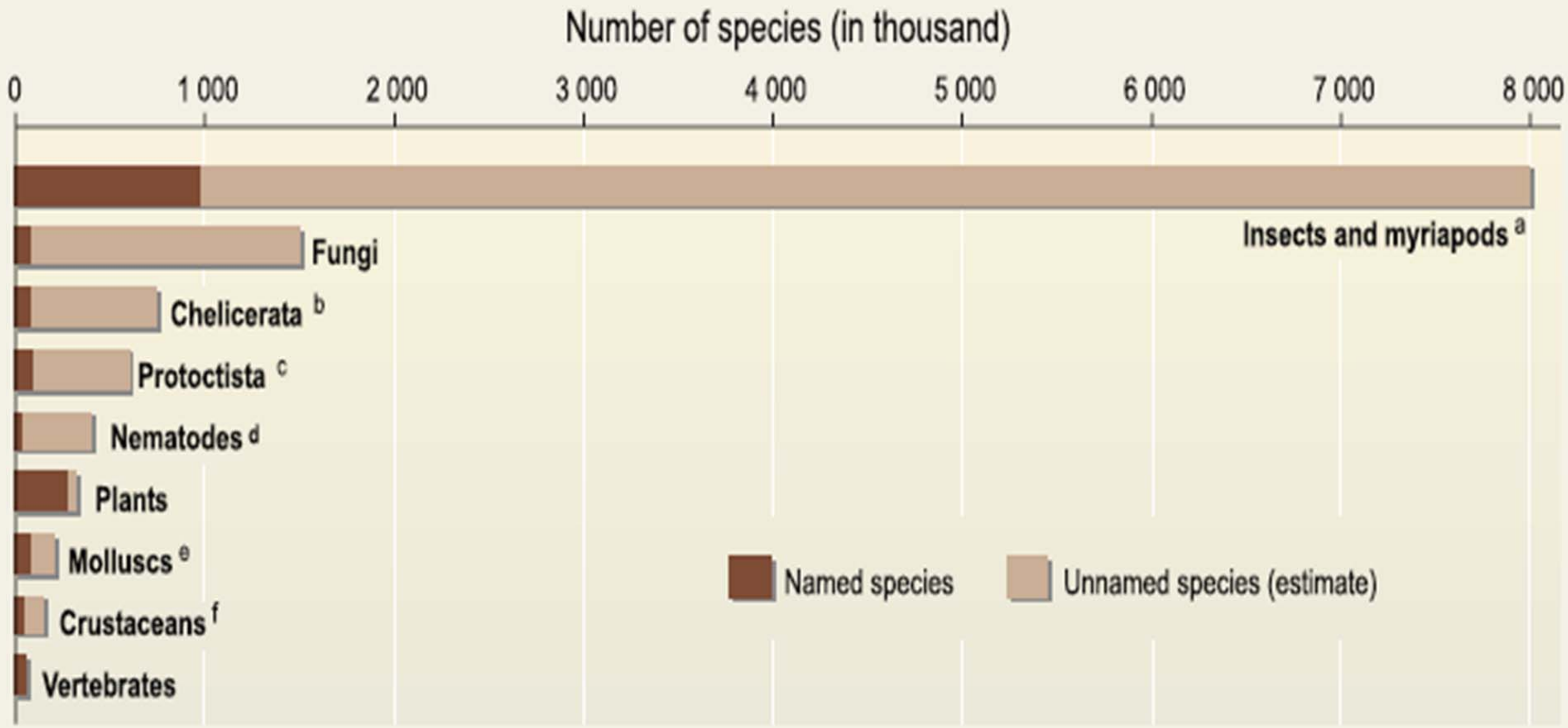


The analysis was made only in forest biomes. Black zones are nonforested areas in the analysis neighborhood.

Source: Wade et al. 2003

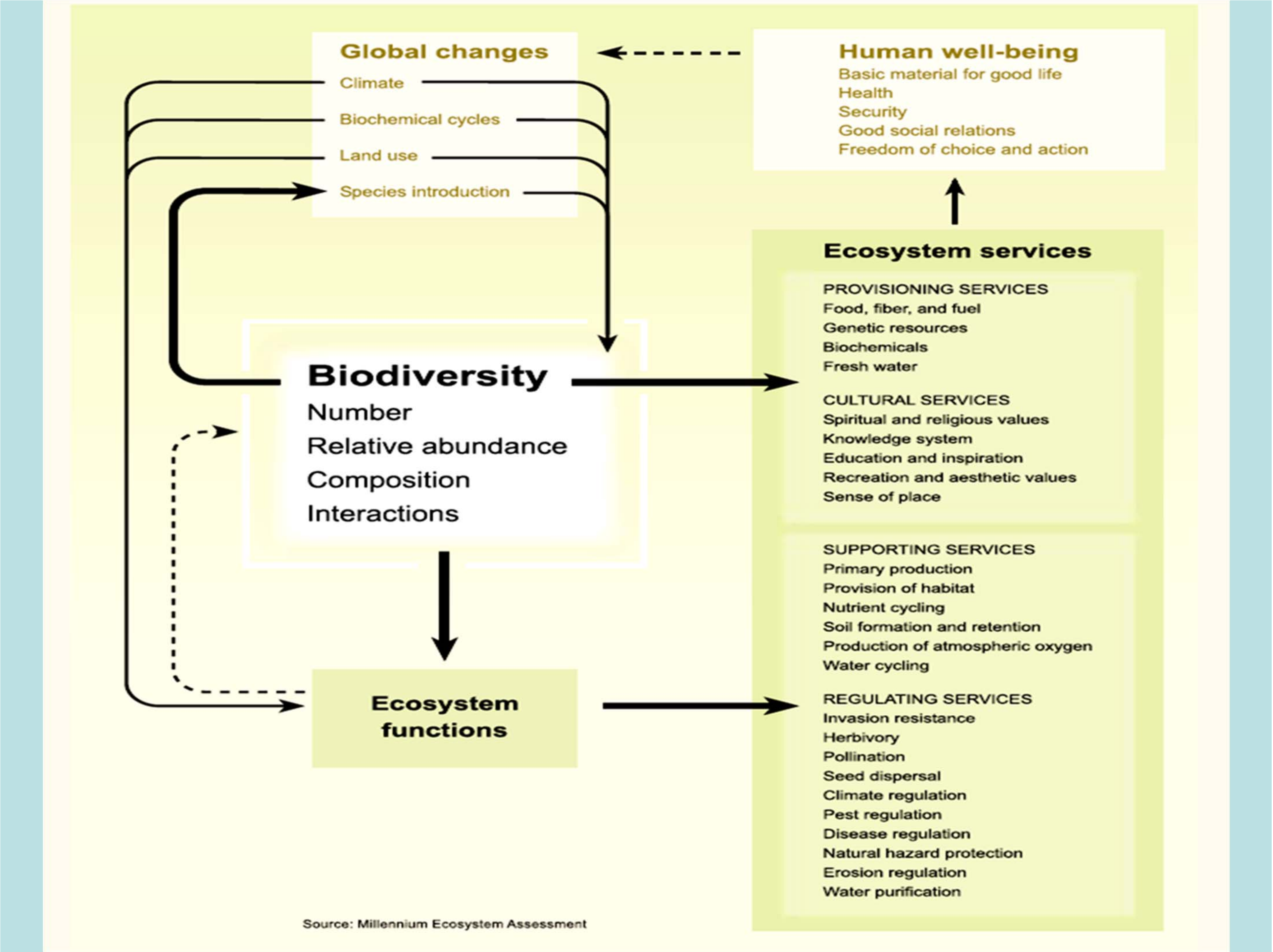
BIODIVERSITY

Figure 1.1. Estimates of Proportions and Numbers of Named Species in Groups of Eukaryote Species and Estimates of Proportions of the Total Number of Species in Groups of Eukaryotes (C4.2.3)



a Myriapods: centipedes and millipedes
b Arachnids
c Algae, slime mold, amoeboids, and other single-celled organisms (excluding bacteria)
d Roundworms
e Snails, clams, squids, octopuses, and kin
f Barnacles, copepods, crabs, lobsters, shrimps, krill, and kin

Source: Millennium Ecosystem Assessment


Global changes
Climate
Biochemical cycles
Land use
Species introduction
Human well-being
Basic material for good life
Health
Security
Good social relations
Freedom of choice and action
Ecosystem services
PROVISIONING SERVICES
Food, fiber, and fuel
Genetic resources
Biochemicals
Fresh water
CULTURAL SERVICES
Spiritual and religious values
Knowledge system
Education and inspiration
Recreation and aesthetic values
Sense of place
SUPPORTING SERVICES
Primary production
Provision of habitat
Nutrient cycling
Soil formation and retention
Production of atmospheric oxygen
Water cycling
REGULATING SERVICES
Invasion resistance
Herbivory
Pollination
Seed dispersal
Climate regulation
Pest regulation
Disease regulation
Natural hazard protection
Erosion regulation
Water purification
Biodiversity
Number
Relative abundance
Composition
Interactions
Ecosystem functions
Source: Millennium Ecosystem Assessment

8 Biogeographical Realms and 14 Biomes

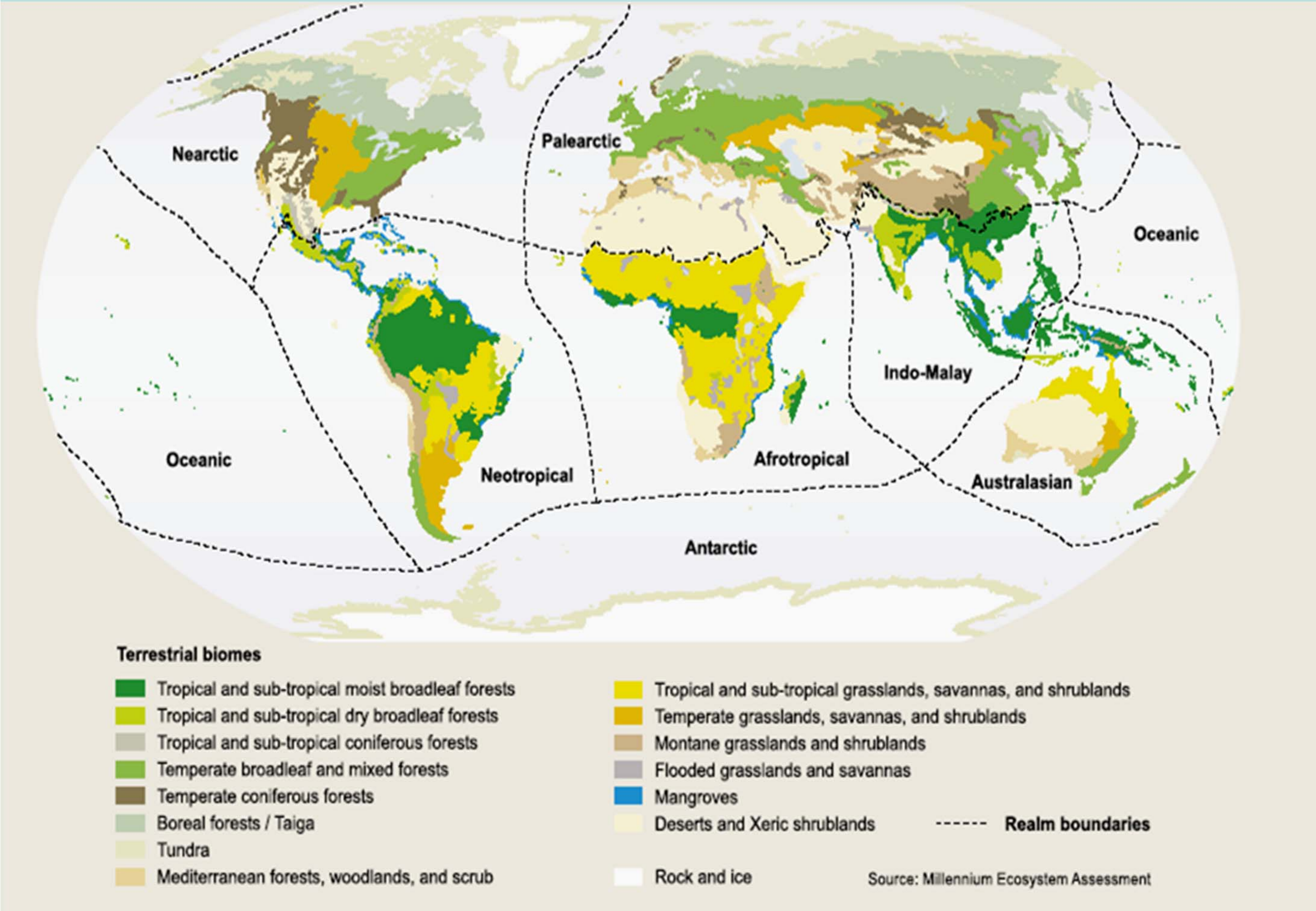


Figure 1.2. Comparisons for the 14 Terrestrial Biomes of the World in Terms of Species Richness, Family Richness, and Endemic Species (C4 Fig 4.7)

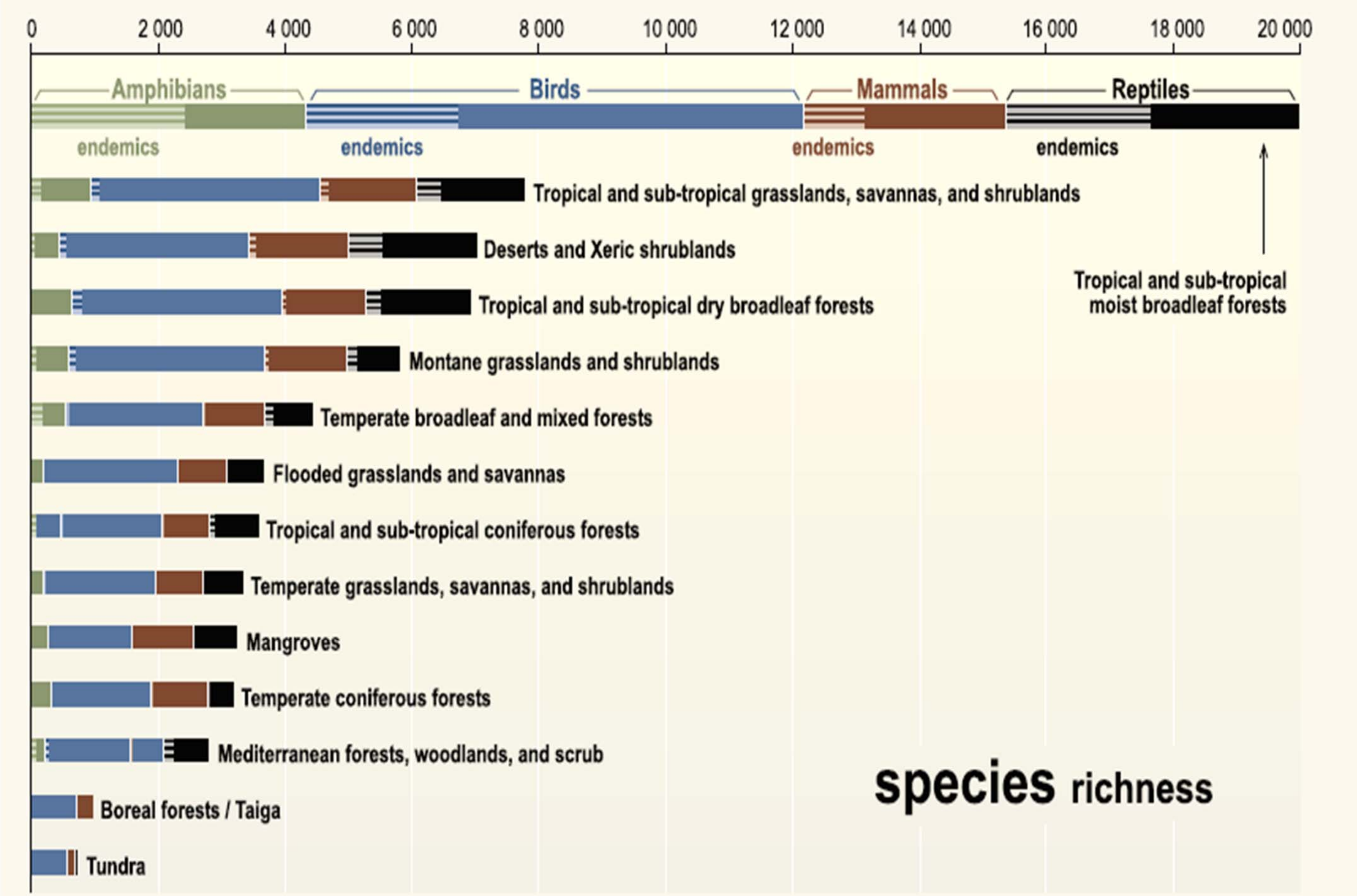
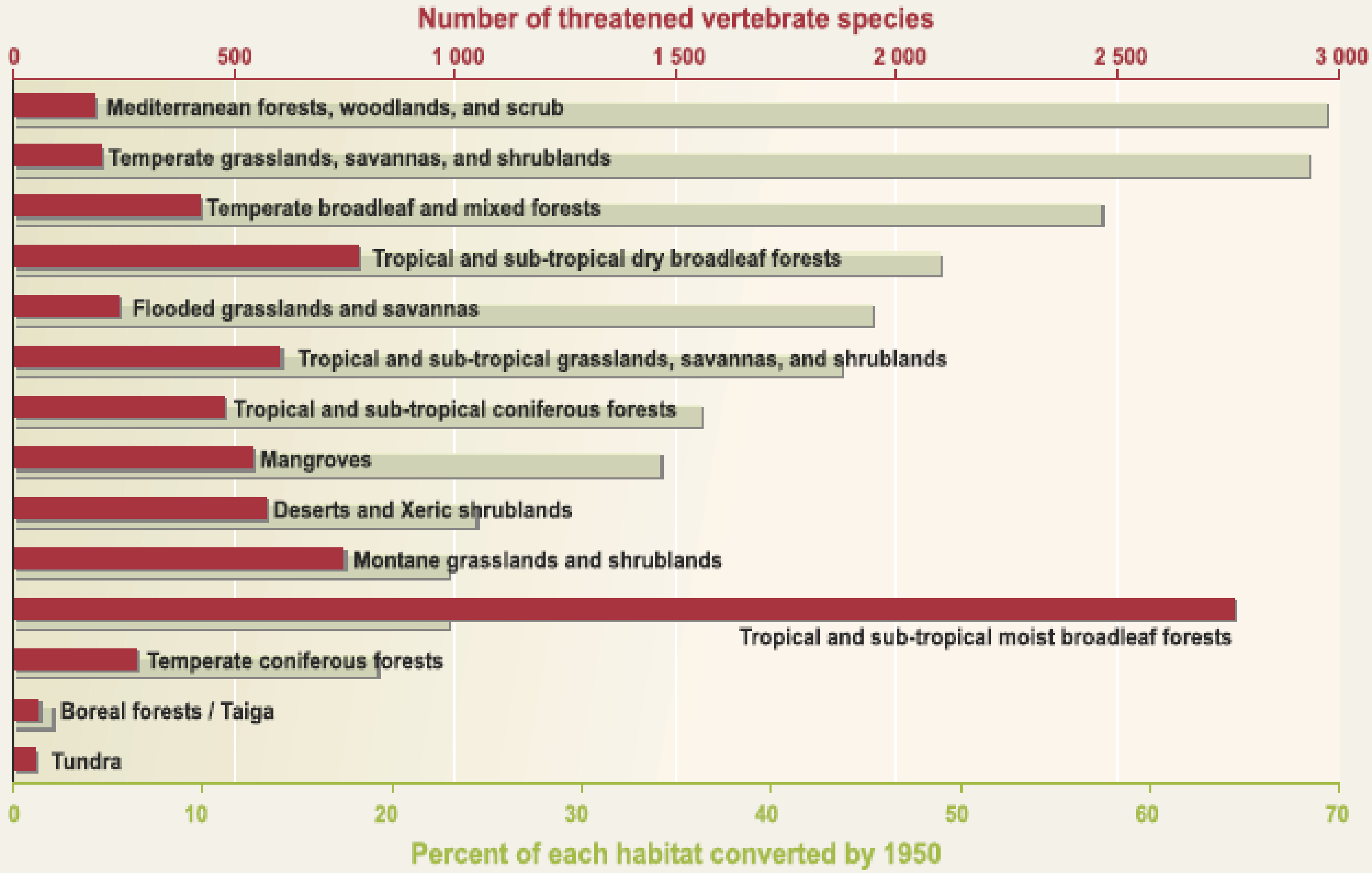


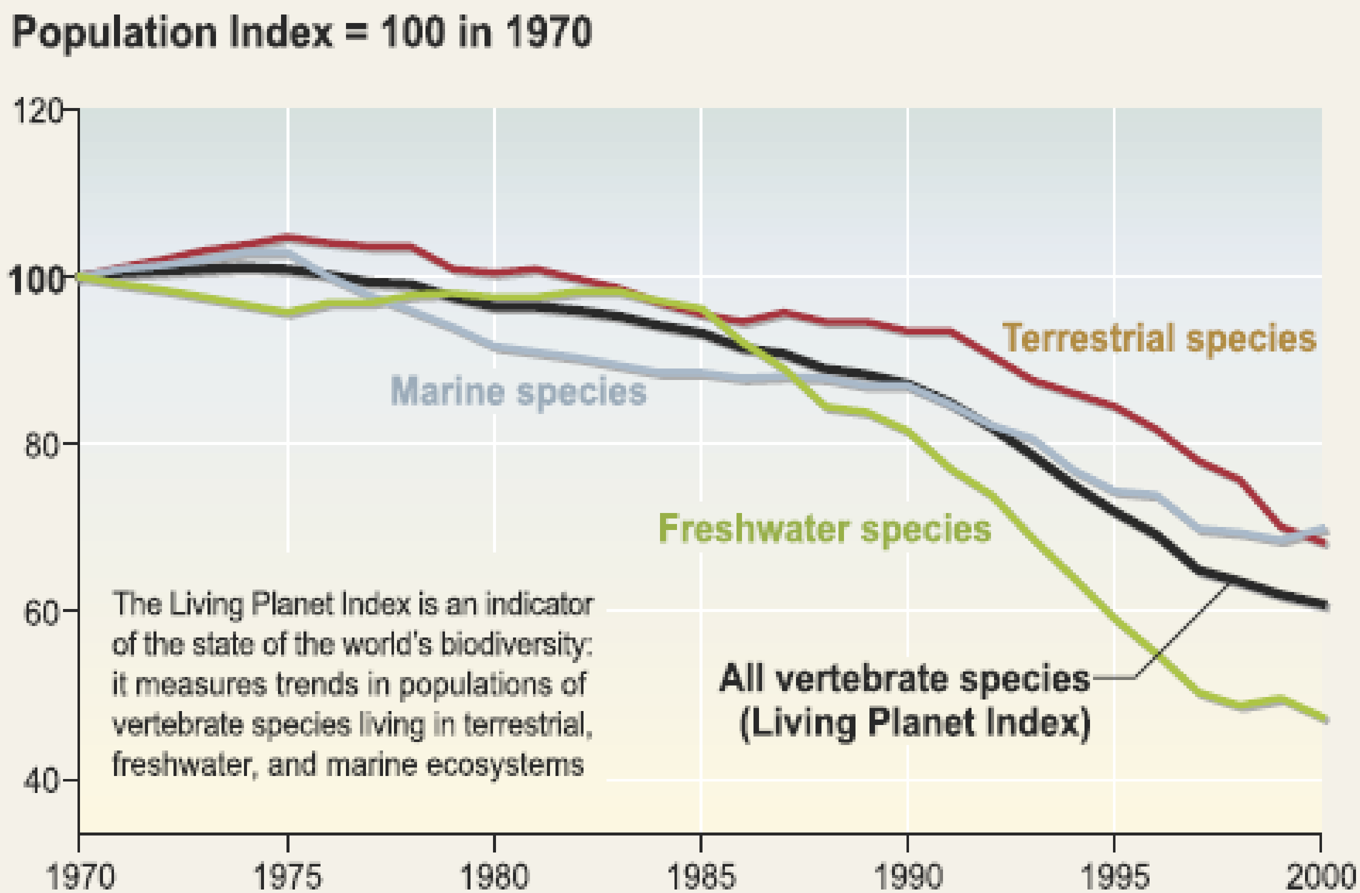
Figure 3.6. Threatened Vertebrates in the 14 Biomes, Ranked by the Amount of Their Habitat Converted by 1950 (C4)



Source: Millennium Ecosystem Assessment

Figure 3.7. THE LIVING PLANET INDEX, 1970–2000

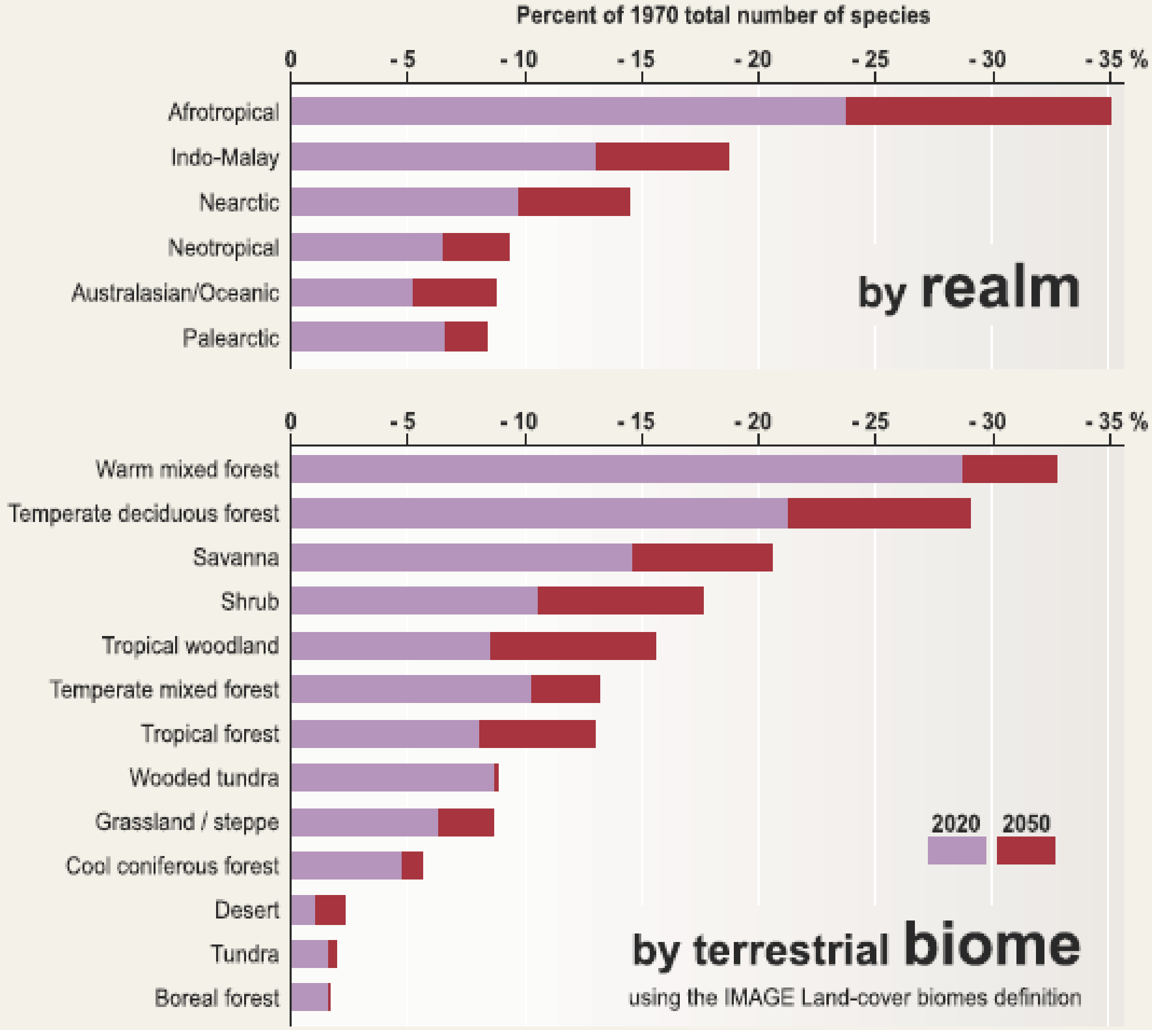
The index currently incorporates data on the abundance of 555 terrestrial species, 323 freshwater species, and 267 marine species around the world. While the index fell by some 40% between 1970 and 2000, the terrestrial index fell by about 30%, the freshwater index by about 50%, and the marine index by around 30% over the same period.



Source: WWF, UNEP-WCMC

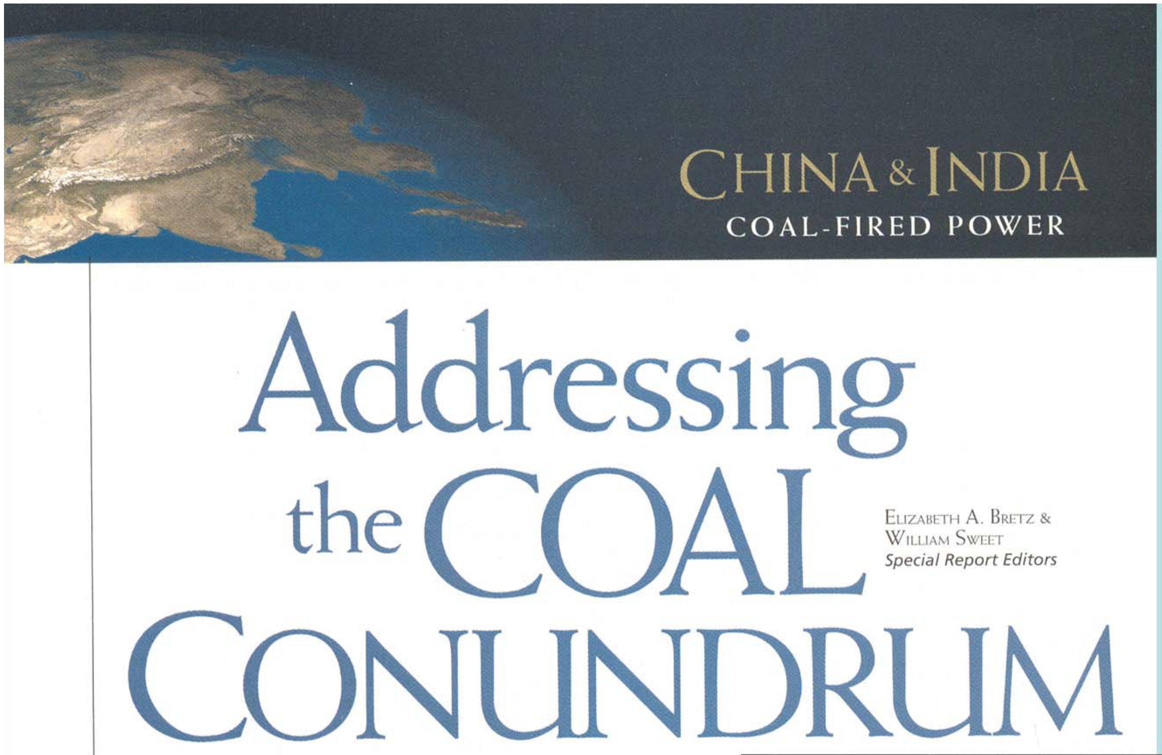
Figure 4.2. Relative Loss of Biodiversity of Vascular Plants between 1970 and 2050 as a Result of Land Use Change for Different Biomes and Realms in the Order from Strength Scenario (S10.2)

Extinctions will occur between now and sometime after 2050, when populations reach equilibrium with remaining habitat. Note that the biomes in this Figure are from the IMAGE model (see Figure 4.3) and are slightly different from the biomes mentioned elsewhere in this report.

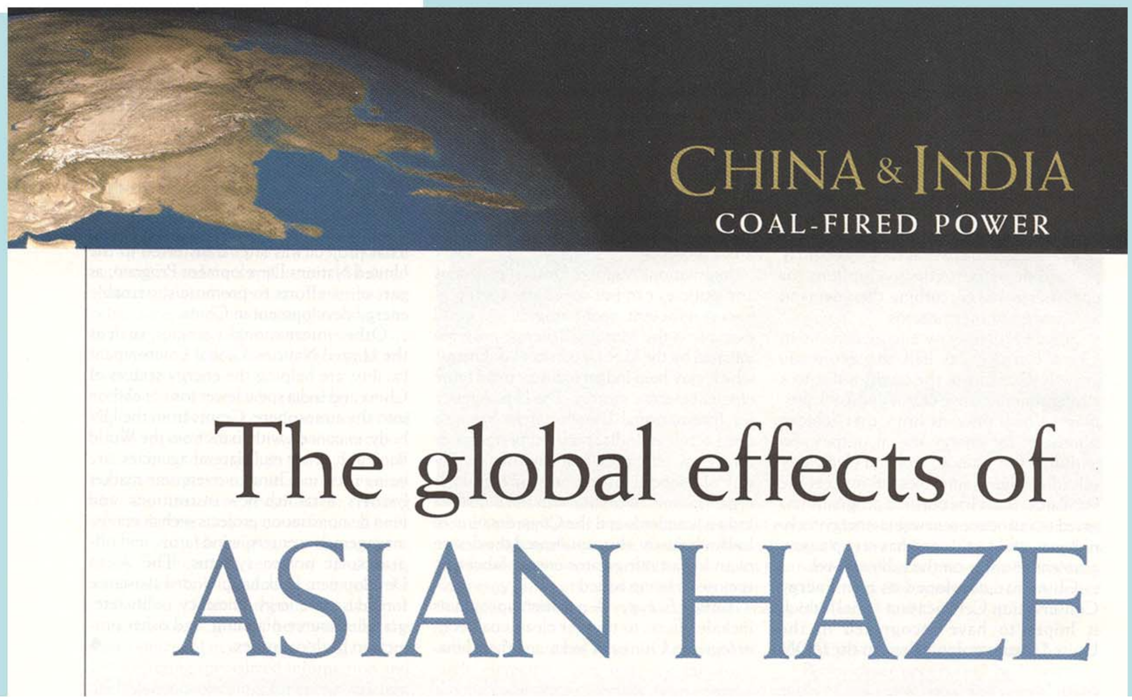


Source: Millennium Ecosystem Assessment

ENERGY



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/m³
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

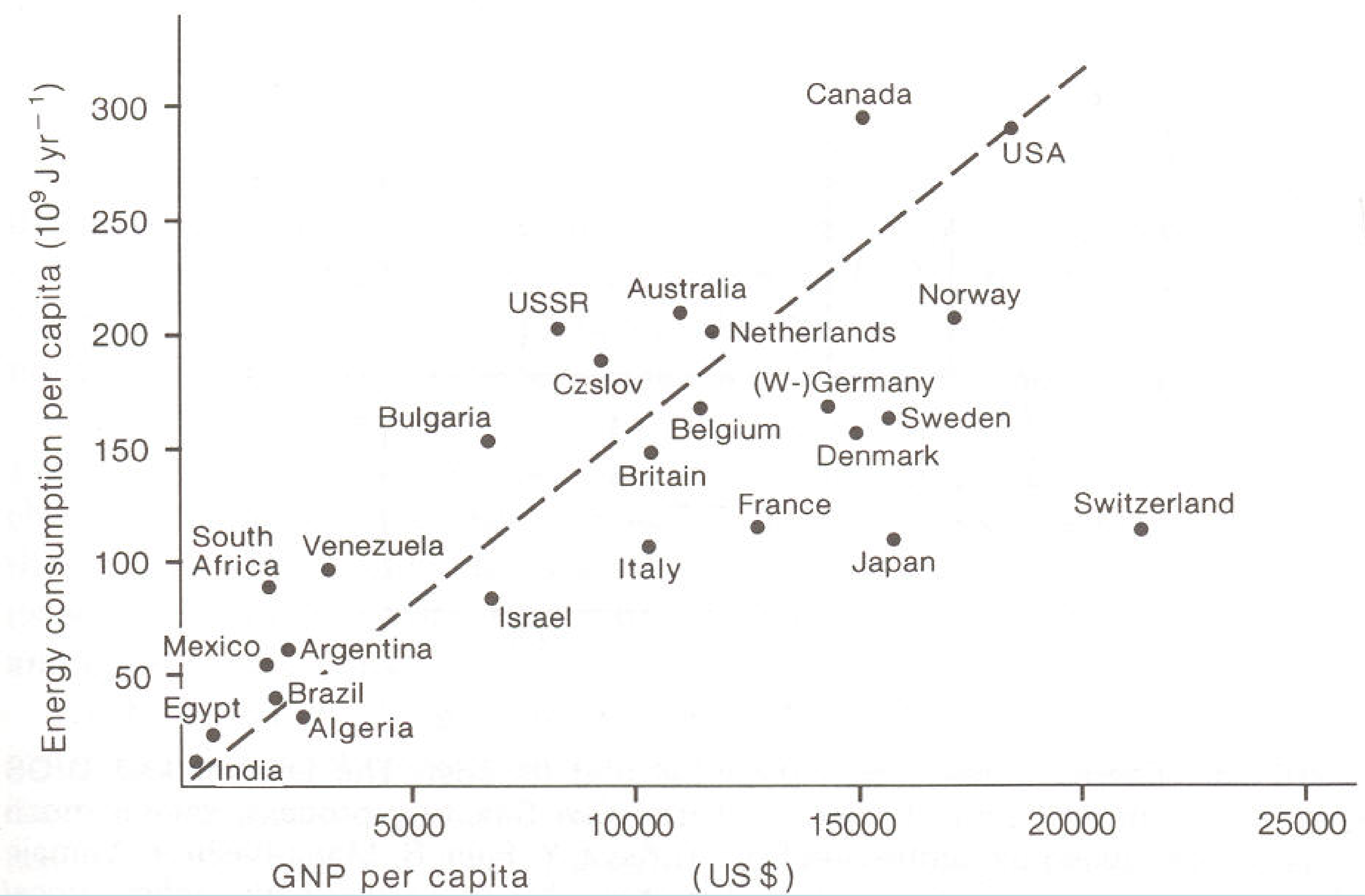
[a] These are chlorofluorocarbons CFC-11 and -12, phased out under the Montreal Protocol. The mixing ratio for CFC-11 is declining by 0.3 percent per year, for CFC-12 increasing by 0.7–1 percent per year.

[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.

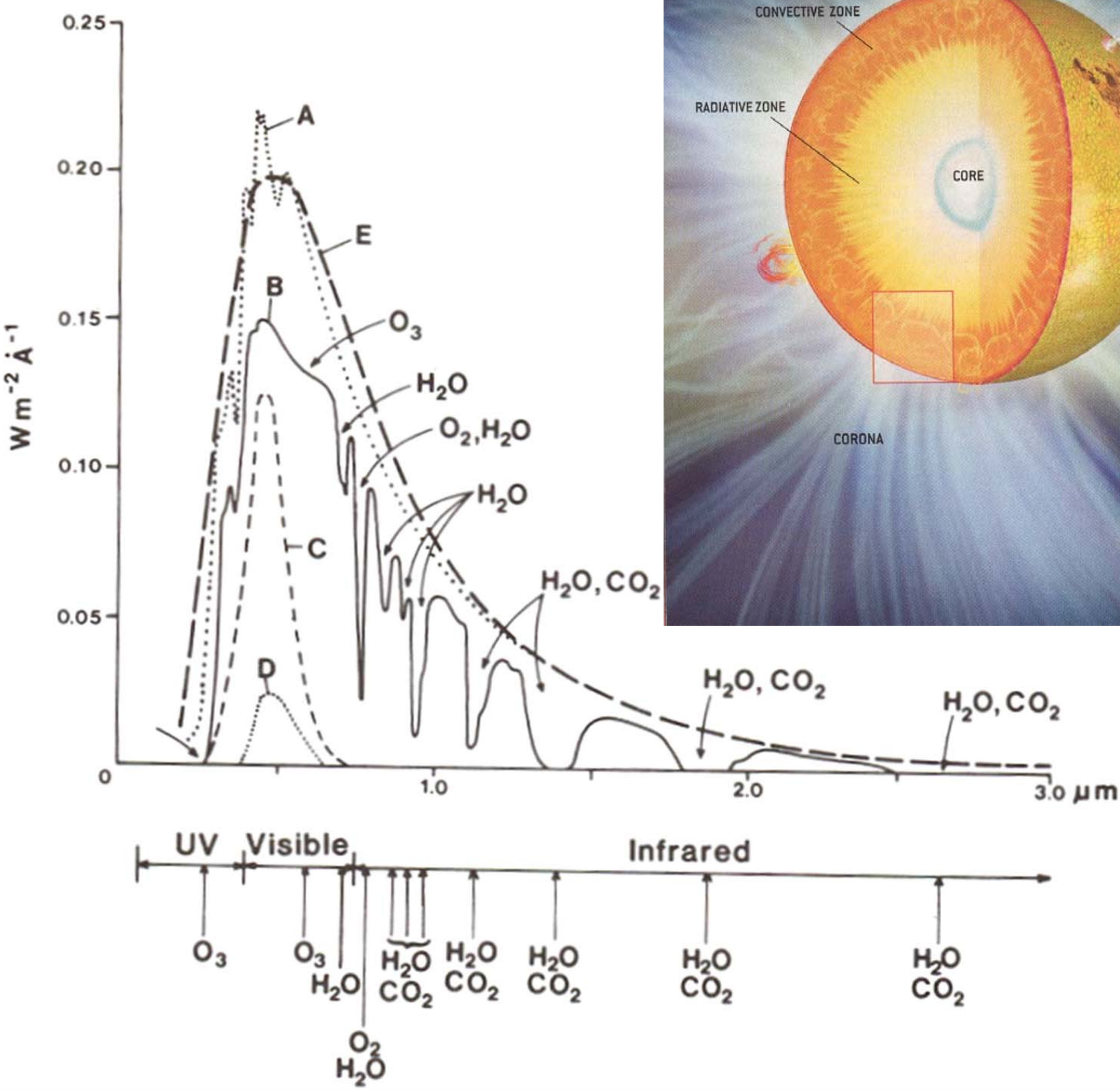
China & India: The Dilemma of Coal-Fired Power - IEEE Spectrum, Nov and Dec 1999

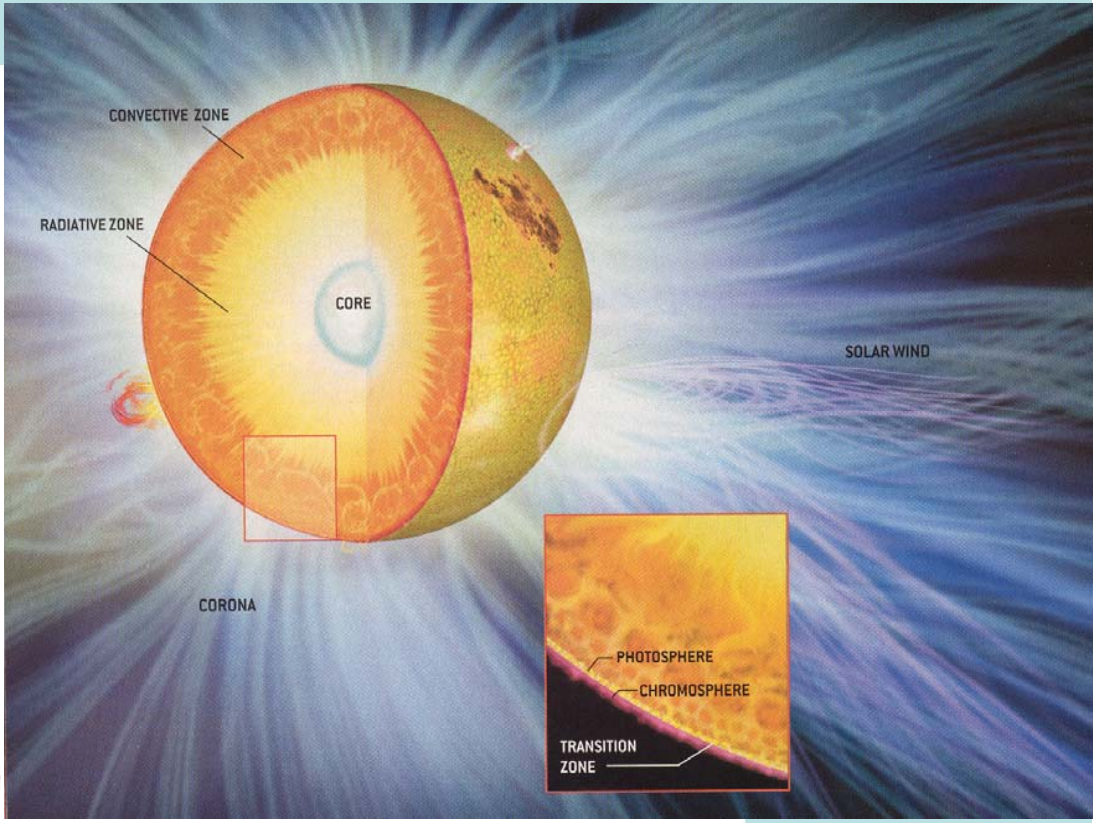
Energy Consumption Compared with Gross National Product



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

Our Primary Energy Source

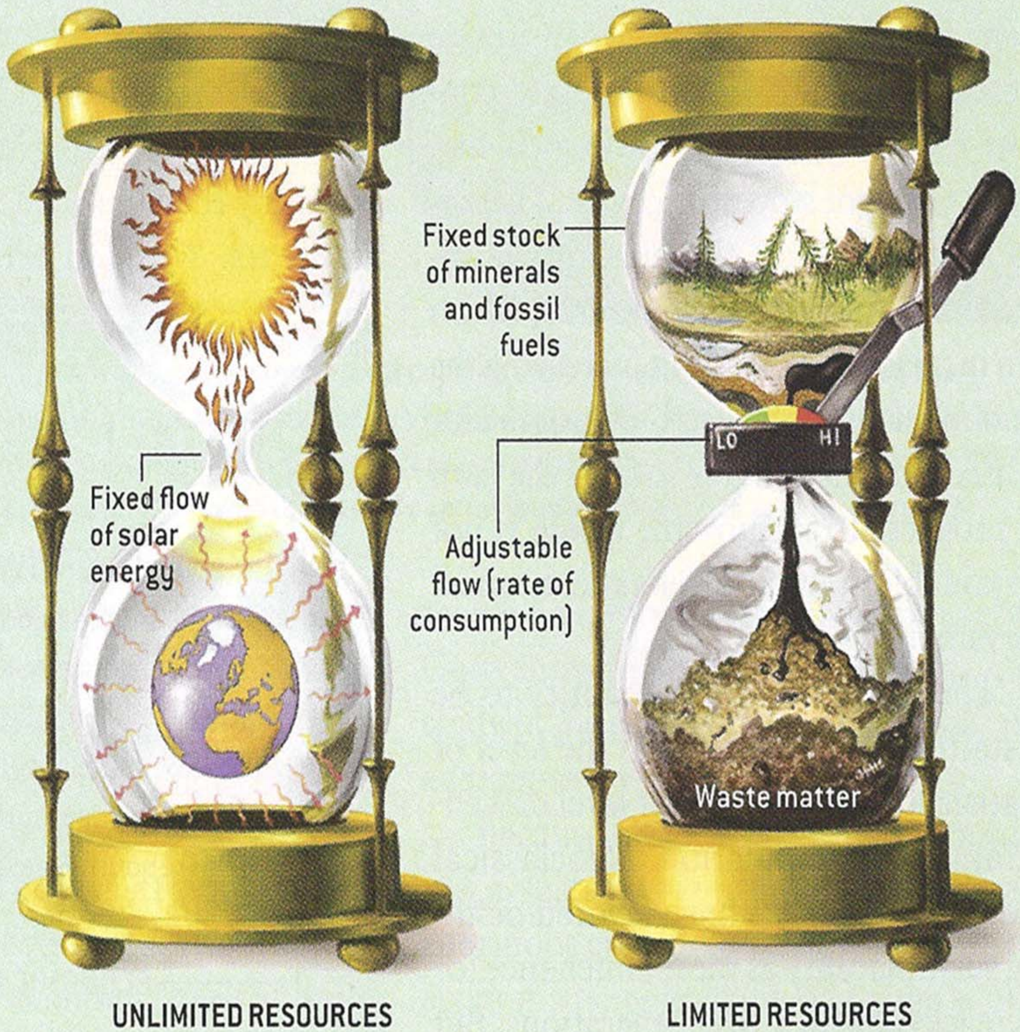




ECONOMY AS AN HOURGLASS

HUMANKIND'S CONSUMPTION of resources is somewhat akin to sand flowing through an hourglass that cannot be flipped over. We have a virtually unlimited supply of energy from the sun (*left*), but we cannot control the rate of its input. In contrast, we have a finite supply of fossil fuels and minerals (*right*), but we can increase or decrease our consumption rate. If we use those resources at a high rate, we in essence borrow from the supply rightly belonging to future generations and accumulate more wastes in the environment. Such activity is not sustainable in the long run.

Some economists express these facts in terms of physical laws. They argue that this lack of sustainability is predicted by the first two laws of thermodynamics, namely that energy is conserved (finite) and that systems naturally go from order to disorder (from low to high entropy). Humans survive and make things by sucking useful (low-entropy) resources—fossil fuels and concentrated minerals—from the environment and converting them into useless (high-entropy) wastes. The mass of wastes continuously increases (second law) until at some point all the fuel is converted to useless detritus. *—H.E.D.*

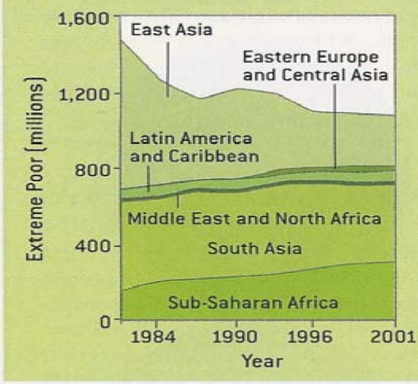


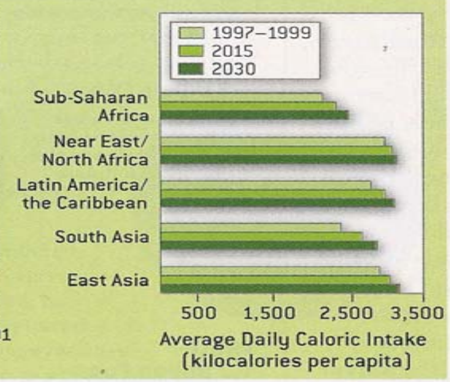
(Scientific American, September 2005)

Millennium Goals

GOAL 1 ERADICATE EXTREME POVERTY AND HUNGER

Target: Halve the proportion of people living on less than $1 a day and the proportion of those who suffer chronic hunger.
Status: Between 1990 and 2001, the fraction of the populations in sub-Saharan Africa, Latin America and the Caribbean living in extreme poverty remained stagnant and, ominously, increased in Central Asia. Food intake is rising, but hunger is still widespread in several regions.





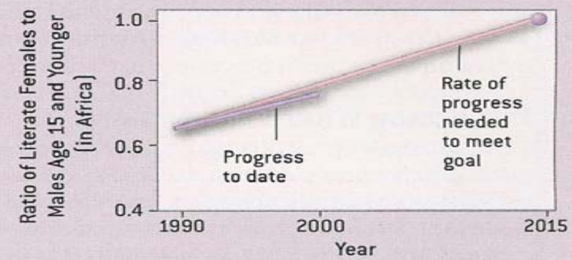
GOAL 2 ACHIEVE UNIVERSAL PRIMARY EDUCATION

Target: Ensure that by 2015 all children complete a full course of primary education.

GOAL 3 PROMOTE GENDER EQUALITY AND EMPOWER WOMEN

Target: Eliminate gender disparity in primary, secondary and tertiary education by 2015.

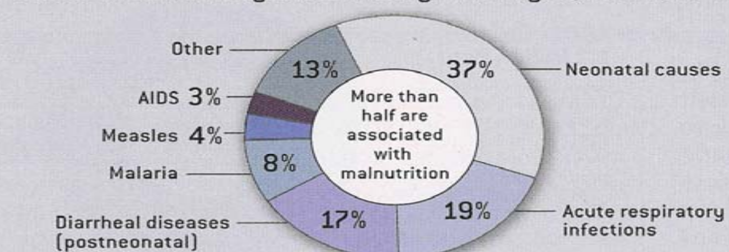
Status: Education is probably the best way to promote gender equality. The greatest challenges are in sub-Saharan Africa, where overall school completion rates have hovered around 50 percent. Women and girls fare even worse, as shown below by the ratio of literate females to males on the African continent.

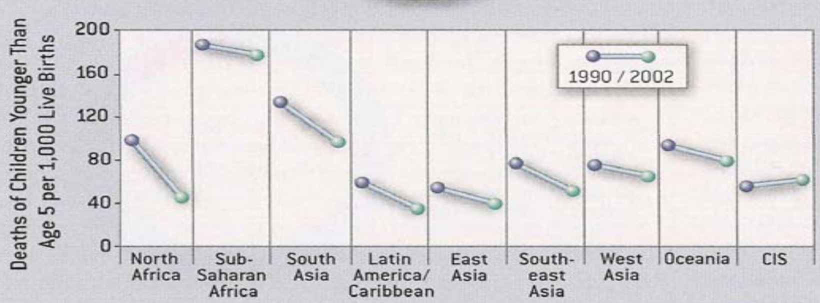


GOAL 4 REDUCE CHILD MORTALITY

Target: Reduce by two thirds the mortality rate of children younger than five years.
Status: Child mortality rates fell in every region except the former Soviet republics in the Commonwealth of Independent States (CIS), but rates remain high in sub-Saharan Africa and in South Asia. For comparison, the child mortality rate in high-income countries in 2000 was about six per 1,000 births.

Causes of Death among Children Younger Than Age 5, from 2000–2003





GOAL 5 IMPROVE MATERNAL HEALTH

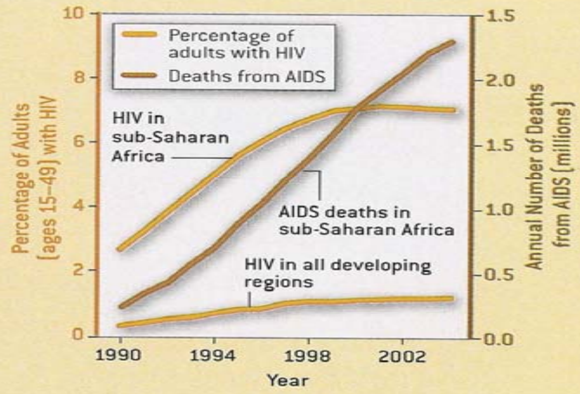
Target: Reduce by 75 percent the maternal mortality rate by 2015.
Status: Maternal mortality rates remain shockingly high in every developing region of the world. Increasing the proportion of deliveries attended by skilled health workers will be critical to lowering maternal mortality.

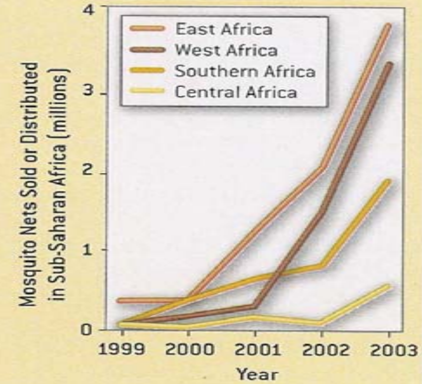
Region	Maternal deaths per 100,000 live births in 2000	Deliveries attended by skilled health care personnel 1990	2003
Sub-Saharan Africa	920	40%	41%
South Asia	540	28%	37%
Southeast Asia	210	34%	64%
West Asia	190	61%	62%
Latin America and the Caribbean	190	74%	86%
North Africa	130	41%	76%
East Asia	55	51%	82%
All Developing Regions	450	41%	57%

SARA BEARDSLEY (*data compilation*); JEN CHRISTIANSEN (*illustrations*); SOURCES: GOAL 1: WWW.WORLDBANK.ORG/DATA/WDI2005/WDITEXT/SECTION1_1_1.HTM (*graph*); WWW.FAO.ORG/DOCREP/007/Y5650E/Y5650E04.HTM (*bar chart*); GOALS 2 AND 3: *ACHIEVING THE MILLENNIUM DEVELOPMENT GOALS IN AFRICA*, JUNE 2002 (*graph*); GOAL 4: *THE MDG REPORT 2005* (*pie chart*); HTTP://UNSTATS.UN.ORG/UNSD/MI/MI_COVERFINAL.HTM (*line graph*); GOAL 5: *THE MDG REPORT 2005* (*bar chart*)

GOAL 6 COMBAT HIV/AIDS, MALARIA AND OTHER DISEASES

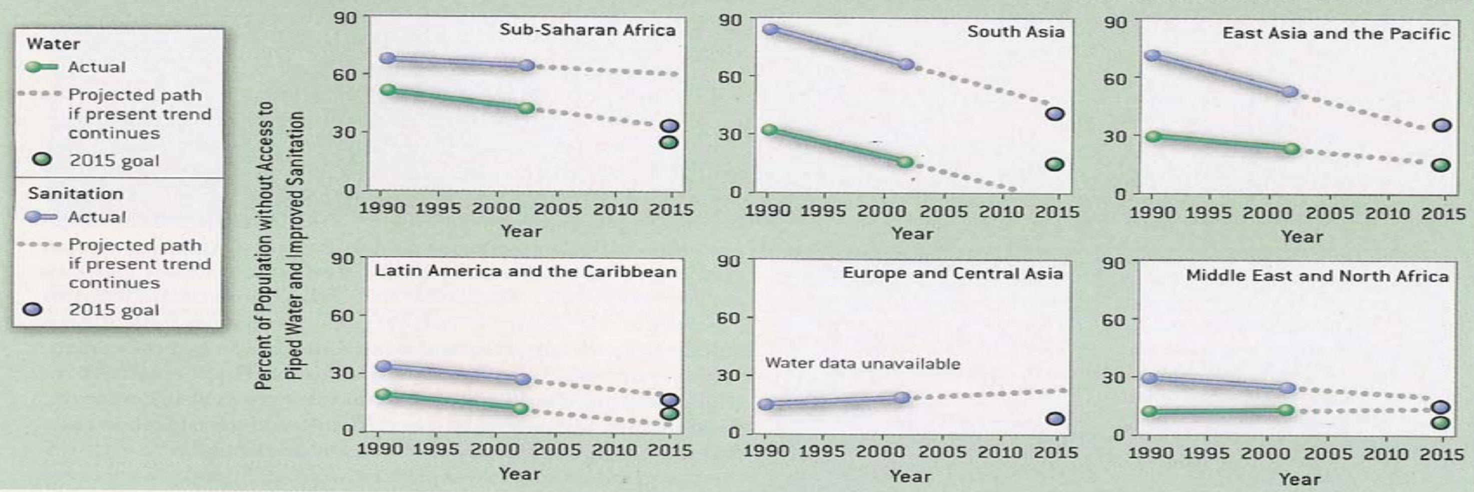
Targets: Halt and begin to reverse the spread of HIV/AIDS. Slow the spread of malaria and other diseases.
Status: HIV, now affecting about 40 million people, is widespread in parts of sub-Saharan Africa and poses a serious threat to other developing regions. Meanwhile malaria kills around three million people a year, mostly in Africa, the vast majority of them children. In recent years, the distribution of mosquito nets has expanded, but hundreds of millions in malarious regions still need nets.





GOAL 7 ENSURE ENVIRONMENTAL SUSTAINABILITY

Target: Halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation.
Status: With the exception of sub-Saharan Africa, access to drinking water in urban areas is generally relatively high, although rural access remains limited. Low availability of sanitation services in sub-Saharan African and South Asia contributes to widespread diarrheal disease.



GOAL 8 DEVELOP A GLOBAL PARTNERSHIP FOR DEVELOPMENT

Target: Address the special needs of the least developed countries (including more generous development assistance).
Status: Rich countries have repeatedly pledged to give 0.7 percent of their national income as foreign aid, yet 17 of 22 donors have failed to reach that target. Some progress has occurred, however: European Union countries recently committed to attaining the 0.7 percent mark by 2015. Meanwhile other donors claim that poor countries are too corrupt to achieve economic growth. The table at the right helps to dispel that myth; in fact, many fast-growing Asian economies have higher levels of perceived corruption than some slow-growing African ones.

CORRUPTION AND ECONOMIC GROWTH

		Rank of perceived corruption levels (lower means less corrupt)	Average yearly percent growth in GDP per capita, 1980–2000
Sub-Saharan Africa	Ghana	70	0.3
	Senegal	76	0.5
	Mali	78	−0.5
	Malawi	83	0.2
East Asia	India	83	3.5
	Pakistan	92	2.4
	Indonesia	122	3.5
	Bangladesh	133	2.0

GOAL 6: *THE MDG REPORT 2005* (*graphs*); GOAL 7: *GLOBAL MONITORING REPORT 2005: MDG: FROM CONSENSUS TO MOMENTUM* (*data*); GOAL 8: *GLOBAL CORRUPTION REPORT*, BY TRANSPARENCY INTERNATIONAL, 2004 (*table*)

Perspective –

Our universe has been here about 12 billion years,

our solar system formed about 4 billion years ago,

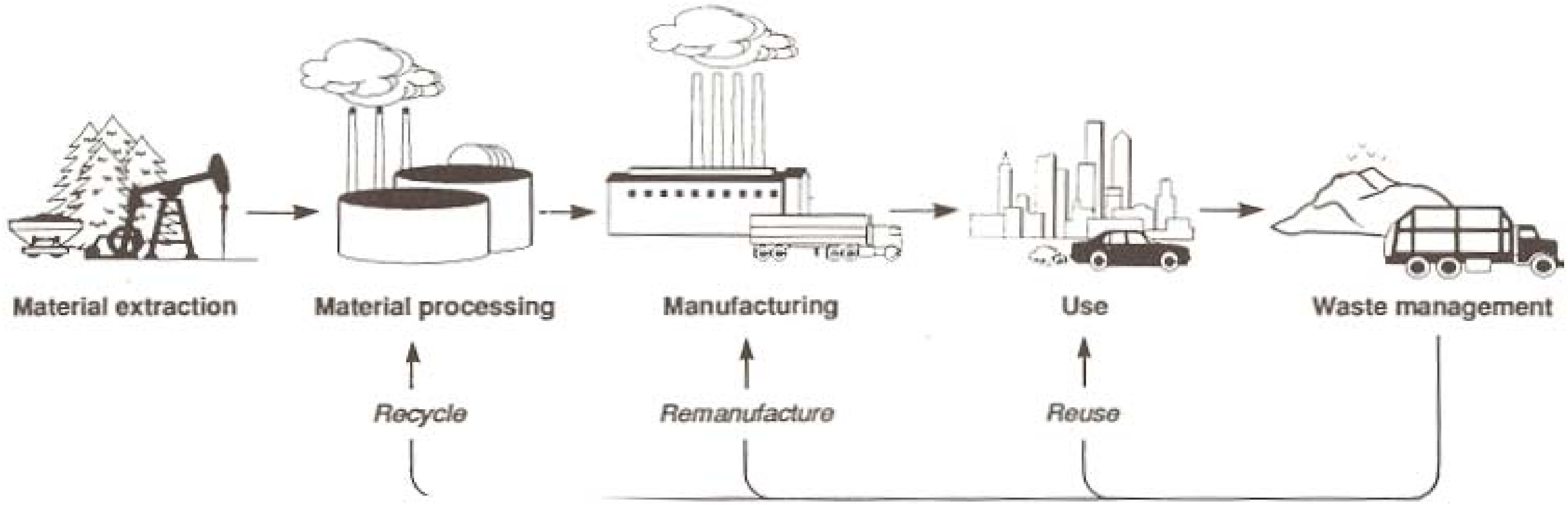
man has been walking this planet about 4 million years,

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.

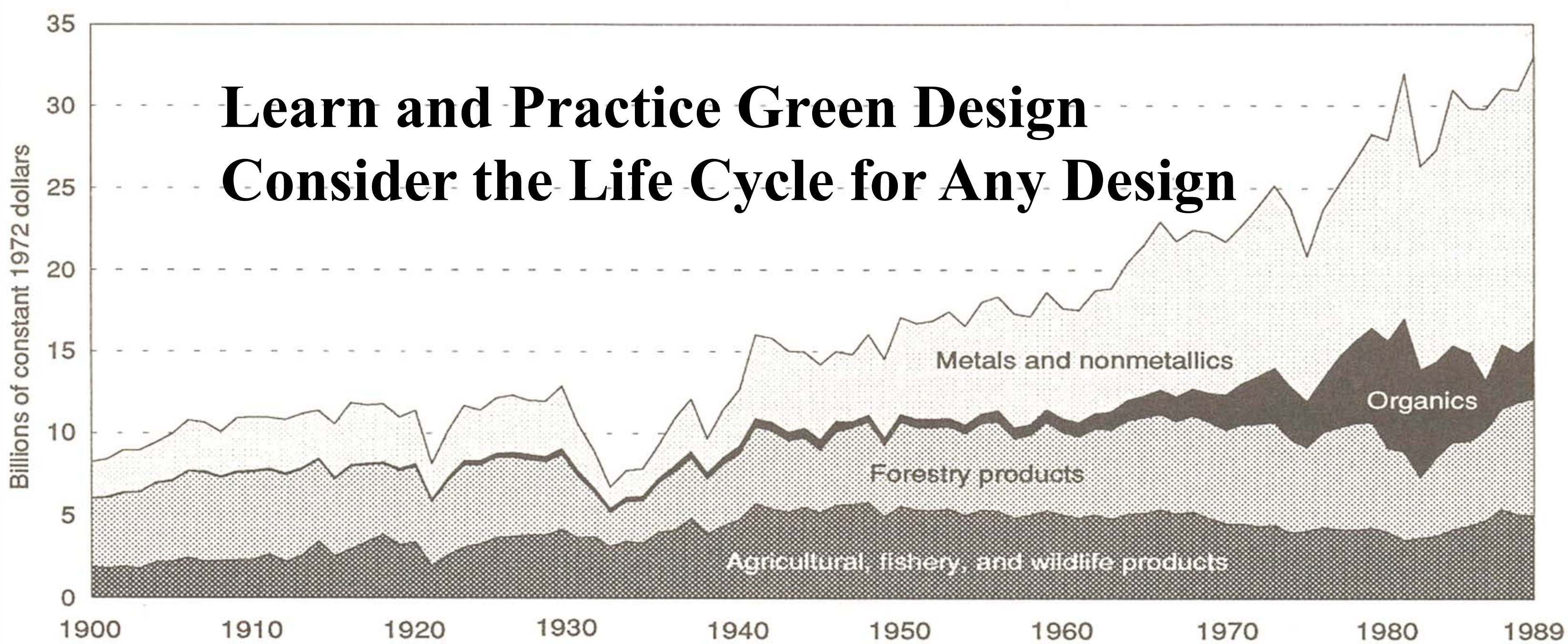
Olympus Photo Deluxe, 2000

ENGINEERING OPPORTUNITIES

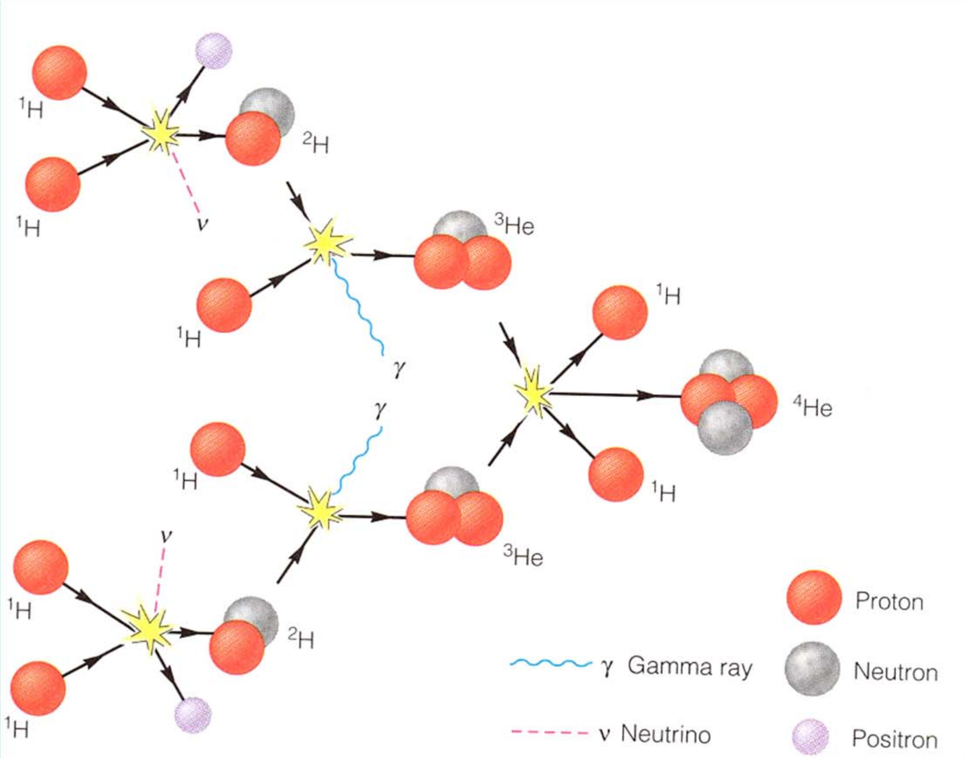


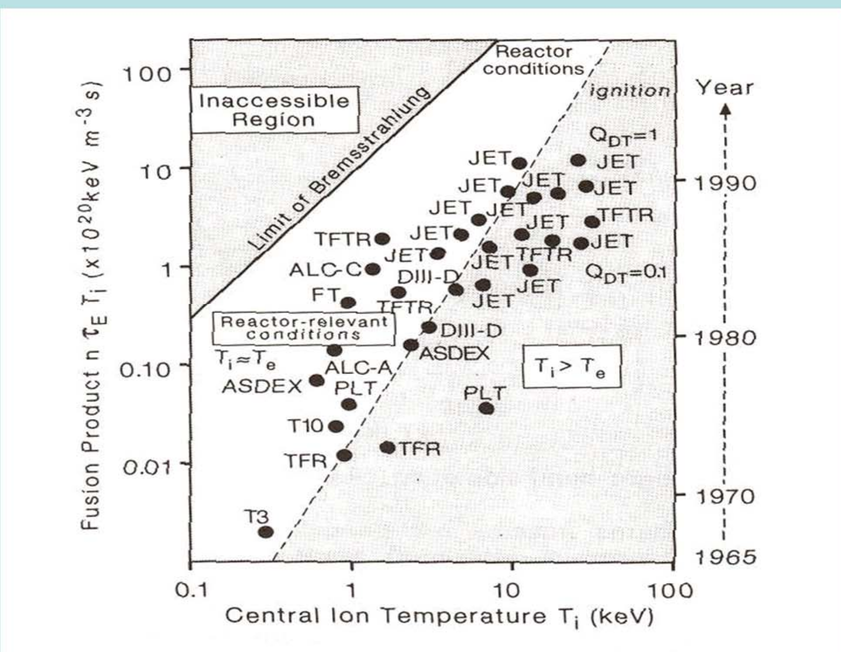
Learn and Practice Green Design

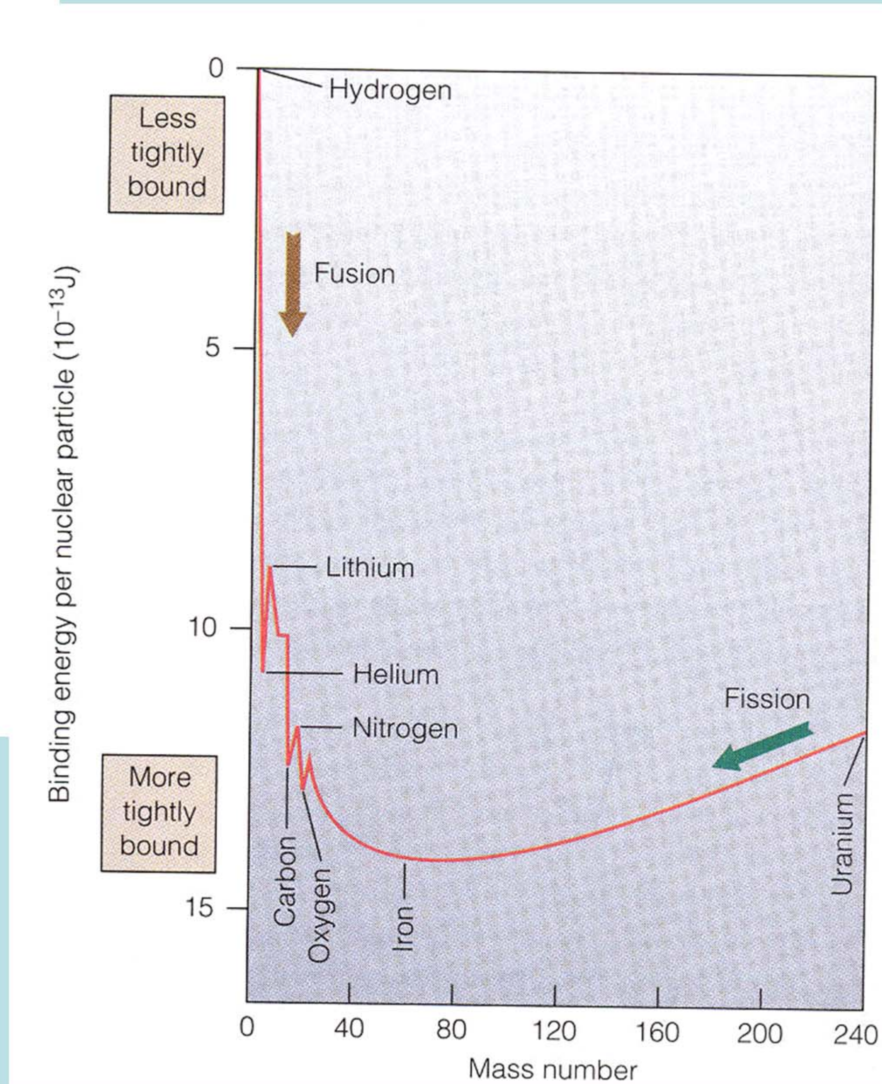
Consider the Life Cycle for Any Design



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







Nuclear Energy

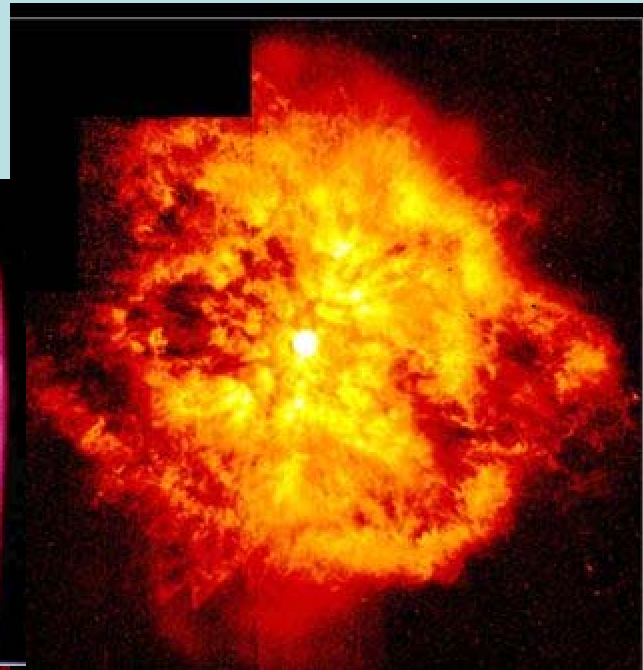
Horizons, Exploring the Universe – MA Seeds, Wadsworth Publishing, 1998.

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

Plasma Fusion

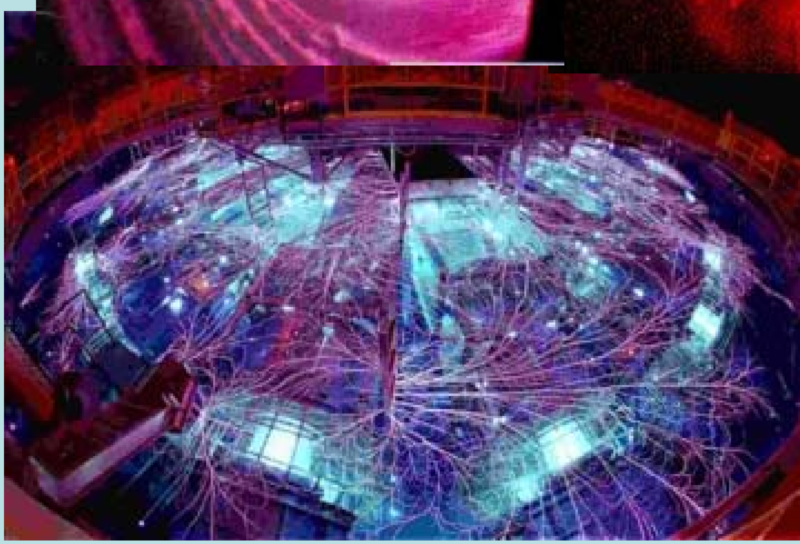
Plasma fusion reactors hold the promise for a long term, relatively clean energy source.

Nebula M1-67



Tokamak Plasma - Princeton

Inertial Confinement – Univ Rochester

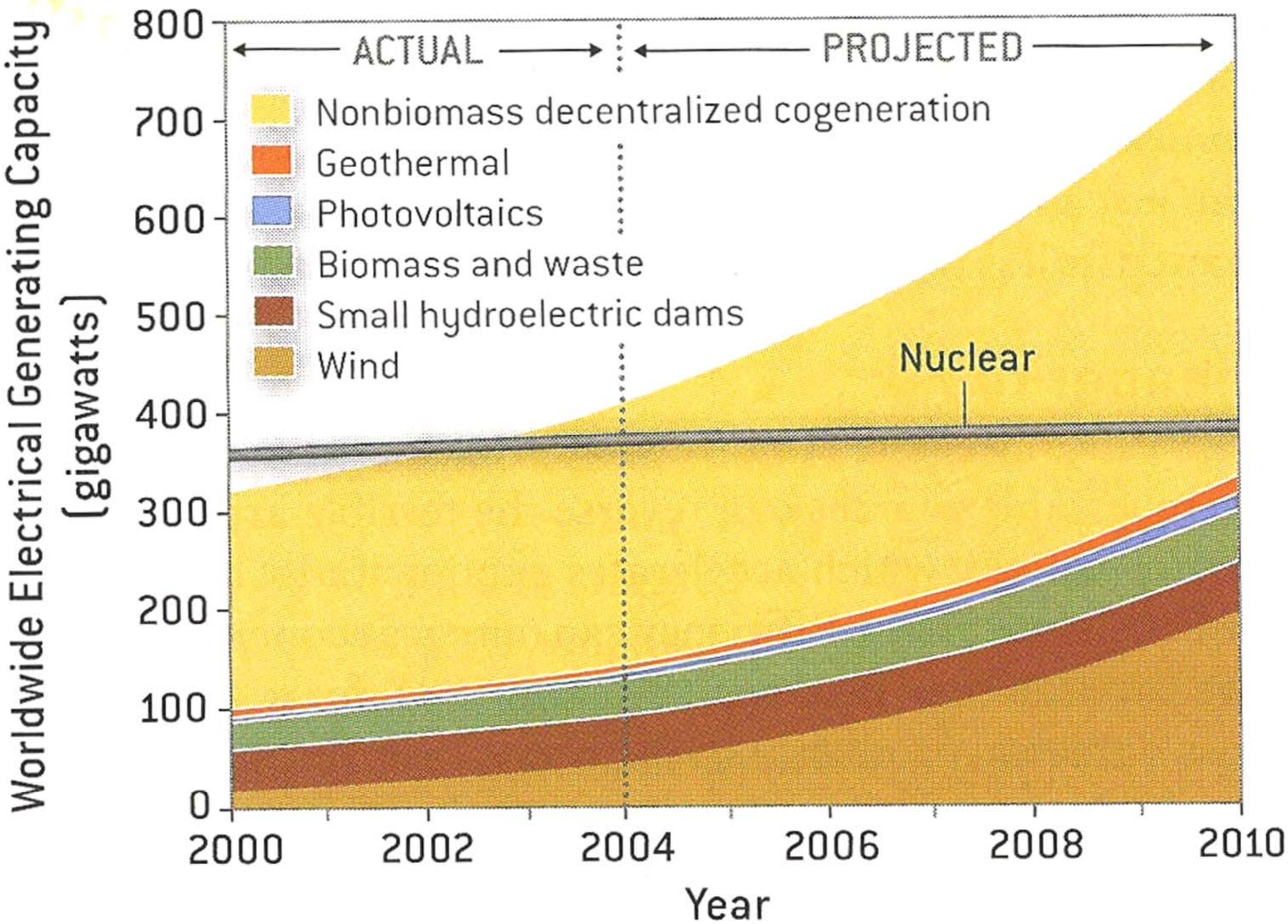


Z-Machine
Sandia

JET-Tokamak
UK Physics

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

ELECTRICITY ALTERNATIVES

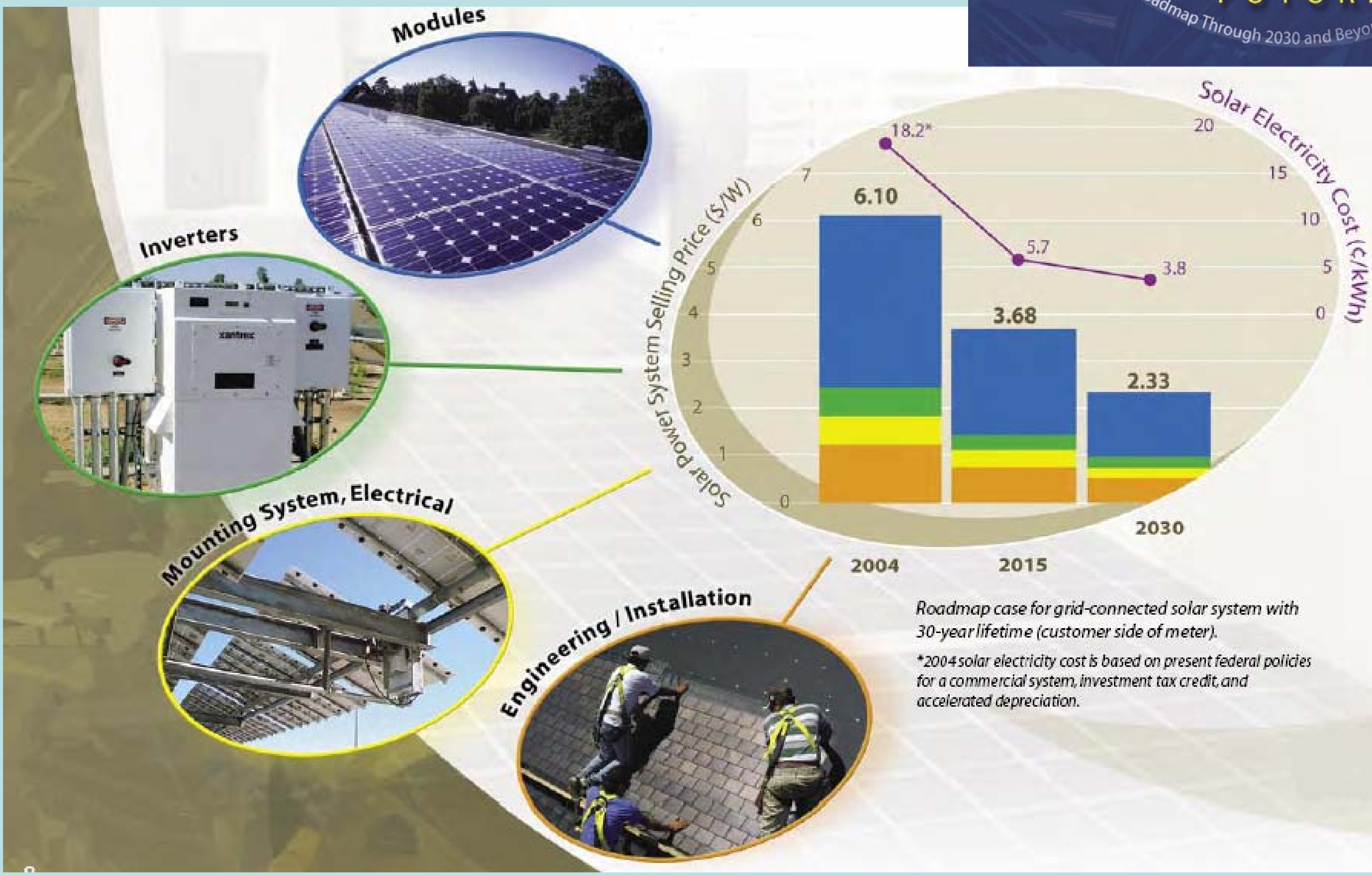


DECENTRALIZED SOURCES of electricity—cogeneration (the combined production of electricity and heat, typically from natural gas) and renewables (such as solar and wind power)—surpassed nuclear power in global generating capacity in 2002. The annual output of these low- and no-carbon sources will exceed that of nuclear power this year.

(Scientific American, September 2005)

The Goal: Solar provides half of all new U.S. electricity generation by 2025

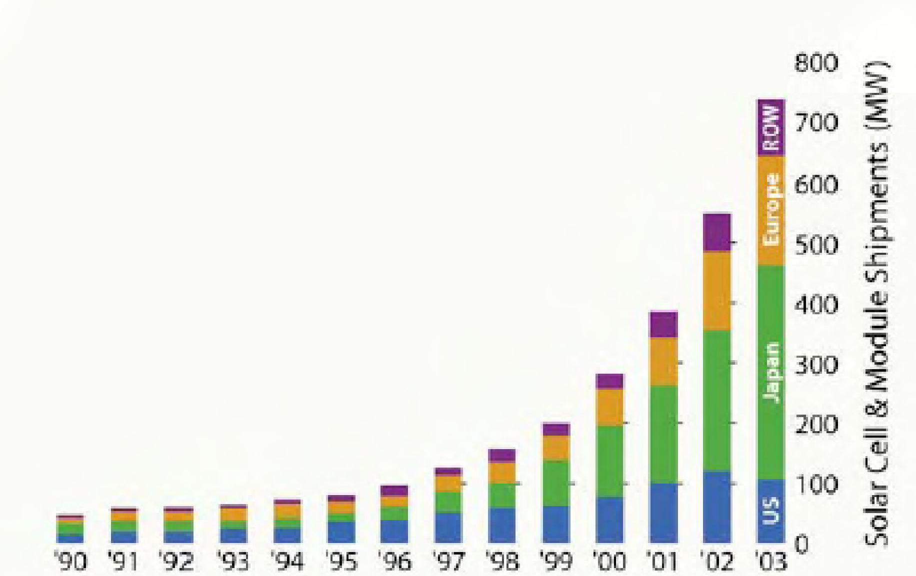
OUR Solar Power FUTURE
The U.S. Photovoltaics Industry Roadmap Through 2030 and Beyond



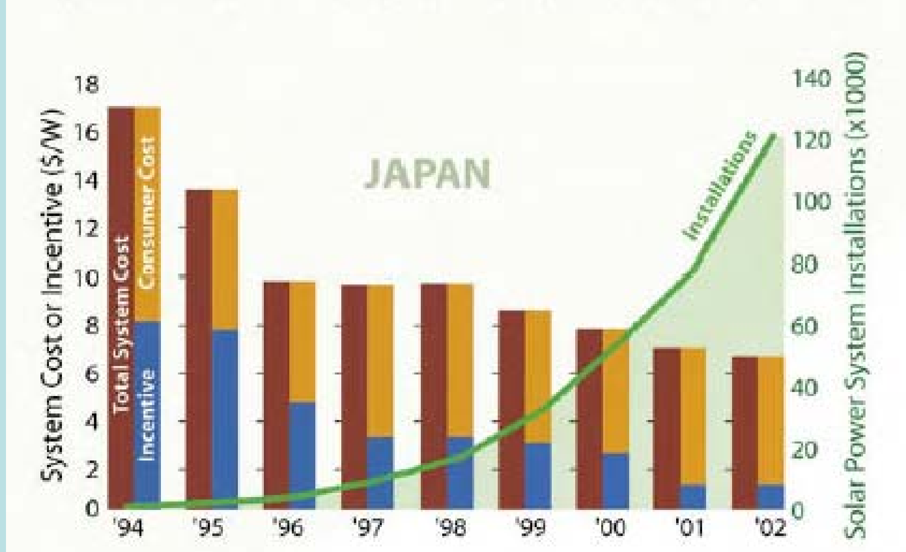
Roadmap case for grid-connected solar system with 30-year lifetime (customer side of meter).

**2004 solar electricity cost is based on present federal policies for a commercial system, investment tax credit, and accelerated depreciation.*

Solar Cell Market Growth



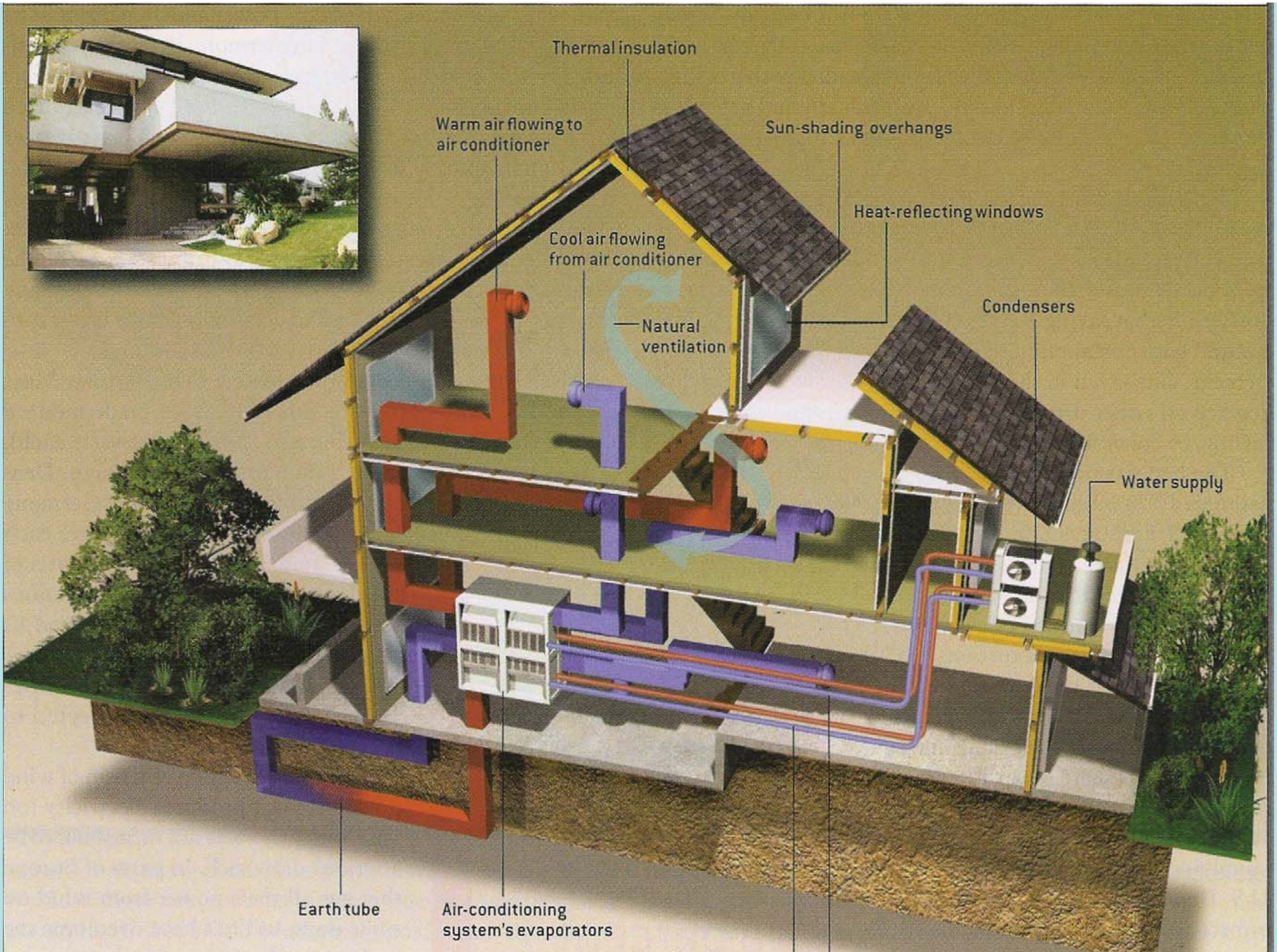
Worldwide solar power shipments in 2003 totaled 744 MW, with the U.S. share at only 14%.



Wind and Geothermal

Table of Targets and Projections for Solar Power for 2004 to 2050

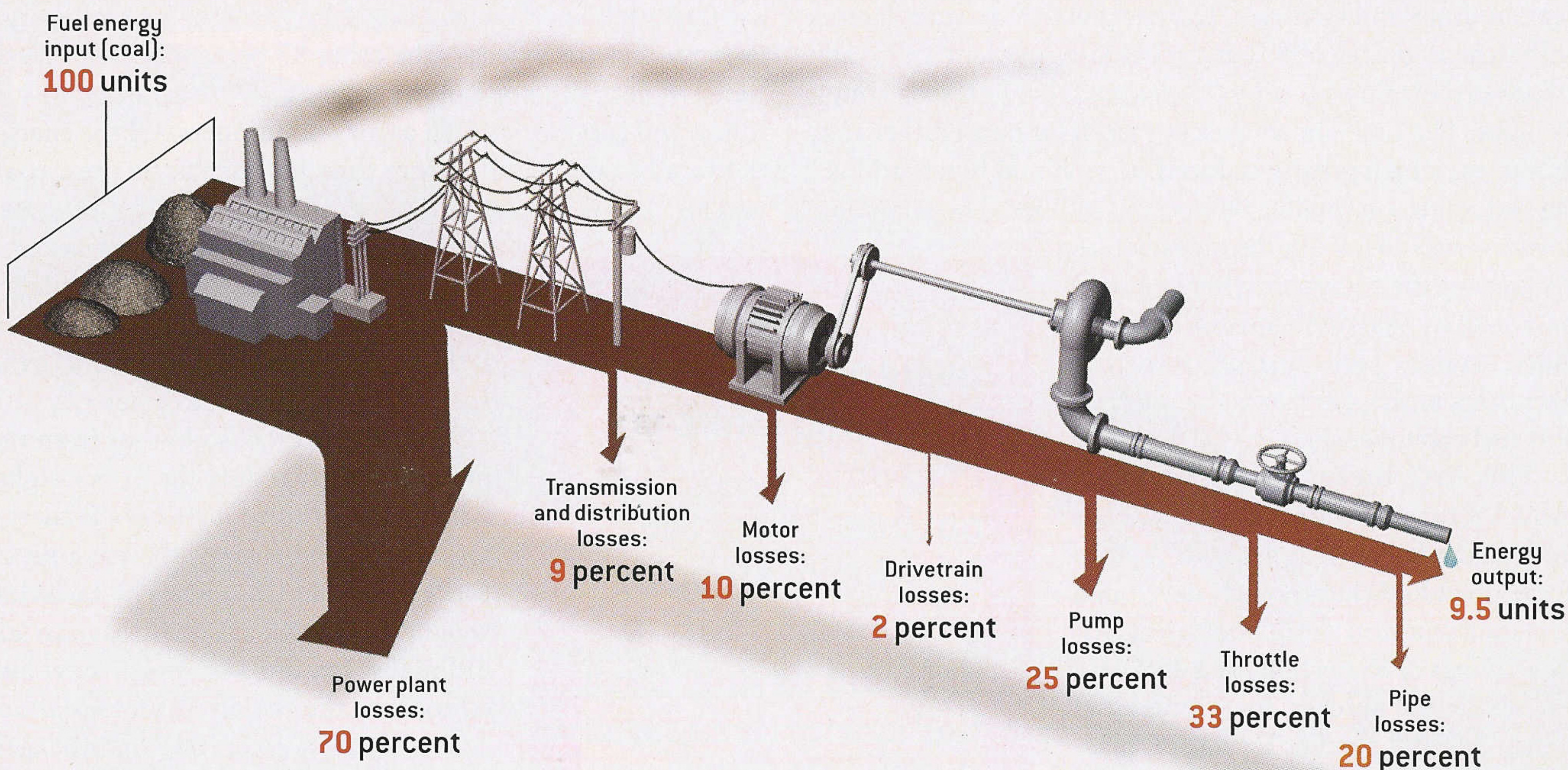
System Price and Electricity Cost, Commercial Systems		2004	2010	2015	2020	2030	2050
Best System Selling Price [a] ($/W)	Baseline	6.10	4.87	4.24	3.76	3.12	2.56
	Roadmap	6.10	4.65	3.68	3.01	2.33	1.93
Electricity Cost [b] (¢/kWh)	Baseline	18.2	13.4	11.5	10.0	8.2	6.8
	Roadmap	10.5	7.4	5.7	4.6	3.8	3.7
U.S. Solar Power Shipments, Installations, and Employment							
Annual U.S. Shipments (MW peak)	Baseline	120	240	480	950	2,400	5,500
	Roadmap	120	510	2,300	7,200	19,000	31,000
Cumulative U.S. Installations (MW peak)	Baseline	340	1,500	3,800	8,200	28,000	100,000
	Roadmap	340	2,100	9,600	36,000	200,000	670,000
Employment [c]	Baseline	20,000	23,000	28,000	37,000	59,000	95,000
	Roadmap	20,000	29,000	62,000	130,000	260,000	350,000
Performance Advances [d]							
Conversion Efficiency (%)	Cell	10–20	15–25	19–28	20–35	22–40+	Ultra-High Efficiency > 40
	Module	8–15	12–17	16–20	18–24	20–30	Ultra-Low Cost > 15
	System	6–12	9–14	13–18	14–20	18–25	



(Scientific American, September 2005)

COMPOUNDING LOSSES

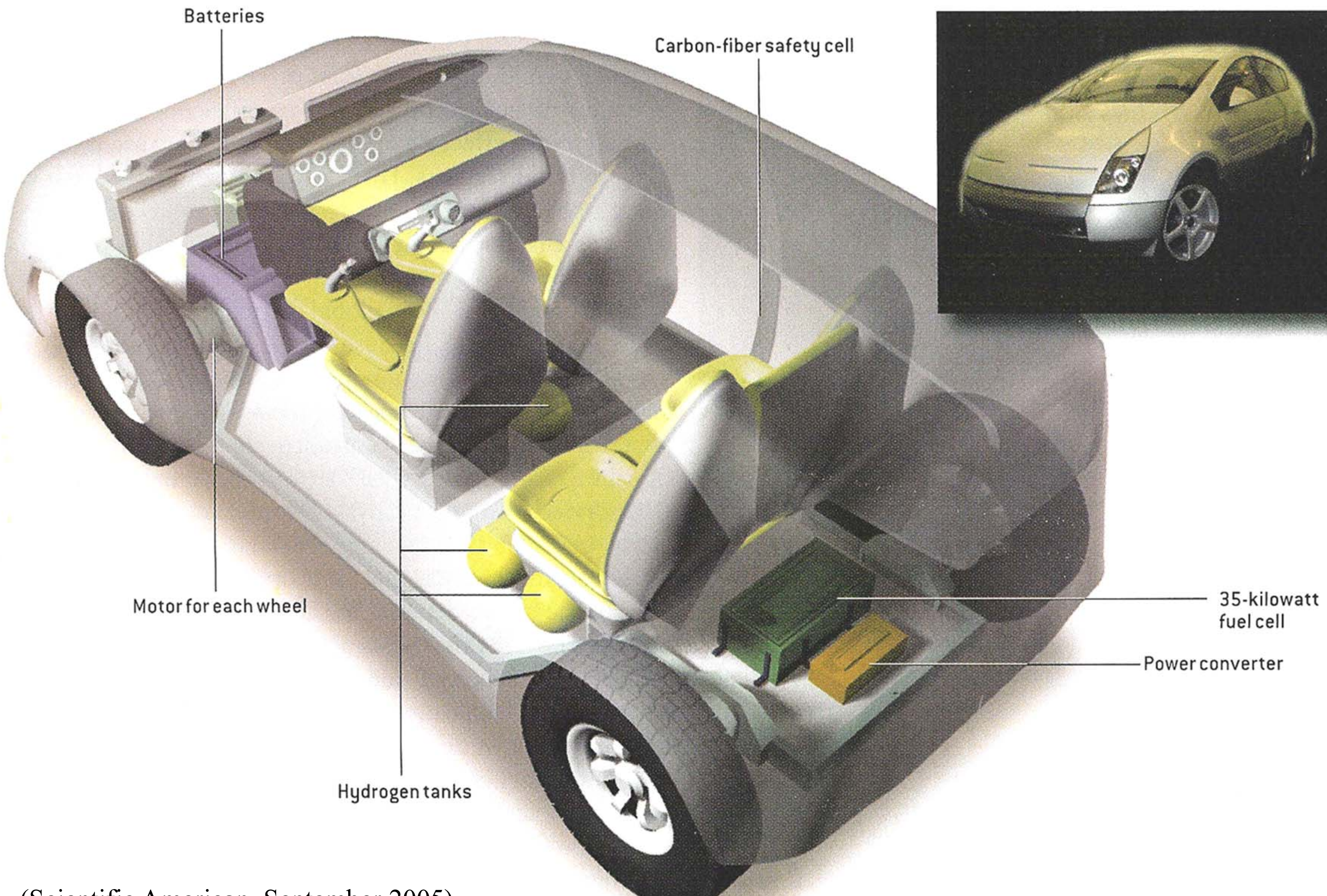
From the power plant to an industrial pipe, inefficiencies along the way whittle the energy input of the fuel—set at 100 arbitrary units in this example—by more than 90 percent, leaving only 9.5 units of energy delivered as fluid flow through the pipe. But small increases in end-use efficiency can reverse these compounding losses. For instance, saving one unit of output energy by reducing friction inside the pipe will cut the needed fuel input by 10 units, slashing cost and pollution at the power plant while allowing the use of smaller, cheaper pumps and motors.



(Scientific American, September 2005)

A LEAN, MEAN DRIVING MACHINE

Ultralight cars can be fast, roomy, safe and efficient. A concept five-seat midsize SUV called the Revolution, designed in 2000, weighs only 857 kilograms—less than half the weight of a comparable conventional car—yet its carbon-fiber safety cell would protect passengers from high-speed collisions with much heavier vehicles. A 35-kilowatt fuel cell could propel the car for 530 kilometers on 3.4 kilograms of hydrogen stored in its tanks. And the Revolution could accelerate to 100 kilometers per hour in 8.3 seconds.



(Scientific American, September 2005)

What can you do?

Become environment steward

Electricity, Water, Recycle

Improve use of energy resources

Use computer for paperless society

Design for conservation

Consider the life cycle

Plan for resource preservation

Teach others, educate young and adult

Practice personal conservation

Be an example

Additional

Work by a High Ethical Standard

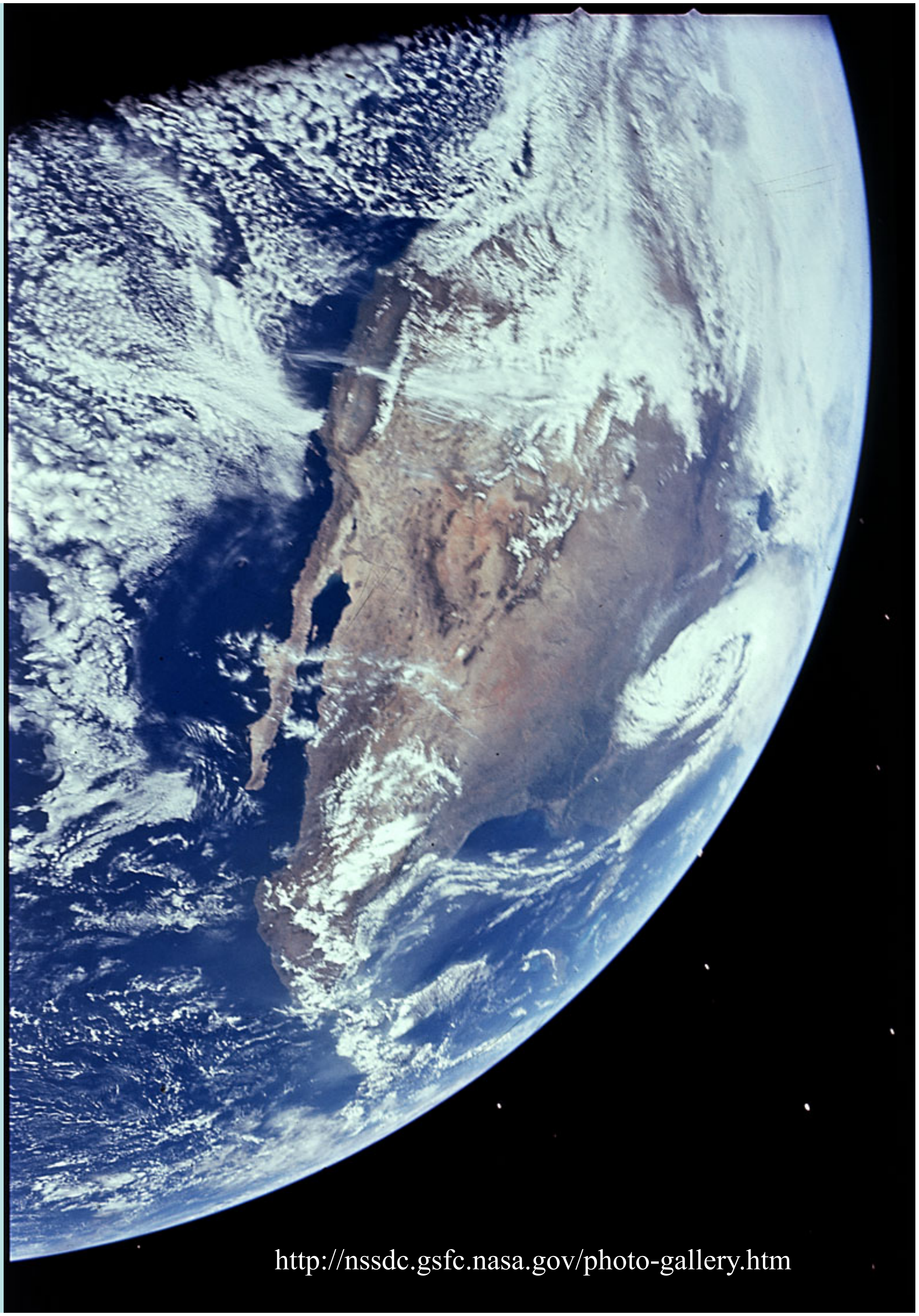
Develop Technical Competence

(Curious Observer)

Be Efficient Worker

(Project Tools)

Create Environment for Success



What can I do as an individual to conserve resources?

Olympus Photo Deluxe, 2000

Use low phosphate detergent
Use low flow faucet aerator
Reuse containers
End junk mail
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.

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

Millennium Ecosystem Assessment Publications

Technical Volumes (available from Island Press)

Ecosystems and Human Well-being: A Framework for Assessment

Current State and Trends: Findings of the Condition and Trends Working Group, Volume 1

Scenarios: Findings of the Scenarios Working Group, Volume 2

Policy Responses: Findings of the Responses Working Group, Volume 3

Multiscale Assessments: Findings of the Sub-global Assessments Working Group, Volume 4

Our Human Planet: Summary for Decision-makers

http://www.millenniumassessment.org/en/index.aspx

Synthesis Reports (available at MAweb.org)

Ecosystems and Human Well-being: Synthesis

Ecosystems and Human Well-being: Biodiversity Synthesis

Ecosystems and Human Well-being: Desertification Synthesis

Ecosystems and Human Well-being: Human Health Synthesis

Ecosystems and Human Well-being: Wetlands Synthesis

Ecosystems and Human Well-being: Opportunities and Challenges for Business and Industry

If you want a pdf copy of this presentation or the Millennium report, send me an email:
crp3@psu.edu

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Olympus Photo Deluxe, 2000

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